Data Flow Systems

TAC Pack TCU

Installation & Operation Manual

TAC Pack TCU
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Data Flow Systems also reserves the right to make changes to the specifications of TAC Pack TCU and to the information contained in this document at any time without notice.

This document contains information related to special features and functions that are only available when the TAC Pack TCU is utilized in a DFS TAC II SCADA System. These special features and functions may not be available when the TCU001 is utilized in a 3rd party SCADA System. If you are unsure about the availability of a feature or function, please contact DFS for clarification.

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PREFACE

PURPOSE OF THIS MANUAL

This manual is a reference guide for installing and operating the TAC Pack TCU (Telemetry Control Unit). It contains information meant to guide and assist you through the installation and configuration procedure. This includes mounting and wiring instructions, product features and specifications, I/O listings, instructions for integrating with telemetry, information on Modbus compatibility, and instructions for configuring and using the TCU's pump control process. It should be noted that the information in chapters 9 through 12 refers only to the TCU's built-in pump control process. Refer to this manual when designing, installing, configuring, or troubleshooting systems that use Data Flow Systems' TCU. For information on customizing the TCU's operations with your own program, refer to the *TCU Programming Reference* (part number DFS00367-011-03). It provides detailed information on DFS BASIC-52's commands and statements.

DOCUMENT CONVENTIONS

The following conventions are used throughout this manual:

- Bulleted lists provide information, not procedural steps.
- Numbered lists provide sequential steps or hierarchal information.
- ***Bold italic*** type is used for emphasis
- *Italic* type is used to indicate text displayed on the LCD screen.
- *ALL CAPITALIZED ITALIC* type is used for terminal names.

ABBREVIATIONS USED IN THIS MANUAL

H-O-A – Hand-Off-Auto

I/O – Input/Output

PCU – Pump Control Unit

PLC – Programmable Logic Controller

RTU – Remote Terminal Unit

SCU – Supervisory & Control Unit

TCU – TAC Pack Telemetry Control Unit

Notes

Chapter 1: PRODUCT OVERVIEW

DESCRIPTION

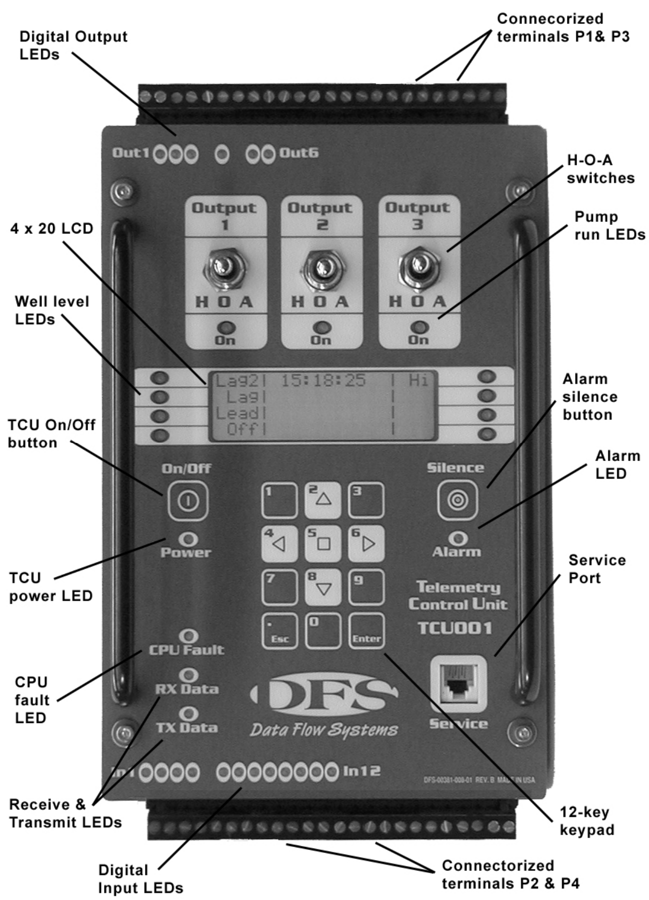
The TAC Pack Telemetry Control Unit (TCU) is a microprocessor-controlled device.

There are several options for using the TCU's multiple input and output points.

- They can be used as non-intelligent I/O by setting the number of pumps to 0 (zero).
- They can be used in a pump control application.
- They can be manipulated logically with a DFS BASIC-52 program (much like a PLC).

Additionally, the TCU:

- Can communicate with and manipulate the I/O of up to 15 remote modules via a radio or network link.
- Can be incorporated into a Remote Terminal Unit (RTU) by using a Bus Extender Module (BEM). [Note that with this configuration, the TCU cannot be used as a simple central site (that is, it cannot poll remote modules).]



The installed pump control application program enables the TCU to be easily implemented in lift station or storage tank applications. For a pump control application, the TCU contains all the hardware and software needed to control up to three motor starters.

Placing a custom BASIC program on the TCU enables it to perform a variety of automated tasks when interfaced with other telemetry equipment (DFS equipment, or RS-485 or RS-232 compatible devices). When used as a programmable device, the TCU can control up to six digital output devices, and monitor up to 12 digital and two analog input devices.

The TCU's dual functionality (its ability to use the built-in pump control process ***or*** a custom program) helps reduce overhead by enabling one unit to be used in either a pump control or programmable application.

FEATURES

Legacy PCU operation	The TCU is backward compatible with DFS' Pump Control Unit (PCU). Very few wiring changes are required. Existing PCU configurations can be easily transferred to the TCU.
Autodialer (optional)	The TCU001 can be ordered with an autodialer or can be retrofitted at the factory to add this feature to an existing TCU001. The TCU001-AD (TCU001 with optional autodialer) enables utilities to be alerted of active alarm conditions at remote well/storage tank stations that aren't part of a SCADA telemetry system. For more information on this feature, see "Appendix H: TCU001-AD Autodialer."
Network Adapter (optional)	The TCU001 can be ordered with an optional integrated 10/100 network adapter or can be retrofitted at the factory to add this feature to an existing TCU001. The TCU001-IP presents an ideal solution where radio may not be preferred, but where networking is available. For more information on this feature, see "Appendix I: TCU001-IP."
Twelve digital inputs	Twelve digital inputs for monitoring level, contact closure, or pulse counter. *
Two 12-bit analog inputs	Two 12-bit analog inputs offer enhanced accuracy and increased resolution. *
Six digital outputs	Six digital outputs – four solid state and two contact closure (1 normally closed).
Integrated digital radio	Integrated digital radio (2 W, 200 MHz) is on-site programmable.
RS-485 Modbus fieldbus half-duplex serial interface	RS-485 Modbus fieldbus half-duplex serial interface enables communication with industry standard devices and VFD motor controllers. *
Dual double-speed microcontrollers	Dual double-speed microcontrollers (one for controlling functions; one for communication).
True RMS AC phase monitor	True RMS AC phase monitor produces accurate and exact voltage readings for single- and three-phase power.
Pulse input	Configurable, auxiliary digital input (P2-12) can be used with pulse-type flow meters and rain gauges.
Standard RS-232 Modbus radio interface	Standard RS-232 Modbus radio interface acts as an interface to external industry standard radios. (Note that the TCU must be factory configured by DFS to provide Modbus slave support.)
34 LEDs	34 LEDs provide system status at a glance.
Three H-O-A switches	Three fail-safe Hand-Off-Auto (HOA) switches.

Four connectorized wire terminals	Four connectorized wire terminals allow servicing or replacement of the unit without rewiring the control panel. No user configuration straps or jumpers are required.
On-board BASIC line editor and 128 Kbytes of NOVRAM	On-board BASIC line editor and 128 Kbytes of non-volatile random access memory (NOVRAM) for storing basic programs and for system use.
4 x 20-character LCD	4 x 20-character LCD provides a large area for displaying data. The LCD's contrast is controlled by an onboard temperature sensor that ensures that the screen is easy to read in both high- and low temperature conditions.
12-key membrane switch keypad and soft power switch	12-key membrane switch keypad and soft-power switch offers ease of use when powering up/down the TCU and when entering TCU configurations, and viewing and resetting alarms.
Self-monitoring	Self-monitoring capabilities include an On state self test and monitoring of radio current and unit temperature.
Pump run time meters	For each pump, elapsed run time and average run time meters are provided.
HT3 telemetry interface	Telemetry interface enables operators to remotely monitor off-site conditions and control equipment from a central location.
Mounting options	Mounting options allow the TCU to be mounted to a front panel, or mounted flush against or stood off from the back plate of a control panel.
Protection	• Integrated switching power supply • Surge protection (non-destructive) and on-board voltage regulation • Sealed radio compartment protects the internal radio against corrosion • Battery backup with external battery (12V, 2.6Ah or 12V, 7.0Ah)

* This feature not available with legacy PCU configuration.

COMPATIBILITY ISSUES

When developing the TAC Pack TCU, DFS made every effort to make the TCU downward compatible with the Pump Control Unit (PCU), PCU TAC Pack, Supervisory & Control Unit (SCU), and SCU TAC Pack. There are a few important differences, however, that must be addressed when replacing one unit type with another.

Please note that the PCU, PCU TAC Pack, SCU, and SCU TAC Pack are not "upward" compatible with the TCU. DFS' Sales Department can provide assistance with ensuring that your system has appropriate replacement units on hand. Contact DFS' Sales Department (321-259-5009; sales@dataflowsys.com) for more information.

PCU and PCU TAC Pack

Analog Level Transducer

When using a TCU to replace a PCU that was providing power to an analog level transducer, transducer power must be acquired from pin P2-16 of the TCU. In a PCU installation, power could be acquired from pins P2-21 or P2-16. When upgrading to a TCU, the wire from P2-21 (PCU) must be moved to P2-16 (TCU). More information on wiring an analog level transducer can be found on page 73.

Alarm Output Relays

The alarm output relays (light and horn) on both the TCU and PCU are mechanical-type relays whose outputs are UL rated at 0.5 ampere AC and 1 ampere DC. Some PCU users have been using alarm devices that exceed these ratings. Because the PCU's alarm output relays were more "forgiving," many users did not experience problems from overloading the PCU relays, except possibly premature contact failure. However, when a TCU was placed in one of these installations, users began experiencing failures (alarm output remained constantly in the ON state).

When replacing a PCU with a TCU, it is necessary to install an interposing relay with either a snubber (for AC interposing relays) or a diode (for DC interposing relays) if either of the PCU's alarm outputs were being used to drive devices that exceed these specifications. This is especially important for AC strobe-type lights due to their high peak current demands. These solid-state strobe lights require large surge currents (>3 amps for several milliseconds) to charge capacitors for the strobe operation. These large surge currents tend to weld together the normally closed contacts of the alarm light output relay resulting in the Alarm Light Output remaining in the ON state.

It is important to note that interposing relays are not required if the TCU is replacing a PCU whose alarm relay outputs were being used within the rated current.

For details on wiring the alarm outputs, see "Alarm Light and Horn Outputs" starting on page 61.

SCU and SCU TAC Pack

In order for an existing SCU program to run interchangeably on both an SCU and a TCU, at least four modifications must be made to the program:

- Add code that determines if the program is running on a TCU or an SCU
- Change how the program reads the phase monitor. The TCU's C3 and C4 points (Phase AB Voltage and Phase AC Voltage, respectively) have greater ranges for the engineering and raw units values than those for the SCU. The ranges for an SCU are 151-300 VAC over a 0-255 raw units span. The ranges for a TCU can be found in the section titled "HT3 Software Configuration" on page 91.
- Remap two I/O points wired to connector P2. In the SCU, pin P2-12 is mapped to HT3 address point A11; pin P2-13 is mapped to point A12. In order for the TCU to be downwardly compatible with the Legacy PCU, and have the ability to transmit pulse input data to HT3, the TCU doesn't map these two inputs the same as the SCU. In the TCU, pin P2-12 (Legacy PCU auxiliary digital monitor input, now available for use as a digital pulse input) is mapped to HT3 address point A12; pin P2-13 (Legacy PCU alarm silence switch digital monitor input) is mapped to HT3 address point B7.
- Change how the menus are displayed and how keypad entries are made.
- Add a loop timer (optional) to compensate for the TCU's quicker loop time.

These differences need to be addressed in the configuration and programming of any SCU being replaced by a TCU. Contact DFS' Service Department for assistance with making the required modifications.

TECHNICAL SPECIFICATIONS

Box Dimensions	5.75" x 8.75" x 5.45"
Supply Voltage	120 VAC +/-10%
Frequency	60 Hz
Current	0.5 A
Phase Monitor	240 VAC single- or three-phase; 480 VAC three-phase using external resistors
Battery Backup	12 V, sealed, lead-acid battery
Analog Inputs	4-20 mA @ 250 Ω /1-5 V @ 100 kΩ; both inputs are 12-bit accurate
Digital Input Voltages	10-30 VAC/VDC 30-300 VAC/VDC with external resistors
Digital Input Impedance	6 KΩ
Digital Outputs	120-240 VAC, 60 Hz, 1 A, Pilot Duty
Bias	100 mA
Integrated Radio	2 W; 200 MHz; 10-14 VDC; 1 A Optional 5 W; synthesized 400 MHz; 9-18 VDC; 1.8 A [requires installation of an Analog Radio Converter (ARC001)]
RS-232 Interface	9600 Bd serial interface for polling TCU as Modbus slave device (Requires factory configuration by DFS)
RS-485 Interface	9600 Bd serial interface for Modbus ASCII/RTU devices
Ethernet Interface (optional)	10Base-T; TCP/IP (UDP Datagram); 12-14 VDC; 500 mA
ISO+24V / ISOGND	24 VDC at 60 mA (100 mA max), unregulated, isolated
Input Protection	M.O.V., Transorb (Transient Voltage Suppressor), and Opto-isolated
Alarm Relays	120 VAC, 60 Hz, 0.5 A, Tungsten, 0-24 VDC, 1.0 A
Alarm Light / Horn	Normally closed contacts
LCD w/Keypads	Liquid Crystal Display; keypad is used to page through programmed menu items
H-O-A Switches	3 x 3 position switches hardwired to 3 solid state control points for Hand-Off-Auto operation
Replacable Fuse	.375 A fuse designed to protect the TCU's DC power circuitry from its operating AC input voltage
Environmental Conditions	Ambient Operating Temperature Range: -10°C (14°F) to 60°C (140°F). The upper temperature limit is 50°C (122°F) when using the recommended backup battery. Note that the LCD display may become unreadable at temperatures below 0°C. Relative Humidity: 0-100% Atmospheric Pressure: 75-106 kPa Overvoltage Category II Pollution Degree 2
Safety Approval	UL listed for Process Control Equipment (UL1092)

PIN NAME / WIRING DEFINITIONS FOR PUMP CONTROL APPLICATION

Top Connector 1: P1

PIN#	Name	Description	Electrical Rating
P1-1	PHASE_C	Phase C of the three-phase power monitor	120-240 VAC, 60 Hz, 100 mA, 3-phase
P1-2	PHASE_B	Phase B of the three-phase power monitor	120-240 VAC, 60 Hz, 100 mA, 3-phase
P1-3	PHASE_A	Phase A of the three-phase power monitor	120-240 VAC, 60 Hz, 100 mA, 3-phase
P1-4	UNUSED	DO NOT CONNECT	
P1-5	AC_PWR	TCU's AC power	120 VAC, 60 Hz, 0.5 A
P1-6	AC_NEUT	TCU's AC power neutral	120 VAC, 60 Hz, 0.5A
P1-7	TGND	Safety ground	Ground
P1-8	BAT+	Backup battery positive terminal	<24 V / Not Rated
P1-9	BAT-	Backup battery negative terminal	<24 V/ Not Rated
P1-10	BEMGND	Isolated ground (wire to BEM001, pin 12)	<24 V/ Not Rated
P1-11	BEM_PWR	Isolated power (wire to BEM001, pin 10)	<24 V/ Not Rated
P1-12	BEM_CTS	Isolated clear to send (wire to BEM001, pin 6)	<24 V/ Not Rated
P1-13	BEM_RXD	Isolated receive data (wire to BEM001, pin 4)	<24 V/ Not Rated
P1-14	BEM_TXD	Isolated transmit data (wire to BEM001, pin 2)	<24 V/ Not Rated
P1-15	BEM_RTS	Isolated request to send (wire to BEM001, pin 8)	<24 V/ Not Rated
P1-16	ALM_HORN	Load side of alarm horn relay (NO)	120 VAC, 60 Hz, 0.5A, Tungsten, 0-24 VDC, 1A
P1-17	ALM_LITE	Load side of alarm light relay (NC)	120 VAC, 60 Hz, 0.5 A, Tungsten, 0-24 VDC, 1 A
P1-18	ALM_PWR	Line side of alarm relays	120 VAC, 60 Hz, 1 A, 0-24 VDC, 2 A, Source
P1-19	AUX_OUT	Load side of auxiliary relay	120-240 VAC, 60 Hz, 1 A, Pilot Duty
P1-20	AUX_PWR	Line side of auxiliary relay	120-240 VAC, 60 Hz, 1 A, Source
P1-21	MTR3_STR	Load side of motor starter 3 relay	120-240 VAC, 60 Hz, 1 A, Pilot Duty
P1-22	MTR2_STR	Load side of motor starter 2 relay	120-240 VAC, 60 Hz, 1 A, Pilot Duty
P1-23	MTR1_STR	Load side of motor starter 1 relay	120-240 VAC, 60 Hz, 1 A, Pilot Duty
P1-24	STRT_PWR	Line side of motor starter relays	120-240 VAC, 60 Hz, 3 A, Source

Top Connector 2: P3

PIN#	Name	Description	Electrical Rating
P3-1	ST_ADDR0	Station address bit 0 (value 1)	<24 V/ Not Rated
P3-2	ST_ADDR1	Station address bit 1 (value 2)	<24 V/ Not Rated
P3-3	ST_ADDR2	Station address bit 2 (value 4)	<24 V/ Not Rated
P3-4	ST_ADDR3	Station address bit 3 (value 8)	<24 V/ Not Rated
P3-5	ST_ADDR4	Station address bit 4 (value 16)	<24 V/ Not Rated
P3-6	ST_ADDR5	Station address bit 5 (value 32)	<24 V/ Not Rated
P3-7	ST_ADDR6	Station address bit 6 (value 64)	<24 V/ Not Rated
P3-8	ST_ADDR7	Station address bit 7 (value 128)	<24 V/ Not Rated
P3-9	ST_ADDR8	Station address bit 8 (value 256)	<24 V/ Not Rated
P3-10	GND	Station address ground	<24 V/ Not Rated
P3-11	INV	Invert data	<24 V/ Not Rated
P3-12	SWAP	Swap data	<24 V/ Not Rated
P3-13	CFG_BIT2	Reserved – do not connect	<24 V/ Not Rated
P3-14	CFG_BIT3	Reserved – do not connect	<24 V/ Not Rated
P3-15	GND	Configuration ground	<24 V/ Not Rated
P3-16	EARTH_GND	Earth ground/lanyard	Not Connected
P3-17		Unused	Not Connected
P3-18		Unused	Not Connected

Bottom Connector 1: P2

PIN#	Name	Description	Electrical Rating
P2-1	MTR1_RUN	Motor 1 run digital monitor input	10-30 VAC/VDC @ 10 mA
P2-2	MTR2_RUN	Motor 2 run digital monitor input	10-30 VAC/ VDC @ 10 mA
P2-3	MTR3_RUN	Motor 3 run digital monitor input	10-30 VAC/ VDC @ 10 mA
P2-4	EXT_PM	External phase monitor digital monitor input	10-30 VAC/ VDC @ 10 mA
P2-5	IN_COM_1	Common return for motor run and external phase monitor input	10-30 VAC/ VDC @ 40 mA RTN
P2-6	LOW_LVL	Low Level digital monitor input	10-30 VAC/ VDC @ 10 mA
P2-7	OFF_LVL	Off Level digital monitor input	10-30 VAC/VDC @ 10 mA
P2-8	LEAD_LVL	Lead Level digital monitor input	10-30 VAC/VDC @ 10 mA
P2-9	LAG1_LVL	Lag1 Level digital monitor input	10-30 VAC/VDC @ 10 mA
P2-10	LAG2_LVL	Lag2 Level digital monitor input	10-30 VAC/VDC @ 10 mA
P2-11	HIGH_LVL	High Level digital monitor input	10-30 VAC/VDC @ 10 mA
P2-12	AUX_IN	Auxiliary digital monitor input	10-30 VAC/VDC @ 10 mA
P2-13	ALM_SIL	Alarm Silence Switch digital monitor input	10-30 VAC/VDC @ 10 mA
P2-14	IN_COM_2	Common return for input level, aux inputs, and alarm silence switch	10-30 VAC/VDC @ 80 mA RTN
P2-15	ISOGND	Internally supplied 24 VDC bias source return	<24 V/ Not Rated
P2-16	ISO+24V	Internally supplied 24 VDC bias source voltage	<24 V/ Not Rated
P2-17	TXD_232	RS-232 transmit data to external device	<24 V/ Not Rated
P2-18	RXD_232	RS-232 receive data from external device	<24 V/ Not Rated
P2-19	GND	RS-232 ground	<24 V/ Not Rated
P2-20	TGND	Shield for analog monitor signals	Ground
P2-21	ANALOG2+ (C2)	4-20 mA+ signal from transducer; - signal at pin P2-23	<24 V/ Not Rated
P2-22	ANALOG1+ (C1)	0-5 VDC or 4-20 mA+ signal from transducer; - signal at pin P2-23; jump pin P2-24 to P2-23 for a 4-20 mA C1 signal	<24 V/ Not Rated
P2-23	ANALOG-	- signal return for both analog inputs C1 and C2 at P2-22 and P2-21	<24 V/ Not Rated
P2-24	SHUNT	250 Ω shunt resistor; jump to P2-23 with 4-20 mA signal for C1 at P2-22 only	<24 V/ Not Rated

Bottom Connector 2: P4

PIN#	Name	Description	Electrical Rating
P4-1	Unused	Reserved for future use; do not connect	<24 V/ Not Rated
P4-2	Unused	Reserved for future use; do not connect	<24 V/ Not Rated
P4-3	RS485_B	RS-485 serial interface B	<24 V/ Not Rated
P4-4	RS485_A	RS-485 serial interface A	<24 V/ Not Rated
P4-5	EX_SHIELD	Cable shield for RS-485 or RS-232 cable	Ground
P4-6	EX_GND_RAD	RS-232 ground	<24 V/ Not Rated
P4-7	RTS_RAD	RS-232 Request to send	<24 V/ Not Rated
P4-8	EX_TXD_RAD	RS-232 transmit data to external device	<24 V/ Not Rated
P4-9	EX_RXD_RAD	RS-232 receive data from external device	<24 V/ Not Rated
P4-10	CTS_RAD	RS-232 clear to send	<24 V/ Not Rated
P4-11		Unused	Not Connected
P4-12		Unused	Not Connected
P4-13		Unused	Not Connected
P4-14		Unused	Not Connected

PIN NAME / WIRING DEFINITIONS FOR CUSTOMIZED APPLICATION

Top Connector 1: P1

PIN#	Name	Description	HT3 Address
P1-1	PHASE_C	Phase C of the three-phase power monitor (120-240 VAC, 60 Hz, 100 mA, 3-phase)	C4
P1-2	PHASE_B	Phase B of the three-phase power monitor (120-240 VAC, 60 Hz, 100 mA, 3-phase)	C3
P1-3	PHASE_A	Phase A of the three-phase power monitor (120-240 VAC, 60 Hz, 100 mA, 3-phase)	B11
P1-4	UNUSED	DO NOT CONNECT	--
P1-5	AC_PWR	TCU's AC power (120 VAC, 60 Hz, 0.5 A)	B9
P1-6	AC_NEUT	TCU’s AC power neutral (120 VAC, 60 Hz, 0.5 A)	--
P1-7	TGND	Safety ground	--
P1-8	BAT+	Backup battery positive terminal (<24V/not rated)	--
P1-9	BAT-	Backup battery negative terminal (<24V/not rated)	--
P1-10	BEMGND	Isolated ground (wire to BEM001, pin 12) (<24V/not rated)	--
P1-11	BEM_PWR	Isolated power (wire to BEM001, pin 10) (<24V/not rated)	--
P1-12	BEM_CTS	Isolated clear to send (wire to BEM001, pin 6) (<24V/not rated)	--
P1-13	BEM_RXD	Isolated receive data (wire to BEM001, pin 4) (<24V/not rated)	--
P1-14	BEM_TXD	Isolated transmit data (wire to BEM001, pin 2) (<24V/not rated)	--
P1-15	BEM_RTS	Isolated request to send (wire to BEM001, pin 8) (<24V/not rated)	--
P1-16	DIGITAL OUTPUT POINT	120 VAC, 60 Hz, 0.5 A, Tungsten, 0-24 VDC, 1 A output; normally open contact; source from pin P1-18	B5
P1-17	DIGITAL OUTPUT POINT	120 VAC, 60 Hz, 0.5 A, Tungsten, 0-24 VDC, 1 A output; normally closed contact; source from pin P1-18	B6
P1-18	CONTROL POWER	120 VAC, 60 Hz, 1 A, 0-24 VDC, 2 A source voltage for outputs at pins P1-16 and P1-17	--
P1-19	DIGITAL OUTPUT POINT	120-240 VAC, 60 Hz, 1 A, Pilot Duty output; source voltage at P1-20	B4
P1-20	CONTROL POWER	120-240 VAC, 60 Hz, 1 A, Source voltage for output at pin P1-19	--
P1-21	DIGITAL OUTPUT POINT	120-240 VAC, 60 Hz, 1 A, Pilot Duty output; source voltage at pin P1-24	B3
P1-22	DIGITAL OUTPUT POINT	120-240 VAC, 60 Hz, 1 A, Pilot Duty output; source voltage at pin P1-24	B2
P1-23	DIGITAL OUTPUT POINT	120-240 VAC, 60 Hz, 1 A, Pilot Duty output; source voltage at pin P1-24	B1
P1-24	CONTROL POWER	120-240 VAC, 60 Hz, 3 A, source voltage for outputs at pins P1-21, P1-22, P1-23	--

Top Connector 2: P3

PIN#	Name	Description	HT3 Address
P3-1	ST_ADDR0	Station address bit 0 (value 1) (<24V/not rated)	--
P3-2	ST_ADDR1	Station address bit 1 (value 2) (<24V/not rated)	--
P3-3	ST_ADDR2	Station address bit 2 (value 4) (<24V/not rated)	--
P3-4	ST_ADDR3	Station address bit 3 (value 8) (<24V/not rated)	--
P3-5	ST_ADDR4	Station address bit 4 (value 16) (<24V/not rated)	--
P3-6	ST_ADDR5	Station address bit 5 (value 32) (<24V/not rated)	--
P3-7	ST_ADDR6	Station address bit 6 (value 64) (<24V/not rated)	--
P3-8	ST_ADDR7	Station address bit 7 (value 128) (<24V/not rated)	--
P3-9	ST_ADDR8	Station address bit 8 (value 256) (<24V/not rated)	--
P3-10	GND	Station address ground (<24V/not rated)	--
P3-11	INV	Invert data (<24V/not rated)	--
P3-12	SWAP	Swap data (<24V/not rated)	--
P3-13	CFG_BIT2	Reserved – do not connect	--
P3-14	CFG_BIT3	Reserved – do not connect	--
P3-15	GND	Configuration ground	--
P3-16	EARTH_GND	Earth ground/lanyard	--
P3-17			--
P3-18			--

Bottom Connector 1: P2

PIN#	Name	Description	HT3 Address
P2-1	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Digital monitor point (>30 V requires resistor); common at pin P2-5	A1
P2-2	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Digital monitor point (>30 Vrequires resistor); common at pin P2-5	A2
P2-3	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Digital monitor point (>30 V requires resistor); common at pin P2-5	A3
P2-4	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Digital monitor point (>30 V requires resistor); common at pin P2-5	A4
P2-5	DIGITAL INPUT COMMON	10-30 VAC/VDC @ 40 mA RTN Input Common 1 for digital inputs P2-1 through P2-4 (>30 V require dropping resistors)	--
P2-6	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Low Level digital monitor input	A5
P2-7	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Off Level digital monitor input	A6
P2-8	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Lead Level digital monitor input	A7
P2-9	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Lag1 Level digital monitor input	A8
P2-10	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Lag2 Level digital monitor input	A9
P2-11	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA High Level digital monitor input	A10
P2-12	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Auxiliary digital monitor input	A12
P2-13	DIGITAL INPUT POINT	10-30 VAC/VDC @ 10 mA Alarm Silence Switch digital monitor input	B7
P2-14	DIGITAL INPUT COMMON	10-30 VAC/VDC @ 80 mA RTN Input Common 2 for digital inputs P2-6 through P2-13 (>30 V require dropping resistors)	--
P2-15	ISOGND	Internally supplied 24 VDC bias source return (<24V/not rated)	--
P2-16	ISO+24V	Internally supplied 24 VDC bias source voltage (<24V/not rated)	B10
P2-17	TXD_232	RS-232 transmit data to external device (<24V/not rated)	--

PIN#	Name	Description	HT3 Address
P2-18	RXD_232	RS-232 receive data from external device (<24V/not rated)	--
P2-19	GND	RS-232 ground (<24V/not rated)	--
P2-20	TGND	Shield for analog monitor signals	--
P2-21	ANALOG2+ (C2)	4-20 mA+ signal from transducer; - signal at pin P2-23 (<24V/not rated)	C2
P2-22	ANALOG1+ (C1)	0-5 VDC or 4-20 mA+ signal from transducer; - signal at pin P2-23; jump pin P2-24 to P2-23 for a 4-20 mA C1 signal (<24V/not rated)	C1
P2-23	ANALOG-	- signal return for both analog inputs C1 and C2 at P2-22 and P2-21 (<24V/not rated)	--
P2-24	SHUNT	250 Ω shunt resistor; jump to P2-23 with 4-20 mA signal for C1 at P2-22 only (<24V/not rated)	--

Bottom Connector 2: P4

PIN#	Name	Description	HT3 Address
P4-1	Unused	Reserved for future use; do not connect	--
P4-2	Unused	Reserved for future use; do not connect	--
P4-3	RS485_B	RS-485 serial interface B (<24V/not rated)	--
P4-4	RS485_A	RS-485 serial interface A (<24V/not rated)	--
P4-5	EX_SHIELD	Cable shield for RS-485 or RS-232 cable	--
P4-6	EX_GND_RAD	RS-232 ground (<24V/not rated)	--
P4-7	RTS_RAD	RS-232 Request to send (<24V/not rated)	--
P4-8	EX_TXD_RAD	RS-232 transmit data to external device (<24V/not rated)	--
P4-9	EX_RXD_RAD	RS-232 receive data from external device (<24V/not rated)	--
P4-10	CTS_RAD	RS-232 clear to send (<24V/not rated)	--
P4-11		Unused	--
P4-12		Unused	--
P4-13		Unused	--
P4-14		Unused	--

Notes

Chapter 2: PRINCIPLES OF OPERATION

In the water and wastewater industry, pumps are used to fill tanks and empty wells, in addition to other methods of moving liquid from place to place. In the following discussion and description of pump control systems, pumps and their associated motors are considered inseparable, because they are physically connected and operate as a unit. Whenever the word "pump" is used, it refers to the pump unit, including its associated motor.

MODES OF OPERATION

General RTU

The TCU’s points can be used as non-intelligent I/O by setting the number of pumps to 0 (zero). See “Number of Pumps” on page 112 in “Chapter 10: Configuring the Pump Control Process.”

Pump Controller

The TCU can be used to control up to three pumps using its built-in pump control process. Information on configuring and using this process is provided in “Chapter 9: Pump Controller User Interface,” “Chapter 10: Configuring the Pump Control Process,” and “Chapter 11: Viewing Status.”

Custom Application

For applications that don’t fit the built-in pump control process, the TCU’s I/O can be manipulated logically with a DFS BASIC-52 program (much like a PLC). Information on programming the TCU for a custom application can be found in “Chapter 8: Programming the TCU” and in the *TAC Pack TCU Programming Reference*.

AUTOMATIC/MANUAL CONTROL

When the TCU's Hand-Off-Auto (H-O-A) switches are in the “Auto” position, the TCU provides automatic control over a pump system. However, there are two ways to partially or totally override the TCU and manually control the system.

Note: If the TCU is installed in a motor control panel (MCP), or motor control center (MCC), that includes its own H-O-A switches, the MCP’s/MCC’s H-O-A switches must be in the “Auto” position in order to remotely control the pump motors. If the MCP/MCC switches are in “Hand” or “Off,” the TCU’s switches cannot be used to control the pumps. Additionally, the pumps cannot be controlled from the central computer or server.

H-O-A Switches

Three H-O-A switches on the TCU's front panel are provided to manually override the TCU's automated control. They can be used to manually control the pumps connected to the unit.

Hand	Placing a switch in the "Hand" position overrides the TCU's control and forces the corresponding pump motor on.
Off	Placing a switch in the "Off" position overrides the TCU's control and forces the corresponding pump motor off. Unused switches should be left in the "Off" position.
Auto	The H-O-A switch for a pump motor must be in the "Auto" position for the TCU to provide automatic control of that motor.

The H-O-A switches are fail-safe; they remain operational even if the TCU fails or loses power. They will continue to function in the "Hand" and "Off" positions with the TCU in a faulted state or powered down. Motor Starter faults are reset when the corresponding H-O-A switch is moved from the "Auto" position.

The TCU can also function while *partially* overridden (it can operate when as few as *one* of the H-O-A switches is in the "Auto" position). Automated control continues while outputs are in the automatic state.

All three H-O-A switches must be in the "Hand" or "Off" position before any changes can be made to the TCU's configurations.

Telemetry Interface

Connecting to a telemetry system provides a remote H-O-A system that can be used to override the TCU. Through telemetry, all outputs of the TCU can be individually overridden (forced on) or disabled (forced off). Note that local H-O-A control will ***always*** override any telemetry control.

Level Sensing Transducers

The TCU features interfaces to several industry standard level-sensing devices.

Discrete (Contact Closure) Devices

The TCU can accommodate digital-type devices such as contact closures (for example, floats), float switches, and pressure switches. Several digital-type devices can be connected to up to six discrete digital monitoring points to control the operation of pumps.

The TCU is designed to handle simplex, duplex, and triplex configurations. Other devices such as pressure switches and bubbler mercury switches are adaptable to this design.

Analog Level-sensing Devices

Optionally, analog level-sensing devices, including ultrasonic, hydraulic pressure, and pneumatic pressure transducers, can be monitored through an industry standard 4-20 mA / 0-5 V interface. Any analog level-detection transducer (self powered or TCU powered) that supplies a 4-20 mA current signal or a 0-5 V signal can be used as an analog-level input device.

A station can be controlled by:

1. Connecting an analog-type device to the TCU's analog input terminals
2. Calibrating the maximum, minimum, and intermediate staging points

Variable Impedance Transducers

An interface for monitoring linear resistive devices with 300W/ft impedance is provided.

INTERNAL PHASE MONITOR

A single- or three-phase 240 VAC power monitor is provided. An optional three-phase 480 VAC (using external resistors) power monitor is also available (see "Appendix C: Parts List" for information on the 480 VAC Phase Monitor Kit). All versions of the phase monitor detect phase loss and high and low line-voltage phase faults. High and low phase monitor detection limits are set from the TCU's configuration screens. The three-phase 240 VAC and optional 480 VAC power monitor also detect phase reversal. A fault of phase reversal, phase loss, or line voltage results in an alarm and shuts down all automatically controlled pumps.

The single-phase 240 VAC connection is to the TCU's A and B phase inputs only. The C phase input must *not* be connected. A phase sequence/phase voltage fault will occur if the TCU is configured for single-phase and the C phase is connected. When configured for single-phase, the TCU's phase monitor detects phase voltage failures and displays phase A-B readings only.

Connections to the three-phase lines are used for monitoring phase sequence and voltage levels of the incoming power. The TCU's phase monitor is labeled for clockwise phase sequence. If the three-phase power is labeled for counterclockwise rotation and is connected in accordance to the TCU's terminal label, the TCU will detect a phase sequence fault. To correct this condition, reverse any two leads connected to the TCU's phase monitor.

In some installations, the three-phase power of a station is not balanced. However, at least one leg of the three-phase power is always used as a reference to the other two legs. If the reference phase is not wired to the TCU's A-phase input, erroneous three-phase voltage faults that cause the pump station to inappropriately shut down the pumps may occur. To prevent erroneous faults, wire the reference (or high) leg to the TCU's A-phase input or expand the TCU's three-phase voltage range to compensate for the erroneous voltages. If a Phase Sequence alarm is generated after taking these steps, switch the B and C phase inputs to the TCU. Wiring the A, B, and C phases in the motor control panel to different phase inputs on the TCU will not damage any equipment. The voltages are merely measured by the TCU to detect voltage failures and sequence faults to help prevent damage to the pump motors by shutting them off.

Note: The TCU reads and displays True RMS voltages much the same as modern voltmeters. Readings from older voltmeters that display RMS, but not True RMS, might differ from the TCU's readings.

Solid State Control Outputs

The TCU features four solid-state digital outputs. Three of these outputs are hardwired to the TCU's H-O-A switches and can be manually turned on by placing the switch in the Hand position.

- P1-19 is a 60-280 VAC output whose source voltage is at P1-20.
- P1-21, P1-22, and P1-23 are 60-280 VAC outputs whose source voltage is at P1-24. These outputs are hardwired to the unit's H-O-A switches.

Mechanical Relay Outputs

The TCU includes two contact closure digital outputs. The source voltage for both outputs is at P1-18.

- P1-16 is a 60 VDC / 280 VAC output. This is a normally open set of contacts.
- P1-17 is a 60 VDC / 280 VAC output. This is a normally closed set of contacts.

Status via LED Indicators

LED indicators on the front panel of the TCU provide you with quick status information. When the TCU's on/off state is cycled, all of the TCU's LEDs turn on momentarily for a self-test.

AC Power Status

The TCU's Power LED illuminates when the TCU is in the on state and AC voltage is applied. If a backup battery is connected to the TCU and primary AC power is interrupted, the *ACPwr* alarm is activated and the TCU's Alarm LED flashes.

> **IMPORTANT:** If the TCU's Power LED is not lit, you should assume that the TCU is still powered. The Power LED indicates only that the TCU is in the off state, not that AC power has been removed. To remove power, you must turn off the external circuit breaker.

CPU Fault Status

Internal circuitry is used to monitor the TCU's microcontroller. If the circuitry detects a fault with the microcontroller, it resets it and strobes the CPU Fault LED. If the microcontroller fails to reset, a circuit disables the outputs and the CPU Fault LED flashes. A steady light indicates that the TCU's radio processor is locked in reset mode. When this LED is lit (flashing or steady), all automated controls are disabled. The H-O-A switches, which continue to function under a CPU Fault condition, can continue operation of any devices connected to the digital outputs P1-21, P1-22, and P1-23.

RX DATA & TX DATA Status

The TCU can communicate through the service port located on its front panel, through the Bus Extender Module (BEM), and through the telemetry interface. RX and TX Data LEDs are part of the telemetry and service port interface and are provided to verify the communications function. The RX Data LED strobes each time the TCU receives data; the TX Data LED strobes each time the TCU transmits data.

Digital Output and Input Status

The LEDs at the top and bottom of the TCU's front panel work independently of the TCU's internal computer. These LEDs provide you with a way of verifying that the corresponding output or input is on.

Note: See "Chapter 1: Product Overview" for information on the pin name and wiring definitions for the points referred to below.

The six LEDs (Outputs 1-6) located along the top edge of the TCU provide field status of the following six digital outputs:

Output 1: P1-23	Output 4: P1-19
Output 2: P1-22	Output 5: P1-17
Output 3: P1-21	Output 6: P1-16

The twelve LEDs (Inputs 1-12) located along the bottom edge of the TCU provide field status of the following 12 digital inputs:

Input 1: P2-1	Input 7: P2-8
Input 2: P2-2	Input 8: P2-9
Input 3: P2-3	Input 9: P2-10
Input 4: P2-4	Input 10: P2-11
Input 5: P2-6	Input 11: P2-12
Input 6: P2-7	Input 12: P2-13

Programmable LEDs

Thirteen of the TCU's LEDs are programmable when not using the built-in pump control process.

- The LEDs below each of the three H-O-A switches
- The LEDs that are located on either side of the LCD
- The Alarm LED
- The LCD backlight

The LEDs that appear on either side of the LCD screen can be used in conjunction with information on the LCD to provide status at a glance. The TCU's pump control process is designed this way. When you are viewing the default status screen, each of the LEDs corresponds to a condition (for example, HiWell) that is listed on the screen. A lit LED indicates that the station is currently in that state. You can create custom status screens using the DGOUT and MENU statements.

More information on programming these LEDs can be found in the section titled "LEDs" beginning on page 101 in "Chapter 8: Programming the TCU."

These LEDs serve specific functions when using the TCU's pump control process. For more information, see the section titled "LED Indicators" beginning on page 108 in "Chapter 9: Pump Controller User Interface."

LCD Screen

The TCU's large 4-line x 20-character LCD, in conjunction with the 12-key keypad, provides an interface for configuring the TCU, viewing and resetting alarms, and analyzing status information. The contrast of the LCD is controlled by an onboard temperature sensor, which helps to ensure that the LCD screen is easy to read in both high- and low-temperature conditions.

The TCU's LCD may be used to display program variables, status conditions, or lists of items. Although the number of displayable menu items is limited to 16 (1-16) at any one time, the use of sub menus allows the total number of menu items to be virtually unlimited. By programming the Enter key to switch to a sub menu, each of the primary 16 menu items can have up to 16 sub menu items, and so on. For more information, see "LCD Menus" on page 99.

When the pump control process is being used, five types of information are available to the operator from the TCU's LCD: Current status, historical status, alarm messages, configuration options, and version information. For more information, see "Information Screens" on page 32.

Keypad and Soft Power On/Off Key

The keys on the TCU's keypad can be used to page through menus items, navigate through configuration options, and enter numeric data.

When programming the TCU for a custom application, these keys may be programmed to perform specific functions. For more information on programming the TCU's keypad, see the section title "Keypad" on page 100 of "Chapter 8: Programming the TCU."

For the pump control process, the TCU's 12-key keypad includes the numbers 0-9, a decimal point, and Enter, Escape, and navigation keys. Some keys are dual functional. For example, the decimal point and the escape function (Esc) share the same key; the number two and the up scrolling function (▲) share the same key. The function of the key is dependent on the TCU's current mode.

The TCU features a soft power key. When the On/Off key is pressed and held, the TCU's state is cycled on or off.

Communications Service Port

The service port on the TCU's front panel provides an RS-232 interface for diagnostics and configuration storage and updating. This service port allows a portable computer to be connected to the TCU through an interface cable. The configuration can be uploaded from the TCU and saved to a portable computer. If the TCU is replaced, the configuration can be downloaded from the portable computer to the new TCU.

> **IMPORTANT:** If the TCU is connected to telemetry, telemetry functions will be interrupted when the service port is used.

The interface cable can be purchased from Data Flow Systems or can be built from parts purchased locally. Figure 2-1, "Service Port Interface Cable" (next page) provides details for building a cable. The cable may be purchased as part of the TCU, PCU & SCU Test Kit (see "Appendix C: Parts List" for ordering information.

All telemetry functions for monitoring and controlling are available via the service port. Additionally, the TCU can be configured and configurations can be saved and restored by connecting a portable computer that is running WinRTU Test to the TCU's service port. The WinRTU Test software is included in the TCU, PCU & SCU Test Kit. See "Appendix C: Parts List" for ordering information.

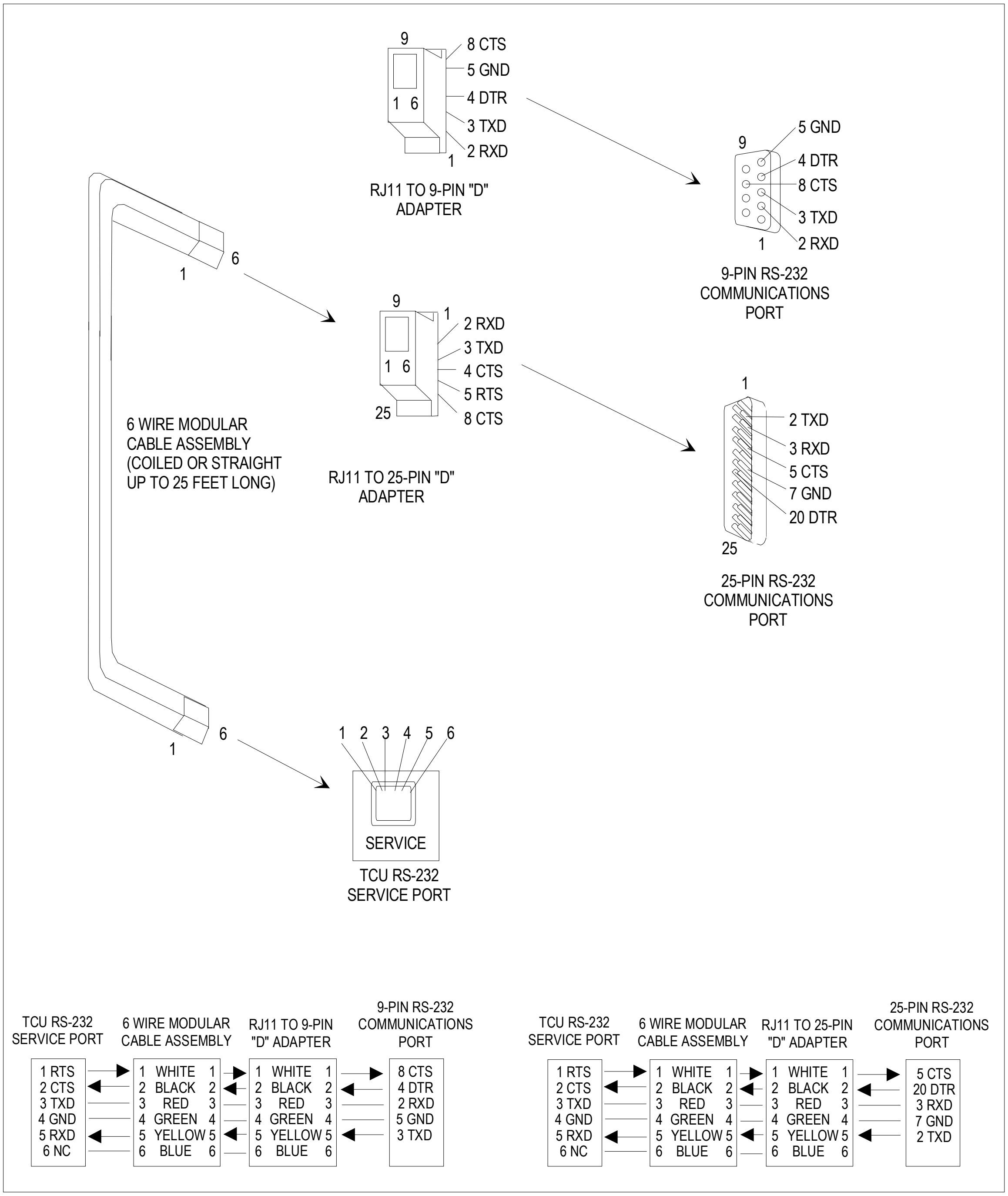


Figure 2-1, "Service Port Interface Cable"

Self-Monitoring Capabilities

The TCU has extensive self-monitoring capabilities. It performs an On state self test, monitors radio current, and unit temperature. Fault codes are stored in internal FLASH or NOVRAM as a First In First Out (FIFO) event log. The event log starts after a Quality Control Stamp reset, and then records Station Address, Problem, and Time Stamp at a minimum. This information can be displayed/uploaded to the LCD/radio/network/service port.

When the TCU is powered up, it goes through a self-check sequence. During the self-check, all of the LEDs should quickly flash on and then off. If this startup sequence does not occur, the TCU may be faulty.

A simple self-test is included for customers to perform.

Last State Recall

The TCU has the ability to recall its last state (on or off) when power is cycled and will return to that state when power is restored. For example, if the TCU was turned off using the On/Off key and AC power was removed, the TCU would return to the off state when power was restored.

Integrated Telemetry Interface (Optional)

The integrated radio allows the TCU to function as a Remote Terminal Unit (RTU) capable of communicating with the HT3 telemetry system. Optionally, the TCU can be ordered with a 10 Mbps Ethernet network interface. These telemetry interfaces allow the TCU to be controlled and monitored remotely. All inputs are available for monitoring through the telemetry system. All outputs of the TCU can be disabled or overridden independently through the telemetry system.

Controlling and Monitoring via Telemetry

When the TCU is interfaced with the TAC II telemetry system, the pump station can be remotely monitored and controlled. All alarm conditions and pump activities are recorded at the telemetry central computer.

Monitored Inputs

The telemetry system can monitor all 12 of the TCU’s digital monitor inputs. Some of the digital monitor inputs can be used for special monitoring functions when not needed to control the station. For example, unused motor run and level inputs can be used to monitor generator status and intrusion switches.

All alarm conditions are monitored by the telemetry system. The operator can be aware of alarm conditions before the situation becomes critical.

Controlled Outputs

All six of the TCU’s outputs can be controlled by telemetry. The remote control allows individual pumps to be overridden to the ON or OFF state. Additionally, the entire station can be disabled (overridden OFF) remotely. Unused outputs (those not needed for other station control functions) can be used for special functions. For example, unused starter outputs can be used to turn on auxiliary equipment.

BATTERY BACKUP (OPTIONAL)

An input is provided for connecting a battery to the TCU at connections P1-8 and P1-9. Connecting a battery to the TCU allows it to communicate and operate (albeit without the ability to run pumps) when primary AC power is lost. The alarm horn and light can be powered from the battery to provide alarm functionality during a power outage. All digital monitor inputs using *ISO+24V* (P2-16) as a bias-voltage source continue to function. If power fails, and the TCU is connected to telemetry, the power outage is reported to the central site.

The TCU includes a battery charger circuit that can be used to float charge a battery for backup operations. Note that statistical and configuration data is retained even without a back up battery. The purpose of the battery is to maintain telemetry functions during a power loss. The battery can also be used to drive a DC powered alarm horn and light.

The internal bias voltage, *ISO+24V,* continues to operate under battery power. Additionally, monitor points connected to it remain operational. With telemetry, the station's well or tank level can be remotely monitored during a power outage.

Operating run times for a typical application running on battery power:

- 12V, 2.6Ah battery - approximately 6 hours.
- 12V, 7.0Ah battery - approximately 14 hours.

These numbers are for a new, well-maintained, and fully charged battery. As the battery ages, operating run times may diminish. Information on using larger batteries with the TCU can be found in the Battery White Paper, which can be downloaded from www.dataflowsys.com/hardwaredocs.php.

The TCU monitors the voltage and will begin a safe shutdown if battery voltage drops below 9.1 VDC. It will not come back up until the voltage reaches 12.3 VDC. See "Power and Voltage Monitoring," below, for more information.

POWER AND VOLTAGE MONITORING

The TCU's Power LED illuminates when the TCU is on and AC voltage is applied. If the TCU determines AC power has been interrupted, the *ACPwr* alarm is activated and the TCU's Alarm LED flashes. Note that the TCU must be on backup battery power in order for this fault to function when the primary AC power fails.

If a battery is connected when AC power is interrupted and the voltage drops below 9.1 VDC, the TCU will begin a safe shutdown and will shut off power to both of its microcontrollers. When this occurs, either the Power LED - and all other LEDs - will be off, or the Power LED will be on and the CPU Fault LED will be flashing.

The TCU continues to monitor voltage after shutdown is complete. When the battery voltage reaches 12.3 V (as a result of AC power being restored and the battery being recharged), the TCU restarts its two microcontrollers.

FUNCTIONS SPECIFIC TO THE PUMP CONTROL PROCESS

Simplex, Duplex, and Triplex Stations

The station type – simplex, duplex, or triplex – is determined by the number of pumps at the station.

Simplex	A simplex station consists of one pump. The simplex station uses as a minimum the Lead and Off staging levels.
Duplex	A duplex station consists of two pumps. The duplex station uses as a minimum the Lead, Off, and Lag staging levels.
Triplex	A triplex station consists of three pumps. The triplex station uses as a minimum the Lead, Off, Lag, and Lag2 staging levels.

The staging levels above are the minimums required for both discrete and analog systems. An analog system can use three additional set points for pump operation: Lead Off, Lag Off, and Lag2 Off.

Both discrete and analog systems can use the option Low Level and High Level discrete inputs as a backup and alarm system.

Pumping Modes

The TCU can be configured to operate in two different pumping modes, "Pump Down" or "Pump Up.”

Pump Down	Pump Down mode is used to empty a well (as is typical in a lift station) by maintaining the well level between the Off and Lead staging levels.
Pump Up	Pump Up mode fills a tank by maintaining the tank level between the Off and Lead levels.

Level-sensing Systems – Discrete versus Analog

A discrete system uses a device that provides an On/Off signal. These are typically float balls submersed into a wet well. The floats are wired to the appropriate inputs on the TCU. The TCU then controls the operation of up to three pumps based on input signals from these floats.

In an analog system, a variable, transducer-supplied 4-20 mA or 0-5 V input that is wired to the TCU’s analog input is used to control up to three pumps. The input is typically supplied by a pressure, level, or ultrasonic transducer. Analog systems use Lead Off, Lag Off, and Lag2 Off set points in addition to the staging levels used by a discrete system.

Staging levels can be monitored using either a discrete system or an analog system. Pumps are automatically started and stopped based on these staging levels.

Discrete System (Contact Closure Devices)

In a discrete system, the TCU controls the pumps based on up to six discrete input signals, typically float balls submersed into a wet well. The floats are positioned at designated levels in the well to enable the pumps to be started and stopped based on the detected contact closure. The float contact closures can be monitored with various voltage levels (see “Chapter 6: Electrical Installation”).

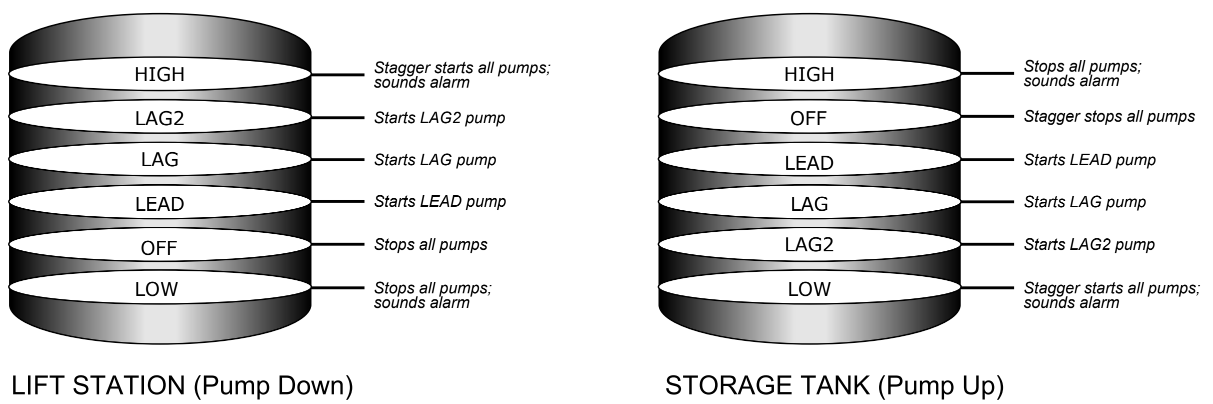
Low and High floats can be added as optional backup and alarm systems. When a low or high level float is activated, an alarm is issued and normal pump control is overridden.

Note: If the Low float is not going to be used, it *must* be disabled in the TCU's local configuration in order for the TCU's pump control operations to function normally in automatic. Failing to disable the Low float configuration in this situation, results in a false alarm condition. This condition, which occurs because the Low float input's normal state is ON, prevents all of the pumps in automatic from running.

Details on configuring a discrete system are provided in "Appendix M: TCU Transducer Configuration Examples."

Staging Levels in a Discrete System

Pumps are automatically started and stopped based on staging levels. The illustration below shows the behavior of pumps at each staging level in a discrete system. Both a lift station (pump down mode) and a storage tank (pump up mode) are shown.



Staging Levels in Pump Down Mode (Discrete System)

The following paragraphs describe the normal function of the TCU's eight staging levels when used in Pump Down mode, such as that used in a lift station. Note that not all of these levels must be configured for a lift station. The minimum number of levels required depends on the type of station – simplex (one pump), duplex (two pump), or triplex (three pump).

Low Level	All pumps are stopped and alarms are activated. Low is active when well's level is *below* Low. Must be set below all other levels.
Off Level	Minimum operational level of a well. All pumps are stopped when the well's level is *below* Off.
Lead Level	Lead (first) pump is started. Lead is active when the well's level is *above* the Lead Level.
Lag Level (duplex and triplex stations only)	Lag (second) pump is started. Lag is active when the well's level is *above* the Lag level.
Lag2 Level (triplex stations only)	Lag2 (third) pump is started. Lag2 is active when the well's level is *above* than the Lag2 level.
High Level	All pumps are stagger started and alarms are activated. High is active when well's level *reaches* High level. Must be set above the other levels.

Staging Levels in Pump Up Mode (Discrete System)

The following paragraphs describe the function of the TCU's eight staging levels when used in Pump Up mode (such as that used in a storage tank). Note that not all of these levels must be configured for a lift station. The minimum number of levels required depends on the type of station – simplex (one pump), duplex (two pumps), or triplex (three pumps).

High Level	All pumps are stopped and alarms are activated. High is active when the tank's level is *above* High. Must be set above the other levels.
Off Level	Maximum operational level of a tank. Lead pump is stopped when the tank's level is *above* Off level.
Lead Level	Lead (first) pump is started. Lead is active when the tank's level is *below* Lead level.
Lag Level (duplex and triplex stations only)	Lag (second) pump is started. Lag is active when the tank's level is *below* Lag level.
Lag2 Level (triplex stations only)	Lag2 (third) pump is started. Lag2 is active when the tank's level is *below* Lag2 level.
Low Level	All pumps are stagger started and alarms are activated. Low is active when tank's level is *below* Low level. Must be set below all other levels.

Analog System (Pressure Transducer)

In an analog system, pumps are controlled by a variable, transducer-supplied 4-20 mA or 0-5 V input that is wired to the TCU's analog input. The operator sets the 4 mA or the 1 V input equal to the transducer's low range (in feet) and the 20 mA or 5 V input equal to the transducer's high range (in feet). Low and High levels, as well as staging levels for the Lead, Lag, and Lag2 pumps, are also set by the operator. The TCU interprets the input signal and starts or stops pumps according to the configured staging levels. When the analog level reaches the set point value, the corresponding Well Level LED illuminates and the TCU starts the appropriate pump(s).

The TCU pump control operation functions with eight possible staging levels: Low, Lead Off, Lead, Lag Off, Lag, Lag2 Off, Lag2, and High. The legacy PCU operation functions with six possible staging levels: Low, Off, Lead, Lag, Lag2, and High. When operating the TCU in legacy PCU mode, the Lag Off and Lag2 Off set points are set to the same level as the Lead Off set point.

An analog system has several options available for handling transducer faults:

- High and/or Low Float Override. Use a high and/or a low float to issue an alarm and override normal pump control.
- Switch to normal float behavior (Floats). This option requires an Off float to shut off the pumps and a miniumum of one float (Lead to High) to start the pumps.
- Switch to a second analog input (Analog2)
- Control the pumps based on the average pump cycle time (Timer)

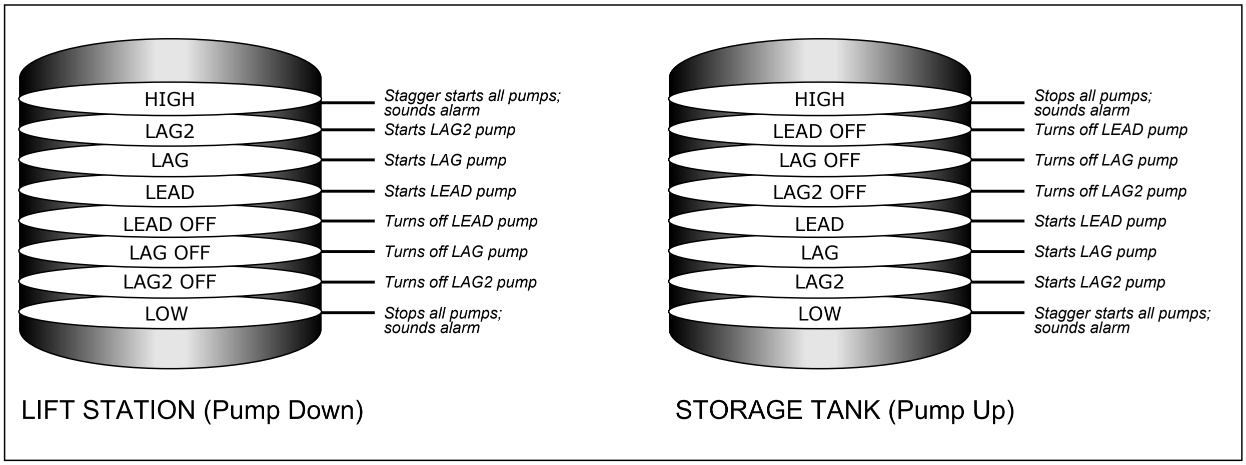
Typical configurations for analog systems are provided in "Appendix M: TCU Transducer Configuration Examples."

Note: If the Low float is not going to be used, it *must* be disabled in the TCU's local configuration in order for the TCU's pump control operations to function normally in automatic. Failing to disable the Low float configuration in this situation, results in a false alarm condition, which fails the transducer.

This condition, which occurs because the Low float input's normal state is ON, prevents all of the pumps in automatic from running.

Staging Levels in an Analog System

Pumps are automatically started and stopped based on staging levels. The illustration below shows the behavior of pumps at each staging level in an analog system. Both a lift station (pump down mode) and a storage tank (pump up mode) are shown.



Staging Levels in Pump Down Mode (Analog System)

The following paragraphs describe the normal function of the TCU's eight staging levels when used in Pump Down mode, such as that used in a lift station. Note that not all of these levels must be configured for a lift station. The minimum number of levels required depends on the type of station – simplex (one pump), duplex (two pumps), or triplex (three pumps).

Low Level	All pumps are stopped and alarms are activated. Low is active when the well's level is below Low level. Must be set below all other levels.
Lead Off Level	Minimum operational level of a well. Lead pump is stopped when well's level is below Lead Off level.
Lag Off Level (duplex and triplex stations only)	Lag (second) pump is stopped. Lag Off is active when well's level is below Lag Off level. When configuring for legacy PCU operation, set the LagOff Pt to the same level as the LeadOff Pt.
Lag2 Off Level (triplex stations only)	Lag2 (third) pump is stopped. Lag2 Off is active when well's level is below Lag2 Off level. When configuring for legacy PCU operation, set the Lag2Off Pt to the same level as the LeadOff Pt.
Lead Level	Lead (first) pump is started. Lead is active when well's level is above Lead level.
Lag Level (duplex and triplex stations only)	Lag (second) pump is started. Lag is active when well's level is above Lag level.
Lag2 Level (triplex stations only)	Lag2 (third) pump is started. Lag2 is active when well's level is above Lag2.
High Level	All pumps are stagger started and alarms are activated. High is active when well's level reaches High. Must be set above the other levels.

Staging Levels in Pump Up Mode (Analog System)

The following paragraphs describe the function of the TCU's eight staging levels when used in Pump Up mode (such as that used in a storage tank). Note that not all of these levels must be configured for a lift station. The minimum number of levels required depends on the type of station – simplex, duplex, or triplex.

High Level	All pumps are stopped and alarms are activated. High is active when tank's level is *above* High level. High *must* be set above the other levels.
Lead Off Level	Lead Off is the maximum operational level of a tank. Lead pump is stopped when the level is *above* the Lead Off level.
Lag Off Level (duplex and triplex stations only)	Lag (second) pump is stopped. Lag Off is active when tank's level is *above* Lag Off. When configuring for legacy PCU operation, set the *LagOff Pt* to the same level as the *LeadOff Pt*.
Lag2 Off Level (triplex stations only)	Lag2 (third) pump is stopped. Lag2 Off is active when tank's level is *above* Lag2 Off level. When configuring for legacy PCU operation, set the *Lag2Off Pt* to the same level as the *LeadOff Pt*.
Lead Level	Lead (first) pump is started. Lead is active when tank's level is *below* Lead level.
Lag Level (duplex and triplex stations only)	Lag (second) pump is started. Lag is active when tank's level is below Lag level.
Lag2 Level (triplex stations only)	Lag2 (third) pump is started. Lag2 is active when tank's level is *below* Lag2 level.
Low Level	All pumps are stagger started and alarms are activated. Low is active when tank's level is *below* Low level. Must be set below all other levels.

Pump Alternation

The TCU includes a pump alternator function that can be used to minimize pump cycle times or equalize pump run times. When enabled, the alternator updates each time it starts a pump. If a pump fails to start, the alternator advances to the next available pump. Pumps can be taken out of service with the H-O-A switches, and the TCU will continue to alternate the remaining pumps.

The following alternation options are available:

- Alternate among ***all*** available pumps.
- Alternate between pumps 1 and 2 (High Service Pump option).
- Alternate between pumps 2 and 3 (Jockey Pump option).
- Disable pump alternation

The TCU uses a numeric alternation scheme. With numeric alternation, the pump assigned as the new Lead pump is always the next pump in the numeric order. For example, in a triplex lift station, if pump 2 (current Lead pump) and pump 3 (current Lag pump) are running when the Lead Off level is reached, pump 3 would become the new Lead pump regardless of the number of pumps running.

If the Jockey Pump or High Service Pump options are enabled, the remaining pumps will alternate per the selected scheme. When the alternator is disabled, Pump 1 is used as the Lead pump, Pump 2 as the Lag pump, and Pump 3 as the Lag2 pump.

For more information on configuring the TCU for pump alternation, see Pump Alternation, Flow

Equalization, Motor Start and Stop Fault: Pump Alternation, p. 117, in “Chapter 10: Configuring the Pump Control Process.”

Use of Unused Pump Outputs

Unused pump outputs can be connected to any other type of control device. These devices can be turned on using the pump override points. For example, in a duplex station (two pump operation), the third pump output could be connected to an odor control injection. You could control the odor control injection using the Pump 3 Override On and Pump 3 Override Off points.

Phase Monitor Options

In addition to the TCU’s internal phase monitor (see page 17), the TCU can use an external phase monitor or the internal phase monitor can be bypassed.

External Phase Monitor

The TCU features an input at P2-4 that can accommodate the use of an external phase monitor where one is required. The external phase monitor must provide a closed set of contacts that open during a phase fault. The voltage used to monitor the set of contacts must be the same used to monitor the pump run statuses.

Phase Monitor Bypass

The TCU’s phase monitor can be bypassed if the internal phase monitor function is not required and there is no external phase monitor. To bypass the TCU’s internal phase monitor, wire the phase monitor input (P2-4) in the ON state. The voltage used to bias this point ON must be the same voltage used to monitor the pump run statuses.

Motor Run-Time Monitor

The TCU provides three digital monitor inputs for monitoring the status of the motors controlled by the TCU's starter relays. They are:

- P2-1, *MTR1_RUN*
- P2-2, *MTR2_RUN*
- P2-3, *MTR3_RUN*

The Motor 1 Run input (*MTR1_RUN*) monitors the circuit controlled by the Motor 1 Starter output (*MTR1_STR*). Correspondingly, *MTR2_RUN* monitors *MTR2_STR,* and *MTR3_RUN* monitors *MTR3_STR*.

Care should be taken to avoid cross-wiring the motor run inputs and starter outputs. For each pump controlled by the TCU, the corresponding motor run input must be connected. After the TCU starts a pump, it checks the motor run input to verify that the pump is running. If the signal is not present, it:

1. Shuts down the pump
2. Activates the pump's motor-starter alarm
3. Tries the next pump

The preferred method for monitoring motor run is to use phase A at the load side of the motor breaker as motor run bias, and feed the bias through the starter auxiliary contacts to the TCU’s motor run input terminal with a proper bias resistor in the circuit. Monitoring the starter auxiliary contacts by using Phase A as bias can provide fault detection of the TCU's starter relays, the motor-starter coils, and heater overloads, as well as an open breaker.

Other monitor points can be selected if motor starter auxiliary contacts are not available. Any voltage point in the motor circuit may be used as a bias voltage with diminishing fault detection. See “Motor Run Monitoring Signal” on page 68.

Solid State Motor Starter Control Relays

The TCU features three solid-state relays, capable of controlling up to three motor starters. *STR_PWR* (starter power), terminal P1-24, will be switched to the starter coils when the TCU's starter relays are energized, or when the H-O-A switches are placed in the “Hand” position. The TCU controls 120-240 VAC starter coils, with each output supporting a maximum of one amp. A 1 amp slow-blow fuse is required to protect the TCU's relays from short-circuited motor-starter coils. Size 3 or larger starters should be isolated with a relay. If starters are not maintained over time, they can draw over one ampere.

Auxiliary Input and Output

The TCU’s auxiliary digital input (*AUX_IN*; P2-12) and output (*AUX_OUT*; P1-19) can function together as a programmable time delay relay or work independently as general monitor and control points for telemetry. Additionally, the auxiliary input can operate as a pulse counter and be used with pulse-type flow meters and rain gauges.

To use *AUX_IN* and *AUX_OUT* as general monitor and control points, or to use *AUX_IN* as a pulse input, the time delay relay function must be disabled. This is done by setting the function’s delay time to 0 (zero). Information on disabling the time delay relay can be found in the section titled “Time Delay Relay” beginning on page 119.

Information on wiring the auxiliary input and output can be found in the section titled “Auxiliary Input and Output Connections” beginning on page 80.

Time Delay Relay

An example of an auxiliary relay application is switching on a backup compressor for a bubbler system. The backup compressor is connected to the *AUX_OUT* terminal; and an airflow switch for the primary compressor is connected to the *AUX_IN* terminal. The Time Delay Relay function can then be configured to turn on the *AUX_OUT* when the flow switch detects no airflow. The Time Delay Relay can also be configured to start the backup compressor only when the flow stops for longer than a set time. This is accomplished by configuring the Time Delay Relay with the ON delay mode and setting the desired delay time.

Other examples of auxiliary use are activating a local light alarm, enabling a backup bubbler function, or starting a chemical feed pump when any of the pumps is running

Information on configuring the auxiliary input and output as a time delay relay can be found in the section titled “Time Delay Relay” beginning on page 119.

Pulse Input

In order for the auxiliary input to be used as a pulse input, its corresponding HT3 point (point 12 of Module A, a DMM002) must be configured as a digital pulse point (select DP for the Point Type). Additionally, the time delay relay function must be disabled in the TCU. See “Time Delay Relay” beginning on page 119 for more information.

The specifications for the pulse input are as follows:

- Supply voltage: 8 to 14 VDC
- Minimum pulse width: 25 ms
- Maximum burst frequency: 40 PPS
- Maximum count frequency: 8 PPS

Alarm Light & Horn/Bell Outputs (Optional)

The TCU contains two mechanical relays for controlling an alarm light and horn. Alarm devices can be AC or DC powered for operation during power outages. If the TCU is connected to telemetry, these devices are not necessary and may be disabled from the TCU’s local configuration. All conditions that activate the alarm horn and alarm light are reported through the telemetry system.

Alarm outputs are activated only when the TCU detects an alarm condition, such as phase faults, high- and low-well conditions, and internal TCU faults (for a list of alarms that can activate the alarm horn and light, see “Alarm Messages” on page 33 in “Chapter 2: Principles of Operation”). The alarm horn can be silenced by pressing the TCU’s Silence switch, by viewing the TCU’s alarm screen, from a telemetry-provided alarm silence control point, or from a momentary switch connected to the TCU’s Alarm Silence input. Any new alarm condition reactivates the alarm horn.

The *ALM_HORN* output relay closes to power a horn or bell when critical alarm conditions occur. The relay opens when all critical alarm conditions clear or when the *ALM_HORN* relay is overridden. All alarm conditions activate the *ALM_LITE* output relay. This is a normally closed set of contacts that opens when no alarms are active. The *ALM_LITE* relay closes when the TCU is faulted or powered down.

A fail-safe feature is incorporated into the TCU. In normal operation, contacts for the alarm light output are open. When power to the TCU is interrupted, the contacts of the alarm light output are closed. If the power source controlling the light is still operating, the alarm light is lit. The alarm horn contacts are not affected on loss of power to the TCU, and the alarm horn is not activated.

Both the alarm light (*ALM_LITE*) and alarm horn (*ALM_HORN*) become inactive when all alarm conditions clear. However, the Alarm LED on the TCU’s front panel continues to flash and the alarm message continues to be displayed until the alarm message is viewed. This is not the case if the TCU is used in a telemetry configuration and the alarm has been acknowledged. See “Chapter 12: Viewing and Troubleshooting Alarms” for details on alarm messages.

The alarm light and alarm horn inputs are powered from *ALM_PWR*, P1-18. Contacts for *ALM_HORN*, terminal P1-16, and *ALM_LITE*, terminal P1-17, are rated for 120 VAC, 60 Hz, 0.5 A, Tungsten, 0-24 VDC, 1 A. A battery connection and charging circuitry for battery backed up operation are provided at P1-8 (*BAT+*) and P1-9 (*BAT-*).

LED Indicators

The TCU provides 34 ultra-bright LEDs to provide system status at a glance.

- Pump Run Indicators (3)
- TCU Power Indicator
- CPU Fault Indicator
- TX Data Indicator
- RX Data Indicator
- Alarm Indicator
- Well Level / Status Indicators (8)
- Digital Output Status (6)
- Digital Input Status (12)

For more information on these LEDs, see “LED Indicators” beginning on page 108 in “Chapter 9: Pump Controller User Interface.”

Information Screens

Five types of information are available to the operator from the TCU’s LCD: Current status (such as TCU or system time), historical status (such as pump or level history, or run times), alarm messages, configuration options, and version information (obtained by pressing specific key combinations). When the TCU is cycled on, it is initialized and then displays the first status screen. During initialization, the TCU’s software revision date and serial number are briefly displayed. Status information, alarm messages, and configuration options can be accessed by using the TCU’s navigation keys to cycle through the available screens.

Status Information

The TCU collects statistical data and maintains a historical log of pump operations. This information can be analyzed by viewing each of the TCU’s seven status screens. During initialization, the TCU displays information including firmware level, process ID, and radio configuration. After initialization, the LCD displays the default status screen and will return to the default screen after 5 (five) minutes of button inactivity. For detailed information on the TCU’s status screens, see “Chapter 11: Viewing Status.”

