PRESSURE SYSTEMS

9000 Series
Intelligent Pressure Scanners
Users Manual

(Models 9010, 9015, 9016, 9020, 9021)

!

4th Edition
March 1998

!

Pressure Systems, Inc.
34 Research Drive
Hampton, Virginia 23666
(757) 865-1243
FAX (757) 766-2644
E-Mail: sales@psih.com
Web: www.psih.com

REV	REVISION HISTORY	PRINT DATE
1	Original - 2nd Edition	4/94
2	3rd Edition (add Model 902x and 9016)	11/97
3	4th Edition	3/98

PREFACE

This manual describes all the System 9000 Intelligent Pressure Scanner modules (models 9010, 9015, 9016, 9020 and 9021). It is divided into seven (7) chapters and several (7) appendixes, each covering a specific topic. These are summarized below:

Chapter 1: General Information:	describes the Models 901x and 902x Intelligent Pressure Scanners, their specifications, and their various options.
Chapter 2: Installation and Set Up:	describes the unpacking and inspection of a module, and its connection to power, pressure, and a communications network.
Chapter 3: Programming & Operation:	provides the information needed to program a module from a host computer, and to get meaningful data from it.
Chapter 4: Calibration:	describes methods of calibrating a module.
Chapter 5: Service:	describes general safety precautions and maintenance procedures.
Chapter 6: Trouble Shooting:	describes module troubleshooting techniques.

Appendix A:	**All Commands — Quick Reference**
Appendix B:	**Response Error Codes**
Appendix C:	**ASCII to Decimal/Hexadecimal Conversion Chart**
Appendix D:	**Binary Bit Map**
Appendix E:	**Cable Diagrams**
Appendix F:	**System 9000 Products**
Appendix G:	**Programming Example - BASIC**
Appendix H:	**Module Mounting Dimensions**
Appendix I:	**9000 Range Codes**

Other System 9000 modules (e.g., models 903x) are documented in their own separate user's manuals. See APPENDIX F for a list of all System 9000 modules.

DISCLAIMER

WARRANTY

PSI warrants that System 9000 products are free from defects in material and workmanship under normal use and service for one year. PSI's liability under this warranty is limited to replacing or repairing any unit the factory deems to be defective in parts or workmanship. The unit(s) must be shipped to the factory at the customer's expense for inspection to determine repairs or replacement. This warranty shall not apply to any unit(s) damaged from misuse, negligence, accidents, incorrect electrical connections, application of excessive signal levels, repairs, or alterations by the user.

FIRMWARE

This manual was prepared for various versions of module firmware, as was released in late 1997. Addenda will be distributed as deemed necessary by PSI. Any questions regarding firmware upgrades may be addressed to the Applications Engineering Department. Firmware revisions, manual addenda, and utility software may also be obtained from the PSI web page at **www.psih.com**.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

APPENDICES

LIST OF FIGURES

TABLE OF CONTENTS (continued)

LIST OF TABLES

Chapter 1

General Information

1.1 Introduction

This manual contains the information needed to install, operate, and program the System 9000 Intelligent Pressure Scanner modules (model series 901x and 902x). Where applicable, each section is labelled as to which models it applies.

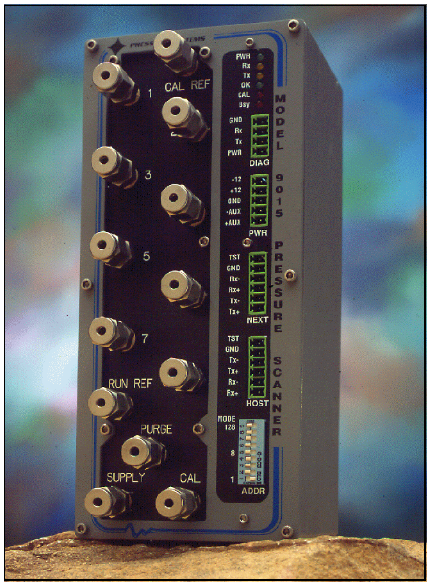
Models 9010, 9015, and 9016 are pneumatic intelligent pressure scanners — each with integral pressure transducers and a pneumatic calibration manifold. They differ primarily in the number of pressure transducers (8 or 16 of the DH200 type), type of pressure fittings, accuarcy, measurement speed, and type of host communications interface.

Models 9020 and 9021 are all-media intelligent pressure scanners which may be fitted with up to twelve (12) external all-media (9400, 9401, 9402 or third party) transducers. Because of the external nature of these transducers, and the variety of pneumatic or hydraulic media supported, the 9020 and 9021 do not contain an integral calibration manifold.

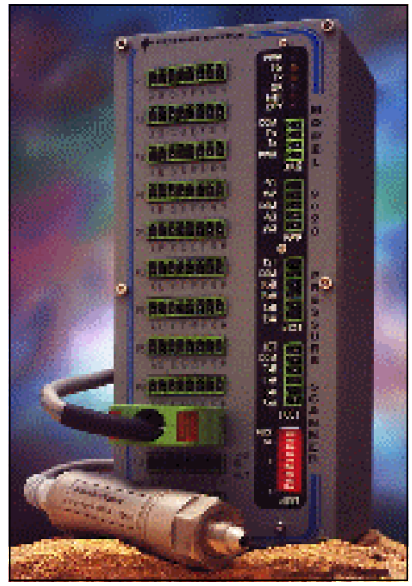
All models provide engineering unit pressure data with guaranteed system accuracy. This is achieved by reading factory-determined *pressure* and *temperature* engineering-unit data conversion coefficients from their transducers' nonvolatile memories at power-up. They also allow additional adjustment coefficients to be "fine-tuned" with a 1- or 2-point (zero and span) calibration under host control (e.g., possibly utilizing optional Pressure Systems 903x Pressure Calibrator modules).

All models may be interconnected into a network via their Host Port — normally using multidrop RS422/485 asynchronous serial communications (with Optomux protocol). The models 9016 and 9021 provide 10-Base-T Ethernet communications for their Host Port (with TCP/IP protocol and Optomux type command format).

All models have a separate RS-232 Diagnostic Port which may be used for diagnostic checks of the module or as an interface to upgrade module firmware.



Model 9015



Model 9020

Model 9016

Figure 1.1: System 9000 Pneumatic Intelligent Pressure Scanners

1.2 Specifications

Specifications for the various Intelligent Pressure Scanner models are listed in the following tables.

Table 1.1: Specifications

Parameter	9010	9015	9016	902x			Units	Comments
PRESSURE CHARACTERISTICS								
Number of Pressure Inputs	16	8	16	12				Mixed ranges allowed
Pressure Ranges[1]	10 " H_2O (2.5 kPa) 20 " H_2O (5.0 kPa)			9400 Gauge	9401 Absolute	9402 Diff		9400 Gauge ranges > 750 psi (5200 kPa) are sealed gauge.
	1 (7) 2.5 (17) 5 (35) 10 (70) 15 (105) 30 (210) 45 (310) 100 (700) 250 (1720) 500 (3450) 600 (4100) 750 (5200)			5 (35) 10 (70) 15 (105) 50 (350) 100 (700) 250 (1725) 500 (3500) 750 (5200) 1500 (10400) 3000 (20800) 5000 (35000) 10000(69000)	- 15 (105) 30 (210) 50 (350) 100 (700) 250 (1725) 500 (3500) 750 (5200) 1500 (10400) 3000 (20800) 5000 (35000) 10000(69000)	5 (35) 10 (70) 15 (105) 50 (350) 100 (700) 250 (1725)	psi (kPa)	940x Ranges > 750 psi have passive compensation only
Media	Dry, non-corrosive gas			compatible w/316 SS & Viton				other materials available
Proof Pressure[2]	3.0X @ < 15 psi 2.0X @ 15-100 psi 1.5X @ > 100 psi			- 3.0X @ ≤ 100 psi 1.5X @ >100 psi			F.S. min	see ranges above for kPa equivalent.
Burst Pressure	5.0X @ <15 psi 3.0X @ 15-100 psi 2.0X @ > 100 psi			5.0X @ <750 psi 3.0X @ 750-3000 psi 2.0X @ >3000 psi			F.S. min	see ranges above for kPa equivalent.
Max Reference Pressure	100 (700) 250 (1725)			n.a. -			psi (kPa) psi (kPa)	Ranges ≤5 psi (35 kPa) Ranges >5 psi (35 kPa)
Manifold Control Pressure	80 (560) 125 (860)			n.a. -			psi (kPa)	Min Max
Purge Pressure	> max input pressure 800 (5600)			n.a. -			psi (kPa)	Min (Use of purge Max is optional)
STATIC ACCURACY, RESOLUTION, & THERMAL STABILITY								
Measurement Resolution	±0.003						% F.S.	
Static Accuracy[3] 901x After Rezero Cal	±0.15 ±0.08		±0.15 ±0.05	- -			% F.S. % F.S.	Range ≤ 2.5 psi (20 kPa) Range > 2.5 psi (20 kPa)
901x After Span Cal	±0.10 ±0.05		N/A N/A	- -				Range ≤ 2.5 psi (20 kPa) Range > 2.5 psi (20 kPa)
902x with digital comp				±0.10			% FS	940x Range ≤ 750 psi
902x with no digital comp				±0.50			% FS	940x Range > 750 psi
Total Thermal Error[4]	±0.0015 ±0.001			 ±0.005 ±0.05			% FS/ºC % FS/ºC % FS/ºC % FS/ºC	Range ≤ 2.5 psi (20 kPa) Range > 2.5 psi (20 kPa) 940x with digital comp 940x with analog comp
Line Pressure Effect	±0.001 ±0.0008 ±0.0003			n.a. - -			% FS/psi % FS/psi % FS/psi	Range ≤ 5 psi (35 kPa) Range > 5 psi (35 kPa) & Range < 100 psi (700kPa) Range≥ 100 psi (700 kPa)

Parameter	9010	9015	9016	902x	Units	Comments
Voltage Measurement[5]	--			±0.025 ±0.025 ±0.05 ±0.05	%F.S. %F.S. %F.S. %F.S.	-4500 to 4500 mV -250 to 250 mV -100 to 100 mV -50 to 50 mV

Notes (Table 1.1 above):

1. Standard ranges listed, consult factory for special ranges
2. Maximum applied pressure without reducing sensor performance within operating pressure range.
3. Static accuracy includes combined errors due to non-linearity, hysteresis and non-repeatability per ISA S51.1.
4. Includes thermal effects of zero & span relative to 25ºC.
5. For 902x scanned channels used in voltage measurement mode.

Table 1.2: More Specifications

Parameter	9010	9015	9016	9020	9021	Units	Comments
DATA SCAN & TRANSFER RATES							
Measurement Scan Rate via RS422/485 Host Port via Ethernet Host Port	 20 -	 30 -	 - 100	 20 -	 - 20	 meas/ch/sec meas/ch/sec	 9010, 9015, 9020 Ethernet avail.on 9016 and 9021
Host Port Baud Rate RS422/485 (Optomux)	1200 to 38400		-	1200 to 38400	-	Baud	9010, 9015, 9020 only
Ethernet (TCP/IP)	-		10	-	10	Mbits/sec.	9016, 9021 only
Diagnostic Port Baud Rate	9600		9600	9600	9600	Baud	
POWER/SIGNAL REQUIREMENTS							
V1	−15 ±1 [a]		18 to 36 [b]	−15 ±1	18 to 36 [b]	VDC	
V2	15 ±1 [a]		-	15 ±1		VDC	9010, 9015, 9020 only
I1	50		200 270	50	200	mA mA	w/out internal purge solenoids on w/ internal purge solenoids on
I2	400		-	200	--	mA	
Hardware Trigger Threshold	-		2.5	-	2.5	VDC	TTL compatible diff.input, ±5 VDC common mode (9016, 9021 only)
ENVIRONMENTAL/PHYSICAL							
Calibrated Temp Range [c]	0 to 50		0 to 50	0 to 50		ºC	Consult factory for extended temps
Operating Temp Range	−20 to 60		-20 to 70	0 to 70 -30 to 100		ºC ºC	<95% non-condensing humidity 940x transducers only
Storage Temp	−20 to 80		-20 to 80	-20 to 80		ºC	
Size	9.5 x 3.5 x 4.0 (24 x 9 x 10)		9.5 x 3.5 x 3.5 (24 x 9 x 9)			inches (cm)	L x W x H
Weight	4.25 (1.9) -	4.25 (1.9) 5.00 (2.25)	-- -- 6.5 (2.95)	-- -- 2.0 (0.9)		lb (kg) lb (kg) lb (kg)	901x w. Bulge tubing plate 9015 w/ c " NPT tubing plate 9016, 9020

Notes (Table 1..2):

a For 901x units manufactured prior to Serial Number 200:

-V1	=	-12 ± .6 VDC
+V2	=	+12 ± .6 VDC
±V3		Do Not Connect - internally connected to +5V.

b Unregulated Supply.

c Consult factory for special temperature range calibrations.

1.3 Description of Instruments

The System 9000 Intelligent Pressure Scanner modules are flexible pressure measuring devices intended for use in test and production environments. Models are available with 8 (model 9015), 12 (model 9020/9021), or 16 (model 9010/9016) channels, each with individual pneumatic or all-media transducers per channel. The most distinctive features are highlighted below:

- Precalibrated Transducer - A memory chip containing full calibration data is embedded within each internal transducer.
- Individual transducer per measurement input channel - Mixed transducer ranges may be installed in a single module.
- Low Cost per Point - module per-channel cost is less than a typical industrial pressure transducer/transmitter.
- High Accuracy - Model 901x pressure scanners are capable of accuracies up to ±0.05% — following single-point span calibration. Accuracy up to ±0.08% F.S. is maintained for twelve months after calibration — through use of built-in rezero capabilities. Model 902x pressure scanners are capable of accuracies of up to ±0.10% F.S. — following appropriate zero and span calibration.
- Low Thermal Errors - Each transducer of a pressure scanner module contains an individual temperature sensor and thermal calibration data for internal use by software correction algorithms. Thermal errors are reduced to ±0.001%/ºC over the calibrated temperature span.
- Rezero Upon Demand (models 901x) - An integrated calibration valve allows for automatic rezero adjustment calibration of dry gas transducers to null offset drift errors.
- Ease of Transducer Replacement - Factory calibrated transducer assemblies may be stocked and rapidly replaced in the field. Storage of thermal coefficients within the transducer allows for '**plug and play**' transducer replacement.
- Ease of Calibration - Each 901x module contains a pneumatic calibration manifold and software commands to automatically perform rezero and span adjustment calibrations. New offset and gain coefficients that result from the most recent calibration may be stored in nonvolatile transducer memory.
- Measurement Flexibility - Each 902x module is capable of measuring general purpose voltage signals on any channel not populated with a 9400 type transducer. Full-scale ranges of ±50, ±100, ±250 and ±4500 mV are supported through programmable gain amplifier circuitry.
- Ease of Use - Modules have simple command sets and provide engineering units output. They may interface directly to a desktop or laptop computer or they may be interconnected into a large network controlled by any type of host computer.
- Connectivity - Use of industry-standard communications network protocols to control and read data from System 9000 modules allows distribution to the point of measurement and ensures compatibility with third party hardware and software.

1.4 Options

1.4.1 Pressure Ranges

Models 9010 and 9016 contain sixteen (16) DH200 transducers, while model 9015 contains eight (8). These DH200 transducers are available with full scale pressure ranges from 10" H_2O (inches of water column) to 750 psid (2.5 kPa to 5200 kPa). Transducers with different pressure ranges may be combined in a single module.

The models 9020 and 9021 can attach up to twelve (12) series 940x or third party external all-media transducers. The 9400 gauge-type transducers are available with full-scale pressure ranges from 5 psi to 10,000 psi (35 kPa to 69000 kPa). The 9401 absolute-type transducers are available with full-scale pressure ranges from 15 psi to 10,000 psi (105 kPa to 69000 kPa). The 9402 wet-wet differential type transducers are available with full scale ranges from 5 psi to 250 psi (35 kPa to 1725 kPa). Transducers with different pressure ranges may be attached to a single module.

All standard pressure ranges of each transducer type are listed in Table 1.1. Please consult the Sales Department at Pressure Systems for availability of other pressure ranges.

1.4.2 Manifolds and Pressure Connections

The model 9010 sixteen-channel Intelligent Pressure Scanner is offered with true differential (reference per channel) or common reference pneumatic manifolds. It is available with .063" (1.60 mm) bulge tubulation only, which can be seen in Figure 1.1. It is supplied with a standard purge and leak check calibration manifold.

The model 9015 eight-channel Intelligent Pressure Scanner is also available with a true differential or common reference pneumatic manifold. It is available with .063" bulge tubulation or optional c "compression fittings (common reference only). The latter type of pneumatic connections can be see in Figure 1.1. It is also supplied with a standard purge and leak check calibration manifold.

The model 9016 sixteen-channel Intelligent Pressure Scanner is also available with a true differential or common reference pneumatic manifold, and has a standard purge and leak check manifold. It is available with standard c " or optional 1/16" and 1/4" compression fittings. All fittings utilize an SAE 5/16 - 24 o-ring boss which supports a variety of other adapter compression fittings. It is also available with a quick disconnect plate which contains 0.063" bulge tubulation. The common differential version is available with all choices of fittings. The true differential version is available with 0.063" bulged tubulaton fittings only.

The model 9020 and 9021 12-channel Intelligent Pressure Scanners have no internal manifold or pressure transducers. Instead, it allows external connection of up to twelve (12) type 9400, 9401, or 9402 all-media pressure transducers. 9400, 9401, and 9402 transducers may be purchased with a variety of standard pressure fittings. Any necessary valves and manifolds must be customer-supplied if automatic calibration with the appropriate medium is desired at the module installation site.

Consult the Sales Department at Pressure Systems for availability of other input fittings.

1.4.3 Communication Interfaces

All standard System 9000 Intelligent Pressure Scanners provide digitally temperature compensated and linearized pressure data in engineering units through a serial communications interface to a host computer.

The models 9016 and 9021 have a 10-Base-T Ethernet host communications interface using industry standard TCP/IP protocol. This interface provides high data transfer rates and system connectivity.

The models 9010, 9015, and 9020 have an asynchronous RS-422/485 host communications interface. These models also include a standard RS-232 diagnostic interface that may also be used as a host interface.

The Optomux style command set is used to send commands and receive responses from all ports. This includes the Ethernet Host Port of the model 9016 and 9021, as well as the standard Diagnostic Port of the model 9010, 9015, and 9020.

Chapter 2

Installation and Set Up

2.1 Unpacking and Inspection

The System 9000 product family has many components which may be purchased either as an entire system, or as individual pieces of equipment. Before assembling the system, use the shipping bill as a reference to ensure that all parts have arrived. Pressure Systems takes no responsibility for equipment that is damaged during shipment. If containers are broken, ripped, or damaged, contact the transportation carrier. If the equipment appears to be damaged, contact the Repair Department at Pressure Systems.

Each System 9000 Intelligent Pressure Scanner shipment will contain the following minimum components:

- Model 901x or 902x Intelligent Pressure Scanner module
- Diagnostic Port Cable (Models 9010, 9015, and 9020 only, one per order)
- PC-221 Diagnostic Loopback Connector (Models 9010, 9015, 9020 only, one per order)
- Start-up Software Diskette
- System 9000 User's Manual for Intelligent Pressure Scanners (Models 901x/902x)

2.2 Safety Considerations

Always wear safety glasses when operating this equipment or when working with pressurized lines. Always ensure that high pressure lines are properly secured.

All system power should be off during installation or removal of any components from a System 9000 module. Failure to turn power off prior to installation may cause permanent damage to the module. Use caution and check line voltages before applying power to the module.

2.3 Preparation for Use

2.3.1 Environment

All Models

All standard Intelligent Pressure Scanners are factory calibrated to be accurate over a specified temperature range, but may be operated or stored over a wider temperature range (see Environmental/Physical Specifications in Table 1.2 in Chapter 1) . Operating or storing an instrument outside its specified range(s) will result in a loss of measurement accuracy and may cause permanent damage to the instrument electronics.

WARNING: Exceeding the specified storage or operating temperatures may result in permanent damage to the System 9000 electronics.

2.3.2 Power

All Models

The model 9016 and 9021 Intelligent Pressure Scanners need only a single unregulated power supply. All other models (9010, 9015, and 9020) require dual regulated input voltages.[1] See Table 1.2 in Chapter 1 for actual power requirements by model number.

Figure 2.1 shows pin assignments for the module's top-panel power connector. This is labeled "PWR" for models 9010, 9015, and 9020. Model 9016 and 9021 have a single military-style circular connector through which all power and input/output signals pass as shown in Figure 2.2.

WARNING: Improper connection of power to the Intelligent Pressure Scanner can result in permanent damage to module electronics.

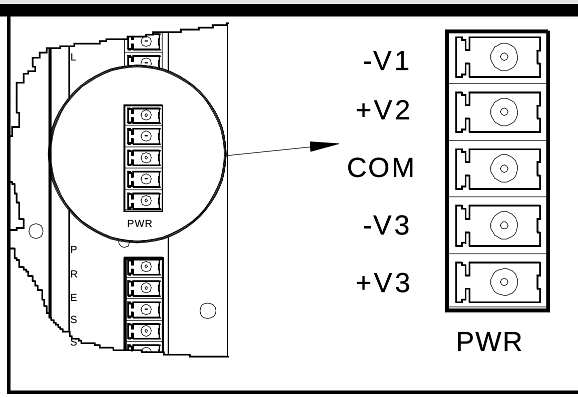


Figure 2.1:
9010,9015,9020 Power Pin Assignments

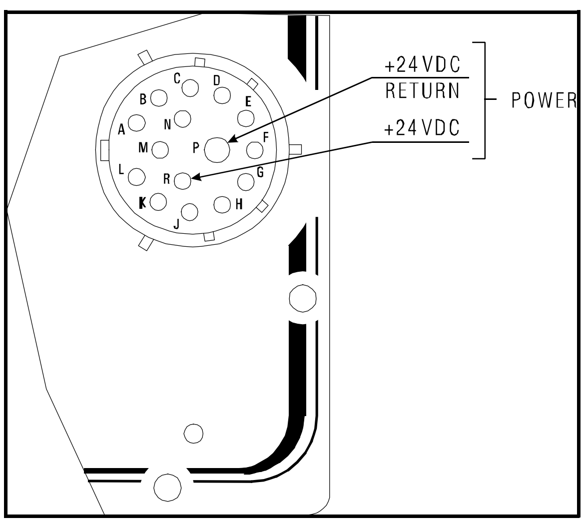


Figure 2.2:
9016,9021 Power Pin Assignments

[1] This power can be supplied by the optional System 9000 Power Supply Module (model 9090). Models 9010 and 9015, with serial numbers prior to 0200, should be operated with input voltages of ±12 VDC ±0.5%.

2.3.3 Mounting and Module Dimensions

All Models

Panel mounting dimensions for models 9010 and 9015 are shown in Figure 2.3. Other models have similar dimensions (see Table 1.2 in Chapter 1 for exact dimensions by model number). Detailed mechanical drawings for each module are also included in Appendix H.

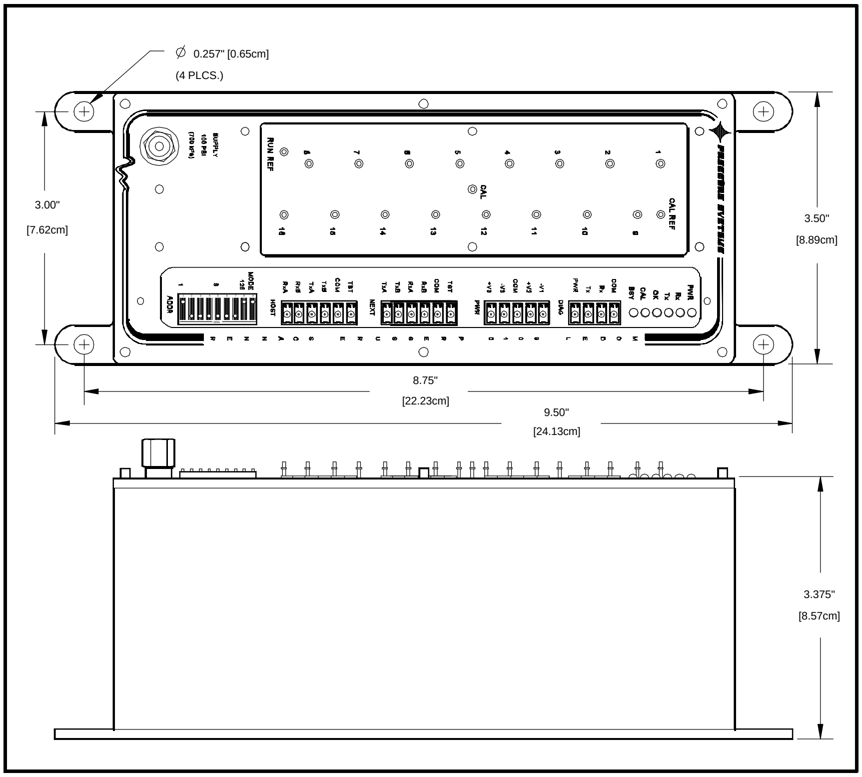


Figure 2.3: Mounting Dimensions

2.3.4 Network Communications Hookup

All Models

Every System 9000 Intelligent Pressure Scanner contains a Host Port, allowing it to be interconnected in a network with other modules and a host computer. Models 9010, 9015 and 9020 have an asynchronous serial (RS422/485) Host Port using a multi-drop Optomux protocol. The model 9016 and 9021 have an Ethernet Host Port using TCP/IP transmission protocol (but retaining basic “core” Optomux command/response formats). **If you have the model 9016 or 9021, proceed directly to Section 2.3.4.2, the following subsections pertain to the 9010, 9015, and 9020 Host Port.**

2.3.4.1 Multidrop Serial (RS-422/485) Host Port Hookup

9010, 9015, 9020 only

Model 9010, 9015, and 9020 modules, along with other modules such as the 903x and 9040, may be interconnected in a network with any host computer via their Host Port’s RS-422/485 asynchronous communications interface. A module’s two 6-pin pluggable terminal connectors are used for multidrop communications interface wiring and are labeled "HOST" and "NEXT" on each module. The HOST connector connects a module to the host computer — or to the previous module's NEXT connector in multiple module configurations. The NEXT connector is used to extend the multidrop communications signals to the next instrument in the network. The last module in the network requires no connections to the NEXT connector (but may require special internal terminations described below).

Host computers with only an RS-232 interface (such as the COM port of a PC) may use an external RS-232 to RS-422 converter such as the PSI model 9091 to interface to System 9000 modules. Several other sources of external or internal RS-422 communications interface products are also available from third party vendors.

2.3.4.1.1 Host Port Connection

9010, 9015, 9020 only

When fabricating a host computer's RS-422/485 communications cable, the host's *transmit* signals (TxA, TxB) should be connected to the (first) module's *receive* signals (RxA, RxB). In order to prevent ground loops, the cable shield drain should be attached to ground *at only one end of the cable*. Refer to cable diagrams in Appendix E for assistance when fabricating these communications cables if a standard cable (model 9093) is not purchased from PSI.

2.3.4.1.2 Multiple Module Connections

9010, 9015, 9020 only

Multiple modules may be attached to the communications network in a daisy-chain manner by repeating the wiring methods used to connect the host computer to the first System 9000 module. The connector labeled NEXT on the first module should be wired to the HOST connector on the second module. When attaching multiple modules, always wire signals coming from the module closer to the host computer into the HOST connector. Signals going to modules further away from the host computer should be wired out of the NEXT connector.

When fabricating module-to-module communications cables, the *transmit* signals on the first module (TxA, TxB) should be wired to the *transmit* signals on the second module (TxA, TxB). Likewise, the *receive* signals on the first module (RxA, RxB) should be wired to the *receive* signals on the second module (RxA, RxB). In order to prevent ground loops, the cable shield drain should be attached to ground *at only one point*. Refer to cable diagrams in Appendix E for assistance when fabricating communications cables if a standard cable (model 9094) is not purchased from PSI.

When using multiple modules, always ensure each module has a unique node address. Refer to Section 2.3.4.1.5 for details concerning node address selection.

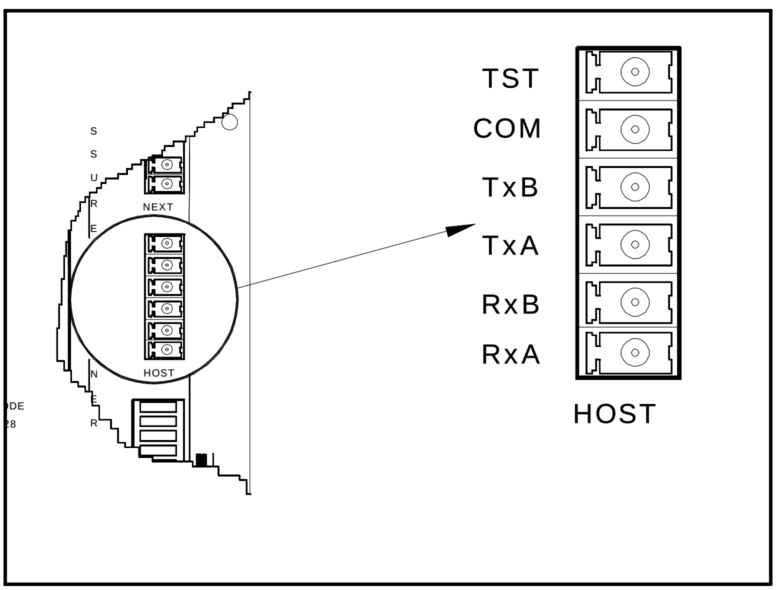


Figure 2.4 RS-422/485 Host Port Connectors

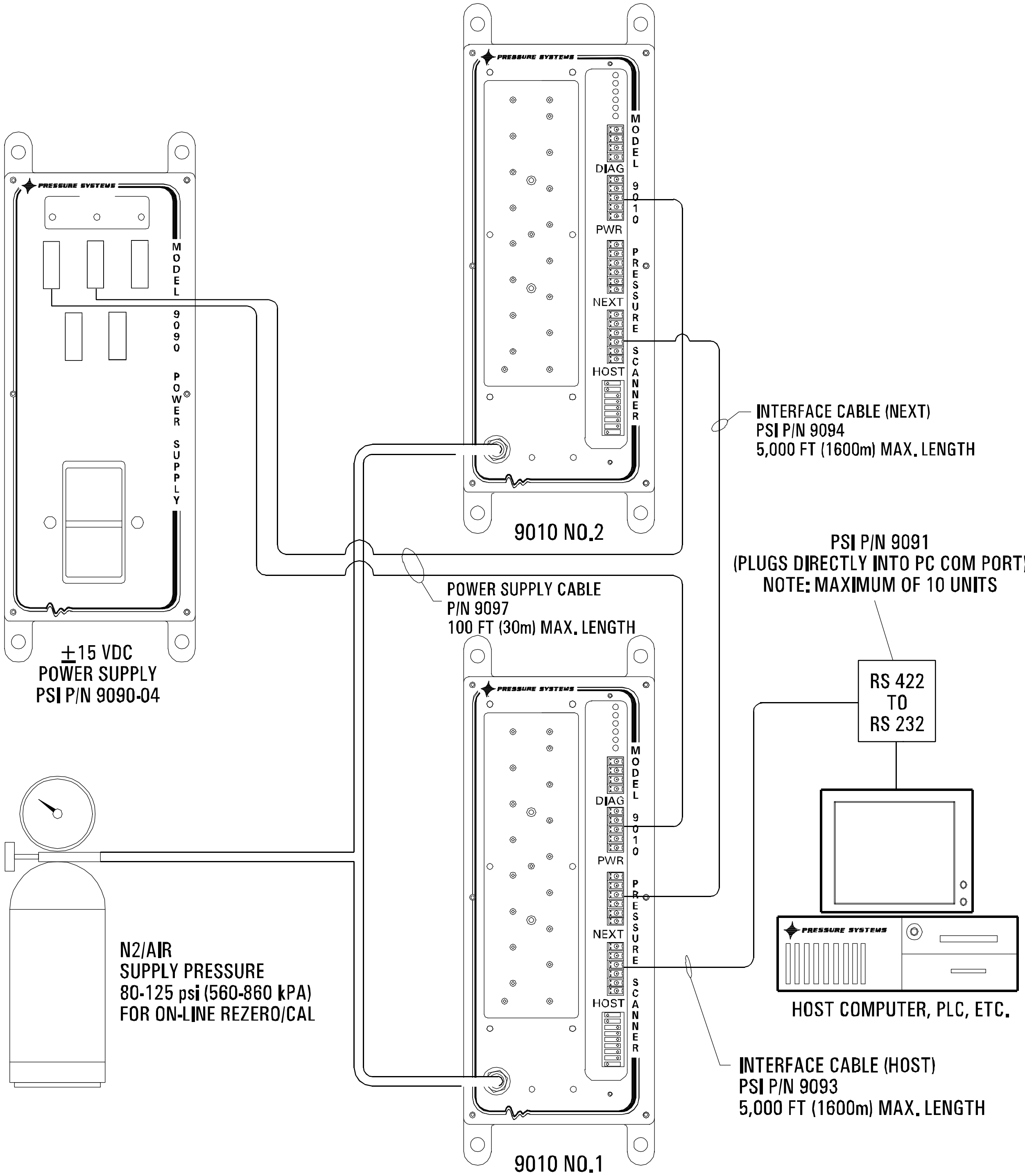


Figure 2.5: RS-422/485 Multidrop Network

2.3.4.1.3 Multidrop Cable Lengths

9010, 9015, 9020 only

Each RS-422/485 segment is limited to a predefined maximum number of nodes and a maximum cable length. Repeaters may be used in order to add additional segments to the RS-422/485 communications link. Most RS-422 interface products will allow each segment to be up to 5000 feet in distance and contain up to 32 System 9000 modules.

2.3.4.1.4 Multidrop Cable Termination

9010, 9015, 9020 only

The RS-422/485 specification requires that both ends of the differential transmission line be terminated in order to minimize signal reflections. This is accomplished by installing a 120 ohm termination resistor at both ends of the network for each differential signal pair. This resistor is connected between the signal plus and signal minus (RxA and RxB or TxA and TxB). Proper termination is increasingly important as RS-422 line lengths and baud rates increase. Each module internally contains selectable 120 ohm termination resistors for both the transmit and receive signal pairs. Each module is shipped with these resistors disabled. The last module in the communications network must have these termination resistors enabled to properly terminate the differential transmission lines. Proper termination may be provided by enabling the built-in resistors as described below, or by installing external termination resistors directly to the last module's NEXT connector.

Depending on the type of RS-422/485 hardware used on the host computer, it may also be necessary to use biasing resistors on the network's transmit and receive signal pairs. Biasing resistors are used to ensure that the signal pairs are left in a MARK or IDLE condition when the line transmitter(s) are in a high-impedance state. Without biasing, the floating signal pairs are susceptible to false bit transitions as a result of surrounding EMI. Such false transitions can result in unwanted character echos — as well as receiver framing errors. Each module contains selectable 10K ohm biasing resistors for both the transmit and receive lines, but it is shipped with these resistors disabled. Signal biasing may be provided by enabling the built-in resistors as described below or by or by installing external biasing resistors directly to any module's HOST or NEXT connector.

For modules containing a PC-203 microprocessor circuit board (Revision G and higher), a DIP switch (SW2) located on the back side of the board is used to enabled termination and biasing resistors. The following table provides the appropriate switch settings. Note that switch positions 7 and 8 must always be set as indicated. If you have a module containing a PC-203 board with a revision earlier than G, contact the PSI Applications Department for proper cable termination techniques.

Position	Description	Default Setting
1	RS-422 Tx Termination	OFF (disabled)
2	RS-422 Tx+ 10K Bias	OFF (disabled)
3	RS-422 Tx- 10K Bias	OFF (disabled)
4	RS-422 Rx Termination	OFF (disabled)
5	RS-422 Rx+ 10K Bias	OFF (disabled)
6	RS-422 Rx- 10K Bias	OFF (disabled)
7	Reserved	OFF
8	Reserved	ON

Note that placing switches in the ON position will enable the associated biasing or termination resistor. Refer to section 5.1.2 for instructions to access the PC-203 electronics.

2.3.4.1.5 Multidrop Node Address Selection

9010, 9015, 9020 only

Each module on a multidrop RS-422/485 communications network must have a unique node address. Each module's node address is selected by setting DIP switch positions 1 through 8 on the module's top panel as shown in Figure 2.6. The DIP switch setting normally represents the *binary integer address* of the module, with switch 1 representing the least significant bit. **When setting a 9000 module node address, switches in the ON position represent a binary zero, while OFF switches represent a binary one.**

> **IMPORTANT: When setting the address switches, always ensure switch 9 is in the ON position. The node address switch is read only during module power-up initialization of the firmware, thus changing the module address switch will have no affect until the module has been turned off and then on again.**

9010, 9015, 9020 only

2.3.4.1.6 Selecting Baud Rate and Data Averaging

System 9000 instruments may be configured to communicate on the multidrop network at selected baud rates using the Optomux protocol. Each module's multidrop RS-422/485 communications interface always operates with no parity, 8 data bits, and 1 stop bit. Its baud rate is initially set to 9600 at the factory, but may be set to other values with the procedure described below. See Table 1.2 in Chapter 1 for the range of possible baud rates by model number.

Changes to baud rate are made, using a special procedure, via the same DIP switch used to select the node address during initialization at power-up. During this special baud rate selection procedure, the *number of averages* used during data acquisition is also selected. This second value is the number of consecutive samples taken of each input channel before moving to the next channel. The factory default is 32 data averages, which results in the specified scan rates shown in each model's specifications (Table 1.2 in Chapter 1). After the *baud rate* and *number of averages* are configured (through the special DIP switch procedure detailed below), their new values are stored in the module's nonvolatile memory and become the module's new default values upon power up. These features, baud rate and number of averages, may also be set with the ***Set Operating Options*** (**'w'**) command at any point during normal module operation.

The configuration process is as follows:

! While module power is OFF, set switch positions 2-7 (per table 2.1 below) to reflect desired operating mode.

! In order to configure new module parameters, set switch 8 to the ON position and switch 9 to the OFF position.

! Turn module power ON. When the module detects these switch 8 & 9 configuration switch settings, the OK LED will blink at a 5 Hz rate to confirm module's acceptance of the new switch 2-7 settings for *baud rate* and *number of averages*.

- **!** Move switch 9 to the ON position. The module confirms by making the OK LED blink at a slower rate of 1 Hz. At this point the new settings are stored in module nonvolatile memory and will subsequently be the module's default power-up settings.

> **Note: The new parameters will not be stored in the module until the confirmation step is executed (switch 9 moved ON).**

- **!** Turn module power OFF and set switches 1-8 to the desired *node address* setting. Ensure switch 9 is in the ON position, so the device will detect the proper node address on each subsequent power-on.

- **!** The instrument is now ready for operation at the new default settings.

Table 2.1: Configuration Switch Definitions

Switch position			A/D Averages	Switch position			Baud Rate
7	**6**	**5**		**4**	**3**	**2**	
0	0	0	1	0	0	0	1200
0	0	1	4	0	0	1	2400
0	1	0	8	0	1	0	4800
0	1	1	16	0	1	1	9600 *
1	0	0	32 *	1	0	0	19.2K
1	0	1	64	1	0	1	38.4K
1	1	0	128	1	1	0	78.4K
1	1	1	256	1	1	1	reserved

0 = switch ON; 1 = switch OFF; * NOTE: factory default

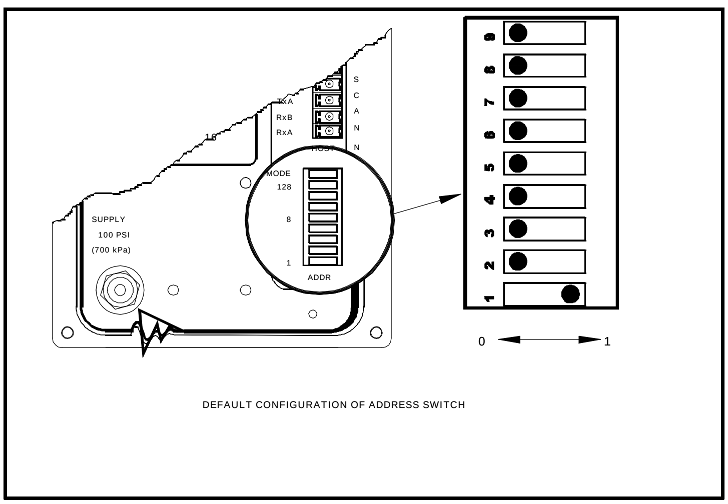


Figure 2.6: Address DIP Switch

9016, 9021 only

2.3.4.2 Ethernet Host Port Hookup

If you have a model 9010, 9015, or 9020 (with serial RS-422/485 Host Port), skip this section and proceed to section 2.3.5. If you have a model 9016 or 9021 (with Ethernet Host Port) continue reading.

The Ethernet Host ports of every model 9016 and 9021 Intelligent Pressure Scanner module, and its host computer, may be interconnected in a “star” network via a standard 10-Base-T interconnection hub. These standard devices will have their own power requirements. Such a hub treats the host computer connection and all System 9000 module connections alike. Ethernet communications pin assignments for the 9016 and 9021 electrical connector are shown in Figure 2.7. See Figure 2.8 for typical network topology.

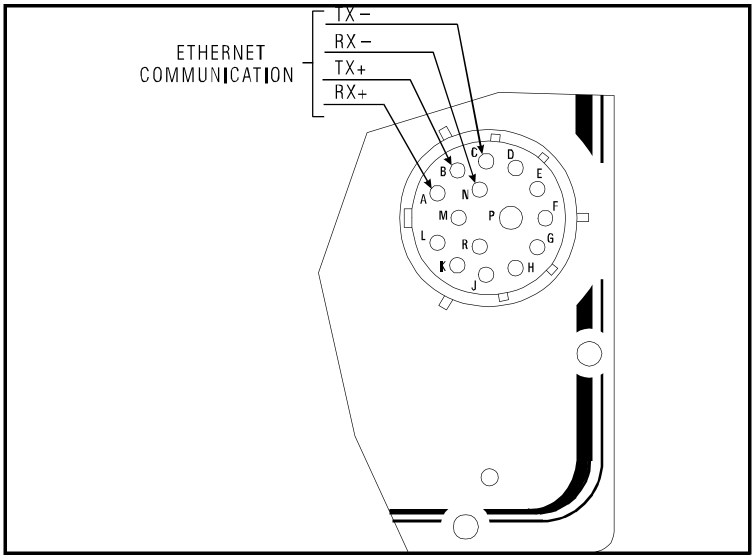


Figure 2.7: Ethernet Host Port Connector Pins

The host and each module must have a unique *Ethernet Hardware or MAC Address* and a unique *IP Address*. The Ethernet Hardware address is generally fixed (at manufacturing time of the Ethernet microprocessor board inside the module). The Ethernet Hardware address is shown on each module’s label. The Ethernet Intelligent Pressure Scanners are capable of supporting various methods for IP address assignment. These are ARP, RARP, and BOOTP. The factory default method is referred to as ARP (Address Resolution Protocol). Unless your application requires the use of the RARP or BOOTP address assignments, it is strongly suggested that the module be left configured for the ARP protocol. This default method is typically the simplest method for using the Intelligent Pressure Scanner.

In the ARP mode, the module will use a factory default IP address on power-up. This default address is set to 200.20x.yyy.zzz where x is derived from the module type (0 for 9016 and 1 for 9021) and yyy.zzz is derived from the module serial number. A similar method is used to calculate each module’s Ethernet hardware address shown on the module tag. Note that each of these fields (separated by a period, '.') is a decimal representation of a byte value. This means that each field may have a maximum value of 255. For 9016 modules with serial less than 255, this default IP address will be 200.200.0.zzz where zzz is the serial number (ie 9016 serial number 212 is IP 200.200.200.212) . For 9016 modules with serial numbers greater than 255, the default IP of 200.200.y.zzz is calculated as follows:

> y is the integer result of dividing the module serial number by 256.
> zzz is the remainder of dividing the serial number by 256 (serial number modulus 256).

These calculations may be verified by checking that y * 256 + zzz equals the original module serial number. Once a module has powered-up and has assigned itself a default IP address it is capable of communications.

An alternate method for assigning an IP address to an Ethernet module is referred to as RARP (Reverse Address Resolution Protocol). This method allows a module to have its IP address dynamically assigned at power-up by an application running on a node of the TCP/IP network. When configured for the RARP protocol, the reset module will broadcast its Ethernet hardware (MAC) address on the network in a RARP Request packet. This broadcast packet identifies the module by its hardware address and requests that a RARP server application return to it an IP address for use. Once this broadcast message is received, the RARP server application will then return an IP address to the module in a RARP Reply packet. Most RARP server applications determine this IP address from a user maintained file that lists Ethernet hardware addresses with their desired IP address. If modules are added to the network or module IP addresses are to be changed, the user can simply edit this configuration file. This capability is common on most UNIX based machines and is also available (although less common) in some TCP/IP packages available for PC platforms.

Support of the RARP protocol is not currently included in the Windows '95 or Windows NT operating systems. In order to allow users of PC platforms to make use of the RARP capabilities of the 9016 and 9021, a simple Windows 95/NT application was developed by Pressure Systems which is capable of acting as a RARP server. This application is referred to as BOOTP Light since it actually makes use of a subset of the BOOTP protocol that closely resembles the RARP Request. Like traditional RARP servers, this application allows the user to configure a file that contains Ethernet hardware addresses and the corresponding IP address to assign to those devices. This application is free of charge and capable of running as a background program on Windows 95 and NT machines.

Use of RARP or ARP may be selected through the ***Set Operating Options*** ('w') command. If you are unsure how your module is configured, check the TX LED during module power-up. If it begins to blink periodically after the module power-up, your instrument is configured for the RARP protocol. If configured for RARP, a RARP server must be configured on the network to return an IP address to the module. Without an IP address, the host will be unable to open a TCP/IP connection to the module.

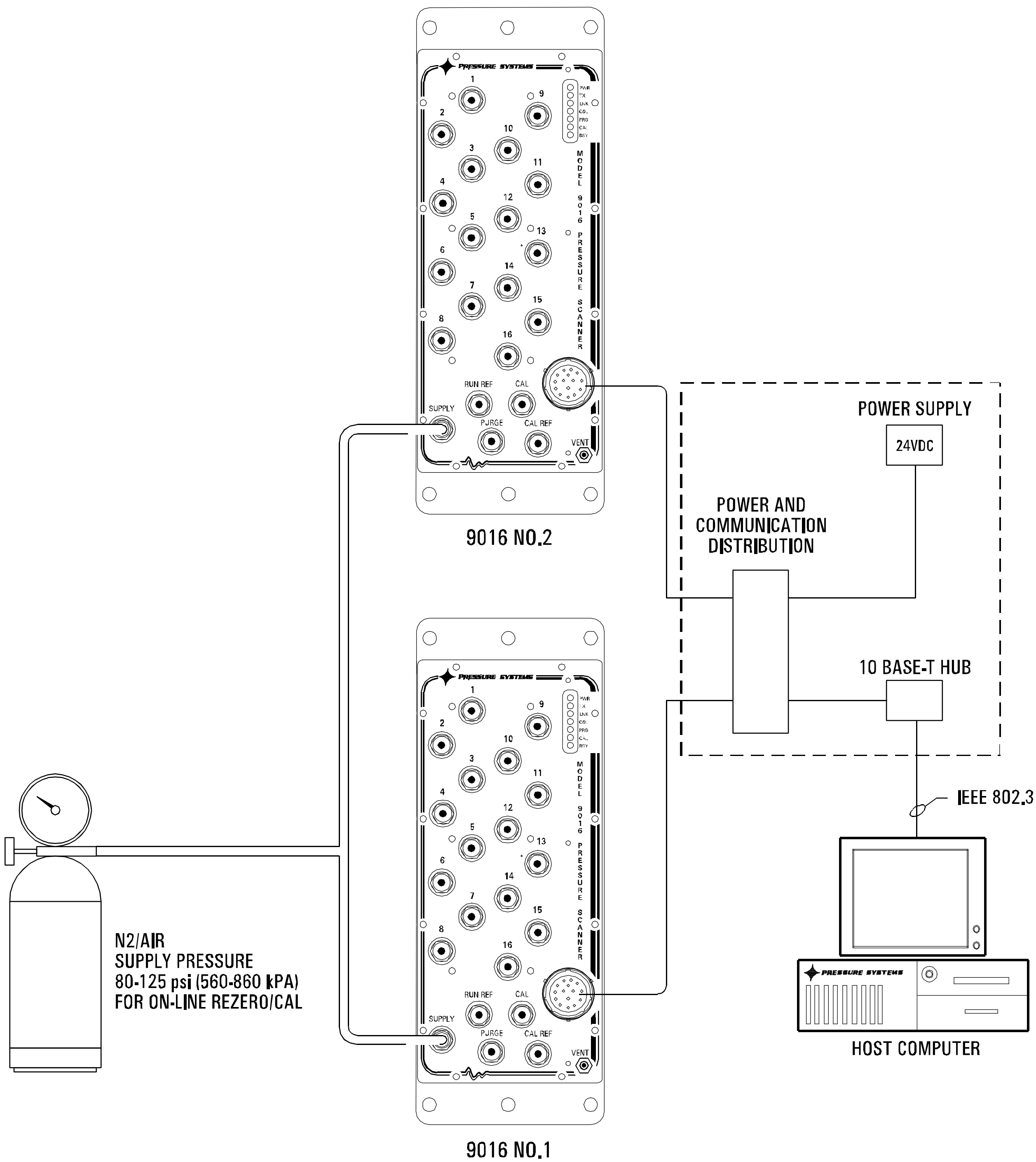


Figure 2.8: Ethernet Network Topology

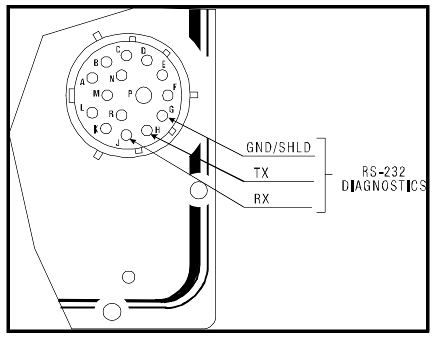
2.3.5 Diagnostic Port Hookup

All Models

Each System 9000 module contains a Diagnostic Port that supports diagnostic and operational functions. The Diagnostic Port has only a simple RS-232 asynchronous serial interface. For models 9010, 9015, and 9020, the Diagnostic Port connections are made to the System 9000 connector labeled "DIAG". For model 9016 and 9021, the Diagnostic Port connections are made via certain pins of its common circular connector. Cable connection should be made according to Table 2.2. Diagnostic port cables for the 9010, 9015, and 9020 may be purchased from Pressure Systems (P/N:9095).

Table 2.2: Diagnostic Port Wiring

Host RS-232 Connector	System 9000 Diagnostic Port Connector
GND	GND
Rx	Tx
Tx	Rx



The RS-232 interface is capable of supporting simple asynchronous communications with fixed parameters of 9600 baud, no parity, 8 data bits, and 1 stop bit. Only communication cable lengths less than 30 feet (10 m) are recommended.

The diagnostic interface supports the full 9010, 9015, and 9020 Optomux protocols. When using only one of these modules, the diagnostic interface may be used in place of the host interface. This simplifies the electrical communications interface to the 9000 module in applications where the limitations of RS-232 versus RS-422 are not an issue (ie. cable length). The 9016 and 9021 use the diagnostic interface for optional configuration and diagnostic purposes only. The diagnostic port functions on the 9016 and 9021 are generally not required by the end user. Standard cables for these modules do not include diagnostic port connections.

2.3.6 Pressure Connections

All Models

All pneumatic connections to models 9010, 9015, and 9016 are found on the instrument top panel. The function of each input port is clearly engraved or printed next to each input. Connections are through bulge tubing, compression fittings or special user-supplied fittings on the tubing plate. All pneumatic inputs to these modules should contain dry, non-corrosive gas only. For the model 9020 and 9021, all pneumatic or hydraulic connections are to the individual 9400, 9401, or 9402 all-media transducers mounted externally from the module itself.

At the time of this manual's writing, all 901x standard Intelligent Pressure Scanners are supplied with the purge/leak check calibration manifold. Through software command to the 901x, this valve may be placed in one of four positions; RUN, CAL, PURGE, or LEAK CHECK. 901x modules without the purge option may be placed in the CAL or RUN modes of operation only. Older modules with self-metering purge are described in a separate applications note (available on request). Pneumatic input requirements for these four operating positions are described in the following sections.

The following guidelines should be used when installing pressure connections to all System 9000 Intelligent Pressure Scanner modules.

- **!** Always wear safety glasses when working with pressurized lines.
- **!** Ensure that user input pressure will not exceed the proof pressure ratings of the corresponding instrument transducer. Applying excessive pressure to measurement inputs can permanently damage the pressure transducers.
- **!** Ensure that all tubing material is rated for the expected pressure and environmental conditions. Failure to use the proper tubing material may result in ruptured lines and possible personal injury.
- **!** Ensure all high pressure lines are properly secured.
- **!** Place retaining springs over all bulge tube fittings to ensure pneumatic lines remain attached and leak free. Springs should be pushed down on connections so that half of the spring length extends past the tube bulge.

Warning: Introduction of contaminants or corrosive materials to the module pneumatic inputs may damage module transducers, manifolds, and O-ring seals.

Users of the 9020 and 9021 may proceed to section 2.3.7 since these modules do not require any pneumatic connections to the module itself.

9010, 9015, 9016 only

2.3.6.1 RUN Mode Inputs

The standard pneumatic tubing plates contain either sixteen (model 9010 and 9016) or eight (model 9015) numbered pneumatic input channels. These numbered inputs are attached to corresponding pressure transducers inside the instrument and should be pneumatically attached to the pressure measurement points under test.

The standard tubing plate also contains an input labeled RUN REF. The RUN REF input is pneumatically connected to the reference side of all internal DH200 pressure transducers. The RUN REF connection is used for situations where all channels have one reference pressure. The reference pressure may be as high as 250 PSI (1720 kPa). See Table 1.1 for detailed specifications. This input may also be left unattached to provide atmospheric reference pressure.

When using instruments with the reference per channel option (true differential), two pneumatic inputs will be provided for every numbered channel. These inputs are labeled 'P' and 'R'. The 'P' connection is the test pressure input. The 'R' connection is the transducer reference input pressure. Since each channel has its own reference pressure input, the RUN REF input is not provided on the true differential tubing plate.

2.3.6.2 CAL Mode Inputs

9010, 9015, 9016 only

The 901x model tubing plates contain inputs labeled CAL and CAL REF. When the module's internal calibration valve is placed in the CAL/REZERO position, all DH200 transducer pressure inputs are pneumatically connected to the CAL input port. All DH200 reference inputs are pneumatically connected to the CAL REF input port. The CAL input may be used to perform on-line zero adjustment of the transducers. The CAL input may also be used for DH200 span adjustment calibrations and accuracy tests if appropriate pressure calibrators (such as the 903x series) are available. Span calibration of multi-range scanners may also utilize the CAL port if the highest applied pressure does not exceed the proof pressure rating of any other installed transducer, otherwise the individual transducers must be calibrated with the valve in the RUN position.

When the internal calibration valve is in the CAL/REZERO position, the RUN inputs (RUN REF and numbered input ports) are pneumatically dead-ended to prevent migration of contaminants into the instrument.

2.3.6.3 Purge Mode Inputs

9010, 9015, 9016 only

All standard 901x models contain a *purge/leak check option*. The purge option allows users to apply positive pressure to the PURGE input which will then be vented out of the user input ports, forcing contaminants (such as moisture) out of the pneumatic input lines. **Note that on common reference 901x scanners, only the numbered input ports will be purged (RUN REF is not purged).** True differential 901x scanners will purge both the run and reference input ports for all channels. The purge supply provided to the 901x must always be a higher pressure than the highest pressure present on the input ports of the module. The purge supply must also be capable of maintaining proper purge pressure at the high flow rates encountered while the module is in the purge mode.

Warning : Failure to provide proper purge supply pressure will result in migration of moisture and contaminants into the 901x module which can result in permanent damage to module components.

When commanded into the PURGE position, the purge input pressure will be connected to the numbered measurement input ports allowing for a flow of air away from the instrument. The purge cycle should be terminated by commanding the 901x into a non-purge mode such as CAL. **Purge cycles should never be terminated by turning off the purge supply air while in the purge position.**

9010, 9015, 9016 only

2.3.6.4 Leak Mode Inputs

The purge/leak check valve design includes a leak check feature capable of testing the integrity of user pneumatic connections as well as those within the 901x module. For the leak mode to be used, all RUN mode pressure inputs must be dead ended (closed) by the user. When the 901x is commanded into the LEAK position, the CAL input port will be pneumatically connected to module run side inputs. Common reference modules will connect only the numbered run side inputs to CAL (RUN REF is not charged). True differential (reference per port) modules will connect both the measurement input and reference port to CAL. While in the LEAK position, a test pressure may be applied through the CAL port which will charge the dead ended run side tubulation.

Test pressures applied to the CAL port during the leak check operation must not exceed the full scale pressure of any internal transducers.

Once the lines are charged, the 901x may be commanded back to the RUN position. This will reattach the charged run side lines to their corresponding internal transducer. Consecutive pressure readings from the 901x will now allow user calculation of the line leak rates. Once returned to the RUN position, lack of a pressure indicates a gross leak. A slowly declining pressure indicates a slight leak. A leak is more difficult to detect as tubing volume increases. In the case of true differential units where both sides of the sensor are pressurized with the leak test pressure, an initial differential pressure of 0.0 psi should be measured when the unit is placed in the RUN position. If the measurement or RUN side of the channel leaks at a rate greater than the reference side, a resulting negative differential pressure will be measured. Likewise, if the reference port tubing leaks at a rate greater than the measurement side, a resulting positive differential pressure will be measured.

9010, 9015, 9016 only

2.3.6.5 Supply Air

The 901x models require a 80 psi minimum air supply which is used to shift the internal calibration valve between its different positions. Each module contains a fitting marked "SUPPLY" for this input. Internal solenoid valves direct this supply pressure to the proper control port on the calibration valve as required by instrument commands. The absence of sufficient supply air to the module will prevent the calibration valve from shifting into requested positions (ie. RUN, CAL, PURGE, LEAK).

WARNING! Supply air should not exceed 125 psi (875 kPa). Excessive pressure may damage the internal solenoids.

9020, 9021 only

2.3.7 9020 and 9021 Transducer Installation

The 9020 and 9021 interface to twelve external transducers or signal sources. Although these modules are intended primarily for use with the Pressure Systems Model 9400, 9401, and 9402 All-Media Transducers, they may also be used with many third party transducers with suitable analog outputs. Transducers should be installed to the 9020 and 9021 as described below.

Warning - Always ensure that 9020 or 9021 power is OFF before connecting or disconnecting external transducers.

Warning - Improper electrical connections between the 9020 or 9021 and external transducers can result in permanent damage to the 902x instrument and the external transducer.

2.3.7.1 Installation of 9400, 9401 and 9402 Transducers

9400, 9401, and 9402 transducer cables are typically ordered from Pressure Systems prewired for use with the 9020 or 9021. If it is necessary to fabricate interface cables to interface the 940x transducer to the 9020 or 9021, the diagrams in Figure 2.9 and 2.10 should be used. Figure 2.9 shows proper cable interface to the 9020 transducer interface connector. This connector is an 8-position pluggable terminal strip. Figure 2.10 shows proper cable wiring to the 9021 transducer connectors. The 9021 makes use of 9-pin D-shell mating connectors. Additional wiring diagrams can be found in Appendix E.

2.3.7.2 Installation of All Other Transducers

If other analog output transducers are used with the 9020 or 9021 they must provide an analog output less than the 902x maximum input range of ±5 VDC. These transducers can be interfaced to the 9020 and 9021 as shown in Figures 2.9 and 2.10. When using external transducers, the 9020 and 9021 modules provide a +15 VDC unregulated supply voltage to power the transducer.

2.3.8 Case Grounding

All Models

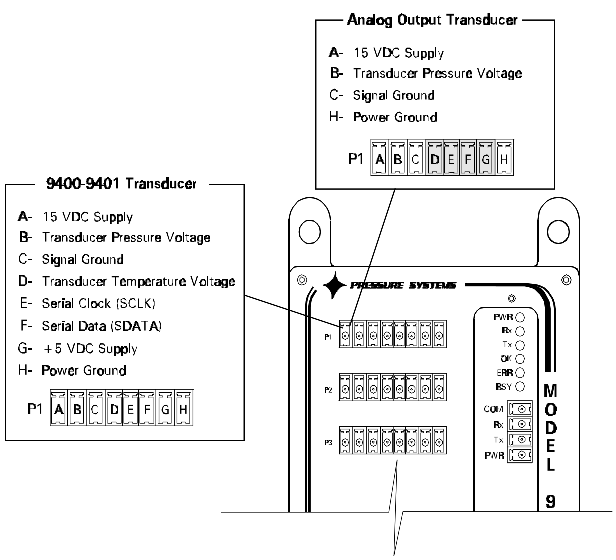


Figure 2.9: 9020 Transducer Wiring

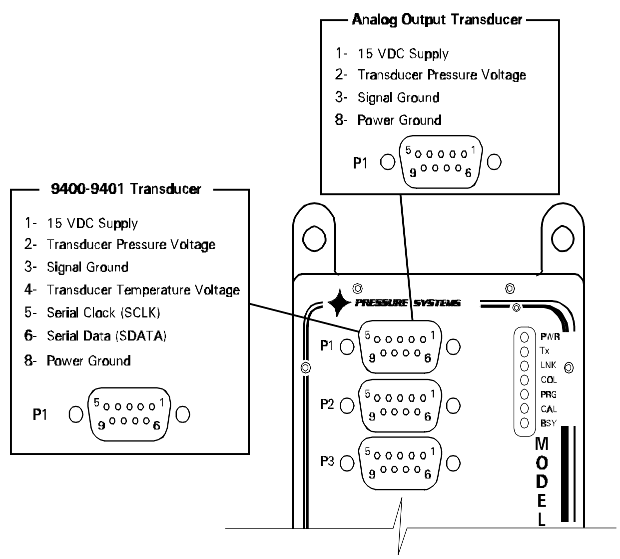


Figure 2.10: 9021 Transducer Wiring

The Model 9010, 9015 and 9020 Intelligent Pressure Scanners are shipped from the factory with the module case connected to power common. Users requirements and environmental conditions will define individual case grounding requirements.

The module case may be made electrically isolated by installing an insulating washer between a mounting screw and a copper trace on the PC-203 circuit board. To do this, first refer to Section 5.1.2 for instructions on accessing the internal electronics. Then, remove the mounting screw nearest the configuration DIP switch, so as to expose the copper trace on the printed circuit board. Next, place the insulating washer over the mounting screw, and reinstall the screw. Spare insulation washers are included in the module.

The 9016 and 9021 contain a case bypass capacitor which allows the module case to be mounted on hardware with a small common mode line voltage (less than 20 Volts).

9016, 9021 only

2.3.9 Trigger Input Signal

The Models 9016 and 9021 each support the use of a data acquisition synchronization, or trigger signal. When configured through the ***Define/Control Host Stream*** **('c')** command, the trigger signal can be used to initiate and synchronize data acquisition and output.

The trigger signal is intended to be a 2-wire differential signal brought in through the 9010 or 9021 main electrical connector. The signal may be driven by a standard TTL compatible device. The switching threshold for this signal is set at 2.5 VDC.

All Models

2.3.10 Power Up Checks and Self-Diagnostics

Upon power up of the module, the internal firmware will perform a number of self-diagnostic checks. The results of these tests are reflected by the 'OK' LED on the top panel and by the *Power-Up Test Status Register* (an internal module register that can be interrogated by a host or diagnostic command). Normal 9010, 9015 and 9020 power up and self diagnostics lasts approximately 20 seconds after which the "OK" LED will be lit indicating the module is ready for host communication. The 9016 and 9021 modules complete the power up and self diagnostics in approximately 10 seconds.

Two major errors will cause the firmware to immediately halt operation, flashing the 'OK' LED to indicate the error condition. These two errors are a *"communications link hardware error"* and an *"A/D hardware error"*.

An A/D timeout condition is a fatal error of the A/D hardware and is indicated by one (1) blink on the 'OK' LED — followed by a five (5) second pause before repeating. This error is frequently the result of incorrect power rails to the module.

The “communications hardware” will only be checked when the PC-221 Diagnostic Loopback connector is connected to the Host Port of a 9010, 9015, or 9020 module during power up. If a failure occurs, the module will blink the 'OK' LED two (2) times — followed by a five (5) second pause before repeating.

If either of these fatal error occurs, contact the Repair Department at Pressure Systems.

Other internal tests are executed during the power-up process. The status of these tests may be determined by reading the *Power-Up Test Status Register* (see the ***Read Module Status*** (**'q'**) command in Chapter 3).

Chapter 3

Programming and Operation

3.1 Commands & Responses

3.1.1 Introduction

This chapter describes all *commands* a host computer program may send to a System 9000 Intelligent Pressure Scanner module— as well as the data or status *responses* returned by the module. Most applications require working knowledge of only a small number of these commands. Most commands apply to all pressure scanner models. However, some apply only to specific models (e.g., model 9016).

The models 9010, 9015, and 9020, which have asynchronous serial (RS-422/485) interfaces, use the Optomux protocol. This protocol has a predefined command and response set, as well as routing and packet error detection fields. The latter control fields are visible to the host computer programmer.

The model 9016 and 9021, which have an Ethernet interface, use the TCP/IP transmission protocol. These models adopt "core" fields of the Optomux command and response formats, deleting unneeded control fields.

3.1.1.1 Optomux Protocol

9010, 9015, 9020 only

The Optomux protocol is an asynchronous ASCII protocol developed by OPTO-22 and is supported by several hardware and software vendors. This asynchronous multidrop protocol was designed to be used on any network using an RS-422 interface — though any similar interface, that allows character strings to be transmitted back and forth, can utilize its command/response formats and methods.

The host computer instructs an Optomux (i.e., System 9000) module to perform tasks and/or return requested data by issuing commands. Each module acts as a slave device to the host computer, with the host computer initiating all communication. Each Optomux module has a unique *Node Address*, used to identify the target for any commands sent by the host. This address allows the host software to communicate with up to 255 different modules.

3.1.1.2 TCP/IP Protocol

9016, 9021 only

The TCP/IP protocol is a well-established set of rules for communicating over a network (LAN, intranet, or internet), and is independent of the network's physical medium. The model 9016 and 9021, having an Ethernet Host Port with 10-base-T physical interface, use TCP/IP protocol for transmission and error detection/correction purposes — while still adopting the basic "core" command and response formats defined for modules using the Optomux protocol.

With TCP/IP protocol, the host computer and interconnected modules are all "peers" that can all communicate equally. Each "peer" must have its own unique "logical" *IP Address* (as well as its own unique "physical" *Ethernet Address*). Any "peer" may initiate transmissions without permission from the receiver. In the System 9000 implementation, the host computer is normally a *client* and generally initiates most transmissions by sending commands to the System 9000 modules, which are normally *servers*. However, a module can initiate its own transmissions in some operating modes (e.g., the *hardware-triggered* or *free-run* autonomous *host streams* generated by the ***Define/Control Host Streams*** (**'c'**) command). A maximum of

255 modules are easily addressed by varying only the low-order byte of a typical IP Address. Many more modules may be addressed by also changing the “network” portion (high-order 3 bytes) of the address.

With TCP/IP, any “peer” may be initially addressed by a *logical name*, that allows its *IP Address* to be looked-up in the sender’s database or in a central network server’s database. Before the host computer and any module can communicate, the host (*client*) must request a *connection* be established with the module (*server*). Each module expects all such requests for *connection* to be requested by its *IP Address*, and directed to “well-known” port 9000. After the connection is made, a *socket* is established as a logical handle to this connection. The host and module may then communicate, via this *socket*, by writing standard Optomux commands and reading standard module responses (core parts only).

3.1.2 Commands

All Models

An Optomux command (used by all models) is a series of ASCII characters. The RS-232 and RS-422/RS-485 links used in the 9010, 9015, and 9020 require that all data be transmitted as printable ASCII characters. When binary data values are transmitted, they are typically converted to ASCII or ASCII-hex representations. Such hexadecimal parameters may include the ASCII number characters '0' through '9' and the *uppercase* ASCII characters 'A' through 'F'. The TCP/IP protocol used on the 9016 and 9021 does allow for the transfer of either printable ASCII characters or binary data.

3.1.2.1 General Command Format

All Models

The standard Optomux command packet has a *prefix* consisting of a *start character* ('>') and a 2-character *hex node address*. This is followed by a *core* consisting of a 1-character *command*, an optional *position field*, and optional (and variable length) *modifier fields*. Finally, it ends with a *suffix* consisting of a 2-character *hex checksum* and a 1-character *delimiter* (always an ASCII carriage return or ‘ **r** ’). The standard command packet has the following format when full Optomux protocol is used:

<---- prefix ---->		<---- core ---->			<---- suffix ---->	
Start Char	Node Address	Cmd Char	Position Field (optional)	Modifier(s) (optional)	Checksum	Delimiter Char
‘>’	FF	‘L’	FFFF	FFFF...	FF	‘ **r** ’

For the model 9016 and 9021 (with Ethernet Host Port), where TCP/IP protocol is used, only the central ***core*** of each Optomux command need be transmitted to the *socket* (a previously opened and dedicated logical connection to the desired module). Thus, the *left* prefix and the *right* suffix are not used — as TCP/IP protocol adds/strips such control and destination information (by means invisible to the host programmer).

Some commands use variations of the standard *position* and *modifier* fields above, which are generally given other field names when they appear. Also, such fields may be specified in other than a hex format. Such formats are clearly marked in each command description.

3.1.2.2 Node Address Field

9010, 9015, 9020 only

The *node address field* is actually the unique 8-bit binary *node address* of the module to receive the command. The node address is expressed as two hexadecimal characters in the Optomux command. The values of this field ranges from 01 hex to FF hex (1-255 decimal). The node address is determined by the setting of the modules top panel DIP switch as described in section 2.3.4.1.5.