The display for the default status screen differs depending on the type of level-sensing device being used.

- Analog level-sensing transducer: Current well or tank level, along with a graph showing the well’s level over the last 5 ½ minutes, is displayed.
- Floats: Current time, along with a graph showing the maximum number of pumps running over the last 5 ½ minutes, is displayed.

The current staging level is indicated by a lit LED next to the corresponding staging level label.

Subsequent status screens, which can be accessed using the TCU's navigation keys, provide the following information:

Total Station Flow (Used in well applications only)	Flow totalization, also referred to as derived flow, is calculated based on accurate well volume and a full pump cycle (from Lead Off to Lead and back to Lead Off again).
Phase Voltage	Phase voltage between legs A and B and between legs A and C.
Total Elapsed Pump Run Time	Cumulative run time for a pump. Readouts are provided for each pump.
Average Pump Run Time	Average time the pump is on. This is calculated each time the pump shuts down. Readouts are provided for each pump.
Average Pump Flow Rate (Used in well applications only)	Calculated as an average based on the station flow volume, the individual pump run time, and the station fill rate. Flow Rate is only displayed if the well volume is configured.
Pump Starts Counter	The total number of times each configured pump has started since the TCU was installed or the time meter was reset.
Analog Input Status	Current values for the TCU's two 12-bit analog inputs displayed as mA or V depending on the TCU's setup and configuration.
Remote Monitor Point Status	A value for a remote monitor point is displayed if one is in use. The TCU can accept data via telemetry from a monitor point and use this data to control pump operations remotely instead of locally. This feature is referred to as remote level auto control.

Alarm Messages

Alarm messages that may be displayed on the LCD screen include those for:

- Floats out of sequence (*FltSeq*)
- Pump did not start (*Strt*)
- Pump did not stop (*Stop*)
- High well condition (*HiWell*)
- Low well condition (*LoWell*)
- DC bias failed (*DCBias*)
- AC power loss (*ACPwr*)
- Transducer fault (*Xducer*)
- Phase voltage fault (*PhaVol*)
- Phase sequence fault (*PhaSeq*)
- Auxiliary input alarm (*AuxIn*)

See "Chapter 12: Viewing and Troubleshooting Alarms" for alarm message descriptions and troubleshooting steps.

An alarm message flashes if there is an active alarm. If the alarm condition clears while the alarm message is being viewed, the alarm message stops flashing. Messages for inactive (cleared) alarms are static (non-flashing). These messages are stored in the TCU's alarm log until they are viewed. Once a message for an inactive alarm condition has been viewed, it is cleared from the TCU's display.

The Alarm LED flashes when there are active alarms and is static on (continuously lit) until all alarms have cleared ***and*** all corresponding alarm messages have been viewed. The Alarm LED is cleared when the alarm screen is exited and there are no active alarms.

When the TCU is used as a remote in conjunction with the telemetry system, active alarms will be displayed both locally (at the TCU) and via the telemetry system at workstation computers. Note that the TCU's alarm messages and alarm LED are ***not*** cleared via telemetry; they must be cleared locally.

Configuration Options

The number of pumps, level-sensor type, pumping method, control levels, etc., are entered into the unit to customize its operation. A keypad is provided as the main method of configuration input. Additionally, information can be transferred to the unit through an RS-232 service port or over a radio link using HT3 telemetry equipment. Configurations are stored in non-volatile memory allowing the unit to retain configuration information even during extended power outages and servicing.

The TCU's configuration options are accessed by:

1. Placing all three of the H-O-A switches in the "Hand" or "Off" position.
2. Navigating to the Change Configurations screen.
3. Pressing the Enter key.

The following are used for entering the TCU's configuration data:

Keypad and LCD	A 4x20-character LCD is provided to view status, alarms, and configuration data. The TCU's 12-key keypad enables you to navigate through displays and change the configuration. The keypad includes the numbers 0-9, navigation keys (up ▲, down ▼, left ◄, and right ►), an ENTER key, and an ESC (escape) key. Some keys have two functions. For example, the number 2 key is also the "up" scrolling key. The function of the key is dependent on the screen currently being displayed.
Communications Service Port	The TCU's front panel features an RS-232 interface that can be used for diagnostics and configuration storage and updating. Configuration data can be uploaded from the TCU to a portable computer and saved. If the TCU is replaced, the configuration can be downloaded from a laptop computer to another TCU. When the TCU configuration is modified using this method, the TCU will reset itself causing any pumps running in automatic to be stopped. The pumps will not start again in automatic until their associated staging level is reached.

For detailed information on configuring the TCU for a pump control process, see "Chapter 10: Configuring the Pump Control Process."

Failure Modes

Pump Failure

The TCU can operate around a pump that has failed, and can be configured to retry the failed pump after a delay. If the retry function is disabled, the TCU will alternate around the faulted pump until it is taken out of service via its corresponding H-O-A switch. See “Auto Retry” on page 131.

Phase Fault

The TCU's phase monitor is designed to detect phase losses, high and low phase faults, and phase sequence faults. When the TCU detects a phase fault, it disables the pump motor outputs and activates the alarm light and horn relays. If a phase is missing or the power is interrupted, the TCU also indicates that a phase sequence fault has occurred by issuing a PhaSeq alarm. The TCU’s H O A switches can be used to override the TCU's phase monitor and control the pumps during a phase fault. See “Phase Sequence Fault” on page 154.

Analog Transducer Fault

The conditions that cause a transducer fault alarm to be generated are based on the TCU’s configuration. A few of the conditions that can cause a transducer fault are:

- Transducer low condition
- High float condition
- Absence of bubbler noise

The TCU provides several options for maintaining well and tank levels when a transducer fault occurs. Control pumps using:

- High and/or low float
- Timer based on the station's pumping history (average cycle per each hour of the day)
- Second analog transducer
- Float system (Off float and at a minimum a Lead or High float)
- Combination of a high and/or low float and the desired fault mode (timer, second transducer, floats)

These options and the conditions that generate a transducer fault are described in more detail in “Chapter 10: Configuring the Pump Control Process” in the sections “Enable a Low Float and/or a High Float,” “Transducer Fault Mode,” “Transducer High Float Fault,” and “Transducer Low Level Fault.” Typical applications and configurations are provided in “Appendix M: TCU Transducer Configuration Examples.”

Notes:

Chapter 3: BEFORE YOU BEGIN

SAFETY PRECAUTIONS

Review the following statements before installing, servicing, or replacing the Tack PAC Telemetry Control Unit (TCU) or any of its components.

GENERAL PRECAUTIONS

Only trained and qualified personnel should install, service, or replace this equipment.

Carefully read the installation and wiring instructions before connecting the TCU to its power source.

Do not work on the TCU, or connect or disconnect any of its cables, during periods of lightning activity.

To prevent overheating the TCU, do not operate it in an area that exceeds the maximum recommended temperature of -10^{O}C (14^{O}F) to 60^{O}C (140^{O}F). The upper temperature limit is 50^{O}C (122^{O}F) when using the recommended backup battery.

Ensure that the unit is connected to earth ground during normal use.

Precautionary measures must be observed when installing, operating, and servicing the TCU in order to prevent shock from voltages present.

If the TCU is to be installed into an existing control panel, make sure that all breakers are shut off before starting the installation.

All wiring should conform to federal, state, and local electrical codes.

WORKING WITH THE TCU

Before working with the TCU where the removal of components is necessary, perform the following steps in the sequence indicated:

1. Power down the unit.
2. Turn off all circuit breakers to the TCU.
3. Ensure that any cables connected to the TCU will not become entangled in or caught on anything in the surrounding area.

> **IMPORTANT:** If the TCU's Power LED is not lit, you should assume that the TCU is still powered. The Power LED indicates only that the TCU is in the off state, not that AC power has been removed. To remove power, you must turn off the external circuit breaker.

When disconnecting a cable, pull on its connector or on its strain-relief loop, not on the cable itself. Some cables have a connector with locking tabs; when disconnecting this type of cable, press in on the locking tabs before disconnecting the cable. When pulling connectors apart, keep them evenly aligned to avoid bending any connector pins. Also, before connecting a cable, make sure both connectors are correctly oriented and aligned.

Protecting Against Electrostatic Discharge

Static electricity can harm delicate components inside the TCU. To prevent static damage, put on an electrostatic discharge wrist strap before touching any of the TCU's electronic components.

In addition to the preceding precautions, the following steps can be taken to prevent damage from electrostatic discharge (ESD):

- When unpacking a static-sensitive component from its shipping carton, do not remove the component's antistatic packing material until ready to install the component in the TCU. Be sure to put on an electrostatic discharge wrist strap before unwrapping the antistatic packaging.
- When transporting a sensitive component, first place it in an antistatic container or packaging.
- Handle all sensitive components in a static-safe area. Place the equipment on a grounded surface. If possible, use antistatic floor pads and workbench pads.

Note: Contact DFS if electrostatic discharge packaging is needed for return shipments. See Return Authorization (RA) Procedure, p. 275 for more information on returning equipment.

Using the TCU

When using the TCU, observe the following safety guidelines:

- To help prevent electric shock, wire the TCU and peripheral power cables into properly grounded power sources.
- Be sure nothing rests on the TCU's cables and that the cables are not located where they can be stepped on or tripped over.

Site Selection

When selecting a site for the TCU, keep the following in mind:

- The TCU requires a 120 VAC power supply.
- The TCU is designed to operate at recommended temperature range of -10^{O}C (14^{O}F) to 60^{O}C (140^{O}F). The upper temperature limit is 50^{O}C (122^{O}F) when using the recommended backup battery.
- The TCU requires a NEMA type 12 or equivalent enclosure.
- Attention should be given to the location of the TCU to provide accessibility for wiring and servicing. Leave enough space around the TCU to access the TCU's fuse (located on the side of the TCU and labled F601) and to remove the connectorized terminal strips. Install the TCU in the panel at a position where the LCD display can be read comfortably. The LCD is best viewed at slightly below eye level.

Receipt of Equipment

When equipment is received, examine the outside of the carton for any damage incurred during shipment. Remove the packing list and the equipment from the shipping carton. Carefully inspect the equipment for damage. Resolve any damage with the local carrier. Report damages to Data Flow Systems (321-259-5009). Include the serial number of the unit and the extent of damage in your report.

Chapter 4: Mounting Instructions

The TCU is intended to be permanently installed in a NEMA 12 or higher rated panel that prevents access to live parts without a tool. The TCU can be mounted in a control panel in several different ways. The unit can be mounted flush to the back plate of the panel, stood off the back plate, or mounted to a front panel. Mounting brackets are provided with the TCU that can be used to mount it in any of these positions. Optional connectors to facilitate the various types of mountings are available as shown in Figure 4-4, "Optional Connector Types" and may be specified as described in “Appendix C: Parts List”

> **⚠WARNING**
>
> This information is provided for qualified personnel only.
>
> Improper installation, service, or maintenance can cause property damage, injury, or death.
>
> Read the installation and operating instructions thoroughly before installing or servicing this equipment.

> **⚠WARNING**
>
> Precautionary measures must be observed when installing, operating, and servicing the TCU in order to prevent shock from voltages present.
>
> If the TCU is to be installed into an existing control panel, make sure that all breakers are shut off before starting the installation.
>
> All wiring must conform to federal, state, and local electrical codes.

IMPORTANT

- A qualified technician should install the TCU.
- Precautionary measures must be observed when installing, operating, and servicing the TCU in order to prevent shock from voltages present.
- The TCU is intended to be permanently installed in a NEMA 12 or higher rated panel that prevents access to live parts without a tool..
- If the TCU is to be installed into an existing control panel, make sure that all breakers are shut off before starting the installation.
- All wiring should conform to federal, state, and local electrical codes.
- Attention should be given to the location of the TCU to provide accessibility for wiring and servicing. Leave enough space around the TCU to access the TCU’s fuse (located on the side of the TCU and labled F601) and to remove the connectorized terminal strips. Install the TCU in the panel

at a position where the LCD display can be read comfortably. The LCD is best viewed at slightly below eye level.

TAC Pack Adapter

This mounting option is available when a TCU is replacing a rear-panel mounted PCU. It uses the preinstalled PCU mounting bracket and brings the TCU to the same level as the PCU it is replacing.

This option uses the Retro installation kit (Basic Install Kit or Full Install Kit). See “Appendix C: Parts List”

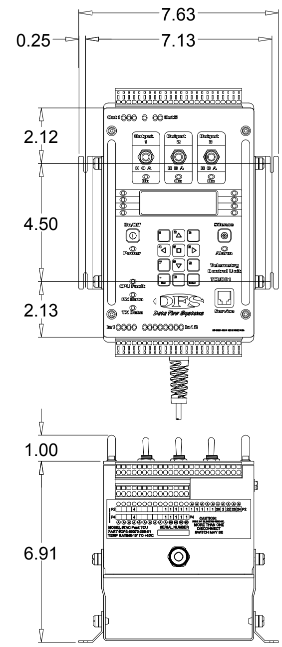


Figure 4-1, "TAC Pack Adapter"

Snap-In (Back Panel) Mount

The snap-in mount is available for new installations (i.e., TCU is not replacing a PCU). The mounting bracket is attached to the back of the control panel, and the TCU is snapped into place. With this mounting option, the TCU can be installed and removed quickly and easily.

This option uses the Snap In installation kit (Basic Install Kit or Full Install Kit). See “Appendix C: Parts List”

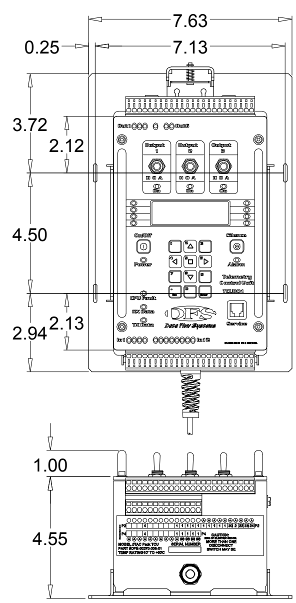


Figure 4-2, "Snap In Mount"

PCU Front Panel Mount

This mounting option uses a PCU-type mounting bracket that is attached to the front of a control panel. With this mounting option, the TCU is attached to the mounting bracket with screws instead of being snapped into place.

This option uses the Front Mount installation kit (Basic Install Kit or Full Install Kit). See “Appendix C: Parts List”

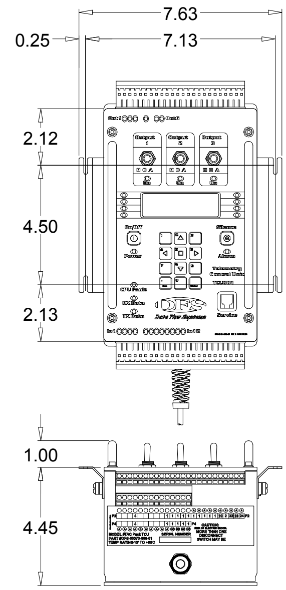


Figure 4-3, "PCU Front Panel Mount"

The graphic below depicts how each of the TCU's three optional connector types can be attached to the unit. The first option uses the Spring-Clamp Connector Tool, (see photo below) which can be ordered from DFS. See "Appendix C: Parts List" for information on ordering connectors and the connector tool.

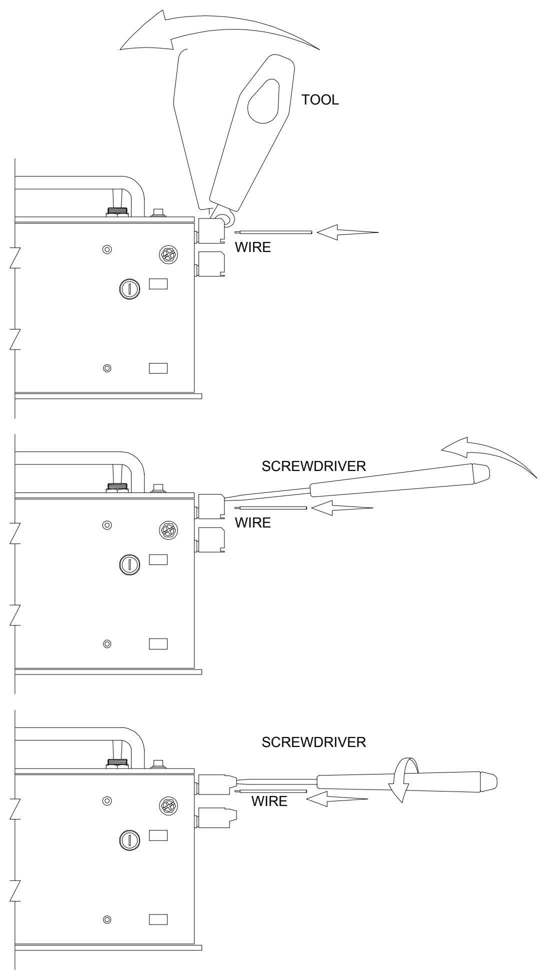


Figure 4-4, "Optional Connector Types"

Figure 4-5, "Spring-Clamp Connector Tool"

A dimensional drawing is provided in Figure 4-6, "Dimensional drawing of the TAC Pack TCU" to aid in installation. If a panel cutout is required, the TCU can be installed with or without edge molding around the front-panel opening. The panel cutout is different for each mounting configuration. See Figure 4-7, "Control panel installation with TCU mounted to dead front" and Figure 4-8, "Control panel installation with TCU mounted to front panel", p. 44.

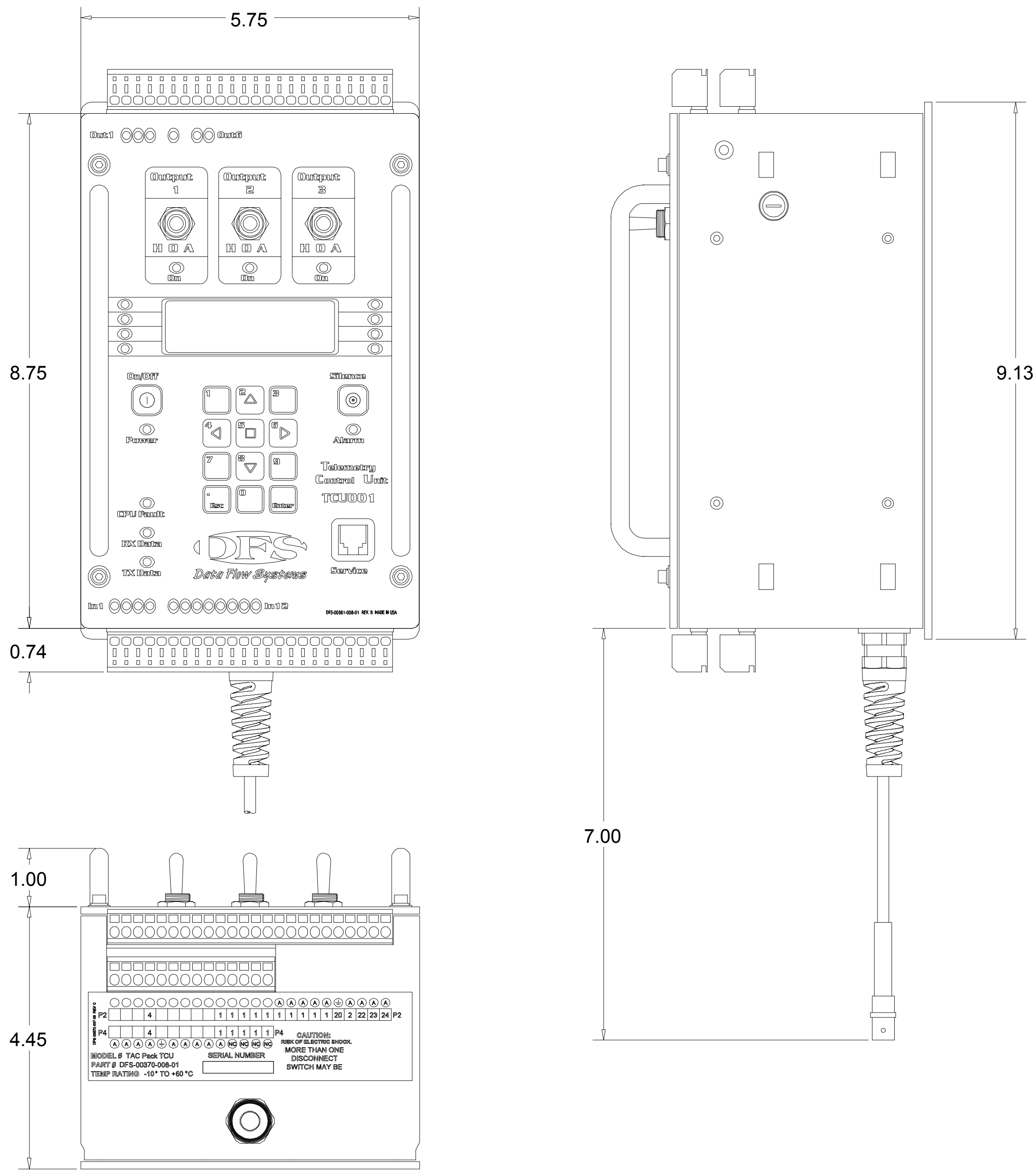


Figure 4-6, "Dimensional drawing of the TAC Pack TCU"

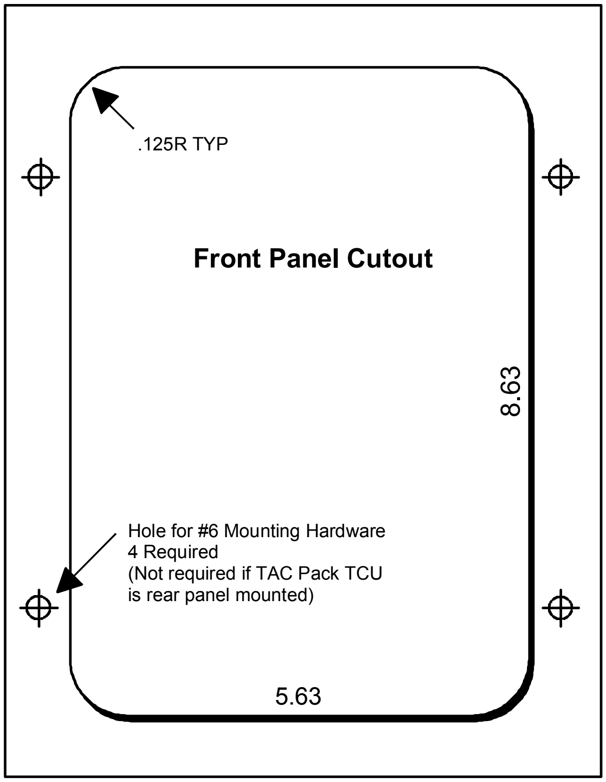


Figure 4-7, "Control panel installation with TCU mounted to dead front"

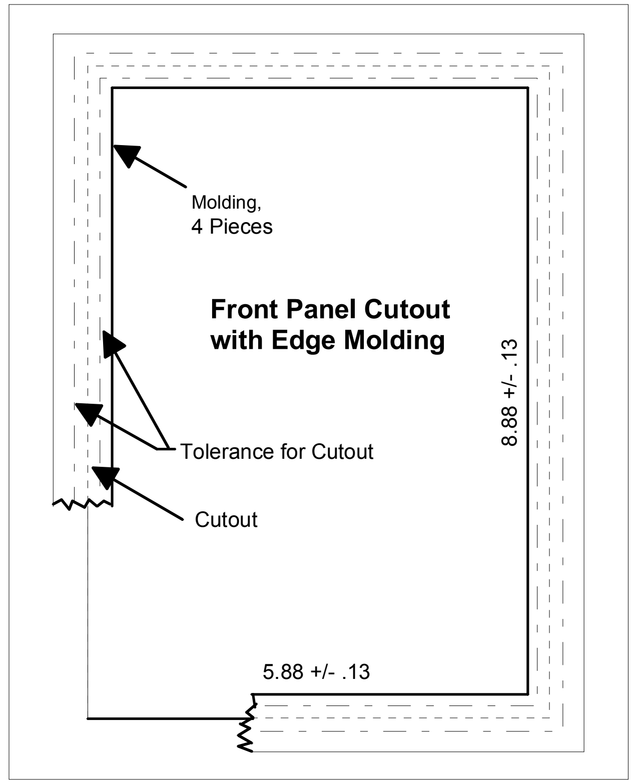


Figure 4-8, "Control panel installation with TCU mounted to front panel"

Chapter 5: MODBUS SUPPORT

The TCU provides support for Modbus slave and master devices via its RS-232 and RS-485 serial interfaces.

Note that the TCU can be used as both simultaneously. For example, it could respond to queries from a Modbus master HMI software package (via RS-232) while querying DIN-rail mounted RS-485 slave devices.

RS-232 Modbus Slave Interface	The TCU's standard RS-232 serial interface allows it to be polled by devices that use 9600 baud and numerous Modbus protocol configurations. See "TCU as Modbus Slave (RS-232 Interface)," below. **Note:** The TCU must be factory configured by DFS to provide Modbus slave support.
RS-485 Modbus Master Interface	The TCU's RS-485 Modbus serial interface enables it to act as a Modbus master device and poll devices at 1200-9600 baud using Modbus serial ASCII or RTU protocol. The baud rate and protocol selected for your installation must be identified in the TCU's configuration. See "Modbus Master Baud Rate and Protocol" on page 129 for more information. For specific instructions on adding a RIO032 to a TCU, see "Appendix K: Adding a RIO to the TCU" beginning on page 219.

TCU AS MODBUS SLAVE (RS-232 INTERFACE)

The TCU's RS-232 Modbus interface acts as an interface to industry standard Modbus-compatible devices, including radios, modems, and PLCs.

Connecting a serial Modbus device to the TCU's RS-232 interface (connector P4) enables the TCU to operate as a Modbus slave device and respond to queries of its I/O.

> **IMPORTANT:** The TCU must be factory configured by DFS to provide Modbus slave support. New TCUs can be ordered with the desired configuration or an existing TCU can be returned to DFS to be reconfigured as a Modbus slave device.

The following Modbus configurations are available:

	Protocol	**Baud Rate**	**Data Bits**	**Parity**	**Stop Bits**
Option 1	Modbus ASCII	9600	7	Odd	2
Option 2	Modbus RTU	9600	8	No	1
Option 3	Modbus RTU	9600	8	Even	1
Option 4	Modbus RTU	9600	8	Odd	1

The illustrations below and on the next page show several examples of how the TCU can be integrated with a Modbus master device.

- Figure 5-1, "TCU Communicating with Modbus Master / PLC"
- Figure 5-2, "TCU Communicating with Modbus Master via Modem"
- Figure 5-3, "TCU Communicating with Modbus Master via Radio"

Note: To disable hardware flow control/hardware handshaking in any of these configurations, place a jumper between the TCU's RTS and CTS pins (as shown in each drawing).

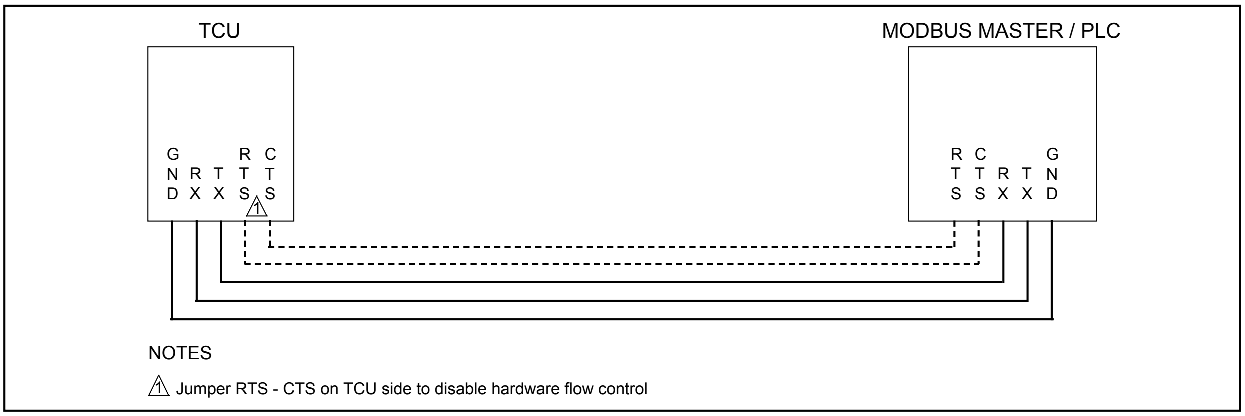


Figure 5-1, "TCU Communicating with Modbus Master / PLC"

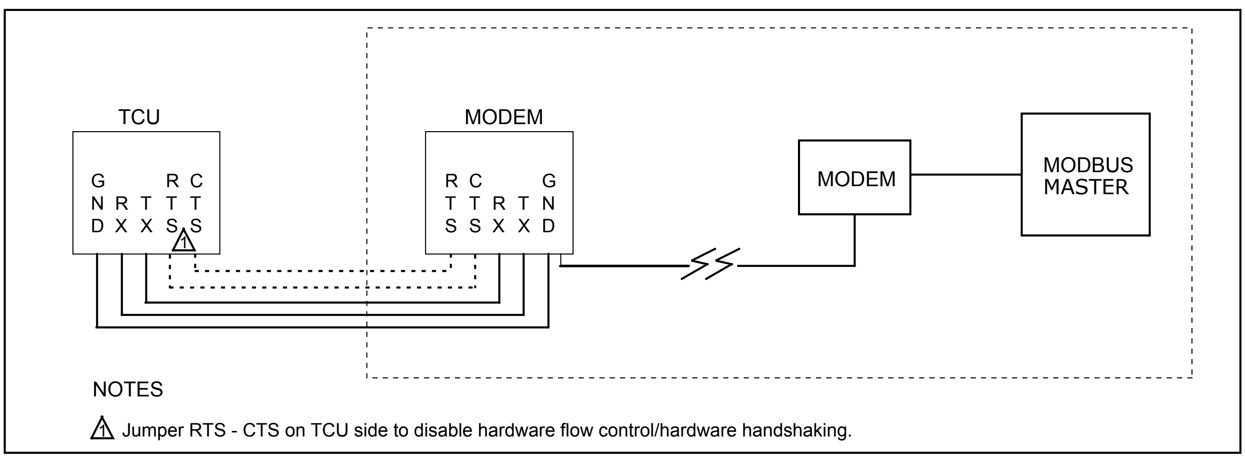


Figure 5-2, "TCU Communicating with Modbus Master via Modem"

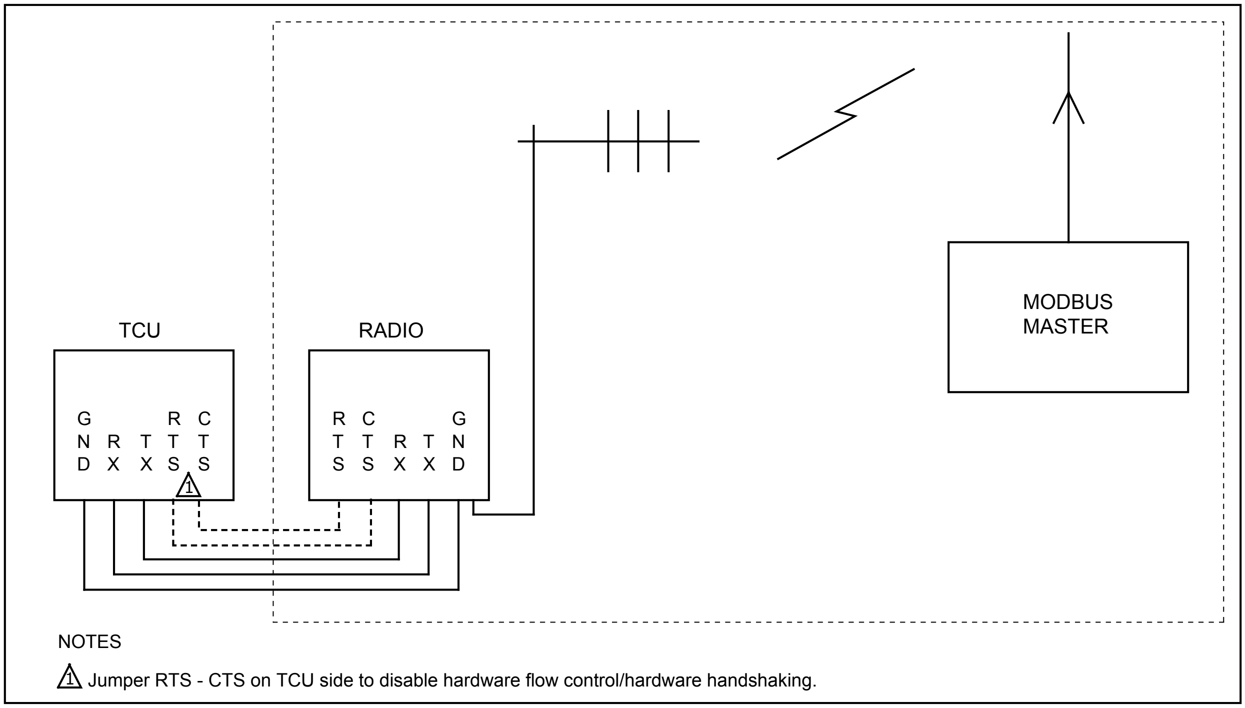


Figure 5-3, "TCU Communicating with Modbus Master via Radio"

Wiring External Modbus-compatible RS-232 Device

> **IMPORTANT:** Do not use the TCU to power an external RS-232 Modbus-compatible device (for example, a radio, modem, or PLC). The device must be powered by a source other than the TCU.

The TCU's P-4 connector provides pins for connecting the TCU to an external RS-232 Modbus compatible device (see table below for pin descriptions for connector P-4).

Connector P-4 Pin Descriptions

PIN#	Name	Description
P4-1		Reserved for future use; do not connect
P4-2		Reserved for future use; do not connect
P4-3	*RS485_B*	RS-485 serial interface B
P4-4	*RS485_A*	RS-485 serial interface A
P4-5	*EX_SHIELD*	Cable shield for RS-485 or RS-232 cable
P4-6	*EX_GND_RAD*	RS-232 ground
P4-7		Unused
P4-8	*EX_TXD_RAD*	RS-232 transmit data to external device
P4-9	*EX_RXD_RAD*	RS-232 receive data from external device
P4-10		Unused

In the diagram below, note that the RTS (request to send) and CTS (clear to send) connections are optional. They are only used for master devices that require hardware handshaking.

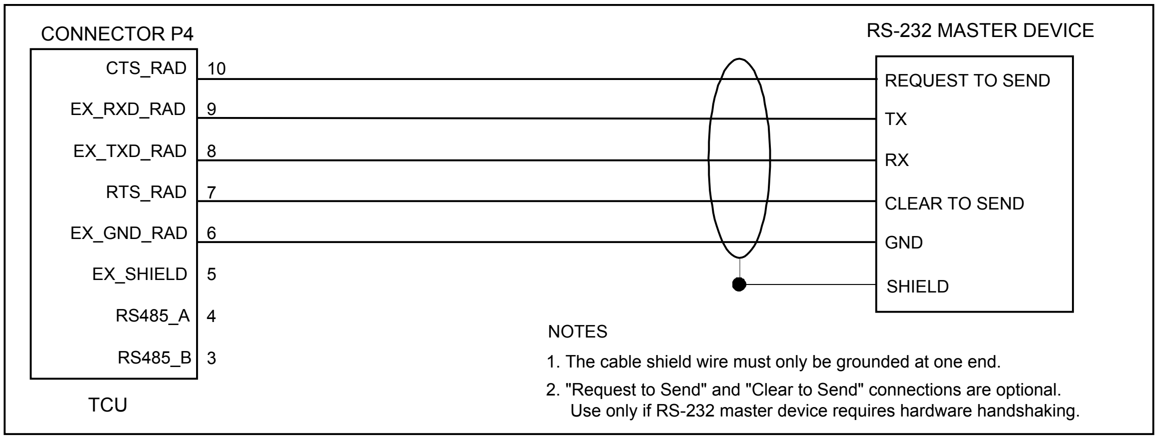
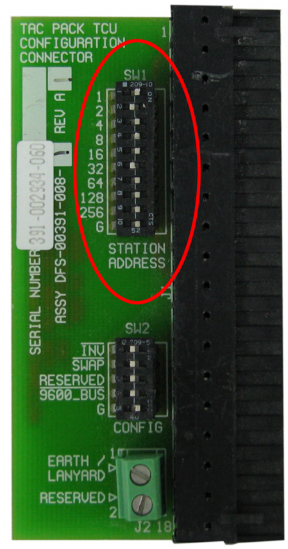


Figure 5-4, "Wiring RS-232 Interface (TCU as Modbus Slave Device)"

Configuring Modbus Device ID

The valid device ID range for the TCU is 1-250.



The TCU's Modbus slave device ID is configured using the TAC Pack TCU Configuration Connector (shown at right). The ID is set by turning off switches on the connector's SW1 DIP switch that add up to the desired station number. The connector is installed in the TCU's P3 connector.

Each switch has an assigned bit value (labeled along the left side of the switch). The device ID is calculated by totaling the bit values of the switches that are in the OFF position. (The OFF position is towards the card edge; the ON position is near the connector side.)

The example at right shows a device ID of 34. The second and sixth switches are in the OFF position. The remaining bits would be left grounded (switch in the ON position).

Device ID = bit value of second switch + bit value of sixth switch

- Second switch: bit value = 2
- Sixth switch: bit value = 32

Invalid ID

If the TCU has been incorrectly addressed, its TX Data LED will not blink when the device is up and running. This is an indication that the device is unable to transmit.

- Leaving ***all*** of the bits grounded (all switches in the ON position) gives the TCU a device ID of 0 (zero), which is an invalid ID number.
- Removing the configuration connector altogether, gives the TCU a device ID of 511 (the sum of all of the bits). This is also an invalid ID number.

Wire Earth/Lanyard Terminal to Control Panel Ground

The TCU Configuration Connector has a terminal named Earth/Lanyard. This terminal must be wired to the control panel's ground. Although wiring the connector to ground is redundant, it serves the purpose of ensuring that the configuration settings remain with the control panel. If the TCU needs to be replaced, the configuration connector can be easily removed and installed in the replacement TCU.

TCU Radio System Setup

Radio communication requires that the TCU be installed in a location, preferably a control panel, with access to an antenna. This illustration provides details on grounding a TCU that is installed in a control panel. Refer to the documentation for your radio and antenna system for details on wiring and installing those parts of your system.

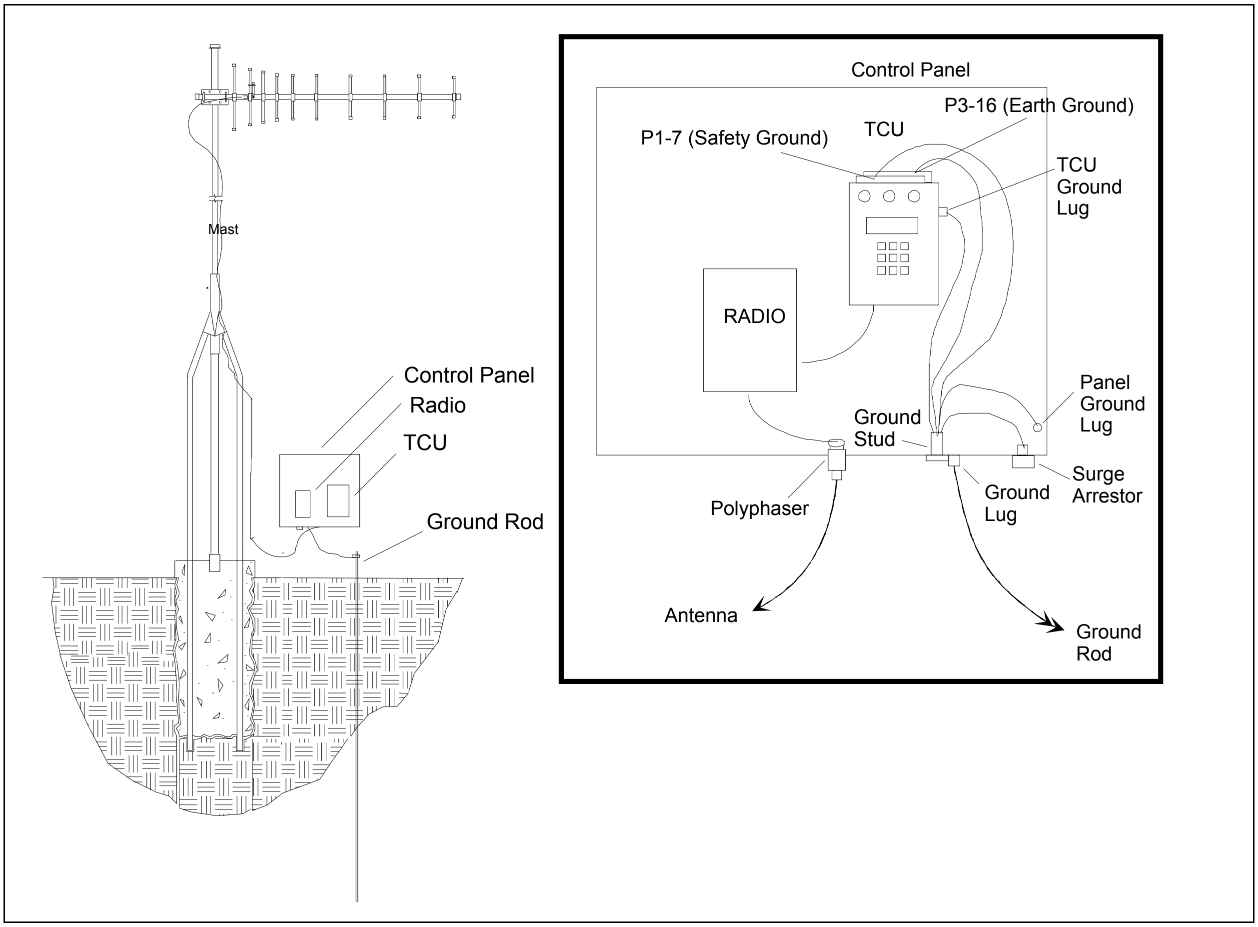


Figure 5-5, "TCU Radio System"

Querying the TCU

When communicating with the TCU via Modbus radio or as a Modbus slave device via the RS-232 port, you must query the TCU using the equivalent Modbus register.

Refer to the section titled “Pump Control Application by Modbus Register” in “Appendix N: Polling the TCU – DFS Point and Modbus Registers.”

The TCU supports the following Modbus functions on its RS-232 serial slave port:

01	Read Coil Status (read digital control registers 1-9999)
02	Read Input Status (read digital status registers 10001-19999)
03	Read Holding Registers (read analog control registers 40001-49999)
04	Read Input Registers (read analog input registers 30001-39999)
05	Force Single Coil (control single control register)
06	Preset single Register (control single analog control register)

The TCU does ***not*** support:

15	Force Multiple Coils (control multiple control registers)
16	Preset Multiple Registers (control multiple analog control registers)

TCU AS MODBUS MASTER DEVICE (RS-485 INTERFACE)

Note: The instructions below are for a generic Modbus device. For information on adding a RIO032 or RIO128, see “Appendix K: Adding a RIO to the TCU.”

When the TCU is used as a fixed-speed pump controller, it can poll Modbus slave devices and place their register data in the TCU’s unused registers (referred to as modules H-O in the TCU’s configuration screens and WinRTU Test).

Modbus polling is activated by entering the Modbus information (address and length) into the TCU’s configuration registers. The TCU will then poll the device(s) automatically.

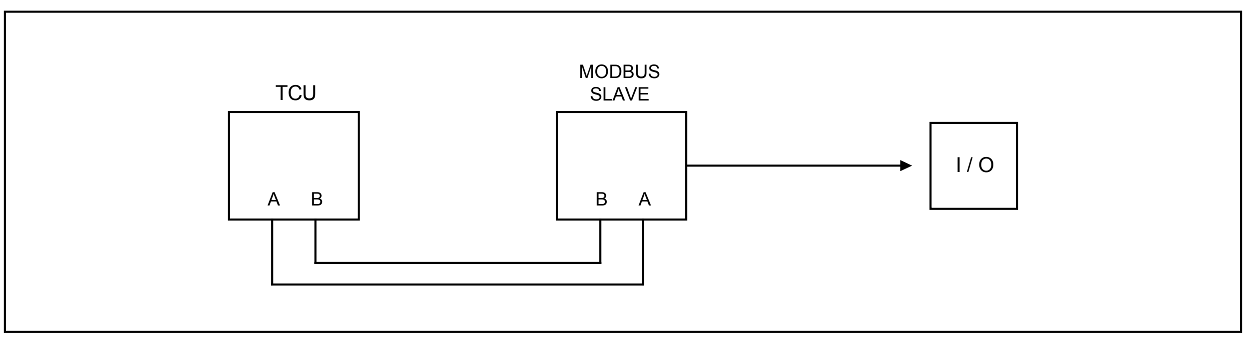


Figure 5-6, "TCU as Modbus Master"

RS-485 Serial Settings

As a Modbus master device, the TCU can communicate with Modbus slave devices at 1200-9600 baud using either ASCII or RTU protocol.

The baud rate and protocol selected for your installation must be identified in the TCU's configuration. See "Modbus Master Baud Rate and Protocol" on page 129 for more information.

The protocol options are:

	Protocol	Data Bits	Parity
Option 1	ASCII	7	No
Option 2	ASCII	7	Even
Option 3	ASCII	7	Odd
Option 4	RTU	8	No
Option 5	RTU	8	Even
Option 6	RTU	8	Odd

Wiring an RS-485 Slave Device

The TCU's P4 connector is its interface to RS-485 devices. Refer to the pin definitions for the TCU's Bottom Connector 2: P4 provided on page 10. A wiring diagram is provided below.

A wiring diagram is provided below. Information on configuring the TCU to poll Modbus slave devices is provided in the sections titled "TCU as Pump Controller (see below) and "TCU in Custom Application" (see page 53).

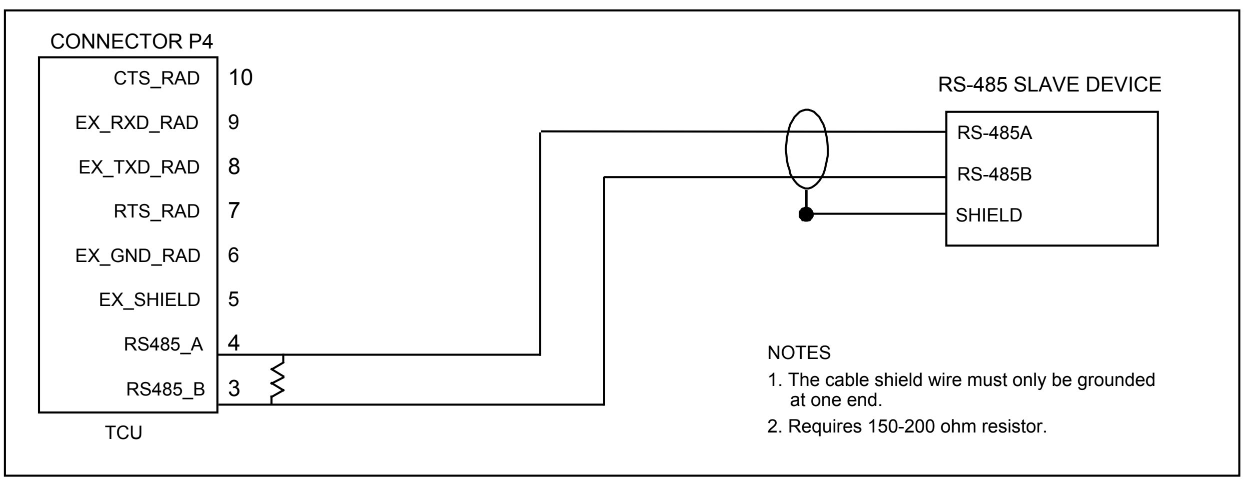


Figure 5-7, "Wiring RS-485 Interface (TCU as Modbus Master)"

Configuring the TCU to Poll Modbus Slave Devices

Pump Control Process

When using the TCU as a fixed-speed pump controller, you configure the TCU to poll Modbus slave devices using one of the following methods:

- Through the TCU's configuration screens (see "Poll Modbus Slave Devices" on page 127)
- Via the TCU editor included in WinRTU Test. WinRTU Test is included in the TCU, PCU & SCU Test Kit (see "Appendix C: Parts List" for ordering information). The Help files included with WinRTU Test provide details on configuring the TCU for Modbus polling.

The TCU polls Modbus registers as follows:

Digital Status (10001-19999) and Analog Status (30001-39999)	Registers are polled continually
Digital Control (0001-9999) and Analog Control (40001-49999)	Registers are updated using the multiple register update command. At TCU power up, the status of Control registers is read once.

Once you have configured the TCU to poll Modbus slave devices, you must configure your HMI to poll the slave device using the registers provided in "DFS Module to Modbus Register Maps" beginning on page 267. The maps are organized by module type (DMM, ACM, etc) and then by module letter (H, I, J, etc.)

After TCU power up, Modbus control registers are updated whenever the corresponding TCU registers are changed via telemetry. Similarly, when Modbus status registers change, their corresponding TCU registers are updated. One module of Modbus data is processed approximately every 2 seconds.

Information on using the TCU in a custom application is provided on the next page.

TCU in Custom Application

The TCU can act as a Modbus master device to provide support for small devices utilizing Modbus communications. Modbus support is provided using 61 bytes of external memory with communication and data parameters manipulated by using the XBY operator to write to these memory locations and read from them. For more information on the XBY operator, see “Chapter 3: Operators and Expressions” in the *TCU Programming Reference*.

Baud Rate and Parity are set at memory location 5CA0H with the format 0PBH, where P is parity and B is baud, as follows:

Baud	Parity			
	No Parity	Mark Parity	Even Parity	Odd Parity
1200	001H	011H	021H	031H
2400	002H	012H	022H	032H
4800	004H	014H	024H	034H
9600	008H	018H	028H	038H

Outgoing Message Structure (binary message image) is built using Hexadecimal (Hex) values starting at memory location 5C60H. Information on Modbus messaging and function formats can be found in the Modicon Modbus Protocol Reference Guide (PI-MBUS-300). This reference guide is available for download from Modicon’s web site (www.modicon.com).

Placing the “:” syntax, LRC (Longitudinal Redundancy Check), and CR-LF (Carriage Return - Line Feed) characters into memory is *not* required since the final message building is performed by the Modbus communications routine.

After the memory locations are set appropriately for the desired command option, call the Modbus Routine at 3000H (e.g. CALL 3000H).

The finished Modbus message is generated with the appropriate syntax and sent to the Modbus device.

The routine waits 1-3 seconds for a valid response from the device and stores the received message at memory location 5C61H up to memory location 5C9DH. The message length (number of bytes) is stored at memory location 5C60H, with the actual received data (not including address, message type, or data byte length) stored at memory location 5C64H.

If there is no response from the Modbus device or the Modbus Routine determines that the received message is bad, a value of zero is stored in memory location 56C0H.

In this example, we poll the Modbus registers.

On entry, the argument stack values should be:

- 1st value on stack should be bus address
- 2nd value on stack should be start register
- 3rd value on stack should be number of registers

On exit, the argument stack values should be:

- 1st value on stack is number of registers received
- 2nd value on stack is 1st register received
- 3rd value on stack is 2nd register received
- etc.

```
REM GetModbus:
7300 Pop ModLn, ModSt, ModAddr
7302 FunC = 1: ModSt = ModSt - 1
7304 If ModSt > 39999 then FunC = 3: ModSt = ModSt - 40000
7306 If ModSt > 29999 then FunC = 4: ModSt = ModSt - 30000
7308 If ModSt >  9999 then FunC = 2: ModSt = ModSt - 10000
7310 XBY(05C61H) = ModAddr             : REM ADDRESS
7312 XBY(05C62H) = FunC                : REM MSSG TYPE
7314 XBY(05C63H) = ModSt/256           : REM REG ADDR HI
7316 XBY(05C64H) = ModSt.and.255       : REM REG ADDR LO
7318 XBY(05C65H) = ModLn/256           : REM LENGTH HI
7320 XBY(05C66H) = ModLn.and.255       : REM LENGTH LO
7322 XBY(05C60H) = 6                   : REM PLACE LENGTH IN APPROP MEMORY LOCATION
7324 CALL 3000H                        : REM CALL ASSEMBLY LANGUAGE MODBUS ROUTINE
7326 RxBtCnt=XBY(05C60H)               : REM GET RECEIVE MSSG LENGTH FROM APPROP MEMORY LOCATION
REM EXTRACT RESPONSE FROM APPROPRIATE MEMORY LOCATIONS:
REM WHEN RESPONSE IS RECEIVED, COPY DATA ONTO STACK:
REM PUT ANALOG REGISTERS ON STACK SO THEY POP OFF IN CORRECT ORDER:
7328 If not( (RxBtCnt>3) )then GoTo 7354
7330 If not( (FunC > 2) )then GoTo 7342
7332 FOR MIX = 05C60H+RxBtCnt-1 to 05C64H step -2    : REM PUT NUM REG'S RECEIVED ON STACK
7334 PUSH XBY(MIX)*256 + XBY(MIX + 1)
7336 NEXT
7338 PUSH int((RxBtCnt-3)/2)
7340 GOTO 7352
REM            else057:
REM DIGITAL REGISTERS
7342 For MIX = ModLn to 1 step -1
7344 MsgIx = 05C64H + (MIX-1)/8
7346 Push (XBY(MsgIx).and.2**((MIX-1).and.7))<>0
7348 Next
7350 PUSH ModLn                              : REM PUT NUM REG'S RECEIVED ON STACK
REM            endif057:
7352 GOTO 7356
REM     ELSE056:
7354 Push 0                                  : REM INDICATE NOTHING RECEIVED
REM            ELSE056:
REM            ENDIF056:
7356 RETURN
```

In this example, we set the Modbus register values.

On entry, the argument stack values should be:

- Last value on stack should be bus address
- Last-1 value on stack should be start register
- Last-2 value on stack should be number of registers to update
- Last-3 value on stack should be 1st new value
- Last-4 value on stack should be 2nd new value
- etc.

On exit, the argument stack values should be: None

```
REM PutModbus:
7500 Pop ModAddr, ModSt, ModLn
7502 If not( ModSt < 40001 )then GoTo 7532
7504 FunC = 15: ModSt = ModSt - 1
7506 B=1
7508 ModVa = 0
7510 MsgAd = 05C68H
7512 For I = 1 to ModLn
7514 Pop X: ModVa = ModVa/2 + (X.and.080H)           : REM PUT DATA IN MESSAGE
7516 IF (B=8) then Xby(MsgAd)=ModVa: MsgAd=MsgAd+1: ModVa=0: B=0
7518 B = B + 1
7520 Next I
7522 For I=B to 8:ModVa = ModVa/2: Next I
7524 If B <> 9 Then Xby(MsgAd) = ModVa
7526 XBY(05C60H) = Int(ModLn/8)+8                    : REM PUT LENGTH IN MESSGE
7528 XBY(05C67H)=Int(ModLn/8)+1                      : REM PUT BYTE COUNT IN MESSAGE
7530 GOTO 7548
REM    Else058:
7532 FunC = 16: ModSt = ModSt - 40001
7534 MsgAd = 05C68H
7536 For I = 1 to ModLn
7538 Pop X: Xby(MsgAd)=Int(X/256)            : REM PUT DATA IN MESSAGE
7540 Xby(MsgAd+1)=X.and.255: MsgAd=MsgAd+2
7542 Next I
7544 XBY(05C60H) = ModLn * 2 + 7             : REM PUT LENGTH IN MESSAGE
7546 XBY(05C67H) = ModLn * 2                 : REM PUT BYTE COUNT IN MESSAGE
REM    Endif058:
7548 XBY(05C61H) = ModAddr                   : REM PUT ADDRESS
7550 XBY(05C62H) = FunC                      : REM MSG TYPE
7552 XBY(05C63H) = ModSt/256                 : REM REG ADDR HI
7554 XBY(05C64H) = ModSt.and.255             : REM REG ADDR LO
7556 XBY(05C65H)=0:XBY(05C66H)=ModLn         : REM & QUANTITY OF REG’S IN MESSAGE
7558 CALL 3000H                              : REM CALL ASSEMBLY LANGUAGE MODBUS ROUTINE
7560 RETURN
```

Chapter 6: ELECTRICAL INSTALLATION

WARNING

This information is provided for qualified personnel only.

Improper installation, service, or maintenance can cause property damage, injury, or death.

Read the installation and operating instructions thoroughly before installing or servicing this equipment.

WARNING

Precautionary measures must be observed when installing, operating, and servicing the TCU in order to prevent shock from voltages present.

If the TCU is to be installed into an existing control panel, make sure that all breakers are shut off before starting the installation.

All wiring must conform to federal, state, and local electrical codes.

The electrical interface to the TCU is broken down into several groups of signals. Wiring of each group is detailed in the following paragraphs.

These instructions are written specifically for a TCU using the built-in pump control process. Although many of them apply to custom applications as well, the Applications Engineer will be primarily responsible for defining and implementing the TCU’s inputs and outputs. In this chapter, functions specific to the pump control process are noted as such.

An installation checkout procedure is provided in “Appendix A: Checkout Procedure for Pump Controller.” A comprehensive wiring diagram of a typical TCU installation is shown on page 83.

CAUTION

Maximum wire size to TCU connectors is 12 AWG.

Use copper conductors only with a minimum rating of 75^{O}C.

Recommended circuit breaker is 10 Amp maximum.

When using connectors with screw-type terminals, tighten screw terminals to a maximum 7 in-lb (.79 Nm).

All AC source power wired to the TCU should be from the same leg of the three-phase system. (Diagrams in this chapter show Phase C (L3) being used.)

The Power LED does *not* indicate that AC power has been removed. Even if the TCU's Power LED is not lit, you should assume that the TCU is still powered. To remove power, you must turn off the external circuit breaker.

AC POWER

The TCU operates from 120 VAC. Verify the input voltage on the TCU's connector label before wiring. Three terminals are provided for wiring power:

- P1-5, *AC_PWR* (AC power)
- P1-6, *AC_NEUT* (AC neutral)
- P1-7, *TGND* (earth ground)

Terminal P1-7 is designated Earth or Safety ground. The TCU's case is also connected to the *TGND* terminal. Wire in accordance with Federal, State, and Local Electrical Codes.

> **IMPORTANT**: The transformer must provide AC neutral. When wiring to a typical three-phase, 4-wire, 240 V transformer that provides AC neutral, refer to Figure 6-1, "Wiring AC Power (typical 240 V, 4-wire transformer)". Refer to Figure 6-2, "Wiring AC Power (typical 480 V, 3-wire transformer)" when connecting to a typical three-phase, 3-wire 480 V transformer with no neutral provided.
>
> Note that these diagrams are for typical installations. If your installation deviates from that shown here, then refer to the National Electrical Code® (NEC®) Handbook.

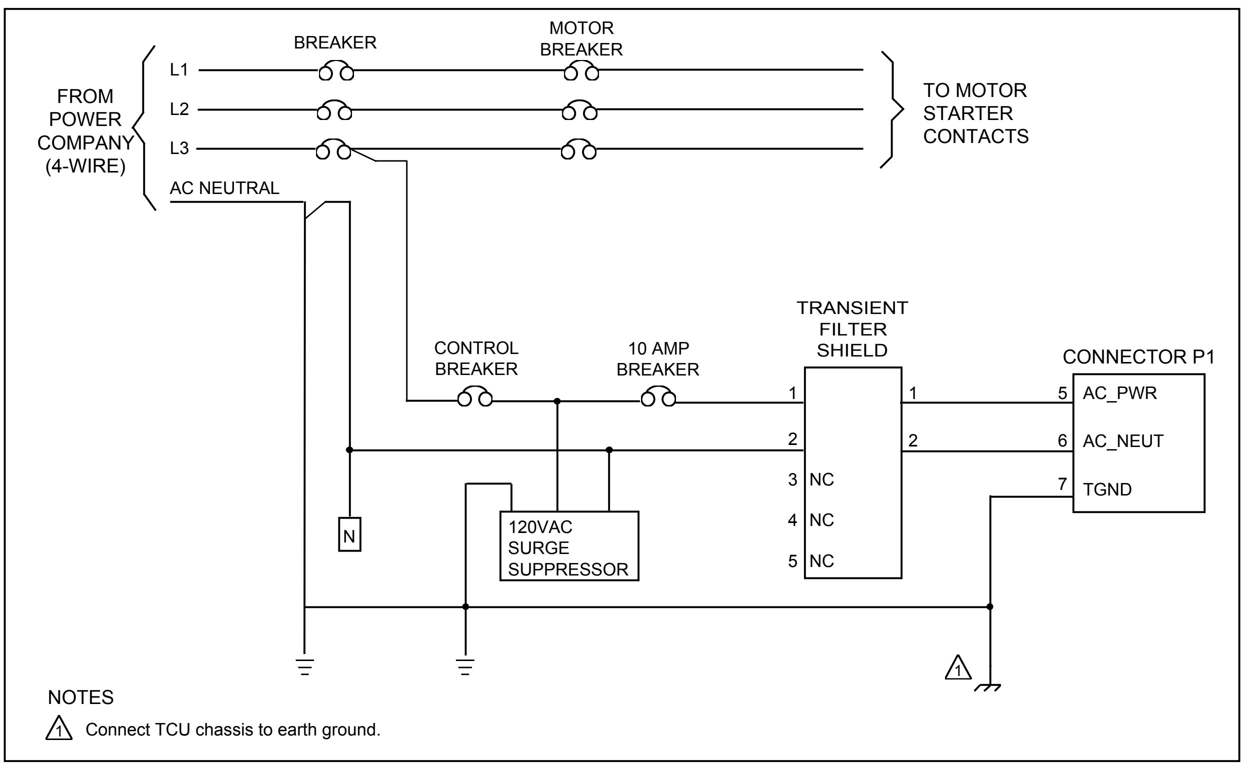


Figure 6-1, "Wiring AC Power (typical 240 V, 4-wire transformer)"

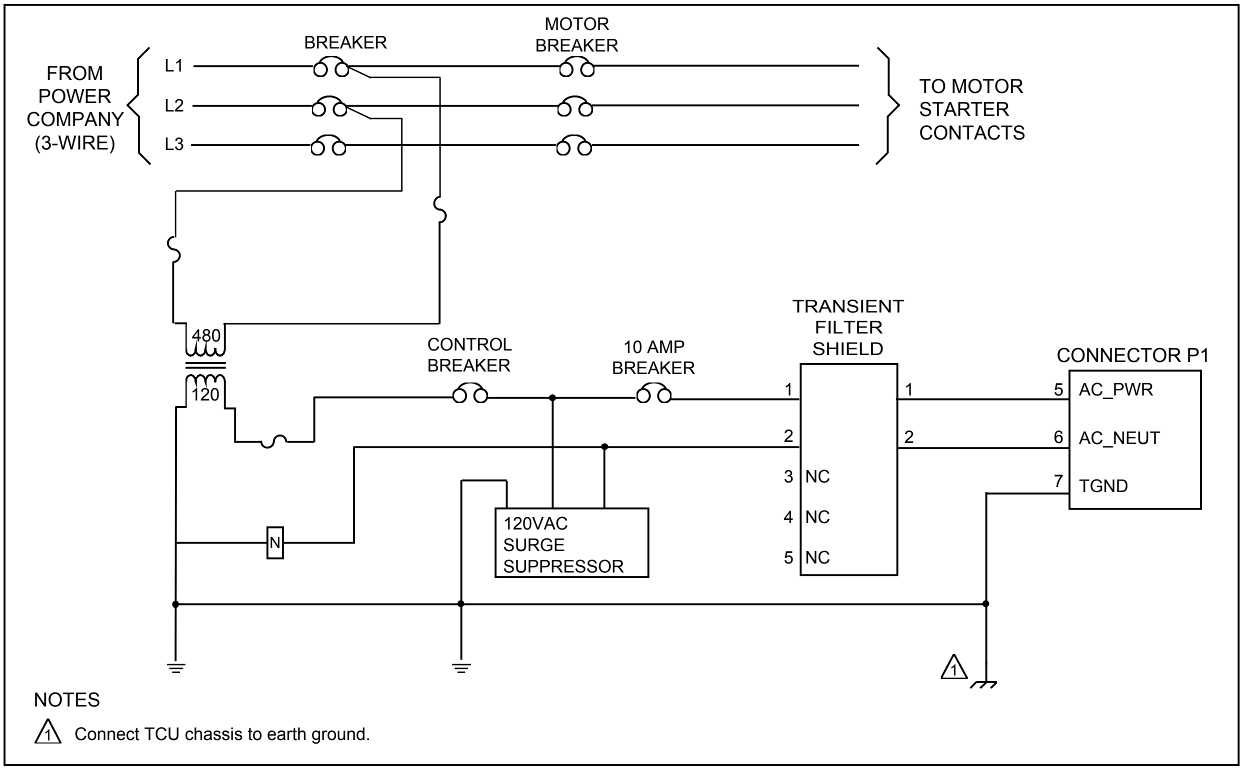


Figure 6-2, "Wiring AC Power (typical 480 V, 3-wire transformer)"

MOTOR STARTER OUTPUTS

1. Connect control power to the *STR_PWR* terminal (P1-24**)**.
2. Connect the *MTR1_STR* terminal (P1-23) through a 1 A slow-blow fuse to the coil of the motor starter or the control relay designated as Pump 1. (This fuse protects the TCU relays from short-circuited coils).
3. Connect the other side of the motor starter coil through appropriate disabling contacts to control power neutral. Make similar connections for Pump 2 and Pump 3 for duplex and triplex stations.

When the alternator function is disabled through the TCU's configuration (see "Pump Alternation, Flow Equalization, Motor Start and Stop Fault" beginning on page 117), *MTR1_STR* controls the Lead pump, *MTR2_STR* controls the Lag pump, and *MTR3_STR* controls the Lag2 pump. They should be wired accordingly.

Simplex stations use only *MTR1_STR*. Duplex stations use *MTR1_STR* and *MTR2_STR*. Triplex stations use all of the motor starter outputs. Unused starter outputs can be used as auxiliary outputs with control provided by telemetry.

Note: Be sure that *STR_PWR* (P1-24) and *AC_PWR* (P1-5) are both connected to the station's control power. This ensures that all pumps under local control receive an emergency shut down signal when the AC power drops. Failure to do this could result in multiple pumps being called to start at the same time. Additionally, be sure that proper fuses are installed for the motor starters (See Figure 6-3, "Motor Starter

Circuit Wiring", below), and that they are located as close as possible to the TCU to protect the TCU relays.

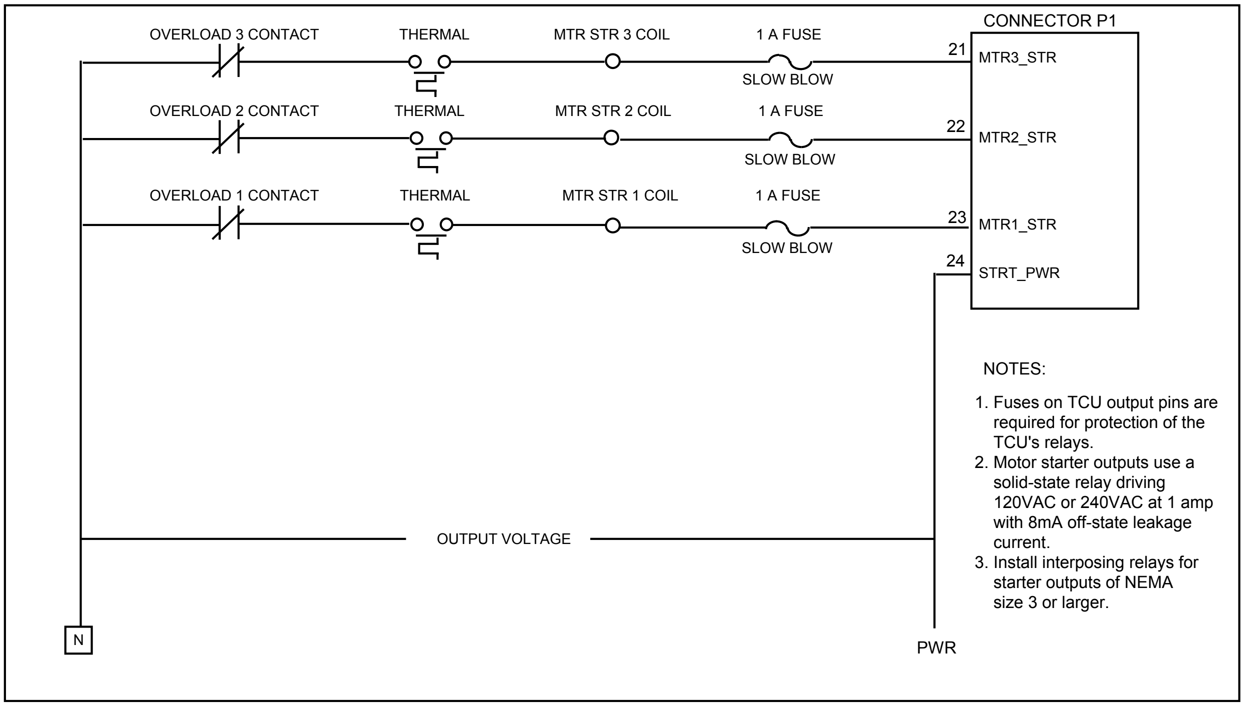


Figure 6-3, "Motor Starter Circuit Wiring"

ALARM LIGHT AND HORN OUTPUTS

The alarm outputs use mechanical relays to drive up to 0.5 A at 120 VAC or 1 A at 0-24 VDC. The addition of 1 A slow blow fuses on the TCU outputs is recommended to protect the TCU's alarm relays from short circuits. The alarm light output is a normally closed set of contacts that is closed when the TCU is powered down.

> **NOTE:** The alarm light output is designed to energize an incandescent lamp. Any other application requires an interposing relay, especially strobe lights due to their high peak current demands.

See Figure 6-4, "Alarm Horn and Alarm Light Wiring" (next page) for a wiring diagram of the alarm circuits.

> **IMPORTANT:** Snubbers (devices which suppress voltage transients) must be installed when either of the TCU's alarm outputs (Alarm Light or Alarm Horn) are being used for switching inductive loads (including the coils of any interposing relays). The best place to install the snubbers is either directly connected across the coil terminals or at the closest practical connection point to the coil terminals of the inductive load.
>
> The snubbers must be electrically connected across the coil terminals – not to any ground(s).
>
> AC and DC applications require different types of snubbers. Detailed information and diagrams are provided on the next page.

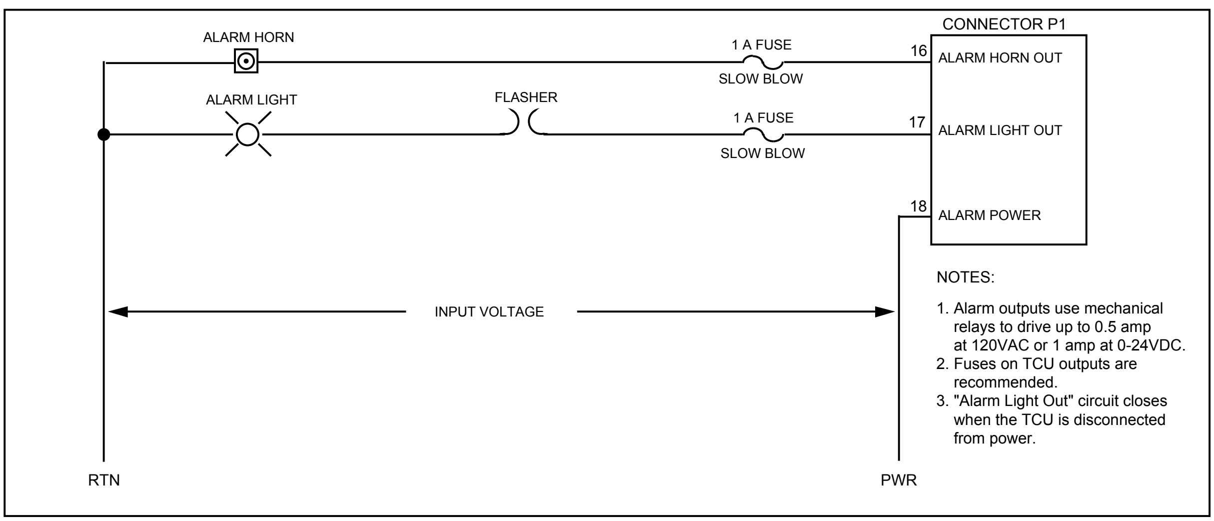


Figure 6-4, "Alarm Horn and Alarm Light Wiring"

Using Snubbers When Connecting Alarm Outputs

AC Applications

We recommend an RC snubber (DFS # 007-0084) using a 0.1uF capacitor in series with a 47 Ω ½ W resistor, such as that manufactured by RED LION (Model # SNUB0000).

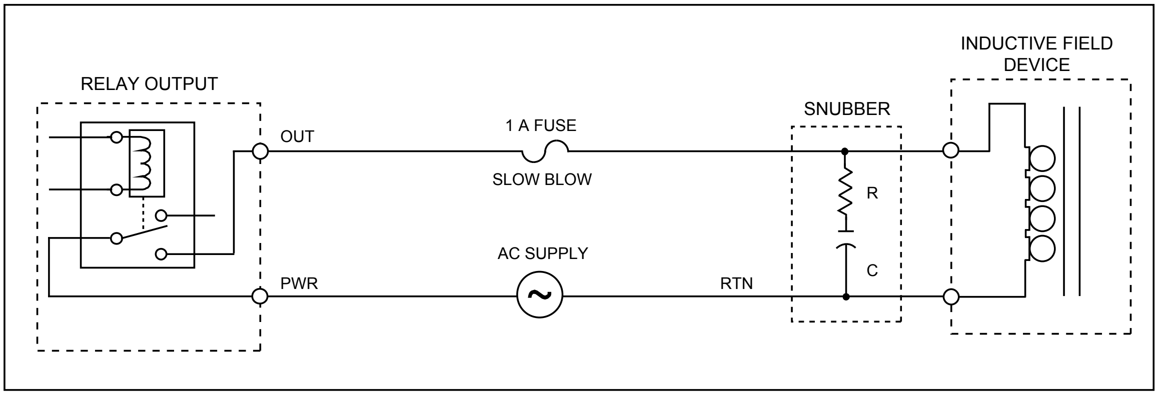


Figure 6-5, "Snubber in AC Alarm Output Application"

DC Applications

We recommend a power diode (DFS # 006-0019) with a minimum 3 A 100 peak inverse voltage (PIV) fast acting rating, such as the industry standard 1N4004 (DIGIKEY # 1N4004CT-ND).