All Models

3.1.2.3 Command Field

The Optomux protocol has a predefined standard command set that is recognized by all models of Intelligent Pressure Scanner modules. Various System 9000 modules may implement the *standard* commands that are applicable to that module. In addition, there may be several *non-standard* commands to which most System 9000 modules respond. Most non-standard commands provide either module-specific control or higher measurement resolution. All standard and non-standard commands are functionally summarized in Section 3.1.4 and detailed in an alphabetic reference in Section 3.2.

3.1.2.4 Position Field

All Models

All System 9000 Intelligent Pressure Scanner models may contain up to sixteen (16) separate input/output channels. When commands affect *certain channels* in the module, specific binary bits in an optional *position field* are used to identify those channels. If a channel's corresponding bit in the position field is set to a one (1), then that channel is affected by the command. The least-significant (rightmost) bit corresponds to Channel 1, and the most-significant (leftmost) bit corresponds to Channel 16. Since no module has more than sixteen (16) channels, the *position field* will usually be 16-bits, represented by four (4) ASCII-hex characters in the command. For example, only Channels 16 and 1 are selected below is this 16-bit (4-character) position field:

Chan#	**16**	15	14	13	12	11	10	9	8	7	6	5	4	3	2	**1**
Binary	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hex	8				0				0				1			

The above *position field*, with *all* applicable bits set (i.e., FFFF for 16-channel module), specifies *all channels*. However, a module-independent variation allows a *missing position field* to designate *all channels* — but only when there are no other parameters following the *position field* in the command. For such commands, the hex *position field* may be reduced to 3, 2, or 1 characters — when no channel bits need be set (1) in the discarded high-order characters (nibbles).

The channel data requested will always be returned in order of highest requested channel to lowest requested channel.

3.1.2.5 Modifier Field

All Models

The flexible *modifier field* accommodates multiple data values that need to be sent to any module. This field is optional and dependent on the command sent to the module.

When a command supplies data values for multiple channels (thus requiring multiple *modifier fields*) they must be specified (from left to right) in order of highest channel number to lowest channel number. For example, consider the modifiers for a command that sends channel-specific data for four (4) channels.

for Highest Chan.#			for Lowest Chan.#
Modifier 1	Modifier 2	Modifier 3	Modifier 4

The size of the modifier field is variable based on the command type and the format in which the data is transferred. Some commands use a variable length *string notation* for a modifier field, to allow fixed point decimal values to be entered directly as ASCII strings. In this case each modifier starts with an ASCII blank character (‘ ’), followed immediately by an optional sign and numerical digits (and decimal point character) of the desired value (e.g., “ vv.vvvvvv”).

3.1.2.6 Checksum Field

9010, 9015, 9020 only

All Optomux models use this field to hold the *Optomux checksum*, which is used to ensure data transmission correctness. The receiving module never executes a command that contains an incorrect checksum field.

The command packet checksum is calculated by adding the decimal values of all the ASCII characters of the packet, except for the start character '>'. This *integer sum* is divided by 256 and the *integer remainder* is converted to two hexadecimal characters, and then placed at the end of the command packet (along with a ‘ **r** ’ delimiter). For diagnostic or debugging purposes, a checksum override of "??" may be used instead of the actual checksum. Always calculate and append the real checksum to ensure data integrity.

Consider this example: an ‘L’ command directed to a module with decimal node address 103 (67 hex):

The full Optomux command is: ">67**L0123**7F **r** ". The checksum is calculated as follows:

ASCII CHAR:	>	6	7	L	0	1	2	3
Value in decimal:	skip	54	55	76	48	49	50	51

54 + 55 + 76 + 48 + 49 + 50 + 51 = 383 / 256 = 1, with remainder 127

127 decimal = 7F hex = Checksum.

3.1.3 Responses

All Models

Three types of responses can be returned from a System 9000 Intelligent Pressure Scanner module: an ***Error*** response, an ***Acknowledge*** response, or an ***Acknowledge with Data*** response.

The Optomux *Error* response consists of the letter 'N' (for NAK, or negative acknowledge), followed by a 2-digit hexadecimal error code and a carriage return character (‘ **r** ’). If the TCP/IP protocol is used (e.g., Ethernet model 9016 or 9021) the ‘ **r** ’ is not appended. This type of response does not return a checksum. Error codes that can be returned from a System 9000 module are listed below in Table 3.1 and in Appendix B.

Table 3.1: Optomux Error Codes

CODE	MEANING
00	Power Up Clear Expected
01	Undefined Command Received
02	Optomux CheckSum Error (unused by TCP/IP)
03	Input Buffer Overrun
04	Invalid ASCII Character Received
05	Data Field Error
06	Communications Watchdog Timeout Error
07	Specified Limits Invalid
08	SYSTEM 9000 error invalid parameter

The *Acknowledge* response is returned from a module when a command is received that requires no data to be returned, and no error is detected. It indicates successful parsing and execution of the last received command. It consists of the letter 'A' (for ACK, or acknowledge) followed by a carriage return delimiter character (‘ **r** ’). No checksum is returned in this response. If the TCP/IP protocol is used the ‘ **r** ’ is not appended.

The *Acknowledge with Data* response is returned when a module receives a command requesting data. For an Optomux module (9010,9015,9020) this consists of the letter 'A', followed by the requested data fields, a checksum, and a carriage return delimiter character (‘ **r** ’). Modules using the TCP/IP protocol (model 9016 and 9021) will typically return the requested data values only without the ‘A’ character. The data in the response can be of variable length, depending on the number of channels and data format requested. **These data are returned in the order of highest requested channel number to lowest requested channel number.**

An Optomux response’s checksum is calculated (by the module) in the same way as a command’s checksum is calculated (by the host), except that the acknowledge letter 'A' is not included in the calculation. Refer to Section 3.1.2.6 for more information on how to calculate the checksum. The host program reading any Optomux module’s “data” response is responsible for checking the integrity of its appended checksum. Responses with incorrect checksums should be discarded as this is an indication of a data integrity error.

3.1.3.1 Interpreting Scaled Analog Data

9010, 9015, 9020 only

The standard Optomux command set specifies that modules return restricted resolution "scaled" data values for each channel. These scaled values range from 1000 hex for minimum values and 2000 hex for full-scale values. Output values less than 1000 hex will be returned if an under range input is applied to a channel. Likewise, output values greater than 2000 hex will be returned if an input greater than full scale is applied to a channel.

When the host computer instructs a module to return the analog value of a channel by using the standard ***Read Scaled Analog Inputs*** (**'L'**) command, the module will return these 'scaled" data, as 4-byte hexadecimal values representing internal higher precision values.

Inside a System 9000 module, each channel's raw or engineering-unit datum is more resolute, so it must be scaled to fit this narrower "scaled" datum value range. The 9010, 9015, and 9020 also support non-standard Optomux commands, such as ***Read High Precision Data*** (**'r'**), which can be used to return values at full internal resolution using various floating point data formats. **For ease of use, the *Read High Precision* ('r') command is the recommended method for reading pressure data from the 9000 modules.**

When interpretting the Optomux scaled data format, the user must take into account that some pressure channels are *differential* and their input pressures go from negative full scale pressure to positive full scale pressure (e.g. -15 to +15 psi) while some pressure channels have only positive pressures (e.g. 0 to +100 psi). Table 3.2 summarizes the "scaled" values for each transducer type:

Table 3.2: Optomux Output Values

	-F.S. Pressure	Zero	+F.S. Pressure	Bit Weight
Differential Transducers (± Pressure)	1000 hex	1800 hex	2000 hex	+ F.S. / 800 hex
Absolute and Gage Transducers (+ Pressure only)	--	1000 hex	2000 hex	+ F.S. / 1000 hex

(1000 hex = 4096 decimal)

Example 1 :

System 9000 Transducer has a range of 0 - 100 psi:
0.0 psi is Zero Scale (1000 hex)
100 psi is Full Scale (2000 hex)

What is the pressure when 1445 hex is returned from the module?
Pressure read :

= (100 psi / 1000 hex) * (Input - 1000 hex)
= (100 psi / 1000 hex) * (1445 hex - 1000 hex)
= (100 / 4096) * (5189 - 4096)
= 26.68 psi

Example 2 :

System 9000 Transducer has a range of -15 to +15 psi:
0.0 psi is Zero Scale (1800 hex)
+15 psi is Full Scale (2000 hex)

What is the Pressure when 1445 hex counts are returned from the module?
Pressure read :

= (15 psi / 800 hex) * (Input - 1800 hex)
= (15 psi / 800 hex) * (1445 hex - 1800 hex)
= (15 / 2048) * (5189 - 6144)
= -6.99 psi

3.1.3.2 Interpreting Offset Values (Rezero Calibration)

All Models

When a System 9000 Intelligent Pressure Scanner module is instructed to execute the standard Optomux command ***Calculate and Set Offsets*** ('**h**'), a datum corresponding to the calculated offset correction term (or coefficient) is returned for each affected channel. For the Optomux 9010, 9015, and 9020 modules, this datum is a 4-character hexadecimal value. Each such number, in a "scaled ratio" format, represents a calculated *offset correction* term: a value that needs to be subtracted from the channel measurement to null zero drift effects. The engineering units value of the offset correction term may be calculated by multiplying the returned signed integer value by the pressure range's bit weight as described in Section 3.1.3.1. The 9016 and 9021 modules return ASCII floating point values representing the calculated *offset correction* term in current engineering units. The use of the ***Calculate and Set Offsets*** (**'h'**) command causes the module to update internal engineering units coefficients and automatically add the new correction term before outputting engineering units data.

If it is desired to view the new "offset" coefficients directly in a higher resolution, the Read Internal Coefficients ('u') command may be used. Refer to Section 4.2 for details on performing rezero calibrations.

3.1.3.3 Interpreting Scaled Gain Values (Span Calibration)

All Models

When a System 9000 Intelligent Pressure Scanner module is instructed to execute the standard Optomux command ***Calculate and Set Gains*** ('**Z**'), a datum corresponding to the calculated gain correction term is returned for each affected channel in the command's response. For the Optomux 9010, 9015, and 9020 modules, this datum is a 16-bit binary value which is transmitted as four ASCII hex characters. This data is in a "scaled fractional" format, scaled down from an implied internal decimal floating point number. The 9016 and 9021 return the requested gain correction terms directly as ASCII floating point values.

The "scaled fractional " format returned by the Optomux modules may be converted to a floating point number as follows. A decimal point is implied after the first digit (left digit) with the remaining three digits as the fractional value. Since the output values are hexadecimal, the fractional positions to the right of the implied decimal should be treated as base-16 fractions. The value of digit positions is summarized below.

first digit (left most)	-	ones position
second digit	-	1/16 position (.0625 * position value)
third digit	-	1/256 position (.0039063 * position value)
fourth digit	-	1/4096 position (.0002441 * position value)

Example 1 :

Returned gain correction term : 1124 hex
= 1 + (1 * .0625) + (2 * .0039063) + (4 * .0002441)
= 1.0713

Example 2 :

Returned gain correction term : 0FF3
= 0 + (15 * .0625) + (15 * .0039063) + (3 * .0002441)
= 0.9968

If it is desired to view the new “gain” coefficients directly in a higher resolution data format, the Read Internal Coefficients (‘u’) command may be used. Refer to Section 4.3 for details on performing span calibrations.

3.1.3.4 Interpreting IEEE Floating-Point Values

9010, 9015, 9020 only

The 9000 modules support several non-standard Optomux commands that can return acquired data and coefficients in high resolution formats. Inside any module, such data are represented as either single precision IEEE floating-point binary values (32-bits) or as double precision IEEE floating-point binary values (64-bits). These single and double precision floating point values comply with the IEEE 754 standard. This floating point format is supported by most compilers and data acquisition software requiring little or no manipulation of the returned binary data. All hexadecimal-encoded or pure binary data are returned with their most-significant internal data byte first (sometimes called big-endian format).

The non-standard command ***Read High-Precision Data*** (**‘r’**) offers several decimal string or pure binary formats (single or double precision) for returning data to the host. The non-standard command ***Read Internal Coefficients*** (**‘u’**) does the same for internal operation and calibration coefficients. Other non-standard commands support the use of these high resolution data formats. Refer to the specific command descriptions for a list of applicable data formats.

See the document ANSI/IEEE std 754-1985, for more detailed information on the interpretation of the various fields (sign, exponent, mantissa) of any single- or double-precision IEEE binary floating-point number.

3.1.3.5 Reading TCP/IP Response Data

9016, 9021 only

When operating in their factory default mode, the 9016 or 9021 response data is simply embedded into the TCP/IP data field.

For some host programming applications, it may be difficult to determine the exact length of the data field returned by the 9016 or 9021. To simplify the host programming interface, the 9016 and 9021 can be instructed to return a byte count for each data response packet. If enabled, each packet returned from a 9016 or 9021 will contain a leading 2-byte length data field followed by the normal response data field. The packet length field is a 16-bit big endian binary value. It’s value is equal to the total number of bytes in the TCP/IP data returned, including the two bytes for length field. This mode of operation is enabled through the ***Set Operating Option*** (**‘w’**) command using option index 16 hex. Setting this value on or off will result in an update to the module’s default mode of operation.

All Models

3.1.3.6 Interpreting Engineering Units Output

All 9000 Intelligent Pressure Scanners perform all internal pressure calculations in units of pounds per square inch (psi). By default, all pressure data responses will be in engineering units of psi. If a different Engineering Unit output is desired from the 9000 module, an internal EU conversion scaler may be applied to all data transmitted to or from the 9000 module. This scalar may be set to any desired value through the ***Download Internal Coefficient*** **('v')** command using Coefficient Array 11 hex, index 01.

3.1.4 Functional Command Overview

All Models

The various System 9000 commands are best introduced by classifying them into functional groups and then describing how each function is carried out in a typical system. The following functions are defined for this purpose:

- Startup Initialization
- Scan List Definition for Acquisition
- Calibration Adjustment of Engineering Unit Conversion Coefficients
- Acquisition/Delivery of Data to Host

Please look ahead to Table 3.3, labeled ***All Commands***, in Section 3.2, for a quick-look summary of all available *standard Optomux* and *non-standard* Intelligent Pressure Scanner commands. This list also indicates which Intelligent Pressure Scanner models use each command. This summary list is also duplicated in Appendix A for future reference. Each command may be referenced by both its *functional title* and by its *command letter* in the functional discussion subsections below.

The ***Detailed Command Description Reference*** immediately follows the table in Section 3.2, with each command description occupying a page (or more if necessary). Command descriptions in this section (as in the table) are ordered by *"command letter" ASCII order*. That is, with commands having *UPPERCASE* letters (***A .. Z***) described first, followed by the commands having *lowercase* letters (***a .. z***) .

3.1.4.1 Startup Initialization

All Models

Since power supplies may be distributed widely across a network of modules and host computer(s), it is not uncommon for modules (singly or together) and the host to lose power independently. Thus, their power may be restored at different times. Startup initialization, for every module, must be performed when its power is restored — as each module enters default states after power-up, which may not be the state the host computer had previously been operating it. The following commands are generally used to detect startup initialization or to force reset, after which other commands may be used to restore the original operating condition.

The ***Power-Up Clear*** (**'A'**) command is used when it is known that power restart has occurred. Otherwise, if any module experiences a power-up cycle autonomously, and does not receive command **'A'** as the first command, the next response it returns to ANY other first command will be the "Power-Up Clear Expected" error message response ("N00"). This "Power-Up Clear Expected" error response is only returned for the first command following a module reset. All following commands will be processed normally. By this mechanism the host will thus know, and must be prepared to handle, any module's power failure restart.

At any point during module operation, the ***Reset*** (**'B'**) command may be used to return any module to its default "reset" state. If the module is then required to enter any other states (that were previously programmed for it by the host), the host must then restore these states accordingly using the appropriate commands.

The ***Set Operating Options*** (**'w'**) command has many purposes, but may first be utilized during the module initialization stage. It may also be executed at any time during data acquisition.

3.1.4.2 Scan Definition for Acquisition

All Models

After power-up, all System 9000 modules will begin to scan all attached transducer channels in channel number order. The data is stored in an internal buffer, available for retrieval by the host computer. Scanning will occur at the module's maximum internal rate using the previously stored number of data averages per channel. Engineering units conversion of the scanned channels is accomplished using thermal correction data extracted from each transducer at power-up. While scanning, the module will automatically monitor the attached transducers' temperature, correcting engineering unit output for any temperature affects.

All System 9000 models effectively defer the host computer’s decision of “which channels of data do I want” until that time when the host chooses to send read commands to actually retrieve the desired data from the latest “buffered copy” of the continuously scanned, averaged, and engineering-unit-converted data. Commands such as ***Read Analog Data*** **('L')**, ***Read High Precision Data*** **('r')**, and ***Acquire High Speed Data*** **('b)** are typically used to retrieve the desired engineering unit data from the module.

The Ethernet model 9016 and 9021 also continuously scan, average, and convert data to engineering units as described above. However, they also have a special ***Define/Control Host Streams*** (**‘c’**) command that can define and control the delivery of up to three (3) independent, concurrent *streams* of data packets to the host. This differs from the above mentioned data acquisition commands in that the requested data streams are transmitted by the modules to the host autonomously. Once host streams are defined and started, the 9016 or 9021 modules will autonomously transmit the requested channel data at the previously defined rate.

While scanning, all modules take multiple samples and average each channel. The *number of samples per scanned channel* defaults to 32, but may be set to one (to disable averaging) or to any suitable higher value to change the degree of averaging (and its effect on maximum scan rate). The ***Set Operating Options*** (**‘w’**) command may change this variable at any time. The same command may be used to store the new averaging value as the module default. Models 9010, 9015, and 9020 also support modification of the default data average value through a DIP switch procedure described in Section 2.3.4.1.6

3.1.4.3 Calibration of Engineering-Unit Coefficients

All Models

All System 9000 Intelligent Pressure Scanners have built in software commands (and pneumatic hardware for Models 901x) to perform periodic zero and span calibration of attached pressure transducers. Use of these periodic calibrations result in the highest possible data accuracy. The result of these calibrations are a new set of internal “offset” and “gain” coefficients. These “adjustment” coefficients are over and above those factory-determined and *unchanging* thermal correction coefficients stored in each transducer's non-volatile memory. The factory coefficients provide the basic engineering unit conversion capability, while also correcting for various non-linear effects — including temperature affect compensation. The offset and gain correction coefficients provide for fine adjustment of the factory calibration of each transducer. **If used properly, the periodic zero and span calibration should be the only calibration required to maintain specified performance through the life of the Intelligent Pressure Scanner.**

It is generally necessary for the transducer to be stimulated with a real “zero” and “span” pressure when calibration adjustment is required. These pressure values may be generated by secondary pressure standards, such as the model 903x calibrator module or by other external means provided by the customer (such as a dead weight calibrator). For the more common zero calibrations, zero differential pressures can typically be provided without the need for external pressure generators. All 901x models have built-in pneumatic inputs (CAL side inputs) and calibration manifolds required for directing the generated pressures to the various channels of the module(s) being calibrated. Model 9020 and 9021 require such pneumatic/ hydraulic plumbing be provided by the customer (if deemed necessary). **Refer to Chapter 4 of this manual for detailed background and procedures for periodic calibration of the Intelligent Pressure Scanners.** A summary of the commands used for calibration purposes is included below.

The ***Calculate and Set Offsets*** (**'h'**) command is executed only when a suitable "minimum" (e.g., zero) pressure has been applied to all channels of the module. The new "offset" coefficients that result from execution of this command are stored in the module's volatile (or temporary) engineering-unit conversion database. They are also returned to the host in the command's response.

The ***Calculate and Set Gains*** (**'Z'**) command should be executed only when "full-scale" (or other suitable specified up-scale) pressure has been applied to the appropriate channels of a module. The new "gain" coefficients that result from this command are stored in the module's volatile (or temporary) engineering-unit conversion database. They are also returned to the host in the command's response.

Althought the calculated zero and span correction coefficients are kept in volatile memory following execution of the calibration commands, they may be stored in non-volatile transducer memory if desired through use of the ***Set Operating Options*** **('w')** command. Although the above commands may return the new calibration *adjustment* coefficients to the host in a "scaled" integer form (9010, 9015, 9020 only), they are maintained in IEEE floating-point format internally. The ***Read Internal Coefficients*** (**'u'**) command and the ***Download Internal Coefficients*** (**'v'**) command can return (or manually set) calibration coefficients to the host in higher resolution formats (e.g, IEEE floating point).

3.1.4.4 Acquisition/Delivery of Data To Host

All Models

The remaining commands apply to host data delivery. Models 9010, 9015, and 9020 may use the ***Read Scaled Analog Inputs*** (**'L'**) command, which returns standard Optomux "scaled" data values (with limited resolution) for only the channels desired. For all models, the alternate ***Read High Precision Data*** (**'r'**) command may be used to obtain high precision data (in various formats). Due to its increased precision and conventional data formats, the *Read High Precision Data* command should generally be used. The *Read Scaled Analog Inputs* command is maintained mainly for compatibility with third party Optomux software packages.

In addition to command **'r'** above, the model 9016 and 9021 provide several high speed, high resolution output commands. The ***Read High-Speed Data*** (**'b'**) command is used to read "pure binary" engineering unit pressure data with minimum overhead (all 16 channels are automatically returned). These modules can also acquire these data in *streams*, which consist of TCP/IP data packets that arrive autonomously in the host (with e.u. *pressure* data from various channels being delivered in various formats at various rates). Up to three independent streams may be configured, started, stopped, and cleared with the ***Define/Control Host Streams*** (**'c'**) command.

The model 9016 also has special purpose data acquisition commands, including: ***Read Transducer Voltages*** (**'V'**) and ***Read Transducer Raw A/D Counts*** (**'a'**), which provide two views of raw *pressure* data. It has similar commands providing e.u. temperature (°C) and other raw views of each channel's special *temperature* signal, including ***Read Transducer Temperatures*** (**'t'**), ***Read Temperature A/D Counts*** (**'m'**), and ***Read Temperature Voltages*** (**'n'**). This command group is generally used for diagnostic purposes.

All Models

3.1.4.5 Other Functions

Some commands defy classification, because they may be used at anytime to obtain information about the internal setup of a module. The ***Read Module Status*** (**'q'**) command is an example. Also, the ***Set Operating Options*** (**'w'**) command, though generally used after power-up reset, may also be used at other times as well to change system operation.

3.2 Detailed Command Description Reference

All Models

All standard and non-standard Optomux commands applicable to the various models of the System 9000 Intelligent Pressure Scanner modules are described on the following pages. They are summarized in the following table. For convenience, this table is also repeated in Appendix A.

Table 3.3 Intelligent Pressure Scanner Commands

Cmd Letter	9010 9015 9020	9016 9021	Command Function
A	!	!	Power-Up Clear
B	!	!	Reset
L	!		Read Scaled Analog Inputs
V		!	Read Transducer Voltages
Z	!	!	Calculate and Set Gains
a		!	Read Transducer Raw A/D Counts
b		!	Acquire High Speed Data
c		!	Define/Control Host Streams
h	!	!	Calculate and Set Offsets
m		!	Read Temperature A/D Counts
n		!	Read Temperature Voltage
q	!	!	Read Module Status
r	!	!	Read High Precision Data
t		!	Read Transducer Temperature
u	!	!	Read Internal Coefficients
v	!	!	Download Internal Coefficients
w	!	!	Set Operating Options

All Models

POWER UP CLEAR (Standard Command 'A')

Purpose: Prevents the module from returning a 'Power-Up Clear Expected' error (N00) in response to the first command it receives after a module power up.

	Core String	Full Optomux String
Command Format:	**"A"** 'A' is the *command* letter.	">aa**A**ss **r** " see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions.
Response Format:	**"A"** 'A' is the *acknowledge* letter.	**"A r "**

Description: Optomux System 9000 instruments (9010, 9015, 9020) return a 'Power-Up Clear Expected' error (N00) in response to the first command (except Power-Up Clear command) received after the module has powered-up. This error response provides an indication of module power loss. After the initial 'Power-Up Clear Expected' error or Power-Up Clear command, the module responds normally to subsequently received commands. The Ethernet models 9016 and 9021 do not return a 'Power-Up Clear Expected' error. This is due to the reset notification mechanisms that are part of the TCP/IP protocol.

Examples:

(1) Send command to model 9010 Optomux module (with node address 2) to acknowledge module power on (include necessary A3 hex checksum):

">02**A**A3 **r** "

Read following response from 9010 :

"**A r** "

(2) Send command to model 9016 TCP/IP module (via its open socket) to acknowledge module power on:

"**A**"

Read following response:

"**A**"

All Models

RESET (Standard Command 'B')

Purpose: Instructs the module to reset, and to set all internal control variables to their default "reset" state (see description below).

	Core String	Full Optomux String
Command:	**"B"** 'B' is the *command* letter.	">aa**B**ss **r** " see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions.
Response:	**"A"** 'A' is the *acknowledge* letter.	**"A r "**

Description: The System 9000 module returns to the following "reset" states if this command is executed:

- The Internal EU Conversion and Calibration Database is reloaded from the nonvolatile memories of all configured transducers into the module's volatile memory.
- Rezero adjustment (offset) terms are set to the last values stored in transducer memory.
- Span adjustment (gain) terms are set to the last values stored in transducer memory.
- Calibration Valve is set to the RUN Position (9010, 9015, 9016 only).
- Number of Samples for Data Averaging is set to 32 samples (all models), or to the last value selected by the configuration DIP switch (models 9010, 9015 and 9020 only).
- Multidrop baud rate is set to 9600 baud, or to the last value selected by the configuration DIP switch (models 9010, 9015, and 9020 only).
- All data stream scan lists are reset (9016 and 9021 only).

Examples:

(1) Send command to model 9015 Optomux module (with node address 6) to set reset defaults. (include A8 hex checksum in command):

">06**B**A8 **r** "

Read following response:

"**A r** "

(2) Send command to model 9016 TCP/IP module (via open socket) to set reset defaults:

"**B**"

Read following response:

"**A**"

9010, 9015, 9020 only

READ SCALED ANALOG INPUTS (Standard Command L)

Purpose: Returns the input value(s) in standard Optomux "scaled" units of each requested channel.

	Core String	Full Optomux String
Command:	**"L[pppp]"** 'L' is the *command* letter 'pppp' is the [optional] *position* field	">aa**L[pppp]**ss **r** " see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions
Response:	**"Adddd..dddd"** 'A' is the *acknowledge* letter 'dddd..dddd' are the returned *data* fields	"**Adddd..dddd**ss **r** "

Description: The *position* field may have 0-4 characters. If no *position* field is specified, a *data* field ('dddd') will be returned for **every** channel scanned by the module. If a 4-byte position field is specified, a *data* field ('dddd') will be returned from every channel with a bit set to 1 in the position field.

The response returns four (4) hexadecimal characters for each *data* field requested, **highest requested channel number's datum first**. Each such datum is a standard Optomux "scaled" value (1000 hex to 2000 hex). However, the string "????" will be returned, instead of 'dddd', for any datum requested from a bit position with no channel to scan (e.g. requesting data from Channel 10 of a Model 9015, which has only 8 channels). Refer to Section 3.1.3.1 to interpret the scaled values returned by this command.

Alternative: For users concerned with better data resolution, the non-standard ***Read High-Precision Data*** (**'r'**) is provided by all System 9000 Intelligent Pressure Scanner modules.

Examples:

(1) Send command to module 144 (90 hex) to read channels 1 and 3 only (include 7A hex checksum):

">90**L0005**7A **r** "

Read this response from module (with 9A hex checksum):

"**A10001888**9A **r** "

This successfully returned 4096 (1000 hex) for channel 3 and 6280 (1888 hex) for channel 1.

(2) Send command to module 69 (45 hex) to read its channels 1, 5, 9, and 13 only (include 79 hex checksum):

">45**L1111**79 **r** "

Read this response from module (with 0E hex checksum):

"A**2000102010301040**0E **r** "

This returned 8192 (2000 hex) for channel 13 (at max.full scale)
4128 (1020 hex) for channel 9
4144 (1030 hex) for channel 5
4160 (1040 hex) for channel 1.

(3) Send command to a model 9015 module (node address 85 (55 hex)) to read channels 1, 5, 9, and 13 (including 7A hex checksum):

">55**L1111**7A **r** "

Read this response from this model 9015 (8-channel) module (with 81 hex checksum):

"A**????????10301040**81 **r** "

The data returned was: ???? (non-existent datum) for channel 13
???? (non-existent datum) for channel 9
4144 (1030 hex) for channel 5
4160 (1040 hex) for channel 1.

9016, 9021 only

READ TRANSDUCER VOLTAGES (Non-Standard Command 'V')

Purpose: Returns for the specified channels, the most recently acquired *raw pressure* data, converted to volts directly from the averaged A/D counts. This simple engineering-unit conversion bypasses any usage of the transducer's factory-calculated coefficients or the final calibration process's adjustment coefficients (offset and gain). Each datum returned in the response will be in the specified high-precision data format. **This command is intended for advanced users only and is not required for normal operation.**

	Core String	Full Optomux String
Command:	**"Vppppf"** 'V' is the *command* letter 'pppp' is the *position* field 'f' is the *format* field	unimplemented
Response:	**" dddd.. dddd"** ' dddd' are the *data* fields, each with a leading space (except binary format 7).	unimplemented

Description: The 4-character hex *position* field (pppp) specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (f) specifies the format of each *data* field (dddd) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number requested, and each datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	ASCII data field returned	internal datum before formatting
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value shown	32-bit binary IEEE *single*-precision floating-point e.u. value
1	8-char. ASCII hex number (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value
2	16-char. ASCII hex number (big-endian)	64-bit binary IEEE *double*-precision floating-point e.u. value
:	:	:
5	8-char. hex number (big-endian)	32-bit binary integer encoding of e.u. value times 1000.
:	:	:

7	4-byte binary (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value

Examples:

(1) Send command to TCP/IP module 5 (via its connected socket) that returns ASCII decimal fixed-point Voltage data for channels 1, 5, 9, and 13:

"**V11110**"

Response contains data for channels 13, 9, 5, and 1 (left to right):

" **4.999999 -4.989500 0.005390 2.500001**"

All Models

CALCULATE AND SET GAINS (Standard Command 'Z')

Purpose: Instructs a module to calculate new gain coefficients, with either *full-scale* or a *specified* pressure value applied to the specified channels. These new coefficients update the module's internal calibration coefficient table, used to convert any subsequent raw data (from any of the specified channels) into engineering units data. Calculated gain values are returned in the response's data.

	Core String	Full Optomux String
Standard Command:	**"Zpppp[vv.vvvv]"** 'Z' is the *command* letter 'pppp' is the *position* field ' vv.vvvv' is an [optional] *fixed-point decimal value* string, preceded by a *space* character.	">aa**Zpppp[vv.vvvv]**ss**r**" see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions
Standard Response: (9010,9015, 9020 only)	**"Adddd..dddd"** 'A' is the *acknowledge* letter 'dddd' are the "scaled" gain data values returned	**"Adddd..dddd**ss**r**"
Alternate Response: (9016 and 9021 only)	**"g.gggg .. g.gggg"** 'g.gggg' are the actual floating point *gain* data values returned and are separated by a space.	none

Description: The *position* field may have 0 or 4 characters. If no *position* field is specified, gain coefficients for all module input channels will be calculated and returned. If a *position* field is specified, gain coefficients for only the channels whose bits are set (1) will be calculated and returned. If the optional *fixed-point decimal value* string (vv.vvvv) is specified, the *position* field must be 4 characters, even when all channels are to be specified.

The ***standard*** form of this command requires that the *exact full scale* input pressure be applied to the affected channels. An ***alternate*** form allows the user to specify *any suitable upscale pressure* in the current engineering units. For best results when specifying an upscale span pressure, pressures in excess of 90% of full scale should be applied. A leading blank ' ' must precede the *decimal fixed-point value* string parameter used to specify this optional upscale pressure.

The desired calibrating pressure must be applied to all of the specified channels before this command is executed. Such a pressure is presumably generated by a separate model 903x calibrator module or suitable user-supplied substitute. Notice that unlike the ***Calculate and Set Offsets*** (**'h'**) command, this command does not automatically move the module's calibration valve to its Cal position. The reader is also referred to Section 4.3 of Chapter 4 for additional details concerning the performance of a Span Calibration.

Refer to Section 3.1.3.3 for information concerning interpreting the returned “scaled” gain values. These values are software limited to values between 0.0 and 100.0. Any calculated value outside of this range will result in the gain coefficient being set to 1.00.

Note: The calculated offset values will be lost when the module is powered off. To save these offset terms to each transducer’s nonvolatile memory refer to the *Set Operating Options* ('w') command.

Examples:

(1) Send command to Optomux module 08 to calculate and set gain coefficients for channels 8 through 4 (include the A0 hex checksum). Assume “full-scale” pressure is applied to all channels :

">08**Z00F8**A0 **r** "

Read the response, containing all the returned “scaled” gain values that were calculated and stored in the module’s volatile main memory (includes the F3 hex checksum):

"**A1368145017000F791254**F3 **r** "

The following gain values are returned in the response above:

channel 8 =	1368 hex,	gain = 1.21289
channel 7 =	1450 hex,	gain = 1.26953
channel 6 =	1700 hex,	gain = 1.43750
channel 5 =	0F79 hex,	gain = 0.96704
channel 4 =	1254 hex,	gain = 1.14551.

(2) Send command to a model 9016 TCP/IP module (via its open socket) to calculate and set gain coefficients for channels 8 through 4. Instruct the module to use 14.8890 psi as the applied pressure instead of each transducer’s full-scale value:

"**Z00F8 14.8890**"

Read response, containing the new gain values (also stored in the module’s volatile main memory):

"**1.21289 1.26953 1.43750 0.96704 1.14551**"

Actual gain values are returned in the above response as decimal fixed-point ASCII strings with single blank characters separating them. From left-to-right: they are for channels 8, 7, 6, 5, and 4. Please note that the ‘A’ (acknowledge) value is not used by the 9016 when actual data is returned.

9016, 9021 only

READ TRANSDUCER A/D COUNTS (Non-Standard Command 'a')

Purpose: Returns the most recently acquired *raw pressure* data for the specified channels in averaged A/D counts (in the range -32768 to +32767). This simple data bypasses any usage of the transducer's factory-calculated coefficients or the final calibration process's adjustment coefficients (offset and gain). Each datum returned in the response will be in the specified high-precision data format, but representing A/D counts as a truncated integer average. **This command is intended for advanced users only and is not required for normal operation.**

	Core String	Full Optomux String
Command:	**"appppf"** 'a' is the *command* letter 'pppp' is the *position* field 'f' is the *format* field	unimplemented
Response:	**" dddd.. dddd"** ' dddd' are the *data* fields, each with leading space (except binary format 7).	unimplemented

Description: The 4-character hex *position* field (pppp) specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (f) specifies the format of each *data* field (dddd) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number requested. Each datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	ASCII data field returned	internal datum before formatting
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value returned	32-bit binary IEEE *single*-precision floating-point e.u. value
1	8-char. ASCII hex number (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value
2	16-char. ASCII hex number (big-endian)	64-bit binary IEEE *double*-precision floating-point e.u. value
:	:	:
5	8-char. hex number (big-endian)	32-bit binary integer encoding of e.u. value times 1000.
:	:	:
7	4-byte binary (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value

Examples:

(1) Send command to TCP/IP module 5 (via its connected socket) that returns ASCII decimal fixed-point raw “pressure” A/D counts data for channels 1, 5, 9, and 13:

"**a11110**"

Response contains data for channels 13, 9, 5, and 1 (left to right):

“ **32767.000000 -32700.000000 10.000000 16385.000000**"

Please note that channel 13 is saturated at +full scale and channel 9 is almost saturated at -full scale. Channel 5 reads near zero and channel 1 is about ½ +full-scale.

9016, 9021 only

READ HIGH-SPEED DATA (Non-Standard Command ‘b’)

Purpose: Returns the most recent scanned/averaged data from *all channels* of the module as fast as possible. Data is returned in internal (IEEE single-precision float) binary form. It is used as a *faster alternative* to the ***Read High-Precision Data*** (**‘r’**) command, since **‘b’** does not have to parse the position or format parameters, nor does it have transform or encode the internal data into any other format when the response is generated.

	Core String	Full Optomux String
Command:	**`“b”`** ‘b’ is the *command* letter	unimplemented
Response:	**`“aaaabbbbcccc..dddd”`** each 4-byte datum (e.g, ‘aaaa’) is an unprintable binary 32-bit value (format 7) representing an IEEE single-precision floating point.	unimplemented

Description: Always returns data for all of the module’s channels, in order highest channel number to lowest channel number. Thus for a 9016, channel #16 will always be the first 4-byte (32-bit binary, big-endian, IEEE floating-point) value (‘aaaa’) sent in the response. It is followed by similar values (‘bbbb’, ‘cccc’, ... ‘oooo’) for channels #15, #14, ... #1. Please note that no ‘A’ (acknowledge) character is included in this response.

Unless the E.U. conversion scalar is altered, the returned data will be in units of psi.

Examples:

(1) Send command to a model 9016 module (via its “socket” connection) to return data as fast possible:

“b”

Data from the most recent scan of all the module’s channels are returned in pure binary form, 4-bytes per channel (big endian):

aaaabbbbcccc .. oooopppp

Note that this response is not shown within quotes “ ” since it is not a valid ASCII character string.

9016, 9021 only

DEFINE/CONTROL HOST STREAM (Non-Standard Command 'c')

Purpose: Defines and controls the autonomous delivery of any of up to three concurrent high-speed data streams to the host computer. Such data streams may be delivered "continuously" without bound (until a command explicitly stops them) — or be delivered until a fixed number of data packets have been sent ("limited"). Each packet delivered may be synchronized by a "hardware trigger" or each packet may be delivered periodically (as controlled by an internal software clock). These concurrent host streams are an alternate method of acquiring data rather than using the ***Read High-Precision Data*** (**'r'**) command or the ***Read High-Speed Data*** (**'b'**) command.

Host data streams, once activated in a module, deliver a sequence of TCP/IP data packets autonomously to the host (i.e., without host sending any particular command to the module to request each packet). If these data streams are defined to occur at high rates, then each data packet received by the host must be processed and disposed of in a timely manner.

Various subcommands are used to identify the various definition and control options of this command.

	Core String	Full Optomux String
Command:	**"c ii .. "** 'c' is the *command* letter ' ii' is a blank + a subcommand index (augment code) ' .. ' are other blank-separated optional data fields, per subcommand augment code 'ii'	unimplemented
Response:	**"A"** 'A' is the *acknowledge* letter	unimplemented
Autonomous Packet:	Depends upon the particular subcommand (' ii') sent. See below.	unimplemented

Description: The firmware of a model 9016 module, once fully initialized, continuously scans and converts data for all pressure channels at the highest possible speed, in channel number order (1-16). The result of such scanning is a continuously-updated *eu data buffer*, available to three concurrent host data delivery tasks — or available to other standard data acquisition commands in the module. Each host delivery task can grab engineering-unit data values from the *eu data buffer* and deliver them to the host in its own programmable data stream (a sequence of TCP/IP packets that autonomously arrive in the host, as long as the host has enough TCP/IP buffering space to hold them).

Special augments of this command can configure each data stream with the particular channels whose data are delivered, the datum format, the delivery rate, and other characteristics. It can also start, stop, or undefine a single stream or all defined streams.

The maximum rate of any one stream's delivery is practically limited to the maximum possible scan and data conversion rate of all the module's channels. Normally, these programmable host streams deliver host data at rates equal to or slower than this natural cycle. For a typical application, the first stream delivers a few channels — at a high rate as defined by a hardware trigger. The second stream delivers other channels at a medium rate (some multiple of the trigger), and the third stream can deliver still other channels at a slow rate (a larger multiple of the trigger).

Command 'c'— Subcommand Index 00: *Configure A Host Delivery Stream*

This subcommand is used to configure the parameters of each of the three possible concurrent host delivery streams, one at a time. Following this configuration phase, the stream (1, 2, or 3) may be started with another subcommand. The configure subcommand's format is:

	Core String	**Full Optomux String**
Command:	**`"c 00 st pppp trig per f num"`** 'c' is the *command* letter '00' is the *subcommand index* ('ii') for configuration 'st' is the *stream identifier* character (1, 2, or 3) 'pppp' is a hex *position* field (channel selection bit map) 'trig' is *trigger type* character (0 or 1) 'per' is the *period* (# trigger periods or delay timer period) 'f' is the *format* of the data delivered 'num' is the *number of packets delivered* in the stream **NOTE: all parameters are separated by a blank character**.	unimplemented
Response:	**`"A"`** 'A' is the *acknowledge* letter	unimplemented
Autonomous Packet:	none generated	unimplemented

Description: Configures a particular stream ('**st**') to deliver data packets autonomously to the host, with each packet containing engineering unit data samples only for the channel positions specified. The channels included is the stream are specified by a standard 16-bit *position* field bit map (encoded as 4 hex characters '**pppp**') as used by other standard Optomux commands.

The individual data packets of the stream may be synchronized with either an external hardware trigger or a periodic clock interrupt generated inside each module. This choice is made with the '**trig**' parameter (a single character) where: 0 = synchronize with hardware trigger; 1= synchronize with periodic software clock.

When the hardware trigger is used to synchronize **data output** (‘trig’ = 0), it is assumed that the user would prefer to also synchronize internal data acquisition. For this reason, when a scan list utilizing hardware trigger is started, the module firmware switches out of the free-running continuous data acquisition mode described earlier. Instead, the 9016 or 9021 waits in an idle mode until a hardware trigger is received to initiate a host stream output. Only on the receipt of that hardware trigger will the module scan and EU convert all attached channels. Following completion of the EU conversion, the module will output the requested data channels. In this manner, users are provided with highly synchronized data from multiple modules. When all hardware triggered scan lists are complete or aborted, the modules will return to their mode of continuous scanning and EU conversion. If a module waits in the idle mode for an extended period of time without receiving a data request, it will periodically initiate its own internal data acquisition cycles so as to update internal thermal coefficients.

When the internal software timer is used to control host stream output rates (‘trig’=1), note that the internal clock frequency variances will result in slightly different timing between modules. Although these differences in timing are slight, they may result in noticeable differences in output timing between modules over a long period of time. If synchronized data output is required from multiple modules, the hardware trigger mode should be used.

The ‘**per**’ parameter is a positive integer count (specified with 1 to 5 numerical characters as needed), and its meaning depends on the ‘**trig**’ mode selected above. Thus:

‘**trig**’	meaning of ‘**per**’
0	number of hardware trigger periods to wait before sending each packet
1	delay to wait before sending a packet (specified in milliseconds)

The ‘**f**’ parameter identifies the *format* of each datum in each stream packet, and is a single numerical digit character. Valid format codes are listed in the following table:

f	**ASCII data field returned**	**internal datum before formatting**
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value shown	32-bit binary IEEE *single*-precision floating-point e.u. value
1	8-char. ASCII hex number (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value
2	16-char. ASCII hex number (big-endian)	64-bit binary IEEE *double*-precision floating-point e.u. value
:	:	:
5	8-char. ASCII hex number (big-endian)	32-bit binary integer encoding of e.u. value times 1000.
:	:	:
7	4-byte binary (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value

Unless the E.U. conversion scalar is altered, the returned data will be in units of psi.

The '**num**' parameter is a positive integer count (specified with 1 to 5 numerical characters as needed) which sets a limit on the number of packets delivered in the host data stream. The value 0 means "continuous" output (no limit).

Examples:

(1) Configure three (3) separate autonomous host delivery streams, and divide the module's channels between them. Channels (1-4) must be delivered to host as fast as possible, channels 5-8 may be delivered at half that rate, while the remaining channels 9-16 are delivered at half the previous rate. All streams are generated continuously and synchronized with the internal clock at 100 msec., 200 msec., and 400 msec. periods, respectively. Data is requested in single precision binary format.

"**c 00 1 000F 1 100 7 0**"
"**c 00 2 00F0 1 200 7 0**"
"**c 00 3 FF00 1 400 7 0**"

Command 'c'— Subcommand Index 01: *Start Stream*

This subcommand is used to start the delivery of any previously configured host stream in a module. If the stream started is of "continuous" duration, then it will be necessary to use the Stop Stream subcommand later. Otherwise, the stream will end automatically if a finite number of packets has been specified for it. The ***Start Stream*** subcommand's format is:

	Core String	Full Optomux String
Command:	**"c 01 st"** 'c' is the *command* letter '01' is the subcommand index ('ii') for ***Start Stream*** 'st' is the stream identifier character (0 (all), or 1, 2, or 3) **NOTE: all parameters are separated by a blank character**.	unimplemented
Response:	**"A"** 'A' is the *acknowledge* letter	unimplemented
Autonomous Packet:	"tssssdddd .. dddd" 't' is a 1-byte binary value identifying the stream number (1-3). 'ssss' is a 4-byte binary integer packet sequence number. 'dddd' are the data values in the selected format.	unimplemented

Description: This subcommand starts a particular specified host stream (st=1-3) — or starts all configured host streams with a single command (st=0). The sequence number (ssss) is always a binary unsigned integer in each packet. It starts at 1 (for the first packet generated in each run of each stream) and increments as necessary. A "continuous" stream may eventually overflow this value, which then wraps to 0, before continuing to be incremented for additional packets. A "limited" stream will terminate once this sequence number equals the requested number of packets for the stream.

The data in each packet will be ordered: from highest channel number requested to lowest channel number requested. Each datum (dddd) may be 4 bytes minimum for the binary IEEE single float (format 7) or it may have more bytes as needed by its format.

Examples:

(1) Start all the streams configured in the previous example:

"c 01 0"

Command 'c'— Subcommand Index 02: *Stop Stream*

This subcommand is used to abort the delivery of any previously started host stream in a module, one at a time or all together, whether the stream was "continuous" or "limited". The ***Stop Stream*** subcommand's format is:

	Core String	Full Optomux String
Command:	**"c 02 st"** 'c' is the *command* letter '02' is the subcommand index ('ii') for ***Stop Stream*** 'st' is the stream identifier character (0 (all), or 1, 2, or 3) **NOTE: all parameters are separated by a blank character**.	unimplemented
Response:	**"A"** 'A' is the *acknowledge* letter	unimplemented
Autonomous Packet:	command stops generating them	unimplemented

Description: This subcommand stops the current "run" of a particular specified host stream (st=1-3) — or stops the current "run" of "all configured" host streams with a single command (st=0).

The stopped stream may be restarted for any new "runs" with the ***Start Stream*** subcommand — as long as that stream remains defined in the module. The ***Clear Stream*** subcommand may be used to undefine a stream.

Examples:

(1) Stop all the streams configured in the previous example:

"**c 02 0**"

Command 'c'— Subcommand Index 03: *Clear Stream*

This subcommand is used to "undefine" any previously configured host stream in a module, one at a time, or all together. The ***Clear Stream*** subcommand's format is:

	Core String	Full Optomux String
Command:	**"c 03 st"** 'c' is the *command* letter '03' is the subcommand index ('ii') for ***Stop Stream*** 'st' is the stream identifier character (0 (all), or 1, 2, or 3) **NOTE: all parameters are separated by a blank character**.	unimplemented
Response:	**"A"** 'A' is the *acknowledge* letter	unimplemented
Autonomous Packet:	none generated	unimplemented

Description: This subcommand undefines the particular specified host stream (st=1-3) — or undefines "all configured" host streams with a single command (st=0).

Examples:

(1) Stop all the streams configured above. Then clear (undefine) only stream 3 and then restart the remaining defined streams 1 and 2:

"c 02 0"
"c 03 3"
"c 01 0"

All Models

CALCULATE AND SET OFFSETS (Standard Command 'h')

Purpose: Instructs a module to calculate new offset coefficients for the specified channels. These new coefficients are updated in the module's internal calibration coefficient database, used to convert any subsequent raw data into engineering units data. The calculated offsets are returned in the response's data. Prior to executing this command, a zero pressure should be applied to all affected channels.

	Core String	Full Optomux String
Command:	**"hpppp"** 'h' is the *command* letter 'pppp' is the *position* field	">aa**hpppp**ss**r**" see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions
Alternate Command: (9020, 9021 only)	**"hpppp vv.vvvv"** 'h' is the *command* letter 'pppp' is the *position* field ' vv.vvvv' is a *space* + *pressure value* applied	">aa**hpppp vv.vvvv**ss**r**" see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions
Standard Response:	**"Adddd .. dddd"** 'A' is the *acknowledge* letter 'ddd' are the returned data fields	"**Adddd .. dddd**ss**r**"
Alternate Response: (9016, 9021 only)	**"g.gggg .. g.gggg"** 'g.gggg' are the actual *floating point offset* data values returned. They are in the current E.U. and separated by *spaces*.	none

Description: The *position* field may have 0 or 4 characters. If no *position* field is specified, *offset* coefficients for all of a module's input channels will be calculated and returned. If a 4-character hex *position* field is specified, *offset* coefficients for only the channels whose bits are set (1) will be calculated and returned.

Before acquiring data, any addressed model 9010 or 9015 or 9016 module will attempt to place the calibration valve in the CAL position, so that a zero differential pressure can be applied to all channels via the module's CAL and CAL Ref input port. Simply leaving these ports unattached will allow the transducers to read the appropriate zero differential pressure if ambient air pressure is stable. After data are acquired, the calibration valve will be placed in the RUN position. To disable the automatic shifting of the calibration valve, refer to the ***Set Operating Options*** (**'w'**) command. The reader is also referred to Section 4.2 of Chapter 4 for additional details concerning the performance of a Rezero Calibration.

For the model 9020 and 9021, which have no internal manifold or valving, a *minimum* pressure must be applied to all specified transducers by suitable user-supplied plumbing. Since in many instances a true zero psi(a) pressure can not be applied to the 902x transducers, the alternate form of the command allows the value of the actual applied pressure to be specified. For more accurate calculation of the offset correction coefficient, this pressure should be as close to zero as possible.

Refer to Section 3.1.3.3 for information concerning interpreting the returned "scaled" offset values (models 9010, 9015, and 9020 only).

Note: The calculated offset values will be lost when the module is powered off. To save these offset terms to each transducer's nonvolatile memory refer to the *Set Operating Options* ('w') command.

Examples:

(1) Send command to Optomux module 175 (AF hex) to calculate and set offset coefficients for channels 16 through 9, and channel 1 (include the DC hex checksum). Assumes "zero" pressure is applied to all channels :

">AF**hFF01**DC **r** "

Read the response, containing all the returned "scaled" offset values that were calculated and stored in the module's volatile main memory (also read the 2C hex checksum):

"**A000300040005000400030006000700080030**2C **r** "

The following offset values are returned in the response above:

channel 16 = 0003.
channel 15 = 0004.
channel 14 = 0005.
channel 13 = 0004.
channel 12 = 0003.
channel 11 = 0006.
channel 10 = 0007.
channel 9 = 0008.
channel 1 = 0030.

(2) Send command to a model 9016 TCP/IP module (via its open socket) to calculate and set offset coefficients for channels 16 through 13.

"**hF000**"

Read response, containing all new offset values (also stored in the module's volatile main memory):

"**0.0010 0.0020 0.0015 0.0025**"

Actual offset values are returned in the above response as decimal fixed-point ASCII strings, with single space characters separating them. From left-to-right: they are for channels 16, 15, 14, and 13. Please note that the 'A' (acknowledge) value is not used by the 9016 when such actual data are returned.

9016, 9021 only

READ TEMPERATURE COUNTS (Non-Standard Command 'm')

Purpose: Returns the most recently acquired *raw temperature* data for the specified channels in averaged A/D counts (in the range -32768 to +32767). It is the same as command **'a'**, except that the raw data reflects a channel's *temperature* signal instead of its *pressur*e signal. Each datum returned in the response will be in the specified high-precision data format, but representing A/D counts as a truncated integer average. **This command is intended for advanced users only and is not required for normal operation.**

	Core String	Full Optomux String
Command:	**`"mppppf"`** 'm' is the *command* letter 'pppp' is the *position* field 'f' is the *format* field	unimplemented
Response:	**`" dddd.. dddd"`** ' dddd' are the *data* fields, each w. leading space (except binary form 7).	unimplemented

Description: The 4-character hex *position* field (pppp) specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (f) specifies the format of each *data* field (dddd) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number supplied, and each datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	ASCII data field returned	internal datum before formatting
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value shown	32-bit binary IEEE *single*-precision floating-point e.u. value
1	8-char. ASCII hex number (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value
2	16-char. ASCII hex number (big-endian)	64-bit binary IEEE *double*-precision floating-point e.u. value
:	:	:
5	8-char. ASCII hex number (big-endian)	32-bit binary integer encoding of e.u. value times 1000.
:	:	:
7	4-byte binary (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value

Examples:

(1) Send command to TCP/IP module 5 (via its connected socket) that returns ASCII decimal fixed-point raw “temperature” A/D counts data for channels 1, 5, 9, and 13:

"**m11110**"

Response contains data for channels 13, 9, 5, and 1 (left to right):

“ **32767.000000 -32700.000000 10.000000 16385.000000**"

Please note that channel 13 is saturated at +full scale, channel 9 is almost saturated at -full scale. Channel 5 reads near zero, and Channel 1 is about ½ +full-scale.

9016, 9021 only

READ TEMPERATURE VOLTAGES (Non-Standard Command 'n')

Purpose: Returns the most recently acquired *raw temperature* data for the specified channels converted to engineering-unit Volts directly from the averaged A/D counts. It is the same as command **'V'**, except that the raw data reflects a channel's *temperature* signal instead of its *pressur*e signals. Each datum returned in the response will be in the specified high-precision data format. **This command is intended for advanced users only and is not required for normal operation.**

	Core String	Full Optomux String
Command:	**"nppppf"** 'n' is the *command* letter 'pppp' is the *position* field 'f' is the *format* field	unimplemented
Response:	**" dddd.. dddd"** ' dddd' are the *data* fields, each w. leading space (except binary format 7).	unimplemented

Description: The 4-character hex *position* field (pppp) specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (f) specifies the format of each *data* field (dddd) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number supplied, and each datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	ASCII data field returned	internal datum before formatting
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value shown	32-bit binary IEEE *single*-precision floating-point e.u. value
1	8-char. ASCII hex number (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value
2	16-char. ASCII hex number (big-endian)	64-bit binary IEEE *double*-precision floating-point e.u. value
:	:	:
5	8-char. ASCII hex number (big-endian)	32-bit binary integer encoding of e.u. value times 1000.
:	:	:
7	4-byte binary (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value

Examples:

(1) Send command to TCP/IP module 5 (via its connected socket) that returns ASCII decimal fixed-point Voltage data (of the raw *temperature* signal) for channels 1, 5, 9, and 13:

"**n11110**"

Response contains data for channels 13, 9, 5, and 1 (left to right):

" **4.999999 -4.989500 0.005390 2.500001**"

Please note that channel 13 is saturated at +full scale, channel 9 is almost saturated at -full scale. Channel 5 reads near zero, and Channel 1 is about ½ +full-scale.

All Models

READ MODULE STATUS (Non-Standard Command ‘q’)

Purpose: Returns requested module status information.

	Core String	Full Optomux String
Command:	**“qii”** ‘q’ is the *command* letter ‘ii’ is the *status index* field	“>aa**qii**ss **r** ” see Section 3.1.2.1 for ‘aa’ and ‘ss’ extra Optomux field definitions
Response: (9010, 9015, 9020 only)	**“Adddd”** ‘A’ is the *acknowledge* letter	**“Adddd r ”**
Alternate Response: (9016, 9021 only)	**“dddd”**	unimplemented

Description: The *Index* field (ii) chooses a particular status field to be returned. It is two characters in length with functions as indicated in the following table:

Status Index	Data Returned Description	
00	Returns the model number (e.g, 9010) of the module as a 4-character string (eg., ‘9010')	
01	Returns the firmware version number of the module. Value is four (4) hex characters, indicating (Version * 100). Example: ‘0100' = 256 = Ver. 2.56	
02	Returns 4-character ASCII hex representation of a 16-bit binary status value. Each bit has the following meaning:	
	Bit 0 (LSB):	A/D Failure Error
	Bit 1:	Transducer Rezero Adjustment (offset) Term Range Error (out-of-range values set to 0.0 internally)
	Bit 2:	Transducer Span Adjustment (gain) Term Range Error (out-of-range values set to 1.0 internally)
	Bit 3:	Temperature Correction Coefficients Not Present or Out-of-Range (if transducer has one or more bad coefficients, all set to 0.0)
	Bit 4:	reserved (for transducer checksum)
	Bit 5:	FLASH Initialized Data Section Checksum Error (if error detected, all initialized data variables set to factory defaults and stored in FLASH)
	Bit 6:	SRAM Error

03	reserved - module status bits
04	reserved - module error status bits
05	Return Current A/D Average Count as 4-byte hex value. (model 9016 and 9021 only)

Examples:

(1) Request Model Number from Optomux module 1 (with 32 hex checksum):

">01**q00**32 **r** "

Read response (with CF hex checksum) indicating its a model 9015:

"**A9015**CF **r** ”

(2) Request same information from a TCP/IP (model 9016) module:

"**q00**"

Read response indicating its a model 9016:

"**9016**”

All Models

READ HIGH-PRECISION DATA (Non-Standard Command 'r')

Purpose: Returns the most recently acquired *engineering-unit* ***pressure*** data for the specified channels. Each datum returned in the response will be in the specified high-precision data format.

	Core String	Full Optomux String
Command:	**"rppppf"** 'r' is the *command* letter 'pppp' is the *position* field 'f' is the *format* field	">aa**rppppf**ss **r**" see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions
Standard Response: (9010, 9015, 9020 only)	**"A dddd.. dddd"** 'A' is the *acknowledge* letter ' dddd' are the *data* fields, each with leading space.	**"Adddd.. dddd** ss **r**" ' ss' is checksum w.leading space.
Alternate Response: (9016, 9021 only)	**" dddd.. dddd"** ' dddd' are the *data* fields, each with leading space (except binary format 7).	unimplemented

Description: The 4-character hex *position* field (pppp) specifies a 16-bit binary bit-map, with each bit (set to 1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (f) specifies the format of each *data* field (dddd) that will be returned in the requested response. **The first datum returned in the response will be for the highest channel number supplied.** Each following datum (and the Optomux checksum) will be preceded by a space character (except in the case of binary format 7). Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	ASCII data field returned	internal datum before formatting
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value shown	32-bit binary IEEE *single*-precision floating-point e.u. value
1	8-char. ASCII hex number (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value
2	16-char. ASCII hex number (big-endian)	64-bit binary IEEE *double*-precision floating-point e.u. value
:	:	:
5	8-char. ASCII hex number (big-endian)	32-bit binary integer encoding of e.u. value times 1000.
:	:	:

7	4-byte binary (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value

Unless the E.U. conversion scalar is altered, the returned data will be in units of psi.

Examples:

(1) Send command to Optomux module 5 that returns ASCII decimal fixed-point data for channels 1, 5, 9, and 13 (include CB hex checksum):

">05**r11110**CB **r** "

Response contains "acknowledge" and data for channels 13, 9, 5, and 1 (left to right):

"**A 1.234000 0.989500 1.005390 0.899602**

where 'xx' represents the calculated checksum.

(2) Send command to TCP/IP (e.g., model 9016) module 1 (via its connected socket), that returns same format and channels of first example:

"**r11110**"

Response contains data for channels 13, 9, 5, and 1 (left to right):

" **1.234000 0.989500 1.005390 0.899602**"

READ TRANSDUCER TEMPERATURE (Non-Standard Command 't')

9016, 9021 only

Purpose: Returns the most recently acquired *engineering-unit* ***temperature*** data (in °C) for the specified channels. Each datum returned in the response will be in the specified high-precision data format.

	Core String	Full Optomux String
Command:	**"tppppf"** 't' is the *command* letter 'pppp' is the *position* field 'f' is the *format* field	unimplemented
Response:	**" dddd.. dddd"** ' dddd' are the *data* fields, each with leading space (except binary format 7).	unimplemented

Description: The 4-character hex *position* field (pppp) specifies a 16-bit binary bit-map, with each set bit (1) specifying a particular channel number (16-1, left-to-right).

The 1-character *format* field (f) specifies the format of each *data* field (dddd) that will be returned in the requested response. **The first datum returned in the response will be for the highest channel number supplied.** Each following datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	ASCII data field returned	internal datum before formatting
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value shown	32-bit binary IEEE *single*-precision floating-point e.u. value
1	8-char. ASCII hex number (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value
2	16-char. ASCII hex number (big-endian)	64-bit binary IEEE *double*-precision floating-point e.u. value
:	:	:
5	8-char. ASCII hex number (big-endian)	32-bit binary integer encoding of e.u. value times 1000.
:	:	:
7	4-byte binary (big-endian)	32-bit binary IEEE *single*-precision floating-point e.u. value

Examples:

(1) Send command to TCP/IP module 5 (via its connected socket) that returns ASCII decimal fixed-point temperature data for channels 1, 5, 9, and 13:

"**t11110**"

Response contains data (in °C) for channels 13, 9, 5, and 1 (left to right):

" **21.234000 20.989500 21.005390 20.899602**"

All Models

READ INTERNAL COEFFICIENTS (Non-Standard Command 'u')

Purpose: Returns one (or more contiguous) requested internal coefficient(s) in a specified internal coefficient array, and in the specified response data format.

	Core String	Full Optomux String
Command:	**"ufaacc[-cc]"** 'u' is the *command* letter. 'f' is the *format* field. 'aa' is the *array index* field. 'cc[-cc]' is *coefficient index* [or contiguous *range*].	">aa**ufaacc[-cc]**ss**r**" see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions.
Standard Response:	**"A dddd.. dddd"** 'A' is the *acknowledge* letter. 'dddd' are the *data* fields w. leading blank.	**"A dddd.. dddd** ss**r**" ' ss' is checksum w. leading blank.
Alternate Response: (model 9016 and 9021)	**" dddd.. dddd"** 'dddd' are the *data* fields w. leading blank	unimplemented

Description: The 1-character *format* field (f) is a single decimal digit that defines the format of each returned datum in the response. All *data* fields returned (and the Optomux checksum) will be preceded by a *space* character. Most coefficients have a floating point datum type (f=0-1), while others have an integer datum type (f=5). Requesting an improper format will result in an "N08" error response. Valid format types for coefficients are shown in the following table:

f	ASCII data field returned	internal datum before formatting
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value shown	32-bit binary IEEE *single*-precision ***float***
1	8-char. hex number (big-endian)	32-bit binary IEEE *single*-precision ***float***
:	:	:
5	8-char. hex number (big-endian)	32-bit binary ***integer***

The 2-character *array index* field (aa) is a **hexadecimal value** selecting a particular internal coefficient array. The first *array index* (aa=01) refers to channel 1's transducer, the 16th (aa=10) refers to channel 16's transducer. Finally, the last array (aa=11) refers to a special global array.

A single 1- or 2- character *coefficient index* field (c or cc) is a hexadecimal value that selects a particular coefficient within the specified array. Multiple contiguous coefficients may be specified by using a *coefficient index"range"* specified by adding a hyphen (negative sign) between two such indexes.

Transducer Coefficient arrays are selected with ***array indexes*** **01 through 10 (hex).** All valid *coefficient indexes* (for these arrays) are listed in the following table:

Coefficient Index	Transducer Coefficient Description	Datum Type
00	rezero adjustment calibration (offset) correction term	FLOAT
01	span adjustment calibration (gain) correction term	FLOAT
02	EU conversion coefficient c0	FLOAT
03	EU conversion coefficient c1	FLOAT
04	EU conversion coefficient c2	FLOAT
05	EU conversion coefficient c3	FLOAT
06	EU conversion coefficient c4	FLOAT
07	user defined date field (described below)	INTEGER
08	date of factory calibration (described below)	INTEGER
09	transducer manufacturing reference number	INTEGER
0A	transducer full-scale range code (refer to Appendix I)	INTEGER
0B	temperature 1 pressure 1 voltage	FLOAT
0C	temperature 1 pressure 2 voltage	FLOAT
0D	temperature 1 pressure 3 voltage	FLOAT
0E	temperature 1 pressure 4 voltage	FLOAT
0F	temperature 1 pressure 5 voltage	FLOAT
10-14	temperature 2, pressures 1-5 voltages	FLOAT
15-19	temperature 3, pressures 1-5 voltages	FLOAT
1A-1E	temperature 4, pressures 1-5 voltages	FLOAT
1F-23	temperature 5, pressures 1-5 voltages	FLOAT
24-28	temperature 6, pressures 1-5 voltages	FLOAT
29-2D	reserved for future use (temperature 7)	FLOAT
2E	temperature 1 temperature output voltage at 0 psi	FLOAT
2F	temperature 2 temperature output voltage at 0 psi	FLOAT
30	temperature 3 temperature output voltage at 0 psi	FLOAT
31	temperature 4 temperature output voltage at 0 psi	FLOAT
32	temperature 5 temperature output voltage at 0 psi	FLOAT

Coefficient Index	Transducer Coefficient Description	Datum Type
33	temperature 6 temperature output voltage at 0 psi	FLOAT
34	temperature 7 temperature output voltage at 0 psi	FLOAT
35	temp vs pressure correction coef t0	FLOAT
36	temp vs pressure correction coef t1	FLOAT
37	temp vs pressure correction coef t2	FLOAT
38	temp vs pressure correction coef t3	FLOAT

The date of calibration field (coefficient index 08) identifies the date of factory calibration for the DH200 transducer. It is stored internally as a 32-bit integer whose value is in the formate of yymmdd (year, month, day). The user defined date field (coefficient index 07) is a 32-bit integer which may be encoded in a similar manner. Possible uses are to indicate the date of last user zero and/or span calibration or possibly the date of next required calibration. If this optional field is used, the user is responsible for correctly encoding the date into the proper 32-bit integer value. Any modifications of the user defined field (using the Download Internal Coefficients ('v') command) will result in the new value automatically being entered to transducer nonvolatile memory.

A special single ***EU Conversion Scaler Coefficient*** array is selected with ***array index*** **11 (hex).** All the valid *coefficient indexes* (for this array only) are listed in the following table:

Coefficient Index	EU Conversion Scaler Coefficient Description	Datum Type
00	reserved - EU conversion offset term	FLOAT
01	EU conversion output scaler	FLOAT
02	reserved - EU conversion nonlinearity term	FLOAT
03	Vref measured (902x only)	FLOAT
04	Ref G1 (902x only)	FLOAT
05	Ref G20 (902x only)	FLOAT
06	Ref G45 (902x only)	FLOAT
07	Ref G90 (902x only)	FLOAT

Examples:

(1) Send command to Optomux module 5, requesting the most recent calibration adjustment's *offset* and *gain* terms (cc=00-01), and the adjacent factory-determined transducer coefficients C0 through C4 (cc=02-06). Fetch these from channel # l's array (aa=01). Return each single float datum encoded as a hexadecimal value (f=1). Include 5F hex checksum:

">05u10100-065F **r** "

Response returns the data in the order requested by cc (xx is an unspecified hex checksum):

"A 3B200A6E . . 00000000 xx **r** "

(2) Send same command as above, but to TCP/IP module 5 (via its connected socket):

"u10100-06"

Response returned is:

" 3B200A6E . . 00000000"

All Models

DOWNLOAD INTERNAL COEFFICIENTS (Non-Standard Command 'v')

Purpose: Downloads one or more internal coefficients to the module.

	Core String	Full Optomux String
Command:	**"vfaacc[-cc]dddd..dddd"** 'v' is the *command* letter. 'f' is the *format* field. 'aa' is the *array index* field. 'cc[-cc]' is coefficient index [or contig.range]. 'dddd' are the *data* field(s).	">aa**vfaacc[-cc]dddd..dddd**ss **r**" see Section 3.1.2.1 for 'aa' and 'ss' extra Optomux field definitions
Response:	**"A"** 'A' is the *acknowledge* letter.	**"A r"**

Description: The 1-character *format* field (f) is a single decimal digit that defines the format of each datum to be downloaded in the command's data fields. All *data* fields (and Optomux checksum) must be preceded by a *space* character. Most coefficients have a floating point datum type (f=0-1), while others have an *integer* datum type (f=5). Sending a datum in the improper format will result in an "N08" error response. Valid format types for coefficients are shown in the following table:

f	ASCII data field returned	internal datum before formatting
0	11-char. decimal fixed-point number (6 digits after decimal point) with sign and extra leading spaces as needed per the value shown	32-bit binary IEEE *single*-precision ***float***
1	8-char. ASCII hex number (big-endian)	32-bit binary IEEE *single*-precision ***float***
:	:	:
5	8-char. ASCII hex number (big-endian)	32-bit binary ***integer***

The 2-character *array index* field (aa) is a **hexadecimal value** selecting a particular internal coefficient array to receive the downloaded data. The first *array index* (aa=01) refers to channel 1's transducer, the 16th (aa=10) refers to channel 16's transducer. Finally, the last array (aa=11) refers to a special global array.

A single 1- or 2- character *coefficient index* field (c or cc) is a hexadecimal value that selects a particular coefficient within the specified array. Multiple contiguous coefficients may be specified by using a *coefficient index "range"* specified by adding a hyphen (negative sign) between two such indexes.

Transducer Coefficient arrays are selected with ***array indexes*** **01 through 10 (hex).** A special single ***EU Conversion Scaler Coefficient*** array is selected with ***array index*** **11 (hex).** All the valid *coefficient indexes* (for each array type) are listed in the appropriate tables included in the description of the previous ***Read Internal Coefficients*** **('u')** command.

Examples:

(1) Send command to Optomux module 3, with replacement values for the channel's offset and gain correction terms loaded into the module's volatile memory (cc = 00-01). Load these into channel # 8's ***Transducer Coefficient*** array (aa=08). Each value will be a single fixed-point decimal datum (f=0). Include an unspecified xx hex checksum:

">03**v00800-01 0.000 1.000** xx **r** "

Response returned is:

"A **r** "

(2) Send same command (above), but to TCP/IP module 5 (i.e., via its connected socket):

"**v00800-01 0.000 1.000**"

Response returned is:

"A"

(3) Send command to TCP/IP module (via its connected socket) to change its default EU output from psi to kPa. This will be done by changing the EU conversion scaler to 6.894757.

"**V01101 6.894757**"

Response returned is

"A"

All Models

SET OPERATING OPTIONS (Non-Standard Command ‘w’)

Purpose: Change a module’s default operating settings, or invoke special internal operations.