IMPORTANT: DC polarity is important. The diode must be connected in reverse bias across the coil terminals or as close as is practical. That is, the cathode (the side with the white band on the diode body) must be connected to the (+) supply power and the anode connected to the (-) supply power. Most DC relays do not have a polarity requirement on their coils, so you must trace out the polarity or use a Voltmeter. Remember that the inductive transient is a reverse voltage, which causes the diode to conduct and short out the voltage.

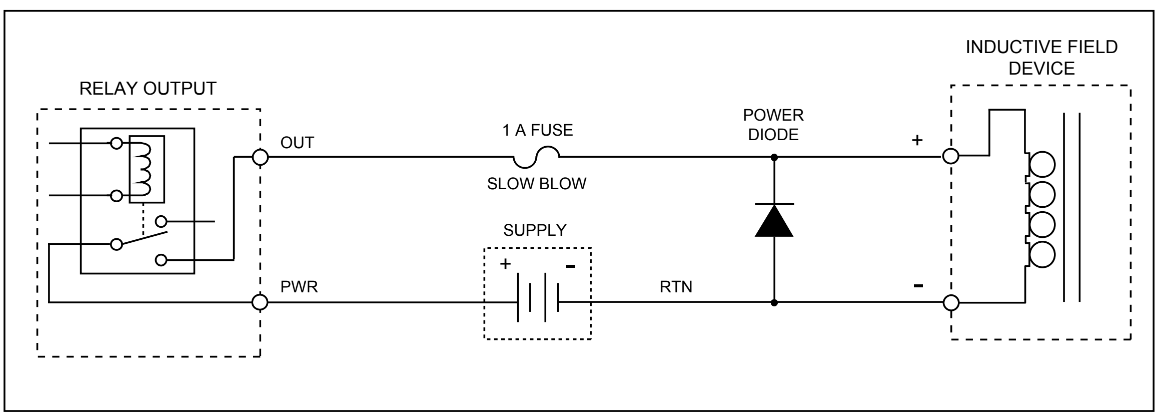


Figure 6-6, "Snubber in DC Alarm Output Application"

PHASE MONITOR

Three-Phase Option

Connect terminals *PHASE_C* (P1-1), *PHASE_B* (P1-2), and *PHASE_A* (P1-3) through 1 A slow-blow fuses to phases A, B, and C, respectively, at the load side of the main breaker.

480 VAC three-phase power requires 49.9k resistors on *PHASE_C* (P1-1), *PHASE_B* (P1-2), and *PHASE_A* (P1-3) inputs (see "Appendix C: Parts List" for information on 480 VAC Phase Monitor Kit).

If a phase sequence alarm occurs at initial installation, swap any two legs at the load side of the main breaker. If the alarm was caused by improper phases, this will clear the alarm. The fuses must be located as close as possible to the voltage source. Refer to Figure 6-7, "Three-Phase Monitor Wiring", below.

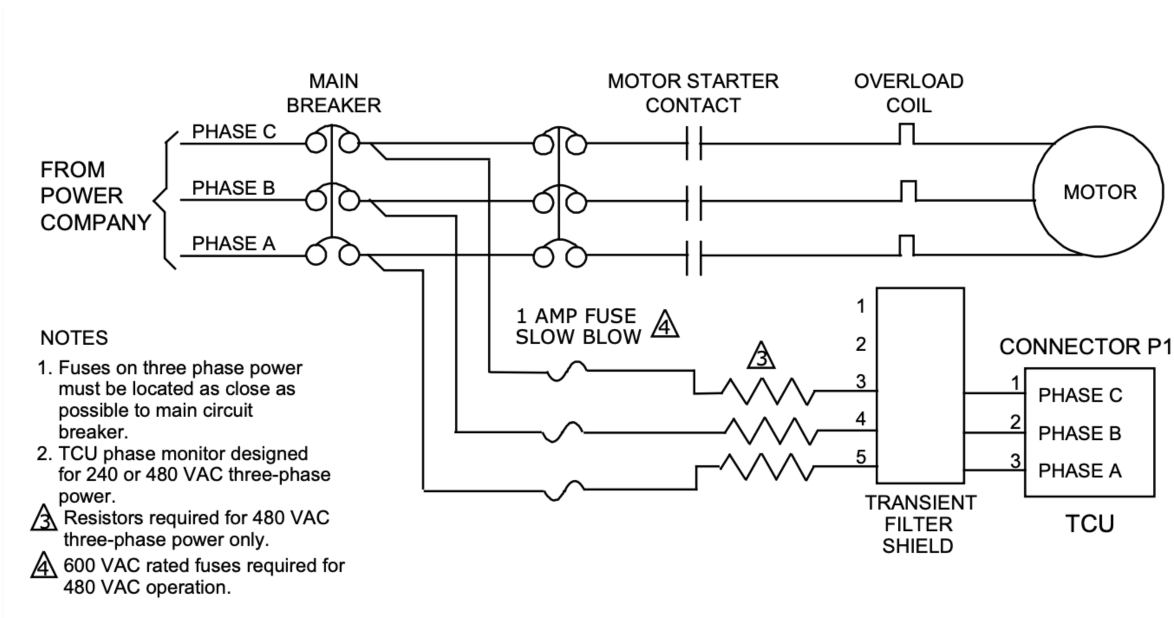


Figure 6-7, "Three-Phase Monitor Wiring"

The type of phase monitor selected for your installation must be identified in the TCU's configuration. See "Phase Monitor Range" on page 125 for more information.

> **IMPORTANT:** The configuration option selected must match the physical wiring. An incorrect configuration could cause the TCU to not protect pump motors from undesirable power conditions.

Note: Instructions for wiring 240 VAC single-phase appear on the next page.

Single-Phase Option (240 VAC Only)

Connect terminal *PHASE_B* (P1-2) through a 1 A slow-blow fuse to phase B at the load side of the main breaker; connect terminal *PHASE_A* (P1-3) through a 1 A slow-blow fuse to phase A at the load side of the main breaker. The fuses must be located as close as possible to the voltage source.

The single-phase 240 VAC connection is to the TCU's A and B phase inputs *only*. The C phase input must *not* be connected. A phase sequence/phase voltage fault will occur if the TCU is configured for single-phase and the C phase is connected.

Refer to Figure 6-8, "Single-Phase Monitor Wiring", below.

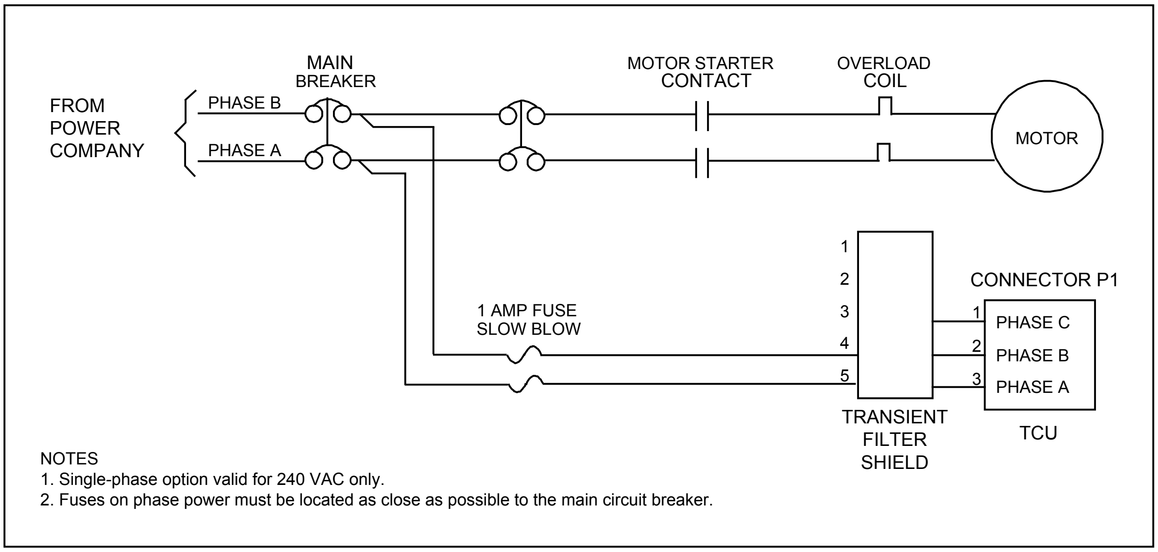


Figure 6-8, "Single-Phase Monitor Wiring"

The type of phase monitor selected for your installation must be identified in the TCU's configuration. See "Phase Monitor Range" on page 125 for more information.

IMPORTANT: The configuration option selected must match the physical wiring. An incorrect configuration could cause the TCU to not protect pump motors from undesirable power conditions.

Digital Monitor Point Inputs

The TCU has 12 optically isolated digital monitor point inputs. These monitor points require an input and a return. To reduce the amount of wiring, several inputs share the same return. There are two common return terminals for the inputs.

The following circuits are internally connected to the *IN_COM_1* terminal (P2-5):

- *MTR1_RUN* (P2-1)
- *MTR2_RUN* (P2-2)
- *MTR3_RUN* (P2-3)
- *EXT_PM* (P2-4)

The following circuits are internally connected to the *IN_COM_2* terminal (P2-14):

- *LOW_LVL* (P2-6)
- *OFF_LVL* (P2-7)
- *LEAD_LVL* (P2-8)
- *LAG1_LVL* (P2-9)
- *LAG2_LVL* (P2-10)
- *HIGH_LVL* (P2-11)
- *AUX_IN* (P2-12)
- *ALM_SIL* (P2-13)

> **IMPORTANT:** Inputs with a common return must use the same bias voltage. No more than two bias voltage sources can be used to bias the 12 digital inputs – one for biasing inputs using the *IN_COM_1* terminal and one for biasing inputs using the *IN_COM_2* terminal.
>
> Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.

Figure 6-9, "Using ISO+24V and ISOGND as Common Bias Source" on the next page, illustrates the use of *ISOGND* and *ISO+24V* as the common bias source for all 12 of the digital monitor point inputs.

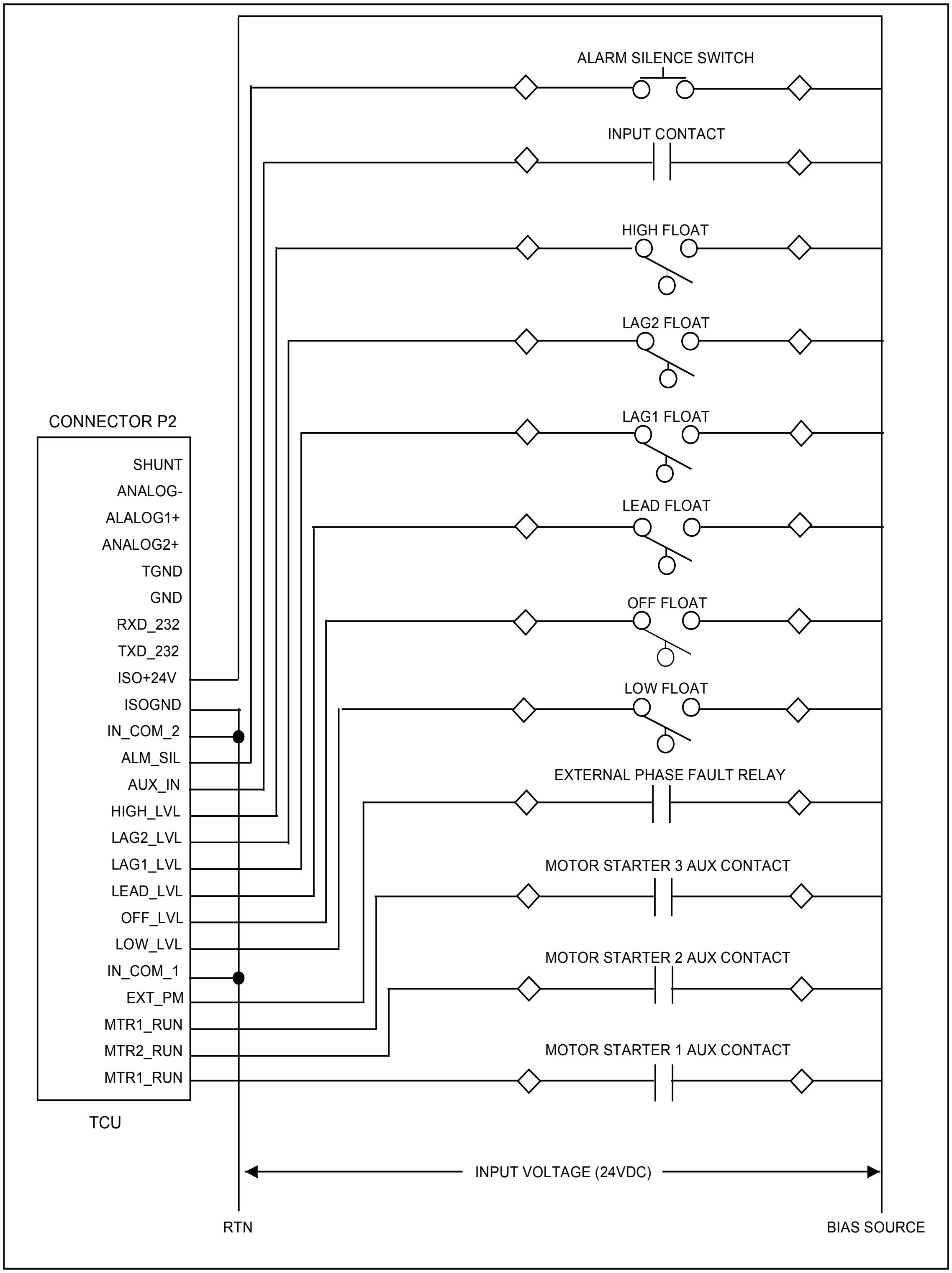


Figure 6-9, "Using ISO+24V and ISOGND as Common Bias Source"

Bias Voltage Source Options

Internally Supplied Bias Voltage Source

A voltage of 10-30 VAC or VDC will bias the digital monitor inputs in the ON state. Any voltage less than 2 VAC or 2 VDC will force the digital monitor inputs to the OFF state.

The internal bias source is the *ISO+24V* terminal (P2-16**)** and the *ISOGND* terminal (P2-15).

See Figure 6-10, "Biasing an Input with ISO+24V / ISOGND Voltage".

> **IMPORTANT:** Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.

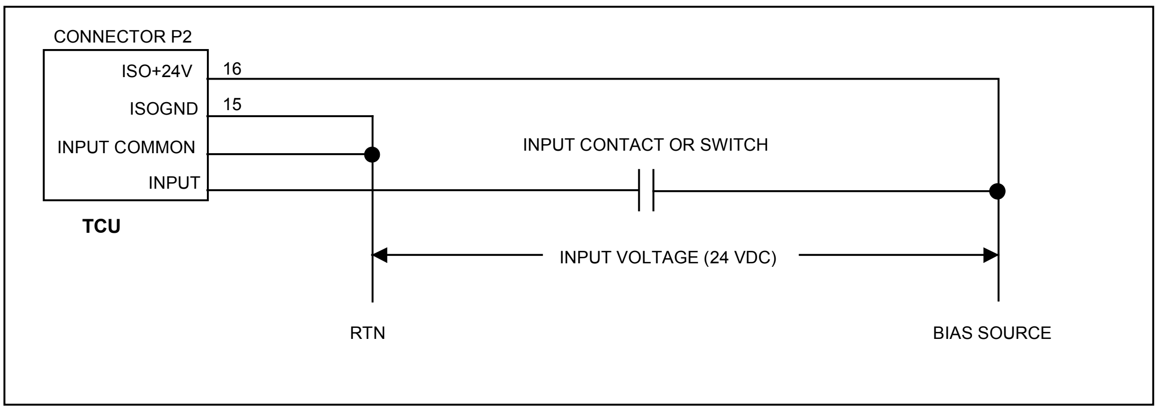


Figure 6-10, "Biasing an Input with ISO+24V / ISOGND Voltage"

Externally Supplied Bias Voltage Source

Externally supplied bias voltages can be used to bias the inputs. If the voltage is greater than 30 VAC/VDC, a voltage-dropping resistor must be placed in line with the input. See Table 6-1, "Resistor Sizing Chart" for voltage and resistor values. A minimum voltage of 10 VAC/VDC is required to indicate an ON state for the digital monitor inputs. See Figure 6-11, "Biasing an Input with an External Source" for a general wiring diagram showing an input biased with an external source.

> **IMPORTANT:** Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.

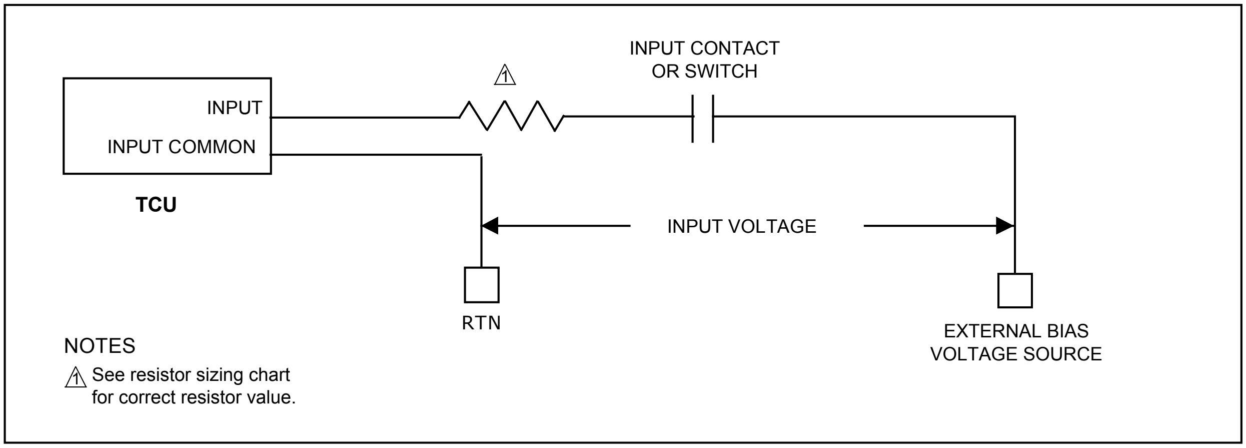


Figure 6-11, "Biasing an Input with an External Source"

Motor Run Monitoring Signal

For each pump controlled by the TCU, a corresponding motor run input (*MTRx_RUN*) must be connected.

The bias voltage for the motor run input (*MTRx_RUN*) is taken from one phase of the motor power at the output of the motor breaker and through the motor starter auxiliary contact. Connect a wire from this point, through a voltage-dropping resistor, to the corresponding motor run input (P2-1 for *MTR1_RUN*, P2-2 for *MTR2_RUN*, and P2-3 for *MTR3_RUN*). Connect the *IN_COM_1* terminal (P2-5**)** to the neutral. See Table 6-1 for the resistor value that corresponds to the line-to-neutral voltage used.

IMPORTANT: The transformer must provide AC neutral. When wiring to a typical three-phase, 4-wire, 240 V transformer that provides AC neutral, refer to Figure 6-12, "Motor Run Monitoring Signal (4-wire transformer)". Refer to Figure 6-13, "Motor Run Monitoring Signal (3-wire transformer)" when connecting to a typical three-phase, 3-wire 480 V transformer with no neutral provided.

Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.

Note that these diagrams are for typical installations. If your installation deviates from that shown here, then refer to the National Electrical Code® (NEC®) Handbook.

Resistor Sizing Chart

Input Bias Voltage	Resistor Size
BIAS +	None
10-30 VDC/ VAC	None
31-100 VDC/ VAC	22K, ½ W
101-200 VDC/ VAC	47K, ½ W
201-300 VDC/ VAC	100K, 1 W

Table 6-1, "Resistor Sizing Chart"

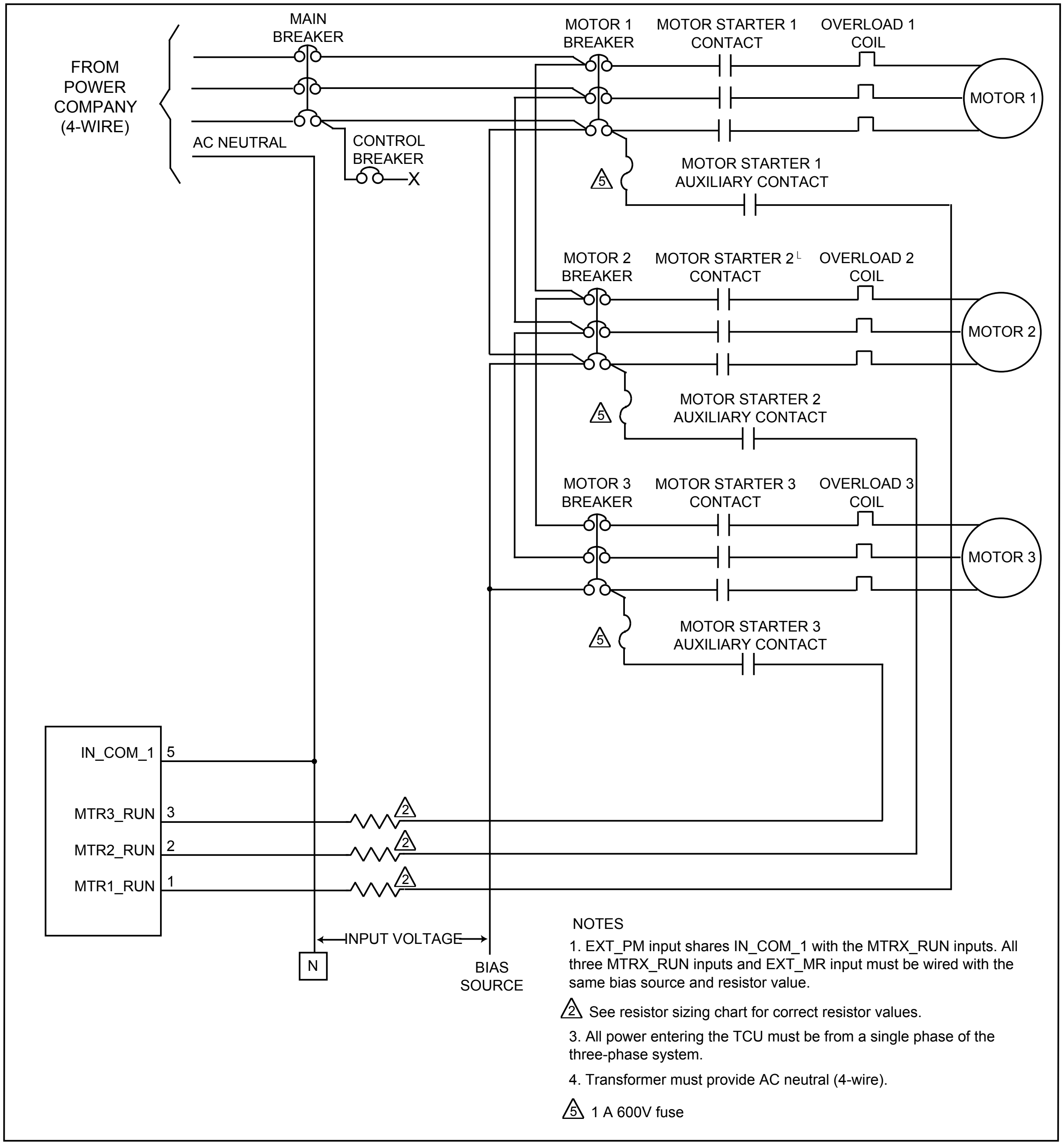


Figure 6-12, "Motor Run Monitoring Signal (4-wire transformer)"

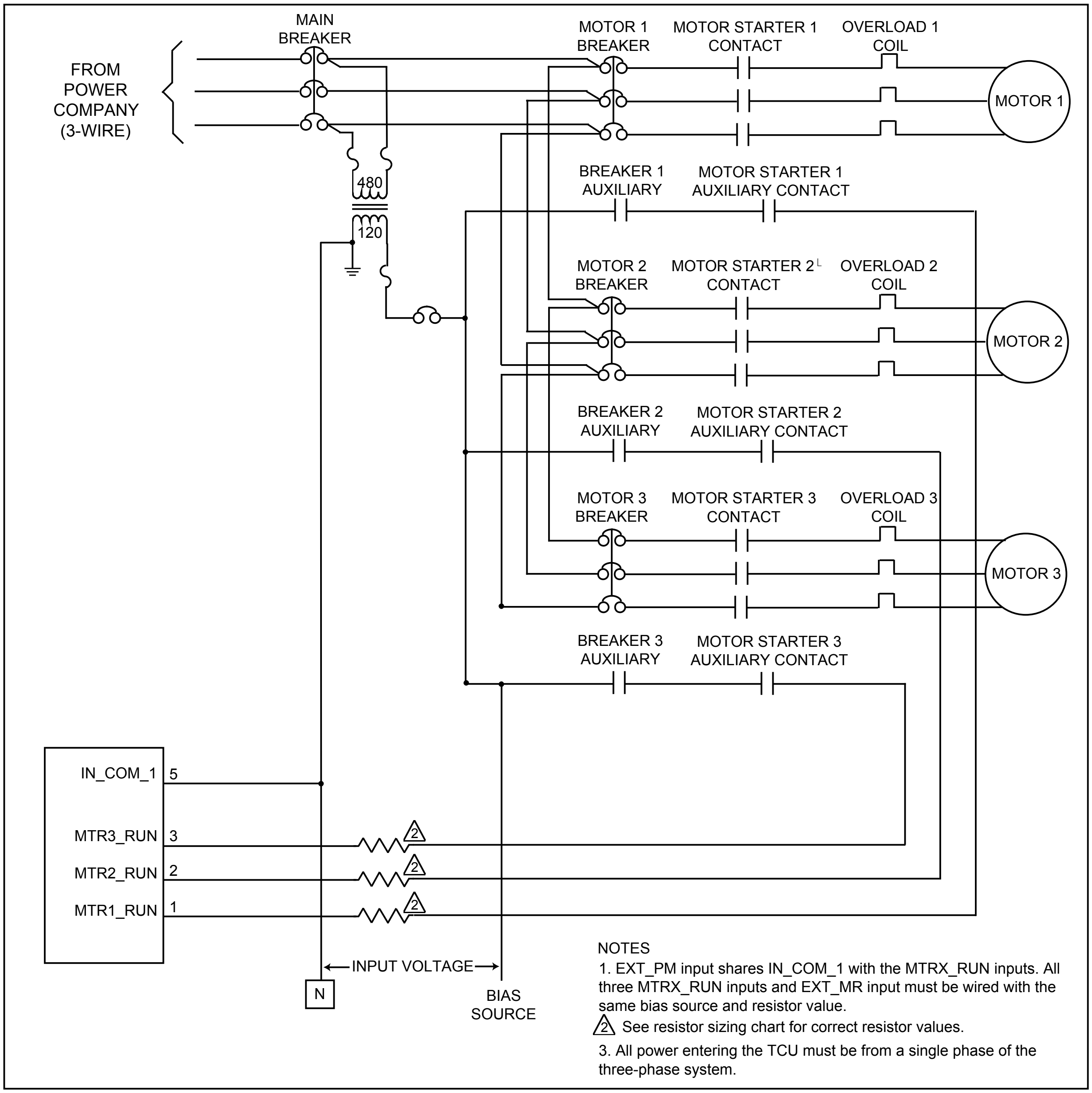


Figure 6-13, "Motor Run Monitoring Signal (3-wire transformer)"

Level Sensing Transducers

A TCU using the pump control process can accommodate two different types of input-supported transducers:

- Digital-type devices such as contact closures, float switches, and pressure switches
- Analog-type devices that are either analog current (4-20 mA) or analog voltage (0-5 V).

Note: The information below pertains to TCU's using the built-in pump control process. For information on using the TCU's digital inputs in a custom application, see "Chapter 8: Programming the TCU" and the *TCU Programming Reference*.

Contact Closure Devices

The input terminals for the contact closure devices are:

- *LOW_LVL* (P2-6)
- *OFF_LVL* (P2-7)
- *LEAD_LVL* (P2-8)
- *LAG1_LVL* (P2-9)
- *LAG2_LVL* (P2-10)
- *HIGH_LVL* (P2-11)

These six inputs, plus the *AUX_IN* (P2-12) and *ALM_SIL* (P2-13) inputs, are internally connected to *IN_COM_2* (P2-14). All eight of these inputs must be biased with the same voltage source.

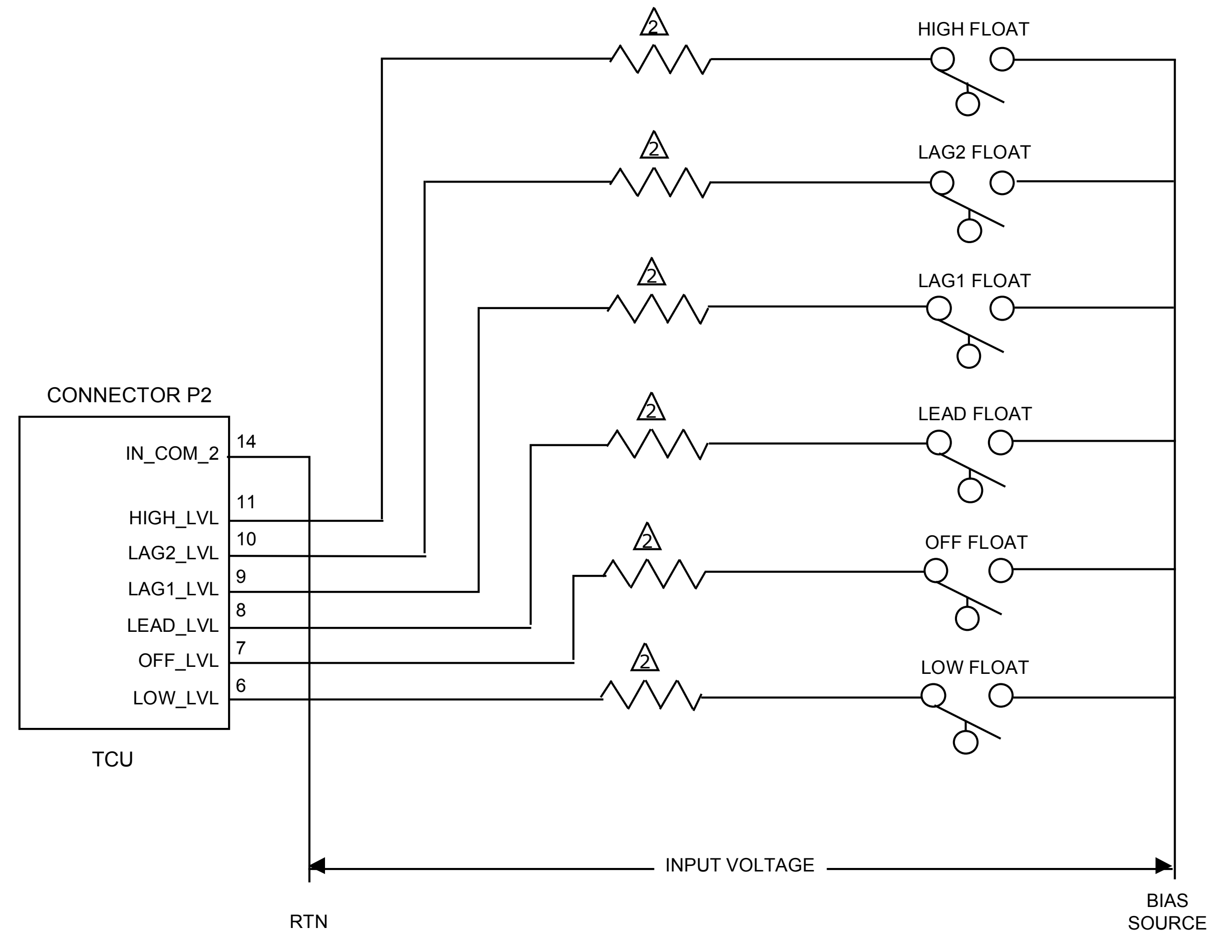
- Simplex stations use input terminals *LOW_LVL* (P2-6), *OFF_LVL* (P2-7), *LEAD_LVL* (P2-8), and *HIGH_LVL* (P2-11).
- Duplex stations add input *LAG1_LVL* (P2-9).
- Triplex stations add input *LAG2_LVL* (P2-10).

It is recommended that you use *LOW_LVL* and *HIGH_LVL* inputs. However, *HIGH_LVL* can be omitted. If a *LOW_LVL* is not used, the *LOW_LVL* function must be disabled in the TCU's configuration (see "Enable a Low Float and/or a High Float" p. 113).

1. Connect the bias voltage to the common side of all float or pressure switches.
2. Connect the output of each switch to the corresponding input terminal on the TCU. Use voltage-dropping resistors if required.

See Table 6-1, "Resistor Sizing Chart" on p. 68 for dropping resistor sizes. See Figure 6-14, "Monitoring Circuit for a Contact-Closure Level-Detection Device" for a wiring diagram of a float-input circuit. For normally closed switches (inverted floats), see "Appendix G: Inverted Float Interface."

> **IMPORTANT:** Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.



NOTES

1. All six level inputs (XXX_LVL) shown here can monitor the status of dry contact switches. See functional description of these inputs for more information.
2. See resistor sizing chart for correct resistor values.
3. ALM_SIL, AUX_IN, and all level inputs share IN_COM_2 as a return. These inputs must all be wired with the same bias source and resistor value.
4. Diagram shows wiring for normally open switches. For normally closed switches, see Appendix F, Connecting a TCU to a Remote RTU.

Figure 6-14, "Monitoring Circuit for a Contact-Closure Level-Detection Device"

Analog Level Transducer

The terminals for the analog interface are:

- *ISO+24V (P2-16)* – *ISO+24V* is a 24 VDC bias source voltage with a maximum source current of 100 mA .
- *TGND* (P2-20) – *TGND* is provided to terminate the shield of a shielded transducer cable. This terminal is connected to the *TGND* terminal (P1-7) and the case of the TCU.
- *ANALOG1+* (P2-22) – *ANALOG1+* is the positive input for current and voltage signals.
- *ANALOG2+* (P2-21) – *ANALOG2+* is the positive input for current and voltage signals for an optional backup analog transducer.
- *ANALOG-* (P2-23) – *ANALOG-* is the return terminal for current ***and*** voltage signals. Additionally, *ANALOG-* is the common return for both *ANALOG 1+* and *ANALOG2+*.
- *SHUNT* (P2-24) – *SHUNT* must be tied to *ANALOG-* for current signals.

Note: *ANALOG-* is bonded internally to *ISOGND*.

Jumping *SHUNT* to *ANALOG-* places a 250 Ω load across the *ANALOG1+* and *ANALOG-* terminals, which converts the voltage input to a current input.

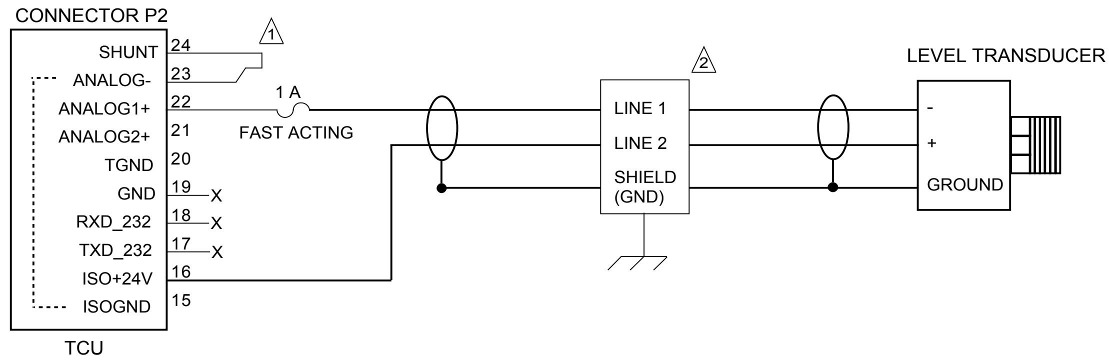
1. Wire the power for the analog transducer according to the transducer manufacturer's instructions.
2. Connect the positive current or voltage signal from the transducer to the terminal *ANALOG1+* (P2-22).
3. If required by the transducer, connect from the *ANALOG-* terminal (P2-23) back to the return on the transducer.
4. For current signals, jumper the *ANALOG-* terminal (P2-23**)** to the *SHUNT* terminal (P2-24**)**.

> **IMPORTANT:** If this TCU installation is an upgrade from a PCU that was providing power to the transducer, note that transducer power must be acquired from pin P2-16 of the TCU. In a PCU installation, power could be acquired from pins P2-21 or P2-16. When upgrading to a TCU, the wire from P2-21 (PCU) ***must*** be moved to P2-16 (TCU). If you are not receiving the analog signal, verify that the TCU is properly wired.

Wiring Notes:

- Because *ANALOG1+* and *ANALOG2+* are tied to a common isolated ground (*ANALOG-*), the TCU must be the last device in a multiple device analog loop (see Figure 6-17, "Externally Powered Non-submersible Transducer" on page 75 for an example).
- When using the isolated bias to power monitor points and the analog loop, the device can't exceed 100 mA at 24 VDC. Exceeding 100 mA will cause the analog signal to not operate correctly.
- Each digital input biased by the same 24 V can use up to 4 mA each.

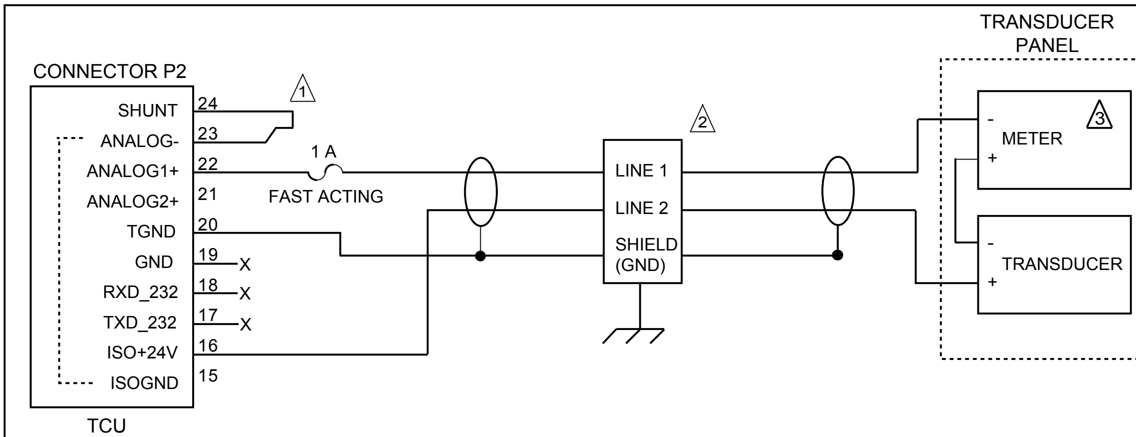
Diagrams for typical analog level transducer connections are provided on pages 74-75.



NOTES

1. 4-20mA interface shown. Remove jumper from P2-24 to P2-23 for 0-5V interface.
2. Surge arrestor required. Installation without required surge protection will void the surge and lightning damage warranty.
3. Analog- is bonded internally to ISOGND.
4. The analog shield wire must only be grounded at one end.

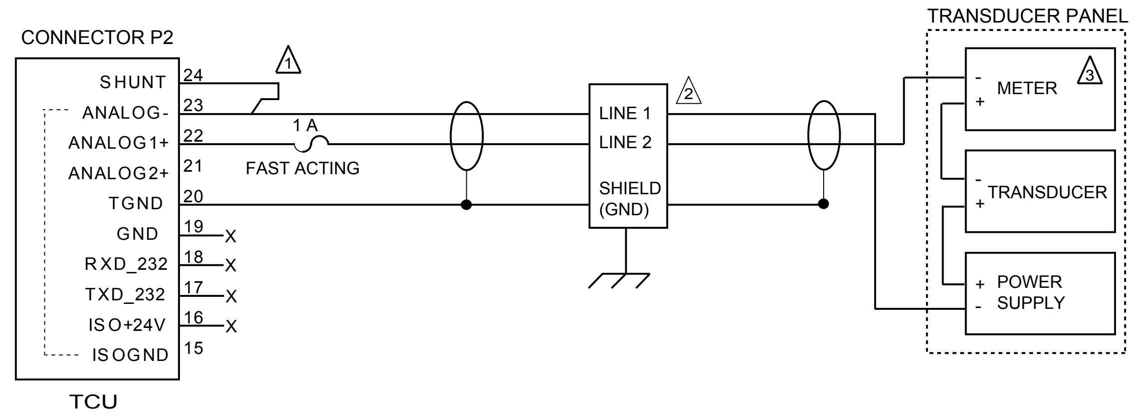
Figure 6-15, "TCU Powered Submersible Transducer"



NOTES

1. 4-20mA interface shown. Remove jumper from P2-24 to P2-23 for 0-5V interface.
2. Surge arrestor required. Installation without required surge protection will void the surge and lightning damage warranty.
3. Meter is optional.
4. Do not ground cable shield in transducer panel.
5. Analog- is bonded internally to ISOGND.
6. The analog shield wire must only be grounded at one end.

Figure 6-16, "TCU Powered Non-submersible Transducer"



NOTES

1. 4-20mA interface shown. Remove jumper from P2-24 to P2-23 for 0-5V interface.
2. Surge arrestor required. Installation without required surge protection will void the surge and lightning damage warranty.
3. Meter is optional.
4. Do not ground cable shield in transducer panel.
5. The analog shield wire must only be grounded at one end.

Figure 6-17, "Externally Powered Non-submersible Transducer"

AUXILIARY ANALOG INPUT

The TCU's secondary analog input can be used as a backup to the primary analog level transducer, or can be used for a general purpose analog input (for example, a flow transducer). For more information on using analog input 2 as a backup to the primary transducer, see "Transducer Fault Mode" on page 115.

It is important to note that analog input 2 supports 4-20 mA only; 0-5 V is not supported.

The diagram below presents a simplified wiring example. Refer to the diagrams in the previous section ("Analog Level Transducer") for information on using the auxiliary analog input in different applications – for example, when using the TCU as the power source for the device.

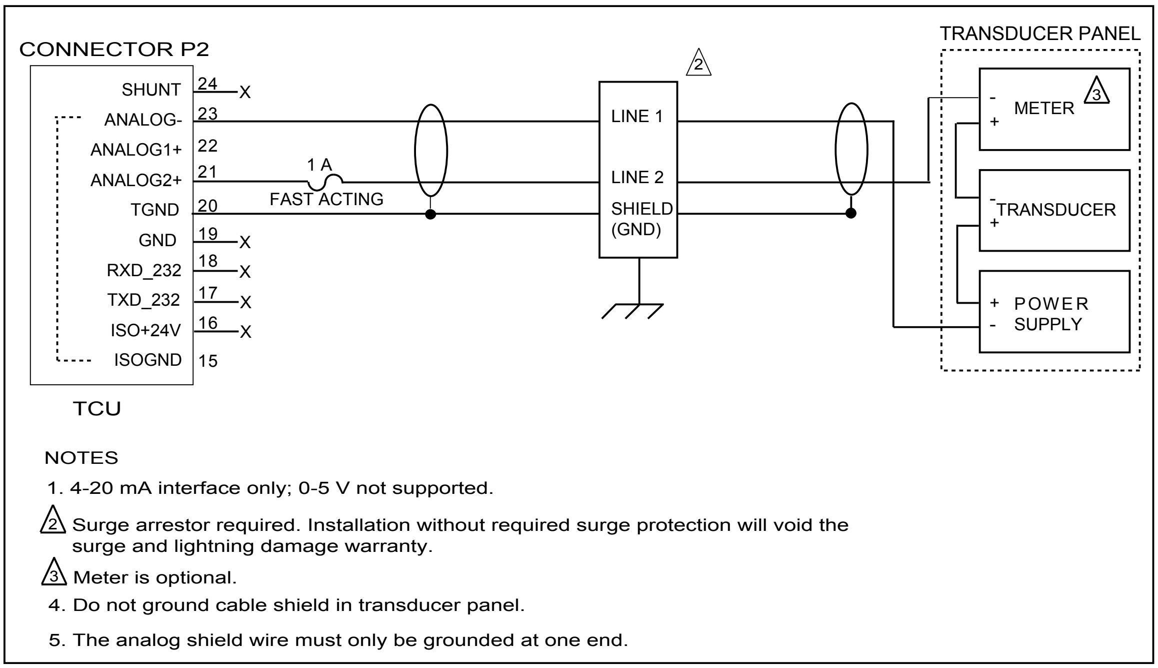


Figure 6-18, "Auxiliary Analog Input"

Optional Configurations and Hookups

Backup Battery

Two optional backup batteries are available for use with the TCU. Although a backup battery is not necessary for operation of the TCU, it is recommended to prevent telemetry data loss from a power failure.

Note that statistical and configuration data is retained even without a backup battery. The purpose of the battery is to maintain telemetry functions during a power loss.

Based on intended usage, the selected battery can be one of the following:

- 12 V, 2.6 Ah model – part number DFS-00363-008-02; rated at 12 V, 2.6 Ah
- 12 V, 7.0 Ah model – part number DFS-00363-008-01; rated at 12 V, 7.0 Ah.

These batteries are interchangeable and maintenance free.

Connect terminal P1-8 (*BAT+*) to the positive terminal of the battery. Connect terminal P1-9 (*BAT-*) to the negative terminal of the battery. It is important to observe polarity when connecting the backup battery, since this circuit is not diode protected.

Alarm Silence Switch

The alarm horn, if installed, can be silenced in three ways: through the *ALM_SIL* input, by pressing the TCU's Silence button, or by navigating to the TCU's Alarm screen and viewing the alarm. The following describes the wiring of a momentary alarm silence switch.

ALM_SIL (P2-13), *AUX_IN* (P2-12), and the six level (*xxx_LVL*) input circuits (P2-6, P2-7, P2-8, P2-9, P2-10, P2-11) are internally connected to the *IN_COM_2* terminal (P2-14). Each of these inputs must be wired with the same bias voltage and use the same voltage-dropping resistor value for proper operation.

Connect a momentary switch from the bias voltage source through the proper voltage-dropping resistor, if required, to the *ALM_SIL* terminal (P2-13**)**. The return for the bias voltage must be connected to the *IN_COM_2* terminal (P2-14**)**. See Table 6-1, "Resistor Sizing Chart", p. 68 for the resistor value. See Figure 6-19, "Alarm Silence Switch" on the next page for a wiring diagram of the alarm-silence switch circuit.

> **IMPORTANT:** Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.

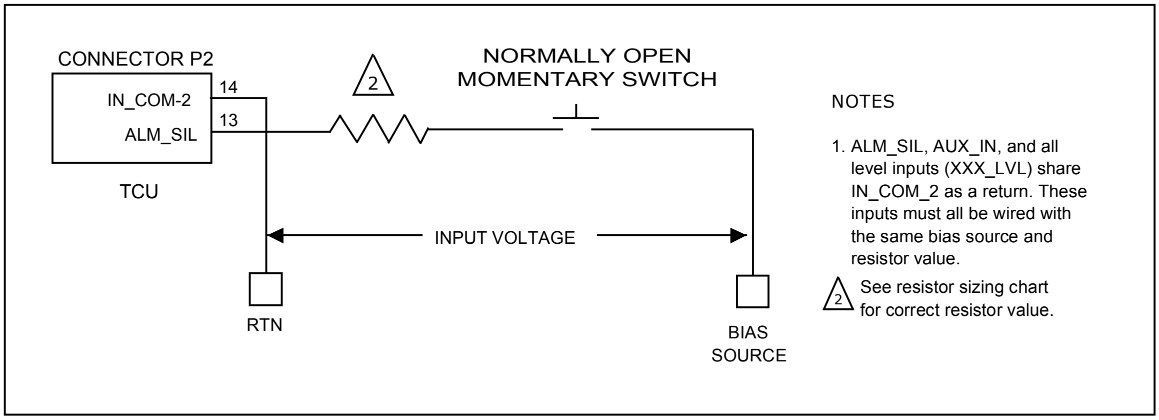


Figure 6-19, "Alarm Silence Switch"

External Phase Monitor

Connect a bias voltage to one side of the external phase monitor contacts. Connect the opposite side of the contacts through the proper voltage-dropping resistor to the *EXT_PM* terminal (P2-4). See Table 6-1, "Resistor Sizing Chart", p. 68 for resistor value. ***Use the same bias voltage source as used to bias the motor run inputs***. The return for the bias voltage must be connected to the *IN_COM_1* terminal (P2-5). The *MTRx_RUN* (P2-1, P2-2, P2-3) and *EXT_PM* (P2-4) input circuits are internally connected to the *IN_COM_1* terminal (P2-5). Phase Monitor contacts must open when a phase fault occurs. See Figure 6-20, "External Phase Monitor" for a wiring diagram showing the external phase monitor circuit.

> **IMPORTANT:** Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.

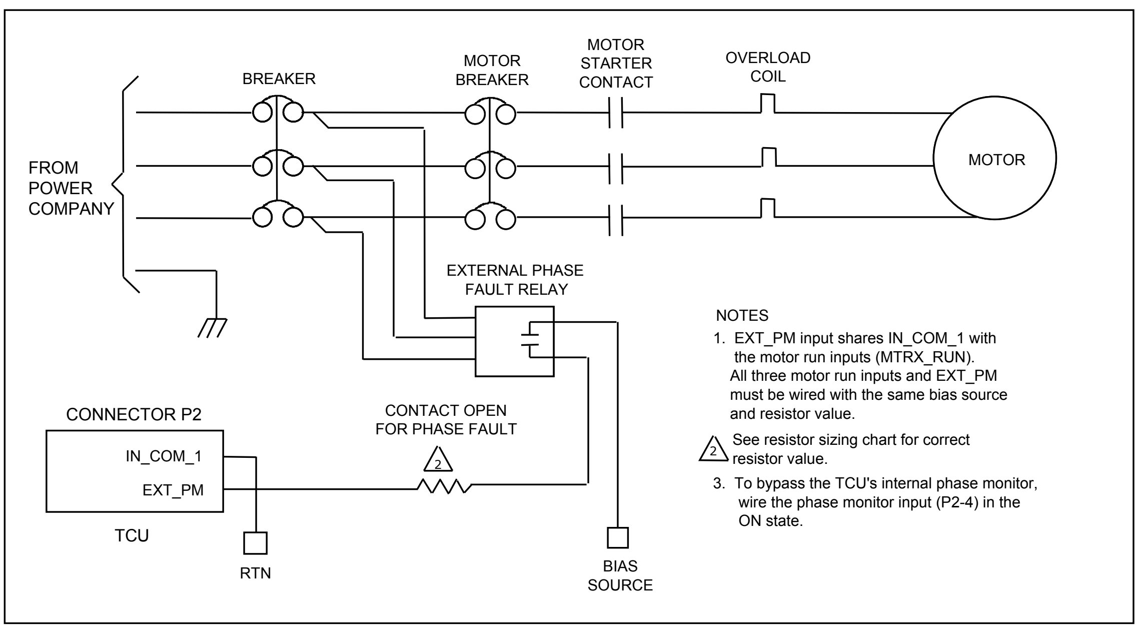


Figure 6-20, "External Phase Monitor"

Phase Monitor Bypass

The TCU's internal phase monitor can be bypassed (i.e., disabled) if it is not required. To bypass the TCU's phase monitor, connect a bias voltage (through a voltage-dropping resistor if required) directly into the *EXT_PM* terminal (P2-4**)**. Use the same bias voltage source that was used to bias the motor run (*MTRx_RUN*) inputs (P2-1, P2-2, P2-3). The return for the bias voltage must be connected to the *IN_COM_1* terminal (P2-5**)**. The *MTRx_RUN* and *EXT_PM* input circuits are internally connected to the *IN_COM_1* terminal (P2-5**)**. Note that the TCU's Phase Monitor is designed for 200-240 VAC or 480 VAC (using external resistors) 3-phase only.

If you are using an external phase monitor and would like to have the voltage values available to HT3 for monitoring and trending purposes, you can wire the TCU's three phase inputs. For this option to work correctly you must also configure the TCU's phase monitor range and alarm trip points. This is necessary, because if the external phase monitor trips, the TCU will apply these user-configured, internal phase monitor settings when deciding whether or not to run the pumps. Consider the acceptable run conditions for your system when selecting phase monitor settings.

For information on wiring the TCU's three phase inputs, see "Three-Phase Option" on page 63 and "Single-Phase Option (240 VAC Only)" on page 64.

For information on configuring the TCU's phase monitor settings, see see "Low- and High-Limit Phase Voltage" on page 123 and "Phase Monitor Range" on page 125.

> **IMPORTANT:** Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.

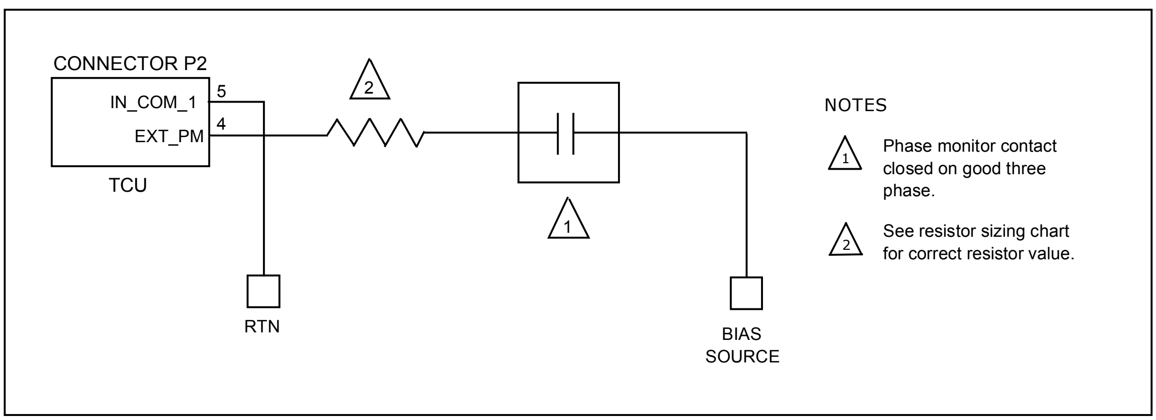


Figure 6-21, "Phase Monitor Bypass"

Auxiliary Input and Output Connections

The TCU provides an auxiliary digital input and output that can be configured together to function as an auxiliary relay. The *AUX_IN* terminal (P2-12) functions as one side of a relay coil and the *IN_COM_2* terminal (P2-14) as the other. The *AUX_PWR* terminal (P1-18**)** and *AUX_OUT* terminal (P1-19) function as contacts for the relay.

> **IMPORTANT:** Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.

Auxiliary Digital Input

AUX_IN is an optically isolated digital monitor point and is wired the same as the other monitor points. Connect a bias voltage to one side of a contact closure device. Connect the other side through a voltage-dropping resistor, if required, to the *AUX_IN* terminal (P2-12**)**. See Table 6-1, "Resistor Sizing Chart", p. 68 for resistor value. *AUX_IN* must use the same bias voltage source as the ALM_SIL input (P2-13) and the six level (*xxx_LVL*) inputs (P2-6, P2-7, P2-8, P2-9, P2-10, P2-11). Connect the return for the bias source to the *IN_COM_2* terminal (P2-14**)**. See Figure 6-22, "Auxiliary Digital Input" for a wiring diagram of the *AUX_IN* circuit.

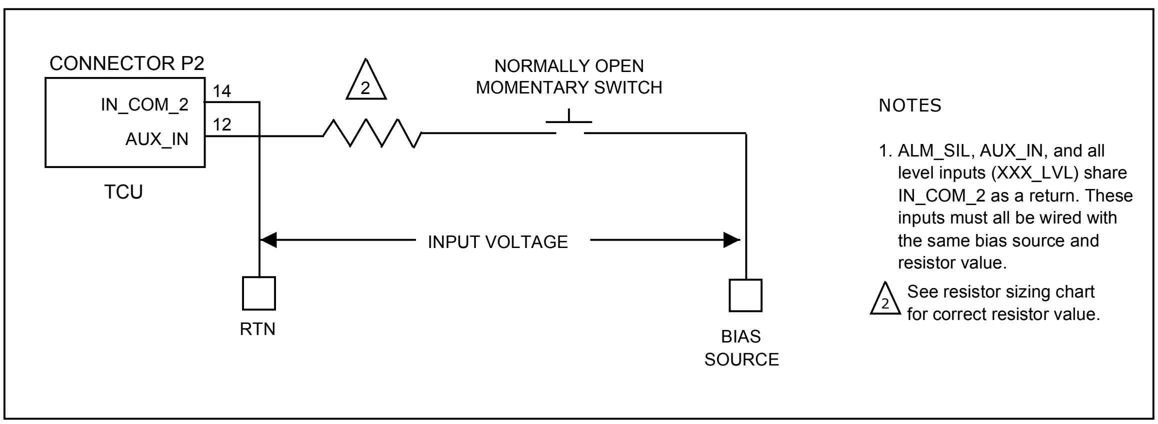


Figure 6-22, "Auxiliary Digital Input"

Auxiliary Digital Output

AUX_OUT is a solid-state relay. Power is connected to the *AUX_PWR* terminal (P1-20). A load is connected between the *AUX_OUT* terminal (P1-19) and the power source return. See Figure 6-23, "Auxiliary Digital Output" for a wiring diagram of the *AUX_OUT* circuit.

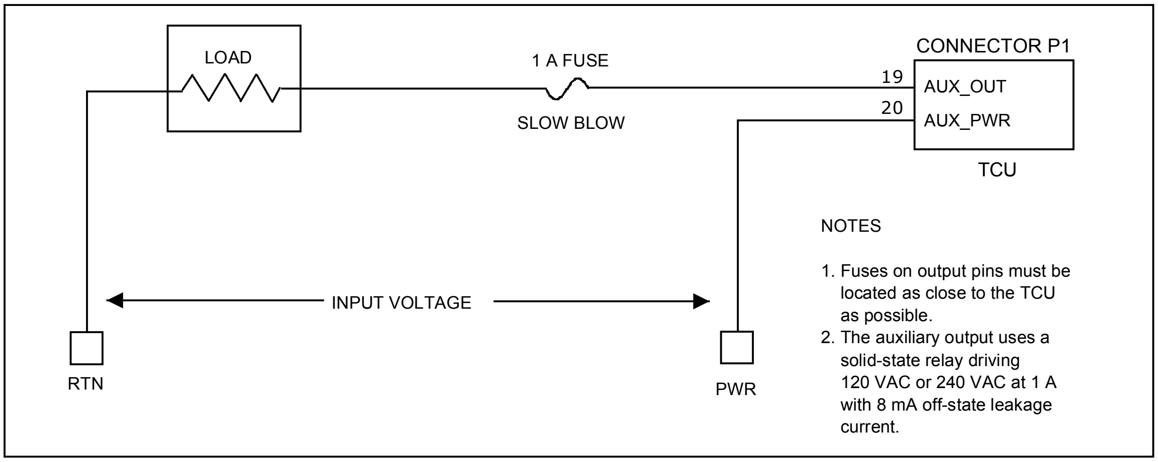
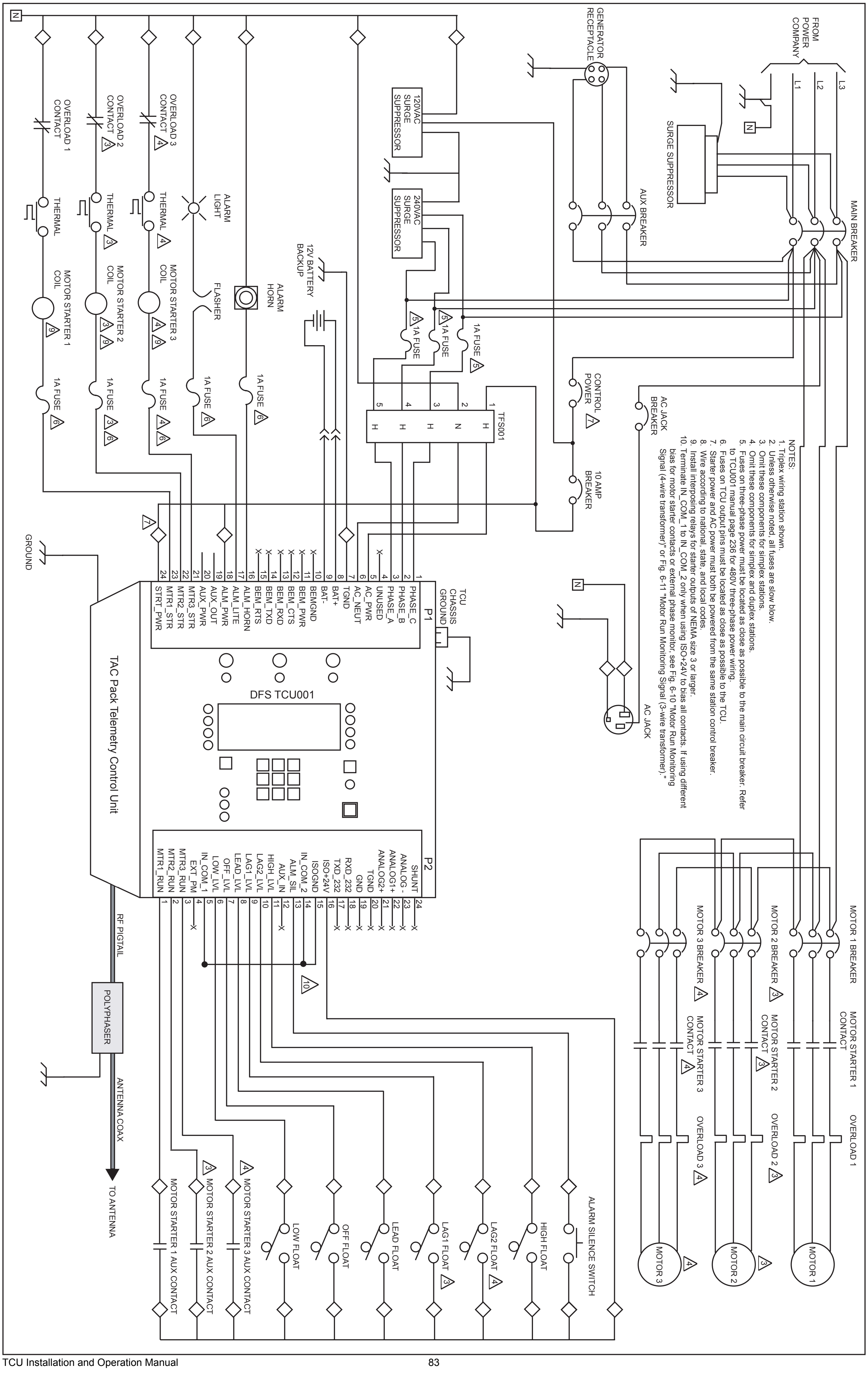


Figure 6-23, "Auxiliary Digital Output"

Comprehensive Wiring Diagram for Typical TCU Installation

A comprehensive wiring diagram of a typical TCU installation is provided on the next page.

> **IMPORTANT:** Maximum wire size to TCU connectors is 12 AWG. Wire all connectors in accordance with National, State, and Local Electrical Codes.
>
> Input commons on the TCU must be either AC neutral (with no voltage potential when referenced to earth ground) or the negative terminal of a DC power supply.



FROM POWER COMPANY
L1
L2
L3
N
SURGE SUPPRESSOR
MAIN BREAKER
GENERATOR RECEPTACLE
AUX BREAKER
120VAC SURGE SUPPRESSOR
240VAC SURGE SUPPRESSOR
1A FUSE 5
CONTROL POWER 7
AC JACK BREAKER
10 AMP BREAKER
TFS001
1 H
2 N
3 H
4 H
5 H
NOTES:
1. Triplex wiring station shown.
2. Unless otherwise noted, all fuses are slow blow.
3. Omit these components for simplex stations.
4. Omit these components for simplex and duplex stations.
5. Fuses on three-phase power must be located as close as possible to the main circuit breaker. Refer to TCU001 manual page 236 for 480V three-phase power wiring.
6. Fuses on TCU output pins must be located as close as possible to the TCU.
7. Starter power and AC power must both be powered from the same station control breaker.
8. Wire according to national, state, and local codes.
9. Install interposing relays for starter outputs of NEMA size 3 or larger.
10. Terminate IN_COM_1 to IN_COM_2 only when using ISO+24V to bias all contacts. If using different bias for motor starter contacts or external phase monitor, see Fig. 6-10 "Motor Run Monitoring Signal (4-wire transformer)" or Fig. 6-11 "Motor Run Monitoring Signal (3-wire transformer)."
AC JACK
OVERLOAD 1 CONTACT
OVERLOAD 2 CONTACT 3
OVERLOAD 3 CONTACT 4
THERMAL
ALARM LIGHT
ALARM HORN
FLASHER
12V BATTERY BACKUP
MOTOR STARTER 1 COIL 9
MOTOR STARTER 2 COIL 3 9
MOTOR STARTER 3 COIL 4 9
1A FUSE 6
GROUND
TCU CHASSIS GROUND
P1
1 PHASE_C
2 PHASE_B
3 PHASE_A
4 UNUSED
5 AC_NEUT
6 AC_PWR
7 TGND
8 BAT+
9 BAT-
10 BEMGND
11 BEM_PWR
12 BEM_CTS
13 BEM_RXD
14 BEM_TXD
15 BEM_RTS
16 ALM_HORN
17 ALM_LITE
18 ALM_PWR
19 AUX_OUT
20 AUX_PWR
21 MTR3_STR
22 MTR2_STR
23 MTR1_STR
24 STRT_PWR
DFS TCU001
TAC Pack Telemetry Control Unit
P2
24 SHUNT
23 ANALOG -
22 ANALOG1+
21 ANALOG2+
20 TGND
19 GND
18 RXD_232
17 TXD_232
16 ISO+24V
15 ISOGND
14 IN_COM_2
13 ALM_SIL
12 AUX_IN
11 HIGH_LVL
10 LAG2_LVL
9 LAG1_LVL
8 LEAD_LVL
7 OFF_LVL
6 LOW_LVL
5 IN_COM_1
4 EXT_PM
3 MTR3_RUN
2 MTR2_RUN
1 MTR1_RUN
10
RF PIGTAIL
POLYPHASER
ANTENNA COAX
TO ANTENNA
MOTOR 1 BREAKER
MOTOR 2 BREAKER 3
MOTOR 3 BREAKER 4
MOTOR STARTER 1 CONTACT
MOTOR STARTER 2 CONTACT 3
MOTOR STARTER 3 CONTACT 4
OVERLOAD 1
OVERLOAD 2 3
OVERLOAD 3 4
MOTOR 1
MOTOR 2 3
MOTOR 3 4
ALARM SILENCE SWITCH
HIGH FLOAT
LAG2 FLOAT 4
LAG1 FLOAT 3
LEAD FLOAT
OFF FLOAT
LOW FLOAT
MOTOR STARTER 3 AUX CONTACT 4
MOTOR STARTER 2 AUX CONTACT 3
MOTOR STARTER 1 AUX CONTACT

Notes

Chapter 7: TELEMETRY CONFIGURATION

Setting up the TCU as a component of the telemetry system enables you to remotely monitor conditions at the site and control equipment from a central location via the HT3 SCADA software. For example, you can determine if a pump is currently running and force it on if necessary.

In order for the TCU to interface with the central site and the HT3 server, it must have access to radio or network communications and be properly configured in HT3's Configuration Editor.

HARDWARE CONFIGURATION

There are several options for connecting the TCU to the telemetry system. A TCU can be installed with a DFS RTU station, or it can interface with industry standard radios using the TCU's RS-232 Modbus radio interface. Alternately, the TCU can operate as a stand-alone unit and communicate with the central computer or server via its integrated radio or network interface.

Using the TCU in conjunction with a radio-based telemetry system requires that you obtain an FCC-licensed radio frequency if you do not already have a licensed frequency that can be utilized. Even when adding a site to an existing frequency, the FCC requires that a complete application be submitted. DFS can assist you in obtaining a new licensed frequency or adding a site to an existing frequency.

TCU Installed in DFS RTU

If the TCU is being interfaced with an RTU station:

- A Bus Extender Module (BEM) must be installed in the RTU and connected to the TCU.
- The TCU must be addressed as 0 (zero). See "Addressing and configuring the radio" on page 87 for information on addressing the TCU.
- If the TCU's pump controller process is being used, the TCU must be configured with the number of real modules already on the bus (see "Number of BEM-connected Modules" on page 126 in "Chapter 10: Configuring the Pump Control Process"). The TCU will then occupy the next available module addresses. If there are already four modules on the bus (A, B, C, D), the TCU will start at module E. Note that this module offset also applies to a TCU configured as a legacy PCU.
- If the TCU is being used as a pump controller or a legacy PCU, it must be configured as such in HT3. A legacy PCU occupies a single module address. A pump controller TCU occupies eight module addresses starting at the next available modules address. The TCU responds as individual modules or a single PCU module based on how it is polled. See "HT3 Software Configuration" beginning on page 91 for more information.
- If the TCU is running a custom program, it is important to remember that the TCU defines its internal modules without exception. Any additional modules added to the RTU must be addressed beginning with the module letter after the last dummy module defined in the TCU. See "Chapter 8: Programming the TCU" for more information.

Instructions for installing the Bus Extender Module appear on the next page.

Installing the BEM

1. Place the BEM in one of the RTU's unused module slots.
2. Remove the corresponding address block or strap for the selected module slot.
3. Make the following connections:

BEM	Description	TCU
P1-2	*Telemetry TX*	P1-14
P1-4	*Telemetry RX*	P1-13
P1-6	*Telemetry CTS*	P1-12
P1-8	*Telemetry RTS*	P1-15
P1-10	*Telemetry PWR*	P1-11
P1-12	*Telemetry GND*	P1-10

> IMPORTANT: Do not jumper pins 43, 41, 39, 37, and 35 on the BEM.

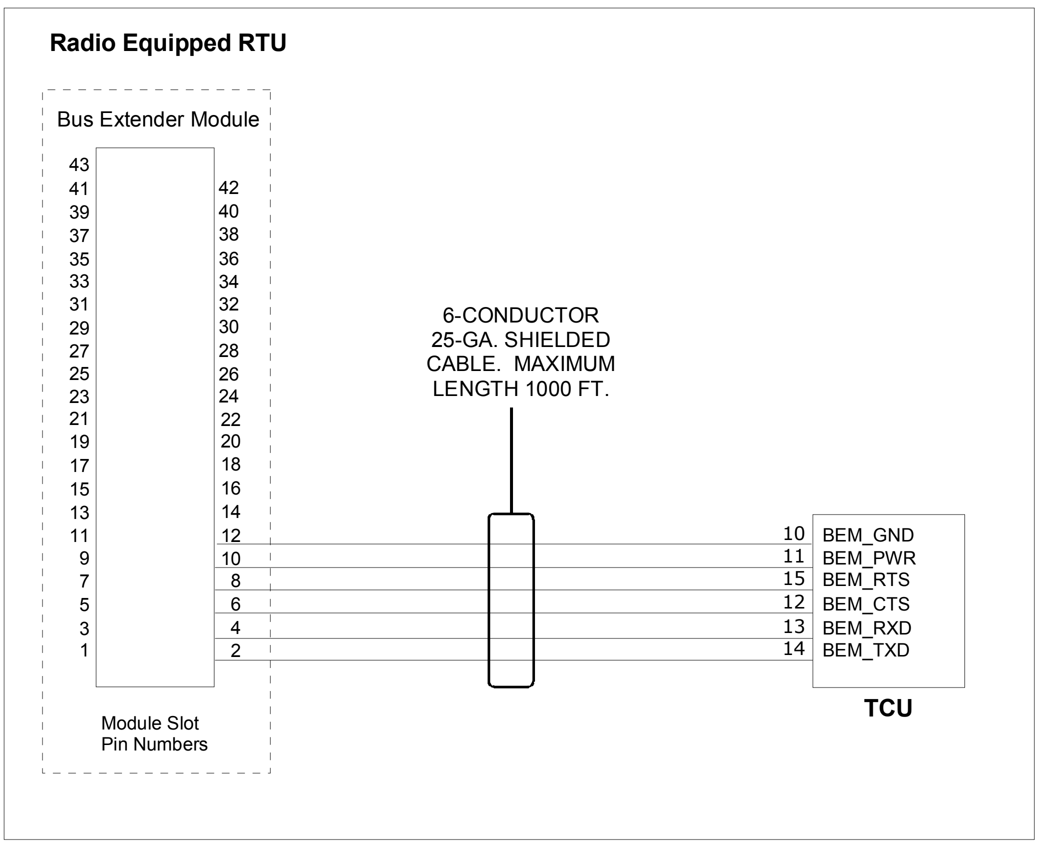


Figure 7-1, "Bus Extender Module Wiring Diagram"

TCU Used with Modbus Compatible Radio

The TCU includes an RS-232 Modbus radio interface, which acts as an interface to industry standard radios.

Pins on the TCU's second bottom connector, P-4, are provided for connecting the TCU to an external RS-232 Modbus compatible radio. For more information on this option, see "Chapter 5: Modbus Support."

Connector P-4 Pin Descriptions

PIN#	Name	Description
P4-1		Reserved for future use; do not connect
P4-2		Reserved for future use; do not connect
P4-3	*RS485_B*	RS-485 serial interface B
P4-4	*RS485_A*	RS-485 serial interface A
P4-5	*EX_SHIELD*	Cable shield for RS-485 or RS-232 cable
P4-6	*EX_GND_RAD*	RS-232 ground
P4-7		Unused
P4-8	*EX_TXD_RAD*	RS-232 transmit data to external device
P4-9	*EX_RXD_RAD*	RS-232 receive data from external device
P4-10		Unused

TCU as Stand Alone Unit

The TCU can be ordered with an integrated 2 W, 200 MHz radio or 5 W, synthesized 400 MHz radio and operate independently of an RTU. The TCU's integrated digital radio enables radio communication between the TCU and the HT3 central computer or server (Hyper SCADA Server). Through this radio link, you can remotely monitor and control TCU operations.

This configuration requires that the TCU be installed in a location, preferably a control panel, with access to an antenna. Typical setups, including proper grounding, are illustrated on pages 89 and 90.

Connecting the TCU to the antenna

Connect the antenna cable to the pigtail that extends from the bottom of the TCU.