	Core String	Full Optomux String
Command:	**“woo[dd[bbbb]]”** ‘w’ is the *command* letter. ‘oo’ is the *option index* field. ‘dd’ is an [optional] hex *datum* field. ‘bbbb’ is an [optional] hex *backoff* field.	“>aa**woo[dd]**ss **r**” see Section 3.1.2.1 for ‘aa’ and ‘ss’ extra Optomux field definitions.
Response:	**“A”** ‘A’ is the *acknowledge* letter.	**“A r”**

Description: The *option index* field (oo) identifies a new value for a specified option setting or causes an internal operation to be initiated. The optional hexadecimal *datum* field (dd) must contain 2 characters. The optional *backoff* field [bbbb] is only used by certain options of the TCP/IP model 9016 or 9021 *option indexes* (and associated *datum)* are listed in the following table (-- indicates that no datum should be supplied in the command):

Option Index (hex)	**Datum** (hex)	**Option or Operation Description**
00	--	Execute Internal Self Test.
01	--	Update Internal Thermal Coefficients.
02	--	Reserved - Set CPU Clock Speed.
:	:	:
07	--	Store Nonvolatile Data to Flash Memory (9010, 9015, 9016 only).
08	--	Store current transducer *offset* terms in all transducers’ non-volatile memories.
09	--	Store current transducer *gain* terms in all transducers’ non-volatile memories.
0A	01-10	Set Number of Channels in Module (default: 8, C, or 10, is model dependent).
0B	00 01	**(for models 9010, 9015, 9016 only)** Enable ***Automatic Shifting of Calibration Valve*** during calibration command ***Calculate and Set Offsets*** (‘**h**’) (default). Disable this function. User will manually control calibration value.
	--	**(For models 9020 and 9021)** Store Nonvolatile Data to Flash Memory
0C	00 01	**(for models 9010, 9015, 9016 only**; reserved for model 9020 and 9021) Place calibration valve in the RUN position NOW. Place calibration valve in the CAL position NOW.

Option Index (hex)	Datum (hex)	Option or Operation Description
0D	--	Reserved - Store transducers' raw thermal calibration data.
0E	--	Reserved - Store transducers' temperature correction coefficients.
0F	00 01	Disable periodic ***Thermal Coefficient Update*** task. Enable periodic ***Thermal Coefficient Update*** task (default).
10	01-FF	Set ***Number of A/D Samples to Average.*** **(default = 20 hex or 32 decimal)**
11	 01 02 03 04 05 06 07	(**for models 9010, 9015, or 9020 only**; reserved for 9016 and 9021) Set RS-422/485 Host Port's baud rate to 1200 Set RS-422/485 Host Port's baud rate to 2400 Set RS-422/485 Host Port's baud rate to 4800 Set RS-422/485 Host Port's baud rate to 9600 (default) Set RS-422/485 Host Port's baud rate to 19.2K Set RS-422/485 Host Port's baud rate to 38.4K Set RS-422/485 Host Port's baud rate to 76.8K
12	 1	(**for models 9010, 9015, and 9016 only**; reserved for 9020 and 9021) Set Calibration Valve to RUN/CAL position (default) Set Calibration Valve to PURGE/LEAK position
13	 0 1	(**for model 9016 and 9021 only**; reserved for 9010, 9015, 9020) Disable use of RARP/BOOTP server for configuring IP addresses (default) Enable use of RARP/BOOTP server for configuring IP addresses
14	 00 01 02	(**for model 9016 and 9021 only**; reserved for 9010, 9015, 9020) Disable use of Back-Off Delay for Transmitted TCP/IP Messages (default). Enable use of Back-Off Delay for Transmitted TCP/IP Messages. Delay is calculated as the last byte of Ethernet Address * 20 uSec. Enable use of Back-Off Delay for Transmitted TCP/IP Messages, using specified backoff field's value (bbbb) * 20 microseconds. Max bbbb=8000
15	 00 01 02 03	(**for model 9020 and 9021 only**; reserved for 9010, 9015, or 9016) Set Amplifier Gain to 5000 mV FS Range (default) Set Amplifier Gain to 250 mV FS Range (G=20) Set Amplifier Gain to 100 mV FS Range (G=45) Set Amplifier Gain to 50 mV FS Range (G=90)
16	 00 01	**(for model 9016 and 9021 only)** TCP/IP data field contains command response only (default) Include 2-byte binary value at the beginning of TCP/IP data field containing total length of TCP data returned. See Section 3.1.3.5.

Modification of option index 13, 14, or 16 hex will result in the specified operating mode becoming the new module power-on default. All other configuration parameters must be saved to module Flash memory in order to be retained after module power cycles.

Examples:

(1) Send command to Optomux module 8 setting the Cal valve to the Cal/Rezero position (include B3 hex checksum):

">08**w0C01**B3 **r** "

Response will normally be:

"**A r** "

(2) Send same command (above) to TCP/IP module (via its connected socket):

"**w0C01**"

Response will normally be:

"**A**"

3.3 Obsolete Commands

Users of older model 9010 and 9015 modules will notice that several previously documented commands are missing. Most of these missing commands were “standard” Optomux commands that were never of functional value for System 9000 modules. This is mainly because of basic design philosophy differences between PSI and vendors of other less capable Optomux modules. These commands were included in the original System 9000 documentation and module firmware for compatibility with third party software packages. Such commands have now been removed from the System 9000 documentation in the interest of easier learning and product simplicity. They may still continue to exist in newer firmware versions of several older models. However**, they are not available in the 9016 and 9021 models, and will eventually be removed from all System 9000 firmware**.

Obsolete commands fall into three classes:
! *dummy* commands (that executed but essentially did nothing),
! *duplicate* commands (with capabilities less than (or the same as) other “alternative” commands), and
! *piecemeal* commands (that executed only parts of other “complete” commands).

Obsolete *dummy* commands include:
‘C’ Set Turn-Around Delay,
‘G’ Configure Positions,
‘H’ Configure as Inputs;
and users should remove any usage of these from host programs if use of newer System 9000 modules is contemplated.

Obsolete *duplicate* commands include:
‘j’ Read Module Configuration, and
‘M’ Read and Average Analog Inputs;
which should be replaced by commands Read ***Module Status*** (‘**q’**) and ***Read Scaled Analog Inputs*** (**‘L’**) or **Read High Precision Data ('r')**.

Obsolete *piecemeal* commands include:

‘T’ Start Input Averaging,
‘I’ Read Average Completion Bits,
‘U’ Read Input Averaged Data,
‘g’ Calculate Offsets,
‘W’ Set Offsets,
‘X’ Calculate Gains,
‘Y’ Set Gains;

which should be replaced as follows. The sequence ‘T’, ‘I’, and ‘U’ were piecemeal parts of the (now obsolete) command ‘M’ — which was itself replaced by ***Read Scaled Analog Inputs*** (**‘L’**). Also, there is the higher-resolution alternative ***Read High-Precision Data*** (**‘r’**) command. The piecemeal pair of calibration commands ‘g’ and ‘W’ have always had a complete alternative, the ***Calculate and Set Offsets*** (**‘h’**) command. Likewise, the other pair of calibration commands ‘X’ and ‘Y’ have always had a complete alternative, the ***Calculate and Set Gains*** (**‘Z’**) command.

Chapter 4

Calibration

4.1 Introduction

Each System 9000 pressure transducer contains nonvolatile read/write memory capable of storing the transducer's full thermal and pressure calibration data[1]. The internal firmware of each module reads all of these calibration data from each transducer upon power up — and then dynamically calculates other conversion coefficients that convert transducer output into pressure at the current measured temperature. The firmware uses these coefficients for all subsequent engineering-unit data conversions performed.

All System 9000 Intelligent Pressure Scanner modules use a third-order polynomial to convert transducer output voltage to pressure. All calculations are carried out internally using high precision math. The following formula is used for all pressure output calculations.

$$P_T(V) = [C_0(T) - C_{RZ} + C_1(T)*V + C_2(T)*V^2 + C_3(T)*V^3] * C_{SPAN}$$

where:

P_T	=	Applied pressure
V	=	Transducer output voltage
$C_0(T)$ .. $C_3(T)$	=	Conversion coefficients generated from calibration data at temperature T.
C_{RZ}	=	Rezero correction coefficient
C_{SPAN}	=	Span correction coefficient

Since the polynomial's coefficients are a function of the current temperature, they are dynamically re-calculated by the module firmware (with other equations) to compensate for each transducer's measured temperature change.

The model 9020 and 9021 allow their channels to be independently configured with or without an attached digital pressure transducer. When the model 9020 detects the presence of a 9400 (gauge) or 9401 (absolute) pressure transducer on a channel, all pressures calculated and returned for that channel are in gauge pressure units or absolute pressure units, respectively. Likewise, the 9020 firmware expects any user-specified calibration pressures to be in these appropriate gauge or absolute units.

When the model 9020 detects no digital pressure transducer on a channel, all data calculated and returned for that channel are in engineering-unit volts. By default, all such voltage channels will measure ±5 volts full-scale. However, the user may specify any of three (3) more sensitive voltage ranges — using the ***Set Operating Conditions*** (**'w'**) command (see *option index* = 15 hex).

For reference when operating the 9010, 9015 or 9016 calibration manifolds, Figures 4.1 thru 4.4 show simplified pneumatic diagrams of the calibration manifold in its various operating positions.

1 Models 9400 and 9401 greater than 750 psi, all 9402, and other analog only transducers do not contain internal calibration data. These units are generally measured as scaled voltages only.

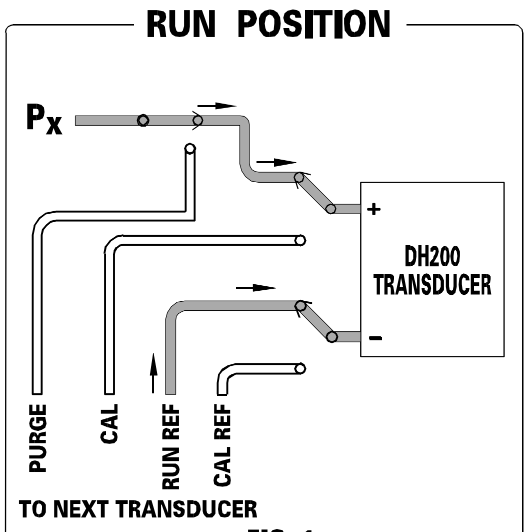


FIG. 1

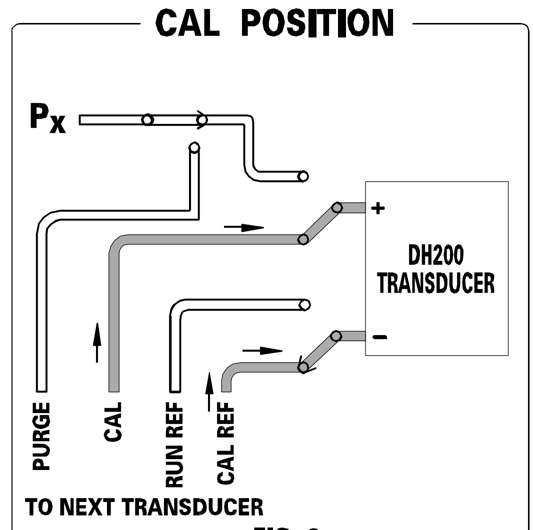


FIG. 2

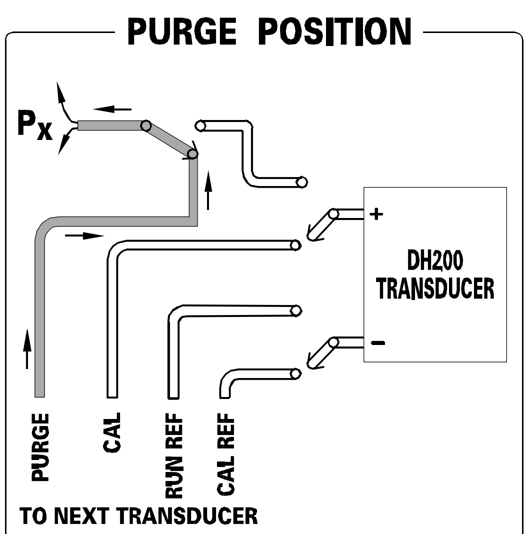


FIG. 3

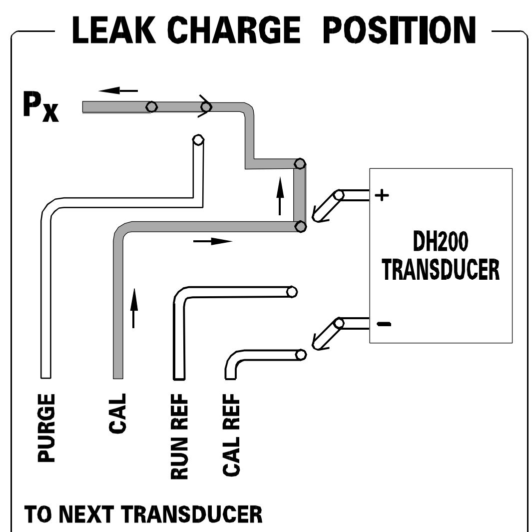


FIG. 4

Figures 4.1 - 4.4: Pneumatic Diagrams of the Calibration Manifold

4.2 Rezero Calibration

The System 9000 Intelligent Pressure Scanners are capable of independently performing a transducer calibration function, referred to as *Rezero adjustment* (or simply Rezero Cal). The Rezero calibration will result in a recalculated "offset" coefficient for each channel being calibrated, which automatically compensates for any transducer offset drift errors. Since the factory-set coefficients in each transducer (that characterize both pressure and temperature) are extremely stable over time, these simple offset corrections compensate for the majority of transducer errors over time. For this reason, a Rezero may be the only calibration adjustment required by many applications. An optional Span calibration adjustment is also available for those applications requiring more accuracy.

For the models 9010, 9015, and 9016, with integral DH200 pneumatic transducers, internal manifolds and valves allow a Rezero calibration to be accomplished easily and automatically. For the model 9020 and 9021, which have external 9400, 9401 or 9402 all-media transducers, the user must perform off-line rezero or supply any necessary valves and controls to accomplish the application of a "minimum" pneumatic or hydraulic pressure to these transducers.

When instructed to execute a ***Calculate and Set Offsets*** ('**h**') command, the System 9000 module will automatically perform the *Rezero adjustment* calibration, and then update the *offset coefficients* in its memory. It will subsequently use the newly calculated terms for all future engineering-unit calculations.

Note: When using the *Calculate and Set Offsets* command ('h'), only local terms in the module's volatile main memory (RAM) are updated. Under normal operation, it is not recommended to store these new coefficients in transducer non-volatile memory. Instead the rezero should be performed at regular intervals. Refer to Section 4.4 if it is desired to also store these *new* rezero terms in transducer nonvolatile memory.

4.2.1. Rezero Calibration Valve Control

When instructed to execute a Rezero (***Calculate and Set Offsets*** ('**h**') command), the model 9010, 9015, and 9016 modules will normally shift the internal calibration valve into the CAL position — and use the pressures present at the CAL and CAL REF inputs for the "minimum" (e.g., zero) calibration pressure. After the Rezero adjustment is complete, the calibration valve will be placed in the RUN position. This automatic shift of the calibration valve can be disabled through use of the ***Set Operating Options*** ('**w**') command. This allows independent control of the calibration valve by the user using other options (see *option index* = 0C hex) of the same command.

4.2.2 Rezero Calibration Summary

The following is a simple, step-by-step procedure for executing a rezero calibration of a 9010, 9015, or 9016 Intelligent Pressure Scanner.

Description	TCP/IP Data	Optomux Command
Disable automatic valve shifting after module power up (optional)	w0B01	>010B01??
… normal data acquisition		
Apply 0.0 psi differential to the module CAL and CAL REF inputs		
Place the module calibration manifolds into the CAL position	w0C01	>01w0C01??
Delay for settling of pneumatic inputs		
Instruct module to calculate new offset coefficients for all 16 channels	hFFFF	>01hFFFF??
Verify offset null of measured data (optional)	rFFFF0	>01rFFFF0??
Place calibration manifold back into the RUN position	w0C00	>01w0C00??
Store new zero coefficients to transducer nonvolatile memory	w08	>01w08??
… continue normal data acquisition		

The following is a simple, step-by-step procedure for executing a rezero calibration of a 9020, or 9021 Intelligent Pressure Scanner with 12 attached Model 9401 external absolute pressure transducers. For the purposes of this example, it will be assumed that a minimum pressure of 2.5 psia is available for the calibration.

Description	TCP/IP Data	Optomux Command
… normal data acquisition		
… halt data acquisition		
Through external manifolding, apply 2.5 psia to the input ports of the 12 9401 transducers		
Delay for settling of pneumatic inputs		
Instruct module to calculate new offset coefficients for all 12 channels	h0FFF 2.5	>01h0FFF 2.5 ??
Verify offset null of measured data (optional)	r0FFF0	>01r0FFF0??
Store new zero coefficients to transducer nonvolatile memory	w08	>01w08??
Restore 9401 pneumatic inputs to test points		
… continue normal data acquisition		

4.3 Span Calibration

For improved accuracy, the System 9000 Intelligent Pressure Scanners are capable of independently performing a transducer calibration function, referred to as *Span adjustment* (or simply Span Cal). Actually, there is a provision to supply any suitable “upscale” pressure (e.g., actual transducer full-scale) during such a calibration adjustment. The *Span adjustment* calibration will result in a recalculated “gain” coefficient for each channel being calibrated, to compensate for any transducer or module gain errors. For best results, a Rezero calibration should be performed before performing a span calibration.

For the models 9010, 9015, and 9016, with integral DH200 transducers, internal manifolds and valves allow a Span adjustment pneumatic calibration to be accomplished easily and automatically. For the model 9020 and 9021, which has external 9400, 9401 or 9402 all-media transducers, the user must supply any necessary valves and controls to accomplish the application of an upscale pneumatic or hydraulic pressure to these transducers.

It is recommended that a *Span adjustment* be performed whenever new transducers are installed in the instrument. In such cases, the new span coefficients should always be stored back into the transducer’s nonvolatile memory afterwards. In other cases, the user’s application may not require periodic span adjustment — as the other factory-determined pressure/temperature coefficients (stored permanently inside each transducer) are extremely stable. Only an occasional *Rezero adjustment* may be all that is necessary.

When instructed to execute a ***Calculate and Set Gains*** ('**Z**') command, the module will perform the *Span adjustment* calibration, and then update the *gain coefficients* in its memory. It will subsequently use the newly calculated terms for all future engineering-unit calculations.

Note: When using the *Calculate and Set Gain* (‘Z’) command, only the local variables in the module’s volatile main memory (RAM) are changed. Refer to Section 4.4 if it is desired to also store these new span terms in transducer nonvolatile memory.

4.3.1. Span Calibration Valve Control

Before executing a Span adjustment (***Calculate and Set Gains*** (**‘Z’**) command), the model 9010, 9015, and 9016 modules should have their calibration manifold valve placed in the proper position. For single pressure range units the CAL position should be used since the span calibration pressure can be applied between the CAL and CAL REF ports. Since the module will not attempt to shift this valve automatically, as it does for Rezero adjustment, it should be placed in the desired position with the ***Set Operating Options*** (**‘w’**) command (option index = 0C).

When span calibrating Model 9010, 9015, and 9016 modules with multiple ranges installed, the CAL port may be used to apply pressure to all transducers only if the specified proof pressure is not exceeded on any channel. Refer to ***Calculate and Set Gains*** (‘Z’) command to specify the channels to be affected by the command in a multi-range unit. If the application of a specific span pressure exceeds the proof pressure rating of any other transducer contained within the same scanner, the calibration pressures must be applied to the RUN side pneumatic input ports.

4.3.2. Span Calibration Summary

The following is a simple, step-by-step procedure for executing a span calibration of a 9010, 9015, or 9016 Intelligent Pressure Scanner. It is assumed that all channels in the unit are of the same full scale pressure range.

Description	**TCP/IP Data**	**Optomux Command**
Disable automatic valve shifting after module power up (optional)	w0B01	>010B01??
… normal data acquisition		
Perform Rezero calibration		
Place the module calibration manifolds into the CAL position	w0C01	>01w0C01??
Apply exact full scale pressure to the module CAL and CAL REF inputs		
Delay for settling of pneumatic inputs		
Instruct module to calculate new gain coefficients for all 16 channels	ZFFFF	>01ZFFFF??
Verify measured data reads expected full scale (optional)	rFFFF0	>01rFFFF0??
Place calibration manifold back into the RUN position	w0C00	>01w0C00??
Store new gain coefficients to transducer nonvolatile memory	w09	>01w09??
… continue normal data acquisition		

The following is a simple, step-by-step procedure for executing a gain calibration of a 9010, 9015 or 9016 Intelligent Pressure Scanner. For the purposes of this example, it will be assumed that an upscale pressure of 14.9800 psi is available from a dead weight tester for the calibration of 15 psi internal transducers. All sixteen channels are 15 psi full scale.

Description	**TCP/IP Data**	**Optomux Command**
Disable automatic valve shifting after module power up (optional)	w0B01	>010B01??
… normal data acquisition		
Perform Rezero calibration		
Place the module calibration manifolds into the CAL position	w0C01	>01w0C01??
Apply exact full scale pressure to the module CAL and CAL REF inputs		
Delay for settling of pneumatic inputs		
Instruct module to calculate new gain coefficients for all 16 channels	ZFFFF 14.98	>01ZFFFF 14.98??
Verify measured data reads expected full scale (optional)	rFFFF0	>01rFFFF0??
Place calibration manifold back into the RUN position	w0C00	>01w0C00??
Store new gain coefficients to transducer nonvolatile memory	w09	>01w09??

… continue normal data acquisition		

4.4 Coefficient Storage

The Rezero adjustment and Span adjustment calibration commands update local *offset* and *gain* coefficients, respectively, in the module's volatile main memory (RAM) only. These newer calibration coefficients will be lost when instrument power is turned off. The ***Set Operating Options*** ('**w**') command may be used to also store these coefficients back in each transducer's nonvolatile memory. This command's *option index* = 08 will store new *offset* coefficients, while its *option index* = 09 will store new *gain* coefficients. The validity of these coefficients should be verified before storing them into the transducer's nonvolatile memory.

With the Optomux 9010, 9015 and 9020 the standard calibration commands ('h' and 'Z') return new coefficients to the host in a standard Optomux "scaled" data format. The user may prefer to inspect these with the non-standard command ***Read Internal Coefficients*** (**'u'**). This command returns these data to the host in one of several more common high-resolution formats.

If the user finds it necessary to load a particular transducer's coefficients ***manually***, the ***Download Internal Coefficients*** (**'v'**) command may be used for this purpose. It allows the coefficients to be easily specified in a decimal fixed point numerical string format. Other high-resolution formats are also permitted for coefficient entry.

This page intentionally left blank.

Chapter 5

Service

5.1 Maintenance

All Models

This section provides a detailed step-by-step guide for performing repair and maintenance of typical System 9000 Intelligent Pressure Scanners.

Figure 5.1 is an exploded view of the model 9010 while Figure 5.2 contains an exploded view of the model 9016. Refer to these drawings for an understanding of the construction of all the Intelligent Pressure Scanners models.

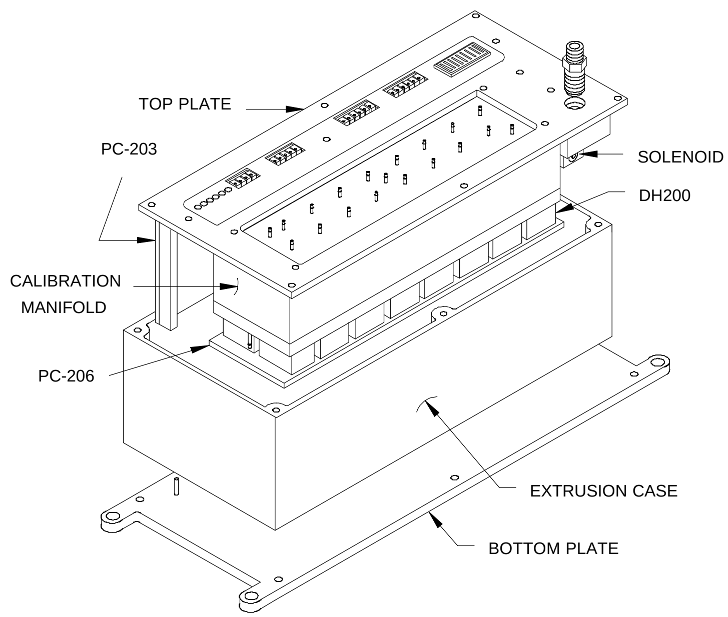


Figure 5.1: Exploded View of the Model 9010

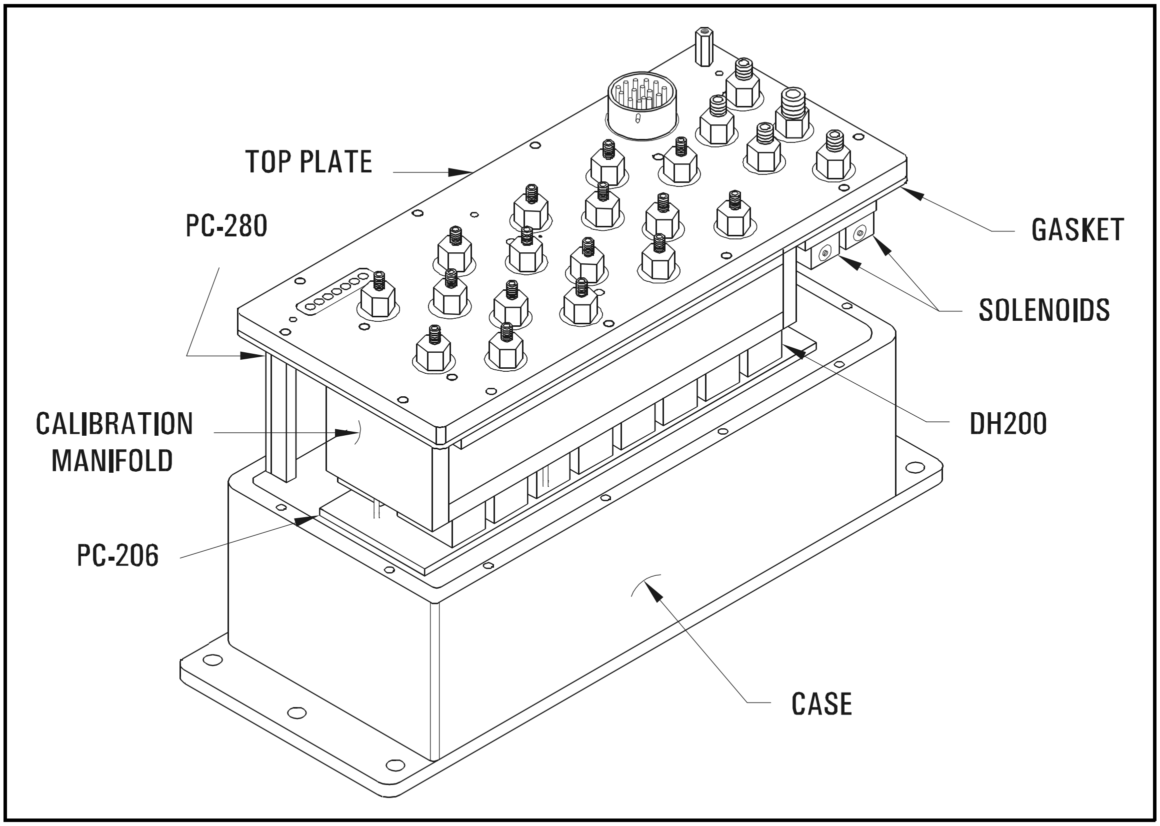


Figure 5.2: Exploded View of 9016

Table 5.1 provides a convenient cross reference summary of the components found in each Intelligent Pressure Scanner. This may be used as a guide to identify the appropriate component replacement sections in this chapter.

Component	Section	9010	9015	9016	9020	9021
PC-203 Microprocessor PCB Assembly	5.1.3.3	✓	✓		✓	
PC-280 Microprocessor PCB Assembly	5.1.3.4			✓		✓
PC-206 Amplifier/MUX PCB Assembly	5.1.3.1	✓	✓	✓		
PC-242 Amplifier/MUX PCB Assembly	5.1.3.2				✓	✓
Internal Pneumatic Calibration Manifold	5.1.6.x	✓	✓	✓		
Internal Solenoid Valves	5.1.5	✓	✓	✓		
Internal DH-200 Transducer	5.1.4	✓	✓	✓		
External 9400/9401 Transducer					✓	✓

Table 5.1: Component Cross Reference

5.1.1 Common Maintenance

All Models

The System 9000 Intelligent Pressure Scanners are designed for rugged use. No special preventive maintenance is required, although periodic maintenance may be required to replace worn or damaged components. Upgrades or modifications of module hardware or firmware may also be required periodically. For users who wish to do their own maintenance and repairs, maintenance kits and replacement parts for each model may be purchased from the factory.

When performing any type of maintenance of System 9000 components, the following guidelines and precautions should always be followed :

- **Verify that the work area and technicians are properly grounded to prevent damage to electronic components due to electrostatic discharge.**
- **Ensure that all electrical and pneumatic connections have been removed from the module.**
- **Ensure that the work area is free of dust and other possible contaminants that may affect the high tolerance machined parts (and pneumatic seals, if model has an integral manifold).**
- **Care must be taken to prevent contaminants from reaching O-ring surfaces. If O-ring surfaces require cleaning, use a lint-free applicator with Acetone to remove dirt and lightly lubricate the O-ring surface with Krytox® provided in the maintenance kit.**
- **Never use sharp objects to cut tubing from the bulged tubes. The tiny scratches left on the tubes could cause leaks.**

In the process of performing general maintenance on a module and in printed-circuit board replacement, the following tools may be required:

3/32" and 5/64" Allen-head screwdrivers,
a 3/16" hex wrench,
a needle nose tweezers,
a Phillips-head screwdriver, and
a small adjustable wrench.

5.1.2 Module Disassembly

All Models

The following procedure should be used to disassemble any model prior to any maintenance.

(1) Place the scanner with its external connectors facing up. With one hand holding the module housing, remove all screws securing the top plate to the module housing. These are located around the outer edge of the top panel of the module housing. For 9010, 9015, 9020, and 9021 scanners these will be six (6) 4-40 Allen-head screws which require a 3/32" Allen driver. The 9016 uses twelve (12) Phillips head screws around the top plate outside perimeter.

(2) When all screws have been removed, gently lift the top panel and attached electronics up and out of the extrusion housing. All components of the pressure scanner are attached to the top plate and will lift out of the module housing when the top plate is removed. See Figures 5.3 and 5.4. For 9016 scanners, carefully remove the Viton gasket with the module top plate. In some cases, it may be easier to hold the top plate and turn the module over, lifting the extrusion housing off of the top panel.

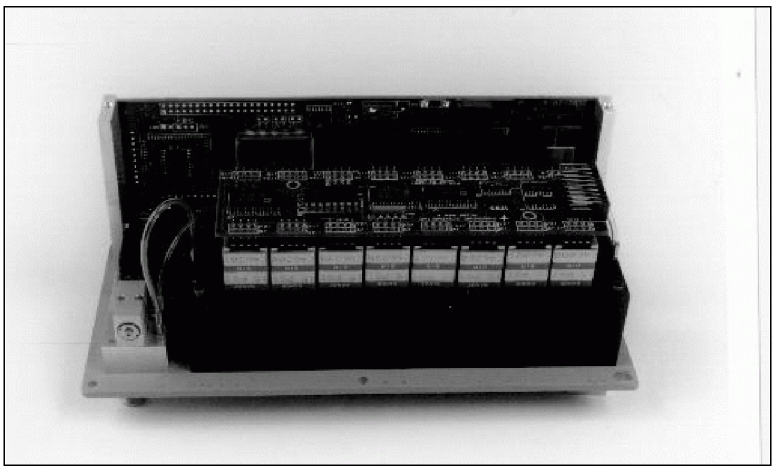


Figure 5.3: 9010 Instrument Out of Extrusion

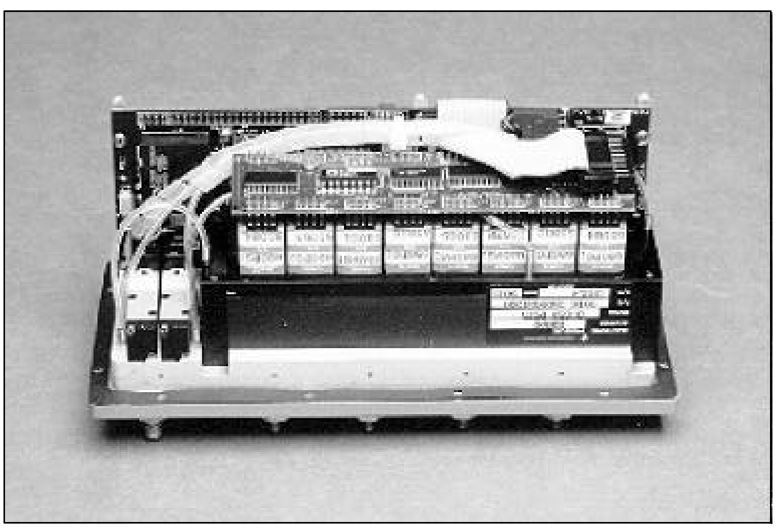


Figure 5.4: 9016 Instrument Out of Extrusion

5.1.3 Electronic Circuit Board Replacement

All Models

Different models of the System 9000 Intelligent Pressure Scanner use different combinations of the four basic circuit boards described below. To the right of each section title is a list of the modules which contain the particular circuit board assembly. Also refer to the cross reference in Table 5.1 for a summary of applicable components in each Intelligent Pressure Scanner.

5.1.3.1 PC-206 Amplifier/Multiplexer Board

9010, 9015, 9016 only

The following procedures should be used for replacement of the PC-206 Amplifier/Multiplexer Board. Use the tools and follow the general precautions described in section 5.1.1.

(1) Disassemble the module as described in Section 5.1.2. Carefully remove the wiring harness from connector P1 of the PC-206 board. Note the orientation of the PC-206 relative to the rest of the module to ensure the new PC-206 is installed in the same position.

(2) Remove the two (2) Phillips-head screws securing the PC- 206 board to the DH200 transducers. Carefully disconnect the PC-206 board from the DH200's by slowly working the board off of the DH200s; starting at one end and moving down the length of the board. It is important that the gold pins are not bent when removing the board.

(3) Replace the old PC-206 board with a new one by placing it loosely on top of the DH200's. Ensure the board end containing connector P1 is oriented the same as the board just removed. Inspect and make sure that all the gold pins fit easily into the female end of the connector on the DH200 transducers. Press the board down evenly until all pins are firmly seated.

(4) Install the two (2) Phillips-head screws to secure the PC-206 to the DH200s. Be careful not to over tighten. Install the wiring harness to connector P1 of the PC-206, **ensuring proper pin 1 location. (Pin 1 of the ribbon cable has a red stripe while pin one of P1 will contain a square solder pad on the PC-206.)**

(5) For 9016, carefully align the viton gasket on the top plate ensuring it is free of contaminants. Install the module electronics back into the extrusion case. Ensure that the alignment posts in the module's bottom panel align with the PC-203 or PC-280 electronics support brackets when placing the top panel and electronics back in the extrusion housing.

(6) Replace the screws that secure the top panel to the scanner housing and tighten. Do not over tighten, 7-9 inches-pounds torque should be sufficient.

(7) Test your scanner to ensure proper operation.

9020, 9021 only

5.1.3.2 PC-242 Amplifier/Multiplexer Board

The following procedures should be used for replacement of the PC-242 Amplifier/Multiplexer Board. The PC-242 is attached directly to the top plate of the 9020 and 9021. Note that slightly different revisions of the same board are used which contain different external connector styles. The 9020 version typically uses pluggable terminal strip connectors for external transducer interfaces. The 9021 makes use of 9-pin D-shell connectors. Use the tools and follow the general warnings already described at the start of Section 5.1.

(1) Disassemble the module as described in Section 5.1.2. Carefully remove the wiring harness from connector P1 of the PC-242 board.

(2) Remove the screws fastening the PC-242 board to the top panel and remove the board assembly. For a 9020 this will consist of six (6) Phillips head screws accessed from the circuit board side of the top plate. For the 9021 (with D-shell top plate connectors), this will consist of two (2) standoff screws attached to each top plate D-shell connector (for a total of 24 hex standoffs).

(3) Install the new PC-242 board by aligning the twelve interface connectors on the board with the cutouts on the top panel.

(4) Reinstall the hardware that secures the PC-242 to the top panel. Install the wiring harness to connector P1 of the PC-242, **ensuring proper pin 1 location. (Pin 1 of the ribbon cable has a red stripe while pin one of P1 will contain a square solder pad on the PC-206.)**

(5) Install the module electronics into the extrusion case. Ensure that the alignment posts in the module's bottom panel align with the PC-203 or PC-280 electronics support brackets when placing the top panel and electronics back in the extrusion housing.

(6) Replace the six (6) Allen-head screws that secure the top panel to the scanner housing and tighten.

(7) Test your scanner to ensure proper operation.

9010, 9015, 9020 only

5.1.3.3 PC-203 Microprocessor/A-D Board

The following procedures should be used for replacement of the PC-203 Microprocessor/A-D Board. Use the tools and follow the general warnings already described in section 5.1.1.

(1) Disassemble the module as described in Section 5.1.2.

(2) Remove the wiring harnesses from connectors P3 and P6 of the PC-203 board. The P6 connector may not be used in all models.

(3) Remove the three (3) 2-56 screws securing the PC-203 mounting brackets to the module top plate (requires 5/64" Allen-head screwdriver). These screws will be in line with the PC-203 connectors that protrude through the top plate. Carefully lift the board out of the top panel. See Figure 5.5.

(4) Using the Phillips-head screwdriver, remove the three (3) PC-203 mounting brackets from the old circuit board and reinstall them on the new circuit board. Be sure to reinstall nylon insulating washers in the same position on the new PC-203. (Note: Some PC-203 assemblies have a heat sink attached to one of the mounting brackets. This heat sink will contain one additional screw that must also be removed.)

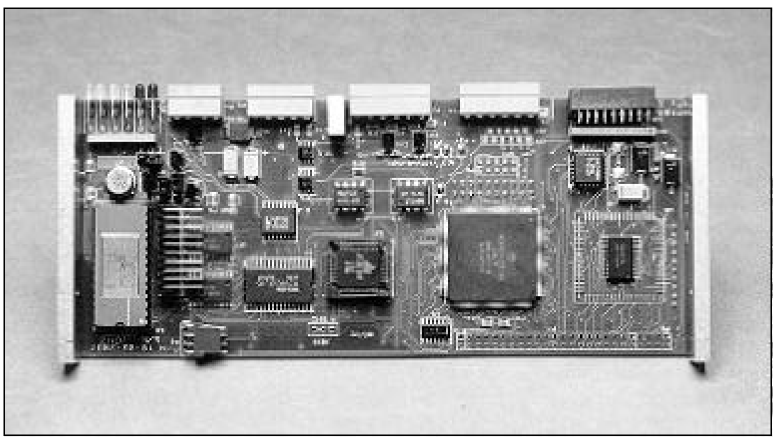


Figure 5.5: PC-203 Board

(5) Place the new PC-203 board so that its connectors and LEDS protrude through the top panel. **Loosely** install the three (3) 2-56 screws to secure the PC-203 mounting brackets to the top panel. (To ease reassembly, they will be tightened after installing the electronics back into the module case.)

(6) Reinstall the wiring harness on connector P3 of the PC-203 board **ensuring proper pin 1 orientation**. **(Pin 1 of the ribbon cable has a red stripe while pin one of P1 will contain a square solder pad on the PC-206.)** Also reinstall the wiring harness on connector P6 if it was present.

(7) Install the module electronics into the extrusion case, ensuring that the alignment posts in the module's bottom panel align with the holes in the PC-203 mounting brackets. Install the six (6) screws that secure the top panel to the extrusion housing. Tighten the three (3) screws attached to the PC-203 mounting brackets.

(8) Test your scanner to ensure proper operation.

9016, 9021 only

5.1.3.4 PC-280 Ethernet Microprocessor/A-D Board

The following procedures should be used for replacement of the PC-280 Ethernet Microprocessor/A-D Board. Use the tools and follow the general warnings already described in Section 5.1.1.

(1) Disassemble the module as described in Section 5.1.2.

(2) Carefully remove any attached wiring harnesses from connectors P1, P3, and P6 of the PC-280 board. In the 9016, this will require cutting one nylon tie-wrap attached to the center mounting bracket.

(3) Remove the three (3) 2-56 Phillips head screws securing the PC-280 mounting brackets to the top plate. These screws will be in line with the PC-280 LEDs that protrude through the top plate. Carefully lift the board out of the top panel. See Figure 5.6.

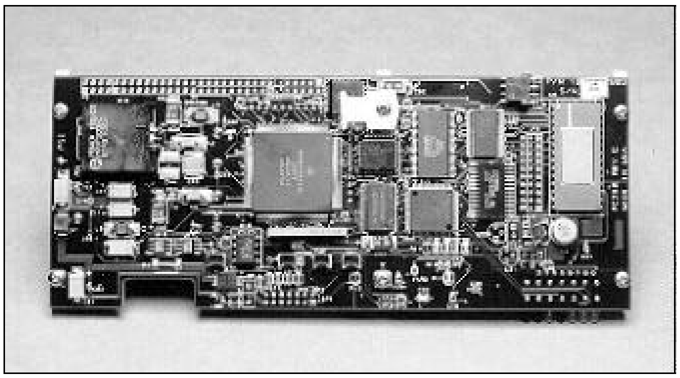


Figure 5.6: PC-280 Board

(4) Using the Phillips-head screwdriver remove the three (3) PC-280 mounting brackets from the old circuit board and reinstall them on the new circuit board. **Ensure that the mounting brackets are installed so that the clearance areas machined into the mounting brackets are towards the PCB assembly.** This will prevent electrical shorts between the mounting bracket and electrical traces on the PCB.

(5) Place the new PC-280 board so that its connectors and LEDS protrude through the top panel. **Loosely** install the three (3) 2-56 screws to secure the PC-280 mounting brackets to the top panel. (To ease reassembly, they will be tightened after installing the electronic back into the module case.)

(6) Reinstall any previously installed wiring harnesses on connectors P1, P3, and P6 of the PC-280 board. **Ensure proper pin 1 orientation when installing these connectors**. (Pin 1 of the ribbon cable has a red stripe while pin one of P1 will contain a square solder pad on the PC-206.)

(7) Install the module electronics into the extrusion case, ensuring that the alignment posts in the module's bottom panel align with the holes in the PC-280 mounting brackets. Ensure that there are no conductors from the P1 harness pinched between the top plate and the extrusion. On the model 9016, also ensure that the top plate gasket is properly installed. Install the screws that secure the top panel to the extrusion housing. Tighten the three (3) screws attached to the PC-280 mounting brackets.

(8) Test your scanner to ensure proper operation.

5.1.4 Replacement of Transducers

9010, 9015, 9016 only

The model 9020 Intelligent Pressure Scanner module has *external* 9400, 9401 or 9402 all-media transducers that are easily serviceable and replaceable without opening the module case. **Users of the model 9020 may skip the remainder of these sections.** All other models (9010, 9015, and 9016) have *internal* DH200 pneumatic transducers, as well as an *internal* calibration manifold with associated valves and O-rings. All these elements occasionally require service or replacement — as described in the following sections.

The following is a step-by-step procedure to replace a DH200 transducer in a model 9010, 9015, or 9016 Intelligent Pressure Scanner. Use the tools and follow the general warnings already described in Section 5.1.1.

(1) Disassemble the module as described in Section 5.1.2.

(2) Remove the PC-206 Amplifier/Multiplexer board as described in Section 5.1.3.1. Lay the circuit board aside on an anti-static surface.

(3) Remove the retaining screw from the desired DH200 transducer. Lift the transducer straight up to remove it. Make sure that the two (2) O-rings remain with the transducer as it is removed from the adapter plate. Ensure that the adapter plate O-ring sealing surface is clean and free of contaminants. See Figure 5.7.

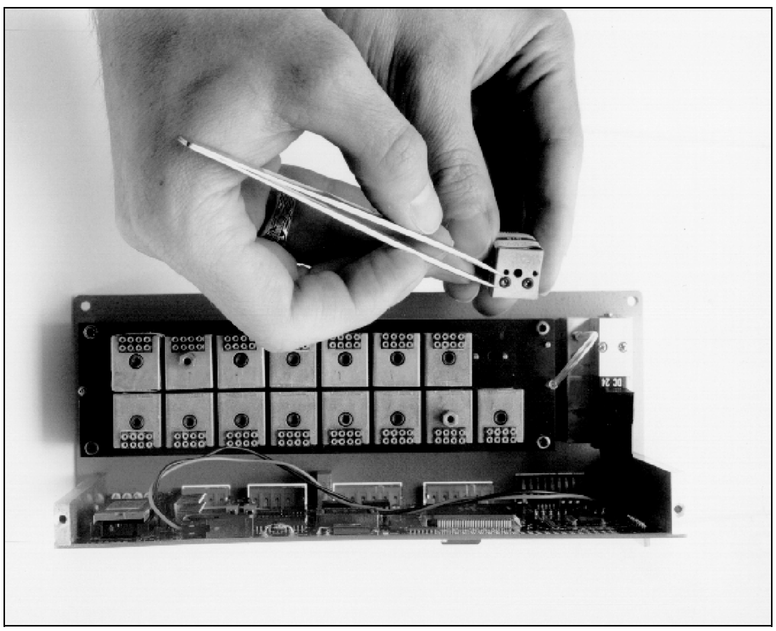


Figure 5.7: Top View of DH200

(4) Replace the DH200, making sure that the electrical connections are located on the outer edge of the cubic design. Be sure that the two (2) O-rings are in place on the DH200 and that O-ring surfaces are free of contaminants. The DH200 must fit the guiding pins smoothly and be aligned with all other DH200 transducers. Tighten the retaining screw snugly (finger tight plus 1/4 turn).

Note: The hex-head standoff screws used on DH200 positions 2 and 15 are used to secure the PC-206. These hex-head screws should not be overtightened or else the screw may break.

(5) Replace the PC-206 board as described in Section 5.1.3.1 and reassemble the module. Ensure that the two hex-head standoff screws are installed on DH200 positions 2 and 15 and that they align with the two PC-206 mounting holes.

(6) Test your scanner to ensure proper operation.

5.1.5 Calibration Valve Solenoid Replacement

9010, 9015, 9016 only

The following is a step-by-step procedure to replace the Calibration Valve Solenoids in a model 9010, 9015, or 9016 Intelligent Pressure Scanner. Modules containing the purge and leak check calibration manifold will contain two solenoid valves. Models without this feature will contain only one solenoid. Use the tools and follow the general warnings already described at the start of Section 5.1.1. Refer to Section 5.1.6.5 for details concerning solenoid o-ring replacement.

(1) Disassemble the module as described in Section 5.1.2.

(2) Carefully remove the two (2) Phillips-head screws from the top of the solenoid. Disconnect the solenoid from connector P6 of the PC-203 CPU board (models 9010 and 9015) or the PC-280 CPU board (model 9016). See Figure 5.8.

(3) If the either the new or old solenoid does not have a pluggable wiring harness at the solenoid, the new solenoid wires will require crimp pins to be installed for insertion in the P6 mating housing. The proper crimp pin is Molex part number 08-56-0110. After installing the crimp pins to the solenoid wiring, remove the old crimp pins from the Molex P6 housing and insert the new solenoid's wiring. Ensure that the new wires are installed in the same position as the old wires.

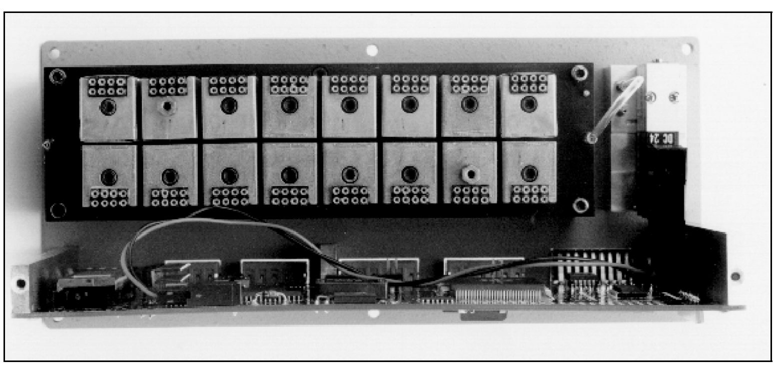


Figure 5.8: Solenoid in Module

(4) Ensure that the three (3) solenoid manifold O-rings are present and free of contaminants. Replace the solenoid with the new one by carefully aligning and gently tightening the screws.

(5) Attach the wiring harness to the solenoid and connector P6 of the PC-203 or PC-280 CPU board.

(6) Reassemble the module.

(7) Test your scanner to ensure proper operation.

5.1.6 Replacement of O-Rings

9010, 9015, 9016 only

Pressure Systems' calibration valves include static and dynamic o-ring seals. When used properly the rated durability of the dynamic o-rings is in excess of 1,000,000 shifts of the calibration valve.

The procedures described below should be used for replacement of all the O-rings in the models 9010, 9015, and 9016 Intelligent Pressure Scanners. Use the tools and follow the general warnings already described at the start of Section 5.1.

The material needed for the O-ring replacement can be acquired through the proper maintenance kit available from Pressure Systems. Specifically needed for these procedures are calibration manifold and piston O-rings, a fast evaporating cleaning fluid (i.e. acetone, alcohol, etc.), 50 PSI dry air supply, and Krytox Fluorinated grease **(read product warnings and recommendations thoroughly)**. **Service of O-ring seals requires a clean working environment.** Introduction of contaminants to the O-ring or internal calibration manifold surfaces can result in internal pneumatic leaks.

5.1.6.1 DH200 Pressure Tranducer O-Ring Replacement

9010, 9015, 9016 only

Please note that the DH200 O-rings are used for static seals only. They will typically not require replacement unless exposed to improper liquid medias (which will also damage other 901x components). The following is a step-by-step procedure to replace a DH200 O-Ring should it be required:

(1) Disassemble the module as described in Section 5.1.2.

(2) Remove the PC-206 Amplifier/Multiplexer board as described in Section 5.1.3.1. Lay the circuit board aside on an anti-static surface.

(3) Remove the DH200 transducer(s) as described in Section 5.1.4. If more than one DH200 is removed, record their serial numbers prior to removal to ensure they are reinstalled in the same locations.

(4) Remove the two (2) O-rings that are in need of replacement from the DH200 using tweezers. Clean the O-ring cup with a lint-free applicator moistened with a cleaning fluid such as acetone, alcohol, Freon, or any other substance that evaporates quickly and leaves very little residue. Remove any excess cleaner with the air supply as soon as possible. Do not blow air directly into the holes of the surface since that can drive the fluid into the transducer and/or rupture the silicon pressure transducer.

(5) With clean hands, apply a small amount of Krytox fluorinated grease to the palm of one hand and rub it out evenly with your index finger. Place one new O-ring onto your greased palm. Work the O-ring around until it is evenly greased. The O-ring should shine when properly lubricated. There should be no white area of excess grease on the O-ring. Make sure there is only a thin film of lubrication on the O-ring. Using your greased finger, place the greased O-rings in the cups on the DH200. Ensure that no grease enters the hole that leads into the transducer.

(6) Reinstall the DH200 as described in Section 5.1.4.

(7) Repeat steps 3, 4, 5 and 6 for each set of O-rings in need of replacement.

(8) Replace the PC-206 board as described in Section 5.1.3.1 and reassemble the module.

(9) Test your scanner to ensure proper operation.

5.1.6.2 Tubing Plate O-Ring Replacement

9010, 9015, 9016 only

The following is a step-by-step procedure to replace a Tubing Plate O-Ring in a model 9010, 9015, or 9016 Intelligent Pressure Scanner.

(1) Disassemble the module as described in Section 5.1.2.

(2) Place the scanner with the tubing plate on a clean, lint free surface.

(3a) 9010, 9015 only
Using a 3/32" Allen-head screwdriver, remove the four (4) Allen-head screws that secure the tubing plate to the top panel. Remove the top panel and then remove the remaining two screws in the center of the tubing plate. Proceed to step 4.

(3b) 9016 only
Hold the top plate/calibration valve assembly with one hand, supporting the bottom assembly to prevent dropping when all screws are removed. Remove the six (6) Phillips head screws on the top plate that secure the valve assembly to the top plate.

(4) Carefully rotate or slide the tubing plate back and forth, pivoting on the guiding pin about 1/8" four times. This is done to loosen the O-rings from the calibration manifold. Lift the tubing plate straight up. Do not touch the calibration manifold.

(5) Remove and replace the O-rings needing maintenance, using the procedure described in Section 5.1.6.1. Note that some O-ring seals use an additional Teflon cup seal placed on top of the O-ring. If the tubing plate requires these seals, they should also be lightly greased after installing onto the O-rings.

(6) Examine the tubing plate and calibration manifold to verify that no contaminants are on either surface. Replace the tubing plate by slowly placing the plate on the calibration manifold. Make sure that the O-ring side is down towards the pneumatic sliding manifold and the guiding pin on the calibration valve housing fits into the mating hole of the tubing plate.

(7a) 9010, 9015 only
Replace the two (2) Allen-head screws in the center of the tubing plate. Align the valve assembly on the module top plate and install the remaining four (4) Allen-head screws that pass through the top plate and the tubing plate corners. Tighten evenly, making sure that the screws are only finger tight plus 1/8 turn. It is important not to over tighten the screws since the pneumatic seal is made using dynamic O-rings.

(7b) 9016 only

Replace the six (6) Phillips-head screws that pass through the top plate to secure the calibration valve assembly. Tighten evenly, making sure that the screws are only finger tight plus 1/8 turn. It is important not to over tighten the screws since the pneumatic seal is made using dynamic O-rings.

(8) Reassemble the module.

(9) Test your scanner to ensure proper operation.

5.1.6.3 Adapter Plate O-Ring Replacement

9010, 9015, 9016 only

The following is a step-by-step procedure to replace an Adapter plate O-Ring in a model 9010, 9015, or 9016 Intelligent Pressure Scanner. The adapater plate is located opposite of the tubing plate on the calibration manifold. All DH200 transducers are attached to the adapter plate.

(1) Disassemble the module as described in Section 5.1.2.

(2) Remove the PC-206 Amplifier/Multiplexer board as described in Section 5.1.3.1. Lay the circuit board to the side on an anti-static surface.

(3) Remove the six (6) 3/32" Allen-head screws that secure the adapter plate to the calibration valve housing. To remove the two (2) center screws, you must remove the DH200 transducers near the screws. Make sure to note the DH200 serial number and location. The plate should be gently lifted from the calibration housing.

(4) Carefully rotate or slide the adapter plate back and forth, pivoting on the guiding pin about 1/8" four times. This is done to loosen the O-rings from the calibration manifold. Lift the adapter plate straight up. Do not touch the calibration manifold.

(5) Remove and replace the O-rings needing maintenance using the procedure described in Section 5.1.6.1. Note that some O-ring seals use an additional Teflon cup seal placed on top of the O-ring. If the tubing plate requires these seals, they should also be lightly greased after installing onto the O-rings.

(6) Examine the adapter plate and calibration valve surface to verify that no contaminants are on either surface. Replace the adapter plate by slowly placing the plate on the calibration manifold. Make sure that the O-ring is down towards the pneumatic sliding manifold and the guiding pin on the adapter plate fits into the mating hole of the calibration valve housing. Fasten the adapter plate evenly on all sides.

(7) Install the DH200 transducers that were previously removed. It is suggested to intall them back in their original location.

(8) Replace the PC-206 board as described in Section 5.1.3.1 and reassemble the module.

(9) Test your scanner to ensure proper operation.

5.1.6.4 Calibration Manifold Piston O-Ring Replacement

9010, 9015, 9016 only

The following is a step-by-step procedure to replace a Calibration Manifold O-Ring in a model 9010, 9015, or 9016 Intelligent Pressure Scanner.

(1) Disassemble the module as described in Section 5.1.2.

(2) Remove the PC-206 Amplifier/Multiplexer board as described in Section 5.1.3.1. Lay the circuit board aside on an anti-static surface.

(3) Remove the tubing plate as described in Section 5.1.6.3.

(4) Using your index finger, shift the calibration manifold back and forth four (4) times to loosen its connection with the tubing plate O-rings. Carefully lift the calibration valve housing with one hand and turn it over, letting the calibration manifold fall into the free hand. It is imperative that the calibration manifold does not fall on a hard surface since scratches on the manifold could result in pneumatic leaks. Using the air supply, apply about 30 psi (200 kPa) to the two bulge tubes on the adapter plate. This will result in the pistons being forced out of their cavity. If the pistons stick, apply a higher pressure. Place your free hand over the calibration valve housing to prevent the pistons from coming out of the housing.

(5) Remove the piston O-rings from their slot. Replace the O-ring as described in Section 5.1.6.1. Replace the pistons in their cavity by placing the O-ring side of the piston in first and then pressing the piston completely into its cavity with one finger.

(6) Clean and LIGHTLY grease the calibration manifold, being careful to not get grease in the openings of the manifold. Replace the calibration manifold in the housing, making sure that the guiding pin fits into the slot of the cal-valve housing.

(7) Replace the tubing plate as described in Section 5.1.6.3.

(8) Replace the PC-206 board as described in Section 5.1.3.1 and reassemble the module.

(9) Test your scanner to ensure proper operation.

5.1.6.5 Solenoid Valve O-Ring Replacement

9010, 9015, 9016 only

The following is a step-by-step procedure to replace the internal solenoid valve O-Rings in a model 9010, 9015, or 9016 Intelligent Pressure Scanner. Note that modules with the C3-C4 leak check/purge calibration manifold will contain two internal solenoid valves.

(1) Disassemble the module as described in Section 5.1.2.

(2) Remove the solenoid valve by unscrewing the two Phillips-head screws on top of the solenoid. Gently lift it out of the module.

(3) Remove and replace the O-rings needing maintenance using the procedure described in Section 5.1.6.1.

(4) Replace the solenoid valve and gently tighten the screws.

(5) Reassemble the module.

(6) Test your scanner to ensure proper operation.

5.2 Upgrading Module Firmware

All Models

All System 9000 Intelligent Pressure Scanner modules contain electronically reprogrammable memory devices that store the module firmware. Pressure Systems will occasionally provide new releases of module firmware to provide enhanced instrument performance. All models may have new firmware downloaded via the module's Diagnostic Port. This process generally requires taking the module to a computer (e.g., PC in a lab) or bringing the computer to the module. The Ethernet models 9016 and 9021 may also have their firmware downloaded via their Ethernet Host Port. This allows for firmware upgrade while the module is installed in its normal communications network environment. These new firmware releases may be obtained free of charge by contacting the factory for a copy on a DOS/Windows compatible diskette or by downloading from PSI's internet home page at www.psih.com. Links to the firmware download page can be found on the home page and in the information page for each model. All firmware is stored as a self-extracting archive file. Once downloaded, simply execute the download file to extract the archived file(s).

5.2.1 Upgrading Firmware Via Diagnostic Port

9010, 9015, 9020 only

Although all models may have their firmware upgraded through their Diagnostic port, users of the Model 9016 and 9021 are recommended to follow the Ethernet firmware upgrade procedures described in Section 5.2.2. For all other models (9010, 9015, and 9020) a PC compatible computer with one available COM port is required to upgrade module firmware via the module's Diagnostic Port. A new firmware update file can be transferred to the module by executing either the standard Start-Up software or by executing a special download program (dnload.exe) included on the diskette with the new firmware. Use the RS-232 Diagnostic Port Cable, described in Section 2.3.5. The following steps are used to upgrade to a new version of module firmware.

! Connect the RS-232 Diagnostic Port Cable (Model 9095 or user supplied) between the user's host computer (e.g., ports COM1 or COM2 on a PC) and the System 9000 module.

! Turn the module's power OFF, place DIP switches 8 and 9 in the OFF position, and then turn the module's power ON. This switch configuration places the module in the firmware upgrade mode. The module will not execute data acquisition functions in this mode.

! Carry out one of the following steps based on the desired download program.

Via START Program:

! Execute the START program on the host PC.

! Ensure the proper COM port is selected (INIT-COM PORT menu).

! Select the S9000 menu selection from the main menu.

! From the S9000 submenu select the DOWNLOAD function.

! Enter the name of the firmware download file (including drive path if required). This file name should be written on the firmware upgrade floppy diskette's label (e.g.,. V200_8.HEX).

Via DNLOAD Program on Diskette:

- Execute the DNLOAD program on the host PC.
- When requested by the program, enter the PC COM port that is attached to the System 9000 module.
- Next enter the name of the firmware download file (including drive path if required). This file name should be written on the firmware upgrade floppy diskette's label (e.g., V200_16.HEX).

Continuing With Either Program:

- The download program will transmit each line of the firmware hex file to the module with the module verifying receipt of each line. In the event that the download program does not receive an acknowledgment from the module, the program will retransmit the packet in question. After three failed retries, the program will abort. The complete download process requires approximately five minutes (longer for slow computers or floppy disk execution).
- After all data have been transmitted, the module will move all data to nonvolatile memory. After verification of the program cycle, the download program will report the download status and terminate, returning to the main program menu (or DOS prompt). The program and verification cycle takes approximately thirty seconds.
- After the download program has verified completion of the download process, turn module power OFF. Set ADDR switch 9 in the ON position and switches 1 through 8 in the appropriate position for the desired module address. Finally, turn module power ON.
- The System 9000 module with new firmware is now ready for use.

5.2.2 Upgrading Firmware Via Host TCP/IP Port

9016, 9021 only

For the model 9016 and 9021, with Ethernet (TCP/IP) Host Port, new firmware may be upgraded by the host computer, or any computer on the TCP/IP network, directly via the module's Host Port. This is much more convenient and faster than use of the RS-232 Diagnostic Port. New firmware releases are provided on a DOS/Windows formatted diskette. On this diskette a special **TCP/IP Command Test Program** that runs under Windows 95 or Windows NT will also be provided. Current firmware releases and utility programs such as TCP/IP Command Test may be downloaded from the PSI internet home page (www.psih.com). It is recommended that this program (and the new firmware update file) be installed to a suitable subdirectory of your hard disk for better performance. Installation instructions for this support software are provided with the application. Ensure that the TCP/IP communications is properly configured for the PC running the application. The following steps describe how to use this program to upgrade module firmware via your TCP/IP network.

- Execute PSI's host program called **TCP/IP Command Test Program** under Windows 95 or NT.
- Using the screen selected by the default **Connection Information** tab, enter either the *Name* or *IP Address* of the module to be updated in the ***Host IP Address*** field. Select the ***Connect*** button to make the connection between host and module.
- Using the screen selected by the **Download Upgrade** tab, enter the name of the file containing the firmware upgrade in the ***Filename to Download*** field. The ***Locate File*** button may be pressed to located this file on the hard disk or diskette drive.

- Select the ***Download*** button to initiate transfer of the file to the module. Other fields show the progress of the transfer, and display any errors that might occur. When the entire file is transferred, other information fields indicate that the Flash memory inside the module is being reprogrammed with the new file's contents. When this is successfully completed the module has the new firmware, and you may exit the program. This process requires approximately 90 seconds.
- When the 9016 or 9021 detects that the download procedure is complete, it will automatically reset itself and begin execution of the new firmware version.

Chapter 6

Troubleshooting Guide

6.1 Optomux Module Troubleshooting

9010, 9015, 9020 only

The typical troubleshooting strategy for an Optomux System 9000 Intelligent Pressure Scanner module is as follows:

- First, module operation will be tested to verify that the instrument is operating correctly and has not detected an internal failure.
- After verifying that the module is in good working order, the configuration of the host communications hardware and software drivers will be checked. This discussion assumes a PC-compatible host computer is available to communicate with the module.
- After ensuring that the host computer is configured to communicate properly, the interface between the host computer and the System 9000 module will be examined. Communications will be established with a single module via its RS-232 Diagnostic Port or its Host Port.

If the module does not appear to function correctly, after the following steps have been completed, consult the Applications Department or Repair Department at Pressure Systems.

6.1.1 Checking Optomux Module Operation

9010, 9015, 9020 only

(1) Verify proper power is present at the module. Measure voltages at the PWR connector to verify proper levels. The pin labeled -V1 should read -15 VDC and the pin labeled +V2 should be +15 VDC when measured relative to the power ground pin.

> **Note : Models 9010 or 9015 instruments with serial numbers less than 0200 should be operated with input voltages of +12 VDC and –12 VDC instead of 15 VDC. The input marked V3 should not be connected.**

(2) Run the module’s internal self tests described in Section 2.3.10. This is accomplished by installing the supplied PC-221 Diagnostic Loopback Connector on the HOST and NEXT connectors. If no internal errors are detected, the OK LED will remain on steadily (no blinking) after tests are complete.

(3) Remove the diagnostic connector and turn module power off and then on again. After the module power is turned on, verify the following top panel LED functions:

- OK LED should remain ON
- PWR LED should remain ON
- CAL LED should remain OFF
- Busy LED should blink 8-16 times at a rate of approximately 1 Hz (slower for 9020), delay ON for approximately 5 seconds and then start to continuously blink at approximately 100 Hz (rate dependent on number of internal averages). This rapid blink rate will appear as a dimly lit LED.

Any significant variation from this power up LED sequence is an indication of a possible PC-203 microprocessor board error or an error with the installed firmware.

6.1.2 Checking Host PC Operation

9010, 9015, 9020 only

The following items should be checked after verifying that the module is operating properly in the above tests. These items are used to verify that the host hardware, software drivers, and user test software are configured correctly for System 9000 operation.

When using a computer with an attached serial port mouse, the mouse should be located on serial port #1 (COM1). The System 9000 instrument should be installed on COM2 (or higher if additional COM ports are available).

If operating the System 9000 module from COM1, verify that your computer's AUTOEXEC.BAT and CONFIG.SYS do not load a mouse driver upon power up. If changes are made to the AUTOEXEC.BAT or CONFIG.SYS files, you must reboot your computer before the changes take effect.

Execute the provided START program. Issue the INIT-COM PORT command to select the proper COM port, baud rate, and time out value. **When interfacing through the System 9000 Diagnostic Port, the baud rate should always be set at 9600.** When using the RS-422/485 Hort Port, the baud rate must match that for which the module is also configured, as described in Section 2.3.4.1.6 (factory default is 9600).

Note: If using a serial communications program other than START, verify that the equivalent of the above steps are executed to initialize the correct serial port for the desired baud rate.

6.1.3 Checking System 9000 Interface Wiring

9010, 9015, 9020 only

Once the System 9000 is verified to be operating, and the host computer has been configured to communicate on the proper serial interface, the final step is to verify that the communications cables are connected correctly. When testing any RS-422 multidrop interface, always begin testing with only one module attached to the network. After communications is verified with the first module, add additional modules (one at a time), and repeat testing procedures.

6.1.3.1 RS-232 Diagnostic Port Operation

(1) Use the 9095 Diagnostic Port cable, or verify that as user supplied cable is constructed as described in Section 2.3.5. Connect the cable to the appropriate PC COM port. Note that PC COM ports always have a MALE D-shell connector on the PC. FEMALE D-shell connectors on the PC are not COM ports!

(2) Remove the Diagnostic Port cable from the System 9000 module end only and jumper together the Tx signal to the Rx signal at the end of the 9095 cable. This creates a loopback configuration where the output from the PC COM port will be echoed back into the PC.

(3) While in the START program, type a command using the RAW COMMAND menu selection. After

pressing the enter key, the command typed should be displayed in the SENT display box at the bottom of the screen. The RCV box should display the same data sent since the transmit and receive lines are jumpered together. If the sent data is not echoed in the RCV box, one of the following has probably occurred:

- The COM port was not initialized before sending data.
- The Diagnostic Cable is not fabricated properly (or has a broken or shorted conductor).
- The Diagnostic Cable is not attached to the proper PC COM port.
- The COM port is not configured for the proper base address and interrupt level.
- The COM port hardware has failed.

If the above test does not function correctly, the cause of the problem must be resolved before going any further.

(4) If the loopback test worked correctly, remove the jumper between Tx and Rx and reinstall the cable into the module's Diagnostic Port. Issue the INIT-COM PORT command again to flush any spurious characters that may have been generated. Issue the INIT-MODULE command. Module commands should be shown in the SENT box and module responses in the RCV box. If the software indicates a communications error when attempting to communicate, one of the following has probably occurred.

- A baud rate other than 9600 was selected in the INIT-COM port menu.
- The Diagnostic Port cable's COM (signal ground) signal was not attached correctly.
- The Tx and Rx signals are reversed (possible when using gender changers, 9 to 25 D-Shell converters, etc). Swap Tx and Rx on the Diagnostic Port connector and repeat step 4 above.

6.1.3.2 RS-422 Multidrop Host Port Operation

9010, 9015, 9020 only

(1) Verify that the HOST cable is constructed as described in Section 2.3.4.1 and Appendix E (P/N 9093). **Note that the cable fabrication diagram in Appendix E is based on the use of the PSI Model 9091 RS-232 to RS-422 converter. If any other type of RS-232 to RS-422 converter is used, refer to its documentation to verify the proper assignment of pin numbers.**

(2) Verify that the baud rate is set to same value for both the host and 9000 module (9600 baud is factory default). The procedure for setting a module's baud rate is described in Section 2.3.4.1.6. The host computer's baud rate should be configured through the INIT-COM port menu as previously described.

(3) For testing purposes, set the module node address to 01. This is accomplished by placing switch 1 in the OFF position and all other switches (2-9) in the ON position. Turn module power off and then on again after setting the node address switches.

(4) Remove the HOST connector from the System 9000 module**.** At the end of the cable jumper together the TxA signal to the RxA signal and the TxB signal to the RxB signal. This creates a loopback

configuration where the output from the host RS-422 port will be echoed back into the host computer.

(5) Using the START program, type a command using the RAW COMMAND menu selection. After pressing the enter key, the command typed should be displayed in the SENT display box at the bottom of the screen. The RCV box should display the same data sent since the transmit and receive lines are jumpered together. If the sent data is not echoed in the RCV box, one of the following has probably occurred:

- The PC’s COM port was not initialized before sending data.
- The Host Port’s cable is not fabricated correctly (or has a broken or shorted conductor).
- The Host Port cable is not attached to the proper COM port.
- The Host Port cable is not installed in the module HOST connector.
- The COM port is not configured for the proper base address and interrupt level.
- The COM port hardware has failed.