Addressing and configuring the radio

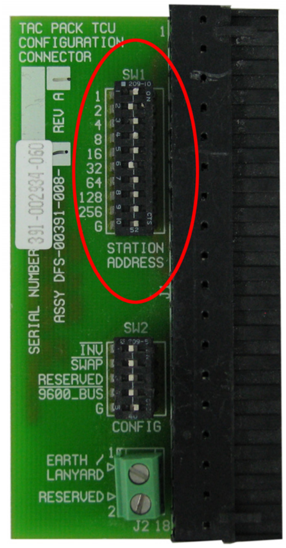
The TAC Pack TCU Configuration Connector is used to configure the station address and data format (invert data or swap data).

Station Address

The TCU's station address is configured by turning off switches on the TAC Pack TCU Configuration Connector's SW1 DIP switch that add up to the desired station number. The connector (shown on the next page) is installed in the TCU's P3 connector.

The valid station address range for the TCU is 1-250 and 255-511 (the addresses 251-254 are reserved).

Each switch has an assigned bit value (labeled along the left side of the switch). The station address is calculated by totaling the bit values of the switches that are in the OFF position. (The OFF position is towards the card edge; the ON position is near the connector side.)



The example at right shows a station address of 34. The second and sixth switches are in the OFF position.

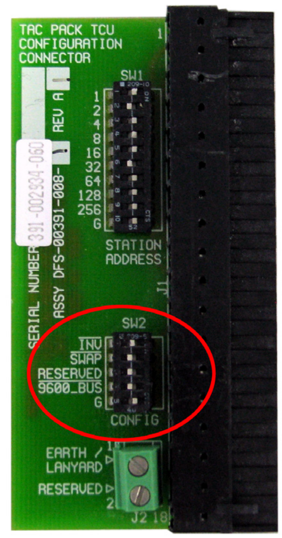
- Second switch: bit value = 2
- Sixth switch: bit value = 32

When we add the values of these bits together, we get a total value of 34 (2+32). The remaining bits would be left grounded (switch in the ON position).

Leaving all of the bits grounded (all switches in the ON position) gives the TCU a station address of 0 (zero), which is an invalid address. Removing the configuration connector altogether, gives the TCU a station address of 511 (the sum of all of the bits). If the TCU has been incorrectly addressed, its TX Data LED will not blink when the device is up and running. This is an indication that the device is unable to transmit.

The TCU Configuration Connector also features a terminal named Earth/Lanyard. This terminal must be wired to the control panel's ground. Although wiring the connector to ground is redundant, it serves the purpose of ensuring that the configuration settings remain with the control panel, or station. If the TCU needs to be replaced, the configuration connector can be easily removed and installed in the replacement TCU.

Data Format



The TCU's radio can be configured to invert data or swap data by moving the INV and SWAP switches on the TAC Pack TCU Configuration Connector to the ON position.

This is useful in situations where the station is experiencing interference from a telemetry system at another location that is on the same frequency. These are used to change the data format by byte inverting or nibble swapping.

- To invert data, place the INV switch in the ON position. (*INV* switch corresponds to pin P3-11.)
- To swap data, place the SWAP switch in the ON position). (*SWAP* switch corresponds to pin P3-12.)

(The OFF position is towards the card edge; the ON position is near the connector side.)

The photo to the right shows a connector with the INV switch in the ON position and SWAP switch in the OFF position.

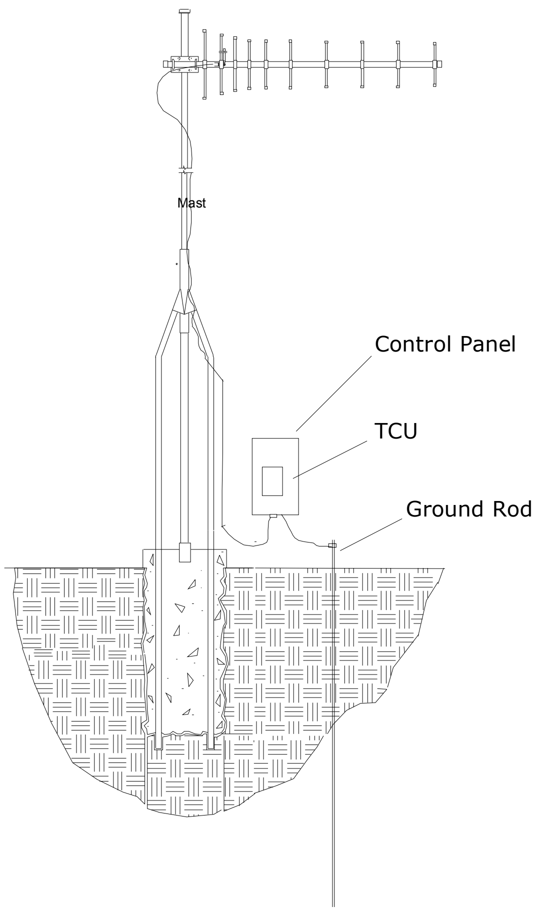
Configuring the TCU in HT3

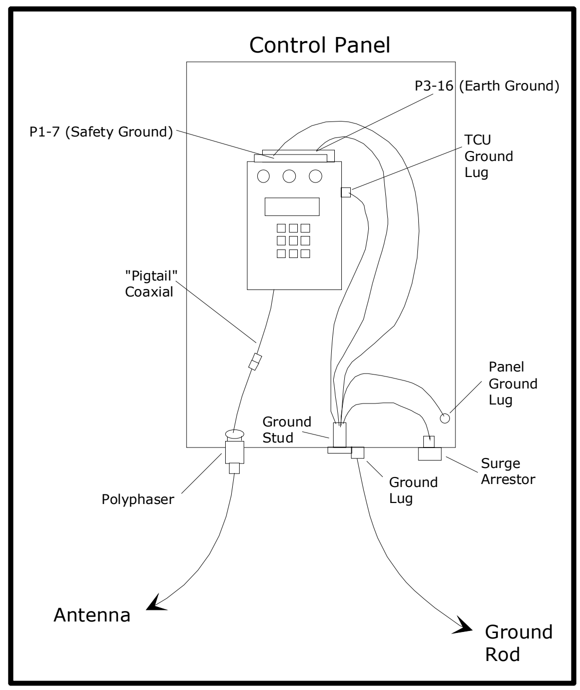
The TCU must be configured in HT3 as either a Legacy PCU or a TCU Pump Controller. A legacy PCU occupies a single module address. A pump controller TCU occupies seven module addresses starting at the next available modules address. See "HT3 Software Configuration" beginning on page 91 for more information.

Typical Setups

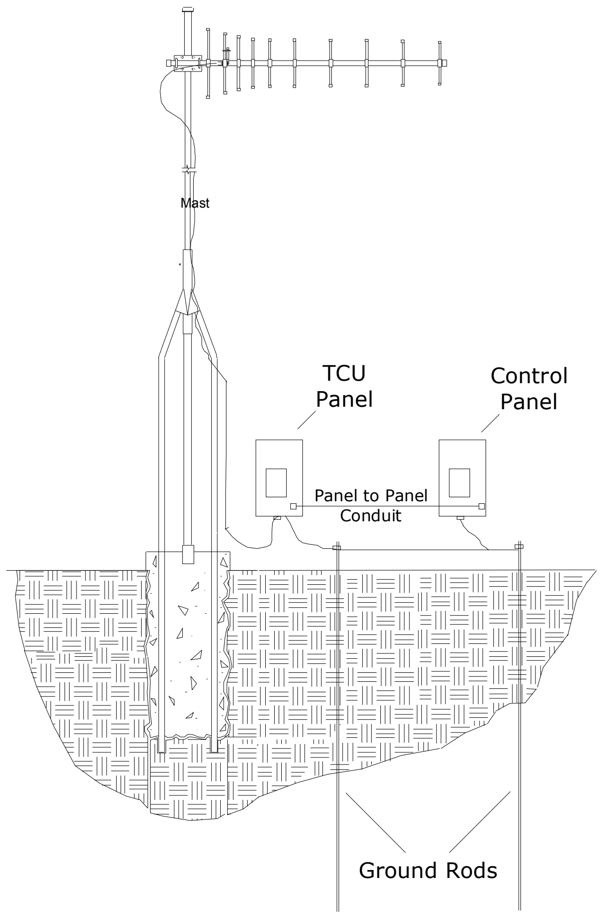
Refer to the TAC II Telemetry System Installation Planning Guide supplied with the TAC II telemetry equipment for detailed wiring instructions.

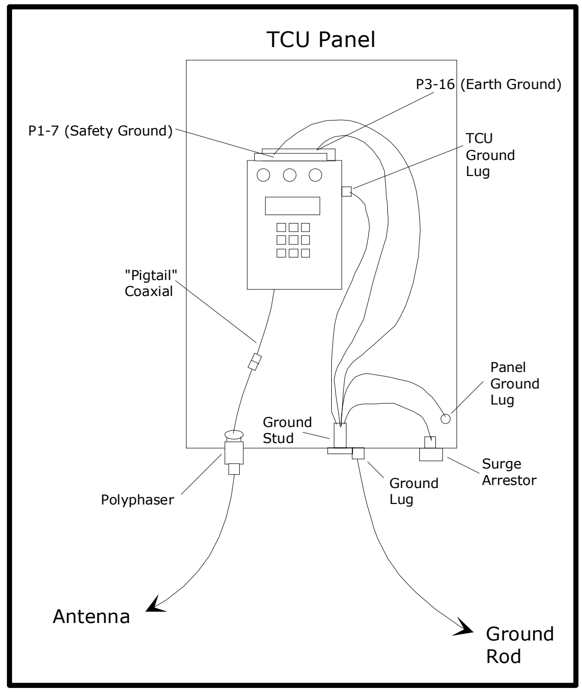
TCU Installed in Existing Control Panel





TCU Installed in Separate Control Panel





TCU Used without Telemetry

The TCU can operate independent of telemetry with limited data logging capabilities. Historical data can be accessed via WinRTU Test or the TCU's status screens.

Historical data that can be reviewed includes:

- Derived total flow for the station
- Elapsed run time for each configured pump
- Average run time for each configured pump
- Average amount of flow each configured pump moves per pumping cycle
- Total start time for each configured pump

The TCU begins logging these running totals and averages when the unit is installed. The unit continues accumulating data until the time meters are reset.

HT3 Software Configuration

Telemetry components (drivers, stations, modules, points, etc) are configured using HT3's Configuration Editor. To access Configuration Editor, log in to HT3, click the "Configuration Tools" button, and then click the "View and Configure Telemetry" button.

Each HT3 system includes a Templates driver (driver #7). The Templates driver contains frequently used standard station configurations, including the TCU Pump Control configuration and the legacy PCU Station template.

In most situations, you will be configuring the TCU using the TCU Pump Control template. This template allows you to take advantage of all of the TCU's features, including the second analog input, new pump alternation options, and the enhanced accuracy of the 12-bit analog inputs. The legacy PCU template would only be used if the TCU were replacing an existing PCU. The TCU's ability to accept a PCU configuration allows the two units to be interchangeable.

To see a list of the modules and points associated with the TCU Pump Control Template and the legacy PCU Station template, refer to "Appendix N: Polling the TCU – DFS Point and Modbus Registers."

To use a template to configure a new TCU, copy the template to the correct station. Refer to the *HT3 User Guide* for detailed information on using Configuration Editor.

- See Configuring Your System -> Stations -> Copying a Station for information on copying a station.
- See Configuring Your System -> Modules for information on adding and copying modules.
- See Configuring Your System -> Points for information on configuring points. You can safely delete any points that do not apply to your TCU application. For example, if the TCU is controlling a two-pump station, you can delete points associated with Pump 3 (i.e., Pump #3 Status, Pump #3 Starter, Pump #3 Stop, etc).

Notes

Chapter 8: Programming the TCU

Introduction

If the TCU is being used in a non-pump control application or in an application that requires control processes beyond those provided in the TCU's built-in pump control process, a customized program can be developed. Using DFS BASIC-52, the TCU can be programmed to perform a variety of automated tasks when interfaced with other DFS or Modbus-compatible telemetry equipment and field instrumentation.

This section of the manual provides an overview for programming the TCU. Refer to the *TCU Programming Reference* for information on the DFS BASIC-52 commands and syntax that can be used when programming the TCU. Instructions and diagrams for power, phase monitor circuitry, individual I/O point, and telemetry wiring can be found in "Chapter 6: Electrical Installation."

Applications

As a customizable device, the TCU is designed to operate using three asynchronous communications and control functions.

- Running a foreground Industrial BASIC program
- Conducting local (internal) module communications
- Communicating with the central computer via a radio or network connection.

The TCU's non-pump control applications include:

- The TCU's digital monitor, digital control, and analog monitor points can be used as non-intelligent I/O, or they can be manipulated logically with a BASIC program (much like a PLC).
- The TCU can be incorporated into a larger Remote Terminal Unit (RTU) using a Bus Extender Module (BEM).
- The TCU can operate as a simple central site and monitor and/or control up to 15 remote I/O function modules.
- The TCU can operate as a central polling backup device, which allows it to poll its own local modules if the central site stops polling.

Simple (DFS BASIC) Central

A TCU operates as a DFS BASIC central when a remote module, regardless of its attached radio address, is configured using the DEFMOD statement. When operating as a central, the TCU can be addressed at anything but 0 (zero).

The TCU is limited to polling up to 15 remote I/O function modules in addition to its own sequentially defined local modules when configured as a central site. The remote modules must be located at stations addressed from 1 to 15. Therefore, one module (A through O) may be polled at each station (1 - 15), or up to 15 modules may be polled at just one station. (Note that sequential module addressing in the central program is only required for local modules; remote modules do not have to be sequentially addressed.). Even though the DFS BASIC central is limited to monitoring and/or controlling 15 remote function modules, it automatically monitors RIM status points and radio communications data for every defined remote station.

The polling loop of a DFS BASIC central program runs much slower than the polling loop of the central computer or server. Every POLLON loop the BASIC central:

- Requests status from every module defined in its program
- Obtains radio communications data and RIM status for each site defined
- Uses normal control point updating (fast control point updating is not available for control modules at remote RTUs)

The remote polling loop can run asynchronously to the local polling and foreground program. In order to synchronize the data, however, a general POLLOFF statement is customarily used. When the BASIC central is attempting to close out a remote polling loop, the foreground program and local polling will stop at that line of code.

Much care must be taken when developing a BASIC central that is responsible for controlling modules in RTUs that include other intelligent devices (PCMs, PCUs, PLCs, SCUs, or TCUs). The central polling loop can become locked up because it is attempting to update a digital or analog control point that is being controlled differently by the remote RTU's intelligent device. The TCU central expects to have ultimate control over all of the defined control points. If the status of a control point at a remote site does not match the command of the TCU central, the central will keep repeating the control point command and wait for status verification before moving on. If an intelligent device at the remote RTU is setting the control point differently than the TCU central, the TCU central will become locked in the remote polling loop. By default, the TCU central will attempt to turn all remote control points off and analog controls to zero.

The remote polling loop will run faster and will never lock up due to uncontrollable control points when a remote module is off-line. When bench testing a BASIC central program, make sure all of the defined remote modules are on-line and operating with real simulated I/O.

- If remote polling appears to lock up, verify that all control points are under the sole control of the TCU central.
- If bench testing passes but startup fails, again verify that all control points are under the exclusive control of the TCU central.

Central Polling Backup Device

The TCU can operate as a central polling backup device and automatically switch between remote RTU mode (normal operation) and central polling backup mode. Central polling backup mode enables the TCU to begin polling its own local modules when it detects that the central site has stopped polling.

When the central site starts polling again and the TCU switches back to remote RTU mode, memory locations 6000H-6F00H must be cleared (set to zero) to completely disable central polling backup mode.

Installed in RTU

When a TCU is included in an RTU via a BEM, it is important to remember that the TCU defines its internal modules without exception. Any additional modules added to the RTU must be addressed beginning with the module letter after the last dummy module defined in the TCU. For more information on using a TCU in an RTU, see "TCU Installed in DFS RTU" on page 85 and the section titled "Internally Defined Modules," below.

DFS BASIC-52

The DFS BASIC-52 interpreter is an enhanced Industrial BASIC that was developed in order to enable telemetry communications within BASIC language syntax. It provides most of the features of standard BASICs and includes features unique to process control applications. Some of the unique hardware and software features of DFS BASIC-52 include the ability to:

- Store and execute the user program out of an on-board write-protected memory.
- Maintain an accurate battery backed up time/date clock function that is synchronized by telemetry.

One of the more powerful features of DFS BASIC-52 is its ability to execute and save programs stored in write-protected memory. The programs are stored sequentially in the protected memory in a location referred to as the ROM File. Any program stored in the ROM File can be retrieved and executed.

Programs are downloaded to the TCU via a communications cable that connects the TCU's RS-232 service port to a serial communications port on a computer. WinRTU Test's BLOAD form is used to download new and updated programs to the TCU. Terminal programs such as HyperTerm, Procom, or Kermit can be used to temporarily insert lines of code for debugging purposes.

Internally Defined Modules

The TCU has four real, internally defined I/O function modules that ***cannot*** be altered:

- Module A – DMM002
- Module B – DCM001
- Module C – AMM002
- Module R – RIM006

The rest of the TCU's modules are either DUMDCM ("Dummy" DCM) or DUMACM ("Dummy" ACM) depending on the BASIC process routine.

Sample TCU-HT3 Configuration

The TCU's three internal function modules (discussed above) don't have to be defined with the DEFMOD statement. Dummy modules (not included in this example configuration) can be defined in the TCU as modules D through O [refer to the DEFMOD statement in "Chapter 2: Commands and Statements" of the *TCU Programming Reference*]. However, no additional real hardware modules can be defined in the TCU.

Each monitor and control point whose description begins with "signal" can be modified based on the application's field wiring requirements. All other specifically defined point functions are unchangeable. The ALARM, AUTO, and KEYWORD options can be altered in HT3 as usual. A control point's AUTO option would be set to PLC if the TCU were automatically operating the point. Points B9-B12 have no hardwire input and cannot be controlled by the TCU. These points ***can*** act as dummy remote control points from a PLC that is on the same bus as the TCU, or directly from the Hyper SCADA Server or a central computer. These points can be used for signals such as communication status, flow management, or an all-pump shutdown and can be monitored in the TCU like regular monitor points (for example, with the statement DGIN B7 : POP B7STAT). Any other desired control or status signals, such as set points and out-of-range phase voltages, must be passed to the Hyper SCADA Server/central computer using dummy modules (not shown here).

Station 1, "Generic TCU Configuration"

Module A, Type =DO		
Point #	**Description**	**Low/High Label**
PT 1	Signal in at P2-1	OFF/ON
PT 2	Signal in at P2-2	OFF/ON
PT 3	Signal in at P2-3	OFF/ON
PT 4	Signal in at P2-4	OFF/ON
PT 5	Signal in at P2-6	OFF/ON
PT 6	Signal in at P2-7	OFF/ON
PT 7	Signal in at P2-8	OFF/ON
PT 8	Signal in at P2-9	OFF/ON
PT 9	Signal in at P2-10	OFF/ON
PT 10	Signal in at P2-11	OFF/ON
PT 11	Signal in at P2-12	OFF/ON
PT 12	Signal in at P2-13	OFF/ON

Module B, Type=C8					
Point #	**Description**	**Low/High Label**	**Alarm**	**Auto Control**	**Keyword**
PT 1	Signal out P1-23	OFF/ON	ON	PLC	PUMP
PT 2	Signal out P1-22	OFF/ON			
PT 3	Signal out P1-21	OFF/ON			
PT 4	Signal out P1-19	OFF/ON			
PT 5	Signal out P1-17	ON/OFF [Normally Closed Contact]			
PT 6	Signal out P1-16	OFF/ON			
PT 7	Signal aux remote	OFF/ON		PLC	
PT 8	Signal aux remote	OFF/ON			

Module B, Type=C8					
Point #	**Description**	**Low/High Label**	**Alarm**	**Auto Control**	**Keyword**
PT 9	AC Power Status	OKAY/FAULT	FAULT		
PT 10	DC Bias Status	OKAY/FAULT	FAULT		
PT 11	3-Phase Inversion	OKAY/FAULT	FAULT		
PT 12	Program Running	YES/NO	NO		

Module C, Type A				
Point #	**Description**	**Resolution/Units**	**Low Engineering/Raw Value**	**High Engineering/Raw Value**
PT 1	Signal in at P2-22	1/UN	0/819	100/4095
PT 2	Signal in at P2-21	1/UN	0/819	100/4095
PT 3	Phase A-B Volts	1/VOLT	151/0	300/255
PT 4	Phase A-C Volts	1/VOLT	151/0	300/255

Using TCU Control Points with a PLC

To successfully integrate a TCU into an RTU that contains a PLC, you must ensure that neither the local bus PLC or HT3 is attempting to directly control the TCU's (real or dummy) output points. The control point may toggle on and off erratically if the PLC or HT3 attempts to directly control it. This occurs because when the TCU receives a control message from the PLC, it sets the point to the state requested by the PLC. The TCU then evaluates the point according to its own criteria and resets the point. The state to which the TCU sets the control point may be the opposite of the PLC's command. The PLC will then try to set the output point again. This cycle will continue as long as the TCU and PLC are trying to set the same control point to an opposing state.

To reconcile this situation, the PLC and HT3 must be configured to indirectly control the outputs or only monitor them. The TCU should be the only device that is directly controlling the outputs.

There are two options for accomplishing this:

- In the PLC and HT3, configure the module as a control module (DCM). Create a dummy monitor point in the TCU and use this point to send the control command to the PLC. This enables the PLC to operate the control point in accordance with the TCU.
- In the PLC and HT3, configure the module as a monitor module type (DMM). Create a dummy control point in the TCU, and set up the PLC to send control information to this dummy control point. Note that with this configuration, the TCU, which can respond faster than the PLC, is forced to wait and rely on the PLC for the actual control.

In the case where the TCU output is being manually controlled from the Hyper SCADA Server/central computer, the PLC will pass the state of the manual control point from the central computer/Hyper SCADA server to the TCU as usual. The TCU should not be "PUSHing" a command to the output point in this circumstance.

In the example below, the PLC is toggling the TCU’s B7 control point to allow the TCU to monitor PLC communications. If the toggling ever stops, the TCU (sensing that the PLC has stopped communicating) will control the outputs directly (section 300). Otherwise, the control command sent to the PLC through an arbitrary dummy monitor point (D6) is appropriately mirrored in the PLC back to points B1 and B6.

```
>LIST5
5       REM *** PLC PROGRAM ***
10      DEFMOD A,DMM002 : REM TCU MODULE A
12      DEFMOD B,DCM001 : REM TCU MODULE B
14      DEFMOD C,AMM002 : REM TCU MODULE C
16      DEFMOD D,DMM001 : REM TCU DUMMY MODULE
100     POLLON  :  POLLOFF
102     FLASH=NOT(FLASH)110  PUSH FLASH : DGOUT B7112  DGIN D6 : POP SCUCAL
120     PUSH NOT(SCUCAL) : DGOUT B1
122     PUSH (SCUCAL) : DGOUT B6
150     GOTO 100

READY
>
```

The TCU program is shown below.

```
>LIST
5       REM *** TCU PROGRAM ***
10      DEFMOD D,DUMDCM : REM A-C AUTO DEFINED
50      PUSH 30 :  SETIMER 1 : REM STARTUP COND.
100     POLLON : POLLOFF
110     DGIN B7 :  POP PLC
150     PUSH CAL : DGOUT D6
200     X=X+1
202     IF (X=300) THEN CAL=NOT(CAL) : X=0
250     IF (PLC<>PLCL) THEN  PUSH 30 :  SETIMER 1
252     PLCL=PLC
254     CHKTIMER 1 : POP TD1
259     REM CHECK TO SEE IF PLC STOPPED COM.
260     IF (TD1=0) THEN  GOSUB 300
290     GOTO 100300 REM PLC STOPPED COMMUNICATING SO CONTROL OUTPUT POINTS
310     PUSH NOT(CAL) : DGOUT B1
312     PUSH (CAL) : DGOUT B6
320     RETURN

READY
>
```

TCU Analog Output Option

Although the TCU does not come equipped with an analog output control point, it is still possible to control an analog device using the TCU's RS-232 Modbus interface. See "Chapter 5: Modbus Support" for information on this feature.

Polling

Polling is a function where a control device actively requests status from and sends control messages to other static devices, which do not respond unless requested. The TCU polls its internal modules and can poll up to 15 modules located at remote stations 1 through 15 if operating as the central site.

Fast Control Point Updating

In normal control point updating, the TCU sends a status request message to the control module after ***every*** individual control point update. With fast control point updating, the TCU requests status of a local control module. Any control points that are not correct are updated ***before*** the next status request message is sent to the module. Fast control point updating is not available for polling control modules at a remote RTU.

H-O-A Switches

The three 3-position switches on the front of the TCU are hardwired internally to control points B1, B2, and B3. In the event of a program disruption, the devices wired to these points can be manually controlled from the H-O-A switches. These switches can also be monitored in the BASIC program (for more information, see DGIN statement in "Chapter 2: Commands and Statements" of the *TCU Programming Reference*) to allow the program to control the devices when the associated switch is in the "Auto" position. Additionally, if these points are to be controlled from the central computer/server as non-intelligent I/O, the corresponding H-O-A switch must be in the "Auto" position.

In the TCU's BASIC program, the switch positions are designated as follows (e.g., DGIN SL1 : POP L_HOA_1):

SL1 = Left switch in "Hand" position	SR1 = Left switch in the "Auto" position
SL2 = Center switch in the "Hand" position	SR2 = Center switch in the "Auto" position
SL3 = Right switch in the "Hand" position	SR3 = Right switch in the "Auto" position

LCD Menus

The TCU's LCD may be used to display program variables, status conditions, or lists of items.

- When the MENU feature is OFF, the LCD displays information sent from the BASIC program with the PRINT @ Statement.
- When the MENU feature is ON, the LCD is controlled by a routine to display defined menu items and respond correctly to the up, down, right, and left arrow keys.

The LCD's backlight may be turned on or off with the DGOUT statement (see "Chapter 2: Commands and Statements" of the *TCU Programming Reference*).

Although the number of displayable menu items is limited to 16 (1-16) at any one time, the use of sub menus allows the total number of menu items to be virtually unlimited. By programming the Enter key to switch to a sub menu, each of the primary 16 menu items can have up to 16 sub menu items, and so on. If one of the sub menus contains only one item (MENU 1), the Up and Down arrow keys can be monitored to allow an operator to adjust set point values. The Enter key can be monitored then to set the new value while returning to the previous menu list. For information on manipulating the LCD Menus, refer to the MENU statement in “Chapter 2: Commands and Statements” of the *TCU Programming Reference*.

KEYPAD

The keys on the TCU’s keypad can be used to page through menus items, navigate through configuration options, and enter numeric data.

Three keypad functions are not programmable:

- When the one (1) key is held down on power up, the TCU will switch into program, or debug, mode.
- When the MENU is ON and any key is pressed and released, the backlight of the LCD remains lit for 20 seconds.
- When more than one menu item is defined and the MENU is ON, the up-, down-, right-, and left-arrow keys are used to cycle through the defined menu items.

In the TCU’s BASIC program, the keys are read using the GET command. The GET command retrieves the ASCII value of the key press.

- The up arrow key generates the ASCII code 50 from the GET command.
- The down arrow key generates the ASCII code 56 from the GET command.
- The left arrow key generates the ASCII code 52 from the GET command.
- The right arrow key generates the ASCII code 54 from the GET command.
- The Esc/decimal key generates a decimal point (.) from the GET command.

It is important to note that each key is interpreted according to what the program is expecting. For example, when you are entering a set point on the LCD screen, pressing a key on the TCU’s keypad will generate the expected numeric value.

The GET command also gets characters from the service port. Pressing the 1 (one) key on the TCU’s keypad is equivalent to typing a 1 (one) on the keyboard of a computer connected to the TCU’s service port. See the GET command in “Chapter 2: Commands and Statements” of the *TCU Programming Reference* for more information on this command.

Note that the DGIN SBx designation (for example, DGIN SB1 : POP BUT1) is still supported for SCU compatibility.

- SB1 = Up-arrow key
- SB2 = Down-arrow key
- SB3 = Enter key

LEDs

The LEDs, which operate in a simple off/on manner, are controlled with the DGOUT statement [see DGOUT statement in "Chapter 2: Commands and Statements" of the *TCU Programming Reference* for more details]. Thirteen of the LEDs are controllable from within the BASIC program: DS1-DS13). In the TCU's BASIC program, the LEDs are designated as follows (e.g., PUSH 0 : DGOUT DS13):

DS1: LED below left switch	DS6: Top right LCD LED	DS11: Bottom left LCD LED
DS2: LED below middle switch	DS7: Second left LCD LED	DS12: Bottom right LCD LED
DS3: LED below right switch	DS8: Second right LCD LED	DS13: Alarm LED
DS4: LCD backlight*	DS9: Third left LCD LED	
DS5: Top left LCD LED	DS10: Third right LCD LED	

* You can control the LCD backlight with DGOUT when the menu is off. The menu function automatically controls the backlight when the menu is on.

Hardware Interface

The TCU may be programmed and monitored from a personal computer (PC), laptop, or any VT-100 terminal. The interface between the PC/laptop and the TCU is an RS-232 cable connected from a serial communications (COM) port on the PC/laptop to the service port of the.

The service cable, WinRTU Test Software, and this manual are available in the TCU, PCU & SCU Test Kit. See "Appendix C: Parts List" for ordering information.

Software Interface

The recommended method for programming the TCU is to create the BASIC program using a good text editor and then download the program to the TCU via WinRTU Test. The WinRTU Test software enables you to perform a variety of tasks, including testing analog and digital modules, collecting status information, and viewing radio traffic. The Bload form is used to download new and updated BASIC programs to TCUs, PLCs, and SCUs. WinRTU Test can be installed on any PC/ laptop running a version of the Windows operating system. Once the PC/laptop and the TCU are connected (see Hardware Interface, above), you can start WinRTU Test and download the desired TCU program. WinRTU Test can also be used to download edited programs. Unchecking Bload's "New" option enables it to only send lines that have changed since the last download.

To directly interact with the DFS BASIC-52 program for debugging purposes, use terminal emulation software to temporarily insert debug lines of code. Any terminal emulation program, such as HyperTerm, Procom, or Kermit, that allows a PC/laptop to act as an ANSI / VT-100 terminal will work in establishing a connection to the TCU via a communications port on a PC/laptop.

Below are the MS-DOS KERMIT commands used to set up the PC/laptop communications to the TCU:

C:\RTUTEST> kermit	Type kermit at the DOS prompt to run KERMIT
MS-KERMIT> set port 2	This sets up communications through Com port 2
MS-KERMIT> set speed 9600	This sets the communications speed at 9600
MS-KERMIT> c	This makes the connection, and if the hardware is connected correctly and the device is turned on press the [Enter] key to get the DFS BASIC-52 prompt (‘>’).
>	Type [Alt]-x to return to the MS-KERMIT prompt.
MS-KERMIT> quit	This exits the KERMIT program
C:\RTUTEST> bload /2 patch.bas	This will download the text only file ‘patch.bas’ to the device through Com port 2 at 9600 baud. The download is visible at the terminal, and when it is finished the DOS prompt will reappear.
C:\RTUTEST> bload patch.bas	This will download the text only file ‘patch.bas’ to the device through Com port 1 at 9600 baud. The download is visible at the terminal, and when it is finished the DOS prompt will reappear.

Before you can program the TCU, you must place it in debug/program mode (see next section) For additional information on setting up the communications link, refer to the RTUTest Software Disk, or your PC manual. Included on the disk are all of the utility programs necessary to establish a connection and download a program to the TCU. The Utility software, service cables, and this manual are available in the TCU, PCU & SCU Test Kit.

DEBUG (PROGRAM) MODE

Program, or debug, mode is the state of the TCU when a program can be written, edited, downloaded, or tested through a computer or terminal interface.

Commands can be entered while the DFS BASIC-52 interpreter is operating in the ROM ***or*** the RAM locations, but line numbers followed by programming statements can ***only*** be entered while operating in the RAM location (referred to as line editor mode). In order to start the DFS BASIC-52 interpreter in line editor mode, the interpreter must be operating in the RAM location and the TCU must be brought up in Debug mode (also known as Command, Edit, or Program mode).

To start the DFS BASIC-52 interpreter in Debug mode, press and hold the TCU’s 1 (one) key while powering up the TCU. The 1 (one) key must be pressed and held until the self-check sequence is completed (indicated by the LEDs on the device flashing on and off for a moment). A greater-than-sign (>) will appear when the Enter key is pressed indicating that the TCU is waiting for the user to type in a command or line number followed by statements.

Note: If a line number is entered while operating in the ROM location an ‘ERROR: PROM MODE’ message will appear on the console.

When the TCU is connected to an active terminal screen and started in Debug Mode, a startup screen similar to the following example will appear ending with the DFS BASIC-52 command prompt (‘>’).

```
            )-------------[ DFS Programmable Logical Controller  V#.# ]--------------(

READY
>
```

At this time a new or existing program can be written, edited, run, and debugged in the TCU.

DOWNLOADING

WinRTU Test’s Bload form (BASIC Program Loader) enables you to download a BASIC program to a programmable device (PLC, TCU, or SCU) from any personal computer on which WinRTU Test has been installed. To load the Bload form, choose Bload from WinRTU Tests’ Form menu

To download a program,

1. Connect the TCU to a PC/laptop on which WinRTU Test is installed.
2. Place the TCU in Debug mode by pressing and holding the TCU’s 1 (one) key while powering up the TCU.
3. Start WinRTU Test and load the Bload form (choose Bload from the Form menu).

   The Bload form includes the following options:

   - **New** – Clears the device's RAM (Random Access Memory) location before the selected program is loaded into RAM.
   - **Save (eprog)** – Copies the program currently stored in RAM into the device's onboard EPROM (Erasable Programmable Read-Only Memory).
   - **Erase** – Erases all existing programs from the devices' EPROM before the selected program is loaded into EPROM. This option is normally selected when uploading a program to the EPROM using the Save (eprog) option. If this option is not selected, the Save (eprog) command "stacks" the program into EPROM (that is, it copies the program into the next available memory location of the EPROM).
   - **Run** – Executes the program located in the device's RAM or ROM location after the selected program is loaded. When Run is executed, all variables are set to zero (0), all BASIC-evoked interrupts are cleared, and program execution begins with the first line number of the selected program.
4. Select the desired Bload options.

   If a new program is being installed, select the Bload form’s “New” option (this clears the RAM location). If you are downloading an edited program, uncheck the “New” option. This enables WinRTU Test to only send the lines of code that have changed since the last download.
5. Click Change, locate the program you want to download (must have the extension .bld), and click OK. The file name and path of the program you selected is displayed in the File box.
6. Click Load. The Completion bar shows the upload progress. When it reaches 100%, upload is complete.

If all options were selected, the Basic Program Loader:

1. Clears the device's RAM and loads the new program into RAM
2. Erases the program in the device's EPROM
3. Copies the program from RAM to EPROM
4. Begins running the program

EDITING

If the program on the TCU requires changes, open the program in a text editor, make the desired changes, and then resave the program. You can then download the edited program using WinRTU Test's Bload form. Be sure to uncheck Bload's "New" option. This enables WinRTU Test to only send the lines of code that have changed since the last download. For detailed information on downloading a program to the TCU, see the previous section.

DEBUGGING/TESTING

To debug/test a program already programmed into EPROM, it must be transferred to RAM. In the following example, the program in the ROM 2 location is copied into the RAM location.

```
          )-----------[ DFS Programmable Logical Controller V5.3 11/25/97 ]-----------(

READY
>ROM 2

READY
>XFER

READY
>
```

The program can be modified by retyping existing lines of code and/or adding new lines of code. The DFS BASIC-52 only allows line editing. Refer to the previous section, Editing, if you are making changes to a large number of lines. If the Backspace key does not seem to work properly while editing lines of code, try using the Delete key instead.

The program can be executed, tested, and debugged while resident in RAM by using the RUN command [type: RUN]. Once the program is edited correctly, it can be copied back into the EPROM. In the example above the program was taken out of the ROM 2 location. To place the edited program back into the second location, type ERASE 2 to erase the ROM 2-8 locations, and then type EPROG to copy the program that is currently in RAM into the ROM 2 location.

Keep in mind that the RAM memory is automatically erased on power up unless the following line of code is typed in all capital letters before the TCU power is turned off: 0 REM DEBUG.

CONNECTION/DOWNLOADING DEBUG TABLE

Error	Cause	Fix
Device I/O error...	The TCU power fluctuated in the middle of a downloading sequence.	Make sure power to TCU is secure.
No download occurs	The file was not saved in a TEXT ONLY format.	Open the file using the selected editor and re-save the file as a “TEXT FILE”
Receive an error before some or all lines, but the program keeps downloading	The Tab key was used for spacing in the full screen editor.	Edit file so only space bar is used to provide spacing. Do not use the Tab key.
	The file was not saved in a TEXT ONLY format.	Open the file using the selected editor and re-save the file as a TEXT FILE
Screen and/or keyboard lock up	The RS-232 connection is not made between the TCU and the PC.	Check the RS-232 connection and cycle power to the TCU. If this action does not unlock the keyboard, reboot the PC.
No communications between PC and TCU	RS-232 connection is not working.	Invoke your terminal emulation software and adjust hardware until a DFS BASIC-52 prompt appears on the screen (continue to press Enter after each hardware adjustment for the prompt to appear).
	TCU power is turned off	Verify that the TCU has power by observing the TCU’s Power LED.
	Com port is locked up as a result of the TCU sending a data stream to the port before the port was active with the communications software.	Unplug the cable to the Com port and re-boot the computer. Run the communications software to enable the Com port before plugging the cable into the Com port. Make sure that data is not sent to the Com port from the connected device without the communications software running in the ACTIVE window.
	Communications software is corrupt or has failed. This can occur when the Com port is locked due to the previous explanation.	Unplug the cable to the Com port and re-boot the computer. Re-install the communications software if necessary and then run the communications software to enable the Com port before plugging the cable into the Com port. Make sure that data is not sent to the Com port from the connected device without the communications software running in the ACTIVE window.

Notes

Chapter 9: PUMP CONTROLLER USER INTERFACE

The information contained in this chapter refers to the TCU's built-in pump control process. It does not apply to a TCU with a custom program installed.

KEYPAD AND LCD SCREEN

The TCU has a 12-key keypad and a 4 x 20-character LCD for displaying status information, alarm messages, and configuration data. The keypad and LCD also provide an interface for configuring the TCU and for viewing and resetting alarms. The keypad includes the numbers 0-9, a decimal point, and the Enter function. Some keys have two functions. For example, the decimal point and the escape function (Esc) share the same key; the number two and the up scrolling function (▲) share the same key. The function of the key is dependent on the TCU's current mode.

Navigation Keys

The TCU features four keys – identified by arrows – that enable you to navigate (up ▲, down ▼, left ◄, and right ►) through menu and configuration options.

The ◄ and ► keys are used to navigate through the status, alarm, and configuration screens.

When the TCU is in Configure Mode, the ▲ and ▼ keys are used to navigate to the previous or next configuration option on that screen. To navigate to the next or previous configuration screen, use the ◄ and ► keys.

Enter Key

The Enter key is used to:

- Access the TCU's configuration screens.
- Select a configuration option to change.
- Accept configuration changes.

The Enter key has no function when displaying status information and alarm messages.

Esc Key

The Esc (escape) key is used to return to the previous menu option and to exit a configuration option ***without*** accepting the change.

Numbers 0 – 9

The TCU's keypad includes the numbers 0 through 9. These can be used to input numeric data, such as the number of pumps or the station's computed flow volume.

Silence Key

The Silence key is used to silence the TCU's own alarm horn and an external alarm horn if one has been connected. Note that if the TCU is being used with telemetry, this key is monitored at point B7 (see "HT3 Software Configuration" on page 91 for more information on telemetry points).

On/Off Key

When pressed and held, the TCU's On/Off key cycles the state of the TCU. When the TCU is on, the Power LED is lit and the TCU is fully functional. When the TCU is off, bias power and all outputs are turned off, and communications cease. The LEDs and LCD display are off and all keys except the On/Off key are deactivated.

> **IMPORTANT:** If the TCU's Power LED is not lit, you should assume that the TCU is still powered. The Power LED indicates only that the TCU is in the off state, not that AC power has been removed. To remove power, you must turn off the external circuit breaker.

LED Indicators

LED indicators on the front panel of the TCU provide you with quick status and alarm information. When the TCU's on/off state is cycled, all of the TCU's LEDs turn on momentarily for a self-test.

The following paragraphs describe the status and alarm functions of the LEDs.

Output 1-6 and Input 1-12 Status

At the top and bottom of the TCU's front panel are LEDs that worked independently of the TCU's internal computer. These LEDs provide you with a way of verifying that the corresponding output or input is on. See Pump Control Application Pin Name / Wiring Definitions, p. 9 for a list of all of the TCU's pump control application I/O points.

The six LEDs (Outputs 1-6) located along the top edge of the TCU work independently of the TCU's internal computer. They provide field status of the following six digital outputs:

Output 1: P1-23 (*MTR1_STR*)	Output 4: P1-19 (*AUX_OUT*)
Output 2: P1-22 (*MTR2_STR*)	Output 5: P1-17 (*ALM_LITE*)
Output 3: P1-21 (*MTR3_STR*)	Output 6: P1-16 (*ALM_HORN*)

The twelve LEDs (Inputs 1-12) located along the bottom edge of the TCU work independently of the TCU's internal computer. They provide field status of the following 12 digital inputs:

Input 1: P2-1 (*MTR1_RUN*)	Input 7: P2-8 (*LEAD_LVL*)
Input 2: P2-2 (*MTR2_RUN*)	Input 8: P2-9 (*LAG1_LVL*)
Input 3: P2-3 (*MTR3_RUN*)	Input 9: P2-10 (*LAG2_LVL*)
Input 4: P2-4 (*EXT_PM*)	Input 10: P2-11 (*HIGH_LVL*)
Input 5: P2-6 (*LOW_LVL*)	Input 11: P2-12 (*AUX_IN*)
Input 6: P2-7 (*OFF_LVL*)	Input 12: P2-13 (*ALM_SIL*)

Pump Run Status

Each of the TCU's three H-O-A switches has an LED that provides motor run and motor start fault status. Under normal operation, the LEDs indicate if the corresponding pump is on or off. This LED flashes when a starter circuit fault is detected.

A flashing LED indicates that a pump motor failed to start or stop when controlled by the TCU. The fault condition continues until the pump motor operates properly or until the TCU's control of the pump motor is overridden. If the TCU's *Auto Retry* function is enabled, the faulted pump motor is retried. If this function is disabled, the alarm must be reset manually. There are two ways to reset the alarm:

- Place the H-O-A switches in the "Hand" or "Off" position to override the TCU's control and reset the alarm.
- Use telemetry to override the TCU's automatic control and reset the alarm.

TCU Power Status

The TCU's Power LED illuminates when the TCU is in the on state and AC voltage is applied. If a backup battery is connected to the TCU and primary AC power is interrupted, the *ACPwr* alarm is activated and the TCU's Alarm LED flashes.

If a battery is connected when AC power is interrupted and the voltage drops below 9.1 VDC, the TCU shuts off power to both of its microcontrollers. When this occurs, either the Power LED – and all other LEDs – will be off or the Power LED will be on and the CPU Fault LED will be flashing. The microcontrollers will not power up again until the voltage reaches 12.3 VDC.

> **IMPORTANT:** If the TCU's Power LED is not lit, you should assume that the TCU is still powered. The Power LED indicates only that the TCU is in the off state, not that AC power has been removed. To remove power, you must turn off the external circuit breaker.

CPU Fault Status

Internal circuitry is used to monitor the TCU's microcontroller. If the circuitry detects a fault with the microcontroller, it resets it and strobes the CPU Fault LED. If the microcontroller fails to reset, a circuit disables the outputs and the CPU Fault LED flashes. A steady light indicates that the TCU's radio processor is locked in reset mode. When this LED is lit (flashing or steady), all automated controls are disabled. Only using the H-O-A switches, which continue to function under a CPU Fault condition, can continue operation of the pumps. The disabled state of the alarm light relay activates an alarm light connected to the TCU.

RX DATA & TX DATA Status

The TCU can communicate through the service port located on its front panel, Bus Extender Module (BEM), and through the telemetry interface. RX and TX Data LEDs are part of the telemetry and service port interface and are provided to verify the communications function. The RX Data LED strobes each time the TCU receives data; the TX Data LED strobes each time the TCU transmits data. See “Appendix B: Maintenance and Troubleshooting” if the TCU fails to communicate.

Alarm Status

The Alarm LED flashes when there are active alarms and is static on (continuously lit) until all alarms have cleared and all corresponding alarm messages have been viewed. The Alarm LED is cleared when the alarm screen is exited and there are no active alarms.

When the TCU is used as a remote in conjunction with the telemetry system, active alarms will be displayed both locally (at the TCU) and on HT3’s Alarm Viewer screen. Note that the TCU’s alarm messages and alarm LED are not cleared via telemetry; they must be cleared locally. See “Chapter 12: Viewing and Troubleshooting Alarms” for details on alarm messages.

Well Level Status

On each side of the TCU’s LCD are four LEDs (8 total). Six of these LEDs are used to show the current well or tank staging level (Low, Off, Lead, Lag, Lag2, High). Functional names for each of the LEDS are displayed directly beside them on the TCU’s LCD.

These staging levels can be from discrete switches or analog set points. For example, when the lead level switch closes or the level sensed by a pressure transducer reaches the Lead set point (LeadOn Pt), the Lead LED illuminates, and the TCU starts the Lead, or first, pump.

High and low level inputs can be used for backup alarms in an analog system. If the input devices detect alarm conditions undetected by the transducers, the High or Low LED will flash.

See “Chapter 12: Viewing and Troubleshooting Alarms” for information on alarms. See “Set Point Levels” on page 120 in “Chapter 10: Configuring the Pump Control Process” for information on configuring staging levels.

COMMUNICATIONS SERVICE PORT

The service port on the TCU’s front panel provides an RS-232 interface for diagnostics and configuration storage and updating. More information on this feature is provided in “Chapter 2: Principles of Operation” in the section titled “Communications Service Port” (page 20).

Chapter 10: CONFIGURING THE PUMP CONTROL PROCESS

> The information contained in this chapter refers to the TCU's built-in pump control process. It does not apply to a TCU with a custom program installed.

The TCU's configuration screens make customizing the TCU's operation a simple process. Configuration options include the number of pumps at the station, level sensor type, pumping method (Pump Up/Pump Down), staging levels, and well volume. Configuration options are displayed on the unit's LCD. The keypad is used to select options and enter data. From the configuration screens, you can also set the TCU's internal clock and reset the timers (*Total Run*, *AverageRun*, *Avg Pump Rate*, and *TFlow*).

Configurations can also be transferred to the unit through an RS-232 service port, or over a radio link using HT3 telemetry equipment.

PLACING THE TCU IN CONFIGURE MODE

All three of the TCU's H-O-A switches must be in "Hand" or "Off" before the TCU can be configured. If an H-O-A switch is changed to the "Auto" position while in configure mode, the TCU exits configure mode without saving changes and returns to the initial Status screen. The H-O-A switches can be changed between "Hand" and "Off" positions without affecting configure mode.

To access the TCU's configuration screens, navigate to the Change Configurations screen and press the Enter key. If you are at the TCU's default screen, pressing the ◄ key twice will bring you to the Change Configurations screen. After the TCU is placed in configure mode, the TCU's navigation keys can be used to move through the configuration screens.

CHANGING CONFIGURATION OPTIONS

To change a configuration option, navigate to the correct screen and use the ▲ and ▼ keys to place the cursor on the line of the option you want to change. When the cursor is in place, press the Enter key. A question mark (?) appears next to the option's name indicating that it is ready to be edited. Depending on the option being changed, you can either enter a number by pressing the appropriate key on the TCU's keypad or use the ◄ and ► to navigate through available settings.

EXITING CONFIGURE MODE AND SAVING CONFIGURATIONS

Navigate through all of the configuration screens until you reach the screen that reads *Press Enter to Save, Esc to Abort*.

- Pressing the Enter key while at this screen causes the TCU to replace the old configuration with the changes made during the current session. When changes are saved, the settings are written to non-volatile memory. ***You must then cycle power to the TCU in order for the TCU to begin running on the new configurations.*** If the TCU's power is cycled *before* selecting the Save command, the last saved values are loaded on power up.
- Pressing the Esc key from any screen *except* the Set Time and Reset Timers screens causes the TCU

to exit configure mode without saving any changes made during the current session. The old configuration is retained. Note that the Esc key *cannot* be used to exit configure mode in the Configure Dialer or Configure Modbus sections.

The following methods do *not* save the current changes. They are considered safeguards:

- Pressing the Esc key from any of the TCU's configuration screens *except* the Set Time and Reset Timers screens causes the TCU to exit configure mode and abort any changes made during the current session. Note that the Esc key *cannot* be used to exit configure mode in the Configure Dialer or Configure Modbus sections.
- Changing an H-O-A switch to the "Auto" position before selecting the Save command forces the TCU to exit configure mode and abort the current changes.
- Leaving the TCU unattended for over five minutes without selecting the Save command causes the TCU to abort any changes and return to the main display screen.
- Cycling the TCU's power (press and hold the TCU's On/Off key) before selecting the Save command causes the TCU to reload the old configuration from non-volatile memory and return to the main display screen.

NUMBER OF PUMPS, TRANSDUCER TYPE, LOW FLOAT, HIGH FLOAT

From the first configuration screen, you can:

- Configure the number of pumps
- Select transducer type
- Enable or disable a low float
- Enable or disable a high float

```
No. Pumps  = 3
Xducer Type: Floats
Low Float  : Disable
High Float : Enable
```

Number of Pumps

Configuration option: *No. Pumps*

The TCU can be configured to control one, two, or three pumps for simplex, duplex, or triplex stations, respectively.

Note that the number of pumps configured affects the number of elapsed time meters (Total Run screen), average motor run-time meters (AverageRun screen), and average pump flow rate meters (Avg Pump Rate screen) that the TCU displays. One meter is displayed for each pump that has been configured.

To configure the TCU to operate as a general RTU and use its points as non-intelligent I/O, set *No. Pumps* to 0 (zero).

Transducer Type

Configuration option: *Xducer Type*

The TCU provides four options for configuring a transducer:

- 4-20 mA – analog current-type device.
- 0-5 V – analog voltage-type device (pressure or linear resistive).
- Remote – device located at a remote location; data is sent to the TCU via telemetry.
- Floats – digital-type device, such as contact closures, float switches, and pressure switches.

Enable a Low Float and/or a High Float

The TCU is designed to accommodate both a low-level float and a high-level float to generate alarms and override normal pump control if the primary pump control fails (transducer fault or float failure). These Low- and high-level floats are recommended in both discrete and analog level detection systems.

Low Float

Configuration option: *Low Float*

Modes: *Enable* or *Disable*

Notes:

- If a low level float is being used, *Low Float* ***must*** be enabled.
- *Low Float* must be ***disabled*** if a low level float is not connected. If *Low Float* is not disabled in this situation, the *Low Well* alarm will interfere with station operation.
- In a Pump Down Mode (Lift Station) system, all pumps are stopped on a low float condition. In a Pump Up Mode (Storage Tank) system, all pumps are stagger-started on a low float condition.
- A low float condition generates a low well alarm and an optional transducer fault alarm (see “Transducer Low Level Fault” on page 131).

> **IMPORTANT**: A low float condition has precedence over all other faults and alarms, including high float and high level conditions. If a low float condition exists, no pumps will be allowed to start.

High Float

Configuration option: *High Float*

Modes: *Enable* or *Disable*

Notes:

- If a high level float is being used, *High Float* ***must*** be enabled.
- If a high level float is not connected and *High Float* is enabled, there is ***no*** effect on the operation of the TCU.
- In a Pump Down Mode (Lift Station) system, all pumps are stagger-started on a high float condition. In a Pump Up Mode (Storage Tank) system, all pumps are stopped on a high float condition.
- A high float condition generates a high well alarm and an optional transducer fault alarm (see “Transducer High Float Fault” on page 130).

How low- and high-level float conditions are handled

In a Discrete Pump Down Mode (Lift Station) system, all pumps are stagger-started on a high-level float condition. The pumps will remain on until the high float condition clears. (**NOTE:** to prevent the pumps from short cycling on a high float, configure minimum run and off times for the pumps. See Minimum Pump Run and Off times beginning on page 123.) All pumps will be stopped on a low-level float condition; the same pump timer rules apply. In the event of a High and Low float condition at the same time, the low float condition takes precedence and pumps will not run until the low float condition clears.

In a Discrete Pump Up Mode (Storage Tank) system, all pumps are stagger-started on a low level float condition. The pumps will remain on until the low float condition clears. (**NOTE:** to prevent the pumps from short cycling on a low float, configure minimum run and off times for the pumps. See Minimum Pump Run and Off times beginning on page 123.) All pumps will be stopped on a high level float condition; the same pump timer rules apply. In the event of a Low and High float condition at the same time, the Low float condition takes precedence and pumps will continue to run until the Low float condition clears.

Pump Mode	Transducer	Active Float	Pump Control (All)
Up	OK	Low	Stagger on
Up	OK	High	Off
Up	Fault	--	Stagger on
Up	Fault	High	Off
Down	OK	Low	Off
Down	OK	High	Stagger on
Down	Fault	--	Off
Down	Fault	High	Stagger on

FAULT MODE, ALARM HORN, ALARM LIGHT, AUTO RETRY

From the TCU's second configuration screen, you can:

- Configure how transducer faults are handled
- Enable or disable the alarm horn
- Enable or disable the alarm light
- Configure the TCU to retry a faulted pump after 10 minutes

```
Fault Mode : Disable
Alarm Horn : Disable
Alarm Light: Enable
Auto Retry : Enable
```

Transducer Fault Mode

Configuration option: *Fault Mode*

Modes: *Disable*, *Timer, Analog2* or *Floats*

This setting is only for stations using an analog transducer as the primary method of pump control. If you are using floats as the primary method of pump control, leave Transducer Fault Mode at the default setting (Disable).

Note: High and/or low floats can be used for backup operation in addition to the configured Transducer Fault Mode (Timer, Analog2, or Floats). If the primary transducer were to fail, the TCU would switch to the configured mode (Timer, Analog2, or Floats). If the level were to reach the high or low stage while in one of these modes, the TCU would begin operating the pumps based on the float reading. It would continue operating this way until the float cleared.

Transducer Fault Mode provides four options for operation when a transducer fault occurs.

- *Disable* – Set Transducer Fault Mode to *Disable* if the station will not be using one of the other fault mode options (Timer, Analog2, or Floats). If this option is set to *Disable* and high and/or low floats have ***not*** been enabled, the system will shut down when a transducer fault occurs in either pump up or pump down station operation.
- *Timer* – For each pump, the TCU maintains a log of average run time and average off time for each hour of the day. When the *Timer* option is selected and a transducer fault occurs, the TCU will turn the pumps on and off based on the averages for each hour recorded in the log.
- *Analog2* –When an auxiliary transducer is connected and this option is selected, a fault with the primary transducer will cause the TCU to switch to the backup transducer.
- *Floats* – When this option is selected, a fault with the primary transducer will cause the TCU to switch to normal float behavior. This mode requires an Off float to shut off the pumps and a miniumum of one float (Lead to High) to start the pumps.

For information on what causes a Transducer Fault alarm and how the TCU operates under this fault condition, refer to the section "How low- and high-level float conditions are handled" on page 114 and "Transducer Fault" on page 147 in "Chapter 12: Viewing and Troubleshooting Alarms."

Alarm Horn

Configuration option: *Alarm Horn*

Modes: *Enable* or *Disable*

When *Alarm Horn* is enabled, alarms are reported both at the station and through telemetry. If there are active alarms when the TCU's alarm horn option is enabled, the alarm horn will not sound until the existing alarms have cleared and a new alarm occurs. Disabling the alarm horn option does ***not*** prevent alarms from being reported via telemetry.

Alarm Light

Configuration option: *Alarm Light*

Modes: *Enable* or *Disable*

When the alarm light option is enabled, alarms are reported both at the station and through telemetry. Disabling the alarm light option does ***not*** prevent alarms from being reported via telemetry.

Auto Retry

Configuration option: *Auto Retry*

Modes: *Enable* or *Disable*

The TCU can be configured to retry a faulted pump - one that fails to start when called (Motor Start Fault) or one that is running when it has not being called to run (Motor Stop Fault). The TCU and PCU's responses to Motor Start Faults and Motor Stop Faults with the Auto Retry function enabled are identical. The response to Motor Stop Faults differs if the Auto Retry function has been disabled.

Motor Start Fault

If the Auto Retry option has been enabled, a pump that experiences a Motor Start Fault remains faulted by the TCU (and the PCU) until the pump sequence is complete (tank or well reaches the Off level set point; no pumps are running in automatic). The TCU attempts to start the failed pump during the next regular pump cycle. Be aware that the Motor Start Fault will not clear until the pump actually runs or the H-O-A switch is moved out of Auto.

Motor Stop Fault

If the Auto Retry function is enabled, the TCU will attempt to use the faulted pump the next time its turn comes up in the alternation order. If the TCU is successful at calling the pump to run and receives a pump run status, it will clear the Motor Stop Fault. This response is identical to that of the PCU.

If the Auto Retry function is disabled, the TCU will not clear a Motor Stop Fault and will not use a faulted pump until the pump's operation is overridden (by moving the corresponding H-O-A switch to the Off or Hand position, or by overriding the pump via telemetry). The TCU considers the pump failed and will take the failed pump out of rotation and assign a new lead pump to start with the lead level. A PCU with Auto Retry disabled also will not clear the Motor Stop Fault. However, the PCU will attempt to start the faulted pump the next time its turn comes up in the alternation order. The PCU makes the assumption that the pump run status is accurate and will delay another pump from starting until the number of pumps required is one more than the failed number of pumps. For example if pump 2 has failed, and pump 1 is the lead pump, pump 1 will not start until the Lag 1 level is reached.

Clearing a Motor Start or Stop Fault

A Motor Start or Stop fault can be cleared by switching the H-O-A switch of the faulted pump to either the “Hand” or “Off” position, and then back to “Auto.”

PUMP ALTERNATION, FLOW EQUALIZATION, MOTOR START AND STOP FAULT

From the third configuration screen, you can:

- Configure the TCU to alternate pumps
- Configure a motor start fault timer
- Configure a motor stop fault timer

```
Alternate  : All
Fl Eq Lead  = 14 ft
Start Fault = 5 Sec
Stop Fault  = 5 Sec
```

Flow Equalization (A function utilized by Symphony)

The Fl Eq Lead option is a function utilized by the DFS patented "Symphony - Harmonious Pump & Flow Management" technology. For more information about Symphony please contact the DFS Sales Department at 321-259-5009 or by email at sales@dataflowsys.com.

Pump Alternation

Configuration option: *Alternate*

Modes: *All, Pmp1&2, Pmp2&3, None*

The TCU features an option that enables it to start a different pump each time the station is called to pump. This type of configuration ensures that pumps are exercised equally; one pump isn’t doing all of the work.

- *All* alternates among all available pumps.
- *Pmp1&2* alternates between pumps 1 and 2 (High Service mode). In this mode, pump 3 (high service pump) will only come on if the tank level reaches the Lag2 level. Additionally, when the Lag2 level is reached, both pumps 1 and 2 will be turned off. The high service pump (pump 3) remains on until the Off level is reached.
- *Pmp2&3* alternates between pumps 2 and 3 (Jockey Pump mode). In this mode, pump 1 always comes on with the Lead level. If the Lag1 level is reached, the lead pump is turned off and pump 2 or 3 comes on.
- *None* disables pump alternation. When *Alternate* is set to *None*, pump 1 becomes the Lead pump, pump 2 becomes the Lag pump, and pump 3 becomes the Lag2 pump.

If pump alternation is enabled (set to *All*, *Pmp1&2*, or *Pmp2&3*) and a pump fails to start, the alternator advances to the next available pump. If a pump is taken out of service with the H-O-A switches, the TCU continues to alternate the remaining pumps.

Motor Start Fault Delay

Configuration options: *Start Fault*

Range: 0-510 seconds

The TCU is designed to detect a motor that fails to start. *Start Fault* is the amount of time the TCU waits to receive the motor-run signal after it has attempted to start the motor. If the start-delay timer expires, the motor-starter alarm for that motor is activated, and the TCU shuts down the starter.

This delay time, along with the *Stop Fault* delay (see below), allow the TCU to control solid-state starters with "soft-start" and "soft-stop" features. Some solid-state starters don't close the run contacts until the motor is ramped to 80 percent of the operating voltage. The ramp time is based on the "soft start" time. A similar situation occurs when the starter ramps the motor down; the run contacts stay closed until the output voltage drops by 80 percent. The start delay and stop delay times for the TCU must be set at a value greater than these "soft-start" and "soft-stop" times. If *Start Fault* is set to zero, the alarm feature is disabled and the pumps will continue to be controlled regardless of the pump status inputs.

Note: Due to the TCU's process loop time, this delay may take up to 2 seconds longer.

Motor Stop Fault Delay

Configuration options: *Stop Fault*

Range: 0-510 sec

The TCU is designed to detect a motor that fails to stop. *Stop Fault* is the amount of time the TCU waits to receive the motor-stop signal after it has attempted to stop the motor. If the stop-delay timer expires before the run signal goes away, the motor-starter alarm for that motor is activated.

This delay time, along with the *Start Fault* delay (see above), allow the TCU to control solid-state starters with "soft-start" and "soft-stop" features. Some solid-state starters don't close the run contacts until the motor is ramped to 80 percent of the operating voltage. The ramp time is based on the "soft start" time. A similar situation occurs when the starter ramps the motor down; the run contacts stay closed until the output voltage drops by 80 percent. The start delay and stop delay times for the TCU must be set at a value greater than these "soft-start" and "soft-stop" times. If *Stop Fault* is set to zero, the alarm feature is disabled and the pumps will continue to be controlled regardless of the pump status inputs.

Note: Due to the TCU's process loop time, this delay may take up to 2 seconds longer.

TIME DELAY RELAY

```
Time Dly Rly:
AuxOut Turns: On
: 10 Seconds after
AuxIn Turns : On
```

The TCU's auxiliary input [AUX_IN (P2-12)] and output [AUX_OUT (P1-19)] can be programmed to function together as a time delay auxiliary relay. The auxiliary output can be configured as a time-delayed output based on the ON or OFF state of the auxiliary input. This enables the auxiliary input to control one edge of the auxiliary output.

One example of the auxiliary feature is to operate a redundant bubbler system. The auxiliary input would monitor an airflow fault switch to activate a backup bubbler compressor. Alternatively, the auxiliary input can be used independent of the output as a simple status input.

For example, the TCU can be programmed to turn the auxiliary output ON ten seconds after the auxiliary input turns OFF. If the Time Delay Relay feature is disabled, the AUX_OUT and AUX_IN terminals function as standard control and monitor points for the telemetry system.

The time delay relay option requires that the following three settings be configured: *AuxOut Turns* (On/Off), (xxx) *Seconds after*, *AuxIn Turns* (On/Off).

Define Relationship between AUX_IN and AUX_OUT

Configuration options: *AuxOut Turns* and *AuxIn Turns*

Modes: *On* or *Off*

Together, the settings *AuxOut Turns* (On/Off) and *AuxIn Turns* (On/Off) define how AUX_OUT responds when the state of AUX_IN changes.

Does the state of the auxiliary output follow the state of the auxiliary input?

- AUX_OUT turns ON when AUX_IN turns ON
- *AUX_OUT* turns OFF when *AUX_IN* turns OFF

Or is the relationship inverted?

- AUX_OUT turns OFF when *AUX_IN* turns ON
- *AUX_OUT* turns ON when *AUX_IN* turns OFF

Define Delay Time

Configuration option: *Seconds after*

Range: 0-510 seconds in one-second increments

This setting determines the amount of time that is allowed to pass before turning the auxiliary output on or off. *Seconds after* can be set between 0 and 510 seconds in one-second increments. Assigning this setting a value of zero (0) disconnects the *AUX_IN* and the *AUX_OUT* and makes them available to telemetry as general monitor and control points.

RANGE OF ANALOG TRANSDUCERS

From the TCU's fifth configuration screen, you can enter the well- or tank-level values for the range of the primary (*Xdcr1*) and an optional secondary (*Xdcr2*) analog transducer.

```
Xdcr1 Low  = 0.0 ft
Xdcr1 High = 30.0 ft
Xdcr2 Low  = 0.0 ft
Xdcr2 High = 30.0 ft
```

Configuration options: *Xdcr1 Low*, *Xdcr1 High*, *Xdcr2 Low*, and *Xdcr2 High*

Range: 0-60 ft in one-tenth foot increments

For analog transducer applications only.

The TCU can accommodate both a primary and a backup analog transducer.

- The primary transducer's (*Xdcr1*) positive current or voltage signal is connected to terminal P2-22 (ANALOG1+).
- The backup transducer's (*Xdcr2*) positive current signal is connected to terminal P2-21 (ANALOG2+).

XdcrX Low and *XdcrX High* represent the range of the transducer and are used by the TCU to calculate the well or tank level.

- *XdcrX Low* is the level (measured in feet) at which the transducer outputs 4 mA / 0 V.
- *XdcrX High* is the level at which the transducer outputs 20 mA / 5 V.

Note that the *XdcrX High* value can be less than the *XdcrX Low* value for transducers that provide signals that decrease when the measured distance increases.

SET POINT LEVELS (ANALOG TRANSDUCERS ONLY)

From the sixth and seventh configuration screens, you can set the staging levels for analog systems.

```
Low SetPnt = 2.0 ft
LeadOff Pt = 5.0 ft
LagOff Pt  = 5.0 ft
Lag2Off Pt = 5.0 ft
```

```
LeadOn Pt  = 10.0 ft
LagOn Pt   = 15.0 ft
Lag2On Pt  = 20.0 ft
High SetPt = 25.0 ft
```

Configuration options: *Low SetPnt*, *LeadOff Pt*, *LagOff Pt*, *Lag2Off Pt*, *LeadOn Pt*, *LagOn Pt*, *Lag2On Pt*, *High SetPt*

Range: 0-60 feet in one-tenth foot increments

Staging levels for analog systems are configured using set points. When the analog level reaches a configured set point value, the TCU enters that staging level and the corresponding well or tank level LED illuminates. Levels can be set between 0 and 60 feet in one-tenth foot increments. See "Pumping Modes" on page 24 in "Chapter 2: Principles of Operation" for more information on staging levels.

The set points *LagOff Pt* and *Lag2Off Pt* enable you to define the level at which ***each*** pump is turned off. If you are implementing the TCU in a Legacy PCU well-emptying operation (Pump Down mode), you can set *LagOff Pt* and *Lag2Off Pt* to the same setting as *LeadOff Pt*, which is the desired minimum operational level of the well.

Simplex stations require that *Low SetPnt*, *LeadOff Pt*, *LeadOn Pt*, and *High SetPt* be configured.

Duplex stations require that *Low SetPnt*, *LeadOff Pt*, *LeadOn Pt*, *LagOn Pt*, and *High SetPt* be configured.

Triplex stations require that *Low SetPnt*, *LeadOff Pt*, *LeadOn Pt*, *LagOn Pt*, *Lag2On Pt*, and *High SetPt* be configured.

```
Low SetPnt = 2.0 ft
LeadOff Pt = 5.0 ft
LagOff Pt  = 5.0 ft
Lag2Off Pt = 5.0 ft
```

Low SetPnt

- Pump Up mode – In tank filling operations, all pumps are running and alarms are activated when the tank's level ***falls below*** this set point. This level must be set below all other levels.
- Pump Down mode – In well emptying operations, pumps are shut down and alarms are activated when the well's level ***falls below*** this set point. This level must be set below all other levels.

LeadOff Pt

- Pump Up mode – For tank filling operations, this is the tank's maximum operational level. The TCU turns off the Lead, or first, pump when the tank's level ***rises above*** this set point.
- Pump Down mode – For well emptying operations, this is the well's minimum operational, or Off, level. The TCU turns off the Lead, or first, pump when the well's level ***falls below*** this set point.

LagOff Pt

Note: This setting is used for duplex (two-pump) and triplex (three-pump) stations only.

- Pump Up mode – In tank filling operations, the TCU turns off the Lag, or second, pump when the tank's level ***rises above*** this set point.
- Pump Down mode – In well emptying operations, the TCU turns off the Lag, or second, pump when the well's level ***falls below*** this set point.
- This can be set to the same value as *LeadOff Pt* for either operation.

Lag2Off Pt

Note: This setting is used for triplex (three-pump) stations only.

- Pump Up mode – In tank filling operations, the TCU turns off the Lag2, or third, pump when the tank's level ***rises above*** this set point.
- Pump Down mode – For well emptying operations, the TCU turns off the Lag2, or third, pump when the well's level ***falls below*** this set point.
- This can be set to the same value as *LeadOff Pt* for either operation.

```
LeadOn Pt  = 10.0 ft
LagOn Pt   = 15.0 ft
Lag2On Pt  = 20.0 ft
High SetPt = 25.0 ft
```

LeadOn Pt

- Pump Up mode – In tank filling operations, the TCU starts the Lead, or first, pump when the tank's level ***falls below*** this set point.
- Pump Down mode – In well emptying operations, the TCU starts the Lead, or first, pump when the well's level ***rises above*** this set point.

LagOn Pt

Note: This setting is used for duplex (two-pump) and triplex (three-pump) stations only.

- Pump Up mode – In tank filling operations, the TCU starts the Lag, or second, pump when the tank's level ***falls below*** this set point.
- Pump Down mode – In well emptying operations, the TCU starts the Lag, or second, pump when the well's level ***rises above*** this set point.

Lag2On Pt

Note: This setting is used for triplex (three-pump) stations only.

- Pump Up mode – In tank filling operations, the TCU starts the Lag2, or third, pump when the tank's level ***falls below*** this set point.
- Pump Down mode – In well emptying operations, the TCU starts the Lag2, or third, pump when the well's level ***rises above*** this set point.

High SetPt

- Pump Up mode – In tank filling operations, the TCU stops all three pumps and activates alarms when the tank's level ***rises above*** this set point. This level must be set above all other levels.
- Pump Down mode – In well emptying operations, the TCU starts all three pumps and activates alarms when the well's level ***rises above*** this set point. This level must be set above all other levels.

MINIMUM PUMP RUN AND OFF TIMES, LOW & HIGH PHASE VOLTAGE LIMITS

From the TCU's eighth configuration screen, you can:

- Establish the minimum time that a pump must run before it can be turned off
- Establish the minimum time that a pump must remain off before it can be started again
- Set low and high phase-to-phase voltage limits

```
MinmumRun = 0.1 Min
MinmumOff = 0.2 Min
LoPhaAlm  = 200 VAC
HiPhaAlm  = 260 VAC
```

Minimum Pump Run Time

Configuration option: *MinmumRun*

Range: 0-120 minutes in one-tenth minute increments

To prevent short cycling of the pumps, a minimum run time can be configured. When used, this option will cause a started pump to run for the specified time before it can be turned off. The minimum run time can be set between 0 and 2 hours in one-tenth minute increments. Setting *MinmumRun* to zero disables the function, which allows the pump to be turned off at ***any*** time after it has been started.

Note: In pump-down mode, the minimum run timer is ***not*** overridden by the low float or low-level set point being reached. In pump-up mode, this timer is ***not*** overridden by the high float or high-level set point being reached.

Minimum Pump Off Time

Configuration option: *MinmumOff*

Range: 0-120 minutes in one-tenth minute increments

This option causes a pump that has been turned off to remain off for the specified time before it can be started again. *MinmumOff* can be set between 0 and 2 hours in one-tenth minute increments. Setting *MinmumOff* to zero disables the function, which allows the pump to be turned on at ***any*** time after it has been stopped.

Note: In pump-down mode, the minimum off timer is ***not*** overridden by the high float or high-level set point being reached. In pump-up mode, this timer is ***not*** overridden by the low float or low-level set point being reached.

Low- and High-Limit Phase Voltage

Configuration option: *LoPhaAlm* and *HiPhaAlm*

Range: 151-300 V in 1 V increments (240 VAC phase monitor)

0-600 V in 1 V increments (480 VAC phase monitor)

One of the functions of the TCU's phase monitor is to detect low and high phase-to-phase voltage. The low- and high-phase voltage limits are provided to allow for the usual variations in voltage from the power company. Phase voltage alarms generated by these settings will disable pump controls unless the external phase monitor input is on, which bypasses the internal phase monitor. (**Note:** It is not good practice to wire three-phase to the TCU if using an external phase monitor.)

LoPhaAlm and *HiPhaAlm* can be set in 1 V increments between 151 and 300 for a 240 VAC phase monitor and between 0 and 600 for a 480 VAC phase monitor.

WELL VOLUME, FLOW UNITS, CLOCK SET, TIMERS RESET

From this screen, you:

- Specify the volume of the well
- Indicate how flow is measured
- Set the TCU's internal clock
- Reset the TCU's run timers

```
WellVolume = 500 Ga
Flow Units = MGD
      Set Clock
    Reset Timers
```

Flow Volume Configuration

Configuration option: *WellVolume*

Range: 0-9999

Calculations for total station flow and average pump flow require that a volume be specified in the TCU. The volume, a configured value from 0 to 9999 ("Appendix F: Well Volume Calculations") is calculated between the Lead Off and Lead levels of a well or tank. If the volume is configured as 0 (zero), the meters for total station flow (*TFlow*) and average pump flow (*Avg Pump Rate*) are not displayed. The register and display can handle accumulated numbers up to one billion units (12 digits)

Flow Units Configuration

Configuration option: *Flow Units*

Modes: *MGD* or *GPM*

The TCU allows you to specify if flow is measured in millions of gallons per day (MGD) or gallons per minute (GPM).

Set Clock

The TCU's internal clock can be set from the *Set Clock* screen.

1. Navigate to the *Set Clock* line and press the Enter key.
2. Enter the current time in hours, minutes, and seconds, by scrolling to the corresponding line and entering a value.
3. When all desired changes have been made, press the Enter key.

Reset Timers

Meters for each of the pumps can be reset from the Reset Timers screen. When a timer for a particular pump is reset, the following meters are set to zero:

- *Total Run* – total amount of time the pump motor has run.
- *AverageRun* – average amount of time the pump motor has run over the last 16 pump cycles.
- *Avg Pump Rate* – average amount of flow pump moves per pumping cycle.
- *TFlow* – total amount of flow station has moved.

To reset the meters for a particular pump:

1. Navigate to the *Reset Timers* line and press the Enter key.
2. Use the ▲ and ▼ keys to place the cursor on the line of the pump whose meters you want to reset.
3. Use the navigation keys to change the pump's value from *N* to *Y*.
4. To reset the timers for additional pumps, repeat steps 2 and 3.
5. When all desired changes have been made, press the Enter key.

To reset the total flow of the station, cycle the TCU's power.

PUMP MODE, PHASE MONITOR RANGE, AUXILIARY INPUT ALARM

On the tenth configuration screen, you can:

- Specify the station's pumping mode
- Set the phase monitor's range
- Enable the auxiliary input's alarm
- Configure the auxiliary input's alarm state

```
Pump Mode  : Down
PhMon Rng  : 240VAC
AuxIn Alm  : Enable
AuxAlm On  : Open
```

Pumping Mode

Configuration option: *Pump Mode*

Modes: *Down* or *Up*

The TCU can operate in two pump arrangements: "pump up" or "pump down." Pump up is used to maintain a fill level in a tank system. Pump down is used to keep a well below a set level.

Phase Monitor Range

Configuration option: *PhMon Rng*

Modes: *240V 1PH*, *240V 3PH*, or *480V 3PH*

The TCU's internal phase monitor can be configured as a 240 VAC single- or three-phase monitor; or a 480 VAC three-phase monitor (with external resistors). The phase monitor enables adjustments to phase imbalance and low and high voltage trip points. Select the *PhMon Rng* option that describes the type of phase monitor being implemented.

> **IMPORTANT:** The configuration option selected must match the physical wiring. An incorrect configuration could cause the TCU to not protect pump motors from undesirable power conditions.

Auxiliary Input Alarm Option

The *AUX_IN* terminal can be configured to activate the alarm light. To use the auxiliary input alarm option, you must enable the option and define the input's alarm state. When enabled, the alarm will be latched in the TCU's alarm log until the condition clears and the alarm is viewed from the Alarms screen. The alarm horn is not activated by this option.

Enable Auxiliary Input Alarm

Configuration option: *AuxIn Alm*

Modes: *Enable* or *Disable*

Define Alarm State

Configuration Option: *AuxAlm On*

Modes: *Close* or *Open*

BEM-connected Modules, Trend Rate, Modbus Settings, Dialer Settings

The 11th configuration screen allows you to:

- Specify the number of modules on the RTU Bus that are connected by the BEM
- Supply a trend rate for the default status screens trend
- Configure the TCU to poll Modbus slave devices
- Select the baud rate and protocol to use when polling Modbus slave devices
- Configure the TCU's Autodialer (where applicable)

```
Bem Modules: 0
Trend Rate = 30 secs
  Configure Modbus
   Configure Dialer
```

Number of BEM-connected Modules

Configuration option: *Bem Mods*

Range: 0-8

This number indicates the number of real modules that are already on the RTU bus and connected by the BEM (Bus Extender Module). Configuring the TCU with the number of BEM modules enables it to assign itself to the next available module address(es). For example, if there are already four modules on the bus (A, B, C, D), the TCU will start at module E.

Trend Rate

Configuration Option: *Trend Rate*

Range: 2-999 seconds

Trend rate is the update frequency for the default status screen's trend. The default trend rate is 30 seconds; the trend can display the last eleven (11) updates. At the default trend update rate of 30 seconds, the length of time that can be displayed is 5 ½ minutes (11 x 30 seconds). Shorten or lengthen the trend rate as suits your needs.

Poll Modbus Slave Devices

Configuration Options: *ModX Adr*; *ModX Lth*

The TCU stores data in its internally defined I/O function modules. Modules A-G and module R are used by the pump control process. (See "Pump Control Application by Module Letter and Point" beginning on page 253 of "Appendix N: Polling the TCU – DFS Point and Modbus Registers.")

Modules H-O can be used to store data from Modbus slave devices connected to the TCU on its RS-485 interface. (A typical application would be adding a RIO032/RIO128. See "Appendix K: Adding a RIO to the TCU.")

Each of the modules (H-O) can accomodate:

- Twelve (12) digital status registers, or
- Eight (8) digital control registers, or
- Four (4) analog status registers, or
- Four (4) analog control registers

Modbus polling is activated by entering the correct Modbus information (address and length) into the TCU's configuration registers.

Configuring Modbus Information

Page through the TCU's configuration screens until you reach the screen that includes the "Configure Modbus" option. Navigate to the Configure Modbus line and press Enter.

The first screen allows you to configure the Module H and Module I registers. Use the right navigation button to page to the screens for the remaining modules (J-O). When configuring for Modbus polling, we recommend that you use the first available TCU module. For example, if modules J-O are available, configure module J; don't skip to M.

For each module you want to configure, you must enter an address (*ModX Adr*) and length (*ModX Lth*).

ModX Adr

ModX Adr (address) is the Modbus device ID/node and the first register for the range of registers being added to the current module. The ID and starting register are separated with a dot. For example, ModH Adr would be 1.10001 when adding digital inputs to device 1, module H.

Valid range for Modbus device IDs is 1-250; valid range for starting registers is 0001 to 49999.

ModX Lth

ModX Lth (length) is the number of registers being added to the current module.

Valid length values are:

- 1-12 for digital status registers
- 1-8 for digital control registers
- 1-4 for analog status registers
- 1-4 for analog control registers

For example, ModH Lth would be 8 when adding 8 digital inputs to module H. For Analog registers, the Length field requires an additional value that represents resolution (a bit mask value that represents the number of bits the TCU is emulating when it communicates with Modbus devices). For analog registers, the length and the bit mask value are separated with a dot. For example, 4.15 for a TCU querying for 4 analog registers with a bit masking value of 15 (full-scale output of 32760).

The TCU has a 12-bit resolution with a full-scale (20 mA) output of 4095. When communicating with devices with a greater resolution and output, you must add a 2-digit value to the end of the length parameter. This enables the TCU to use the appropriate value when converting the higher-resolution value into a 12-bit value that it can understand.

The most common bit mask is 15, which applies to a 16-bit signed integer with a full scale value of 32767. The most significant bit (MSB) is the sign bit that designates a positive or negative number. The TCU applies only to unsigned integers; therefore the sign bit in this configuration does not apply. A bit mask of 16 would apply to an unsigned integer with a full scale value of 65535.

A bit value of 00 applies the default resolution of 12 bit. These are the valid bit mask values:

- 00 or 12 – 12-bit resolution with a full-scale output of 4095
- 13 – 13-bit resolution with a full-scale output of 8190
- 14 – 14-bit resolution with a full-scale output of 16380
- 15 – 15-bit resolution with a full-scale output of 32760
- 16 – 16-bit resolution with a full-scale output of 65520

For example, a *ModH Adr* of 3.30001 and *ModH Lth* of 4.15 would allow the TCU to get analog status data from a Modbus slave device (ID = 3) and place it in the TCU's registers 30001, 30002, 30003, and 30004 using a 16-bit word.

Once the correct Modbus device information has been configured in the TCU, the TCU will automatically poll the devices. The TCU polls Modbus registers as follows:

- Digital Status (10001-19999) and Analog Status (30001-39999) registers are polled continually.
- Digital Control (0001-9999) and Analog Control (40001-49999) registers are updated using the multiple register update command. At TCU power up, the status of Control registers is read once.

Configuring HT3 or Third-party HMI to Poll These Registers

HT3

You can view a device's status and initiate controls via telemetry by adding the modules and corresponding points to HT3. You would add the type of module that incorporates the type of I/O added. For example, if 8 (eight) digital input registers were added to module H, you would add a Digital Monitor Module (DMM) at module letter H and configure it with 8 digital input points.

Modbus HMI

If you were using a third-party Modbus HMI and 8 (eight) digital input registers were added to module H, you would add the registers that correspond to a DMM-type module at module H. (Refer to the "DFS Module to Modbus Register Maps" provided on page 267.)

After TCU power up, Modbus control registers are updated whenever the corresponding DFS points are changed via telemetry. Similarly, when Modbus status points change, their corresponding DFS points are updated. One module of Modbus data is processed approximately every 2 seconds.

More information on the TCU Modbus capabilities can be found in "Chapter 7: Telemetry Configuration."

Modbus Master Baud Rate and Protocol

Configuration Options: *Baud*; *Protocol*

Value (*Baud*): 1200, 2400, 4800, 9600
Mode (*Protocol*): 1-A7n, 2-A7e, 3-A7o, 5-R8n, 6-R8e, or 7-R8o

After you have entered all of the information for Modbus slave devices as discussed in the previous section, “Poll Modbus Slave Devices,” you must enter the baud rate and protocol to be used.

The baud rate and protocol screen can be found after the last module screen (Module O).

Baud Rate

With the cursor on the Baud line, press the Enter key to make the option editable (a question mark will appear). Use the numbered keys to enter the baud rate. Valid rates are 1200, 2400, 4800, or 9600. Note that if you enter a rate other than those listed here, then the TCU will resolve the baud rate to the closest valid value.

Protocol

With the cursor on the Protocol line, press the Enter key to make the option editable (a question mark will appear). Use the numbered keys to enter the number of the desired selection.

Option #	Description
1	ASCII, 7 data bits, no parity
2	ASCII, 7 data bits, even parity
3	ASCII, 7 data bits, odd parity
5	RTU, 8 data bits, no parity
6	RTU, 8 data bits, even parity
7	RTU, 8 data bits, odd parity

Configure the TCU’s Autodialer

This configuration applies only to TCUs that have the optional autodialer installed. See “Appendix H: TCU001-AD Autodialer” on page 177.

TRANSDUCER HIGH FLOAT AND LOW LEVEL FAULTS, TRANSDUCER NOISE FAULT, HIGH FLOAT OVERRIDE

The 12th configuration screen allows you to configure the TCU to:

- Generate a transducer fault and switch control to the configured fault mode when a High Float condition occurs
- Generate a transducer fault and switch control to the configured fault mode when a transducer low level or a Low Float condition occurs
- Detect an air pump failure by monitoring air pump induced noise (***bubbler systems only***)
- Give the High Float precedence in the event of an Off Float failure in float control mode.

```
Xdcr Hi   Flt=Enable
Xdcr Low  Flt=Enable
BblrNoise Flt=Enable
High override=Enable
```

Transducer High Float Fault

Configuration option: *Xdcr Hi*

Modes: *Enable* or *Disable*

When this option is enabled, a high float condition generates a transducer fault and switches control to the configured fault mode. Leaving the option disabled leaves pump control on the primary transducer whenever a high float condition occurs or the transducer reaches or exceeds 20 mA.

Operation Overview

If the High float is tripped, transducer fault and high well alarms are generated. The high float condition stagger starts all pumps (pump down mode) or stops all pumps (pump up mode). The transducer fault condition switches pump control to the configured fault mode (see "Transducer Fault Mode" on page 115). For a TCU operating in Timer or Transducer 2 fault mode, the pumps stay on/off (depending on pump mode) until the high float condition clears. For a TCU in Floats fault mode, the pumps will stay on/off until the level reaches the Off float. When the high float condition clears, normal pump operation resumes on the selected fault mode. The transducer fault alarm stays active and control remains with the configured fault mode until the TCU is reset.

Notes:

When you enable Transducer High Float Fault, you must wire a high float and also enable the High Float option. See "Enable a Low Float and/or a High Float" on page 113.

If you select Floats for Fault Mode, you can also enable the High Float Override option (discussed on the next page). This option gives the high float precedence in the event of an Off float failure.

Transducer Low Level Fault

Configuration option: *Xdcr Low*

Modes: *Enable* or *Disable*

When this option is enabled, a low float condition OR a transducer low level condition (level drops below Low set point) generates a transducer fault and switches control to the configured fault mode. Leaving the option disabled leaves pump control on the primary transducer whenever a low float or transducer low level condition occurs.

Note: The Low Float option can remain disabled if you only want a transducer low level fault to be generated if the level drops below the Low set point. To generate a transducer low level fault if either situation occurs (low float condition or low level condition), you must enable Low Float. See “Enable a Low Float and/or a High Float” on page 113.

Operation Overview (Low Float enabled)

If the Low Float option is enabled, a transducer low level fault is generated if the low float is tripped or if the level drops below the Low set point.

> **Low Float Condition:** If the transducer fault is generated by a low float condition, a low well alarm is generated, and all pumps are stopped (pump down mode) or stagger started (pump up mode). The pumps continute operating this way until the low float condition clears. When the low float condition clears, normal pump operation resumes on the selected fault mode. The transducer fault alarm stays active and control remains with the configured fault mode until the TCU is reset.
>
> **Low Level Condition:** If the transducer fault is generated by a low level condition, pump control switches to the configured fault mode (see “Transducer Fault Mode” on page 115). The transducer fault alarm stays active and control remains with the configured fault mode until the TCU is reset.

Operation Overview (Low Float disabled)

If the Low Float option is disabled, a transducer low level fault is only generated if the level drops below the Low set point. Pump control switches to the configured fault mode (see “Transducer Fault Mode” on page 115). The transducer fault alarm stays active and control remains with the configured fault mode until the TCU is reset.

Bubbler Noise Fault

Configuration option: *BblrNoise*

Modes: *Enable* or *Disable*

> **IMPORTANT:** This option is for bubbler systems only (leave disabled for non-bubbler systems). If there is no air bubbler air-pump installed, the TCU generates a "transducer fault" condition.

Enabling this option allows the TCU to detect an air pump failure by monitoring air pump-induced noise on the analog input.

Operation Overview

If no air pump-induced noise is detected for a duration of five (5) minutes when the level is between the Off and Lead levels (pumps are not running), the TCU will generate a transducer fault and switch pump control to the configured fault mode (see “Transducer Fault Mode” on page 115). The transducer fault alarm stays active and control remains with the configured fault mode until the TCU is reset.

High Float Override

Configuration option: *High Override*

Modes: *Enable* or *Disable*

When this option is enabled, the High Float is given precedence in the event of an Off float failure when the TCU is in Float control mode (this can be a floats-only system or an analog transducer system that uses floats for backup). See “Transducer Fault Mode” on page 115 for information on using Floats as a backup to an analog transducer.

Notes:

You must wire a high float and also enable the High Float option. See “Enable a Low Float and/or a High Float” on page 113.

Minimum run and off timers should be configured to prevent short cycling the pumps on high float transitions. See “Minimum Pump Run Time” and “Minimum Pump Off Time” on page 123.

Operation Overview

When a high float condition occurs with High Float Override enabled, all pumps are stagger started (pump down mode) or all pumps are stopped (pump up mode) and a High Well alarm is generated. The pumps remain running (pump down) or stopped (pump up) until the high float condition clears. When the high float condition clears, the High Well alarm is cleared.

High float transitions restart or stop pumps (based on pump mode); minimum pump run and minimum pump off timers are applied to prevent short cycling the pumps.

If a high float condition occurs when the TCU is operating in Floats fault mode, the transducer fault alarm stays active and control remains with the floats until the TCU is reset.

TCU Configuration Options Table

Option	Range/Mode	Description
No. Pumps	1	Simplex station
	2	Duplex station
	3	Triplex station
Xducer Type	4-20 mA	4-20 mA analog transducer
	0-5 V	0-5 V analog transducer
	Remote	Transducer is located at a remote location; data is sent to the TCU via telemetry.
	Floats	Float or pressure switch device
Low Float	Disable	Low level not connected
	Enable	Low level connected
High Float	Disable	High level not connected
	Enable	High level connected
Fault Mode	Disable	Disables fault mode option
	Timer	Control the pumps based on the average pump cycle times when a transducer fault occurs.
	Analog2	Switch control to the second analog input (backup transducer) when a transducer fault occurs.
	Floats	Switch control to float inputs when a transducer fault occurs.
Alarm Horn	Disable	Alarm horn disconnected; output to telemetry only
	Enable	Alarm horn connected
Alarm Light	Disable	Alarm light disconnected: output to telemetry only
	Enable	Alarm light connected
Auto Retry	Disable	Disables the auto retry function
	Enable	Enables the auto retry function
Alternate	All	Alternates among all available pumps
	Pmp1&2	Alternates between pumps 1 and 2
	Pmp2&3	Alternates between pumps 2 and 3
	None	Disables the pump alternator function
Start Fault	0-510 sec	Start delay time for starter fault (0 – disables fault)
Stop Fault	0-510 sec	Stop delay time for starter fault (0 – disables fault)
AuxOut Turns	On	Auxiliary output turns on in response to auxiliary input
	Off	Auxiliary output turns off in response to auxiliary input
Seconds after	0-510 sec	Amount of time before auxiliary output is turned on or off in response to auxiliary input. 0 disables time delay relay function.
AuxIn Turns	On	When auxiliary input turns on, auxiliary output’s state is changed
	Off	When auxiliary input turns off, auxiliary output’s state is changed
Xdcr1 Low	0.0-60.0'	Transducer 0 V or 4 mA level (transducer min)

Option	Range/Mode	Description
Xdcr1 High	0.0-60.0'	Transducer 5 V or 20 mA level (transducer max)
Xdcr2 Low	0.0-60.0'	Transducer 0 V or 4 mA level (transducer min)
Xdcr2 High	0.0-60.0'	Transducer 5 V or 20 mA level (transducer max)
Low SetPnt	0.0-60.0'	Low staging level set point
LeadOff Pt	0.0-60.0'	Level at which Lead (first) pump is turned off
LagOff Pt	0.0-60.0'	Level at which Lag1 (second) pump is turned off
Lag2Off Pt	0.0-60.0'	Level at which Lag2 (third) pump is turned off
LeadOn Pt	0.0-60.0'	Level at which Lead (first) pump is turned on
LagOn Pt	0.0-60.0'	Level at which Lag1 (second) pump is turned on
Lag2On Pt	0.0-60.0'	Level at which Lag2 (third) pump is turned on
High SetPt	0.0-60.0'	High staging level set point
MinmumRun	0.0-120.0 min	Minimum run time to prevent short cycling (one-tenth minute increments)
MinmumOff	0.0-120.0 min	Minimum off time to prevent short cycling (one-tenth minute increments)
LoPhaAlm	151-300 V (240 VAC) 0-600 V (480 VAC)	Lower limit for phase monitor response
HiPhaAlm	151-300 V (240 VAC) 0-600 V (480 VAC)	Upper limit for phase monitor response
WellVolume	0-9999	Set volume between Off and Lead Levels
Flow Units	MGD GPM	Flow is measured in millions of gallons per day Flow is measured in gallons per minute
Set Clock		Reset the TCU's internal clock
Reset Timers		Reset the meters for each pump
Pump Mode	Down Up	Keeps a well below a set level Maintains a fill level in a tank system
Ph Mon Lvl	240 VAC or 480 VAC	Voltage range of phase monitor
AuxIn Alm	Disable Enable	Disable the auxiliary input's alarm Enable the auxiliary input's alarm
AuxAlm On	Close Open	Auxiliary input alarms when closed Auxiliary input alarms when open
BEM Mod's	0-8	Number of real modules that are already on the RTU bus and connected by the BEM (Bus Extender Module)
Trend Rate	2-999 seconds	This is the update frequency for the default status screen's trend

Option	Range/Mode	Description
ModX Adr (where X represents any valid letter H-O)	1.0001-250.49999	Combined device ID and starting register in dot format of Modbus slave devices
ModX Lth (where X represents any valid letter H-O)	1-12 (digital status registers), 1-8 (digital control registers), 1-4 (analog registers)	Length of register (number of points to place in corresponding register). Length is dependent on the type of register being added. For analog registers, ModX Lth is the combined length and bit mask value (00, 12, 13-16) in dot format (e.g., 3.15).
Xdcr Hi	Disable	Leave control with primary transducer when a High Float condition occurs.
	Enable	Generate a transducer fault and switch control to the configured fault mode when a High Float condition occurs.
Xdcr Low	Disable	Leave control with primary transducer when a transducer low level or a Low Float condition occurs.
	Enable	Generate a transducer fault and switch control to the configured fault mode when a transducer low level or a Low Float condition occurs.
BblrNoise	Disable	Disable for non-bubbler systems.
(Used to detect an air pump failure in bubbler systems)	Enable	Generate a transducer fault and switch control to the configured fault mode if the TCU does not sense air pump induced noise on its analog input for a duration of five minutes during the time the pumps are stopped between the Off and Lead levels.
High override	Disable	Give Off float precedence when High float condition occurs without a concurrent Off float condition.
	Enable	Give High float precedence when Off Float failure occurs in float control mode.

Notes

Chapter 11: Viewing Status

> The information contained in this chapter refers to the TCU's built-in pump control process. It does not apply to a TCU with a custom program installed.

The TCU features seven screens that provide you with important information on the station's status, including current well level, total and average run time for each pump, and the number of times each pump has started.

You can move through the TCU's status screens using the ◄ and ► navigation keys.

When the TCU is turned on, it briefly displays firmware revision level, station and radio configuration information, and process ID and version, and then displays the default status screen.

Version and Radio Configuration Information

The first information screen displays the TCU's firmware revision level, station address, and the status of the station address connector's four radio configuration bits. For example, TCU001, Sta=208, Cfg=0000, would be displayed for a TCU at firmware level 1 (one) with a station address of 208 and a normal radio data configuration.

Radio data configuration is indicated as follows:

- CFG=0000 – Radio data is normal
- CFG=I000 – Radio data is inverted (P3-11)
- CFG=0S00 – Radio data is swapped (P3-12)
- CFG=IS00 – Radio data is inverted and swapped (P3-11 and P3-12)

The last two configuration bits are unused at this time.

The second information screen displays a program ID (for example, 90000 indicates that the pump control process is loaded) and program version (for example, 1.0041502, where 1.0 indicates that this is the first release of the software and 041502 indicates that the software was released on April 15, 2002.)

This information can be viewed at any time using the following key combinations.

- Press and hold the three (3) button to view the program ID and version level.

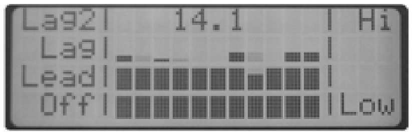
```
  Pump Controller

  Prog ID = 90001
 Version = .3042402
```

- Simultaneously press and hold the three (3) and Alarm Silence buttons to view serial number, station address, radio data configuration, BASIC chip firmware version, and radio chip firmware version.

```
    SN=000000000
  Sta=511 Cfg=0000
B 05/03/02<00/00/00>
R 05/01/02<00/00/00>
```

DEFAULT SCREEN



The TCU's default status screen displays:

- **Float Inputs** – The current time of day (00:00:00), along with a trend showing the maximum number of pumps running over the last 5 ½ minutes*, is displayed if float inputs are being used
- **Analog Level-sensing Transducer** – The current well or tank level (in feet), along with a graph showing changes in level over the last 5 ½ minutes*, is displayed if an analog level sensing transducer is being used. To view the current time of day, press the 5 (five) key.

*The length of time represented by the trend varies according to the configured trend rate. Trend rate is the frequency at which the trend is updated. The trend can display the last eleven (11) updates. At the default trend update rate of 30 seconds, the length of time that can be displayed is 5 ½ minutes (11 x 30 seconds). See "Trend Rate" on page 126 in "Chapter 10: Configuring the Pump Control Process" for instructions on setting the trend rate.

Labels for each of the well/tank's six analog set points are also displayed.

The TCU's six analog set points are: Low, Off, Lead, Lag, Lag2, and Hi. These set points can be ignored if a float control device is being used.

- For a Simplex station, the following labels will be displayed: Low, Off, Lead, and High.
- For a Duplex station, the following labels will be displayed: Low, Off, Lead, Lag, and High.
- For a Triplex station, all of the set points will be displayed: Low, Off, Lead, Lag, Lag2, and Hi.

The TCU indicates the well/tank's current level by illuminating the level's corresponding LED. For example, the LED next to Lag will be lit when the well or tank is at that level.

STATION SCREEN

The Station screen displays the following:

- **TFlow** – Derived total flow for the station; used in well applications (Pump Down mode) only.
- **Pwr @ AB** – Phase voltage between legs A and B
- **Pwr @ AC** – Phase voltage between legs A and C

Total Flow Meter: TFlow

TFlow = xxxxxxxxxxxx (measured in gallons)

The TCU provides a total station flow meter measured in gallons. *TFlow* is a derived total flow for the station that is calculated based on:

- Accurate well volume
- Time required for the well to fill from Lead Off to Lead
- Time required for the well to empty from Lead to Lead Off.

TFlow is only updated when the TCU has called the pumps to run automatically, and does so when the Off float closes (the beginning of a new pump cycle).

TFlow requires that a volume be calculated as outlined in “Flow Volume Configuration,” p.124. This calculated volume must be entered as the TCU’s *WellVolume* configuration. Please note that a *TFlow* value will be displayed even if *WellVolume* has not been configured. However, this will result in an inaccurate total flow value, since the *TFlow* calculation relies on a correct well volume.

Total flow data can be viewed on the TCU’s LCD or can be collected via the TCU’s service port. Note that the value for total flow automatically rolls over after 999,999,999 units (gal, liters, cf, etc.). If the TCU is being used with the HT3 telemetry system, total flow can be generated as a report in HT3.

TFlow can be reset as outlined in “Reset Timers,” p. 124.

Phase Voltage: Pwr @ AB, Pwr @ AC

Pwr @ AB = xxxx VAC, Pwr @ AC = xxxx VAC

Phase voltage between legs A and B (*Pwr @ AB*) and between legs A and C (*Pwr @ AC*) is displayed on the Station screen.

CUMULATIVE PUMP RUN TIME METER

Total Run: PumpX = xxxxxx.xx.xx

The TCU provides an elapsed time meter for each pump that has been configured and is being controlled by the TCU. The elapsed time meter displays the cumulative time that the motor has run (up to 999999 hours and 59 seconds).

The TCU uses the motor run inputs (*MTRx_RUN*) for each pump motor to control its respective elapsed time meter. *Total Run: PumpX* updates whenever the corresponding motor run input is ON regardless of the position of the H-O-A switches.

Data from the timer is stored in non-volatile memory. The elapsed time meter values for each pump can be reset as outlined in “Reset Timers,” p. 124.

AVERAGE PUMP RUN TIME METER

AverageRun: PumpX = xxxxxx.xx.xx

The TCU provides an average run meter for each pump that has been configured and is being controlled by the TCU. The average run time meter displays the average amount of time the pump motor has run over the last 16 pump cycles.

The TCU uses the motor run inputs (*MTRx_RUN*) for each pump motor to control its respective meter. The average run meter for each pump is only updated when the TCU has called the pump to run automatically, and does so after the called pump turns off.

Data from the timer is stored in non-volatile memory. The average run meter values for each pump can be reset as outlined in “Reset Timers,” p. 124.

AVG PUMP FLOW RATE SCREEN

Avg Pump Rate: PumpX = xxxx.xx

The TCU provides an average pump flow rate measured in gallons per minute (GPM) or millions of gallons per day (MGD), depending on the station's configuration, for each of the three pump motors it controls. *Avg Pump Rate* is the average pumping capacity for a particular pump and is calculated using the following equation:

$$\text{Avg Flow Rate} = \frac{\text{Volume}}{\text{Pump Time}} + \text{Influent Rate*}$$

*Influent Rate is equal to the time it takes to fill the well or tank from Lead Off to Lead level. For instructions on calculating volume, see "Appendix F: Well Volume Calculations."

As indicated by the equation, the calculation requires that a volume be calculated and input in the TCU's configuration. The average pump flow rate for each pump is only updated when the TCU has called the pump to run automatically, and does so after the called pump turns off. For information on configuring the TCU for volume, see "Flow Volume Configuration" on page 124.

Avg Pump Rate can be reset as outlined in "Reset Timers" on page 124.

PUMP STARTS SCREEN

Pump Starts: PumpX = x

The TCU features a counter that keeps track of the total number of times each configured pump has started since the TCU was installed or the time meter was reset. For information on resetting the time meter, see "Reset Timers" on page 124.

ANALOGS SCREEN

Analogs: C1 = xx.xx mA/V; C2 = xx.xx mA; Remote = xx.xx mA

The Analogs screen displays the current values of the TCU's two 12-bit analog inputs: C1 – *ANALOG1+* (P2-22) and C2 – *ANALOG2+* (P2-21). C1 can be displayed as mA or V depending on the TCU's setup and configuration.

A current value for Remote is displayed if a remote monitor point is being used. The TCU can accept data via telemetry from a monitor point and use this data to control another point (referred to as an auto control). For example, a sensor at a well two miles away is sent to the TCU, which uses this information to start a pump. This setup requires that an auto control be configured in the telemetry system

Chapter 12: Viewing and Troubleshooting Alarms

> The information contained in this chapter refers to the TCU's built-in pump control process. It does not apply to a TCU with a custom program installed.

The TCU's Alarm LED illuminates if there are any alarms to view. The LED flashes for active alarms and is steady for inactive (cleared) alarms that have not been viewed from the TCU's Alarm screen or acknowledged via telemetry.

To view alarms, use the ◄ and ► keys to navigate to the Alarms screen (If you are at the TCU's initial screen, pressing the ◄ key once will bring you to the Alarms screen). If the alarm horn is active, press the TCU's "Silence" button. Additionally, navigating to the Alarms screen will silence the alarm horn.

Alarms are displayed in 3 rows of 3 columns (see graphic below).

FltSeq	Strt	HiWell
DCBias	ACPwr	Xducer
PhaVol	AuxIn	

Following is a list of possible alarms:

- **FltSeq** – Floats are out of sequence
- **Strt** – Pump did not start
- **Stop** – Pump did not stop (this alarm message is displayed in the same location as *Strt*)
- **HiWell** – High well condition
- **LoWell** – Low well condition (this alarm message is displayed in the same location as *HiWell*)
- **DCBias** – DC bias (*ISO+24V*) failed
- **ACPwr** – AC power loss
- **Xducer** – Transducer fault
- **PhaVol** – Phase voltage fault
- **PhaSeq** – Phase sequence fault (this alarm message is displayed in the same location as *PhaVol*)
- **AuxIn** – Auxiliary input alarm

An alarm message is displayed differently depending on its status.

- Active alarms are indicated by a flashing alarm message. Messages for active alarms continue to flash after they have been viewed.
- Inactive alarms are indicated by a steady (non-flashing) alarm message. Messages for inactive alarms disappear from the Alarms screen after they have been viewed.

An alarm message flashes if there is an active alarm. If the alarm condition clears while the alarm message is being viewed, the alarm message stops flashing. Messages for inactive (cleared) alarms are static (non-flashing). These messages are stored in the TCU's alarm log until they are viewed. Once a message for an inactive alarm condition has been viewed, it is cleared from the TCU's display.

The Alarm LED flashes when there are active alarms and is static on (continuously lit) until all alarms have cleared ***and*** all corresponding alarm messages have been viewed. The Alarm LED is cleared when the alarm screen is exited and there are no active alarms.

When the TCU is used as a remote in conjunction with the telemetry system, active alarms will be displayed both locally (at the TCU) and via the telemetry system at workstation computers. Note that the TCU's alarm messages and alarm LED are ***not*** cleared via telemetry; they must be cleared locally.

AC Power Fault

Alarm message: *ACPwr*

The *ACPwr* alarm is activated when the TCU determines AC power has been interrupted. The TCU must be on backup battery power in order for this fault to function when the primary AC power fails.

> **IMPORTANT:** Be sure that *STRT_PWR* (P1-24) and *AC_PWR* (P1-5) are both connected to the station's control power. This ensures that all pumps under local control receive an emergency shutdown when AC power drops. If this is not done, multiple pumps could be commanded to start at the same time.

If an AC power fault alarm occurs at a TCU that is connected to a backup battery:

- Check that all circuit breakers are on.
- Check if any circuit breaker has tripped. If a station control panel breaker has tripped, resolve the problem.
- Check if the TCU's replaceable fuse has blown. See "Troubleshooting: Blown Fuse" on page 157.

Auxiliary Input Alarm

Alarm message: *AuxIn*

The TCU monitors the *AUX_IN* terminal (p2-12), and it can be configured to activate the **AuxIn** alarm when the terminal is open or closed. If the auxiliary input alarm has been enabled and *AUX_IN* enters its configured alarm state (open or closed), an auxiliary input alarm is generated.

DC Bias Fault

Alarm message: *DCBias*

The *ISO+24V* voltage, which is provided for biasing the digital monitor inputs and/or powering up to two analog transducers, is monitored by the TCU. If a fault occurs with the *ISO+24V* voltage, the *DCBias* alarm is activated.

> **IMPORTANT:** *ISO+24V* is provided ***only*** for biasing the 12 digital monitor inputs of the TCU and/or powering up to two analog transducers while not exceeding the maximum current of 100 mA.

If a DC bias fault alarm occurs, measure the voltage between the *ISO+24V* and *ISOGND* terminals. The voltage should be 20-24 VDC.

- Check for a short circuit condition between the *ISO+24V* and *ISOGND* terminals if the measured voltage is 0 (zero) VDC.
- If the voltage is low, check the current load on the *ISO+24V* source. It should be less than 100 mA.

If the current load is excessive, disconnect and isolate *ISO+24V* and *ISOGND* terminals to determine if the fault is with the bias source or in the external circuitry. If the fault appears to be with the external circuitry, try isolating each input connected to the *ISO+24V* voltage until the problem is found. If the problem cannot be isolated, the TCU may require factory service. See “Appendix O: Support, Service, and Warranty” for removal, replacement, and servicing instructions.

Float Sequence Fault

Alarm message: *FltSeq*

If the TCU detects floats out of sequence, it issues a *FltSeq* alarm. A *FltSeq* fault is not cleared at the TCU until the alarm message is viewed or after 24 hours have passed. A float sequence fault that is reported through telemetry clears on the next valid pump cycle (one without a float sequence fault).

When a float sequence fault alarm occurs:

- Check the floats or pressure switches for the fault. Verify that the corresponding Well Level LED illuminates when each float or pressure switch is on.
- Measure the voltage between the corresponding level input terminal and the *IN_COM_2* terminal. The voltage should be 10-30 VAC or VDC with the switch closed and 0 (zero) V with the switch opened.
- Check the wiring and verify all of the following:
  - Only one bias source is used to bias all floats or pressure switches.
  - The same voltage-dropping resistor is used for all floats or pressure switches.
  - The return for the bias voltage is properly connected to the *IN_COM_2* terminal.
  - If *ALM_SIL* and *AUX_IN* are used, verify that they use the same bias voltage and dropping resistor value as the level inputs.

If the problem cannot be resolved, the TCU may require factory service. See “Appendix O: Support, Service, and Warranty” for removal, replacement, and servicing instructions.

High Well Alarm

Alarm message: *HiWell*

The *HiWell* fault indicates that the *HI_LVL* input terminal is ON. Alternatively, if an analog transducer is being used, *HiWell* indicates that the level has risen above the High-level set point

If an erroneous alarm occurs, check the high float or pressure switch and wiring.

- When the switch is opened, 0 (zero) VAC/VDC, should be measured at the *HIGH_LVL* input.
- Measure the voltage between the *HIGH_LVL* and *IN_COM_2* terminals.
- Make sure the high float or pressure switch is not fouled or shorted.
- If necessary, disconnect the *HIGH_LVL* input to isolate the problem further.

If the problem is determined to be with the TCU, see “Appendix O: Support, Service, and Warranty” for removal, replacement, and servicing instructions.

LOW WELL ALARM

Alarm message: *LoWell*

The *LoWell* alarm indicates that the *LOW_LVL* input terminal is OFF. Alternatively, if an analog transducer is being used, *LoWell* indicates that the level has dropped below the Low-level set point.

If a *LoWell* alarm occurs, take the following steps:

- If a low level or pressure switch is not being used, disable the function in the configuration.
- If a low level or pressure switch is used and an erroneous alarm occurs, check the switch and wiring. When the switch is closed, 10-30 VAC or VDC should be measured at the *LOW_LVL* input.
- Measure the voltage between the *LOW_LVL* and *IN_COM_2* terminals.
- Make sure the return for the *LOW_LVL* input bias source is connected to the *IN_COM_2* terminal.

PHASE SEQUENCE FAULT

Alarm message: *PhaSeq*

The TCU's phase monitor is designed to detect phase losses, high and low phase faults, and phase sequence faults.

When the TCU detects a phase fault, it disables the pump motor outputs and activates the alarm light and horn relays. If a phase is missing or the power is interrupted, the TCU also indicates that a phase sequence fault has occurred by issuing a *PhaSeq* alarm.

If a sequence fault occurs, check the phase rotation of the incoming power. The label on the TCU's connector indicates the connection for clockwise phase rotation.

If the incoming power is labeled for counter-clockwise phase rotation, two of the leads wired into the TCU must be swapped. Turn off the main breaker before making any wiring changes. After the changes are made, turn on the main breaker and reconfigure the TCU's High and Low phase-voltage thresholds See “Low- and High-Limit Phase Voltage” on page 123 in “Chapter 10: Configuring the Pump Control Process” for instructions on changing these thresholds.

If the problem cannot be resolved, the TCU may require factory service. See “Appendix O: Support, Service, and Warranty” for removal, replacement, and servicing instructions.

PHASE VOLTAGE FAULT

Alarm message: *PhaVol*

The TCU's phase monitor is designed to detect phase losses, high-and low-phase voltage faults and phase sequence faults. When the TCU detects a phase fault, it disables the pump motor outputs and activates the alarm light and horn relays. The H-O-A switches can be used to override the TCU's phase monitor and control the pumps during a phase fault.

> **IMPORTANT:** The internal Phase Monitor of the TCU is only compatible with a 240 VAC phase-to-phase system (without external drop resistors) or a 480 VAC phase-to-phase system (with external drop resistors).

If a fault occurs, measure the TCU’s Phase A-B and Phase A-C line-to-line voltages. If a voltage is missing, turn off the main breaker and check the external phase monitor fuses.

The phase voltage set points establish the range used by the TCU to detect a phase voltage fault. If an erroneous alarm occurs, check to see that the upper and lower voltage limits are set properly. See Minimum Pump Run and Off Times, Low & High Phase Voltage Limits: Low- and High-Limit Phase Voltage” (p. 123) in “Chapter 10: Configuring the Pump Control Process” for instructions on setting voltage limits.

If the problem cannot be resolved, the TCU may require factory service. See “Appendix O: Support, Service, and Warranty” for removal, replacement, and servicing instructions.

MOTOR STARTER FAULT

Alarm message: *Strt*

A motor starter fault indicates that the TCU’s motor run inputs do not agree with its motor run outputs when the H-O-A switch is in the “Auto” position. The default time allowed for the input to follow the output is two seconds, but the start delay and stop delay time intervals can be configured from 2-510 seconds. Zero disables the starter fault alarm, and the output remains on regardless of the run status input.

To accommodate applications where the run signal may not be immediate, such as soft starts or Run signals from check valves, you can configure the TCU with a longer start and stop delay. See “Motor Start Fault Delay and Motor Stop Fault Delay” beginning on page 116 for more information.

A pump that experiences a Motor Start Fault (with or without Auto Retry enabled) remains faulted by the TCU (and the PCU) until the pump sequence is complete (tank or well reaches the Off level set point; no pumps are running in automatic). The TCU attempts to start the failed pump during the next regular pump cycle. Be aware that the Motor Start Fault will not clear until the pump actually runs or the H-O-A switch is moved out of Auto.

The TCU requires proper feedback to monitor pump motor run status. If the feedback signal malfunctions, the TCU activates the *Strt* alarm. The LED of the faulted pump (located under its H-O-A switch) flashes when a motor starter fault occurs.

The TCU's starter relays are solid-state devices with up to 0.1 mA off-state leakage current. This should not cause any problems with starter coils. However, it may force a solid-state starter with a high-input impedance to energize. If this occurs, there are two options to try.

- Try connecting a bleed resistor across the solid-state starter input. Select a resistance and wattage to shunt the leakage current.
- Install isolating relays between the TCU and the solid-state starter. Connect the TCU's starter relays to the coils of the isolating relays and control power through the isolating relay contacts to the solid-state starter inputs.

Check the starter circuit for faults by using the H-O-A switches to control the pumps. Verify that the pump run LED and the corresponding pump motor turn on when the H-O-A switch is in the “Hand” position and off when the switch is in the “Off” position. Switching the H-O-A switch out of the “Auto” position should clear the flashing pump run LED. If the LED does not turn on when the motor starts and turn off when the motor stops, check the wiring and verify that:

- Only one bias source is used to bias all motor run inputs.
- The same voltage-dropping resistor is used for all motor run inputs.
- The return for the bias voltage is properly connected to the *IN_COM_1* terminal.
- If the *EXT_PM* input is used, make sure that it uses the same bias voltage and dropping resistor as the motor run inputs.

Verify that the TCU’s configured motor start fault delay (*Start Fault*) is set to an adequate length of time. If necessary, increase the *Start Fault* delay.

If the problem cannot be resolved, the TCU may require factory service. See “Appendix O: Support, Service, and Warranty” for removal, replacement, and servicing instructions.

MOTOR STOP FAULT

Alarm message: *Stop*

A motor stop fault indicates that either the TCU sent a signal to turn off a pump and the pump remained on, or a pump came on without the TCU calling it. When this occurs, the LED under the faulted pump’s H-O-A switch flashes.

The default time allowed for the input to follow the output is two seconds. To accommodate applications where the stop signal may not be immediate, such as occurs with solid-state motor controllers, you can configure the TCU with a start and stop delay from 2-510 seconds. See Pump Alternation, Flow Equalization, Motor Start and Stop Fault: Motor Start Fault Delay and Motor Stop Fault Delay” (p. 116-118) for more information.

If the Auto Retry function is enabled (see Auto Retry, page 116), the TCU will attempt to use the faulted pump the next time its turn comes up in the alternation order. If the TCU is successful at calling the pump to run and receives a pump run status, it will clear the Motor Stop Fault. This response is identical to that of the PCU.

If the Auto Retry function is disabled, the TCU will not clear a Motor Stop Fault and will not use a faulted pump until the pump’s operation is overridden (by moving the corresponding H-O-A switch to the Off or Hand position, or by overriding the pump via telemetry). The TCU considers the pump failed and will take the failed pump out of rotation and assign a new lead pump to start with the lead level. A PCU with Auto Retry disabled also will not clear the Motor Stop Fault. However, the PCU will attempt to start the faulted pump the next time its turn comes up in the alternation order. The PCU makes the assumption that the pump run status is accurate and will delay another pump from starting until the number of pumps required is one more than the failed number of pumps. For example if pump 2 has failed, and pump 1 is the lead pump, pump 1 will not start until the Lag 1 level is reached.

If a motor stop fault occurs, verify that:

- The TCU's configured motor stop fault delay (*Stop Fault*) is set for an adequate length of time. If necessary, increase the *Stop Fault* delay.
- The mechanical auxiliary contacts on the motor controller's starter contactor are functioning properly. If they have been damaged and are stuck in the closed position, the motor controller will not receive the pump stop signal.
- The motor controller's starter contactor is functioning properly. If it has been damaged and is stuck in the closed position, the motor controller will not receive the pump stop signal.

If a sufficient *Stop Fault* has been configured and the starter contactor and its mechanical auxiliary contacts are determined to be functional, the TCU may require factory service. See "Appendix O: Support, Service, and Warranty" for removal, replacement, and servicing instructions.

TRANSDUCER FAULT

Alarm message: *Xducer*

The conditions that cause a transducer fault to be generated are based on the TCU's configuration. A few of the conditions that can cause a transducer fault are:

- Transducer low condition
- High float condition
- Absence of bubbler noise

The TCU provides several options for maintaining well and tank levels when a transducer fault occurs. Control pumps using:

- High and/or low float
- Timer based on the station's pumping history (average cycle per each hour of the day)
- Second analog transducer
- Float system (Off float and at a minimum a Lead or High float)
- Combination of a high and/or low float and the desired fault mode (timer, second transducer, floats)

The TCU uses the selected backup scheme until the problem with the transducer has been identified and fixed, and the TCU has been reset.

These options and the conditions that generate a transducer fault are described in more detail in "Chapter 10: Configuring the Pump Control Process" in the sections "Enable a Low Float and/or a High Float," "Transducer Fault Mode," "Transducer High Float Fault," and "Transducer Low Level Fault." Typical applications and configurations are provided in "Appendix M: TCU Transducer Configuration Examples."

If none of these options have been implemented (floats, timer, secondary transducer) and the primary analog transducer malfunctions, the TCU will be unable to provide automatic control until the malfunction is resolved. The alarm light and horn relays may be activated. See the section "Fault Mode, Alarm Horn, Alarm Light, Auto Retry" beginning on page 115 for more information on enabling the alarm horn and light.

When using an analog transducer, measure the voltage across the *ANALOG1+* and *ANALOG-* terminals. This voltage should be 1-5 VDC for a 4-20 mA transducer and 0-5 VDC for a 0-5 VDC transducer. The voltage measured between the *ANALOG1+* and *ANALOG-* terminals should vary according to the well or tank level.

> IMPORTANT: Only 4-20 mA transducers should have a jumper installed between the *ANALOG-* and *SHUNT* terminals. If you are using a 0-5 VDC transducer, verify that the jumper is ***not*** installed.

If the transducer is determined to be functional, the TCU may require factory service. See "Appendix O: Support, Service, and Warranty" for removal, replacement, and servicing instructions.

Leaving the Alarms Screen

Use the TCU's navigation keys to exit the Alarms screen. All inactive alarms are cleared from the TCU's alarm log when the Alarms screen is exited. Additionally, if no active alarm conditions exist, leaving the Alarms screen clears the Alarm LED.

Appendix A: Checkout Procedure for Pump Controller

Step 1: Electrical Termination Review

NEC code and OSHA safety standards should be observed during all installation, grounding and testing procedures. Modifications to the following should be made as necessary to stay within NEC and OSHA guidelines. Confirm with DFS regarding proper procedure if the following becomes obsolete due to code or regulation changes.

1. Visually inspect all wiring. Check for loose wires and short circuits.
2. Verify 120 VAC exists at the line termination ***and*** between neutral and ground terminals on the TCU's P1 connector.
3. Verify proper voltage dropping resistors are in place on all TCU digital input pins where voltage exceeds 30 VAC/VDC.
4. Verify that surge arrestor components are installed correctly as detailed in DFS approved drawings.
5. Verify that DFS onboard 24 VDC supply is not being used for any control devices. ***This onboard source is for biasing analog and digital monitor inputs to the TCU only.***
6. Verify that grounding is installed correctly. Bonding should occur between the DFS tower ground rod and Power Company ground rod and finally to the DFS supplied Polyphaser. Refer to illustrations provided in "Chapter 7: Telemetry Configuration."
7. If 3-phase power is input directly to the TCU, verify that:
   - Voltage exists at the P1 terminals for the appropriate phases.
   - 3-phase power is fused and correctly routed through the TFS supplied by DFS.

   If the TCU shows an active 3-phase error, follow the steps provided in "Chapter 10: Configuring the Pump Control Process" to adjust the Low Phase and High Phase limits. To facilitate a start-up, the 3-phase limits can initially be adjusted fully open, and then later adjusted for less tolerance.
8. If the Phase Monitor Bypass is used to monitor third party 3-phase monitors with contacts that remain closed when the 3-phase is within specifications, wire the contacts using the same common as the pump run input circuits. The TCU will only run the pumps if the Phase Monitor Bypass input is ON. If the third party phase monitor contacts should open, all Auto operation will cease. This input takes precedence over the direct 3-phase input. Although the on-board 3-phase monitor and phase-monitor-bypass input can be used simultaneously, we do not recommended that configuration.
9. Verify that the level detection device(s) connected to the TCU are properly wired. If floats or pressure switches are used, check that they are in the correct sequence. If an analog 4-20 mA transducer is used, check that the jumper between the *ANALOG-* and *SHUNT* terminals is installed. If an analog 0-5 V transducer is used, you must check that the jumper between the *ANALOG-* and *SHUNT* terminals is removed. Verify the wiring of the alarm light and horn, if used. The voltage connected to *ALM_PWR* is switched to the *ALM_LITE* and *ALM_HORN* terminals when the alarms are activated. The returns for the light and horn must be connected to the return of the source used to power them.

…continues on next page

10. Verify that the proper fuses are installed in the output circuits of the motor starter, alarm light and horn, and auxiliary.
11. If telemetry is used, verify the wiring of the interface cable.

STEP 2: OPERATIONS TESTING

Test all of the TCU functions listed below. If the tested function fails, first verify the circuit between the TCU and the device. When verifying the circuit, check fuses, resistors, signal contacts, isolators, relays bias, and return voltages and conductors, where applicable, as these components are occasionally subject to failure**.**

1. Before powering the TCU, place all three H-O-A switches in the Off position.
2. Turn circuit breakers on one at a time. Turn the TCU on last.
3. Verify Hand operation of the contactors (pumps) by placing each of the TCU's H-O-A switches in the Hand position.
4. Verify that each Pump Run LED illuminates when its respective control is engaged in Hand operation. If the LED flashes, the TCU has failed to receive the Motor Run Input for the contactor. If this occurs, verify the pump run circuit integrity.

   Note: There is an LED above each digital input terminal. The LED illuminates when the respective input is on.
5. Check float input operation by tipping the floats and verifying that the correct, corresponding, Float Input LED is illuminated.
   - When the High float is tipped and the high float is enabled, the bell or alarm should go on.
   - If the Low float's contact is open, the bell or alarm should go on.
   - If the TCU is using an analog input for level control, refer to "Chapter 10: Configuring the Pump Control Process" for information on setting the level set points along with other options for analog and float back-up operation.

   Note: The alarm light and alarm horn have to be enabled in the TCU's configuration in order for them to operate.
6. If an alarm silence button is wired, verify the Alarm Silence input is operational by attempting to silence the bell or alarm. The bell/alarm is silenced by pressing and holding the Alarm Silence Button for 2 seconds after the High float is tipped. The Alarm Silence input shares the same common, and therefore the same voltage source, as the float inputs.
7. Configure the TCU for the site (station) in which it is installed. Refer to "Chapter 10: Configuring the Pump Control Process" for assistance on configuring the TCU.
8. Check the TCU's Alarm screen to verify that all alarms have cleared. Refer to "Chapter 12: Viewing and Troubleshooting Alarms" for assistance in understanding the Alarm screen's characteristics.
9. Place the necessary TCU H-O-A switches in the Auto position. Allow the water level to rise, or manipulate the level inputs manually, to verify Auto operation.
10. Verify alternation of the pumps by manipulating the "OFF" and "LEAD" inputs to the TCU in the correct and natural order based on what pump mode you have selected in the configuration. The TCU

control outputs should respond by alternating the lead pump position with alternation enabled. Allow for some delay on pump start after the level input is activated.

11. Verify, as the LAG1 and LAG2 inputs are toggled, that the TCU starts additional pumps that the level input demands. Allow for some delay on pump start after the level input is activated.
12. After the system is checked out, connect the backup battery, if used. Make sure the battery is properly connected. Observe polarity markings.
13. If the battery is charged, cycle the TCU's AC power off and verify battery backup operation. Make sure to turn the TCU on when finished with the checkout procedure.

Notes

Appendix B: MAINTENANCE AND TROUBLESHOOTING

MAINTENANCE

The TCU is designed for a minimum amount of maintenance. It is ***more*** important to maintain the station and the components connected to the TCU.

Cleaning the TCU

When cleaning the TCU's front panel, use only mild detergents and a damp rag. Do not use solvents to clean the TCU's front panel.

Maintaining and Replacing the Backup Battery

The TCU can accommodate a backup battery. The battery used in the TCU has a sealed leak proof construction that is designed to be nearly maintenance free.

Battery Maintenance	To keep the battery in optimal condition, do periodic battery maintenance: • Keep the top free of grime • Check cables, clamps, and case for obvious damage or loose connections • Clean terminals and connectors as necessary • Test the battery with a voltmeter
Battery Selection and Replacement	When installing or replacing the backup battery, select one of the recommended backup batteries listed below. • 12V, 7.0 Ah Rechargeable Battery (Part No. DFS-00363-008-01) • 12V, 2.6 Ah Rechargeable Battery (Part No. DFS-00363-008-02)
Expected Service Life	Per the manufacturer's specifications, the battery has an expected service life of five years in float standby applications.

RESTORING FACTORY DEFAULT CONFIGURATIONS

If you make changes to the TCU's default configuration, you can restore the default settings using the key sequence described on the next page.

We recommend that you save the TCU's current configuration before restoring the factory default settings. You can upload and download TCU configurations using WinRTU Test. WinRTU Test is included in the TCU001 Test Kit. See "Appendix C: Parts List" for ordering information.

Note: The restore to factory default feature does not apply to a TCU with a custom program installed (i.e., one that has replaced the factory default pump control program). Please refer to the O&M manual that DFS supplied when your TCU was installed.

Procedure for Restoring Factory Default Configuration

Hold down the 8 (eight) key while powering up the TCU.

TROUBLESHOOTING

Troubleshooting of the TCU and station control panel should only be performed by DFS personnel or a certified electrical technician. Ensure that all breakers have been turned off before modifying any panel wiring or removing any device from the station control panel. Use caution when making voltage and current measurements. The TCU's H-O-A switches can be used to manually control the pump motors during troubleshooting.

If the problem occurs with a new wiring installation, first review all wiring. Refer to "Appendix A: Checkout Procedure for Pump Controller" for new-installation checkout procedures.

Radio Test Mode

To place the TCU in radio test mode, press and hold the 2 (two) button while cycling power to the TCU. Release the 2 (two) button when a string of question marks (????...) begin displaying on the LCD.

To key the radio and measure output and reflective power, press the 2 (two) button while the TCU is in radio test mode. Release the 2 (two) button once measured values have been recorded.

> **IMPORTANT:** To prevent an overcurrent reset from occurring, do not hold down the 2 (two) button for more than 3 seconds. An overcurrent condition is indicated by the RX and TX LEDs blinking simultaneously.

While in test mode – and after an initial successful attempt at communication with the CTU – the TCU's LCD will display a series of 1's and 0's to indicate poor or good communications, respectively. Zeroes (0's) indicate good communications with the Central Radio. Ones (1's) indicate poor communications with the Central Radio.

A typical good link is determined by achieving a solid LCD display of 0's (zeroes) with the maximum attenuation.

- Ones (1's) displayed are an indication that the TCU is receiving communications from the CTU radio, but the CTU radio is not receiving good communications from the TCU.
- Zeroes (0's) displayed indicate that the TCU and the CTU radio are in good communication with each other.
- Having neither Ones (1's) nor Zeroes (0's) displayed at the TCU is an indication that the TCU may not be receiving or understanding communications from the CTU radio.

Regardless of communication status, the TCU will remain in test mode – waiting to establish communications – until a test mode time-out or a manual TCU reset. While waiting for communications from the CTU radio, the TCU will not display any digits and will remain idle with only the initial question marks (????...) displayed as described above. The same will occur during testing (idle TCU display) if communications are lost after they had been established.

Typical example: 200 MHz radio links should achieve 21 dB minimum fade margin. The final result would be all 0's displayed on the TCU's LCD with 21 dB of attenuation inserted inline of the antenna path.

To exit radio test mode, simply cycle power to the TCU or let the TCU time out of radio test mode. [The TCU automatically exits radio test mode after six (6) minutes.]

Alarm Messages and the Alarm LED (Pump Control Process only)

The TCU monitors itself and the station for alarm conditions.

If an alarm condition is detected:

- The TCU activates the appropriate alarm output relays and flashes the Alarm LED.
- If the alarm light relay has been enabled, it becomes active for all alarm conditions.
- If the alarm horn relay has been enabled, it becomes active for critical alarms, such as High and Low Level faults, Phase faults, transducer faults, and TCU memory faults.
- The TCU generates the appropriate alarm message. Alarm messages can be viewed from the TCU's Alarm screen

Alarm LED on TCU:

- Flashes if there are active alarms.
- Remains steady if there are inactive alarms that have not been viewed or acknowledged.
- Goes out when all alarm conditions have cleared and all alarm messages have been viewed or acknowledged.

Alarm messages on the TCU's Alarms screen:

- Flash for active alarms. Messages for active alarms continue to flash after they have been viewed.
- Remain steady (non-flashing) for inactive alarms that have not been viewed. Messages for inactive alarms disappear from the Alarms screen after they have been viewed.

Alarm messages, probable causes of the alarms, and troubleshooting steps are detailed in "Chapter 12: Viewing and Troubleshooting Alarms." If the problem is determined to be with the TCU, see "Appendix O: Support, Service, and Warranty" for removal, replacement, and servicing instructions.

CPU Fault

When a CPU Fault occurs, the disabled state of the alarm light relay activates an alarm light connected to the TCU. The H-O-A switches continue to function. They can be used to control operation of the pumps.

Internal circuitry monitors the TCU's main microcontroller and radio microcontroller. A CPU Fault typically results from a fault in one of these microcontrollers.

Steps for resolving a CPU Fault are provided on the next page.

Main microcontroller	If the circuitry detects a fault with the main microcontroller, it attempts to reset the main microcontroller and flashes the CPU Fault LED. If the main microcontroller fails to reset, additional circuitry disables the outputs and flashes the CPU Fault LED.
Radio microcontroller	If the circuitry detects a fault with the radio microcontroller, it first attempts to reset the radio microcontroller and flashes the CPU Fault LED on each attempt. If the radio microcontroller is locked in reset mode, the CPU Fault LED will remain steadily lit (not flashing). **Note:** Failure of the radio processor only shuts down telemetry; the TCU's main microcontroller will continue to control the site.

Resolving a CPU Fault

1. Try cycling power to the TCU.
2. If a backup battery is connected, disconnect it.

If the CPU Fault LED remains lit, the TCU requires Factory service. See “Appendix O: Support, Service, and Warranty” for removal, replacement, and servicing instructions.

Offline Alarm

HT3 includes a built-in station offline alarm (OFFLINES). HT3 determines if a station is offline based on the communication settings configured for the station, such as Offline Count, Timeout, Retries. See “Station Offline Alarm” in the HT3 User Guide for instructions on configuring the settings for this alarm.

The following conditions could cause a TCU station to go offline:

Radio TCU

- Obstructions such as trees or structures are blocking signal
- Antenna orientation (direction) has changed
- Antenna ground system is no longer good
- Interference on the frequency
- Interference due to proximity to other high power radio transmitters or power company transmission lines
- TCU’s replaceable fuse is blown and backup battery is dead or below tolerance
- Bad or damaged antenna or coax (including polyphaser surge protection)
- Bad or damaged TCU (no power or damaged circuitry)
- Bad or dead radio
- TCU is incorrectly addressed

BEM TCU

- Bad or damaged BEM module
- BEM wiring incorrect or disconnected
- TCU’s replaceable fuse is blown and backup battery is dead or below tolerance
- BEM wiring without proper conductor or shielding
- BEM wiring not properly installed (in conduits with high voltage current carrying conductors)
- Bad or damaged TCU (no power or damaged circuitry)
- TCU is incorrectly addressed

Ethernet TCU

- Ethernet surge protection damaged
- Media converter damaged
- Bad or damaged fiber or ethernet cabling
- TCU’s replaceable fuse is blown and backup battery is dead or below tolerance
- Bad or damaged TCU (no power or damaged circuitry)
- Firewall or router not configured properly
- TCU is incorrectly addressed

Blown Fuse

The TCU001 includes one .375 A replaceable fuse. The fuse is located on the side of the TCU and is labled F601. The fuse is designed to protect the TCU's DC power circuitry from its operating AC input voltage.

If this fuse blows, you will see one of the following responses depending on the status of the TCU's backup battery:

Functioning DC Battery	TCU triggers a local *ACPwr* alarm and reports an AC Power Fault to the central SCADA system. TCU indicators, such as LED lights and LCD screen, will be normal.
DC Battery Dead or Below Tolerance	No local *ACPwr* alarm is generated; No AC Power Fault is reported to the central SCADA system. TCU indicators, such as LED lights and LCD screen, will be off. The TCU station will eventually be shown as Offline in HT3.

Conditions that could cause the fuse to blow:

- Incorrect operating voltage
- Surge in operating AC power voltage greater than .375 A
- Heat condition that exceeds designed operating temperature of 160 degrees
- Incorrect control voltage wiring
- Shorted circuit within the TCU

Before replacing the fuse:

- Inspect the TCU site and wiring to see if any of the conditions listed above may have occurred
- If you received an offline alarm for this station, check the battery to verify it is functioning properly. Replace the battery if you find it is unable to hold a charge.
- Measure the input voltage and check the wiring to the TCU's connector. The operating voltage is marked on the connector label. Try replacing the fuse only when the proper voltage is connected.

Replacing the fuse:

Replace the fuse with a new identical one. See page 161 of Appendix C: Parts List for the recommended fuse.

After replacing the fuse, verify that the TCU is functioning properly (LED lights are lit; LCD screen is working).

If the TCU isn't working after you've replaced the fuse, the TCU may require Factory service. See "Appendix O: Support, Service, and Warranty" for removal, replacement, and servicing instructions.

TCU REPLACEMENT

The TCU can easily be removed and replaced with a backup TCU if it is determined that the TCU needs servicing.

1. Before removing the TCU, either make a note of the TCU configuration or download the configuration to a computer.*
2. Turn off all circuit breakers before attempting to remove the TCU.
3. The terminals are connectorized for removal. Use an insulated screwdriver and gently pry the connectors free.
4. Remove the mounting fasteners that connect the TCU to its mounting brackets. You should be able to easily lift the TCU from its mounting brackets.
5. Install the replacement TCU, replace the fasteners, and reconnect the terminals.
6. Place the replacement TCU's three H-O-A switches into the “Off” position and turn the breakers back on.
7. Reconfigure the replacement TCU. If the faulted TCU's configuration was backed up on a portable computer, it can be restored on the replacement TCU.*
8. After configuring the replacement TCU, place the required H-O-A switches in the “Auto” position.

*TCU configurations can be uploaded/downloaded through telemetry using PCU Editor. You can also connect the TCU directly to a laptop computer and use the WinRTU Test software to download/upload configurations. Refer to the help files of these applications for more information.

FURNISHED PARTS

TAC Pack Telemetry Control Unit (TCU)

With no radio (Part No. DFS-00367-008-03)
With 148-174 MHz radio (Part No. DFS-00367-008-04)
With 217-220 MHz radio (Part No. DFS-00367-008-01)
With 450-470 MHz radio (Part No. DFS-00367-008-02)
With autodialer (Part No. DFS-00367-008-10)
With 10/100 network adapter (Part No. DFS-00367-008-09)

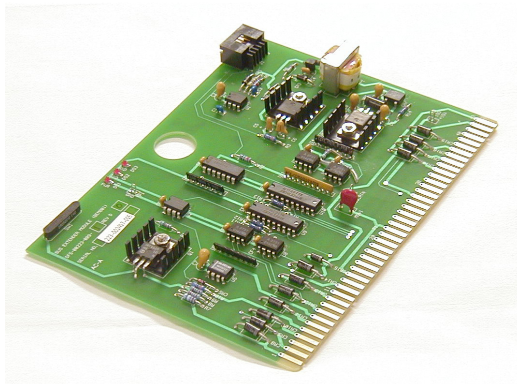
OPTIONAL PARTS

Batteries

12V, 7.0Ah Rechargeable Battery
Part No. DFS-00363-008-01

12V, 2.6Ah Rechargeable Battery
Part No. DFS-00363-008-02

Bus Extender Module

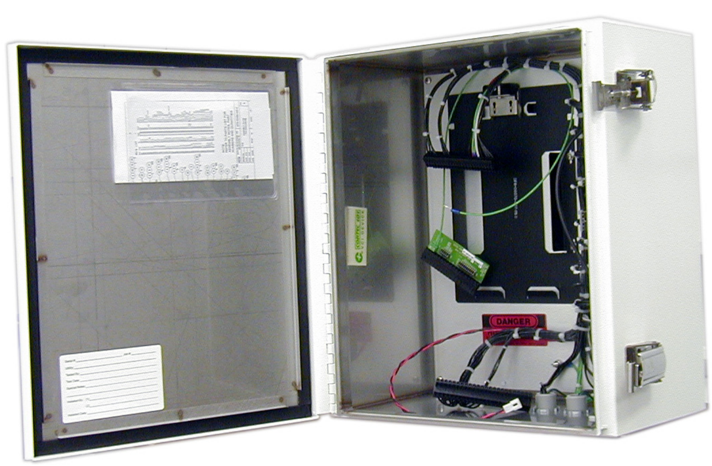


Part No. DFS-00223-009

Circuit Breaker (10A)

DFS Part No. 014-0010

Enclosures



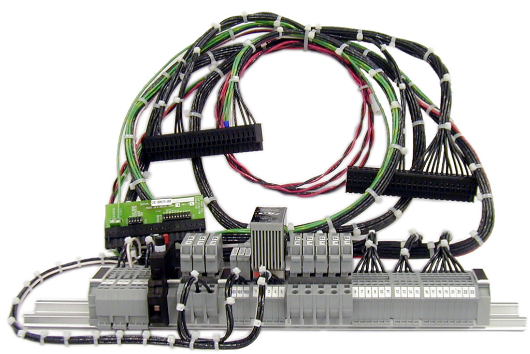
Fiberglass Enclosure (Part No. DFS-00275-008-04)

Stainless Steel Enclosure (Part No. DFS-00275-008-05)

Fuse

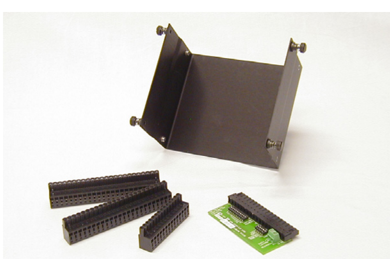
1A Slow Blow Fuse
Part No. DFS-00271-008-09

Harness

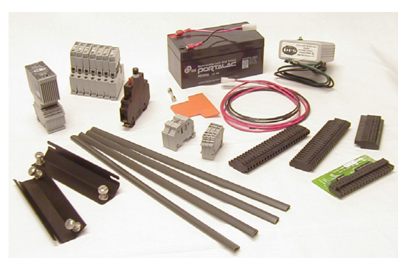


Wire/Component Harness
Part No. DFS-00396-108-02

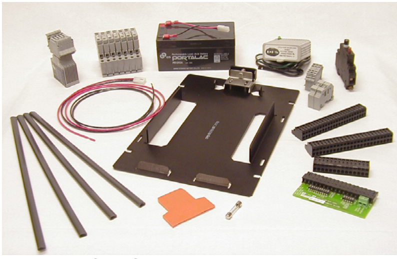
Installation Kits



TCU Retro Install Kit
Part No. DFS-00392-008-07

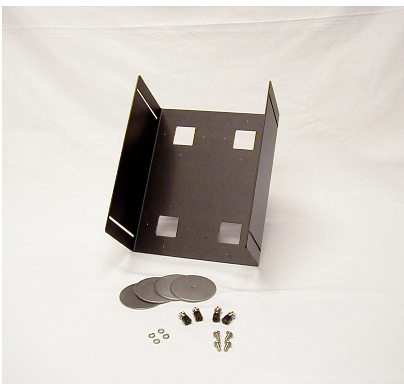


TCU Front Mount Install Kit
Part No. DFS-00392-008-05

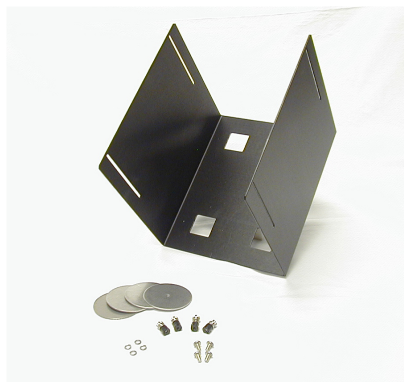


TCU Snap In Install Kit
Part No. DFS-00392-008-09

Mounting Bracket Kits
(use in conjunction with Snap-In Installation Kit)



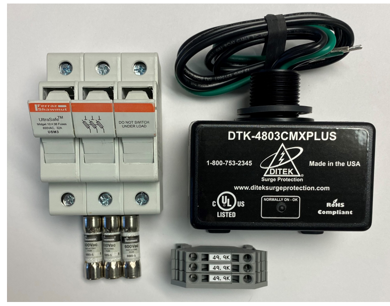
Adjustable Mounting Bracket (Short)
Part No. DFS-00394-008-01



Adjustable Mounting Bracket (Medium)
Part No. DFS-00394-008-02

Adjustable Mounting Bracket (Tall)
Part No. DFS-00394-008-03

480 VAC Phase Monitor Kit



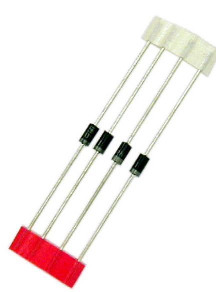
480 VAC Phase Monitor Kit
Part No. DFS-00393-008-05

(kit includes 480 VAC, three-phase surge arrestor; Three (3) DIN-rail mounted terminal blocks with end plate; Fuse block with three (3) 1 A fuses; Three (3) 49.9k resistor assemblies)

Polyphaser Kit

TCU Polyphaser Kit
Part No. DFS-00392-008-01

Power Diode



Part No. 006-0019

Resistors

47K Resistor (Part No. DFS-00271-008-01)
100K Resistor (Part No. DFS-00271-008-07)

Snubber

RC Snubber
Part No. 007-0084

Spring-Clamp Connector Tool

Part No. DFS-00389-008-01

Submersible Level Sensor

Trident Submersible Level Sensor

0-5 PSI (Part No. 025-0091)
0-10 PSI (Part No. 025-0092)
0-15 PSI (Part No. 025-0093)

Surge Protection

Telephone Line Surge Protector
DFS Part No. 002-0044

100Base-T Network Surge Arrestor
DFS Part No. 002-0279

Surge Suppressors

120 VAC (DFS Part No. 005-0061)
240 VAC, 3-Phase (DFS Part No. 005-0062)

Test Kit

TCU, PCU & SCU Test Kit
Part No. DFS-00242-008-02

USB to Serial Adapter

USB to RS-232 Adapter
Part No. 002-0351

Appendix D: KEYPAD FUNCTIONS

The TCU features several keypad functions that include

- Viewing information on the TCU (for example, serial number)
- Testing radio communications
- Returning the TCU to its factory default setting
- Placing the TCU in debug, or prompt, mode
- Adjusting the LCD screen's contrast
- Auto downloading a configuration to the TCU

VIEW PROCESS ID AND VERSION LEVEL

With the TCU powered, press and hold the 3 button to view the TCU's process ID and version level. As an example, a process ID of 9000 would indicate that the pump control process is loaded. A process revision level of 1.0041502 would indicate that this is the first release of the software (1.0) and that the software was released on April 15, 2002 (041502).

VIEW SERIAL NUMBER, STATION ADDRESS, RADIO CONFIGURATION, AND FIRMWARE VERSIONS

Simultaneously press and hold the three (3) and Alarm Silence buttons to view serial number, station address, radio data configuration, BASIC chip firmware version, and radio chip firmware version. For example, TCU001, Sta=208, Cfg=0000, B 05/03/02, R 05/01/02 would be displayed for a TCU at firmware level 1 (one) with a station address of 208, a normal radio data configuration, a BASIC firmware version of 05/03/02, and a radio chip firmware version of 05/01/02.

Radio data configuration is indicated as follows:

- CFG=0000 – Radio data is normal
- CFG=I000 – Radio data is inverted (P3-11)
- CFG=0S00 – Radio data is swapped (P3-12)
- CFG=IS00 – Radio data is inverted and swapped (P3-11 and P3-12)

PLACE TCU IN RADIO TEST MODE

To place the TCU in radio test mode, press and hold the 2 button while cycling power to the TCU. Continue holding the 2 button until a string of question marks (????…) appears on the LCD screen. The question marks indicate that the test message was sent. When you see the string of question marks, release the 2 button. When the button is released, the LCD screen will display a series of 1's and 0's to indicate communication status.

- 0's indicate that there is good transmission and reception
- 1's indicate that there is good reception, but no transmission
- If nothing appears on the screen, nothing is being transmitted or received

KEY RADIO AND MEASURE ANTENNA REFLECTIVE POWER

To key the TCU's radio and measure the reflective power of the attached antenna, press the 2 button while the TCU is in radio test mode.

RESTORE FACTORY DEFAULT CONFIGURATIONS

To restore the TCU to its factory default pump control configuration, press and hold the 8 button during TCU power up. We recommend you save the TCU's current configuration before restoring the TCU. The current configuration can be downloaded to a laptop or PC using WinRTU Test, which is included in the TCU001 Test Kit. See "Appendix C: Parts List" for ordering information.

Note: The restore to factory default feature does not apply to a TCU with a custom program installed (i.e., one that has replaced the factory default pump control program). Please refer to the O&M manual that was supplied by DFS when your TCU was installed.

PLACE TCU IN DEBUG MODE

To start the TCU's DFS BASIC-52 interpreter in Debug mode, press and hold the TCU's 1 (one) key while powering up the TCU. The 1 (one) key must be pressed and held until the self-check sequence is completed (indicated by the LEDs on the device flashing on and off for a moment). A greater than sign (>) will appear when the Enter key is pressed indicating that the TCU is waiting for the user to type in a command or line number followed by statements.

ADJUST THE LCD SCREEN'S CONTRAST

The LCD's contrast is controlled by an onboard temperature sensor that normally ensures that the screen is easy to read in both high- and low temperature conditions. However, if the LCD screen is difficult to read, you can adjust the contrast using the following procedure:

1. Press and hold the TCU's 5 (five) key while cycling power to the TCU.
2. When the TCU is powered up, the LCD screen will show a series of characters.
3. Use the TCU's (up) ▲ and (down) ▼ navigation keys to adjust the contrast.
4. When you are satisfied with the contrast, press the Enter key.

AUTO DOWNLOAD TCU CONFIGURATION

The TCU features an auto download function that allows you to download a configuration via telemetry. With this feature, there is no need to configure the TCU locally or to manually configure it using WinRTU Test.

This function can only be implemented if your system uses the Hyper SCADA Server and the TCU is using the standard 90000 built-in pump controller program. It cannot be used with a TCU running a custom or VFD (90001) program.

AutoCFG files need to be stored for each station even if they use the same configuration. Repeat the steps below for each TCU station that you want to auto configure.

The sections that follow provide instructions for:

- Creating an AutoCFG file
- Uploading the file to the HT3 SCADA server
- Auto downloading the configuration to the TCU

Creating an AutoCFG File

An AutoCFG file stores a TCU pump controller configuration in a special format and allows it to be broadcast to a specified TCU when the TCU is powered up in Auto Download mode. This allows installation of a new or replacement TCU with only minimal user interaction. An installer can replace a TCU with a new one (factory default settings), power it up, and have the configuration automatically download over the radio link.