If the above test does not function correctly, the cause of the problem must be resolved before going any further.

(6) If the loopback test worked correctly, remove the jumpers between the Tx and Rx signal pairs and reinstall the cable to the module’s Host Port.

(7) Issue the INIT-COM PORT command again to flush any spurious characters that may have been received in the PC. Cycle power on the System 9000 module to ensure spurious characters have not been received by the module. Wait for the module to complete the power-up cycle. Issue the INIT-MODULE command, verifying that the module node address box matches the address set on the module. Module commands should be shown in the SENT box and module responses in the RCV box. Watch the module Tx and Rx LED's for brief activity when confirming the INIT-MODULE command. If the software indicates a communications error when attempting to communicate, one of the following has probably occurred.

- The System 9000 module is configured for a different baud rate than the host computer.
- The System 9000 module is configured for a different node address than the one entered in the INIT-MODULE command.
- The A-B signal pairs are reversed for either the transmit or receive signal pair (TxA signal installed where TxB should be installed).
- The Tx/Rx signal pairs are reversed (Tx pair installed where Rx pair should be installed).
- If using an external RS-232 to RS-422 converter, RS-232 Tx and Rx signals may be reversed between the host computer's RS-232 interface and the converter's RS-232 interface.
- Communications cables are not terminated correctly at one or both ends of the RS-422 cable. Refer to Section 2.3.4.1.4 for details of proper cable termination.

Refer to the following section, Section 6.1.4, for hints to help determine the exact nature of the communications failure.

6.1.4 Network Communications Testing Hints

9010, 9015, 9020 only

When communicating with System 9000 modules over a network (RS-422 multidrop interface), the System 9000 module’s top panel Tx and Rx LED's can be used to identify possible communications or configuration errors. These LED's are directly connected to the appropriate interface’s *receive* and *transmit* hardware. They will not be active for RS-232 Diagnostic Port operation of the module.

The module’s Rx LED should normally be off when the Host Port cable is attached and the host COM port is initialized. (If the Rx LED remains on after the host COM port is initialized, either the host cable or the host RS-422 converter hardware is in error.) When any command is sent to a module through the RS-422 interface, *all* modules’ Rx LEDs should flash briefly, regardless of whether the module was the addressed module. If a module’s Rx LED does not flash appropriately, one of the following has occurred:

- Commands are not being transmitted out of the host computer due to the transmitter not being enabled or having failed. The loop back test described in steps 4 and 5 of Section 6.1.3 will determine if the host is operating correctly.
- The wiring between host computer and module is not correct.

If the addressed module’s Rx LED blinks when commands are transmitted to it from the host computer, but the Tx LED never blinks, one of the following has probably occurred:

- The host computer and module are configured for different baud rates.
- The command string sent to the module was not terminated with a carriage return character.
- Cable termination or biasing is not correct for the RS-422 converter in use.

A System 9000 module’s Tx LED will blink briefly whenever the module transmits a command response back to the host computer. Such activity is an indication that the module received a proper command, recognized its address, and then sent a command response.

If the module’s Rx and Tx LED's both blink, but no response is received at the host computer, one of the following has probably occurred :

- Transmit pair from the module (TxA/TxB) is not wired correctly, therefor preventing the transmitted response from reaching the host computer.
- The RS-232 interface between the external RS-422 converter and host computer is not wired correctly.
- The RS-422 receiver is either not enabled or has failed.

6.2 Ethernet Module Troubleshooting

9016, 9021 only

6.2.1 Checking Module Power-Up Sequence

9016, 9021 only

(1) Proper power to the module should first be verified. If possible, verify that the output of the module power supply is set within the range of 18-36 VDC. This should be nominally set for 24 VDC. Ensure that the power supply setting is high enough to compensate for cable voltage drops if long interface cable lengths are used.

(2) Turn module power on and verify the following top panel LED status following initial power-up :

- PWR LED should remain ON
  If this LED is not on, all other LED's will likely also be off. Check the PSI 90DB or customer provided power supply to ensure the proper voltage (18-36 VDC) is being provided. Also verify that the power pins in the module interface cable are wired as described in Section 2.3.2 and Appendix E.

- COL LED should remain OFF

- TX LED should remain OFF
  Note that any activity of the TX LED during the power up sequence is an indication that the RARP/BOOTP protocol is enabled. This will typically occur following the initial Busy LED cycle and continue until an appropriate RARP reply is received.

- LNK LED should remain ON
  This LED indicates proper connection to an Ethernet hub or switch. If this LED is off, verify that the module is properly connected to the communications hub or switch. Verify proper power is applied to the hub. Also try connecting the 9016 or 9021 cable to a different port of the hub. Note that most hubs have similar link LED's to indicate proper connection to the hub itself. If present, verify that the hub link LED for the pressure scanner and the host computer are both active. If the hub is functioning correctly, verify that the communications pins in the module interface cable are wired as described in section 2.3.4.2 and Appendix E.

- CAL LED should remain OFF

- PRG LED should remain OFF

- Busy LED should blink 8-16 times at a rate of approximately 1 Hz (slower for 9021), delay ON for approximately 5 seconds and then start to continuously blink at approximately 100 Hz (rate dependent on number of internal averages). This faster toggle rate may simply appear as a dimly lit LED. Note that the Busy LED will not begin its 100 Hz toggle rate if the RARP/BOOTP protocol is enabled and the module has not received a proper IP address response.

Any significant variation from this power-up LED sequence is an indication of a possible cabling or PC-280 microprocessor board error. If the proper power-up LED sequence is not achieved after following the above suggestions, contact the repair department at Pressure Systems for additional assistance.

9016, 9021 only

6.2.2 Checking Module TCP/IP Communications

If the LED indicators of the 9016 or 9021 are correct, the module is normally capable of proper communications. In order for communications to be established with a functional 9016 or 9021 (assuming correct interface cables are used), two user controlled parameters must be met. First, the 9016 must be configured to obtain a proper (and unique) module IP address. Secondly, the user's host computer must have its TCP/IP communications interface properly configured.

6.2.2.1 Module IP Address Assignment

Before an Ethernet 9016 or 9021 can communicate with a host computer, it must have a valid IP address assignment. As explained in Section 2.3.4.2, there are two methods for assigning an IP address to an Ethernet device, ARP and RARP. The ARP protocol is the default method for IP address assignment in the 9016 and 9021. This is primarily because it allows the module to assign its own IP address based on a factory default value. The RARP protocol is slightly more complicated since it requires a RARP server to be present and properly configured on the network. Before host communications can be established, the user must ensure that the 9016 or 9021 has been assigned a known IP address through either ARP or RAPR.

To determine whether ARP or RARP is enabled, observe the module TX LED on module power-up. As explained in section 6.2.1, if RARP is enabled the module TX led will flash one or more times during the power-up sequence. If the module receives a valid reply, the BUSY LED will begin to flash rapidly (appearing dim) and the TX LED will remain off. If it appears the module received a RARP reply or that it is configured for ARP, proceed to section 6.2.2.2 to verify proper host TCP/IP configuration.

If the module does not receive a response to a RARP request, its TX LED will continue to flash with an increasing delay between TX attempts. The BUSY LED will also remain off until a RARP reply is received. If a RARP reply is not received, verify that a RARP server is present on the network. If the RARP server is present, verify that it contains an entry for the 9016 or 9021 Ethernet hardware (MAC) address. Verify this address against the Ethernet address printed on the module label to ensure it has been entered correctly into the RARP server. After making the required changes to the RARP server, repeat the above steps until the module receives a valid RARP reply.

Note: A simple Windows 95/NT BOOTP/RARP server is available free of charge from Pressure Systems. For additional information on the BOOTP Lite application contact the Pressure Systems Sales or Applications Department. The application can also be downloaded from the Pressure Systems web sight found at www.psih.com.

6.2.2.2 Host IP Address Assignment for Windows 95/NT

In order to communicate with the Ethernet 9016 or 9021, the host computer must also be configured with an appropriate IP address. For Windows 95 and Windows NT, a typical configuration is described below. Note that this configuration assumes that a host PC Ethernet adapter is installed and not in use for any other TCP/IP application. If your Ethernet adapter is used for other TCP/IP communications, contact your MIS or network administrator to determine proper host IP address and subnet mask configurations before proceeding.

Activate the Windows control bar (left click the START icon). Select the SETTINGS line followed by the CONTROL PANEL folder. In the CONTROL PANEL folder, select the NETWORK icon. Once in the NETWORK setup, select the tab labeled CONFIGURATION. Scroll through the list of installed configuration protocols. Select the one labeled 'TCP/IP->xxxx' where xxxx will typically identify your Ethernet adapter card. There may be other TCP/IP protocols listed for other items such as dial up adapters, these are not used for the 9000 Ethernet configuration. If the TCP/IP protocol is not listed in the configuration menu, left click the ADD button. Continue by selecting to add a PROTOCOL. Select

MICROSOFT from the Manufacturers list. Then select TCP/IP from the networks protocol list.

Once in the proper TCP/IP protocol setup, select the 'IP Address' tab. Click on the button to enable the field 'Specify IP Address'. Once selected, the fields for IP address and Subnet will be enabled. In the IP address, enter a TCP/IP address for your host computer. An IP address of 200.200.200.001 will work if the 9016 or 9021 is using the factory default IP address. If the leftmost fields of the 9016 or 9021 module IP addresses are different than the factory default of 200.20x.yyy.zzz then the leftmost fields of the host computer's IP address must match the module's leftmost IP address field. In the Subnet field a value of 255.0.0.0 can be entered for most configurations.

When these fields are entered, click the OK icons until Windows prompts you to restart your computer. Once the computer has restarted, it should be capable of communications with the Ethernet 9000 module.

6.2.2.3 Verifying Host TCP/IP Communications

At this point the 9000 module should be configured to obtain its IP address through either ARP or RARP. The module's IP address must be assigned and known to proceed. The host computer has also been configured for TCP/IP protocol and assigned an IP address compatible with the 9000 IP address. A simple method to verify proper operation is through the ping utility. This is a simple TCP/IP utility that is found in Windows 95/NT as well as most other TCP/IP packages. The ping utility simply sends a test packet to the specified IP address and waits for reply to be returned. The System 9000 Ethernet modules are programmed to reply to these ping requests.

To run the ping utility from Windows 95/NT follow these steps. Left click the Windows START button. Move the mouse pointer to 'RUN' and left click on it. At the prompt type 'ping xxx.xxx.xxx.xxx' where xxx.xxx.xxx.xxx represents the IP address of the device to test. The IP address of an Ethernet 9000 module should be used. A small DOS window will appear as the ping application executes. The ping program will either report that a reply was received or that it failed to receive a reply. If the ping application reported receiving a reply, the host computer and the 9000 module are both properly configured for TCP/IP communications.

If an error free ping reply was not received, rerun the ping application using the IP address of the host computer. This will verify if the TCP/IP protocol was properly configured on the host computer. If a ping reply was not received, verify the TCP/IP installation steps for your host computer. Also verify that the host computer is configured for the proper IP address and subnet mask.

If the ping test of the host computer's IP passed while the ping of the 9000 module failed, check the following possible sources for error:

- Ensure that the 9000 module's IP has been assigned (as explained in section 6.2.2.1) and that the correct IP was used for the ping test.

- Ensure that the IP address of the host computer and the 9000 module are not duplicated on the network.

- Ensure that the link LED's are active on the 9016 and the Ethernet hub or switch to which it is attached. Also ensure that the link LED's are active on the host computer's Ethernet adapter and the hub or switch to which it is attached.

- Ensure that the Ethernet adapter card installed in the host is properly configured without conflict. In Windows 95 this can be verified by entering the CONTROL PANEL under SETTINGS. Under CONTROL PANEL select the SYSTEM icon. When the DEVICE MANAGER tab is selected, a list of all installed hardware devices will be listed. Any possible hardware conflicts will be marked in this list with a yellow warning symbol next to the device in question.

! Ensure that the Ethernet adapter is configured for 10 Mbit/Sec. Many adapters are capable of higher speeds that are not compatible with the System 9000 modules.

6.3 Zero and Gain Calibration Troubleshooting

Incorrect pneumatic setup or incorrect command usage when executing a module's Rezero or Span calibration can result in unexpected module operation. A common source of errors during these operations is incorrect control of the module's internal calibration valve and pneumatic inputs (models 9010, 9015, or 9016) or their external pneumatic/hydraulic equivalents (model 9020, 9021).

Pressure connections are described in Section 2.3.6 while details of calibration procedures are described throughout Chapter 4. Some common errors and problems are listed below. These common problems apply primarily to models 9010, 9015, and 9016 with internal transducers and calibration manifold. However, similar symptoms may be encountered with external pneumatic/hydraulic calibration equipment connected to a model 9020's all-media transducers.

! Module's Supply Air input is either not attached or does not provide enough pressure to shift the calibration valve. This results in the calibration valve remaining in its current position even though module commands have requested movement of the valve. This causes incorrect pneumatic inputs during calibration commands.

! The module's calibration valve is not placed in the correct position before executing the Span calibration command (***Calculate & Set Gain***). This command will not automatically shift the valve to the CAL position before taking data (as the Rezero calibration command does). The user must manually control the calibration valve position using the ***Set Operating Options*** (**'w'**) command if the CAL and CAL REF inputs are to be used.

! The ReZero calibration command (***Calculate & Set Offsets***) will automatically shift the calibration valve unless the option is disabled with the ***Set Operating Options*** ('w') command. The valve will be placed in the CAL position (with a small delay) before taking Rezero data. Afterwards, the valve will be placed in the RUN position.

! Zero *(offset)* and Span *(gain)* correction terms are not automatically saved in transducer nonvolatile memory. If they are not saved using the ***Set Operating Options ('w')*** command, they will be lost when module power is turned off. Verify that new coefficients produce valid data before saving them.

! When Span calibrating a multi-range unit, attach the calibration pressures to the individual measurement input ports of the range being calibrated and not to the CAL input port. Use of the common CAL input may result in overpressuring lower range channels. When sending the ***Calculate and Set Gain*** (**'Z'**) command, ensure that the position field bits are set only for those channels that are attached to the calibration pressure.

! When using the standard ***Calculate and Set Gain*** (**'Z'**) command, the module firmware assumes, by default, that each particular transducer's full-scale pressure is present at its pneumatic/hydraulic input. All internal calculations of gain correction are based on the exact full scale pressure being applied to the transducers. If it is not possible to provide this exact pressure (as when using a dead weight tester), the alternate form of this command should be used. This allows the host to specify the exact upscale pressure applied to the transducers being calibrated.

! When using the standard ***Calculate and Set Offsets*** (**'h'**) command, the module firmware assumes, by default, that each particular transducer's zero pressure is present at its pneumatic/hydraulic input. All internal calculations of zero correction are based on an input pressure of 0.0 psi. If it is not possible to provide this exact pressure (as when calibrating an absolute pressure transducer), the alternate form of this command should be used. This allows the host to specify the exact minimum pressure applied to the transducers being calibrated.

This page intentionally left blank.

Chapter 7

Start-Up Software

7.1 Introduction

The System 9000 **Start-Up** Software (sometimes called simply START) is provided to all customers who have purchased a System 9000 Intelligent Pressure Scanner. The Optomux 9010, 9015, and 9020 are all supported by the same start-up software, the 9016 and 9021 are supported by a TCP/IP specific version of the start-up program. This software is provided as a Windows installable application. The Optomux start-up software for the 9010, 9015, and 9020 is also available as a DOS only application.

The **Start-Up** program is easy to use and requires minimal user input. It can be setup to communicate with up to eight (8) different modules, but only one module can actually be operated at a time. The software can perform simple data acquisition and calibration functions by converting easy to understand pull-down menu functions into module specific commands. The software also allows the user to enter and transmit raw commands to the module which are typed directly into a transmit dialog box. This provides user's with a simple method for experimenting with the 9000 command set.

To install the start-up software, follow the directions provided with the diskettes. For Windows installations this will generally be initiated by executing the SETUP program on the first installation diskette. The SETUP application can be executed by double clicking on it from the Windows File Manager or Windows Explorer. SETUP will install the required Windows files and create a new program group. The program may be started by selecting the program icon from the new program group.

The ethernet model 9016 and 9021 are provided with an auxiliary host program called the **TCP/IP Command Test Program**. It is a 32-bit Windows application program, designed to run on Windows 95 or Windows NT. It has extra diagnostic capabilities not available in the Start-Up program, and can also be used to download new firmware while the module is connected to its TCP/IP network via the Host Port.

For users of the DOS version of the start-up software, simply copy the contents of distribution diskette onto a suitable subdirectory of your hard disk. If performance is not an issue, you may also run the DOS software from the distribution diskette. The following files are needed for the DOS program to run:

START.EXE (program)
START.UIR (graphics file)
START.DEF (defaults file)

To execute the DOS **Start-Up** program, change the DOS command prompt to the drive and directory containing the software and type "START" and the <Enter> key.

7.2 General Configuration Requirements **All Models**

In order for the **Start-Up** software to communicate with RS-422/485 modules (9010, 9015, 9020) on the network, these modules must be attached to an available COM port on the PC, and must communicate at a proper speed. All data transmitted is at a certain speed, called the baud rate, and both module(s) and PC must use the same speed. Selection of a module's baud rate is described in Section 2.3.4.1.6. An additional communications option to configure is the Time Out Delay for the COM port. This value is the amount of time the PC waits before it decides that a module is not going to respond to the command. Available configuration selections are as follows:

COM Port:	COM1, COM2 (default), COM3, or COM4
Baud Rates:	2400, 4800, 9600 (default), 19200, or 38400.
Time-Out Value:	5 - 30 seconds (default = 10 seconds).

7.2.1 Getting Around

This software accepts user input from a mouse or the keyboard. To use the mouse, just point to the item or menu and press the left mouse button. That item or menu will now be activated.

To activate a menu with the keyboard, hold down the ALT key and the starting letter of the desired menu.

To activate any submenu, press the arrow keys to highlight the desired item or press the starting letter of the submenu. Once it is highlighted, pressing ENTER will activate the submenu. To activate a submenu with the mouse, just left click on the submenu.

Some submenus have pop up windows that require user input. It is possible to advance through different input areas in the screen may by pressing the TAB key or Shift-TAB key combination or by simply pointing to the desired field with the mouse and left clicking. Input values can be typed directly from the keyboard followed by pressing the ENTER key or by clicking the OK button on the screen with the mouse.

Selection buttons are used to turn on or off certain functions, such as selecting the active module. These can be activated by either pressing the SPACE bar to toggle the button on or off or by pressing the UP or DOWN arrows. Selection buttons can by turned on or off by pointing to the button with the mouse and clicking the left button.

Slide Bars are used when there are multiple choices for one thing, such as units to be displayed. The UP and DOWN arrows are used to change the choice. To select with the mouse, point to the current selection, and move the mouse while holding down the left mouse button. Let go of the mouse button when the selection is reached.

7.2.2 Menu Bar

The Menu Bar, at the top of the screen, allows the user to execute any available function. To activate any of the commands in the menu bar, just press the ALT key and the starting letter of the menu item simultaneously. With a mouse, point and click the left mouse button to activate the menu. The menus are INIT, CAL, S9000, RAW, GO, QUITACQ, HELP, NEXT, and EXIT. Menus followed by the exclama-tion point, '!', execute immediately and have no submenus. To activate any of these commands, press:

Alt-I	=	INIT Menu appears.
Alt-C	=	CALIBRATION Menu appears.
Alt-S	=	SYSTEM 9000-specific Menu appears.
Alt-R	=	RAW, send a Raw command.
Alt-G	=	GO, Data Acquisition starts.
Alt-Q	=	QUITACQ, Data Acquisition stops.
Alt-H	=	HELP Menu appears.
Alt-N	=	NEXT, make Next Module Active.
Alt-E	=	EXIT this program.

7.2.2.1 Init Menu

The Init menu allows the user to change items such as the PC COM port, baud rate, time out value, and the default module addresses. Users may configure up to 8 modules to be available for communication via the “modules” selection. This menu also allows the user to change the engineering units displayed for each channel and to save the specific initialization parameters used at start up into a default file.

7.2.2.2 Cal Menu

The Cal Menu allows the user to perform a transducer rezero, full span calibration, or module accuracy checks. It also allows the user to instruct the module to store the rezero and span coefficients in each transducer's nonvolatile memory.

7.2.2.3 S9000 Menu

The S9000 Menu contains commands that are System 9000 specific. The commands contained in this menu include calibration valve control, transducer information and module firmware download.

7.2.2.4 Raw Menu

The Raw menu allows the user to enter any Optomux command and send it to any module on the network. The packets sent and received are displayed in the boxes at the bottom of the screen.

7.2.2.5 Go Menu

The Go menu will start data acquisition, displaying all data received on the screen. Data will be acquired until QuitAcq is pressed. Data is acquired only from the module selected in the INIT menu.

7.2.2.6 QuitAcq Menu

The QuitAcq Menu will stop any data acquisition in progress and display the latest measurement set.

7.2.2.7 Help Menu

The Help menu provides an on-line help screen describing all of the functions in this software.

7.2.2.8 Next Menu

The Next menu allows the user to change the current module address used during data acquisition. This is used when more than one module is selected in the Init-Module menu.

7.2.2.9 Exit Menu

The Exit menu allows the user to quit this program and return to DOS.

7.3 Initialization Submenus

7.3.1 COM Port

Highlighting and executing this submenu will cause a pop-up window to be displayed. Three communication parameters can be changed in this window: PC COM port, Baud Rate and Time Out Value.

To change the PC COM port, press the TAB key until the COM port box is highlighted. Use the Arrow Keys to go up or down to choose the correct value. The mouse can be used by pointing to the selection bar and holding down the left mouse button while dragging the selection bar. Release the mouse button to choose the COM port. The valid COM ports are 1 - 4.

To change the baud rate, press the TAB key until the Baud Rate box is highlighted. Use the Arrow keys to choose the value desired. The mouse can be used by pointing to the selection bar and holding down the left mouse button while dragging the selection bar. Release the mouse button to choose the COM port. The current choices for Baud Rate are:

2400
4800
9600
19200
38400 baud.

To change the Time Out value, press the TAB key until the Time Out box is highlighted. Enter the new numeric time out value. Please note that this number should never be less than 10 seconds if module rezeros are to be executed.

Once done changing these values, TAB to the OK button and Press ENTER. The COM port chosen will be initialized with the new values. You may also press the F1 key to initialize the COM port with the existing parameters. Press the ESCAPE key to do nothing and exit the submenu.

7.3.2 Units

This submenu allows the user to change the engineering units that are displayed during data acquisition. Available display units are as follows:

InH_20	=	Inches of Water Column,	PSI * 27.708
PSI	=	Pounds per Square Inch.	
InHg	=	Inches of Mercury,	PSI * 2.042
KPA	=	kiloPascals,	PSI * 6.8948
Mbar	=	milliBars,	PSI * 68.948
ATM	=	Atmospheres,	PSI * 6.805 x 10^{-2}
BAR	=	Barometric Pressure	PSI * .068948

To change to new units, press the first letter of the unit desired, or press and hold the left mouse button while moving the slide bar. When the mouse button is released, the units will be chosen.

Press F1 to keep the units selected, or press the ESCAPE key to quit without any changes to the current units.

7.3.3 Module

This submenu allows the default module address to be changed. This PC software will only talk to one module at a time. All module commands are sent to the address set by the default module address, except for the Raw Optomux commands entered by the user.

When the new module address is entered, a ***Power-Up Clear*** (**'A'**) command is sent to that module to make sure that it exists. If no response is received from the module, an error message will be displayed. Ensure that the address DIP switch settings are correct on the module before selecting a new module address.

After a Power-Up Clear message is sent, the module is queried for the ranges of each transducer. These ranges are then used to auto-range the values displayed during data acquisition and display.

This submenu allows the user to enter up to 8 different default addresses to be used during execution of this program. Enter the address of each module in the OPTOMUX network or **0 for none**. After all addresses are selected, the user must select the *current* address to be used. This is done by TABBING to the appropriate selection button and pressing the SPACE bar. If two modules are selected, the lowest module address will be used as the *current* module.

Once all modules have been entered, pressing the NEXT menu will change the current module address to the one listed next in this list.

7.3.4 Save Defaults

This submenu allows the user to save all of the defaults set up during the execution of this program. All of the default values are saved in the file "START.DEF". DO NOT CHANGE THIS FILE WITH AN EDITOR. The default file is read each time this program is started.

7.4 Calibration Submenus

7.4.1 Rezero

This command will build a ***Calculate and Set Offsets*** ('**h**') command and send the packet to the *current* module. Before starting a Rezero calibration, make sure that zero pressure is applied to the CAL and CAL REF Ports of the module.

This command allows the user to choose which channels are to be calibrated — either all (F8) or selected ones.

If the module being calibrated has an internal manifold (models 9010, 9015), the internal calibration value is set to the CAL position — and an appropriate delay expires — before calibration data are read from the transducers selected — and the valve eventually returned to the RUN position.

When the Rezero calibration is complete, the new *offset* coefficients are generated, and will be displayed in the selected engineering units and in raw Optomux hex data values. These new coefficients will also be updated in the module's volatile main memory, but will not be written back to the affected transducer's nonvolatile memory (see the ***Store Coefficients*** menu item in Section 7.4.4 below).

7.4.2 Span

This command will build a ***Calculate and Set Gain*** ('**Z**') command and send the packet to the *current* module. Full-scale pressure must be applied to the appropriate input ports of the default module before this command is executed. If the module being calibrated has an internal manifold (models 9010, 9015), its internal valve must be manually placed in the proper (CAL or RUN) position before executing this command (see Section 7.5.1 below).

This command allows the user to choose which channels are to be calibrated — either all (F8) or selected ones).

When the Span calibration is complete, the floating point span values generated will be displayed along with the raw Optomux hex data values. These new coefficients will also be updated in the module's volatile main memory, but will not be written back to the affected transducer's nonvolatile memory (see the ***Store Coefficients*** menu item in Section 7.4.4 below).

7.4.3 Accuracy

This command will perform an accuracy check on all channels of the *current* module. The software reads pressure from the module and then calculates pressure measurement errors. The applied and measured pressure will be displayed in the selected engineering units, along with the pressure difference and percent error (percent of full scale pressure).

When this is first executed, the applied pressure is set to 0.0.   The user must then specify the applied pressure by activating the APPLIED PRESSURE menu. Press ALT-A or click on this menu with the mouse to activate. This will then ask for the current pressure that is being applied.

During accuracy check, the pressure can be read from the module at any time by activating the READ PRESSURE menu. Press ALT-R or click on the menu with the mouse to activate. The measured pressure and errors calculated will be updated every time the READ PRESSURE menu is selected.

The user can also change the *current* module that is used to read measured pressure by activating the INC MODULE menu. This will advance the program to the next module listed during initialization. The user can now read pressure from this module.

7.4.4 Store Coefficients

The ***Store Coeffs*** command allows the user to instruct the module to store the Rezero and Span calibration terms (*offset* and *gain*, respectively) to each individual transducer's nonvolatile memory. **It is recommended that the accuracy function described above, or another method be used to verify that the coefficients are correct prior to issuing this command.**

7.5 System 9000-Specific Commands Submenus

7.5.1 Valve

This command allows the user to shift the calibration valve in the *current* module between the RUN and CAL positions. Note: The screen displays the last transmitted command. It does not provide an indication of the current valve position.

7.5.2 Transducer Information

This command queries each module's transducer ranges and then displays the pressure range of each channel in PSI.

7.5.3 Download

This command is used to upgrade module firmware when new software revisions are released (see Section 5.2).

7.5.4 Raw

The user can type raw Optomux commands that will be sent directly to the specified module. The user must be familiar with the format of the Optomux command. The complete packet must be specified, including the start character, the module address, the command byte, the data, the calculated checksum and the delimiter character (a carriage return). Alternatively, the “??” may be used in place of a calculated checksum. The command sent will be displayed in the "Sent" box at the bottom of the screen and any response returned by the module will be displayed in the "Recd" box at the bottom of the screen. Refer to Section 3 for detailed command format and proper use of the checksum feature.

7.5.5 Acquisition

The software displays each channel's measured value in the engineering units selected. These values are updated for each data set acquired by the host. The "Sent" and "Recd"' boxes at the bottom of the screen display the actual Optomux packets being sent and received.

7.5.6 Help

Executing Help displays a screen giving a brief description of each menu of this software. There is also a help line at the bottom of the screen, which displays help messages as execution of the program takes place.

7.5.7 Next

Executing Next will increment the default module that is used to perform all of the functions of this program. The new module will be the next one initialized in the module list set up during initialization.

7.5.8 Exit

Exit quits this program and returns to DOS.

Appendix A

All Optomux Commands — Quick Reference:

Cmd Letter	9010 9015 9020	9016 9021	**Command Function**
A	!	!	Power-Up Clear
B	!	!	Reset
L	!		Read Scaled Analog Inputs
V		!	Read Transducer Voltages
Z	!	!	Calculate and Set Gains
a		!	Read Transducer Raw A/D Counts
b		!	Acquire High Speed Data
c		!	Define/Control Host Streams
h	!	!	Calculate and Set Offsets
m		!	Read Temperature A/D Counts
n		!	Read Temperature Voltage
q	!	!	Read Module Status
r	!	!	Read High Precision Data
t		!	Read Transducer Temperature
u	!	!	Read Internal Coefficients
v	!	!	Download Internal Coefficients
w	!	!	Set Operating Options

This page intentionally left blank.

Appendix B

9000 Response Error Codes:

These error codes will be sent in response to an error condition detected in the module after a command is received. Instead of an ***acknowledge***, ('A') or ***acknowledge with data***, a ***negative acknowledge*** ('Nxx') will be sent followed by the error codes (xx) listed below.

CODE	MEANING
00	***Power-Up Clear Command Was Expected***: *(unused by TCP/IP)* A command, other than 'A' , was attempted following module's power-up. Once the error is received, it is unnecessary to execute the 'A' command, as the next command will be executed normally. Command was ignored. **IMPORTANT** This power-up error also indicates that all parameters have been reset to Power-Up defaults.
01	***Undefined or Unimplemented Command:*** The command received was not a legal command character.
02	***Optomux CheckSum Error:*** *(unused by TCP/IP)* The checksum received in the last command doesn't match the sum of the characters received. Command was ignored.
03	***Input Buffer Overrun:*** The received command contained more than 512 characters for PSI System 9000. The command was ignored.
04	***Invalid Character Received:*** Only printable ASCII characters from 21H to 7FH are permitted within commands. The command was ignored.
05	***Data Field Error:*** Invalid data field characters were received (too many or too few). The command was ignored.
06	***Communications WatchDog Timeout Error.*** Not implemented in System 9000
07	***Specified Limits Invalid.***
08	***System 9000 error - Invalid Parameter.***

This page intentionally left blank.

Appendix C

ASCII to Decimal/Hexadecimal Conversion Chart

DEC	HEX	ASCII	DEC	HEX	ASCII
65	41h	**A**	97	61h	**a**
66	42h	**B**	98	62h	**b**
67	43h	**C**	99	63h	**c**
68	44h	**D**	100	64h	**d**
69	45h	**E**	101	65h	**e**
70	46h	**F**	102	66h	**f**
71	47h	**G**	103	67h	**g**
72	48h	**H**	104	68h	**h**
73	49h	**I**	105	69h	**i**
74	4Ah	**J**	106	6Ah	**j**
75	4Bh	**K**	107	6Bh	**k**
76	4Ch	**L**	108	6Ch	**l**
77	4Dh	**M**	109	6Dh	**m**
78	4Eh	**N**	110	6Eh	**n**
79	4Fh	**O**	111	6Fh	**o**
80	50h	**P**	112	70h	**p**
81	51h	**Q**	113	71h	**q**
82	52h	**R**	114	72h	**r**
83	53h	**S**	115	73h	**s**
84	54h	**T**	116	74h	**t**
85	55h	**U**	117	75h	**u**
86	56h	**V**	118	76h	**v**
87	57h	**W**	119	77h	**w**
88	58h	**X**	120	78h	**x**
89	59h	**Y**	121	79h	**y**
90	5Ah	**Z**	122	7Ah	**z**

DEC	HEX	ASCII	DEC	HEX	ASCII
10	0Ah	**< s >**	13	0Dh	< **r** >
32	20h	**space**			
48	30h	**0**			
49	31h	**1**			
50	32h	**2**			
51	33h	**3**			
52	34h	**4**			
53	35h	**5**			
54	36h	**6**			
55	37h	**7**			
56	38h	**8**			
57	39h	**9**	126	7Eh	~

Appendix D

Binary Bit Map

Bit Value (if Set)	Bit Position	Binary Number			
1	1	0000	0000	0000	0001
2	2	0000	0000	0000	0010
4	3	0000	0000	0000	0100
8	4	0000	0000	0000	1000
16	5	0000	0000	0001	0000
32	6	0000	0000	0010	0000
64	7	0000	0000	0100	0000
128	8	0000	0000	1000	0000
256	9	0000	0001	0000	0000
512	10	0000	0010	0000	0000
1024	11	0000	0100	0000	0000
2048	12	0000	1000	0000	0000
4096	13	0001	0000	0000	0000
8192	14	0010	0000	0000	0000
16384	15	0100	0000	0000	0000
32768	16	1000	0000	0000	0000

Decimal to Binary Conversion:

892 dec = 512 + 256 + 64 + 32 + 16 + 8 + 4

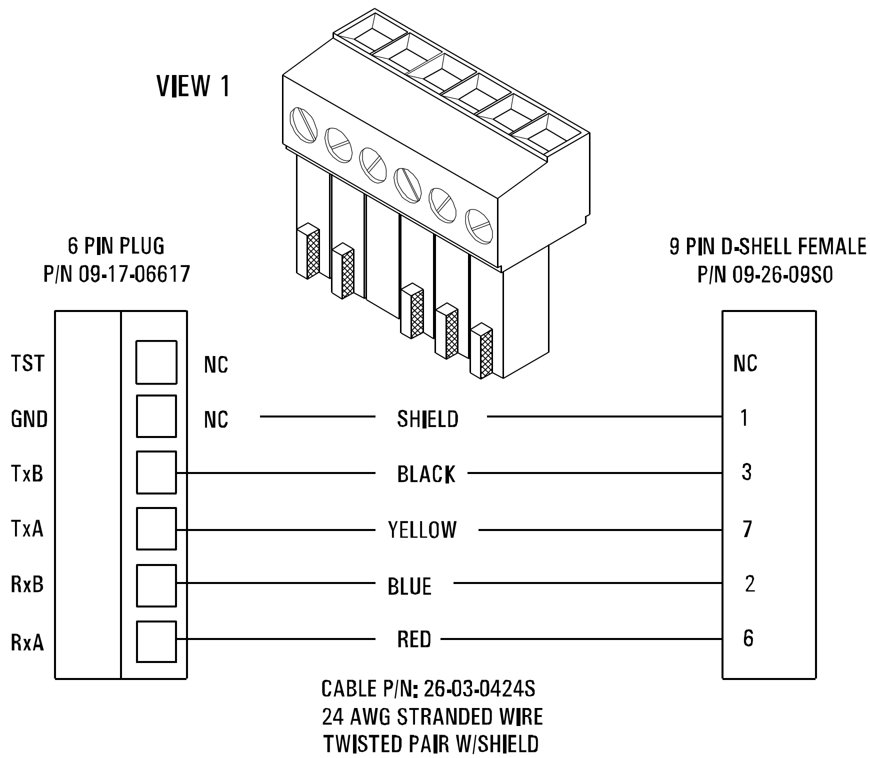
0000	0011	0111	1100	binary
	3	7	C	hexadecimal

This page intentionally left blank.