1. Login to HT3 and open PLC Editor (select **PLC Editor** from the **Build** menu).
2. Open a saved configuration file (select **Open** from the **File** menu), or create a new TCU pump controller configuration.
3. Choose the station you are creating the AutoCFG file: Open the Address Selection Tool by selecting **Station** from the **Select** menu. Browse to the station, select it, and then click **OK**.
4. Select **Make AutoCFG** from the **PLC** menu. Click **Yes** on the **Make autocfg file for stn** dialog box that opens.
5. A **Save As** dialog box opens with an automatically generated file name: stn#.autocfg (where stn# represents the actual station number, for example, 4511.cfg for a station numbered 4511).
6. Keep the default file name and click **Save** (review the information in Valid File Locations, below, for important information on where to save files).
7. Click **OK** on the **AutoCFG has been saved** dialog that opens.
8. Close PLC Editor and upload the AutoCFG file to the server using HT3's File Upload tool (see “Uploading Configuration File to HT3” on the next page).

Valid File Locations

PLC Editor files can only be saved in and opened from one of the directories listed below (or a subdirectory contained therein). If you try to save a file to a different directory, you will get an "I/O error writing file...." Attempting to open a file from a different directory results in an "I/O error reading file...."

- Windows Vista / 7 – For computers running these versions of the Windows operating system, the files can only be saved to the home directory (C:\Users) of the user that is currently logged in. For example, C:\Users\jane, where jane is the Windows user name of the individual currently logged in.
- Windows 2000 / NT / XP – For computers running these versions of the Windows operating system, the files can only be saved to the home directory (C:\Documents and Settings) of the user that is currently logged in. For example, C:\Documents and Settings\jane, where jane is the Windows user name of the individual currently logged in.
- Windows 95/98/ME – For computers running Windows 95/98/ME, the files can only be saved to the C:\My Documents directory.

The Java policy file that you installed on your computer when it was first set up to connect to HT3 controls where files can be saved to and opened from. The Java policy file is designed to protect your computer from "hostile" Java applets that could try to access or damage the data on your computer (for example, to insert a virus). The HT3 policy file gives HT3's Java applets permission to write to specific directories on your computer. In effect, the policy file says that only Java applets from this server can write to this computer's drive; and this server can only write to this specific directory (and any subdirectories contained therein).

To keep your files in their own directory, create a folder within your user directory (location based on your operating system, see list above) and save the files there.

To store a file in another location (for example, a backup location on your network server), save the file to the correct directory (e.g.,Documents and Settings) and then copy it to the backup location. Additionally, to open a file that is stored in another directory, you must first copy the file to the correct directory (e.g., Documents and Settings).

Uploading Configuration File to HT3

1. On HT3's **Tools** menu, click **Upload**.
2. In the **Send Files to the Server** list, click **TCU Auto-Download Configuration File**.
3. Click **Browse** and select the .autocfg file you saved in “Creating an AutoCFG File,” above. Click **Submit**.
4. The screen displays the message "File transfer successful" along with information on the file submitted (file name, size, and type).
5. The AutoCFG file is now stored on the server and is ready to be auto downloaded to the TCU.

Auto Downloading the TCU Configuration

To auto download a TCU configuration, hold down the 3 button while powering up the TCU.

1. The TCU sends a message to the server requesting its configuration. The message “Waiting for configuration download” appears on the TCU’s LCD screen.
2. The server searches for the correct configuration.
3. When the configuration is found, the server sends it to the requesting TCU.
4. When download is complete, the message “Config Updated” appears on the TCU’s LCD screen.

Appendix E: CONFIGURATION WORKSHEET

Use the worksheet below or the one on the next page to document the TCU's configuration. File a copy of the completed sheet with the TCU.

CONFIGURING A STATION WITH ANALOG INPUT DEVICES

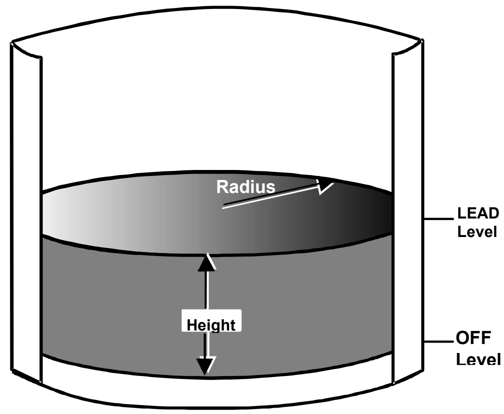
No. Of Pumps	[1]	[2]	[3]		(circle one)
Xdcr Type	[4-20 mA]	[0-5V]	[REMOTE]	[FLOATS]	(circle one)
Low Float	[DIS]	[ENA]			(circle one)
High Float	[DIS]	[ENA]			(circle one)
Fault Mode	[DIS]	[TIMER]			(circle one)
Alarm Horn	[DIS]	[ENA]			(circle one)
Alarm Light	[DIS]	[ENA]			(circle one)
Auto Retry	[DIS]	[ENA]			(circle one)
Alternate	[ALL]	[PMP1&2]	[PMP2&3]	[NONE]	(circle one)
Start Delay	[ ] seconds (0-510) (0 disables fault)				
Stop Delay	[ ] seconds (0-510) (0 disables fault)				
AuxOut Turns	[ON]	[OFF]			(circle one)
Seconds after	[ ] seconds (0-510)				
AuxIn Turns	[ON]	[OFF]			(circle one)
Xdcr1 Low	[ ] feet (0-60) (equivalent to 4 mA or 0 V)				
Xdcr1 High	[ ] feet (0-60) (equivalent to 20 mA or 5 V)				
Xdcr2 Low	[ ] feet (0-60) (equivalent to 4 mA or 0 V)				
Xdcr2 High	[ ] feet (0-60) (equivalent to 20 mA or 5 V)				
Low SetPt	[ ] feet (0-60) (activates low alarm)				
LeadOff Pt	[ ] feet (0-60) (first pump OFF)				
LagOff Pt	[ ] feet (0-60) (second pump OFF)				
Lag2Off Pt	[ ] feet (0-60) (third pump OFF)				
LeadOn Pt	[ ] feet (0-60) (first pump ON)				
LagOn Pt	[ ] feet (0-60) (second pump ON)				
Lag2 On	[ ] feet (0-60) (third pump ON)				
High SetPt	[ ] feet (0-60) (activates high alarm)				
Minmum Run	[ ] HH:MM:SS				
Minmum Off	[ ] HH:MM:SS				
LoPhaAlm	[ ] V (151-300) (lower limit)				
HiPhaAlm	[ ] V (151-300) (upper limit)				
Well Volume	[ ] units (0-9999) [gal] [cu ft] [other:]				(circle one)
Flow Units	[MGD]	[GPM]			(circle one)
Pump Mode	[DOWN]	[UP]			(circle one)
PhMon Lvl	[ ] VAC (range of phase monitor)				
AuxIn Alm	[DIS]	[ENA]			(circle one)
AuxAlm On	[OPEN]	[CLOSE]			(circle one)
Module Address	[ ] units A through O				
BEM Modules	[ ] units (0-14) (modules connected by BEM)				
Trend Rate	[ ] seconds (2-999)				
Xdcr Hi	[DIS]	[ENA]			(circle one)
Xdcr Low	[DIS]	[ENA]			(circle one)
Xdcr Noise	[DIS]	[ENA]			(circle one)
High Override	[DIS]	[ENA]			(circle one)

CONFIGURING A STATION WITH FLOAT BALL INPUTS

No. Of Pumps	[1]	[2]	[3]		(circle one)
Xdcr Type	[4-20 mA]	[0-5 V]	[REMOTE]	[FLOATS]	(circle one)
Low Float	[DIS]	[ENA]			(circle one)
Alarm Horn	[DIS]	[ENA]			(circle one)
Alarm Light	[DIS]	[ENA]			(circle one)
Auto Retry	[DIS]	[ENA]			(circle one)
Alternate	[ALL]	[PMP1&2]	[PMP2&3]	[NONE]	(circle one)
Start Delay	[ ] seconds (0-510) (0 disables fault)				
Stop Delay	[ ] seconds (0-510) (0 disables fault)				
AuxOut Turns	[ON]	[OFF]			(circle one)
Seconds after	[ ] seconds (0-510)				
AuxIn Turns	[ON]	[OFF]			(circle one)
LoPhaAlm	[ ] V (151-300) (lower limit)				
HiPhaAlm	[ ] V (151-300) (upper limit)				
Well Volume	[ ] units (0-9999) [gal] [cu ft] [other:]				(circle one)
Flow Units	[MGD]	[GPM]			(circle one)
Pump Mode	[DOWN]	[UP]			(circle one)
PhMon Lvl	[ ] VAC (range of phase monitor)				
AuxIn Alm	[DIS]	[ENA]			(circle one)
AuxAlm On	[OPEN]	[CLOSE]			(circle one)
Module Address	[ ] units A through O				
BEM Modules	[ ] units (0-14) (modules connected by BEM)				
Trend Rate	[ ] seconds (2-999)				
High Override	[DIS]	[ENA]			(circle one)

Appendix F: WELL VOLUME CALCULATIONS

To calculate Well Volume, determine the well volume between the Off Level (*LeadOff Pt*) and the Lead Level (*LeadOn Pt*).



1. Determine the difference between the Off Level and the Lead Level (height) in feet.
2. Determine the area of the well. For a rectangular well, multiply width times length; for a circular well, square the radius and multiply by 3.14.
3. Multiply height by area to give volume in cubic feet. To convert to gallons, multiply the volume in cubic feet by 7.48.

IMPORTANT: Well volumes less than 500 gallons or 37 ft^3 are prone to accuracy errors.

Example: Assume a circular well of 10 feet diameter (5-foot radius) with Off Level at 2 feet and Lead Level at 5 feet.

Calculate Liquid Height

Lead Level	5 feet
- Off Level	-2 feet
Liquid Height	3 feet

Calculate Area of Well

Well radius (5') squared	25 ft^2
x conversion constant (pi)	x 3.14
Area	78.5 ft^2

Calculate Volume

Liquid Height	3 feet
x Area	x 78.5 ft^2
Volume (cu. ft)	235.5 ft^3 (Enter 236 if configuring Volume in cubic feet)

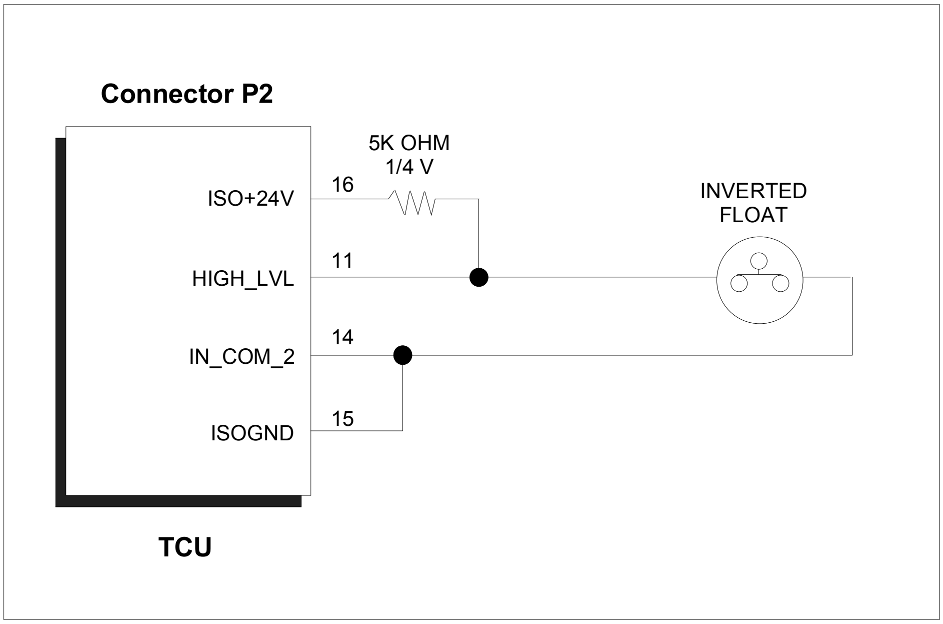
Convert Volume to Gallons

Volume	235.5 ft^3
x conversion constant (7.48 gal/ft^3)	x 7.48 gal/ft^3
Volume (gallons)	1761.54 gallons (Enter 1762 if configuring Volume in gallons)

The display shows VOLUME in the same terms as you have entered. For instance, if you entered "236" in this example, VOLUME would display in cubic feet; if you entered 1762, VOLUME would display in gallons.

Notes

In some instances, it is necessary to detect a float failure (such as in a high-well float) during normal operation. Such failure can be detected by using an inverted float (contacts closed when in the "down" position) and using the connections to the TCU as indicated below.



Notes

Appendix H: TCU001-AD AUTODIALER

OVERVIEW

Product Overview

The TCU001-AD (TCU001 with optional autodialer; DFS-00367-008-10) is a stand-alone device that enables utilities to be alerted of active alarm conditions at remote well/storage tank stations that aren't part of a SCADA telemetry system. When a station experiences one or more of the 22 statically-coded alarm conditions, the autodialer uses its onboard, V.92 voice modem to call a series of preconfigured telephone numbers (up to four) and announce the alarm via prerecorded voice messages. The alarm announcement includes the station number and a description of the alarm (for example, "high well").

The autodialer uses a code to prevent an unauthorized person from acknowledging alarms. The recipient of a call must enter a one- to four-digit code, using the keys on their touch-tone phone, before any alarms will be announced. The autodialer then announces the first alarm and prompts the recipient to press 1 (one) to acknowledge or press 2 (two) to replay the message. If there are multiple alarms, each will be announced once the preceding alarm has been properly acknowledged.

An existing TCU001 can be retrofitted at the factory to add this feature. Contact DFS for more information.

Principles of Operation

The autodialer can be configured with up to four telephone numbers to call in the event that any of the 22 possible alarm conditions occurs. Each alarm condition can be configured with a delay of up to 9,999 seconds (~167 minutes). Any of the alarm conditions can be disabled for call out by entering a 0 (zero) in the dial delay field for that alarm.

When there is an active alarm at the station, the autodialer waits the configured delay time for that alarm and then dials the first number on the list. The autodialer calls each telephone number in sequence until all of the alarms are acknowledged.

Once an alarm has been acknowledged, the autodialer will ***not*** call out again unless the alarm clears and then becomes active again. If an alarm occurs and then clears ***within*** the alarm's configured delay time, you will ***not*** be notified.

Once call out begins, all alarms are announced regardless of their current status – active or cleared – and they remain in the queue until they are acknowledged. The autodialer checks the status of all points between each phone call. If a call isn't answered and an alarm clears before the next phone call is placed, the autodialer will change the status of the point to "cleared" and will announce it as such when the phone call is eventually answered. Similarly, if a new alarm occurs between calls, it will be added to the alarm list. Alarms will continue accumulating this way until they are all acknowledged.

Before any alarms are announced, the recipient is given three opportunities to enter the correct acknowledgement code. Once the correct code is entered, the autodialer begins playing voice messages for each alarm condition.

After each alarm message is played, the call recipient is prompted to press 1 (one) on the phone's keypad to acknowledge the alarm or to press 2 (two) to replay the message. If the alarm isn't acknowledged after it is announced for the third time or if the time out period expires, the autodialer will hang up and call the next number on the list.

If the autodialer gets to the end of the list and there are still unacknowledged active alarms, it cycles back to the first telephone number. This process is continued until all of the alarms have been acknowledged.

Available alarm conditions

The TCU001-AD provides call out for 22 alarm conditions (see table below). These 22 conditions are organized into eight groupings and are enabled or disabled using the corresponding alarm delay for that group. For example, the six motor faults are controlled by one delay field (*MtrFlt Delay*).

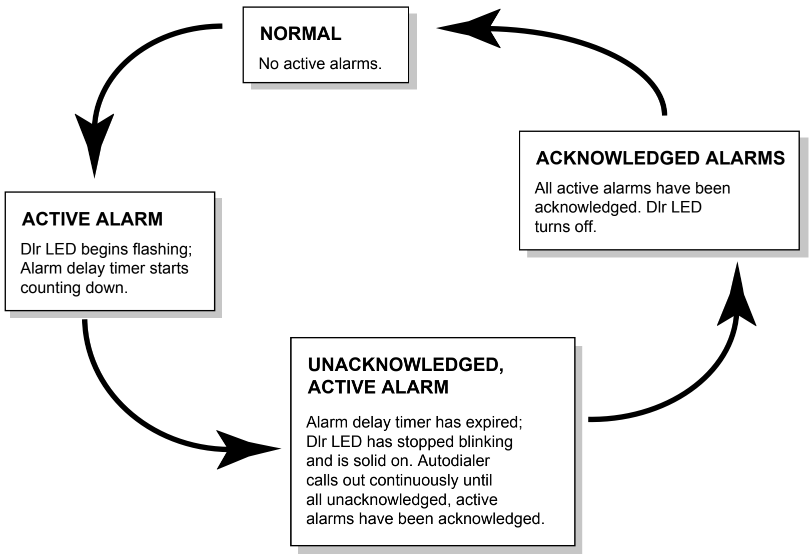
The corresponding delay field for each alarm condition is listed in the "Enable/Disable using…" column in the table below. The delay field tells the autodialer how long (in seconds) to wait before calling out an alarm. If a zero (0) is entered in the delay field, the autodialer will not call out when an alarm included in that grouping occurs.

Alarm	Description	Enable/Disable using…
High well level	Indicates that the HI_LVL input terminal is ON. Alternatively, if an analog transducer is being used, this alarm indicates that the level has risen above the High-level set point	HiWell Delay
Low well level	Indicates that the LOW_LVL input terminal is OFF. Alternatively, if an analog transducer is being used, this alarm indicates that the level has dropped below the Low-level set point.	LoWell Delay
Float out of sequence	Indicates that the TCU001-AD has detected floats out of sequence.	FltSeq Delay
Level transducer fault	Indicates that an analog transducer's current/voltage has fallen outside the normal operating range (4-20 mA / 0-5 V).	
Motor 1 failed to start	Indicates that the TCU001-AD is trying to run pump 1 but has no indication that the pump is on (associated input is off). This can occur if the pump is called to turn on but does not, or if the pump turns off prematurely.	MtrFlt Delay
Motor 1 failed to stop	Indicates that the TCU001-AD sees that pump 1 is on without being called to run. This can occur if the pump fails to turn off when the call is removed (associated output turned off), or if the pump comes on without being called. [The second condition is common if someone is on site and turns the pump on from outside of the TCU001-AD (not using the TCU001-AD's H-O-As).]	
Motor 2 failed to start	Indicates that the TCU001-AD is trying to run pump 2 but has no indication that the pump is on (associated input is off). This can occur if the pump is called to turn on but does not, or if the pump turns off prematurely.	

Alarm	Description	Enable/Disable using…
Motor 2 failed to stop	Indicates that the TCU001-AD sees that pump 2 is on without being called to run. This can occur if the pump fails to turn off when the call is removed (associated output turned off), or if the pump comes on without being called. [The second condition is common if someone is on site and turns the pump on from outside of the TCU001-AD (not using the TCU001-AD's H-O-As).]	
Motor 3 failed to start	Indicates that the TCU001-AD is trying to run pump 3 but has no indication that the pump is on (associated input is off). This can occur if the pump is called to turn on but does not, or if the pump turns off prematurely.	
Motor 3 failed to stop	Indicates that the TCU001-AD sees that pump 3 is on without being called to run. This can occur if the pump fails to turn off when the call is removed (associated output turned off), or if the pump comes on without being called. [The second condition is common if someone is on site and turns the pump on from outside of the TCU001-AD (not using the TCU001-AD's H-O-As).]	
AC power failure	This alarm is activated when the TCU001-AD determines AC power has been interrupted. Note that the TCU001-AD must be on battery backup power in order for the autodialer to call out for this alarm.	PwrFlt Delay
Phase voltage fault	Indicates that the voltage measurement on the three phase inputs (A - B or A - C) went above or below the configured fault parameters. When this occurs, the TCU001-AD shuts off all pumps, because a high or low voltage can damage the pumps.	
Phase voltage sequence (or phase reversal) fault	Indicates that the phases are not in the correct order on the TCU001-AD. When this occurs, the TCU001-AD will shut off the pumps, because a phase reversal will cause the pump motors to run backwards.	
Auxiliary input alarm	The TCU001-AD monitors the AUX_IN terminal (p2-12) and can be configured to activate this alarm when the terminal is open or closed. If the auxiliary input alarm has been enabled and AUX_IN enters its configured alarm state (open or closed), an auxiliary input alarm is generated.	AuxIn Delay
H-O-A switch 1 is in the Off position	Indicates that H-O-A switch 1 has been placed in the Off position. This condition allows the TCU001-AD's control to be overridden and forces the corresponding pump motor off.	HOAOff Delay
H-O-A switch 2 is in the Off position	Indicates that H-O-A switch 2 has been placed in the Off position. This condition allows the TCU001-AD's control to be overridden and forces the corresponding pump motor off.	

Alarm	Description	Enable/Disable using…
H-O-A switch 3 is in the Off position	Indicates that H-O-A switch 3 has been placed in the Off position. This condition allows the TCU001-AD's control to be overridden and forces the corresponding pump motor off.	
H-O-A switch 1 is in the Hand position	Indicates that H-O-A switch 1 has been placed in the Hand position. This condition allows the TCU001-AD's control to be overridden and forces the corresponding pump motor off.	
H-O-A switch 2 is in the Hand position	Indicates that H-O-A switch 2 has been placed in the Hand position. This condition allows the TCU001-AD's control to be overridden and forces the corresponding pump motor off.	
H-O-A switch 3 is in the Hand position	Indicates that H-O-A switch 3 has been placed in the Hand position. This condition allows the TCU001-AD's control to be overridden and forces the corresponding pump motor off.	
DC bias fault	Indicates that a fault with the ISO+24V voltage has occurred. The ISO+24V voltage is provided for biasing the digital monitor inputs and/or powering up to two analog transducers.	HdwFlt Delay
Process fault	Indicates that a fault has occurred with the TCU001-AD's internal process software.	

Alarm Process



1. Autodial-enabled alarm occurs.
2. Alarm delay timer starts counting down; Dialer (Dlr) LED begins flashing to indicate an alarm has occurred.
3. Alarm delay timer expires; Dialer (Dlr) LED changes to solid to indicate the autodialer is calling out.
4. If call is answered, welcome message is played (includes station number) and user is prompted to enter the four-digit acknowledgement code. User is given three opportunities to enter correct code. If user fails to enter correct code or the call is not answered, the autodialer hangs up and continues to the next number in the dial out list.
5. When a successful call out connection is made and the correct acknowledgement code is entered, autodialer begins announcing alarms.
6. After each alarm is announced, user is prompted to press 1 (one) to acknowledge the alarm or 2 (two) to replay the message. Message will be played a maximum of three times. If alarm isn't acknowledged after the third time, the autodialer will hang up and call the next number in the dial out list.
7. If there is more than one alarm, the autodialer will announce each alarm after the previous one is acknowledged.
8. When all alarms have been acknowledged, the Dialer (Dlr) LED will turn off.

   Note: The autodialer will only call one time for a specific alarm regardless of how long the alarm remains active. Once an alarm is acknowledged, it is the user's responsibility to ensure that the alarm has cleared. The autodialer will not call out for that type of alarm again unless the alarm clears and then becomes active again.

Pre-programmed digital synthesized voice messages

The autodialer comes pre-programmed with all the voice recordings necessary for operation. There's no need for end users to record messages. These recordings include the following phrases:

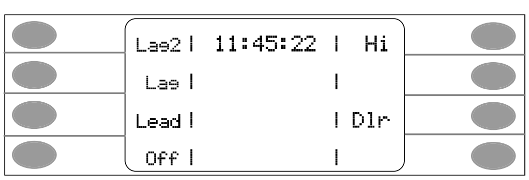
- "auxiliary input"
- "AC power"
- "DC bias"
- "phase sequence"
- "process stopped"
- "phase voltage"
- "motor one start"
- "motor one stop"
- "motor two start"
- "motor two stop"
- "motor three start"
- "motor three stop"
- "low well level"
- "high well level"
- "HOA one in hand"
- "HOA one in off"
- "HOA two in hand"
- "HOA two in off"
- "HOA three in hand"
- "HOA three in off"
- Numbers 0 – 20 => "zero," "one," "nineteen," "twenty," etc.
- Numbers 30, 40, ... 90 => "thirty," "forty," "ninety," etc.
- "fault"
- "station"
- "point"
- "has cleared"
- "Welcome to the TCU autodialer, there is an alarm at"
- "Thank you for using the TCU autodialer, goodbye"
- "Press 1 to acknowledge, press 2 to replay"
- "All alarms have been acknowledged"
- "That code is incorrect"
- "Please enter your code"
- "Not all alarms have been acknowledged"

Power and backup battery

The autodialer, because it is an integrated part of the TCU001-AD, requires no additional hookups for power or a backup battery. All power for the autodialer comes from the TCU001-AD.

Autodialer status LED

Eight status LEDs surround the TCU001-AD's LCD screen. The Dlr (autodialer) LED (located on the right side of the LCD; third LED from the top) is used to indicate the status of the autodialer.



The Dlr LED has four states:

Blinking pattern	Indication
Off	There is currently no autodialer activity.
Steady, slow flash (i.e., on-off-on-off)	Call out alarm. A Dlr LED with a slow, steady flash indicates that there is an active alarm and the unit is preparing to call out.
Solid	Calling out. A solid (continuously lit) Dlr LED indicates that the autodialer is in the process of calling out.
Irregular, slow flash (on for 3 beats, off 1 beat) (i.e., on-on-on-off-on-on-on-off)	Maintenance mode. A Dlr LED with an irregular, slow flash indicates that the TCU001-AD is in maintenance mode (call out has been temporarily suspended by pressing and holding the Silence key while cycling power to the TCU001-AD). See Maintenance Mode on page 198 for more information.

CONNECTING THE TCU001-AD TO A PHONE LINE

Compatible phone systems

The TCU001-AD is compatible with analog, or POT ("plain old telephone"), systems only.

It is important that you ***not*** connect the TCU001-AD to a digital-type system – doing so will cause damage to the TCU001-AD. If you aren't sure what type of system you have, contact the person or department that oversees your telephone system ***before*** connecting the telephone line to the TCU001-AD.

Phone line connection

The TCU001-AD comes equipped with a short length of telephone cable terminated with a standard RJ-11 modular plug and female-to-female coupler for connecting to a dial-out telephone line.

The telephone line connected to the TCU001-AD should be a dedicated line. The line should not be shared with another telephone or telephone-enabled device.

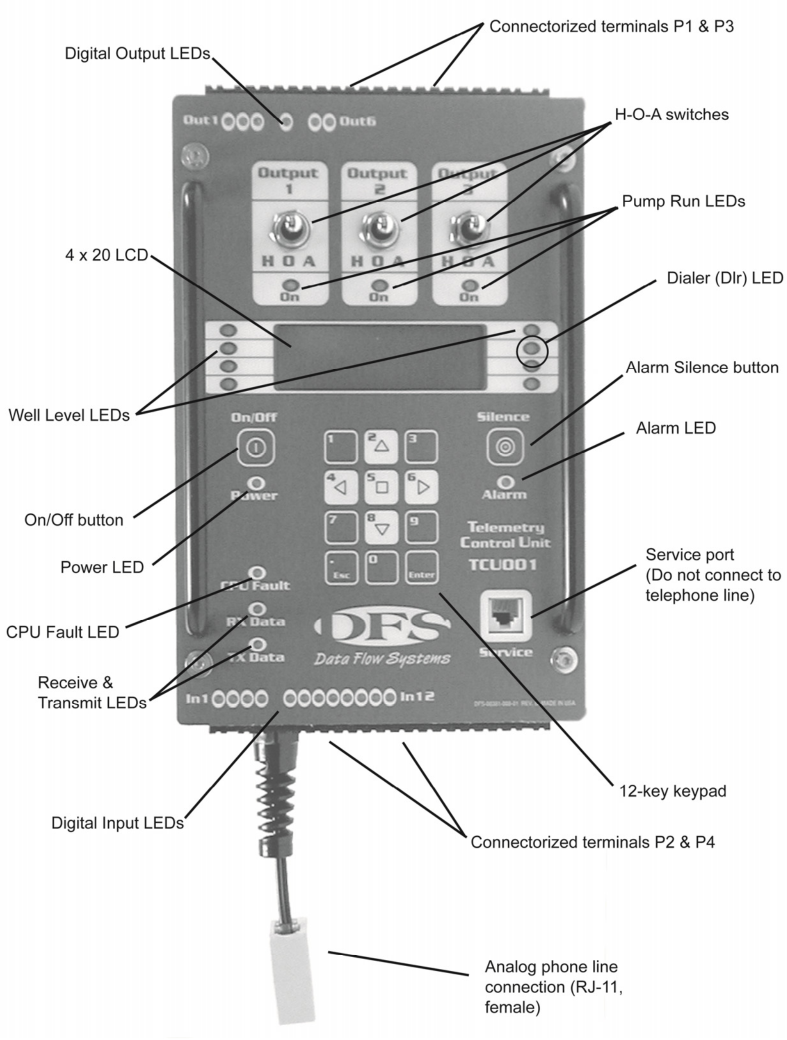
We recommend that you install a surge arrestor between the telephone line and the TCU001-AD to protect the unit from damage from electrical surges.

IMPORTANT: Do not connect the phone line to the service port that is located on the front of the TCU001-AD. The service port is used for factory service, BASIC programming, and troubleshooting only. Connecting a phone line to the service port could cause serious damage to the TCU001-AD if a phone call were to come in while the telephone line was connected to the service port.

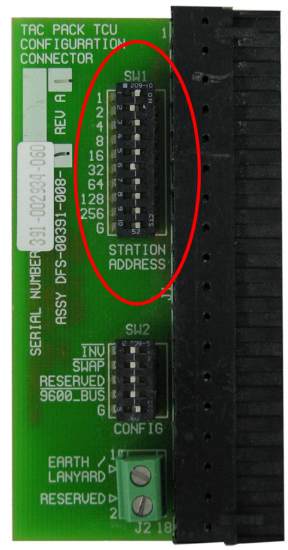
CONFIGURING THE AUTODIALER

The autodialer is configured via the TCU001-AD's LCD screen and keypad interface. Before configuring or using the autodialer, it is recommended that you review the information in "Chapter 9: Pump Controller User Interface" for a detailed description of the function of each of the TCU001 AD's LED's, keys, and switches.

TCU001-AD User Interface



Addressing the station number



The TCU001-AD's station number is used to identify the location where the alarm has occurred. Assigning a unique number to each station enables you to instantly identify the station that is in alarm when the autodialer calls out – the station number will be one of the first items announced.

The valid station address range for the TCU001-AD is 1-250.

The TCU001-AD's station address is configured by turning off switches on the TAC Pack TCU Configuration Connector's SW1 DIP switch that add up to the desired station number. The connector (shown at right) is installed in the TCU's P3 connector.

Each switch has an assigned bit value (labeled along the left side of the switch). The station address is calculated by totaling the bit values of the switches that are in the OFF position. (The OFF position is towards the card edge; the ON position is near the connector side.)

The example at right shows a station address of 34. The second and sixth switches are in the OFF position.

- Second switch: bit value = 2
- Sixth switch: bit value = 32

When we add the values of these bits together, we get a total value of 34 (2+32). The remaining bits would be left grounded (switch in the ON position).

Leaving ***all*** of the bits grounded (all switches in the ON position) gives the station an address of 0 (zero), which is an invalid address. Removing the configuration connector altogether, gives the station an address of 511 (the sum of all of the bits). This is also an invalid address. If the TCU has been incorrectly addressed, its TX Data LED will not blink when the device is up and running. This is an indication that the device is unable to transmit.

If you have a large number of stations, you can complete the "Station ID List" on page 200 as a further aid. On this list, you can note the station's number and its common name or physical address.

Placing the TCU001-AD in Configure Mode

All three of the TCU001-AD's H O A switches must be in the "Hand" or "Off" position before the TCU001-AD can be configured. If an H O A switch is changed to the "Auto" position while in configure mode, the TCU001-AD exits configure mode without saving changes and returns to the initial Status screen. The H-O-A switches can be changed between "Hand" and "Off" positions without affecting configure mode.

To access the TCU001-AD's configuration screens, navigate to the screen the displays the *Change Configurations* option and press the Enter key.

If you are at the TCU001-AD's default screen, pressing the key twice will bring you to the *Change Configurations* screen.

After the TCU001-AD is placed in configure mode, the TCU001-AD's navigation keys can be used to move through the configuration screens.

Changing Configuration Options

To change a configuration option, navigate to the correct screen and use the 2 and 8 keys to place the cursor on the line of the option you want to change. When the cursor is in place, press the Enter key. A question mark (?) appears next to the option's name indicating that it is ready to be edited. Depending on the option being changed, you can either enter a number by pressing the appropriate key on the TCU001-AD's keypad or use the 4 and 6 to navigate through available settings.

Exiting Configure Mode and Saving Configurations

Navigate through all of the configuration screens until you reach the screen that reads Press *Enter to Save, Esc to Abort*.

- Pressing the Enter key causes the TCU001-AD to replace the old configuration with the changes made during the current session. When changes are saved, the settings are written to the non-volatile memory. ***You must then cycle power to the TCU001-AD in order for the TCU to begin running on the new configurations.*** If the TCU001-AD's power is cycled before selecting the Save command, the last saved values are loaded on power up.
- Pressing the Esc key from any screen ***except*** the Set Time and Reset Timers screens causes the TCU001-AD to exit configure mode without saving any changes made during the current session. The old configuration is retained. ***Note that the Esc key cannot be used to exit configure mode in the Configure Dialer or Configure Modbus sections.***

The following methods do ***not*** save the current changes. They are considered safeguards:

- Pressing the Esc key from any of the TCU001-AD's configuration screens ***except*** the Set Time and Reset Timers screens causes the TCU001-AD to exit configure mode and abort any changes made during the current session. ***Note that the Esc key cannot be used to exit configure mode in the Configure Dialer or Configure Modbus sections.***
- Changing an H-O-A switch to the "Auto" position before selecting the Save command forces the TCU001-AD to exit configure mode and abort the current changes.
- Leaving the TCU001-AD unattended for over five minutes without selecting the Save command causes the TCU001-AD to abort any changes and return to the main display screen.
- Cycling the TCU001-AD's power (press and hold the TCU001-AD's On/Off key) before selecting the Save command causes the TCU001-AD to reload the old configuration from non-volatile memory and return to the main display screen.

Configuration overview

1. Place the TCU001-AD in configure mode.
2. Use the 4 or 6 key to navigate to the screen that reads *Change Configurations*. Press the Enter key to enter the configuration section. (If you are at the TCU001-AD's default screen, pressing the 4 key twice will bring you to the *Change Configurations* screen.)

```
     Change
 Configurations

     (enter)
```

3. Page through the TCU001-AD configuration screens until you reach the screen that includes the *Configure Dialer* option.

```
Bem Modules: 0
Trend Rate = 30 secs
  Configure Modbus
   Configure Dialer
```

4. Use the 8 key to place the cursor on the line that reads *Configure Dialer* and then press the Enter key.
5. Use the directional keys 2 4 6 8 on the TCU001-AD keypad to move through each of the four configuration screens and through each screen's configuration options.
6. Select the configuration that you want to edit and press the Enter key. A question mark will appear.
7. Use the numbered keys on the keypad and the Silence key to enter the data and then press the Enter key.

   Note: If you make a mistake while entering data, press the Silence key four times to delete the last character on the current line. The Silence key enables you to cycle through the special characters pound (#), comma (,) and asterisk (*) as well as access the delete function.
8. When you are finished entering all data, press the Esc key.
9. Use the 4 and 6 keys to move to the screen that reads *Press Enter to Save Esc to Abort*.
10. Press the Enter key to save your changes.

Selecting alarms

Each alarm condition can be configured with a delay of up to 9,999 seconds (~167 minutes). If an alarm occurs, the autodialer will wait the specified period of time before dialing out. To disable dial out for a specific alarm condition, enter a 0 (zero) in the dial delay field for that condition. When you enter a 0 (zero) in the field and press the Enter key, the 0 (zero) will change to read *Disab* to indicate that the alarm has been disabled.

There are eight options that control call out for the 22 available alarm conditions. For example, *MtrFlt Delay* controls the alarms for six motor fault conditions (motor 1 failed to start; motor 1 failed to stop; motor 2 failed to start; motor 2 failed to stop; motor 3 failed to start; motor 3 failed to stop). To enable call out for these alarm conditions, you only need to enter a single delay time in the *MtrFlt Delay* field.

The "Alarm Configurations Table" on the next page lists:

- The configuration screen that the option appears on
- The field (configuration label) that must be set
- The alarms the option controls
- A brief description of the option

Detailed directions for configuring call out for these alarms conditions can be found directly following the table.

Alarm Configurations Table

Screen	Configuration label	Affected alarms	Description
1	HiWell Delay	• High well level	Length of time (in seconds) before the autodialer should begin calling out when a high well level alarm occurs. Enter a 0 (zero) to disable call out for this alarm. Maximum delay time is 9,999 seconds (~ 167 minutes).
	LoWell Delay	• Low well level	Length of time (in seconds) before the autodialer should begin calling out when a low well level alarm occurs. Enter a 0 (zero) to disable call out for this alarm. Maximum delay time is 9,999 seconds (~ 167 minutes).
	FltSeq Delay	• Float out of sequence • Level transducer fault	Length of time (in seconds) before the autodialer should begin calling out when a float out of sequence or level transducer fault occurs. Enter a 0 (zero) to disable call out for this alarm. Maximum delay time is 9,999 seconds (~ 167 minutes).
	MtrFlt Delay	• Motor 1 failed to start • Motor 1 failed to stop • Motor 2 failed to start • Motor 2 failed to stop • Motor 3 failed to start • Motor 3 failed to stop	Length of time (in seconds) before the autodialer should begin calling out when a motor start/stop fault occurs (motor 1, 2, or 3). Enter a 0 (zero) to disable call out for this alarm. Maximum delay time is 9,999 seconds (~ 167 minutes). Note: If the TCU001-AD is installed at a simplex or duplex station (where motor 2 and/or motor 3 have not been configured or connected) dial out is automatically disabled for those motor starter contacts.
2	PwrFlt Delay	• AC power failure • Phase voltage fault • Phase voltage sequence (or phase reversal) fault	Length of time (in seconds) before the autodialer should begin calling out when an AC power failure, phase voltage fault, or phase voltage sequence fault occurs. Enter a 0 (zero) to disable call out for this alarm. Maximum delay time is 9,999 seconds (~ 167 minutes).
	AuxIn Delay	• Auxiliary input alarm	Length of time (in seconds) before the autodialer should begin calling out when an auxiliary input fault occurs. Enter a 0 (zero) to disable call out for this alarm. Maximum delay time is 9,999 seconds (~ 167 minutes).

Screen	Configuration label	Affected alarms	Description
	HOAOff Delay	• H-O-A switch 1 is in the Off position • H-O-A switch 2 is in the Off position • H-O-A switch 3 is in the Off position • H-O-A switch 1 is in the Hand position • H-O-A switch 2 is in the Hand position • H-O-A switch 3 is in the Hand position	Length of time (in seconds) before the autodialer should begin calling out when any of the TCU001-AD's HOA switches are in the Off or Hand position. Enter a 0 (zero) to disable call out for this alarm. Maximum delay time is 9,999 seconds (~ 167 minutes). **IMPORTANT**: If the TCU001-AD is installed at a simplex or duplex station (where H-O-A switch 2 and/or H-O-A switch 3 are not being used), the unused H-O-A switches must be left in the Auto position to disable call out for those switches .
	HdwFlt Delay	• DC bias fault • Process fault	Length of time (in seconds) before the autodialer should begin calling out when a hardware fault occurs (DC bias fault or process fault). Enter a 0 (zero) to disable call out for this alarm. Maximum delay time is 9,999 seconds (~ 167 minutes).

Determine the alarm conditions that you want to enable for call out and the delay desired for each. The delay is the amount of time the autodialer waits to call out once an alarm occurs. To disable an alarm condition, enter 0 (zero) in the corresponding delay field. When you enter a 0 (zero) in the field and press the Enter key, the 0 (zero) will change to read *Disab* to indicate that the alarm has been disabled.

1. Place the TCU001-AD in configure mode. Use the 4 and 6 keys on the keypad to navigate to the screen that reads *Change Configurations*. Press the Enter key to enter the configuration section.

```
      Change
  Configurations

     (enter)
```

2. Page through the TCU001-AD configuration screens until you reach the screen that includes the *Configure Dialer* option.

```
Bem Modules: 0
Trend Rate = 30 secs
  Configure Modbus
   Configure Dialer
```

3. Use the 8 key to place the cursor on the line that reads *Configure Dialer* and then press the Enter key. The first autodialer configuration screen features *HiWell Delay, LoWell Delay, FltSeq Delay*, and *MtrFlt Delay*.

```
HiWell Delay = Disab
LoWell Delay = Disab
FltSeq Delay = Disab
MtrFlt Delay = Disab
```

4. Use the 2 and 8 keys on the keypad to place the cursor on the line you want to edit (for example, the *LoWell Delay* line) and then press the Enter key. A question mark will appear at the end of the line.

```
HiWell Delay = 60
LoWell Delay = ?
FltSeq Delay = Disab
MtrFlt Delay = Disab
```

5. Use the numbered keys on the keypad to enter the desired delay time. For example, to enter a delay time of two (2) minutes, enter 120. Press the Enter key after entering the time.

   Note: If you make a mistake while entering data, press the Silence key four times to delete the last character on the current line. The Silence key enables you to cycle through the special characters pound (#), comma (,) and asterisk (*) as well as access the delete function.

6. Repeat step four for each of the options on the first configuration screen.

```
HiWell Delay = 90
LoWell Delay = 90
FltSeq Delay = 60
MtrFlt Delay = 60
```

7. When you are finished with configuration screen 1, use the 6 key on the keypad to navigate to the next screen. The second configuration screen features *PwrFlt Delay, AuxIn Delay, HOAOff Delay*, and *HdwFlt Delay*.

```
PwrFlt Delay = Disab
AuxIn Delay = Disab
HOAOff Delay = Disab
HdwFlt Delay = Disab
```

8. Repeat step four for each of the options on the second configuration screen.

```
PwrFlt Delay = 60
AuxIn Delay = 60
HOAOff Delay = 60
HdwFlt Delay = 60
```

9. To enter call out telephone numbers, proceed to the next section “Entering phone numbers.”

   Otherwise, press the Esc key to exit the Configure Dialer section and use the 4 and 6 navigation keys to move to the screen that reads *Press Enter to Save Esc to Abort*.

   To save your changes, press the Enter key on the keypad. To exit without saving, press the Esc key.

Entering phone numbers

The autodialer can be configured with up to four telephone numbers to be called when an alarm occurs. Each telephone number is called in sequence until all of the alarms are acknowledged. Each phone number field can hold up to 16 characters.

Note: To enter special characters in phone numbers, use the Silence key on the TCU001-AD keypad. Pressing the Silence key will cycle through the following special characters/functions:

- Comma (,) – Can be used to add pauses between the telephone number and an extension number, or between a telephone number and a pager message. Each comma represents a four-second pause.
- Pound (#) – Can be used to let a telephone paging system know that the message is complete.
- Asterisk (*) – Can be used to gain an outside line or enter an extension number.
- Delete – Pressing the Silence key a fourth time will delete the last character on the current line.

After cycling to the desired special character, you must press the Enter key to register the entry. (Note that this does not apply to the Delete function. As soon as the Silence key is pressed for the fourth time, the last character on the current line is deleted.)

Screen	Configuration label	Description
3	#1	First number to be called when an alarm condition occurs. Use commas to represent a pause. The special characters * and # can also be used if required to access an outside line or to indicate to a pager that the message is complete. Use the Silence key on the keypad to cycle through special characters. This field can handle up to 16 characters.
	#2	Second number to be called when an alarm condition occurs. Use commas to represent a pause. The special characters * and # can also be used if required to access an outside line or to indicate to a pager that the message is complete. Use the Silence key on the keypad to cycle through special characters. This field can handle up to 16 characters.
	#3	Third number to be called when an alarm condition occurs. Use commas to represent a pause. The special characters * and # can also be used if required to access an outside line or to indicate to a pager that the message is complete. Use the Silence key on the keypad to cycle through special characters. This field can handle up to 16 characters.
	#4	Fourth number to be called when an alarm condition occurs. Use commas to represent a pause. The special characters * and # can also be used if required to access an outside line or to indicate to a pager that the message is complete. Use the Silence key on the keypad to cycle through special characters. This field can handle up to 16 characters.

Determine which telephone numbers the autodialer should call when an alarm occurs as well as the order they should be called in. The autodialer will call the phone number entered in field *#1* first. If the alarms aren't acknowledged by recipient #1, the autodialer will move on to the telephone number in field *#2*, then *#3*, and finally *#4*. If it gets to the end of the list and there are still unacknowledged alarms, it will cycle through the numbers again.

Note that when entering telephone numbers, you ***must*** enter a number in field *#1* and the fields must be configured in order from *#1* - *#4*.

1. If you have just finished configuring alarm delays and are still in configure mode, skip to step four (4). Otherwise, continue to step two (2).

2. Place the TCU001-AD in configure mode. Use the 4 and 6 keys on the keypad to navigate to the screen that reads *Change Configurations*. Press the Enter key to enter the configuration section.

```
      Change
  Configurations

      (enter)
```

3. Page through the TCU001-AD configuration screens until you reach the screen that includes the *Configure Dialer* option. Use the 8 key to place the cursor on the line that reads *Configure Dialer* and then press the Enter key.

```
Bem Modules: 0
Trend Rate = 30 secs
 Configure Modbus
  Configure Dialer
```

4. Use the 6 key on the keypad to navigate to the screen that displays the options *#1*, *#2*, *#3*, and *#4*. These fields hold the telephone numbers that the autodialer will call.

```
#1 =
#2 =
#3 =
#4 =
```

5. Use the 2 and 8 keys on the keypad to place the cursor on the line you want to edit (for example, the *#1* line) and then press the Enter key. A question mark will appear at the end of the line.

```
#1 = ?
#2 =
#3 =
#4 =
```

6. Use the numbered keys on the keypad to enter the desired telephone number and then press Enter. If the telephone number requires a pause (for example, between the telephone number and an extension number), use the Silence key on the keypad to enter a comma (which represents a pause). Multiple commas can be entered if necessary. Pound (#) and star (*) characters can also be entered using the Silence key. The Silence key cycles through these special characters each time the key is pressed. When the desired character appears on the display, press the Enter key to register the entry.

```
#1 = 9,5551212,,481
#2 = 9,5554545,,,25#
#3 = 9,5552323,,,,
#4 =
```

In the example above, all of the numbers start with "9,". This causes the autodialer to dial 9 to get an outside line and then wait four seconds before dialing the number.

- Field #1 dials the phone number, waits eight seconds, and then dials a three digit extension.
- Field #2 dials a pager, waits 12 seconds, enters a key sequence (the number of the station that is experiencing the alarm), and then enters the pound character to indicate that the message is finished.
- Field #3 dials an answering machine, waits 16 seconds and then begins playing the alarm messages. It won't announce the alarms, since no one is there to enter the acknowledgement code. But, it will announce that there is an alarm at station 25.

Note: If you make a mistake while entering data, press the Silence key four times to delete the last character on the current line. The Silence key enables you to cycle through the special characters pound (#), comma (,) and asterisk (*) as well as access the delete function.

7. Repeat step six for each of the telephone number fields on the third configuration screen.
8. To configure an acknowledgement code, proceed to the next section, "Configuring acknowledgement code."

   Otherwise, press the Esc key to exit the Configure Dialer section and use the ◄4 and 6► navigation keys to move to the screen that reads *Press Enter to Save Esc to Abort*.

   To save your changes, press the Enter key on the keypad. To exit without saving, press the Esc key.

Configuring acknowledgement code

When an alarm occurs and the autodialer calls out, the recipient of the phone call will be prompted for a one- to four-digit acknowledgement code. The acknowledgement code prevents unauthorized users from acknowledging alarms. The call recipient will be given three opportunities to enter the correct code before the autodialer will hang up and proceed to the next number in the list. The call recipient will not be allowed to acknowledge any alarms until they enter the correct code.

Screen	Configuration label	Description
4	Ack Code	One- to four-digit code that must be correctly entered before any alarms are announced.

Determine the four digits to be used for the acknowledgement code. Make sure that everyone on the call out list knows the code, so they can properly acknowledge alarms when they are called.

IMPORTANT: Although the *Ack Code* can be anywhere from one to four digits long, we recommend that you create a four-digit code to make if more difficult for an unauthorized person to guess your *Ack Code*.

1. If you have just finished entering telephone numbers and are still in configure mode, skip to step four (4). Otherwise, continue to step two (2).
2. Place the TCU001-AD in configure mode. Use the ◄4 and 6► keys on the keypad to navigate to the screen that reads *Change Configurations*. Press the Enter key to enter the configuration section.

```
     Change
 Configurations

     (enter)
```

3. Page through the TCU001-AD configuration screens until you reach the screen that includes the *Configure Dialer* option. Use the 8 key to place the cursor on the line that reads *Configure Dialer* and then press the Enter key.

```
Bem Modules: 0
Trend Rate = 30 secs
  Configure Modbus
   Configure Dialer
```

4. Use the 6 key on the keypad to navigate to the screen that displays the option *Ack Code*. This field holds the acknowledgement four-digit acknowledgement code that must be entered by call recipients.

```
  Ack Code =
Retry Time =
```

5. Use the 2 and 8 keys on the keypad to place the cursor on the *Ack Code* line and then press the Enter key. A question mark will appear at the end of the line.

```
  Ack Code = ?
Retry Time =
```

6. Use the numbered keys on the keypad to enter the desired four-digit acknowledgement code. Press Enter.

```
  Ack Code = 5982
Retry Time =
```

   Note: If you make a mistake while entering data, press the Silence key four times to delete the last character on the current line. The Silence key enables you to cycle through the special characters pound (#), comma (,) and asterisk (*) as well as access the delete function.

7. To enter a retry time, proceed to the next section “Configuring dial-out retry time.”

   Otherwise, press the Esc key to exit the Configure Dialer section and use the 4 and 6 navigation keys to move to the screen that reads *Press Enter to Save Esc to Abort*.

   To save your changes, press the Enter key on the keypad. To exit without saving, press the Esc key.

Configuring dial-out retry time

The autodialer can be configured with an interval that represents the maximum length of time between phone calls. If the call recipient is unable to acknowledge the alarms within the *Retry Time* interval (for example, if their phone battery dies during the call or no one answers), the autodialer will hang up and dial the next number in the list when the *Retry Time* expires. This allows you to set a maximum time that each phone call should take and ensures that alarms will be acknowledged as quickly as possible.

Screen	Configuration label	Description
4	Retry Time	Length of time (in seconds) before the next phone number in the dial-out list is called. If the autodialer calls out and the alarms are not acknowledged within this time period, the next phone number will be called. Maximum Retry Time is 9,999 seconds (~167 minutes).

Determine the optimal, acceptable interval for the Retry Time. The table below is provided for your convenience. It converts common minute and hour intervals into seconds.

Minutes/Hours	Seconds
5 minutes	300 seconds
10 minutes	600 seconds
15 minutes	900 seconds
30 minutes	1800 seconds
1 hour	3600 seconds
1 ½ hours	5400 seconds
2 hours	7200 seconds
2 ½ hours	9000 seconds

1. If you have just finished entering the acknowledgement code and are still in configure mode, skip to step five (5). Otherwise, continue to step two (2).
2. Place the TCU001-AD in configure mode. Use the ◄4 and 6► keys on the keypad to navigate to the screen that reads *Change Configurations*. Press the Enter key to enter the configuration section.

```
     Change
 Configurations

     (enter)
```

3. Page through the TCU001-AD configuration screens until you reach the screen that includes the *Configure Dialer* option. Use the 8 key to place the cursor on the line that reads *Configure Dialer* and then press the Enter key.

```
Bem Modules: 0
Trend Rate = 30 secs
  Configure Modbus
   Configure Dialer
```

4. Use the 6 key on the keypad to navigate to the screen that displays the option *Retry Time*.

```
   Ack Code = 5982
Retry Time =
```

5. Use the 2 and 8 keys on the keypad to place the cursor on the *Retry Time* line and then press the Enter key. A question mark will appear at the end of the line.

```
   Ack Code = 5982
Retry Time = ?
```

6. Use the numbered keys on the keypad to enter the desired retry time. Press Enter.

```
   Ack Code = 5982
Retry Time = 300
```

   Note: If you make a mistake while entering data, press the Silence key four times to delete the last character on the current line. The Silence key enables you to cycle through the special characters pound (#), comma (,) and asterisk (*) as well as access the delete function.

7. If you are finished configuring all of the autodialer properties, press the Esc key and scroll through all of the configuration screens until you reach the screen that reads *Press Enter to Save, Esc to Abort*.

   To save your changes, press the Enter key on the keypad. To exit without saving, press the Esc key.

Factory settings

The table below shows the factory default settings for the TCU001-AD's autodialer.

Configuration option	Factory default setting
HiWell Delay	*Disab* (call out is disabled by default)
LoWell Delay	*Disab* (call out is disabled by default)
FltSeq Delay	*Disab* (call out is disabled by default)
MtrFlt Delay	*Disab* (call out is disabled by default)
PwrFlt Delay	*Disab* (call out is disabled by default)
AuxIn Delay	*Disab* (call out is disabled by default)
HOAOff Delay	*Disab* (call out is disabled by default)
HdwFlt Delay	*Disab* (call out is disabled by default)
#1	
#2	
#3	
#4	
Ack Code	0000
Retry Time	0

Return to default values

IMPORTANT: Although it is possible to return these settings to their factory default values, doing so will cause all of the TCU001-AD's settings to revert to default values. Please consider carefully before taking this action.

Hold down the 8 (eight) key during TCU001-AD power up. This will clear ***all*** configuration changes you've made to the TCU001-AD and restore all options to their factory default settings. Before removing all configurations, you may want to download the TCU001-AD's current configuration using WinRTU Test. If you need this configuration in the future, you can easily use WinRTU Test to download it to a TCU001-AD. WinRTU Test is included in the TCU001 Test Kit. See "Appendix C: Parts List" for ordering information.

RECEIVING AND ACKNOWLEDGING AN ALARM CALL

When you answer a call from the autodialer, you will first hear a welcome message that includes the station number of the station in alarm.

The autodialer will then prompt you for the one- to four-digit acknowledgement code. You are given three opportunities to enter the correct code. If you fail to enter the correct code on the third try, the autodialer will play a good-bye message and hang up. It will then call the next telephone number in the dial out list.

Once you have entered the correct acknowledgement code, the autodialer will play the first alarm message. You will then be prompted to press 1 (one) to acknowledge the alarm or 2 (two) to replay the message. The autodialer will only play the message a maximum of three times. If you don't acknowledge the alarm after the third time the message is played, the autodialer will play the good-bye message and hang up. It will then call the next number in the dial out list.

If there are additional alarms at the station, the autodialer will play the message for the second alarm and will again prompt you to acknowledge or replay. It will continue this sequence until either all alarms have been acknowledged or the session ends because you didn't acknowledge an alarm within the three time maximum.

When all alarms have been acknowledge, the autodialer will play the good-bye message and end the call.

MAINTENANCE MODE

The TCU001-AD features a maintenance mode that enables you to temporarily suspend call out. This is useful when you are doing periodic maintenance or repairs on a station that requires you to turn off equipment (actions that would normally cause the autodialer to call out).

The TCU001-AD is placed in maintenance mode by pressing and holding the Silence key while cycling power to unit. The Dlr LED will begin exhibiting a slow, irregular flash (on-on-on-off-on-on-on-off) to indicate that the unit is in maintenance mode.

The TCU001-AD will remain in maintenance mode until you manually cancel maintenance mode by pressing and holding the Silence Button until the Dlr LED stops flashing and turns on solid.

When the unit comes out of maintenance mode, it will call out for any alarms that occurred during maintenance mode, provided the alarm is still active. Call out will not begin until the delay for that alarm expires; the delay timer starts running as soon as the unit comes out of maintenance mode.

Place the TCU001-AD in maintenance mode

1. Turn off the TCU001-AD by pressing the On/Off key.
2. Press and hold the Silence key while simultaneously cycling power to the unit (press the On/Off key).
3. Observe the Dlr LED. Release the Silence key when the Dlr LED starts exhibiting a slow, irregular flash (on-on-on-off-on-on-on-off) that indicates that the unit is in maintenance mode.

   Note: It is important to release the Silence key within 8-10 seconds to prevent canceling maintenance mode.

Cancel maintenance mode

1. Press and hold the Silence key until the Dlr LED stops flashing and turns on solid.
2. Release the Silence key. The Dlr LED will go off. The autodialer will return to normal operation.

CONFIGURATION LOG SHEET

Use the table to record the autodialer's current configuration values. This information can be used to restore the TCU001-AD's autodialer configuration should the unit experience a technical difficulty that causes it to lose its configuration data or necessitates replacement.

Configuration item	Default value	Range	Current value
HiWell Delay	0	0-9,999 seconds*	
LoWell Delay	0	0-9,999 seconds*	
FltSeq Delay	0	0-9,999 seconds*	
MtrFlt Delay	0	0-9,999 seconds*	
PwrFlt Delay	0	0-9,999 seconds*	
AuxIn Delay	0	0-9,999 seconds*	
HOAOff Delay	0	0-9,999 seconds*	
HdwFlt Delay	0	0-9,999 seconds*	
Phone no. 1	n/a		
Phone no. 2	n/a		
Phone no. 3	n/a		
Phone no. 4	n/a		
Ack Code	0000		
Retry Time	0	0-9,999 seconds	

*Entering a 0 (zero) in this field disables call out.

Station ID List

Use this table to record the station number and corresponding common name (for example, Washington Park) or street address (for example, 123 Main Street). This “cheat sheet” will allow you to easily cross-reference and identify a location by its station number.

Station number	Station name/address

FCC NOTICE TO USERS

FCC Requirements

1. The Federal Communications Commission (FCC) has established rules which permit this device to be directly connected to the telephone network. Standardized jacks are used for these connections. This equipment should not be used on party lines or coin phones.
2. If this device is malfunctioning, it may also be causing harm to the telephone network; this device should be disconnected until the source of the problem can be determined and until repair has been made. If this is not done, the telephone company may temporarily disconnect service.
3. The telephone company may make changes in its technical operations and procedures; if such changes affect the compatibility or use of this device, the telephone company is required to give adequate notice of the changes. You will be advised of your right to file a complaint with the FCC.
4. If the telephone company request information on what equipment is connected to their lines, inform them of:

    a. The telephone number to which this unit is connected.

    b. The Ringer Equivalence Number [0.8B].

    c. The USOC jack required [RJ11C].

    d. The FCC Registration Number [EMRUSA-30496-AL-E].

    Items (b) and (d) are indicated on the label. The Ringer Equivalence Number (REN) is used to determine how many devices can be connected to your telephone line. In most areas, the sum of REN's of all devices on any one line should not exceed five (5). If too many devices are attached, they may not ring properly.

Service Requirements

In the event of equipment malfunction, all repairs should be performed by our company or an authorized agent. It is the responsibility of users requiring service to report the need for service to our company or to one of our authorized agents. Refer to "Appendix O: Support, Service, and Warranty" for information on obtaining service.

Notes

Appendix I: TCU001-IP

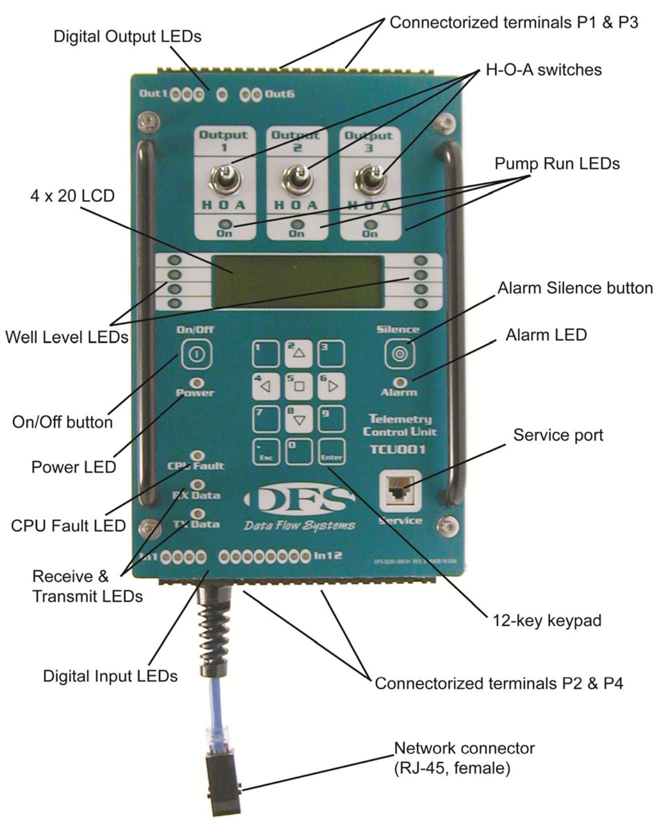
The TAC Pack TCU is offered with an optional integrated 10/100 network adapter. When combined, the two products become model TCU001-IP (Part # DFS-00367-008-09). The TCU001-IP presents an ideal solution where radio may not be preferred, and where networking is available (for example, frame relay, cable internet service, wireless Ethernet, local area network, etc.).

A TCU001-IP can be polled using either Modbus TCP or DFS NIM protocol (protocol that enables serial to network-based communication between DFS network TCUs/RTUs and the Hyper SCADA Server).

Additionally, the TCU001-IP can function as a Modbus master device through its RS-485 Modbus serial interface. Modbus slave devices can be polled at 1200-9600 baud using either Modbus ASCII or RTU protocol. I/O obtained through the TCUs RS-485 interface is mapped to both DFS addresses and Modbus registers and is available from the network interface. Refer to "Chapter 5: Modbus Support" and the section titled "Poll Modbus Slave Devices" in "Chapter 10: Configuring the Pump Control Process" (beginning on page 127) for information on using the TCU as a Modbus master (via RS-485).

> **IMPORTANT:** The TCU001-IP ***cannot*** be polled as a Modbus slave via its RS-232 serial interface. In a TCU001-IP, the RS-232 interface is used internally for network-specific operations.

TCU001-IP USER INTERFACE



Before You Begin

We suggest that you configure the network portion of the TCU001-IP before doing any other configuration and wiring (other than AC power).

Suggested installation order:

- Ask your IT department (or the person/department in charge of your network) to assign a unique IP address to each TCU001-IP.
- Configure the TCU001-IP's network settings: IP address and gateway (optional).
- Connect the TCU001-IP to your network. We suggest that you use network surge protection to insulate the TCU001-IP from voltage surges.
- Use the PING command to verify that you can communicate with the TCU001-IP via the network.
- Wire and configure external devices (pump motors, transducers, alarm lights, etc)

IP Address Requirements

In addition to the configurations for such items as number of pumps, transducer type, and set point levels, the TCU001-IP requires a configured IP address in order for it to communicate over the network. This requires that each TCU001-IP that is on the same network have a unique IP address to avoid network addressing conflicts.

Before installing a TCU001-IP, contact your MIS/IS department, or the person/department that oversees your network, to obtain a unique IP address for each TCU001-IP being installed.

Methods for Configuring the TCU001-IP's IP Address

You will typically configure the IP address by connecting the TCU001-IP to a laptop and using an Internet browser to open the Network Configuration Form. A second method is available for TCU001-IPs that will be polled using Modbus TCP. These devices can also be configured using the TCU001-IP's LCD interface. Note, however, that using the Network Configuration Form is the preferred method.

Configuring IP Address Using the Network Configuration Form

You access the network configuration form by connecting the TCU001-IP to a laptop and using an Internet browser to open the form. In order for the laptop to communicate with the TCU001-IP, the computer's IP address must be temporarily changed so that it is on the same subnet (192.168.1) as the TCU001-IP. The TCU001-IP leaves the factory with a default IP address of 192.168.1.10.

Change Your Computer's IP Address

IMPORTANT: Contact your Network Administrator before making any changes to your computer's network settings.

(The steps below are for a computer running the Windows 7 operating system. If you are using an operating system other than Windows, check the documentation for that operating system.)

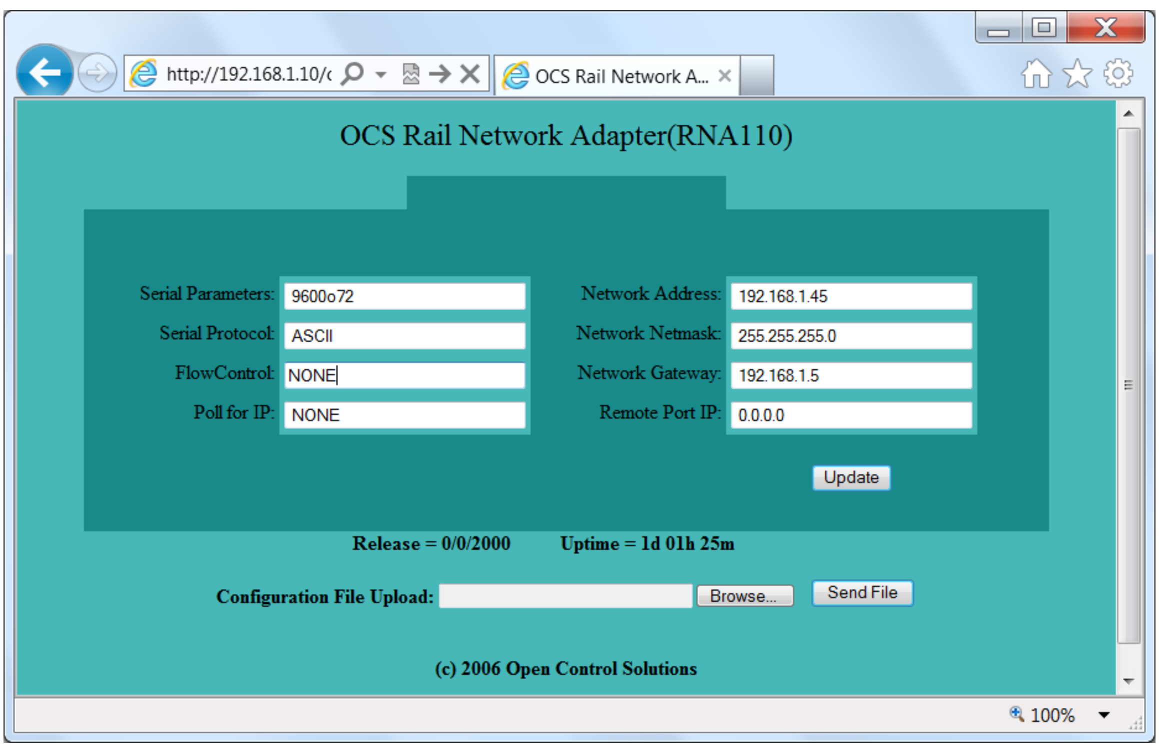
1. Click **Start** and select **Control Panel**.
2. Click **Network and Internet**.

3. Click **Network and Sharing Center**.
4. In the **View your network settings** section, click **Local Area Connection** to open **Local Area Connection Status**.
5. Click **Properties** to open **Local Area Connection Properties**.
6. Under **This connection uses the following properties**, select the internet protocol version that has a check mark next to it and click **Properties**. [This will be either **Internet Protocol Version 6 (TCP/IPv6)** or **Internet Protocol Version 4 (TCP/IPv4)**.]
7. Click the radio button for the **Use the Following IP Address** option. Enter an IP address in the 192.168.1 subnet that is available and click **OK**.

Set the IP Address and Optional Gateway, and Verify Communication Settings

Note: Before continuing, verify that your computer's IP address has been changed as described in the preceeding section.

1. Connect the TCU to a power source as described in "AC Power" on page 58 in "Chapter 6: Electrical Installation." Turn on the TCU001-IP using the On/Off button on the cover of the unit. The power LED will illuminate to indicate the TCU001-IP is powered.
2. Connect the TCU to a laptop using an Ethernet crossover patch cable. The TCU001-IP has an RJ-45 female connector on the bottom of the unit (as shown in "TCU001-IP User Interface" on page 203).
3. Open your Internet browser and enter the TCU001-IP's current IP address in the browser's address bar. (**Note:** The unit leaves the factory with a default IP address of 192.168.1.10.)



4. Verify that:
   - **Serial Parameters** = 9600o72 (9600 baud, Odd parity, 7 data bits, and 2 stop bits)
   - **Serial Protocol** = ASCII
   - **FlowControl** = NONE
   - **Poll for IP** = None
5. Enter the appropriate network information:
   - **Network Address** = IP address assigned by your Network Administrator.
   - **Network Netmask** (optional) = Network netmask (subnet mask) assigned by your Network Administrator. Leave at the default value (255.255.255.0) if not required.
   - **Network Gateway** (optional) = Gateway address assigned by your Network Administrator.
   - **Remote Port IP** (does not apply) = Leave this at its default setting (0.0.0.0).
6. Click **Update**.
7. Enter the user name and password and click **Login** (user name: ***convert***; password: ***solution***). The user name and password are set at the factory and can't be changed.
8. The next screen to appear will include the statement "Reconfiguring System. Will automatically restart in 10 seconds."
9. When reconfiguration is complete, the first configuration screen will be reloaded in your Web browser and will reflect the new values. (Note that if you changed any of the network settings, you will need to reconfigure your computer in order to see the TCU.)
10. If necessary, change your computer's IP address back to its original setting.

When you are finished with this procedure, you are ready to place the TCU001-IP on your network as described in "Connect TCU001-IP to Network" on page 211.

CONFIGURING IP ADDRESS USING TCU INTERFACE (MODBUS ONLY)

If you are configuring a TCU001-IP that will be polled using Modbus TCP, you can use the procedure described in this section. Note, however, that using the Network Configuration Form is the preferred method.

The two components of the TCU001-IP's IP address (network and host) are configured as follows:

- The first three octets of the IP address (the network portion) must be entered in the *#4* phone number field of the Autodialer configuration screens.
- The last octet of the IP address (the host or node portion) is obtained from the TCU001-IP's configured station address.

For example, for the IP address 192.168.66.5

- Network portion = 192.168.66
- Host or node portion = 66

Configuring Host (Node) Portion of IP Address

The last octet of the IP address (host or node portion) is obtained from the TCU001-IP's configured station address.

The valid host (station address) range for the TCU001-IP is 1-250.

The TCU's host (station address) is configured by turning off switches on the TAC Pack TCU Configuration Connector's SW1 DIP switch that add up to the desired host number. The connector (shown at right) is installed in the TCU's P3 connector.

Each switch has an assigned bit value (labeled along the left side of the switch). The host address is calculated by totaling the bit values of the switches that are in the OFF position. (The OFF position is towards the card edge; the ON position is near the connector side.)

The example at right shows a host address of 34. The second and sixth switches are in the OFF position.

- Second switch: bit value = 2
- Sixth switch: bit value = 32

When we add the values of these bits together, we get a total value of 34 (2+32). The remaining bits would be left grounded (switch in the ON position).

> **IMPORTANT:** The 256 bit value switch on the TCU Configuration Connector *must* be left in the ON position for a TCU001-IP.

Leaving all of the bits grounded (all switches in the ON position) gives the TCU a station address of 0 (zero), which is an invalid address. Removing the configuration connector altogether, gives the TCU a station address of 511 (the sum of all of the bits). This is also an invalid address. If the TCU has been incorrectly addressed, its TX Data LED will not blink when the device is up and running. This is an indication that the device is unable to transmit.

The TCU Configuration Connector also features a terminal named Earth/Lanyard. This terminal must be wired to the control panel's ground. Although wiring the connector to ground is redundant, it serves the purpose of ensuring that the configuration settings remain with the control panel, or station. If the TCU needs to be replaced, the configuration connector can be easily removed and installed in the replacement TCU.

Configuring Network Portion of IP address and Optional Gateway

The network portion of the TCU001-IP's IP address must be entered in the *#4* phone number field of the Autodialer phone number configuration screens.

If the TCU001-IP is communicating through a gateway, the gateway's full IP address must be entered in the #3 phone number field of the Autodialer phone number configuration screens.

Additionally, the *#1* phone number field ***must*** be cleared of all characters. If any characters are present in the *#1* phone number field, the TCU001-IP will be unable to communicate via its network card.

The phone number fields can be found on the third Autodialer configuration screen. All other settings can be left at their default values.

Placing the TCU001-IP in Configure Mode

The TCU001-IP is configured via the TCU001-IP's LCD screen and keypad interface. Before configuring or using the TCU001-IP, it is recommended that you review the information in "Chapter 9: Pump Controller User Interface" for a detailed description of the function of each of the TCU001-IP's LED's, keys, and switches.

All three of the TCU001-IP's H-O-A switches must be in the "Hand" or "Off" position before the TCU001 IP can be configured. If an H-O-A switch is changed to the "Auto" position while in configure mode, the TCU001-IP exits configure mode without saving changes and returns to the initial Status screen. The H-O-A switches can be changed between "Hand" and "Off" positions without affecting configure mode.

To access the TCU001-IP's configuration screens, navigate to the screen that displays the *Change Configurations* option and press the Enter key.

If you are at the TCU001-IP's default screen, pressing the 4 key twice will bring you to the *Change Configurations* screen.

After the TCU001-IP is placed in configure mode, the TCU001-IP's navigation keys can be used to move through the configuration screens.

Changing Configuration Options

To change a configuration option, navigate to the correct screen and use the 2 and 8 keys to place the cursor on the line of the option you want to change. When the cursor is in place, press the Enter key. A question mark (?) appears next to the option's name indicating that it is ready to be edited. Depending on the option being changed, you can either enter a number by pressing the appropriate key on the TCU001-IP's keypad or use the 4 and 6 to scroll through available settings.

Exiting Configure Mode and Saving Configurations

Scroll through all of the configuration screens until you reach the screen that reads *Press Enter to Save, Esc to Abort*.

- Pressing the Enter key causes the TCU001-IP to replace the old configuration with the changes made during the current session. When changes are saved, the settings are written to the non-volatile memory. ***You must then cycle power to the TCU in order for the TCU to begin running on the new configurations.*** If the TCU001-IP's power is cycled before selecting the Save command, the last saved values are loaded on power up.
- Pressing the Esc key from any screen ***except*** the Set Time and Reset Timers screens causes the TCU001-IP to exit configure mode without saving any changes made during the current session. The old configuration is retained. ***Note that the Esc key cannot be used to exit configure mode in the Configure Dialer or Configure Modbus sections.***

Methods that do not save the current changes (considered safeguards) are listed on the next page.

The following methods do ***not*** save the current changes. They are considered safeguards:

- Pressing the Esc key from any of the TCU001-IP's configuration screens ***except*** the Set Time and Reset Timers screens causes the TCU001-IP to exit configure mode and abort any changes made during the current session. ***Note that the Esc key cannot be used to exit configure mode in the Configure Dialer or Configure Modbus sections.***

- Changing an H-O-A switch to the "Auto" position before selecting the Save command forces the TCU001-IP to exit configure mode and abort the current changes.
- Leaving the TCU001-IP unattended for over five minutes without selecting the Save command causes the TCU001-IP to abort any changes and return to the main display screen.
- Cycling the TCU001-IP's power (press and hold the TCU001-IP's On/Off key) before selecting the Save command causes the TCU001-IP to reload the old configuration from non-volatile memory and return to the main display screen.

Entering gateway (optional) and network portion of IP address

Note: When entering the network portion of the IP address and the optional gateway address, you will use commas to separate the octets instead of periods, and you ***must*** enter a 0 (zero) in the fourth octet. To enter commas, you will use the Silence key on the TCU001-IP keypad. Pressing the Silence key will cycle through the following special characters/functions:

- Comma (,)
- Pound (#)
- Asterisk (*)
- Delete – Pressing the Silence key a fourth time will delete the last character on the current line.

After cycling to the desired special character, you must press the Enter key to register the entry. (Note that this does not apply to the Delete function. As soon as the Silence key is pressed for the fourth time, the last character on the current line is deleted.)

IMPORTANT: The #*1* phone number field ***must*** be cleared of all characters. If any characters are present in the #*1* phone number field, the TCU001-IP will be unable to communicate via its network card.

Screen	Configuration label	Description
3	#1	This field ***must*** be cleared.
	#2	Leave at default value.
	#3	Enter full IP address of gateway (optional)
	#4	First three octets (network portion) of IP address of TCU001-IP followed by a 0 (zero) in the fourth octet. Use commas to separate each octet (for example, 232,15,26,0). Use the Silence key on the keypad to cycle through special characters. This field can handle up to 16 characters.

1. Place the TCU001-IP in configure mode. Use the 4 and 6 keys on the keypad to navigate to the screen that reads *Change Configurations*. Press the Enter key to enter the configuration section.

```
     Change
 Configurations

     (enter)
```

2. Page through the TCU001-IP configuration screens until you reach the screen that includes the *Configure Dialer* option. Use the 8 key to place the cursor on the line that reads *Configure Dialer* and then press the Enter key.

```
Bem Modules: 0
Trend Rate = 30 secs
  Configure Modbus
   Configure Dialer
```

3. Use the 6 key on the keypad to navigate to the screen that displays the options *#1*, *#2*, *#3*, and *#4*.

```
#1 =
#2 =
#3 =
#4 =
```

4. Use the 2 and 8 keys on the keypad to place the cursor on the line you want to edit (for example, the *#1* line) and then press the Enter key. A question mark will appear at the end of the line.

```
#1 = ?
#2 =
#3 =
#4 =
```

5. Use the numbered keys on the keypad to enter the gateway (optional) and the desired IP address [first three octets ***only*** followed by a 0 (zero)]. Use the Silence key to enter a comma between each octet. The Silence key cycles through the comma, pound, and asterisk characters each time the key is pressed. When the desired character appears, press the Enter key to register the entry. When all characters have been entered, press the Enter key.

```
#1 =
#2 =
#3 = 198,15,26,5
#4 = 198,15,26,0
```

   Note: If you make a mistake while entering data, press the Silence key four times to delete the last character on the current line. The Silence key enables you to cycle through the special characters pound (#), comma (,) and asterisk (*) as well as access the delete function.

6. Scroll through all of the configuration screens until you reach the screen that reads *Press Enter to Save, Esc to Abort*. To save your changes, press the Enter key on the keypad. To exit without saving, press the Esc key.

CONNECT TCU001-IP TO NETWORK

When connecting the TCU001-IP to your network, we suggest that you use network surge protection to prevent the TCU001-IP from being damaged from voltage surges. Model 24540 in the ZoneBarrier series from Atlantic Scientific is recommended. This 100Base-T network surge arrestor with RJ-45 connector can be purchased from DFS. Order DFS part number 002-0136.

The TCU001-IP comes equipped with a short section of CAT5 network cable terminated with an RJ-45 male connector. The male connector is plugged into an RJ-45 female-to-female coupler.

Using CAT5 cable, connect the TCU001-IP to a network surge arrestor.

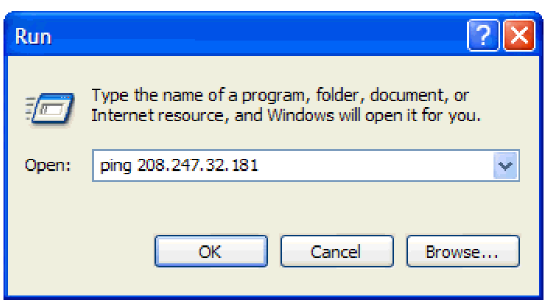
From the surge arrestor, make a connection to the client network (via a device such as a hub, switch, or router) using CAT5 cable. [IMPORTANT: To minimize signal interference, avoid installing CAT5 cable near florescent lighting or other AC conduit.]

TEST NETWORK CONNECTION

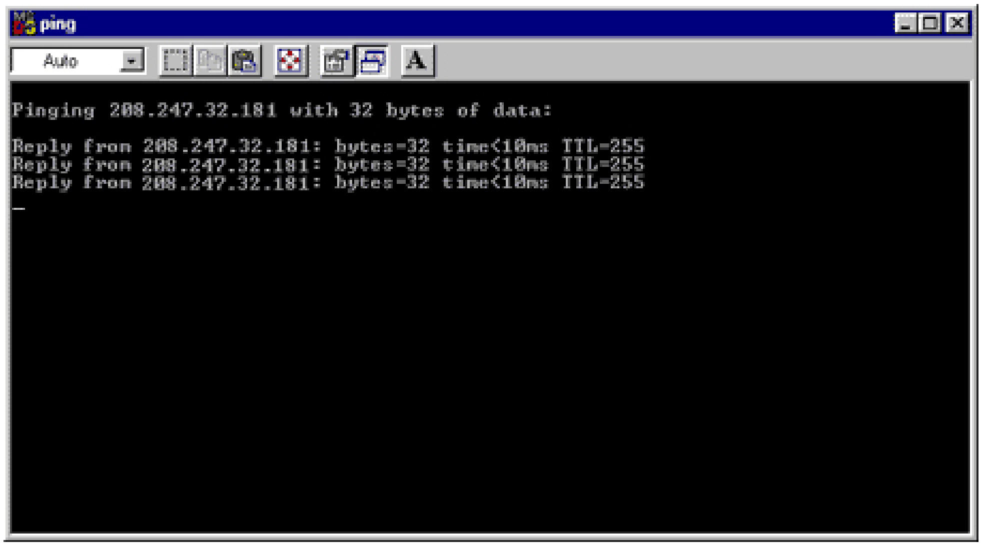
Before proceeding to configure the TCU001's other settings (pump controller and/or Modbus master configurations), you should verify that you can communicate to the TCU001-IP over the network. This is a simple test in which you issue a PING command from a computer that is on the same network as the TCU001-IP.

Note: The instructions below are for a computer running the Windows operating system. Refer to the documentation for your operating system if you are running an operating system other than Windows.

1. Select **Run** from the Windows **Start** menu.
2. Type **ping xxx.xxx.xxx.xxx** in the **Run** dialog box and click **OK** (where xxx.xxx.xxx.xxx is the IP address of the TCU001-IP being tested).



3. A DOS window appears on screen and indicates if a reply has been received from the TCU001-IP.



If you don't get a reply from the TCU001-IP:

- Check that the IP address assigned to the TCU001-IP is unique. There will be a communication conflict if another device has the identical IP address.
- Check that the DIP switches on the station address strap are in the correct position for the assigned IP address (subnet portion).
- Check that the network portion of the IP address has been properly configured in the TCU001-IP's *#4* phone number field.

Appendix J: TCU LEVEL DEVICE (TBU360)

DESCRIPTION

The TCU Level Device (TBU360) is an optional add-on to Data Flow Systems' multi-pump controller, the Telemetry Control Unit. This level sensing and fault detection device is a low-cost well-level solution based on the KISS principle. It has a small, compact design that allows the bubbler transducer unit to be mounted in a control panel – instead of the wet well.

The TBU360's footprint is less than 10% of a typical bubbler system. There's no large and expensive air compressor, air tank, or flow regulator to adjust or maintain. Its patented design also does away with mercury switches and differential pressure settings.

Features

- Patent-pending design with footprint that is less than 10% of a typical bubbler system
- Dramatically outlasts submersible pressure transducers
- Does away with float cables, mercury switches and differential pressure settings
- No more air compressor, air tank, or flow regulator to adjust or maintain
- No voltage signals introduced into wet well
- Non-clogging, self-cleaning
- Detects air-pump failure without the use of flow switches
- Configurable to alternate two air pumps on a 24-hour cycle
- Small compact air pump (3.25" width x 4.25" length x 2.75" height)
- Transducer is powered by the Telemetry Control Unit (TCU)
- Repair and replacement parts available separately
- Full one year warranty on parts

REQUIREMENTS

To integrate the bubbler system into an existing TCU, the TCU must be running the TCU 90000 program version 2.6102411 or later.

```
 Pump Controller

 Prog ID = 90000
Version = 2.6102411
```

To determine your TCU's program ID and version, press and hold the TCU's 3 (three) button until the program information screen appears.

USING AUTO CONFIG FUNCTION ON BUBBLER TCU

If you have an HT3 system, you may experience problems using the TCU Auto Configuration function on a TCU that has been upgraded for bubbler functionality. A fix has been issued for this problem. Contact DFS' Service Department for more information.

OPERATION OVERVIEW

The TCU analyzes a 4-20 mA signal from a pressure transducer to detect well level and proper operation of the bubbler's air pump. The TCU Level Device supports both continuous draw down (pump down) and fill up (pump up) operation, and it can be programmed for incremental level readings similar to floats. Any existing float switches can remain in the well for back-up purposes.

Bubbler Fault Conditions

The conditions listed below will generate a transducer bubbler fault at the TCU.

Transducer High Float Fault

Configuration option: Xdcr Hi (see page 130)

When this option is enabled, a high float condition generates a transducer fault and switches control to the configured fault mode. Leaving the option disabled leaves pump control on the primary transducer whenever a high float condition occurs or the transducer reaches or exceeds 20 mA.

Transducer Low Level Fault

Configuration option: Xdcr Low (see page 131)

When this option is enabled, a low float condition OR a transducer low level condition (level drops below Low set point) generates a transducer fault and switches control to the configured fault mode. Leaving the option disabled leaves pump control on the primary transducer whenever a low float or transducer low level condition occurs.

Bubbler Noise Fault

Configuration option: BblrNoise (see page 131)

Enabling this option allows the TCU to detect an air pump failure by monitoring air pump-induced noise on the analog input. If no air pump-induced noise is detected for a duration of five (5) minutes when the level is between the Off and Lead levels (pumps are not running), the TCU will generate a transducer fault and switch pump control to the configured fault mode. The transducer fault alarm stays active and control remains with the configured fault mode until the TCU is reset.

INSTALLATION AND CONFIGURATION

The instructions provided in this section are only for the bubbler-specific function of the TCU. Instructions for other aspects of the TCU (e.g., mounting the TCU in the control panel, wiring AC power, and wiring and configuring other devices) can be found in the main sections of the manual.

Parts List

The parts listed below are supplied with the TBU360 (DFS Part Number: DFS-00526-008-02).

Additional parts are required. They are listed after the parts list table.

Refer also to Figure J-2, "Installation of Bubbler and Pipe" on page 217.

Part	Features and Specifications
Telemetry Control Unit (TCU)	See "Technical Specifications" on page 8 in "Chapter 1: Product Overview"
Bubbler Pressure Transducer	0 – 15 PSI pressure range (or customer specified) -40° C to 105° C operating temperature Accuracy: • +/- 0.5% full scale for 75 PSI to 5000 PSI • +/- 1% for 15 PSI to 60 PSI • +/- 2% for 3 PSI to 10 PSI Output • 4-20 mA output (with 8-30 V input)
Air Pump for Bubbler	0-15 feet control range 6W, 60Hz @ 120 VAC 2.70" H x 5.180" W x 3.60" D Two-speed switch (pressure boost or conserve) 1/8" barbed brass connector (air outlet) Corrosion resistant, aluminum 36" 120 VAC power cord (optional 24VAC pump available) Easy change intake air filter
Check Valve	Duckbill, 1/8" barb ends
Fittings and Adapters	(1) Tee, SS, 1/4", FemXFemXFem (1) Fitting, SS, 1/4" NPT x 1/8" barbed (2) Adapter, 1/4" socket x NTPF, schedule 80, PVC (2) Fitting, locknut, sealing, 1/2" NPT F (1) Valve, PVC, for TCU360 (2) Bushing, PVC, schedule 40, 3/4" x 1/2", non hexhead (2) Pipe extension, 1", schedule 40, PVC, slip x intern (6) Elbow, 1/4" sockets, scheuld 80, PVC, 90 degree (3) Coupling, 1" sockets, schedule 40, PVC, white (1) Elbow, 1", schedule 40, PVC, white, 90 degree (6) Coupling, 1/4" sockets, schedule 80, PVC, gray
Tubing	Clear, 1/8" ID, 1/4" OD, Flexible

Additional Parts Required

The following are to be supplied by the installer (others):

- (2) Pipe, 1/2” x 10’, schedule 40, galvanized, threaded
- (2) Pipe, 1/4”, schedule 80, CPVC, 20’
- (2) Pipe, 1” x 20’, schedule 40, PVC, belled end, white
- Glue, Christy’s Red, Hot and Blue (use as required)
- Q-tip cotton swab, 6” industrial grade (for small fittings)

Typical Installation

Figure J-1, “Recommended Placement of Bubbler Tube” (page 216) and Figure J-2, “Installation of Bubbler and Pipe” (page 217) depict the typical installation of a TBU360 bubbler and routing of the bubbler pipe into wet-well.

When installation is complete, plug the bubbler pump into an electrical outlet, but do not turn it on until the transducer has been wired. Wire the bubbler system’s transducer to the TCU (P2-22; Analog1+) as shown in “Analog Level Transducer” beginning on page 73 in “Chapter 6: Electrical Installation.”

Note: Any existing float switches can remain in the well for back-up purposes.

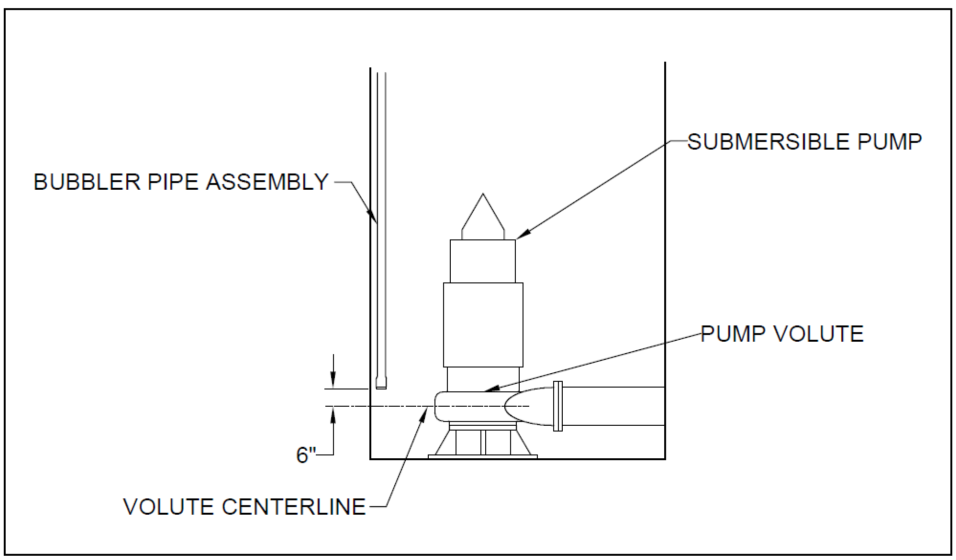


Figure J-1, Recommended Placement of Bubbler Tube

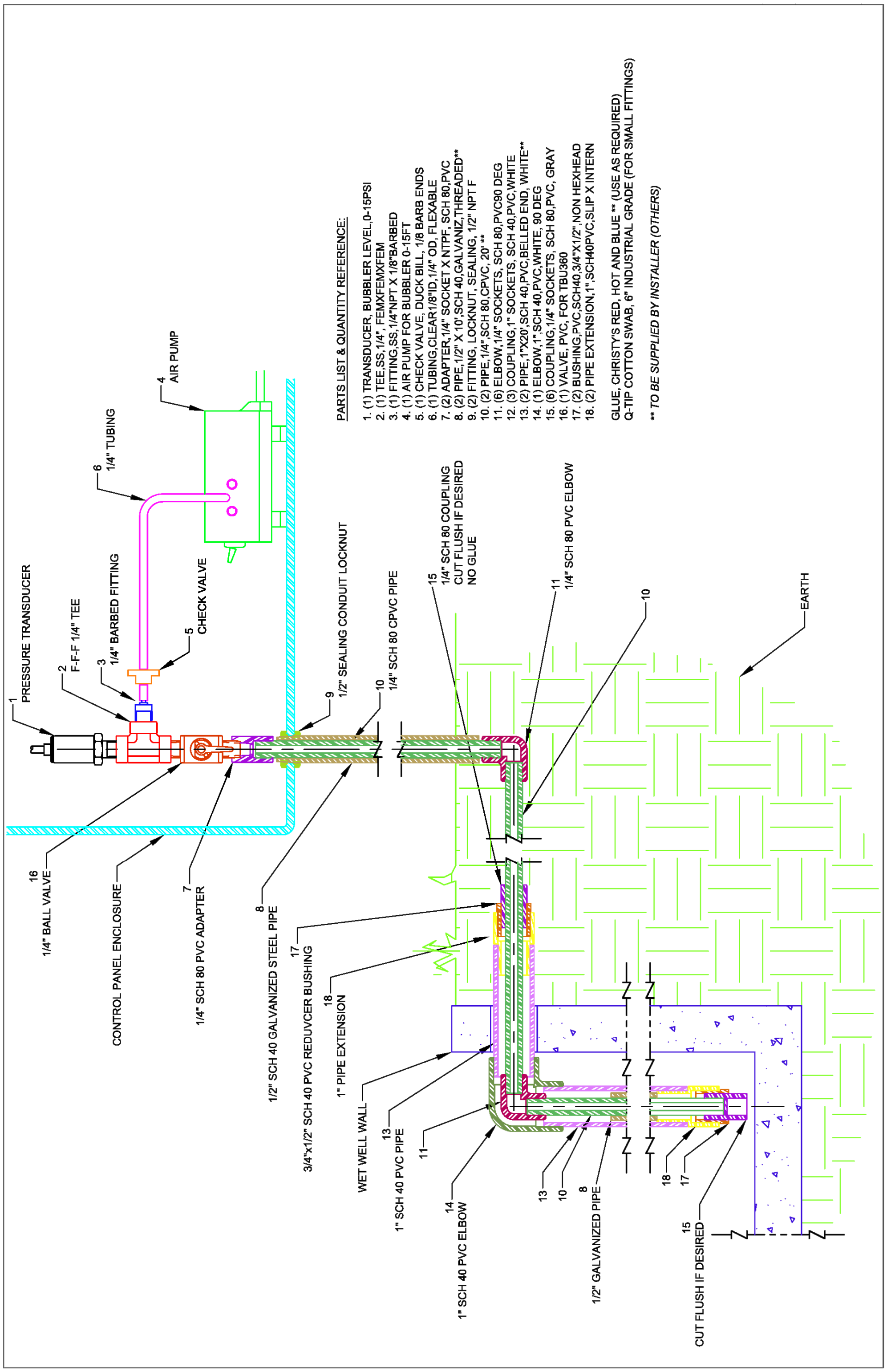


Figure J-2, Installation of Bubbler and Pipe

Configure TCU Settings

More information on these configurations can be found in "Chapter 10: Configuring the Pump Control Process" beginning on page 111.

"Appendix M: TCU Transducer Configuration Examples" provides typical applications and can be used as a guide for configuring your system to obtain the pump control and fault mode behavior required.

Configure the following settings in the TCU:

- **Transducer Type** – Select 4-20 mA or 0-5 V (page 113).
- **Low Float** (optional) – Enable this setting to use a low-level float to override normal pump control if a transducer fault occurs (page 113).
- **High Float** (optional) - Enable this setting to use a high-level float to override normal pump control if a transducer fault occurs (page 113).
- **Transducer Fault Mode** – Select Disable, Timer, Analog2, or Floats (page 115).
- **Transducer Low and High** – Enter values for Xdcr1 Low and Xdcr1 High (page 120).
- **Set Point Levels** – Enter values for Low, LeadOff, LeadOn, LagOn, Lag2On, and High based on station type – simplex, duplex, or triplex (page 120).
- **Transducer High Float Fault** (optional) – Enable to generate a transducer fault when a high float condition occurs (page 130)
- **Transducer Low Level Fault** (optional) – Enable to generate a transducer fault when a low float condition occurs (page 131)
- **Bubbler Noise Fault** (optional – bubbler systems only) – Enable if the system is a bubbler system and you want to generate a transducer fault when the TCU doesn't detect air-pump induced noise (page 131).
- **High Float Override** (optional) – Enable this setting to give the High float precedence in the event of an Off float failure when the TCU is in Floats fault mode (page 132).
- **Minimum Run** - Minimum time pumps should run. Used to prevent short cycling (page 123).
- **Minimum Off** - Minimum time pumps should remain off. Used to prevent short cycling (page 123).

Appendix K: ADDING A RIO TO THE TCU

The TCU can poll Modbus slave devices, such as the RIO032 and RIO128, and store their data in the TCU's unused modules (referred to as modules H-O in the TCU's configuration screen). This information can then be made available to your telemetry system by adding and configuring the modules in HT3.

More information on the TCU's Modbus capabilities can be found in “Chapter 5: Modbus Support.”

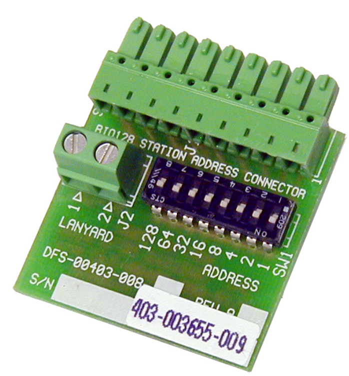
Notes:

- The instructions below are for the typical application of adding a RIO032 to the TCU. The procedure for adding a RIO128 would be similar except for the additional I/O that must be configured in the TCU and your telemetry system (HT3 or third-party HMI).
- If you are using an HMI other than HT3, you will need to configure that software with the correct Modbus register information in order to poll the TCU as a Modbus slave.
- If the TCU is configured for PCU emulation, it must be changed to the TCU module configuration in order to add a RIO, or any other Modbus slave device.

The steps required to add a RIO to a TCU are:

1. Set RIO's device/station address (typically 1).
2. Configure RIO for Learn mode.
3. Mount RIO and wire AC power and I/O as detailed in the *RIO032 Installation and Operation Manual*.
4. Connect RIO to TCU via RS-485 interface.
5. Place RIO in Learn mode.
6. Configure the TCU to poll the RIO by entering and saving RIO's I/O information in the TCU.
7. Verify communication between TCU and RIO.
8. Add and configure the RIO's I/O in HT3.

SET RIO'S DEVICE ADDRESS



The RIO032 features a detachable address board used to configure the RIO032's device/station address. The address board's screw-terminal lanyard enables you to tether it to the control panel (for example, to the panel's earth ground). In the event the RIO032 needs to be replaced, the address board can be disconnected from the RIO032 and attached to a new RIO032. This ensures that the device/station address remains with the site; the new RIO032 doesn't have to be addressed.

The device/station address is configured by turning off switch positions that add up to the desired station number. Each bit (pin on the separate address board – P6-1 through P6-8) has a corresponding value (see table below). The RIO032 is set to a specific device/station address by leaving particular pins on the address board's DIP switch ungrounded, or in the Off position.

The device/station address is calculated by totaling the bit values of the pins that are not grounded. The valid device/station address range for the RIO032 is 1-255.

Pin #	Name	Description
P6-1	ADDR0	Station address bit 0 (value=1 bit)
P6-2	ADDR1	Station address bit 1 (value=2 bit)
P6-3	ADDR2	Station address bit 2 (value=4 bit)
P6-4	ADDR3	Station address bit 3 (value=8 bit)
P6-5	ADDR4	Station address bit 4 (value=16 bit)
P6-6	ADDR5	Station address bit 5 (value=32 bit)
P6-7	ADDR6	Station address bit 6 (value=64 bit)
P6-8	ADDR7	Station address bit 7 (value=128 bit)

To give the RIO032 a device address of one (1), leave the bits for the P6-1 pin (bit value=1) ungrounded (in the Off position). Leave the remaining bits grounded (in the ON position).

Configure RIO for Learn Mode

The RIO032 features an auto configuration, or learn, mode that enables it to automatically detect baud rate and protocol parameters and begin communicating using these parameters.

To configure the RIO for Learn mode, place all the BPS and Protocol switches in the Up (Off) position (value = 1 / TRUE). Refer to the illustration below.

Mount RIO and Wire AC Power and I/O

Refer to the *RIO032 Installation and Operation Manual* for detailed instructions.

- Chapter 4: Mounting the RIO032
- Chapter 5: Electrical Installation

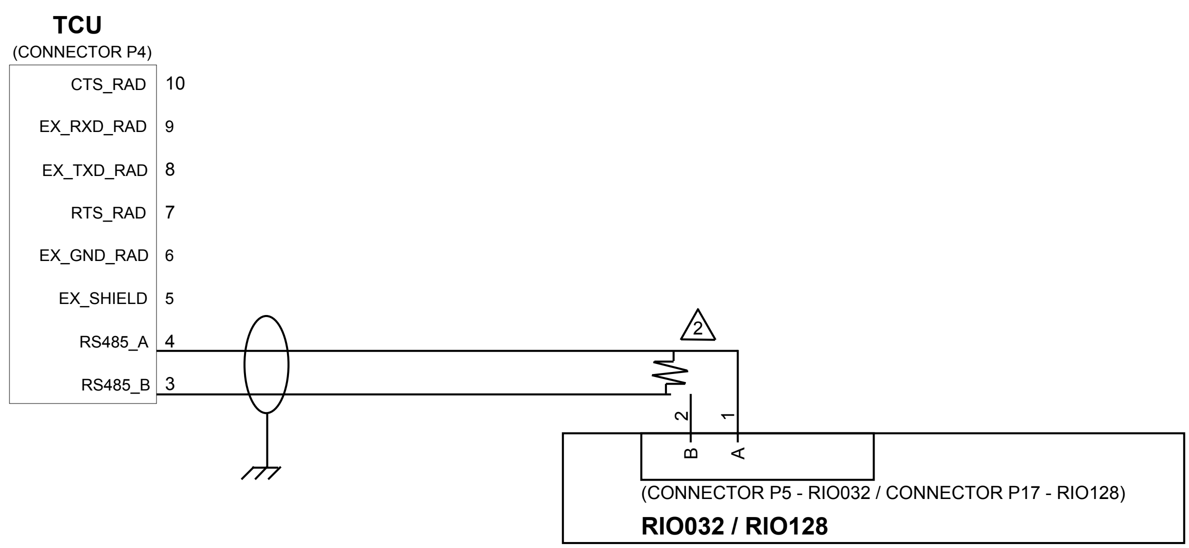
Connect RIO to TCU

The TCU's RS-485 interface is located on the TCU's P4 connector. Pin definitions for the TCU, RIO032, and RIO128 RS-485 interfaces appear below followed by a wiring diagram.

RS-485 Pins

Name	Description	TCU Pin #	RIO032 Pin #	RIO128 Pin #
A	RS-485 serial interface A	P4-4	P5-1	P17-1
B	RS-485 serial interface B	P4-3	P5-2	P17-2
Ground	RS-485 ground (optional; as required)	P4-5	P5-3	P17-3

Wiring



NOTES:

1. The cable shield wire must only be grounded at one end (as close as possible to the selected end).
2. Optional 150-200 ohm resistor designed to eliminate ringing and match impedance on longer cable runs. For short (within the same enclosure) distances, this resistor is not necessary.

PLACE RIO IN LEARN MODE

When all of the RIO's communication configuration switches are left in the Off position (see step 2, Configure RIO for Learn Mode, above) and the RIO's configuration button is held down during power up, the RIO enters learn mode. The RIO then attempts to determine baud and protocol settings within three to ten polling loops (depending on settings such as baud rate).

1. Hold down the configuration button while powering up the device. All of the RIO032's LED's come on.
2. Release the configuration button when the RXD, TXD, and Status LED's go off.
3. The TXD will flash rapidly and then the TXD, RXD, and Status LED's will blink.
4. After a minimum of three polls are received (may take up to ten polls), the RXD will blink three times. The TXD, RXD and Status LED's will turn on and then off indicating that Learn (auto configuration) is complete.

During the Learn process, the RIO032 uses the CTS (clear to send) signal to determine if it is connected to a radio. Radios, unlike other devices, don't activate the CTS signal until an RTS (request to send) is asserted. If the RIO032 determines that is it connected to a radio, it will communicate using the RTU Radio protocol. This protocol is identical to RTU protocol except that the RIO expects a CTS to occur whenever it asserts an RTS, and it will wait for the CTS signal before it transmits any data. This protocol allows the RIO032 to be connected to an RDR (Rail Data Radio) or other manufacturer radio without using special cabling.

CONFIGURING THE TCU TO POLL THE RIO

In order for the TCU to poll the RIO and make the RIO's data available to HT3, the RIO's I/O information must be added to the TCU's configuration.

Modules H-O in the TCU are reserved for Modbus slave devices. Each module can accommodate up to:

- Twelve (12) digital status registers, or
- Eight (8) digital control registers, or
- Four (4) analog status registers, or
- Four (4) analog control registers

The instructions below are for a TCU using the built in pump control application. For information on polling Modbus devices in a custom TCU application, see "Configuring the TCU to Poll Modbus Slave Devices: TCU in Custom Application" beginning on page 54.

1. Page through the TCU's configuration screens until you reach the screen that includes the "Configure Modbus" option. Navigate to the Configure Modbus line and press Enter.
2. The first screen allows you to configure the Module H and Module I registers. Use the right navigation button to page to the screens for the remaining modules (J-O). When configuring for Modbus polling, we recommend that you use the first available TCU module. For example, if modules J-O are available, configure module J; don't skip to M.

3. For each module you want to configure, you must enter an address (ModX Adr) and length (ModX Lth):
    - Address is the RIO's device number and the first of the range of registers being added to the current module. For example, ModH Adr would be 1.10001 when adding digital inputs to device 1, module H.
    - Length is the number of registers being added to the current module. Length can be 1-12 for digital input (status) registers, 1-8 for digital output (control) registers, and 1-4 for analog registers. For example, ModH Lth would be 8 when adding 8 digital inputs to module H.
    - For Analog registers, the Length field requires an additional value that represents resolution (a TCU communicating with a RIO uses a signed 15-bit resolution). For example, ModJ Lth would be 4.15 when adding 4 analog inputs to module J.

    The table below provides the information required for a RIO032 using all 32 I/O points.

I/O Type	Module Letter	Module Type	Address (ModX Adr)	Length (ModX Lth)
8 digital inputs	H	DMM	1.10001	8
8 digital outputs	I	DCM	1.00001	8
4 analog inputs	J	AMM	1.30001	4.15
4 analog inputs	K	AMM	1.30005	4.15
4 analog outputs	L	ACM	1.40001	4.15
4 analog outputs	M	ACM	1.40005	4.15

4. After adding all of the required module and register information, navigate through the TCU's configuration screens until you reach the screen that reads Press Enter to Save, Esc to Abort.

    Press Enter to replace the TCU's existing configuration with the changes made during the current session. After the settings are successfully save, you must cycle power to the TCU.

    IMPORTANT: When the new settings are saved, they are written to a temporary memory location. In order for the TCU to begin running on the new configurations, you must cycle power to the TCU. If the TCU's power is cycled before selecting the Save command, the last saved values are loaded on power up.

VERIFY COMMUNICATION BETWEEN TCU AND RIO.

After cycling the TCU's power, observe the TCU and RIO's TX and RX LEDs to verify communications are occurring between the two devices.

Refer to the troubleshooting sections of the TCU and RIO manuals if you encounter communication problems.

Add and configure the RIO's I/O in HT3 or Third-party HMI

In your HT3 software, browse to the TCU's configuration. Add and configure the modules and I/O that were added to the TCU's settings in step 3, above. The configuration in HT3 should exactly match the settings entered in the TCU.

For a RIO032 using all 32 I/O points, add the following:

Module Letter	Module Type (Number of I/O Points)
Module H	DMM (8 digital input points)
Module I	DCM (8 digital output points)
Module J	AMM (4 analog input points)
Module K	AMM (4 analog input points)
Module L	ACM (4 analog output points)
Module M	ACM (4 analog output points)

If you are using an HMI other than HT3, you will need to configure that software with the correct Modbus register information for the RIO's additional I/O.

Module Letter	Module Type (Number of I/O Points)	Modbus Registers Used for Polling
Module H	DMM (8 digital input points)	14337-14344
Module I	DCM (8 digital output points)	2305-2312
Module J	AMM (4 analog input points)	35505-35508
Module K	AMM (4 analog input points)	35761-35764
Module L	ACM (4 analog output points)	44065-44068
Module M	ACM (4 analog output points)	44321-44324

See "DFS Module to Modbus Register Maps" on page 267 for a list of equivalent Modbus registers for each DFS module type.

Appendix L: VFD OPERATION

> **IMPORTANT**: Review the information provided in “Set Up Procedure,” page 231 and “Notes on Operations,” page 234 before installing and configuring a VFD-TCU.

The VFD-TCU is a factory option that provides automated control of up to three Variable Frequency Drive (VFD) pumps.

In a VFD-TCU, the standard TCU program version 1.5 has been customized to operationally control VFDs. An update to this code is version 2.0, which incorporates the phase monitor hardware but still follows the basic functionality and hardware of the TCU version 1.5 code.

Figure L-1, “Additional Menus for VFD Option,” below, shows the extra menus that have been added to the standard TCU program to enable the VFD functionality. Descriptions of the VFD menu options are provided in “VFD Menu Options” on page 233.

This modified TCU program maintains many functions of the standard TCU operation with the following exceptions:

- The ability to operate regular Float mode.
- The ability to configure Modbus via the LCD screen. Any additional Modbus points that are required beyond the default configuration (1.00001-8, 1.10001-8, 1.30001-4, and 1.40001-4) must be configured via WinRTU Test or the PLC/TCU editor.

```
Bem Modules    : 0
Trend Rate     : 30 sec

VFD Mode       : Enabled
```

```
Pumps Off      : Level
Spd Setpt      : 50
PID PV         : XDUCER 1
Hour Alt       : 24
```

```
      Press
  Enter for VFD
      Menu
```

```
P Gain         : % 10
I Gain         : % 10
D Gain         : % 10
Direction      : Direct
```

```
Lag 2 Stby     : Disabled
Pmp 3 Lag      : Disabled
Process Cntrl  : Vari
Lead Pump      : 1
```

```
VFD1 Accel     : % 5
VFD2 Accel     : % 5
VFD3 Accel     : % 5
```

```
VFD Min Spd    : 50
VFD Max Spd    : 90
Ovrd Spd Set   : 75
Proc Setpt     : 10
```

Figure L-1, Additional Menus for VFD Option

VFD-TCU RTU

The VFD-TCU RTU contains a Telemetry Control Unit with Radio (TACPAC TCU), Rail Input/Output device (RIO032 or RIO128), relays, loop isolators, and other devices necessary for monitoring and controlling up to three pumps both locally and remotely.

Like a standard TCU, the VFD-TCU's automated process can be overridden to provide manual control of the pumps. Manual control can be remote or local:

Remote manual control	A pump can be remotely controlled via the Hyper SCADA Server if the TCU Hand-Off-Auto selector switch for that pump is in the Auto position.
Local manual control	Pumps can be locally controlled using the H-O-A selector switches on the TCU. Placing a selector switch in either the Hand or Off position manually overrides the TCU's automated control.

General Operation Principles

Pumps can be controlled manually ("Hand") or by the automatic algorithm ("Auto").

"Hand"	When a pump's H-O-A selector switch is placed in the "Hand" position, the pump starts. The speed can be manually controlled using the buttons on the TCU's key pad.
"Auto"	When the VFD-TCU is in "Auto" control mode, the pumps are controlled by the automatic algorithm. The "Lead" VFD pump operates first, followed by the Lag and Lag 2 pumps. The methods used to control pump staging and pump speed is dependent on the TCU's configuration and are discussed in the sections "VFD Speed Control," page 229 and "Pump Staging Control," page 229. A pump in "Auto" mode can be manually overridden to start or stop via the telemetry system. When a pump is manually overridden to start, the pump's speed command will be set to the predetermined speed as set in the TCU. The details of the VFD-TCU's operation are outlined below.

Review the information provided in "Notes on Operations" beginning on page 234 before installing and configuring a VFD-TCU.

Note: The sections below include references to the settings available in the VFD menu. The names of the settings appear in italicized text. You can find descriptions of these settings in the section "VFD Menu Options" on page 233.

Process Control

The VFD-TCU is capable of two basic modes of process control: Fixed Set Point and Variable Level Control.

Fixed Set Point Controller

The aim of the Fixed Set Point Controller is to match the Process control Variable (*PV*) to the Process Set Point (*Proc Setpt*). In a lift station application, a Fixed Set Point Controller maintains a fixed level in the Wet Well by matching the effluent flow to the lift station's influent flow. A Fixed Set Point Controller operates from a wet well transducer that controls the pump's staging process. The process control variable (PV) comes from the TCU's ANALOG1+ (C1) input; *Xducer 1* is selected for the *PID PV* setting in the VFD menu.

The Fixed Set Point Controller can also operate using the TCU's ANALOG2+ (C2) input (auxiliary analog input) as the PV with *AUX* selected for the PID PV setting in the VFD menu. An example of this usage would be providing control of a constant flow requirement [PV coming from a flow meter on Analog2+ (C2); *AUX* selected for PID PV] that would match the effluent flow rate of the pumps to the *Process Setpt*. Keep in mind that pump staging will still come from transducer 1 (XDUCER 1, C1). A summary for this scenario would be the pumps are turned on and off by the wet well level (XDUCER 1, C1), and once running would maintain a specific flow rate set point using a process control variable from the auxiliary analog input (AUX, C2).

To achieve either of the above applications, the VFD-TCU uses a PID algorithm to vary the pump speed between the *VFD Min Spd* and *VFD Max Spd* set points in order to maintain the PV as defined by the operator adjustable *Proc Setpt*. The PID algorithm can be tuned by adjusting the *P Gain*, *I Gain*, and *D Gain* set points.

Variable Level Controller

Notes:

- The VFD-TCU level set points referenced in this section (i.e., LagOn Pt, Lag2On Pt, and LeadOn Pt) are set in the TCU's main configuration screens not in the VFD Mode section. See "Set Point Levels (Analog Transducers Only)" on page 120.
- *Proc Setpt* has no effect on variable level control mode for VFD TCU's with code version dates prior to 2.0110712.

A Variable Level Controller allows the well level to travel up and down between the *Pumps Off* setting and the *LagOn Pt* setting (or *Lag2On Pt* setting if more than one VFD is running). The pump speed control is proportional to the level.

For the Variable Level Controller, only the TCU's ANALOG1+ (C1) input (XDCUCER 1) can be used. The *Proc Setpt* sets the minimum speed for the VFD. *LagOn Pt* sets the maximum VFD speed when one VFD is running and *Lag2On Pt* sets the maximum VFD speed when more than one VFD is running.

This permits a unique method of operation for wet well control. As the wet well level reaches the *LeadOn Pt*, the first pump will start. The VFD's start speed is determined by the level of the *Proc Setpt* and the *LagOn Pt*. The closer the *LeadOn Pt* is to the *LagOn Pt*, the closer the VFD's start speed is to the maximum speed (*VFD Max Spd*). Likewise, the closer the *LeadOn Pt* is set to the *Proc Setpt*, the slower the VFD's start speed will be.

With this control arrangement, the system can use more of the wet well area to modulate the VFD speeds thereby damping system surges. Additional measures, such as smaller pumps or a lower minimum speed set point, may need to be employed and considered to limit pump starts and increase duration of pump operation cycles. During periods of low flow, pump starts or short cycles can be minimized; they cannot be entirely prevented. To assist in minimizing these low flow issues, the Variable Level Process was implemented with an area of the wet well's operational zone reserved to permit the pumps to operate at minimum speed. This area can be used as a buffer to prevent pump cycling and increase run durations when moving into periods of low and very low flows. Figure L-2, Variable Level Controller Operations Diagram (next page) illustrates the benefits of this process.

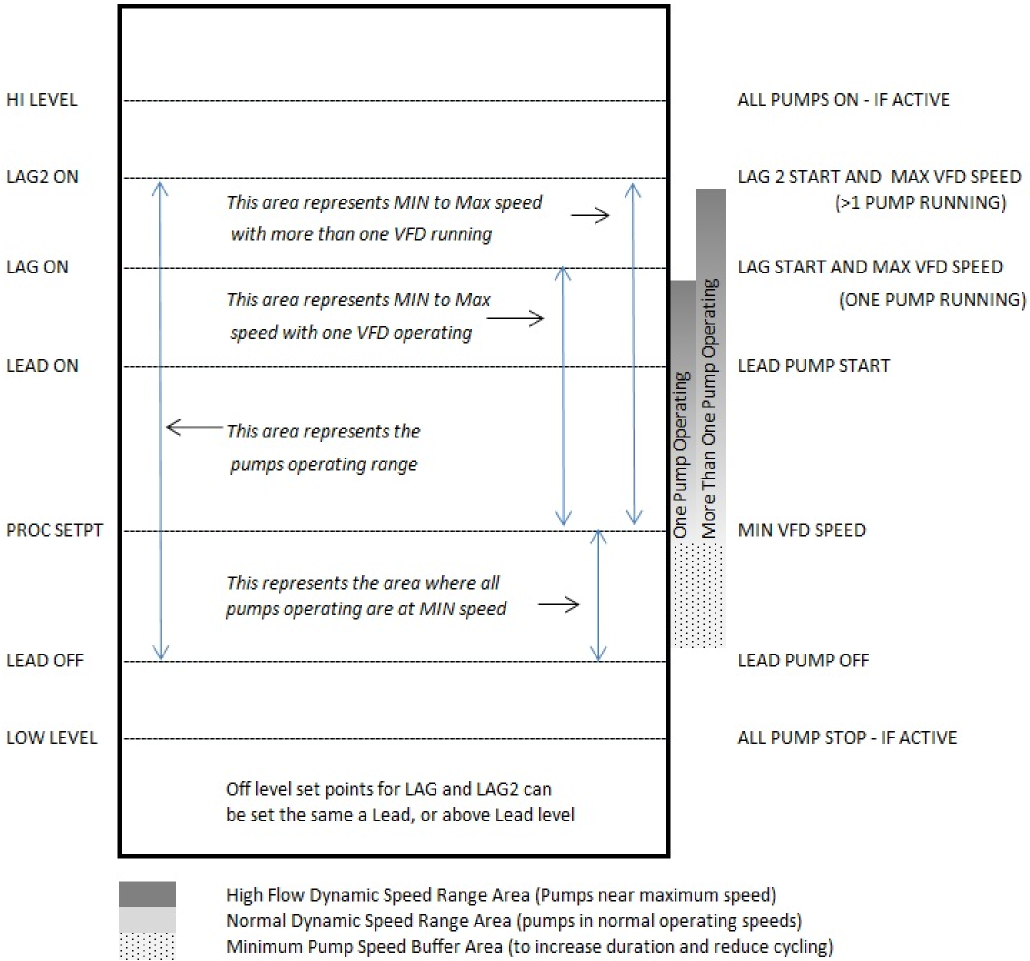


Figure L-2, Variable Level Controller Operations Diagram

VFD Speed Control

In automatic mode, the VFD speed control output is limited by the operator defined *VFD Min Spd* and *VFD Max Spd* set points. The *VFD Min Spd* and *VFD Max Spd* set points are applicable during both automatic and manual operation.

While operating under the automation programming, all pumps will operate at the same speed once ramping is complete, with two exceptions: the TCU H-O-A selector switch for any pump is placed in the Hand position; or the *Pmp 3 Lag* setting is enabled.

- If the TCU H-O-A selector switch for any pump is placed in the HAND position, all pumps will operate at the speed set for the *Ovrd Spd Set* option.
- If the *Pmp 3 Lag* setting is Enabled, pump 3 will operate at the speed set for the *Ovrd Spd Set* option.

The *VFD (1-3) Accel* set points define the acceleration of a pump (ramp speed) when a VFD is initially called to run. The speed will gradually increase from 0% to the desired control output, in increments defined by the acceleration set points, until the pump's speed equals the process control output speed. Once the VFD ramp speed has met the control output speed, the ramp speed function is disabled. Ramp speed is applicable during automatic operation and when placing a pump in HAND.

Pump Staging Control

The VFD-TCU is capable of two modes of pump staging controls: Level and Speed. Select a mode using the *Pumps Off* option in the VFD menu.

Level	When Level mode is selected, the pumps are staged on and off using the ON and OFF set points that correspond to the Lead, Lag, and Lag2 levels of the ANALOG1+ (C1) input (transducer 1).
Speed	When Speed mode is selected for *Pumps Off*, the VFD-TCU stages pumps on using the ON set point that corresponds to the Lead, Lag, and Lag2 levels of the ANALOG1+ (C1) input (transducer 1). Staging off the pumps will use a speed set point (*Spd Setpt*) in conjunction with the ON set points and the minimum pump run time value. Operation will be in the following manner: The basic staging off operation will begin when the speed command to the pumps is at or below the *Spd Setpt*. However, two additional criteria must also be met: • The process control variable from transducer 1 must not be at a level that the Lead, Lag or Lag2 ON set point would be active for the pump being staged off, and • The timer to stage off must have timed out. The minimum pump run time value (*MinmumRun*) is used in the staging timer during the stop process when this method is used. This timer value is configurable in the TCU's menu (see "Minimum Pump Run Time" on page 123).

Additional Alternation Options

The standard alternation scheme may be modified for the VFD-TCU with additional options available in the VFD menu. The names of the settings appear in italicized text. Descriptions of these settings are in the section “VFD Menu Options” on page 233.

Lag 2 Pump Standby	When the *Lag 2 Stby* option is enabled, the Lag 2 position pump is handled as a standby pump and is only called if the Lead or Lag pump faults. This option should not be used with regular TCU Alternation modifiers.
Pump 3 Lag Only	When the *Pmp 3 Lag* option is enabled, Pump 3 is always called to run in the Lag position, and the speed of Pump 3 is fixed at the *Ovrd Spd Set*. This option cannot be used with regular TCU alternation modifiers. The *Lag 2 Stby* and the *Pmp 3 Lag* options can be used together.
Alternation by Time	Alternation is typically triggered when the Lead pump is called to run. The VFD-TCU is also capable of triggering the alternation using an *Hour Alt* set point. When this option is used, pump alternation occurs on the hour that is programmed into the set point; the *Lead Pump* run trigger is disabled. When the *Hour Alt* set point is set to 24, the Alternation by Time function is disabled.
Fixed Pump Rotation	When a fixed pump rotation order is desired: • Set the TCU’s Alternate option to "None" (see “Pump Alternation” on page 117). • Ensure that the VFD-TCU alternation modifiers are disabled (*Lag 2 Stby*, *Pmp 3 Lag*, and *Hour Alt*). • Select the lead pump (1, 2, or 3) using the *Lead Pump* option. In Fixed Pump Rotation mode, the pump assigned to the lead position will always be called to run as the Lead pump. Lag and Lag2 will follow in order. For example, with the *Lead Pump* option set to 2, Lead will call Pump 2, Lag will call Pump 3, and Lag2 will call Pump 1.

Manual VFD Control

When the TCU’s H-O-A selector switch for a particular pump is placed in the Hand position, or is in the Auto position and is overridden via telemetry, the pump is called to run at a fixed speed determined by the operator defined *Ovrd Spd Set* set point. Once called to run, the pump speed can be adjusted using buttons on the TCU’s keypad:

- Press the 1 button to ***increase*** pump speed by ***1%***
- Press the 2 button to ***increase*** pump speed by ***5%***
- Press the 7 button to ***decrease*** the pump speed by ***1%***
- Press the 8 button to ***decrease*** pump speed by ***5%***

Any change made to the manual pump speed is stored in the *Ovrd Spd Set* set point.

Float Backup Mode

Depending on the configurations, the VFD-TCU's float backup mode may operate differently than the standard TCU:

High Float Enabled*	If *High Float* is enabled, the VFD-TCU calls all pumps when actuated; the speed command to all pumps is set at the *Ovrd Spd Set*.
Low Float Disabled†	If *Low Float* is disabled, the VFD-TCU runs the pumps until the *High Float* is no longer actuated and the minimum pump run timer (*MinmumRun‡*) expires. This operation is similar to a standard TCU operation.
Low Float Enabled†	If *Low Float* is enabled, the TCU maintains pumping operation until the Low Float is tripped and the minimum pump run timer (*MinmumRun‡*) expires.

* For information on the *High Float* setting, see "Enable a Low Float and/or a High Float" on page 113.

† For information on the *Low Float* setting, see "Enable a Low Float and/or a High Float" on page 113.

‡ For information on the minimum pump run timer (*MinmumRun*), see "Minimum Pump Run Time" on page 123.

VFD-TCU Set points

All set points residing in the TCU have default factory set points when shipped. New set point values can be entered locally at the TCU via the LCD screen, or remotely from the Central telemetry via the PLC/TCU editor, default, or custom screens (if configured). The new values are retained in the TCU in the event of a power cycle.

SET UP PROCEDURE

The VFD-TCU is an optional TCU configuration. New TCU's must be ordered from DFS as such. Existing TCU's may be retrofitted.

Software Check

The first elements to be checked when setting up a VFD-TCU are the process ID and version level.

Use the procedure in the next section to verify that:

- Process ID = 90001
- Version = 2.0110712 (or newer)

Checking process ID and version levels:

1. Turn the TCU on and allow it to boot.
2. Once the TCU is booted, press and hold the 3 button on the keypad and note the Proc ID and Version.
3. To check the binary software ("B" code") press and hold the 3 and silence buttons at the same time.

If the software is not as listed above, please contact DFS for further instructions.

Hardware and Software Configuration

The VFD-TCU comes configured with additional menu items as shown in Figure L-1, “Additional Menus for VFD Option” on page 226.

The VFD-TCU has its Modbus I/O configured for the RIO032/RIO128:

- Four (4) analog inputs and four (4) analog outputs are reserved and configured for controlling and monitoring three (3) pumps
- Eight (8) digital inputs and eight (8) digital outputs are reserved and configured for reporting status on the firest eight (8) inputs or outputs on the RIO.

Note that if a RIO128 is used, the first four (4) analog inputs and analog outputs and the first eight (8) digital inputs and digital outputs are configured. If additional Modbus points are needed, they must be added via the PLC editor in WinRTU Test, over telemetry via the PLC/TCU editor, or by manually loading the Non Volatile Memory using a Terminal window and Basic commands. Contact DFS for more information.

To set up the TCU and configure the options, do the following:

1. Place the TCU in configure mode by positioning all three of the TCU’s H-O-A selector switches in either the Hand or Off positon.
2. To access the TCU’s configuration screens, navigate to the Change Configurations screen and press the Enter key. If you are at the TCU’s default screen, pressing the ◄ key twice will bring you to the Change Configurations screen. After the TCU is placed in configure mode, the TCU’s navigation keys can be used to move through the configuration screens.
3. Navigate to the *Bem Mods* page of the TCU menu (this is where the Modbus section was located in the standard TCU code). The Bem Mods page is the eleventh (11^{th}) configuration screen. Press the 6 button (right arrow) on the TCU keypad to scroll through the TCU’s pages until you reach the *Bem Mods* page.
4. Use the 8 button (down arrow) on the TCU keypad to select *VFD Mode* and press the enter button.
5. Use either the 4 button (left arrow) or the 6 button (right arrow) to scroll the *VFD Mode* selections (Enable and Disable). Select Enable and press enter.
6. Press the 6 button (right arrow) twice to navigate to the VFD Menu screen. Press enter to access the VFD options and configure the TCU. Brief descriptions of the options are listed below.

VFD MENU OPTIONS

Lag 2 Stby : Disabled Pmp 3 Lag : Disabled Process Cntrl : Vari Lead Pump : 1	**Lag2 Stby** – Special alternation option where the Lag2 pump will be a standby pump. This option can be *Enabled* or *Disabled*. **Pmp 3 Lag** – Special alternation option where Pmp 3 will always be the lag pump with fixed speed. This option can be *Enabled* or *Disabled*. **Process Ctrl** – Selects between variable level (*Vari*) and fixed set point (*Fixed*) operations. **Lead Pump** – Selects a fixed lead pump when alternation is disabled in the TCU Menu. Designate pump 1, 2, or 3 to be the lead pump.
VFD Min Spd : 50 VFD Max Spd : 90 Ovrd Spd Set : 75 Proc Setpt : 10	**VFD Min Spd** – Sets the Minimum speed signal that can be sent to the Pumps. Range for this option is 0 – 100%. **VFD Max Spd** – Sets the Maximum speed signal that can be sent to the Pumps. Range for this option is 0 – 100%. **Ovrd Spd Set** – Sets the override speed signal to the pumps when in hand or overridden. Range for this option is 0 – 100%. **Process Setpt** • Sets the target for a Fixed Set Point Controller • Sets the minimum speed for a Variable Level Controller on VFD-TCU's version 2.0110712 or newer
Pumps Off : Level Spd Setpt : 50 PID PV : XDUCER 1 Hour Alt : 24	**Pumps Off** – Sets how the Lag pumps will be staged off: *Level* or *Speed*. **Spd Setpt** – Sets the speed that the Pumps Off Speed mode will stop pumps. **PID PV** – Indicates which signal the PID will use. *XDUCER 1* = (analog 1); *AUX* = (analog 2) **Hour Alt** – Provides an alternation trigger based on hour of the day. Range for this option is 0-23; disabled when set to 24
P Gain : % 10 I Gain : % 10 D Gain : % 10 Direction : Direct	**P Gain** – Sets reaction of the P portion of the PID. Range for this option is 0 – 999 **I Gain : % 10** – Sets reaction of the I portion of the PID. Range for this option is 0 – 999. **D Gain : % 10** – Sets reaction of the D portion of the PID. Range for this option is 0 – 999. **Direction** – Sets how the PID will operate. *Direct* = Increase speed as PV goes up; *Indirect* = Decrease speed as PV goes up.
VFD1 Accel : % 5 VFD2 Accel : % 5 VFD3 Accel : % 5	**VFD1 Accel** – Used to ramp up pumps per 5 second interval (i.e., 5% speed increase per 5 second interval). Range for this option is 1 – 100%. **VFD2 Accel** – Used to ramp up pumps per 5 second interval (i.e., 5% speed increase per 5 second interval). Range for this option is 1 – 100%. **VFD3 Accel** – Used to ramp up pumps per 5 second interval (i.e., 5% speed increase per 5 second interval). Range for this option is 1 – 100%.

NOTES ON OPERATIONS

Modbus points configured after Module I are polled for status once every five (5) internal TCU Modbus loops (approximately once every 10-15 seconds).

The staging timer for speed staging will start to decay when the speed is reached. If the pump that should be shut off is still under the Min Run Timer (MRT) function, it will not be stopped until the MRT has expired.

Ovrd Spd Set can be set outside the minimum (*VFD Min Spd*) and maximum (*VFD Max Spd*) speeds, but the speed command to the pumps will not exceed the limits.

Enabling the *Lag2 Stby* and *Pmp3 Lag* options at the same time will function as described, but may require one cycle to get in sync.

Using alternation options from the regular TCU main menu with alternation options from the VFD menu is not recommended.

The Lead Off set point should be set below the process set point (*Process Setpt*) when operating in Fixed process control mode (*Process Cntrl*) on transducer 1 (XDUCER 1).

If *Lag2 Stby* is used with the Pmp1&2 Alternation option, the Lag2 pump will not be called unless either:

- Both pumps 1 and 2 have failed, or
- Pumps 1 or 2 fail and the level is, or was, above the Lag2 start level set point at which time the remaining pump 1 or 2 will be stopped and pump 3 will run.

For information on pump alternation modes, see Pump Alternation, Flow Equalization, Motor Start and Stop Fault: Pump Alternation on page 117.

If *Lag2 Stby* is used with the Pmp2&3 Alternation option, the Lag2 pump (either 2 or 3, as pump 1 is always Lead in this mode) will not be called until pump 1 has failed and the level is, or was, above the Lag2 start level set point.

Operations of *Fault Mode* set to *Analog2* has been tested and verified in both *Vari* and *Level* modes of *Process Ctrl*. Pump speed commands, if *Fault Mode* is set to *Timer,* are unpredictable as transducers are used in all speed command adjustments. In addition, the determination for the "run time duration" of the mode is based on a "fixed speed pump" operation, therefore this mode of operation is not recommended.

WIRING

Control Panel Overview

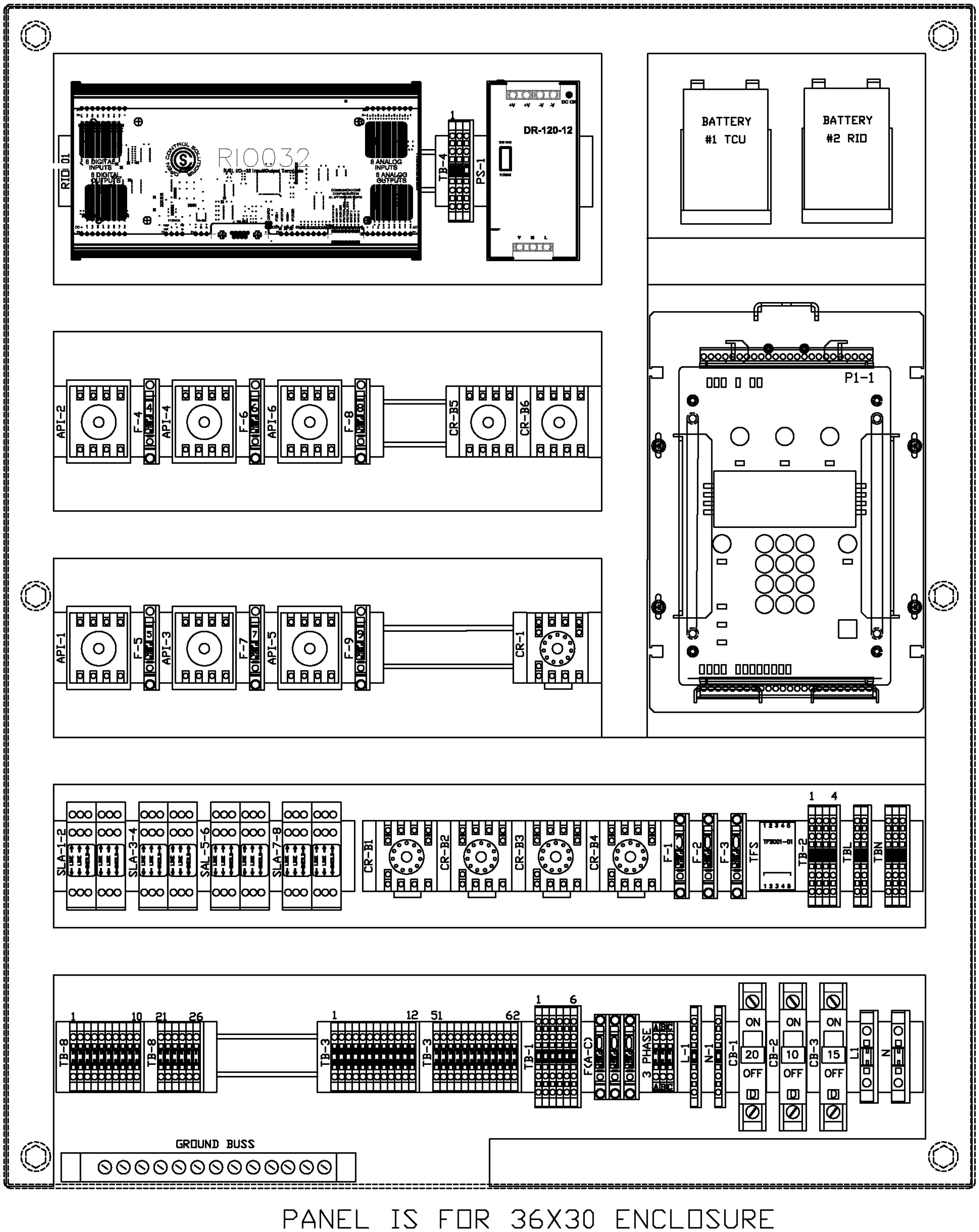


Figure L-3, Control Panel Overview for VFD Operation

AC Power

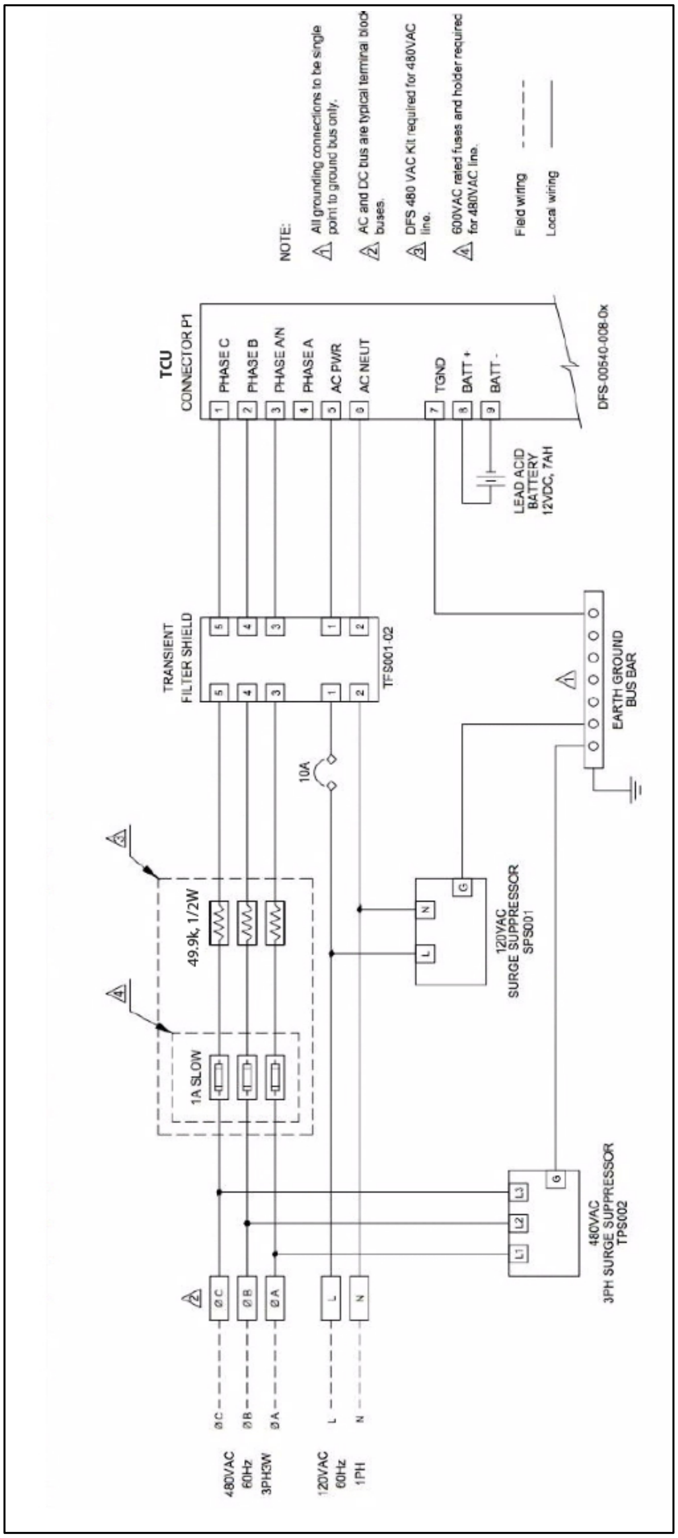


Figure L-4, Powering TCU with Typical 480 Volt, 3-Wire Transformer

DC Power

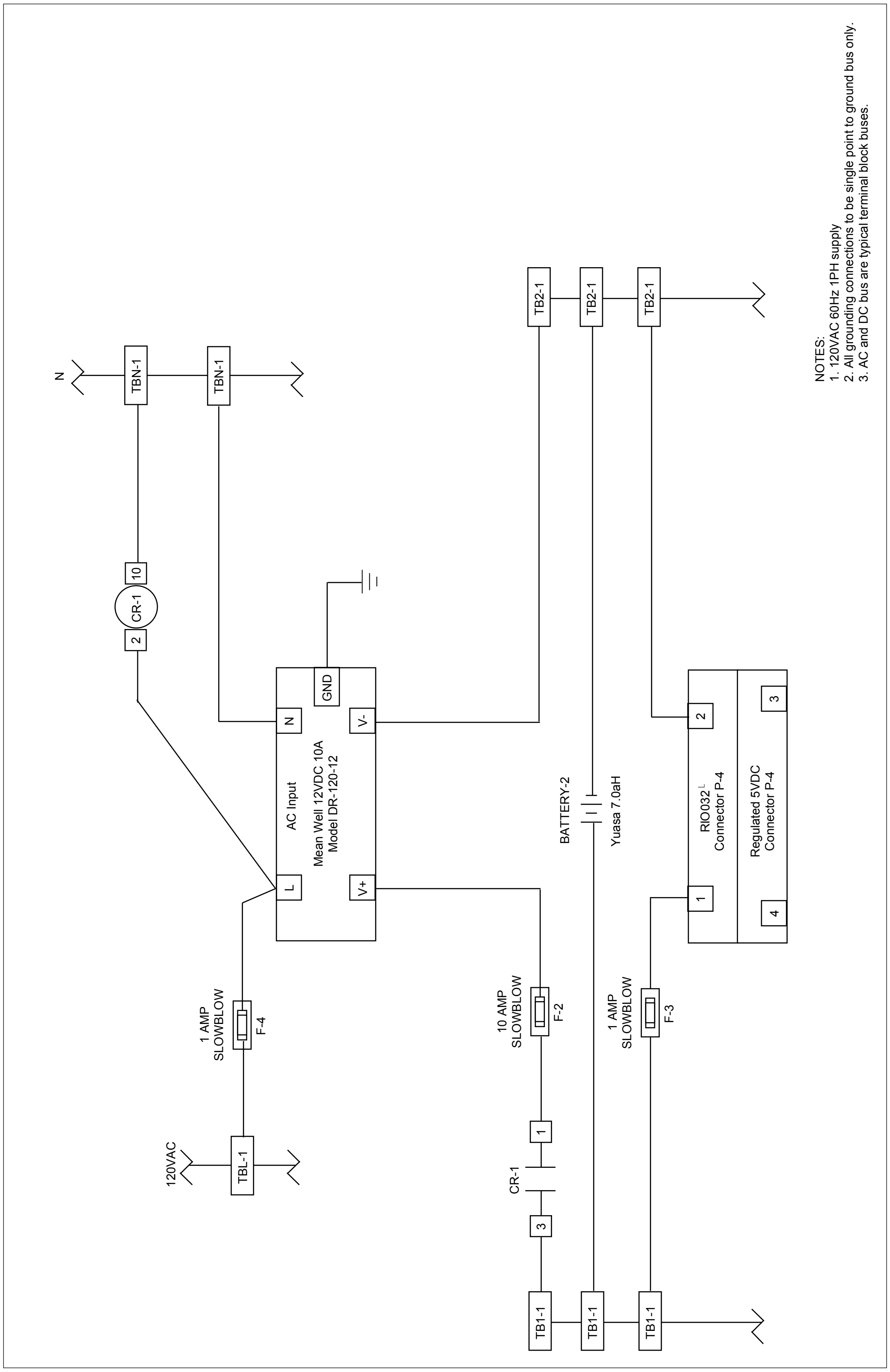


Figure L-5, DC Power Wiring for VFD Operation

TCU001 Digital Output (DO) / Digital Input (DI) Points

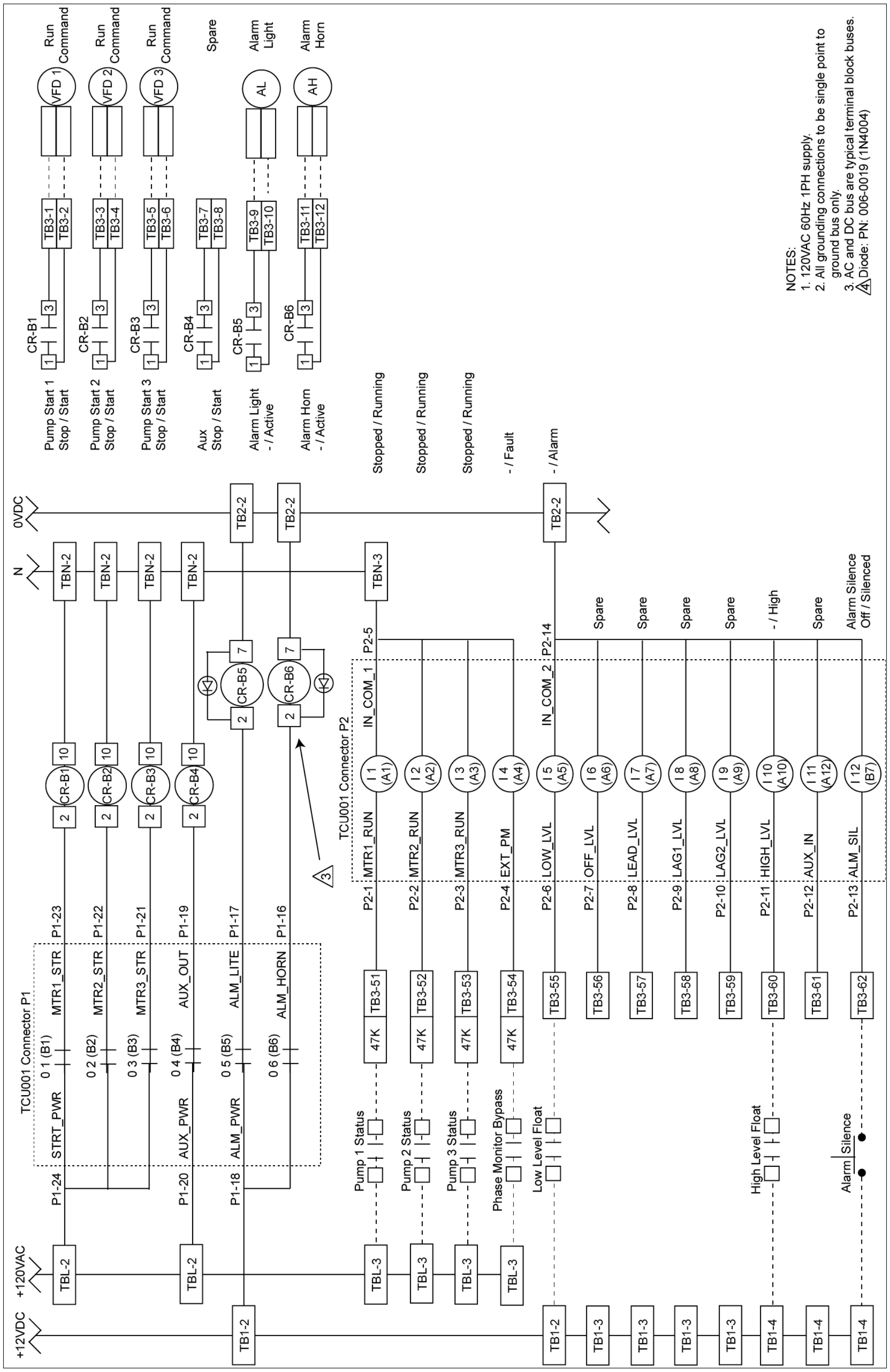


Figure L-6, TCU001 DO/DI Wiring for VFD Operation

RIO032 Analog Input (AI) Points

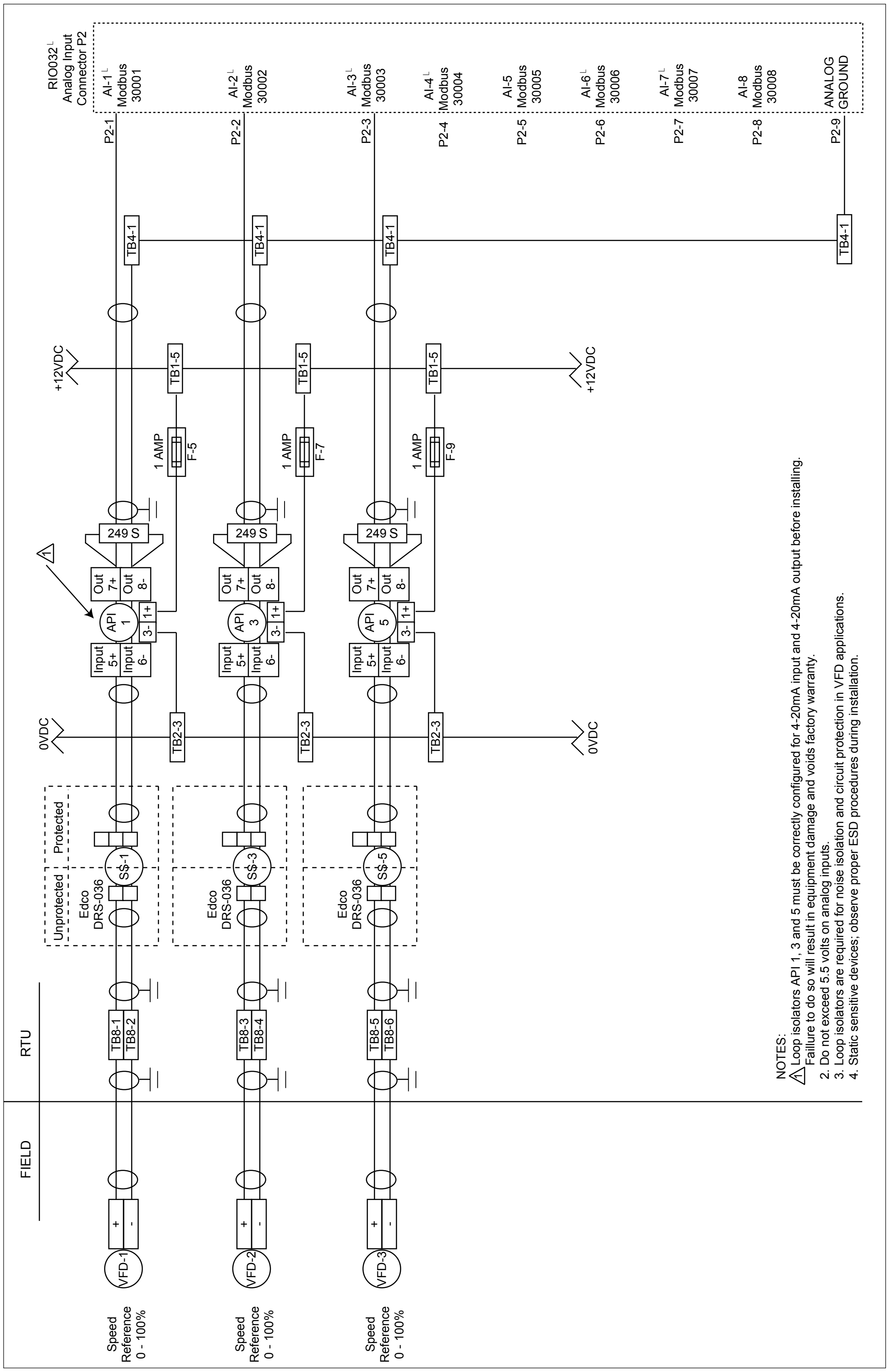


Figure L-7, RIO032 AI Wiring for VFD Operation

RIO032 Analog Output (AO) Points

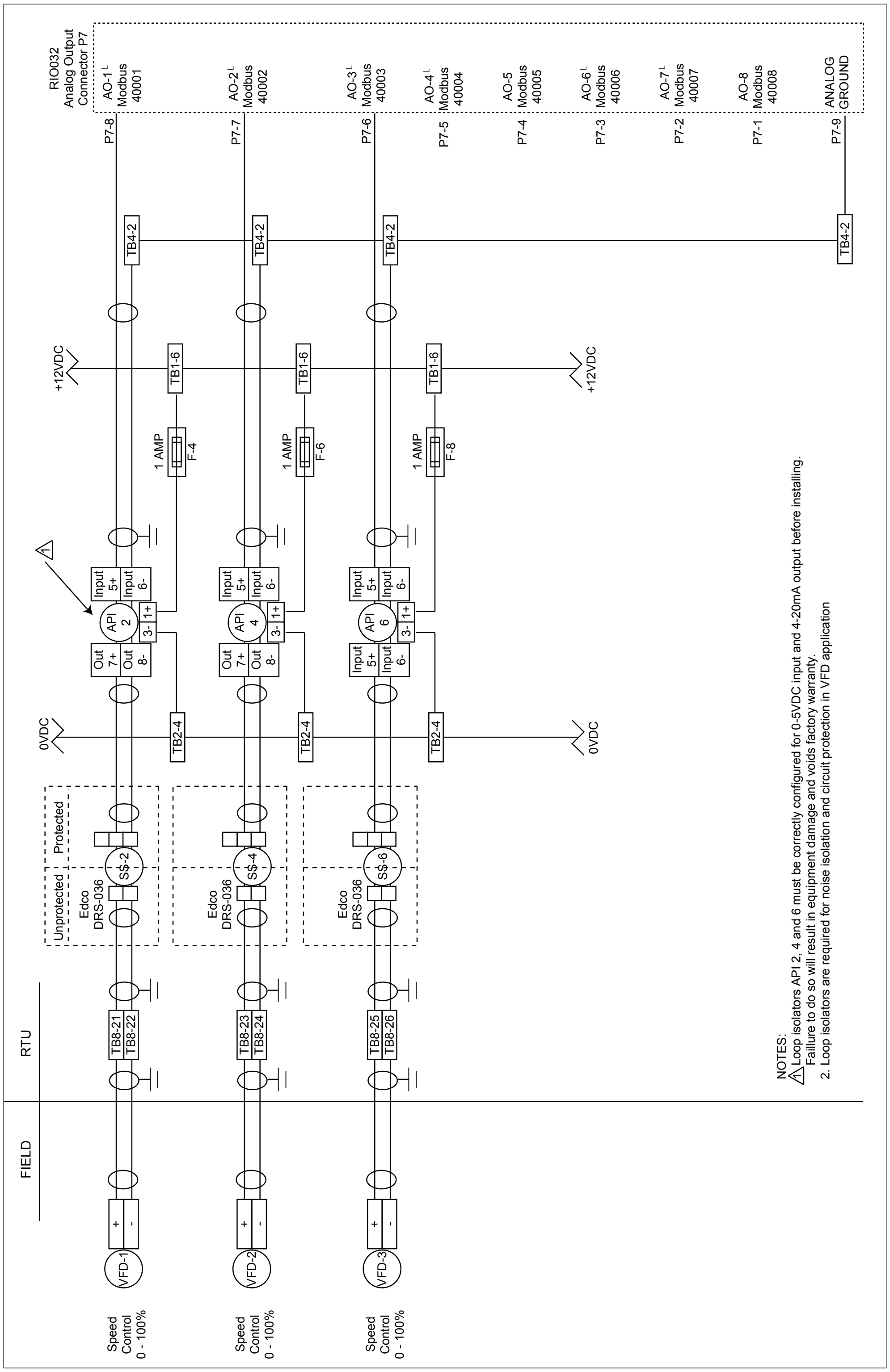


Figure L-8, RIO032 AO Wiring for VFD Operation

TCU001 Analog Input (AI) Points

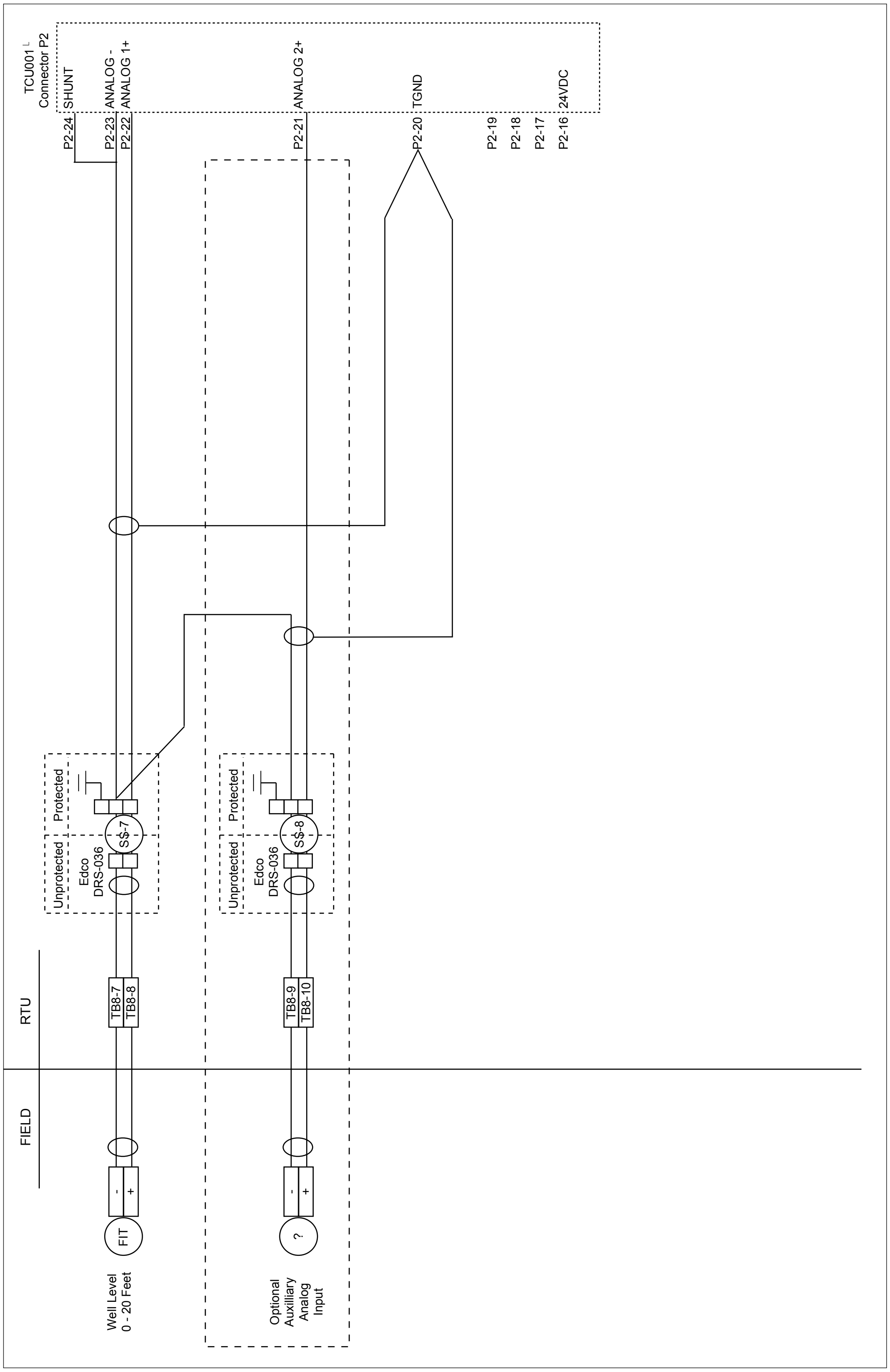


Figure L-9, TCU001 AI Wiring for VFD Operation

TCU001 to RIO032 Interconnect

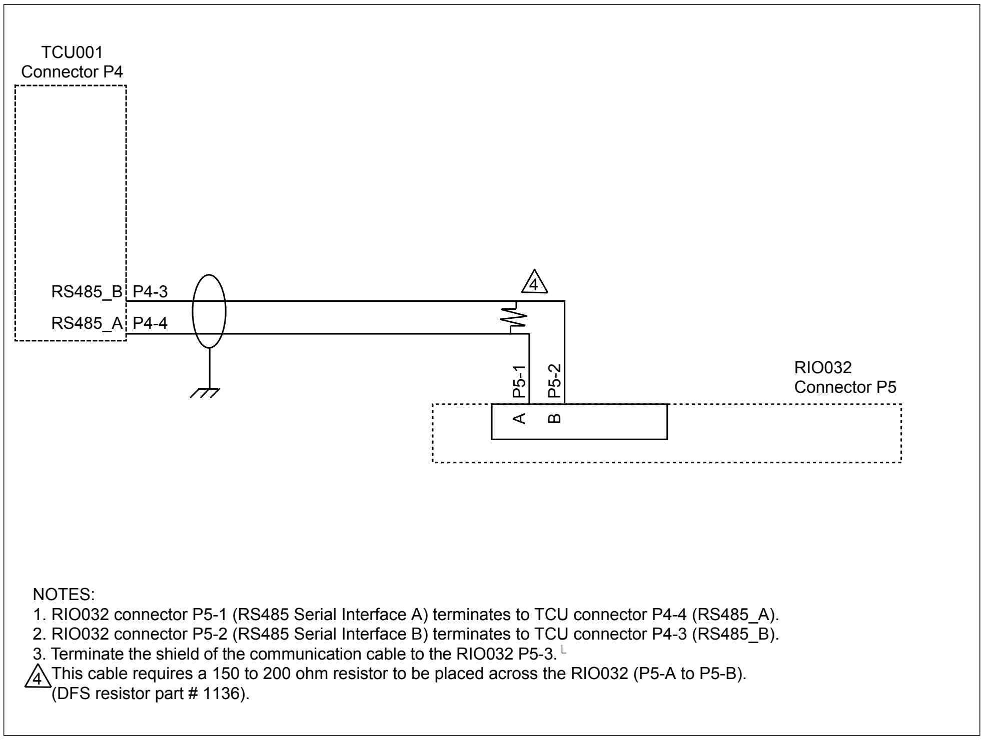


Figure L-10, TCU001 to RIO032 Interconnect for VFD Operation

Registers for VFD Operation

"Appendix N: Polling the TCU – DFS Point and Modbus Registers" provides a list of the Modbus registers used for querying the VFD-TCU. See the section titled "Pump Control Application by Modbus Register." Registers used by the VFD operation that are in addition to the standard TCU pump control application are listed at the end of the section.

In the same appendix, the section "Pump Control Application by Module Letter and Point" lists the TCU's I/O by DFS module letter and point (the corresponding register number is also provided).

Appendix M: TCU Transducer Configuration Examples

The examples in this appendix are the most typical applications and can be used as a guide for configuring your system to obtain the pump control and fault mode behavior required.

Note: The examples provided here are for systems in "pump down" mode (used to empty a well as is typical in a lift station).

4-20 mA or 0-5 VDC Transducer with High Float (Pump Down Mode)

This is the most common configuration, combining a 4-20 ma or 0-5 VDC transducers with a high level float in the well to prevent overflow and generate a high well alarm. Fault mode is disabled in this configuration. An optional low level float to prevent pumping the well dry can also be applied. If more than high or low alarm floats are needed, see "4-20 mA or 0-5 VDC Transducer with Floats Backup" on page 245.

High float events generate a transducer fault and high well alarm and stagger on all configured pumps. The pumps will remain on as long as the high float condition exists. To prevent short cycling on high float transitions, the pumps adhere to the configured minimum run and minimum off timers. In the example below the pumps will run a minimum of one minute and remain off a minimum of 30 seconds regardless of the frequency of float transitions. Minimum run and off timers apply to *all* pump operations – not just fault conditions – so these timers should be set considering the pump and well characteristics during normal pump cycles. Conversely, low float events shut off all pumps.

Note: If a high and low float condition exist simultaneously the low float condition takes precedence and no pumps will be started. If the transducer is a bubbler system, an optional Noise Fault configuration can be enabled to sense a bubbler pump failure and generate a transducer fault alarm.

TCU Settings (Transducer with High Float)

Name	Setting	Description	For more information, see…
Transducer type	4-20 mA or 0-5 V	Select 4-20 mA or 0-5 V for systems using analog transducers.	page 113
Low Float	Enabled or Disabled	Enable this setting to use a low-level float to override normal pump control if a transducer fault occurs.	page 113
High Float	Enabled	Enable this setting to use a high-level float to override normal pump control if a transducer fault occurs.	page 113
Fault Mode	Disabled	Disable this setting if the system isn't using a backup method (other than low- and/or high-float) for pump control when a transducer fault occurs.	page 115
Transducer High Float Fault	Enabled	Enable to generate a transducer fault when a high float condition occurs.	page 130

Name	Setting	Description	For more information, see…
Transducer Low Level Fault	Enabled	Enable to generate a transducer fault when a low float condition occurs.	page 131
Bubbler Noise Fault	Enabled or Disabled	Enable if the system is a bubbler system and you want to generate a transducer fault when the TCU doesn't detect air-pump induced noise.	page 131
High Float Override	Disabled	Disable for systems not using a float system as the primary or backup method of pump control.	page 132
Minimum Run	1.0	Minimum time pumps should run. Used to prevent short cycling.	page 123
Minimum Off	0.5	Minimum time pumps should remain off. Used to prevent short cycling.	page 123

Response to Fault Conditions (TCU with High Float)

Fault(s)	Alarms	Pump Operation	Behavior
Transducer low condition	• Transducer fault alarm • Low well alarm	All pumps off	Low well and transducer fault alarms are generated. All pumps are turned off. When the transducer level returns to the normal range, the low well alarm clears and normal pump operation resumes. The transducer fault alarm remains active until the TCU has been reset.
Transducer high condition	High well alarm	All pumps on	A high well alarm is generated and all pumps are staggered on. When the transducer level returns to the normal range, the high well alarm clears and normal pump operation resumes.
Transducer noise condition	Transducer fault alarm	Normal pump operation	A transducer fault alarm is generated. Pumps operate normally. The transducer fault alarm remains active until the TCU has been reset.
High float condition	• Transducer fault alarm • High well alarm	All pumps on	High well and transducer fault alarms are generated. All pumps are staggered on. Minimum pump run and off timers are applied. When the High float turns off, the high well alarm clears and normal pump operation resumes. The transducer fault alarm remains active until the TCU has been reset.
Concurrent transducer high and high float conditions	High well alarm	All pumps on	A high well alarm is generated. All pumps are staggered on. A transducer fault alarm is not generated if events occur in the following sequence: Transducer high condition precedes the high float condition; and the high float OFF precedes transducer normal. When the high float condition clears, normal pump operation resumes.

Fault(s)	Alarms	Pump Operation	Behavior
Concurrent transducer low and high float conditions	• Transducer fault alarm • Low well alarm • High well alarm	All pumps on	Low well, high well, and transducer fault alarms are generated. High float condition takes precedence over the transducer low condition and all pumps are staggered on. Minimum run and off timers are applied. Normal pump operation resumes if both conditions clear. The transducer fault alarm remains active until the TCU has been reset.
Low float condition	Low well alarm	All pumps off	A low well alarm is generated. All pumps shut off. When the low float condition clears, normal pump operation resumes. IMPORTANT: Low float condition has precedence over all other faults and alarms, including high float and high level. If a low float condition exists, no pumps are allowed to start.

4-20 mA or 0-5 VDC Transducer with Floats Backup (Pump Down Mode)

This configuration is for a system using 4-20 mA or 0-5 VDC transducers. It uses float inputs to operate the pumps in the event of a transducer fault.

> **IMPORTANT:** Float Fault Mode requires an OFF float to shut off pumps, and a minimum of one float (Lead to High) to start pumps. Do not configure Float Fault Mode if there is not an OFF and Start float wired!

Float sequence faults are disabled in this mode. Minimal floats can be used to operate the station until the transducer fault has been resolved, but the TCU utilizes all the float inputs the same as if configured for Floats. The Off through Lag2 float inputs are ignored when the transducer is not faulted, but these inputs can only be used for the specified floats. The High Float Override can be enabled to allow pumping if the off float fails.

To prevent short cycling on high float transitions, the pumps adhere to the configured minimum run and minimum off timers. In the example below the pumps will run a minimum of one minute and remain off a minimum of 30 seconds regardless of the frequency of float transitions. Minimum run and off timers apply to *all* pump operations – not just fault conditions – so these timers should be set considering the pump and well characteristics during normal pump cycles.

Notes:

- If a high and a low float condition exist simultaneously, the low float condition takes precedence and no pumps will be started. If the transducer is a bubbler system, an optional Noise Fault configuration can be enabled to sense a bubbler pump failure and generate a transducer fault alarm.
- If a high float condition exists and the Off float is off, no pumps will be started unless the High Float Override option has been enabled.
- Once a transducer fault has occurred the TCU will remain on float control until it has been reset.

TCU Settings (Transducer with Floats Backup)

Name	Setting	Description	See…
Transducer type	4-20 mA or 0-5 Volts	Select 4-20 mA or 0-5 Volts for systems using analog transducers.	page 113
Low Float	Enabled or Disabled	Enable this setting to use a low-level float to override normal pump control if a transducer fault occurs.	page 113
High Float	Enabled	Enable this setting to use a high-level float to override normal pump control if a transducer fault occurs.	page 113
Fault Mode	Floats	Select Floats to have the TCU switch to float control when a transducer fault occurs.	page 115
Transducer High Float Fault	Enabled	Enable to generate a transducer fault when a high float condition occurs.	page 130
Transducer Low Level Fault	Enabled	Enable to generate a transducer fault when a low float condition occurs.	page 131
Bubbler Noise Fault	Enabled or Disabled	Enable only if the system is a bubbler system and you want to generate a transducer fault when the TCU doesn't detect air-pump induced noise.	page 131
High Float Override	Enabled or Disabled	Enable this setting to give the High float precedence in the event of an Off float failure when the TCU is in Floats fault mode.	page 132
Minimum Run	1.0	Minimum time pumps should run. Used to prevent short cycling.	page 123
Minimum Off	0.5	Minimum time pumps should remain off. Used to prevent short cycling.	page 123

Response to Fault Conditions (Transducer with Floats Backup)

Fault(s)	Alarms	Pump Operation	Behavior
Transducer low condition	• Transducer fault alarm • Low well alarm	All pumps off	Control switches to float inputs. Low well and transducer fault alarms are generated. If float inputs agree, all pumps are turned off. The low well alarm clears if the transducer returns to normal range. However, the transducer fault alarm remains active and control remains with floats until the TCU has been reset.
Concurrent off float and lead float conditions	Transducer fault	Normal pump operation	Example of normal operation under floats control, regardless of which event triggered the transducer fault.
Concurrent transducer low, off float, and high float conditions	• Transducer fault alarm • Low well alarm • High well alarm	All pumps on	Control switches to float inputs. Low well, high well, and transducer fault alarms are generated. All pumps are staggered on. Low and high well alarms clear if the transducer and the High float return to normal. However, the transducer fault alarm remains active and control remains with floats until the TCU has been reset.
Transducer high condition	High well alarm	All pumps on	Control remains with the transducer. All pumps are staggered on. A transducer fault is not generated unless the analog input reaches maximum (20 mA or 5 VDC). When the high transducer condition clears, the high well alarm clears and normal pump operation resumes.
Concurrent transducer high and high float conditions	High well alarm	All pumps on	Control remains with transducer. A high well alarm is generated. All pumps are staggered on. A transducer fault is not generated if events occur in the following sequence: transducer high condition precedes high float condition; and High float clears prior to tranducer returning to normal range. When high conditions clear, normal pump operation resumes.
High float condition and Off float is off (with high float override option disabled)	• Transducer fault alarm • High well alarm	All pumps on/off	Control switches to float inputs. High well and transducer fault alarms are generated. All pumps are staggered on and then shut off after minimum pump run time, even if the High float remains on. High float transitions do not restart pumps. If Off/Lead float activity does not occur, the TCU will not start the pumps until a reset clears the transducer fault.
High float condition and Off float is off (with high float override option enabled)	• Transducer fault alarm • High well alarm	All pumps on	Control switches to float inputs. High well and transducer fault alarms are generated. All pumps are staggered on and remain on if the High float remains true. High float transitions re-start pumps and minimum pump run and off timers are applied. The high well alarm clears if the High float turns off. However, the transducer fault alarm remains active and control remains on floats until the TCU has been reset.

Fault(s)	Alarms	Pump Operation	Behavior
Low float condition (with low float option enabled)	• Transducer fault alarm • Low well alarm	All pumps off	Control switches to float inputs. Transducer fault and low well alarms are generated. The Low float takes precedence, and all pumps are turned off. Pumps remain off while the Low float is off. If Off/Lead float activity does not occur, the TCU will not start the pumps until a reset clears the transducer fault.
Concurrent transducer high and low float conditions (with low float option enabled)	• Transducer fault alarm • Low well alarm • High well alarm	All pumps off	Control switches to float inputs. Transducer fault, low well, and high well alarms are generated. The Low float takes precedence, and all pumps are turned off. Pumps remain off while the Low float is off. If Off/Lead float activity does not occur, the TCU will not start the pumps until a reset clears the transducer fault.
Concurrent low float and high float conditions (with low float option enabled and high float override option disabled)	• Transducer fault alarm • Low well alarm • High well alarm	All pumps off	Control switches to float inputs. High well, low well, and transducer fault alarms are generated. The Low float takes precedence, and all pumps are turned off. If the low float condition clears, but the high float condition remains, the pumps are *not* started. If Off/Lead float activity does not occur, the TCU will not start the pumps until a reset clears the transducer fault.
Concurrent low float and high float conditions (with low float option and high float override options enabled)	• Transducer fault alarm • Low well alarm • High well alarm	All pumps off	Control switches to float inputs. High well, low well, and transducer fault alarms are generated. The Low float takes precedence, and all pumps are turned off. If the low float condition clears, but the high float condition remains, the pumps are *not* started. If Off/Lead float activity does not occur, the TCU will not start the pumps until a reset clears the transducer fault.

4-20 mA or 0-5 VDC Transducer with Analog Input 2 as Backup (Pump Down Mode)

This configuration applies to 4-20 mA or 0-5 VDC transducers. It uses the TCU’s second analog input to operate the pumps in the event of a transducer fault. The second analog input can be wired to any analog level transducer, including a redundant bubbler system, but the signal must be 4-20 mA. Optional High and Low level floats can be used for alarm and limited backup control to prevent overflow in the event of both transducers failing.

Notes:

- The TCU will locally alarm the second analog input if the input is not within operational 4-20 mA range. There is not a separate “Analog Input 2 Fault” I/O point for telemetry as of this code revision. It is recommended that the second analog input be configured in telemetry to alarm on Low and High thresholds when configured as the backup transducer.
- Once a transducer fault has occurred, the TCU will remain on second analog input control until it has been reset.

TCU Settings (Transducer with Second Analog Input Backup)

Name	Setting	Description	See…
Transducer type	4-20 mA or 0-5 Volts	Select 4-20 mA or 0-5 Volts for systems using analog transducers.	page 113
Low Float	Enabled or Disabled	Enable this setting to use a low-level float to override normal pump control if a transducer fault occurs.	page 113
High Float	Enabled or Disable	Enable this setting to use a high-level float to override normal pump control if a transducer fault occurs.	page 113
Fault Mode	Analog2	Select Analog2 to have the TCU switch to the second analog input for pump control when a transducer fault occurs.	page 115
Transducer High Float Fault	Enabled	Enable to generate a transducer fault when a high float condition occurs.	page 130
Transducer Low Level Fault	Enabled	Enable to generate a transducer fault when a low float condition occurs.	page 131
Bubbler Noise Fault	Enabled or Disabled	Enable only if the system is a bubbler system and you want to generate a transducer fault when the TCU doesn’t detect air-pump induced noise.	page 131
High Float Override	Enabled or Disabled	Enable this setting to give the High float precedence in the event of an Off float failure when the TCU is in Floats fault mode.	page 132
Minimum Run	1.0	Minimum time pumps should run. Used to prevent short cycling.	page 123
Minimum Off	0.5	Minimum time pumps should remain off. Used to prevent short cycling.	page 123

Response to Fault Conditions (Transducer with Second Analog Input Backup)

Fault(s)	Alarms	Pump Operation	Behavior
Transducer low condition	• Transducer fault alarm • Low well alarm	Normal pump operation	Low well alarm and transducer fault alarms are generated. Control switched to second transducer. When the transducer level returns to normal range, the Low well alarm clears and normal pump operation resumes. Transducer fault alarm remains active and control remains on second transducer until the TCU has been reset.
Transducer high condition	High well alarm	All pumps on	A high well alarm is generated, and all pumps are staggered on. When the transducer level returns to normal range, the High well alarm clears and normal pump operation resumes.
Transducer noise fault	Transducer fault	Normal pump operation	A transducer fault is generated, and the TCU switches pump control to the second analog input. Pumps operate normally under this condition. The transducer fault alarm remains active until the TCU has been reset.
High float condition	• Transducer fault alarm • High well alarm	All pumps on	High and transducer fault alarms are generated. All pumps are staggered on. The TCU switches pump control to the second analog input. Minimum pump run and off timers are applied. When the high float turns off, the high well alarm clears and normal pump operation resumes. The transducer fault alarm remains active and control remains with the second analog input until the TCU has been reset.
Concurrent transducer high and high float conditions	High well alarm	All pumps on	A high well alarm is generated, and all pumps are staggered on. A transducer fault is not generated if events occur in the following sequence: transducer high condition procedes high float coming on; and high float going off precedes transducer returning to normal level. When all high conditions clear, normal pump operation resumes.
Concurrent transducer low and high float conditions	• Transducer fault alarm • Low well alarm • High well alarm	All pumps on	Low, high, and transducer fault alarms are generated. The TCU switches pump control to the second analog input. The high float on condition takes precedence over the transducer low condition, and all pumps are staggered on. Minimum pump run and off timers are applied. Normal pump operation resumes on the second analog input if both conditions clear. The transducer fault alarm remains active and pump control remains with second analog input until the TCU has been reset.

Fault(s)	Alarms	Pump Operation	Behavior
Low float condition	Low well alarm	All pumps off	A low well alarm is generated, and all pumps are shut off. When the low float condition clears, normal pump operation resumes. **IMPORTANT:** A low float condition has precedence over *all* other faults and alarms, including high float and high level. If a low float condition exists, no pumps will be allowed to start.

DISCRETE SYSTEM (PUMP DOWN MODE)

A discrete system uses contact closure devices that provide an On/Off signal. These are typically float balls submersed into a wet well. The floats are wired to the appropriate inputs on the TCU. The TCU then controls the operation of up to three pumps based on input signals from these floats.

The number of floats required depends on the number of pumps at a station.

- A simplex station (one pump) requires floats at the Lead and Off staging levels.
- A duplex station (two pumps) requires floats at the Lead, Off, and Lag staging levels.
- A triplex station (three pumps) requires floats at the Lead, Off, Lag, and Lag2 staging levels.

A discrete system requires that all float devices be wired to the appropriate TCU inputs, and the transducer type in the TCU's configuration be set to Floats.

In addition to the floats described above, a discrete system has the option of using a Low float and a High float as a backup and alarm system. The behavior of the pumps depends on the pumping mode - pump down mode (used to empty a well) or pump up mode (used to fill a tank).

To use High and/or Low floats as a backup and alarm system, the floats must be wired to the corresponding input on the TCU and the Low Float and/or High Float option must be enabled in the TCU.

To prevent the pumps from short cycling on a High float condition, minimum run and off times can be configured for the pumps. The same pump timer rules apply to the Low float. In the event of a High and Low float condition at the same time, the high float condition takes precedence and pumps will continue to run until the high float condition clears.

TCU Settings (Discrete System)

Name	Setting	Description	See…
Transducer Type	Floats	Select floats for a discrete system	page 113
Number of Pumps	1, 2, or 3	Select the number of pumps at the station	page 112
Low Float	Enabled or Disabled	Enable this setting to use a low-level float to override normal pump control if a transducer fault occurs.	page 113

Name	Setting	Description	See…
High Float	Enabled or Disable	Enable this setting to use a high-level float to override normal pump control if a transducer fault occurs.	page 113
High Float Override	Enabled or Disabled	Enable this setting to give the High float precedence in the event of an Off float failure when the TCU is in Floats fault mode.	page 132
Minimum Run	1.0	Minimum time pumps should run. Used to prevent short cycling.	page 123
Minimum Off	0.5	Minimum time pumps should remain off. Used to prevent short cycling.	page 123

Response to Fault Conditions (Discrete System)

Fault(s)	Alarms	Pump Operation	Behavior
High float condition	High well alarm	All pumps on	A high well alarm is generated. All pumps are staggered on. When the high float turns off, the high well alarm clears and normal pump operation resumes.
Low float condition	Low well alarm	All pumps off	A low well alarm is generated, and all pumps are shut off. When the low float condition clears, normal pump operation resumes. **IMPORTANT:** A low float condition has precedence over *all* other faults and alarms, including high float and high level. If a low float condition exists, no pumps will be allowed to start.
Concurrent high float and low float conditions	High well alarm Low well alarm	All pumps on	High well and low well alarms are generated. The high float condition takes precedence, and the pumps will continue to run until the high float condition clears.

Appendix N: Polling the TCU – DFS Point and Modbus Registers

Pump Control Application by Module Letter and Point

The TCU Pump Control template consists of eight individual modules, including one for the integrated radio. The tables on the following pages list the properties of each module contained in the template and provide a description of each point's function.

For those systems using the Modbus protocol, equivalent Modbus registers are also provided. To see the list organized by Modbus register, see "Pump Control Application by Modbus Register" beginning on page 261.

The legacy PCU template can be found beginning on page 269.

Note: Alarm states are listed for some but not all of the TCU's I/O points. Those listed are common alarms, but any or all configured telemetry points can be set to alarm in any desired state.

Additional modules are used in the VFD-TCU. These are listed on page 260.

Module A – DMM002

Point #	Point Name	Point Type	Modbus Register	Low State Label	High State Label	Alarm State	Description
1	Pump 1 Status	DI	12545	OFF	RUNNING		Detects the state of Pump 1
2	Pump 2 Status	DI	12546	OFF	RUNNING		Detects the state of Pump2
3	Pump 3 Status	DI	12547	OFF	RUNNING		Detects the state of Pump 3
4	Phase Monitor Bypass	DI	12548	OFF	ON		Detects if the phase monitor bypass is OFF or ON
5	Low Float Input	DI	12549	OFF	ON		Detects the state of the Low Float
6	Off Float Input*	DI	12550	OFF	ON		Detects the state of the Off float
7	Lead Float Input*	DI	12551	OFF	ON		Detects the state of the Lead float
8	Lag Float Input*	DI	12552	OFF	ON		Detects the state of the Lag float
9	Lag2 Float Input*	DI	12553	OFF	ON		Detects the state of the Lag2 float
10	High Float Input*	DI	12554	OFF	ON		Detects the state of the High float
11	Any Pump	DI	12555	OFF	RUNNING		Detects the status of any pump in the telemetry system
12	Auxiliary Input	DI	12556	OFF	ON		Detects the state of the Auxiliary input

* For VFD operation, these inputs are reserved as spare I/O.

Module B – DCM001

Point #	Point Name	Point Type	Modbus Register	Low State Label	High State Label	Alarm State	Description
1	Starter 1 Out*	DI	12801	OFF	ON		Detects the state of pump starter 1
2	Starter 2 Out*	DI	12802	OFF	ON		Detects the state of pump starter 2
3	Starter 3 Out*	DI	12803	OFF	ON		Detects the state of pump starter 3
4	Auxiliary Out	DI	12804	OFF	ON		Detects the state of the auxiliary output
5	Alarm Light Status	DI	12805	OFF	ON		Detects the state of the alarm light
6	Alarm Horn Status	DI	12806	OFF	ON		Detects the state of the alarm horn
7	Alarm Silence Input	DI	12807	OFF	ON		Indicates the status of the external alarm silence switch
8	Station Disable	DO	520	OFF	ON		In the ON state, allows telemetry to remove power from all pump motors
9	AC Power	DI	12809	NORMAL	FAULT		Allows telemetry to sense AC power failure and activate the alarm.
10	DC Bias	DI	12810	NORMAL	FAULT		Allows telemetry to sense DC bias failure and activate the alarm.

* These points need not be configured when the TCU is running the pump control process, because they are being controlled by the TCU's pump control program. Points A1 (Pump 1), A2 (Pump 2), and A3 (Pump 3) are used to report pump status.

Module C – AMM002

Point #	Point Name	Point Type	Modbus Register	Low State Label*	High State Label**	Resolution/ Units	Alarm State	Description
1	Analog Input 1	AI	33713	4/820	20/4095	0.01/mA		Settings for the primary analog input
2	Analog Input 2	AI	33714	4/820	20/4095	0.01/mA		Settings for the auxiliary analog input
3	Phase AB Voltage (240)	AI	33715	0/350	300/3102	1/ VAC		Settings for Phase AB voltage (240 option)
	Phase AB Voltage (480)	AI	33715	0/350	600/3114	1/ VAC		Settings for Phase AB voltage (480 option)
4	Phase AC Voltage (240)	AI	33716	0/350	300/3077	1/ VAC		Settings for phase AC voltage (240 option)
	Phase AC Voltage (480)	AI	33716	0/350	600/3077	1/ VAC		Settings for phase AC voltage (480 option)
5	Float Sequence	DI	13089	NORMAL	FAULT		FAULT	Allows telemetry to sense float sequence faults and activate the alarm
6	Level Transducer	DI	13090	NORMAL	FAULT		FAULT	Detects transducer malfunctions and activates the alarm
7	Phase Voltage	DI	13091	NORMAL	FAULT		FAULT	Detects the presence of AC Power and activates the alarm when absent
8	Configuration	DI	13092	–	UPDATED			Detects if the local configuration has been updated; activates the alarm for update

* For analog points, the Low State Label column gives the point's Low engineering value followed by its Low raw value.
** For analog points, the High State Label column gives the point's High engineering value followed by its High raw value.

Module D – DCM001

Point #	Point Name	Point Type	Modbus Register	Low State Label	High State Label	Alarm State	Description
1	Pump 1 Disable	DO	1025	OFF	ON		Allows telemetry to turn off Pump 1 regardless of pump's TCU state
2	Pump 2 Disable	DO	1026	OFF	ON		Allows telemetry to turn off Pump 2 regardless of pump's TCU state
3	Pump 3 Disable	DO	1027	OFF	ON		Allows telemetry to turn off Pump 3 regardless of pump's TCU state
4	Pump 1 Override	DO	1028	OFF	ON		Allows telemetry to turn on Pump 1 regardless of pump's TCU state
5	Pump 2 Override	DO	1029	OFF	ON		Allows telemetry to turn on Pump 2 regardless of pump's TCU state
6	Pump 3 Override	DO	1030	OFF	ON		Allows telemetry to turn on Pump 3 regardless of pump's TCU state
7	Pump 1 Starter	DI	13319	NORMAL	FAULT	FAULT	Allows telemetry to sense a Pump 1 starter failure and activate the alarm
8	Pump 2 Starter	DI	13320	NORMAL	FAULT	FAULT	Allows telemetry to sense a Pump 2 starter failure and activate the alarm
9	Pump 3 Starter	DI	13321	NORMAL	FAULT	FAULT	Allows telemetry to sense a Pump 3 starter failure and activate the alarm
10	Pump 1 Stop	DI	13322	NORMAL	FAULT	FAULT	Allows telemetry to sense a Pump 1 stop failure and activate the alarm
11	Pump 2 Stop	DI	13323	NORMAL	FAULT	FAULT	Allows telemetry to sense a Pump 2 stop failure and activate the alarm
12	Pump 3 Stop	DI	13324	NORMAL	FAULT	FAULT	Allows telemetry to sense a Pump 3 stop failure and activate the alarm

Module E – ACM001

Point #	Point Name	Point Type	Modbus Register	Low State Label*	High State Label**	Resolution/ Units	Alarm State	Description
1	Remote Level	AO	42273	4/820	20/4095	0.01/mA		Calibration point for displaying level for a remote input
2	Unused							
3	Unused							
4	Well Level	AO	42276	0/0	60/600	0.1/FT		Calibration point for displaying well level

* For analog points, the Low State Label column gives the point's Low engineering value followed by its Low raw value.
** For analog points, the High State Label column gives the point's High engineering value followed by its High raw value.

Module F – DCM001

Point #	Point Name	Point Type	Modbus Register	Low State Label	High State Label	Alarm State	Description
1	RESERVED	DO	1537	OFF	ON		RESERVED
2	Low Well Level	DI	13826	NORMAL	ALARM	ALARM	Detects state of Low level sensor
3	Hi Well Level	DI	13827	NORMAL	ALARM	ALARM	Detects state of High level sensor
4	HOA 1	DI	13828	-	HAND	HAND	Detects position of HOA 1 switch and activates alarm for "Hand" position
5	HOA 1	DI	13829	-	OFF	OFF	Detects position of HOA 1 switch and activates alarm for "Off" position
6	HOA 1	DI	13830	-	AUTO		Detects position of HOA 1 switch and activates alarm for "Auto" position
7	HOA 2	DI	13831	-	HAND	HAND	Detects position of HOA 2 switch and activates alarm for "Hand" position
8	HOA 2	DI	13832	-	OFF	OFF	Detects position of HOA 2 switch and activates alarm for "Off" position
9	HOA 2	DI	13833	-	AUTO		Detects position of HOA 2 switch and activates alarm for "Auto" position
10	HOA 3	DI	13834	-	HAND	HAND	Detects position of HOA 3 switch and activates alarm for "Hand" position
11	HOA 3	DI	13835	-	OFF	OFF	Detects position of HOA 3 switch and activates alarm for "Off" position
12	HOA 3	DI	13836	-	AUTO		Detects position of HOA 3 switch and activates alarm for "Auto" position

Module G – DCM001

Point #	Point Name	Point Type	Modbus Register	Low State Label	High State Label	Alarm State	Description
1	Aux Out Override On	DO	1793	OFF	ON		OFF=Normal Operation; ON=Override Aux Output to ON state
2	Alarm Light Override	DO	1794	OFF	ON		OFF=Normal Operation; ON=Override Alarm Light Output to ON state
3	Alarm Horn Override	DO	1795	OFF	ON		OFF=Normal Operation; ON=Override Alarm Horn Output to ON state
4	Aux Out Disable	DO	1796	OFF	ON		OFF=Normal Operation; ON=Disable Aux Output
5	Alarm Light Disable	DO	1797	OFF	ON		OFF=Normal Operation; ON=Disable Alarm Light Output
6	Alarm Horn Disable	DO	1798	OFF	ON		OFF=Normal Operation; ON=Disable Horn Light Output
7	Pump Override Reset	DO	1799	OFF	ON		OFF=Normal Operations; ON=Turn OFF any Pump Overrides when OFF level reached
8	Analog Updating	DO	1800	OFF	ON		Legacy PCU function. Only applies to a TCU being used as a PCU. Has no application in a standard TCU installation. This setting is an on/off switch for logging analog values. It enables the TCU to respond with full analog status each time it is polled. This setting should be used judiciously as it will have a large impact on the radio-polling rate.

Module R – RIM006

Point #	Point Name	Point Type	Modbus Register	Low State Label*	High State Label**	Resolution/ Units	Alarm State	Description
1	Battery test	DO	1	OFF	ON		ON	Control point used to turn off the TCU's AC power and go to battery power
2-10	Unused							
11	Bias Voltage	DI	12299	OFF	ON		OFF	Detects the presence of isolated DC bias and activates the Alarm when absent
12	TCU Power	DI	12300	OFF	ON		OFF	Detects the presence of AC Power and activates the Alarm when absent
13	Radio Key Current	AI	32945	0/0	255/100	0.1/%		Detects the amount of current drawn when the radio is keyed
14	Radio Signal Strength	AI	32946	0/0	255/100	0.1/%		Detects the average receive signal strength
15	Internal Temperature	AI	32947	0/32	100/212	0.1/F		Detects the TCU's internal temperature

* For analog points, the Low State Label column gives the point's Low raw value followed by its Low Engineering value.
** For analog points, the High State Label column gives the point's High raw value followed by its High Engineering value.

Additional Modules Used for VFD Operation

Module H – ACM002

Point #	Point Name	Point Type	Modbus Register	Low State Label*	High State Label**	Resolution/ Units	Alarm State	Description
1	Pump 1 Speed Control Signal	AI	43041	0/819	100/4095	0/%		
2	Pump 2 Speed Control Signal	AI	43042	0/819	100/4095	0/%		
3	Pump 3 Speed Control Signal	AI	43043	0/819	100/4095	0/%		

* For analog points, the Low State Label column gives the point's Low engineering value followed by its Low raw value.
** For analog points, the High State Label column gives the point's High engineering value followed by its High raw value.

Module I – AMM002

Point #	Point Name	Point Type	Modbus Register	Low State Label†	High State Label**	Resolution/ Units	Alarm State	Description
1	Pump 1 Speed Feedback	AI	35249	0/819	100/4095	0/%		
2	Pump 2 Speed Feedback	AI	35250	0/819	100/4095	0/%		
3	Pump 3 Speed Feedback	AI	35251	0/819	100/4095	0/%		

Module J – DMM002

Point #	Point Name	Point Type	Modbus Register	Low State Label	High State Label	Alarm State	Description
1-8	Spares	DO	14849-14856	OFF	ON		Spares for connecting any required additional I/O

Module K – DCM003-1

Point #	Point Name	Point Type	Modbus Register	Low State Label	High State Label	Alarm State	Description
1-8	Spares	DI	2817-2824	OFF	ON		Spares for connecting any required additional I/O

PUMP CONTROL APPLICATION BY MODBUS REGISTER

The information on the following pages lists the properties of each of the TCU's equivalent Modbus registers and provides a description of each register's function.

Notes:

The information is sorted by register number in ascending order.

Labels in italics indicate differences between the standard TCU and the VFD-TCU (specifically registers 12550-12554). Additional Modbus registers are used in the VFD-TCU and are listed at the end of the table.

Alarm states are listed for some but not all of the TCU's I/O points. Those listed are common alarms, but any or all configured telemetry points can be set to alarm in any desired state.

For analog input (AI) and output (AO) points, the Low State Label column gives the point's Low Engineering value followed by its Low Raw value; the High State Label column gives the point's High Engineering value followed by its High Raw value.

Register	Label	Type	Low State Label	High State Label	Resolution/ Units	Alarm State	Description
1	Battery test	DO	OFF	ON		ON	Control point used to turn off the TCU's AC power and go to battery power
520	Station Disable	DO	OFF	ON			In the ON state, allows telemetry to remove power from all pump motors
1025	Pump 1 Disable	DO	OFF	ON			In the ON state, allows telemetry to cut power to Pump 1
1026	Pump 2 Disable	DO	OFF	ON			In the ON state, allows telemetry to cut power to Pump 2
1027	Pump 3 Disable	DO	OFF	ON			In the ON state, allows telemetry to cut power to Pump 3
1028	Pump 1 Override	DO	OFF	ON			In the ON state, allows telemetry to control Pump 1 and bypass the TCU
1029	Pump 2 Override	DO	OFF	ON			In the ON state, allows telemetry to control Pump 2 and bypass the TCU
1030	Pump 3 Override	DO	OFF	ON			In the ON state, allows telemetry to control Pump 3 and bypass the TCU
1537	Reserved	DO					Factory use only. Do not use.
1793	Aux Out Override On	DO	OFF	ON			In the ON state, allows telemetry to control the auxiliary output
1794	Alarm Light Override	DO	OFF	ON			In the ON state, allows telemetry to control the alarm light

Register	Label	Type	Low State Label	High State Label	Resolution/ Units	Alarm State	Description
1795	Alarm Horn Override	DO	OFF	ON			In the ON state, allows telemetry to control the alarm horn
1796	Aux Out Disable	DO	OFF	ON			Detects if the auxiliary output is in the auto or disabled state
1797	Alarm Light Disable	DO	OFF	ON			Detects if the alarm light is in the auto or disabled state
1798	Alarm Horn Disable	DO	OFF	ON			Detects if the alarm horn is in the auto or disabled state
1799	Pump Override Reset	DO	OFF	ON			When set, allows the Off level input to reset pump overrides
1800	Analog Updating	DO	OFF	ON			This is a legacy PCU function, and only applies to a TCU being used as a PCU. It has no application in a standard TCU installation. This setting is an on/off switch for logging analog values. It enables the TCU to respond with full analog status each time it is polled. This setting should be used judiciously as it will have a large impact on the radio polling rate..
12299	Bias Voltage	DI	OFF	ON		OFF	Detects the presence of isolated DC bias and activates the alarm when absent
12300	TCU Power	DI	OFF	ON		OFF	Detects the presence of AC power and activates the alarm when absent
12545	Pump 1 Status	DI	OFF	RUNNING			Detects the state of Pump 1
12546	Pump 2 Status	DI	OFF	RUNNING			Detects the state of Pump 2
12547	Pump 3 Status	DI	OFF	RUNNING			Detects the state of Pump 3
12548	Phase Monitor Bypass	DI	OFF	ON			Detects if the phase monitor bypass is OFF or ON
12549	Low Float Input	DI	OFF	ON			Detects the state of the Low float
12550	Off Float Input *Spare I/O(VFD)*	DI	OFF	ON			Detects the state of the Off float (Spare I/O in VFD-TCU application)
12551	Lead Float Input *Spare I/O(VFD)*	DI	OFF	ON			Detects the state of the Lead float (Spare I/O in VFD-TCU application)

Register	Label	Type	Low State Label	High State Label	Resolution/ Units	Alarm State	Description
12552	Lag Float Input *Spare I/O(VFD)*	DI	OFF	ON			Detects the state of the Lag float (Spare I/O in VFD-TCU application)
12553	Lag2 Float Input *Spare I/O(VFD)*	DI	OFF	ON			Detects the state of the Lag2 float (Spare I/O in VFD-TCU application)
12554	High Float Input *Spare I/O(VFD)*	DI	OFF	ON			Detects the state of the High float (Spare I/O in VFD-TCU application)
12555	Any Pump	DI	OFF	RUNNING			Detects the status of any pump in the telemetry system
12556	Auxiliary Input	DI	OFF	ON			Detects the state of the Auxiliary input
12801	Starter 1 Out	DI	OFF	ON			Detects the state of pump starter 1
12802	Starter 2 Out	DI	OFF	ON			Detects the state of pump starter 2
12803	Starter 3 Out	DI	OFF	ON			Detects the state of pump starter 3
12804	Auxiliary Out	DI	OFF	ON			Detects the state of the auxiliary output
12805	Alarm Light Status	DI	OFF	ON			Detects the state of the alarm light
12806	Alarm Horn Status	DI	OFF	ON			Detects the state of the alarm horn
12807	Alarm Silence Input	DI	OFF	ON			Indicates the status of the external alarm silence switch
12809	AC Power	DI	NORMAL	FAULT			Allows telemetry to sense AC power failure and activate the alarm
12810	DC Bias	DI	NORMAL	FAULT			Allows telemetry to sense DC bias failure and activate the alarm
12811	Phase Sequence	DI	NORMAL	FAULT		FAULT	Allows telemetry to sense phase sequence failure and activate the alarm
12812	Process	DI	RUNNING	STOPPED		STOPPED	Allows telemetry to sense if the TCU's BASIC program is running
13089	Float Sequence	DI	NORMAL	FAULT		FAULT	Allows telemetry to sense float sequence faults and activate the alarm
13090	Level Transducer	DI	NORMAL	FAULT		FAULT	Detects transducer malfunctions and activates the alarm
13091	Phase Voltage	DI	NORMAL	FAULT		FAULT	Detects the presence of AC power and activates the alarm when absent

Register	Label	Type	Low State Label	High State Label	Resolution/ Units	Alarm State	Description
13092	Configuration	DI	–	UPDATED			Detects if the local configuration has been updated and activates the alarm for update
13319	Pump 1 Starter	DI	NORMAL	FAULT		FAULT	Allows telemetry to sense a Pump 1 starter failure and activate the alarm
13320	Pump 2 Starter	DI	NORMAL	FAULT		FAULT	Allows telemetry to sense a Pump 2 starter failure and activate the alarm
13321	Pump 3 Starter	DI	NORMAL	FAULT		FAULT	Allows telemetry to sense a Pump 3 starter failure and activate the alarm
13322	Pump 1 Stop	DI	NORMAL	FAULT		FAULT	Allows telemetry to sense a Pump 1 stop failure and activate the alarm
13323	Pump 2 Stop	DI	NORMAL	FAULT		FAULT	Allows telemetry to sense a Pump 2 stop failure and activate the alarm
13324	Pump 3 Stop	DI	NORMAL	FAULT		FAULT	Allows telemetry to sense a Pump 3 stop failure and activate the alarm
13826	Low Well Level	DI	NORMAL	ALARM		ALARM	Detects the state of the Low level sensor
13827	High Well Level	DI	NORMAL	ALARM		ALARM	Detects the state of the High level sensor
13828	HOA 1	DI	–	HAND		HAND	Detects position of HOA 1 switch and activates alarm for “Hand” position
13829	HOA 1	DI	–	OFF		OFF	Detects position of HOA 1 switch and activates alarm for “Off” position
13830	HOA 1	DI	–	AUTO			Detects position of HOA 1 switch and activates alarm for “Auto” position
13831	HOA 2	DI	–	HAND		HAND	Detects position of HOA 2 switch and activates alarm for “Hand” position
13832	HOA 2	DI	–	OFF		OFF	Detects position of HOA 2 switch and activates alarm for “Off” position
13833	HOA 2	DI	–	AUTO			Detects position of HOA 2 switch and activates alarm for “Auto” position
13834	HOA 3	DI	–	HAND		HAND	Detects position of HOA 3 switch and activates alarm for “Hand” position
13835	HOA 3	DI	–	OFF		OFF	Detects position of HOA 3 switch and activates alarm for “Off” position
13836	HOA 3	DI	–	AUTO			Detects position of HOA 3 switch and activates alarm for “Auto” position

Register	Label	Type	Low State Label	High State Label	Resolution/ Units	Alarm State	Description
32945	Reserved	AI					Factory use only. Do not use.
32946	Reserved	AI					Factory use only. Do not use.
32947	Internal Temperature	AI	0/32	100/212		0.1/F	Detects the TCU's internal temperature
33713	Analog Input 1	AI	4/820	20/4095	0.01/mA		Settings for the primary analog input
33714	Analog Input 2	AI	4/820	20/4095	0.01/mA		Settings for the auxiliary analog input
33715	Phase AB Voltage (240 VAC)	AI	0/350	300/3102	1/ VAC		Settings for Phase AB voltage for 240 VAC 1- or 3-phase monitor
33715	Phase AB Voltage (480 VAC 3-phase)	AI	0/350	600/3114	1/ VAC		Settings for Phase AB voltage for 480 VAC 3-phase monitor
33716	Phase AC Voltage (240 VAC)	AI	0/350	300/3077	1/ VAC		Settings for phase AC voltage for 240 VAC 1- or 3-phase monitor
33716	Phase AC Voltage (480 VAC 3-phase)	AI	0/350	600/3077	1/ VAC		Settings for phase AC voltage for 480 VAC 3-phase monitor
42273	Remote Level	AO	4/820	20/4095	0.01/mA		Calibration point for displaying the level for a remote input
42276	Well Level	AO	0/0	60/600	0.1/FT		Calibration point for displaying well level

Additional Modbus Registers Used in VFD-TCU

Register	Label	Module Letter	Module Type	Point Type	Low State Label	High State Label	Resolution /Units	Notes
43041	Pump 1 Speed Control Signal	H	ACM002	AI	0/819	100/4095	0/%	
43042	Pump 2 Speed Control Signal	H	ACM002	AI	0/819	100/4095	0/%	
43043	Pump 3 Speed Control Signal	H	ACM002	AI	0/819	100/4095	0/%	
35249	Pump 1 Speed Feedback	I	AMM002	AI	0/819	100/4095	0/%	
35250	Pump 2 Speed Feedback	I	AMM002	AI	0/819	100/4095	0%	

Register	Label	Module Letter	Module Type	Point Type	Low State Label	High State Label	Resolution /Units	Notes
35251	Pump 3 Speed Feedback	I	AMM002	AI	0/819	100/4095	0/%	
14849-14856	Spares	J	DMM002	DO	OFF	ON		Spares for connecting any required additional I/O
2817-2824	Spares	K	DCM003-1	DI	OFF	ON		Spares for connecting any required additional I/O

DFS MODULE TO MODBUS REGISTER MAPS

If you are using an HMI other than HT3, you will need to configure that software with the correct Modbus register information in order to poll a Modbus slave device connected to the TCU.

Modules H-O can be used to store data from Modbus slave devices connected to the TCU on its RS-485 interface. (A typical application would be adding a RIO032/RIO128. See “Appendix K: Adding a RIO to the TCU.”)

Modbus polling is activated by entering the correct Modbus information (address and length) into the TCU’s configuration registers as discussed in “Poll Modbus Slave Devices” beginning on page 127.

On the next pages, find the module type that corresponds to the type of Modbus slave I/O you added to the TCU.

- digital inputs = DMM
- digital outputs = DCM
- analog inputs = AMM
- analog outputs = ACM

Then, find the column for the module letter the I/O was added to. Each of the modules (H-O) can accomodate:

- Twelve (12) digital status registers, or
- Eight (8) digital control registers, or
- Four (4) analog status registers, or
- Four (4) analog control registers

For example, if you added 4 (four) digital inputs to module H, you would select the first four registers listed in the module H column of the DMM Module Type table (14337, 14338, 14339, 14340).

DMM Module Type

Point #	Modbus Register by Module Letter							
	H	I	J	K	L	M	N	O
1	14337	14593	14849	15105	15361	15617	15873	16129
2	14338	14594	14850	15106	15362	15618	15874	16130
3	14339	14595	14851	15107	15363	15619	15875	16131
4	14340	14596	14852	15108	15364	15620	15876	16132
5	14341	14597	14853	15109	15365	15621	15877	16133
6	14342	14598	14854	15110	15366	15622	15878	16134
7	14343	14599	14855	15111	15367	15623	15879	16135
8	14344	14600	14856	15112	15368	15624	15880	16136
9	14345	14601	14857	15113	15369	15625	15881	16137
10	14346	14602	14858	15114	15370	15626	15882	16138
11	14347	14603	14859	15115	15371	15627	15883	16139
12	14348	14604	14860	15116	15372	15628	15884	16140

DCM Module Type

Point #	Modbus Register by Module Letter							
	H	I	J	K	L	M	N	O
1	2049	2305	2561	2817	3073	3329	3585	3841
2	2050	2306	2562	2818	3074	3330	3586	3842
3	2051	2307	2563	2819	3075	3331	3587	3843
4	2052	2308	2564	2820	3076	3332	3588	3844
5	2053	2309	2565	2821	3077	3333	3589	3845
6	2054	2310	2566	2822	3078	3334	3590	3846
7	2055	2311	2567	2823	3079	3335	3591	3847
8	2056	2312	2568	2824	3080	3336	3592	3848

AMM Module Type

See note (below ACM Module Type table) on resolution of DFS analog modules.

Point #	Modbus Register by Module Letter							
	H	I	J	K	L	M	N	O
1	34993	35249	35505	35761	36017	36273	36529	36785
2	34994	35250	35506	35762	36018	36274	36530	36786
3	34995	35251	35507	35763	36019	36275	36531	36787
4	34996	35252	35508	35764	36020	36276	36532	36788

ACM Module Type

See note (below) on resolution of DFS analog modules.

Point #	Modbus Register by Module Letter							
	H	I	J	K	L	M	N	O
1	43041	43297	43553	43809	44065	44321	44577	44833
2	43042	43298	43554	43810	44066	44322	44578	44834
3	43043	43299	43555	43811	44067	44323	44579	44835
4	43044	43300	43556	43812	44068	44324	44580	44836

Note: DFS analog modules have 12 bit resolution (0 - 4095). If the Modbus slave device being configured has a higher resolution, the number of bits (typically 15) will need to be configured in the TCU's ModX Lth field (where X represents the module letter being configured) in order for the value to read correctly.

LEGACY PCU

The table below, “Point Values for Legacy PCU,” lists the properties of the legacy PCU template. Point 49 has two possible configurations (labeled 49a and 49b), depending on the device’s type (4-20 mA or 0-5 V). The template defaults to a 4-20 mA device. If necessary, edit the point to fit your system.

The “Point Descriptions for Legacy PCU” table that begins on page 271 provides a description of each point’s function.

Point Values for Legacy PCU

Point #	Point Name	Point Type	Low State Label *	High State Label **	Alarm State	Resolution / Units †
1	Low Float Input	DI	OFF	ON		
2	Off Float Input	DI	OFF	ON		
3	Lead Float Input	DI	OFF	ON		
4	Lag 1 Float Input	DI	OFF	ON		
5	Lag 2 Float Input	DI	OFF	ON		
6	High Float Input	DI	OFF	ON	ON	
7	Auxiliary Input	DI	OFF	ON		
8	Alarm Horn Cond.	DI	ENABLED	SILENCED		
9	Pump #1 Status	DI	OFF	RUNNING		
10	Pump #2 Status	DI	OFF	RUNNING		
11	Pump #3 Status	DI	OFF	RUNNING		
12	Phase Monitor Bypass	DI	OFF	ON		
13	Phase Voltage	DI	OK	FAULT	FAULT	
14	Phase Sequence	DI	OK	FAULT	FAULT	
15	Pump #1 Starter	DI	OK	FAULT	FAULT	
16	Pump #2 Starter	DI	OK	FAULT	FAULT	
17	Pump #3 Starter	DI	OK	FAULT	FAULT	
18	Pump #1 Stop	DI	OK	FAULT	FAULT	
19	Pump #2 Stop	DI	OK	FAULT	FAULT	
20	Pump #3 Stop	DI	OK	FAULT	FAULT	
21	Float Sequence	DI	OK	FAULT	FAULT	
22	Level Transducer	DI	OK	FAULT	FAULT	
23	Backup Memory	DI	OK	FAULT	FAULT	
24	AC Power	DI	OK	FAULT	FAULT	
25	DC Bias	DI	OK	FAULT	FAULT	
26	Low Well Level	DI	OK	ALARM	ALARM	
27	High Well Level	DI	OK	ALARM	ALARM	
31	HOA Switch 1	DI	-	HAND	HAND	
32	HOA Switch 1	DI	-	OFF	OFF	

Point #	Point Name	Point Type	Low State Label *	High State Label **	Alarm State	Resolution / Units †
33	HOA Switch 1	DI	-	AUTO		
34	HOA Switch 2		-	HAND	HAND	
35	HOA Switch 2	DI	-	OFF	OFF	
36	HOA Switch 2	DI	-	AUTO		
37	HOA Switch 3	DI	-	HAND	HAND	
38	HOA Switch 3	DI	-	OFF	OFF	
39	HOA Switch 3	DI	-	AUTO		
40	Auxiliary Output	DI	OFF	ON		
41	Alarm Horn Status	DI	OFF	RINGING		
42	Alarm Light Status	DI	FLASHING	OFF		
43	Any Pump	DI	OFF	RUNNING		
44	PCU Configuration	DI	-	UPDATED	UPDATED	
49a	Analog Input	AI	0/0	20/255		1 / mA
49b	Analog Input	AI	0/0	5/255		.1 / V
50	Phase AB Voltage	AI	151/0	300/255		5 / VAC
51	Phase AC Voltage	AI	151/0	300/255		5 / VAC
52	Well Level	AI	0/0	60/600		0.5 / ft
58	Pump #1 Override	DO	OFF	ON		
59	Pump #2 Override	DO	OFF	ON		
60	Pump #3 Override	DO	OFF	ON		
61	Aux. Output Override	DO	OFF	ON		
62	Alarm Horn Override	DO	OFF	ON		
63	Alarm Light Disable	DO	OFF	ON		
64	Station Disable	DO	OFF	ON		
65	Pump #1 Disable	DO	OFF	ON		
66	Pump #2 Disable	DO	OFF	ON		
67	Pump #3 Disable	DO	OFF	ON		
68	Aux. Output Disable	DO	OFF	ON		
69	Alarm Horn Disable	DO	OFF	ON		
70	Alarm Light Override	DO	OFF	ON		
71	RESERVED	DO	OFF	ON		
72	Override Reset	DO	DISABLE	ENABLE		
73	Analog Updating	DO	OFF	ON		

* For analog points, the Low State Label column gives the point's Low engineering value followed by its Low raw value.
** For analog points, the High State Label column gives the point's High engineering value followed by its High raw value.
† Resolution and units apply to analog points only.

Point Descriptions for Legacy PCU

Point #	Point Name	Description
1	Low Float Input	Detects if the Low Level sensor is in the OFF state or the ON state
2	Off Float Input	Detects if the Off Level sensor is in the OFF state or the ON state
3	Lead Float Input	Detects if the Lead Level sensor is in the OFF state or the ON state
4	Lag 1 Float Input	Detects if the Lag Level sensor is in the OFF state or the ON stat.
5	Lag 2 Float Input	Detects if the Lag2 Level sensor is in the OFF state or the ON state
6	High Float Input	Detects if the High Level sensor is in the OFF state or the ON stat.
7	Auxiliary Input	Detects if the Auxiliary Input is in the OFF state or the ON state
8	Alarm Horn Cond.	Gives status of external alarm-silence switch
9	Pump #1 Status	Detects whether pump 1 is in the OFF state or the RUNNING state.
10	Pump #2 Status	Detects whether pump 2 is in the OFF state or the RUNNING state
11	Pump #3 Status	Detects whether pump 3 is in the OFF state or the RUNNING state
12	Phase Monitor Bypass	Detects whether the phase monitor is ENABLED or BYPASSED
13	Phase Voltage	Allows telemetry to sense phase voltage failure and activate the alarm
14	Phase Sequence	Allows telemetry to sense phase sequence failure and activate the alarm
15	Pump #1 Starter	Allows telemetry to sense Pump 1 Starter failure and activate the alarm
16	Pump #2 Starter	Allows telemetry to sense Pump 2 Starter failure and activate the alarm
17	Pump #3 Starter	Allows telemetry to sense Pump 3 Starter failure and activate the alarm
18	Pump #1 Stop	Activates the alarm any time Pump 1 is running and stops without control by the PCU
19	Pump #2 Stop	Activates the alarm any time Pump 2 is running and stops without control by the PCU
20	Pump #3 Stop	Activates the alarm any time Pump 3 is running and stops without control by the PCU
21	Float Sequence	Allows telemetry to sense float sequence fault and activate the alarm
22	Level Transducer	Detects malfunction of a Transducer and activates the alarm
23	Backup Memory	Detects failure of the EEPROM backup memory and activates the alarm
24	AC Power	Detects the presence of AC Power and activates the Alarm when absent
25	DC Bias	Detects the presence of isolated DC bias and activates the alarm when absent
26	Low Well Level	Detects whether the Low Level sensor is OK or in the FAULT (Emergency Low) state
27	High Well Level	Detects whether the High Level sensor is OK or in the HIGH state

Point #	Point Name	Description
31	HOA Switch 1	Detects position of HOA switch 1 and activates alarm for "Hand" position
32	HOA Switch 1	Detects position of HOA switch 1 and activates alarm for "Off" position
33	HOA Switch 1	Detects position of HOA switch 1 and indicates the "Auto" position
34	HOA Switch 2	Detects position of HOA switch 2 and activates alarm for "Hand" position
35	HOA Switch 2	Detects position of HOA switch 2 and activates alarm for "Off" position
36	HOA Switch 2	Detects position of HOA switch 2 and indicates the "Auto" position
37	HOA Switch 3	Detects position of HOA switch 3 and activates alarm for "Hand" position
38	HOA Switch 3	Detects position of HOA switch 3 and activates alarm for "Off" position
39	HOA Switch 3	Detects position of HOA switch 3 and indicates the "Auto" position
40	Auxiliary Output	Detects whether the auxiliary output is in the OFF or ON state
41	Alarm Horn Status	Detects whether the alarm horn is in the OFF or RINGING state
42	Alarm Light Status	Detects whether the alarm light is in the FLASHING or OFF state
43	Any Pump	Indicates the run status of any pump
44	PCU Configuration	Detects if the Local Configuration has been updated and activates the alarm for UPDATE.
49a	Analog Input	Settings for Analog Input when used with analog-current type transducer
49b	Analog Input	Settings for Analog Input when used with analog-voltage type transducer
50	Phase AB Voltage	Settings for Phase AB Voltage for phase monitor
51	Phase AC Voltage	Settings for phase AC voltage for phase monitor
52	Well Level	Calibration points for displaying Well Level
58	Pump #1 Override	In the OVERRIDE state, allows telemetry to control Pump 1 and bypass the TCU
59	Pump #2 Override	In the OVERRIDE state, allows telemetry to control Pump 2 and bypass the TCU
60	Pump #3 Override	In the OVERRIDE state, allows telemetry to control Pump 3 and bypass the TCU
61	Aux. Output Override	In the OVERRIDE state, allows telemetry to control the Auxiliary Output
62	Alarm Horn Override	In the OVERRIDE state, allows telemetry to control the Alarm Horn
63	Alarm Light Disable	In the OVERRIDE state, allows telemetry to control the Alarm Light
64	Station Disable	In the DISABLED state, allows telemetry to cut power to all pump motors
65	Pump #1 Disable	In the DISABLED state, allows telemetry to cut power to Pump 1
66	Pump #2 Disable	In the DISABLED state, allows telemetry to cut power to Pump 2

Point #	Point Name	Description
67	Pump #3 Disable	In the DISABLED state, allows telemetry to cut power to Pump 3
68	Aux. Output Disable	Detects if the auxiliary output is in the AUTO or DISABLED state
69	Alarm Horn Disable	Detects if the alarm horn is in the AUTO or DISABLED state
70	Alarm Light Override	Allows telemetry to override the Alarm Light and activate the alarm at the central site
71	RESERVED	RESERVED
72	Override Reset	When set, allows the Off Level input to reset pump overrides
73	Analog Updating	Enables Analog readings

Notes

Appendix O: SUPPORT, SERVICE, AND WARRANTY

SUPPORT AND SERVICE

Data Flow Systems, Inc. offers support services nationwide from its home office and through authorized Value Added Resellers (VARs) and System Integrators. Contact your local Data Flow Systems, Inc. representative for:

- Sales and order support
- Product technical training
- Warranty support
- Support service agreements

If you are unsure of whom to contact, call DFS' Melbourne headquarters at 321-259-5009 and ask for the Sales Department. Alternatively, send email to sales@dataflowsys.com.

TECHNICAL PRODUCT ASSISTANCE

Please review the information in "Appendix B: Maintenance and Troubleshooting," before contacting Data Flow Systems, Inc. If you need further assistance, contact your local Data Flow Systems representative. If you are unsure of whom to contact, call DFS' Melbourne headquarters at 321-259-5009 and ask for the Service Department. Alternatively, send email to service@dataflowsys.com.

RETURN AUTHORIZATION (RA) PROCEDURE

Data Flow Systems' function modules are designed to be robust and highly reliable. We back this performance with a 3-year full warranty (see our warranty statement for details). In the event that a function module fails, during or after the warranty period, it may be returned to Data Flow Systems to be repaired or replaced.

All RA's will be subject to standard shipping and handling charges. Minimum handling charge will be assessed, in most cases, for work such as Radio Tuning, Backplanes, "No Problem Found," and other minor repairs. Handling charges will be waved on warranty equipment. Standard shipping and charges will be based on UPS ground, please advise if other arrangements are needed (UPS Red, FedEx, Pickup, Freight…). Standard cost of repairs and shipping charges can be obtained by contacting our RA Department by phone or e-mail.

STEP 1: Replace the failed module with a spare module of the same type, if one is available.

STEP 2: Contact Data Flow Systems Inc. in one of the following ways to receive an RA#.

E-mail – An RA# can be obtained by e-mailing DFS at rma@dataflowsys.com and must include the following information.

- Customer/Utility Name and Ship to Address
- Contact Name and Phone Number
- Products to be returned and Serial Numbers
- Detailed description of failure
- PO#

Phone – RA# will be issued over the phone by calling DFS at 321-259-5009 during normal operating hours. The following information will be needed.

- Customer/Utility Name and Ship to Address
- Contact Name and Phone Number
- Products to be returned and Serial Numbers
- Detailed description of failure
- PO#

Note: The lack of "Detailed description of failure" could result in the return of equipment due to the inability to properly determine the nature of the failure or testing resulting in "No Problem Found"

STEP 3: Place the function module(s) individually in an electrostatic discharge bag and then wrap with foam or bubble wrap. Pack the wrapped module(s) in a sturdy box filled with popcorn-type or bubble wrap packing material. Include a packing slip with the following information:

- Module(s) model, serial number, probable cause of failure, and the RA number
- Shipping address
- Shipping instructions (shipping costs greater than UPS ground are charged to the customer)

STEP 4: Address the box to:

RA Department # {the RA number you received here}
Data Flow Systems, Inc.
605 N John Rodes Blvd.
Melbourne, FL 32934-9105

STEP 5: Ship the box to DFS using any typical shipping carrier (for example, UPS, FedEx, etc.). If circumstances permit, have a DFS employee hand carry the package to the headquarters for you. NOTE: DFS employees are not permitted to hand carry unpacked modules.

Modules are typically repaired and shipped back to the customer within a 2-week period starting at the time the module reaches the RA Department. If additional information is required during the repair of the module(s), the DFS service department will contact you.

To get information on the progress of any of your equipment in for repair, contact the DFS - RA Department at rma@dataflowsys.com or 321-259-5009.

Replacement of equipment may be necessary in the event that the equipment and/or parts are unrepairable. Warranty equipment will be replaced with out prior notification as warranty replacement. The customer will be notified by phone, if equipment not under warranty cannot be repaired, with information of available options.

DFS reserve the right to return any material received without an RA# or not conforming to the requirements of this RA process.

NOTICE

The intended purpose of the TCU is telemetry control. Using the TCU for purposes other than telemetry control is not recommended and will void the warranty.

WARRANTY

DFS products carry a one (1) year warranty against defects in material and workmanship. All Plug-in Function Modules, Telemetry Control Units, Power Supply Modules and Radio Interface Modules carry an extended two (2) year return-to- factory warranty. Products that carry an extended warranty are covered against damage due to lightning and surge for the entire three-year period when installed per factory-approved requirements.

QUESTIONS OR COMMENTS ON THIS MANUAL

If you find a problem with any of the information in this manual or have suggestions on how it could be improved, please contact us at the address below:

Data Flow Systems, Inc.
Documentation Department
605 N. John Rodes Blvd.
Melbourne, FL 32934

Alternatively, e-mail us at:

documentation@dataflowsys.com

Notes

alternation. To pass the turning on of pumps from one pump to another in succession.

bias voltage. Voltage used to bias (or hold) an input in the ON state. Absence of the voltage forces the input in the OFF state.

configure. Choosing from a menu the operating conditions of the station controlled by the PCU.

external. Equipment outside the PCU and not supplied with the PCU.

Failure mode. Failure conditions displayed in the Alarm display mode of the TAC Pack TCU's LCD.

flow volume. Well or tank volume between the Off level and the Lead level set in the system.

Ground. Zero-voltage reference point of a circuit. May be connected to earth ground or used as a common connection point.

input. Inputs to the PCU consist of 3 phase monitor inputs, 6 telemetry inputs, and 12 digital monitor inputs.

input common. Point where multiple leads are terminated

LCD. Liquid-crystal display used to display messages

LED. Light-emitting diode used to indicate an on/off condition

line. Input side of switch or relay contacts

load. Output side of switch or relay contacts

neutral. Zero reference point of an AC voltage

output. Digital monitor output of the PCU

override. Set aside and replace by another

pump mode. Selected method of pumping for either a well (pump down) or storage tank (pump up)

return. AC neutral or ISO.

set points. Those points selected in a station using an analog transducer. Pseudo levels corresponding to the desired levels are selected for the analog input voltage (0-5 V) or current (4-20 mA) from the transducer. After calibrating the minimum and maximum points of the station, the points (equivalent in feet) for starting or stopping pumps and for turning on alarms are selected.

source. External voltage, AC or dc.

staging levels. Levels in a well or tank at which an action (pump start or stop, or alarm activation) occurs.

telemetry. Radio system used to monitor and control a remote unit or units.

Total Flow Volume. The Total Flow Volume is calculated as an average based on the total time it takes the liquid level to move from the Off level to the Lead level.

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