Appendix E

Cable Diagrams

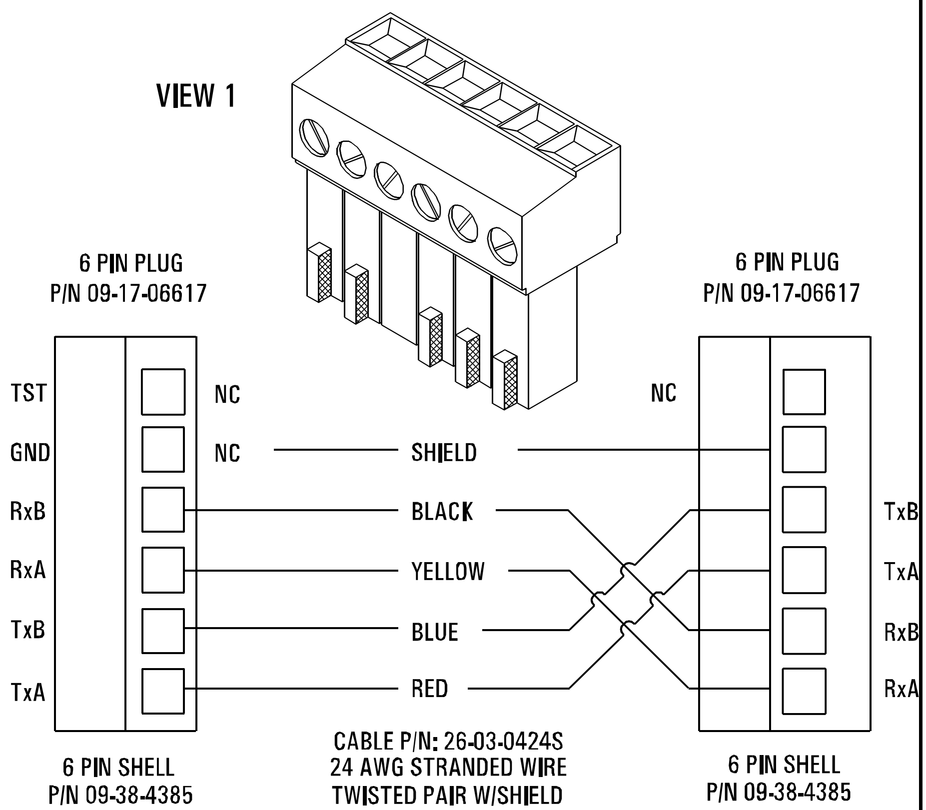
P/N	Description	Applicable Models	Page
9093	RS-422 Host Interface Cable	9010, 9015, 9020	E-2
9094	RS-422 Next Module Interface Cable	9010, 9015, 9020	E-3
9095	RS-232 Diagnostic Cable	9010, 9015, 9020	E-4
9096	9020 to 940x Interface Cable 9021 to 940x Interface Cable 9021 to Series 27 Interface Cable	9020 9021 9021	E-5 E-6 E-7
9097	Power Supply Cable	9010, 9015, 9020	E-8
9080	Ethernet Interface Cable - unterminated host Ethernet Interface Cable	9016, 9021 9016, 9021	E-9 E-10



NOTES:

1. WIRE ENDS SHOULD BE STRIPPED OF INSULATION TO EXPOSE 0.200" OF BARE WIRE ON 6-PIN PLUG END
2. DO NOT TIN WIRE BEFORE INSTALLING IN TERMINAL CLAMP ON 6-PIN PLUG END
3. PLACE HEAT-SHRINK ON BOTH ENDS WHERE OUTER INSULATOR JACKET IS CUT.
4. USE D-SHELL HOUSING ON 9-PIN END. (P/N 09-38-DA9H)
5. USE 6 PIN SHELL ON 6 PIN PLUG END (P/N 09-38-4385)
6. CUT KEY ON TxB PIN OF 6 PIN CONNECTOR AS SHOWN IN VIEW 1

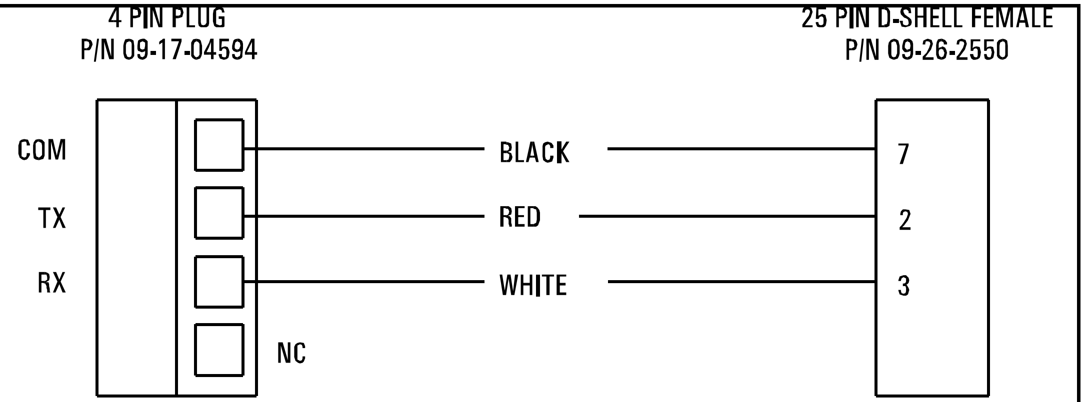
System 9000 RS-422 Host Interface Cable
P/N 9093



NOTES:

1. WIRE ENDS SHOULD BE STRIPPED OF INSULATION TO EXPOSE 0.200" OF BARE WIRE
2. DO NOT TIN WIRE BEFORE INSTALLING IN TERMINAL CLAMP
3. PLACE HEAT-SHRINK ON BOTH ENDS WHERE OUTER INSULATOR JACKET IS CUT
4. CUT KEY ON EACH 6 PIN CONNECTOR AS SHOWN IN VIEW 1

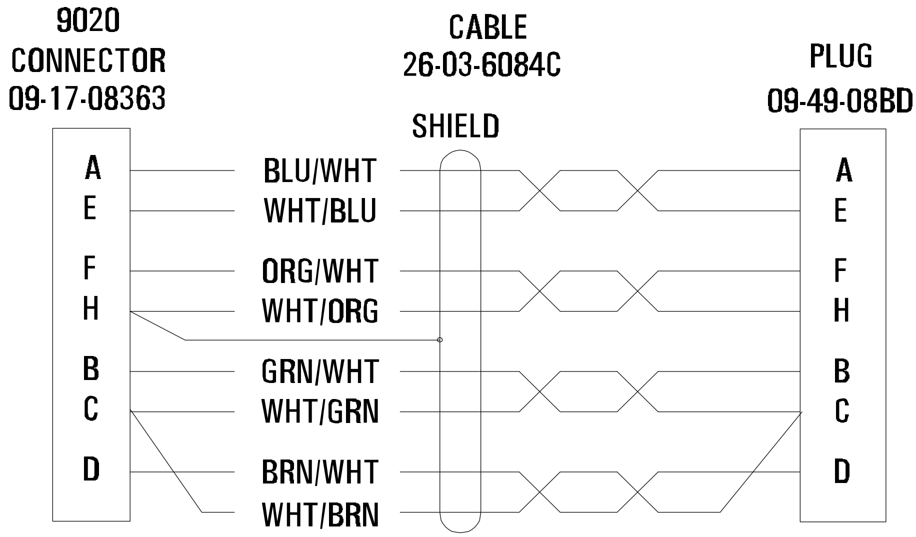
System 9000 RS-422 Interface Cable to Next Module
P/N 9094



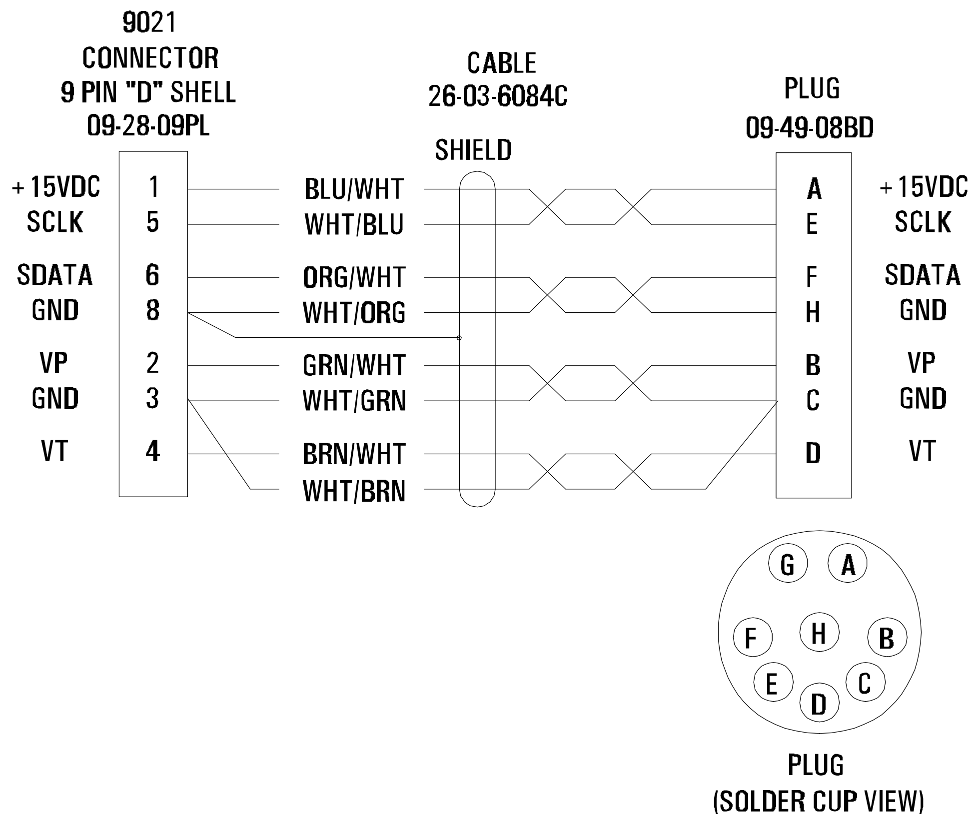
NOTES:

1. WIRE ENDS SHOULD BE STRIPPED OF INSULATION TO EXPOSE 0.200" OF BARE WIRE ON 4-PIN PLUG END
2. DO NOT TIN WIRE BEFORE INSTALLING IN TERMINAL CLAMP ON 4-PIN PLUG END
3. PLACE HEAT-SHRINK ON BOTH ENDS WHERE OUTER INSULATOR JACKET IS CUT.
4. USE D-SHELL HOUSING ON 25-PIN END. (P/N 09-38-25HD)
5. USE 4 PIN SHELL ON 4 PIN PLUG END. (P/N 09-38-4369)

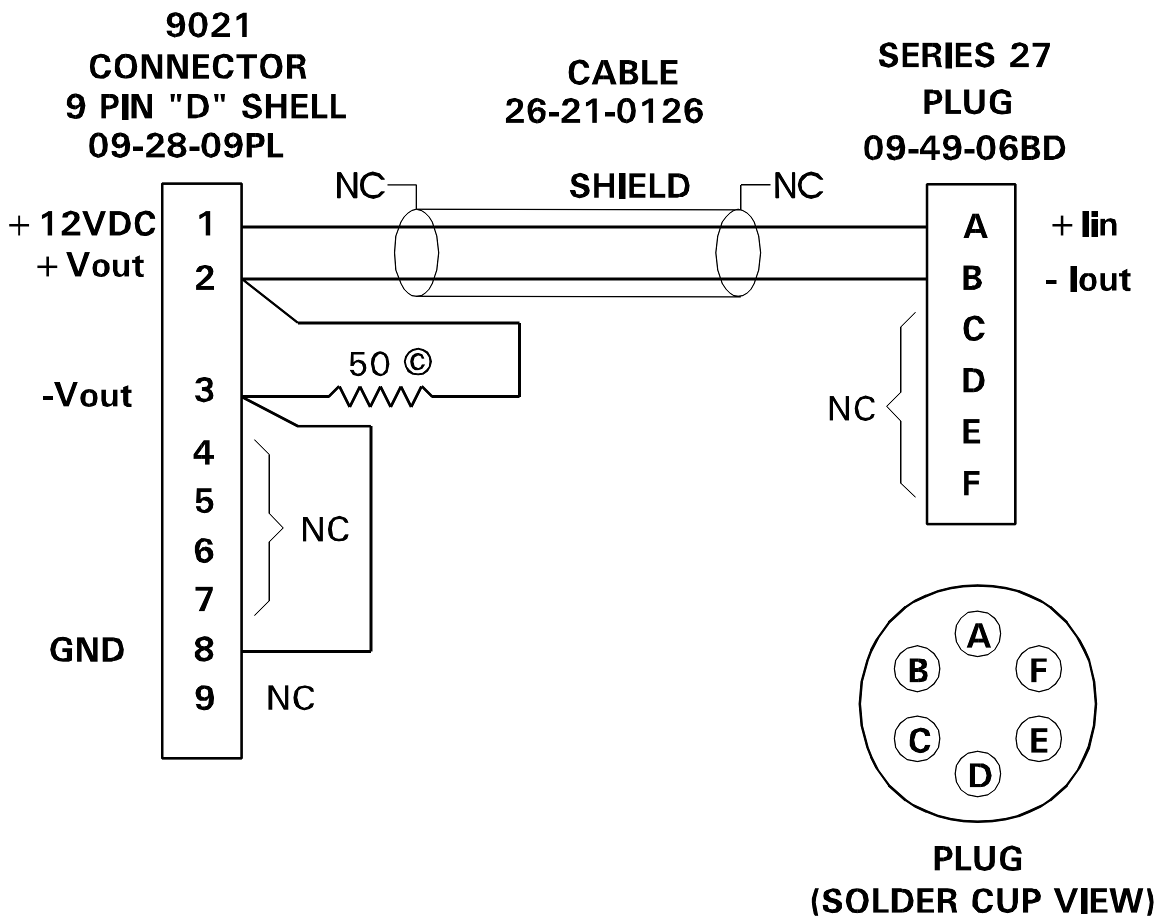
System 9000 RS-232 Diagnostic Cable
P/N 9095



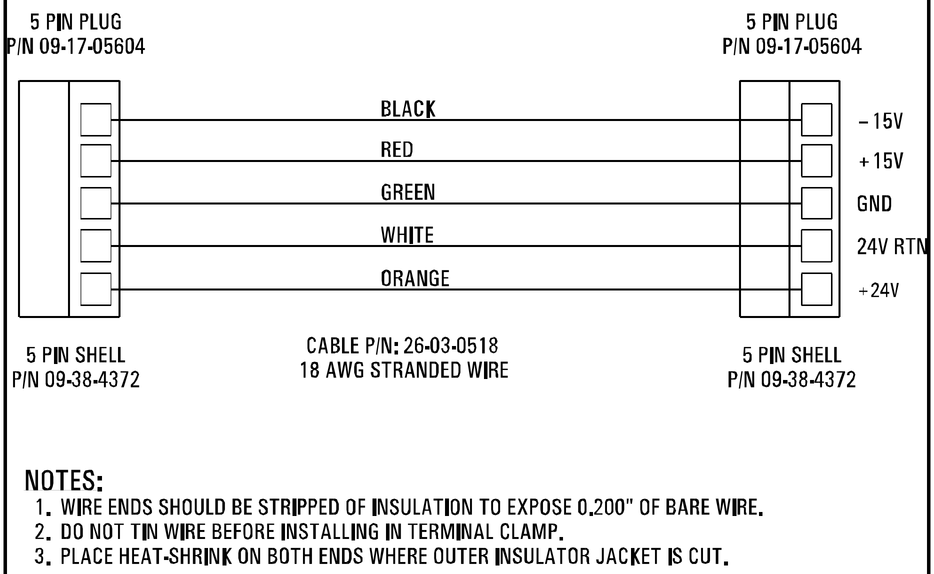
System 9000 9020 to 940x Interface Cable
PN 9096



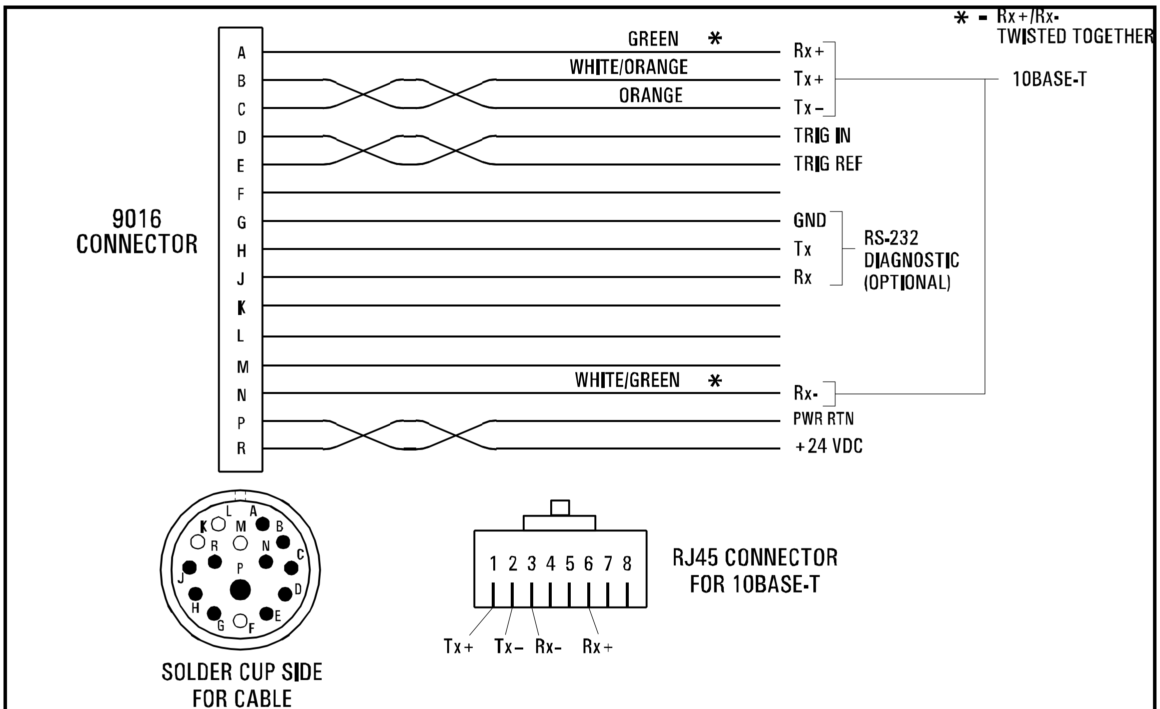
System 9000 9021 to 940x Interface Cable
PN 9096



9021 to Series 27 Interface Cable
9021



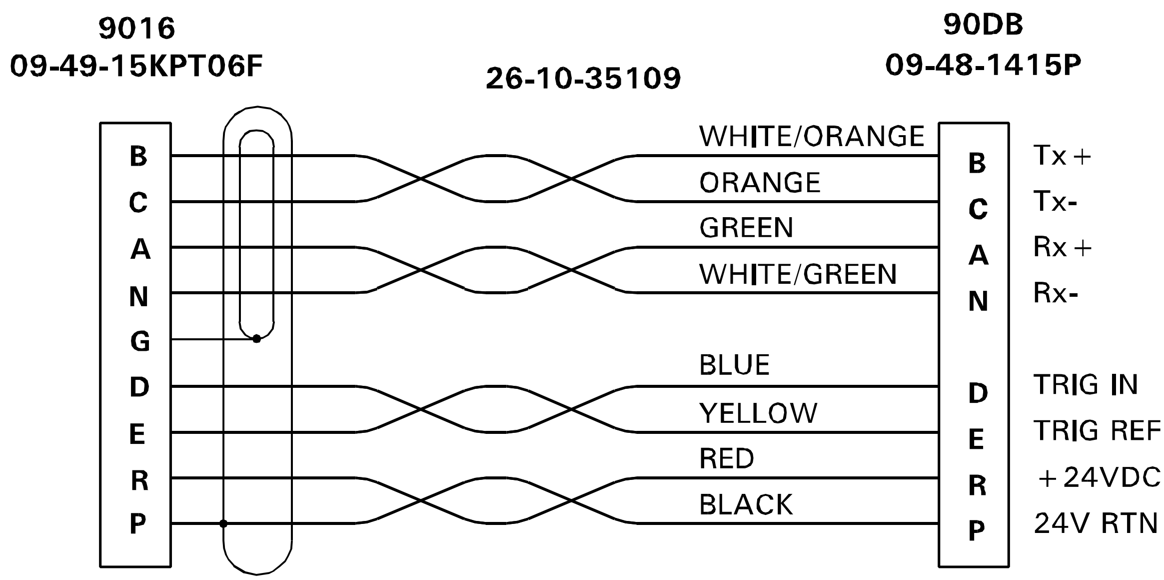
System 9000 Power Supply Cable
P/N 9097



NOTES:

1. WIRE COLORS REFLECT STANDARD RJ45 WIRE ASSIGNMENTS.
2. 10BASE-T SIGNAL WIRES SHOULD MEET CATAGORY 3 OR HIGHER SPECIFICATIONS.
3. POWER AND POWER RETURN CONDUCTORS ARE RECOMMENDED TO BE 18 OR 20 AWG.

System 9000 Ethernet Interface Cable
P/N 9080



System 9000 Ethernet Interface Cable
PN 9080

Appendix F

System 9000 Products

Model		Purpose
9010	-	16-channel Intelligent Pressure Scanner w. Optomux Host Port
9015	-	8-channel Intelligent Pressure Scanner w. Optomux Host Port
9016	-	16-channel Intelligent Pressure Scanner w. Ethernet TCP/IP Host Port
9020	-	12-channel Media-Isolated Intelligent Pressure Scanner w. Optomux Host Port
9021	-	12-channel Media-Isolated Intelligent Pressure Scanner w. Ethernet Host Port
9030/31	-	Pressure Standard Unit w. Optomux Host Port
9032/33	-	Pressure Standard Unit w. Ethernet TCP/IP Host Port
9035/36	-	Pressure Calibrator Unit w. Optomux Host Port
9034/38	-	Pressure Calibrator Unit w. Ethernet TCP/IP Host Port
9090	-	System 9000 Power Supply
9091	-	RS-232 to RS-422 Converter
9093	-	System 9000 Host-to-Module RS-422/485 Interface Cable
9094	-	System 9000 Module-to-Module RS-422/485 Interface Cable
9095	-	System 9000 RS-232 Host-to-Module Diagnostic Port Cable
9096	-	940x Interface Cable
9097	-	System 9000 Power Supply Cable
9400/9401/9402	-	Media-Isolated Pressure Transducer for model 9020 and 9021

This page intentionally left blank.

Appendix G

Optomux Programming Example - BASIC

```
'***********************************************************
'***********************************************************
'*   SAMPLE PROGRAM FOR PSI SYSTEM 9000 OPTOMUX MODULES.
'*
'*   This program will send four commands to a module,
'*              Power Up Clear
'*              Read Scaled Analog Inputs
'*              Rezero
'*              Span Calibrate.
'*  This sample program always uses COM 1,  set up at 9600 Baud, 8
'*    data bits, 1 stop bit , and no parity.
'*  This sample program always uses module node address 1 and assumes
'*    that module has a pressure range of +/-15 PSI and 16 channels.
'*
'***********************************************************
'***********************************************************

Terminator$ = CHR$(13)              ' Terminator of all strings is Carraige Return
Response$   = ""                    ' Response string
ERRCODE%    = 0                     ' Error Code : 0 indicates NO Error
Selection$  = "0"
OPEN "COM1:9600,N,8,1,CS,DS" AS #1      ' Open the COM port
CLS

WHILE  Selection$ <>  "5"
    LOCATE 5, 15
    print "      MAIN MENU          "
    LOCATE 6, 15
    print "  --------------------   "
    LOCATE 7,15
    print "  1) Power Up Clear      "
    LOCATE 8, 15
    print "  2) Read Data           "
    LOCATE 9, 15
    print "  3) ReZero              "
    LOCATE 10, 15
    print "  4) Span Cal            "
    LOCATE 11, 15
    print "  5) Quit                "
    LOCATE 12, 15
    print "  Choose One:            "
    DO
        Selection$ = INKEY$
    LOOP UNTIL Selection$ <> ""
    IF Selection$ <> "5" THEN
        LOCATE 15, 15
        print "Sending Command: "
        LOCATE 16, 18
    ENDIF
    IF  Selection$ = "1"  THEN      ' Send a Power Up Clear
        print #1, ">01A??"          ' Output the command to Module
        print ">01A??"              ' Output the command to Screen
        LOCATE 18, 15
        print "Waiting for Response...."
        LOCATE 19, 18
        GOSUB GetResponse                ' Get response from the Module
        if ERRCODE% <> 0 THEN
            print "  NO RESPONSE FROM MODULE"
        else
            print Response$
        endif
```

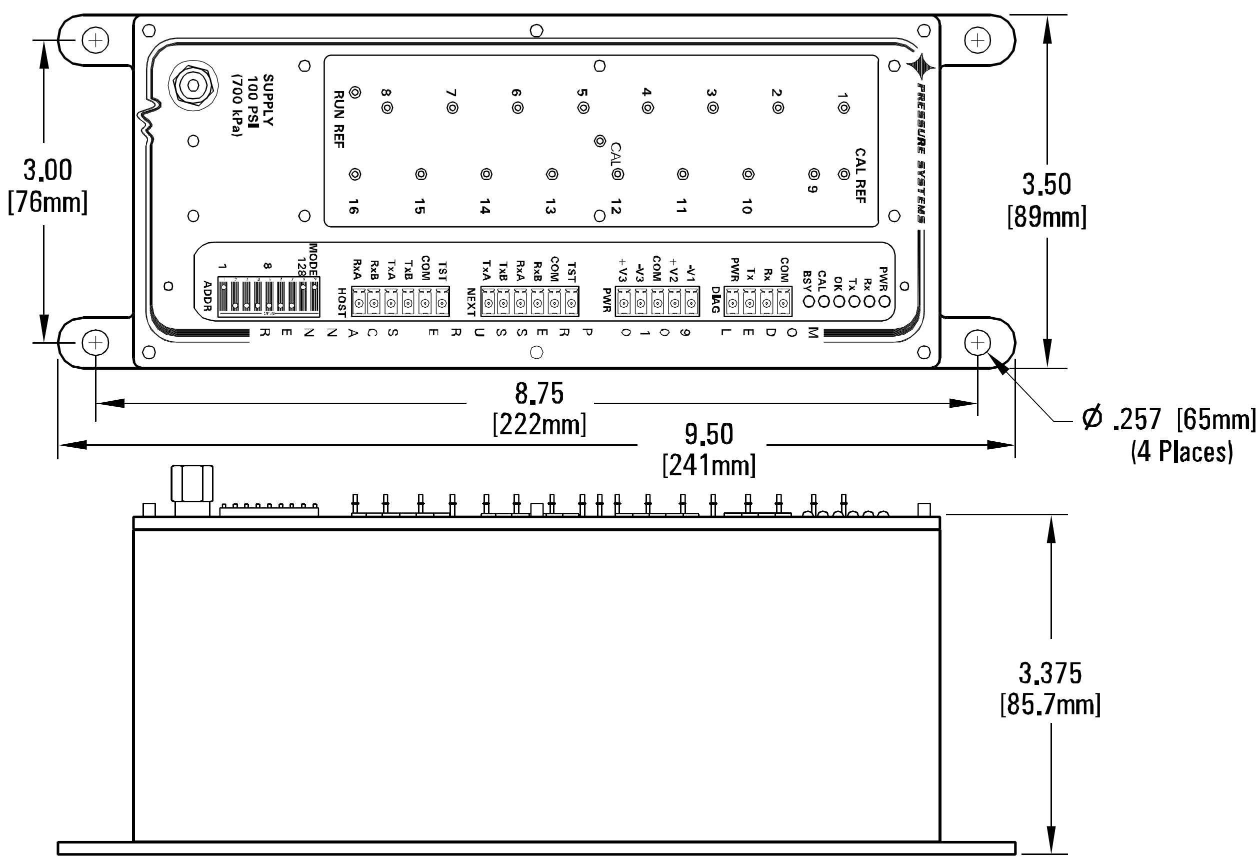
```
    ENDIF
    IF  Selection$ = "2" THEN       ' Send Read Analog Inputs Command
        print #1, ">01LFFFF??"      ' Send the Actual Command
        print ">01LFFFF??"          ' Send the Actual Command to Screen
        LOCATE 18, 15
        print "Waiting for Response...."
        LOCATE 19, 18
        GOSUB GetResponse                ' Get response from the Module
        if ERRCODE% <> 0 THEN
            print "  NO RESPONSE FROM MODULE"
        else
            print Response$
        endif
    ENDIF
    IF  Selection$ = "3" THEN       ' Send Calc and Set Offsets
        print #1, ">01hFFFF??"      ' Send the Actual Command
        print ">01hFFFF??"          ' Send the Actual Command to Screen
        LOCATE 18, 15
        print "Waiting for Response...."
        LOCATE 19, 18
        GOSUB GetResponse                ' Get response from the Module
        if ERRCODE% <> 0 THEN
            print "  NO RESPONSE FROM MODULE"
        else
            print Response$
        endif
    ENDIF
    IF  Selection$ = "4" THEN       ' Send Calc and Set Gain
        print #1, ">01ZFFFF??"      ' Send the Actual Command
        print ">01ZFFFF??"          ' print the Actual Command to Screen
        LOCATE 18, 15
        print "Waiting for Response...."
        LOCATE 19, 18
        GOSUB GetResponse                ' Get response from the Module
        if ERRCODE% <> 0 THEN
            print "  NO RESPONSE FROM MODULE"
        else
            print Response$
        endif
    ENDIF
    IF Selection$ <> "5" THEN
        LOCATE 21,15
        print "Hit any key to continue "
        while INKEY$ = ""
        wend
        CLS
    ENDIF
WEND

END
```

```
'***********************************************************
'*
'*  SubRoutine GetResponse()
'*
'*  This subroutine will input from the Com Port chars until it
'*    receives the Termination CHaracter or times out.
'*
'*    The Error Code is returned as follows:
'*              0 = Successful completion .
'*              1 = Timed Out.
'*
'***********************************************************

GetResponse:

Response$ = ""                            ' Response string
CharIn$ = ""

Elapsed = 0
TimeOut = 10!                       ' Timeout to wait for response is 10 seconds.

OldTime = TIMER                     ' get current time

WHILE (Elapsed < TimeOut) AND (CharIn$ <> Terminator$)
    WHILE (LOC(1) <> 0) AND (CharIN$ <> Terminator$)
       CharIn$ = INPUT$(1, #1)      ' input 1 char from COM Port
       IF CharIn$ <> Terminator$ THEN
            Response$ = Response$ + CharIn$
       ENDIF
    WEND
    Elapsed = TIMER - OldTime
    IF  Elapsed < 0 THEN
        Elapsed = Elapsed + 86400!
    ENDIF
WEND

IF Elapsed >= TimeOut THEN
    ERRCODE% = 1
ENDIF

RETURN
```

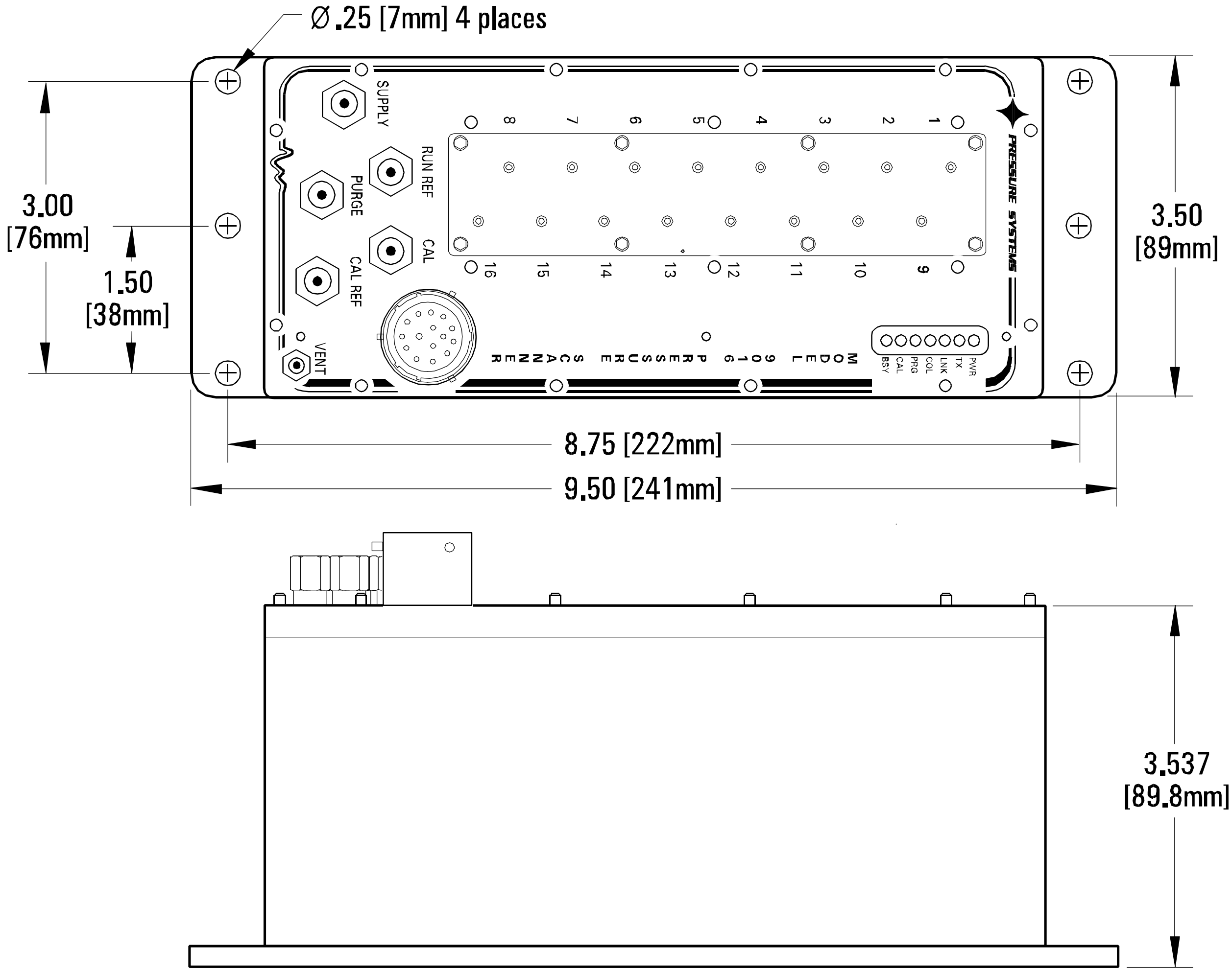
This page intentionally left blank.

Appendix H

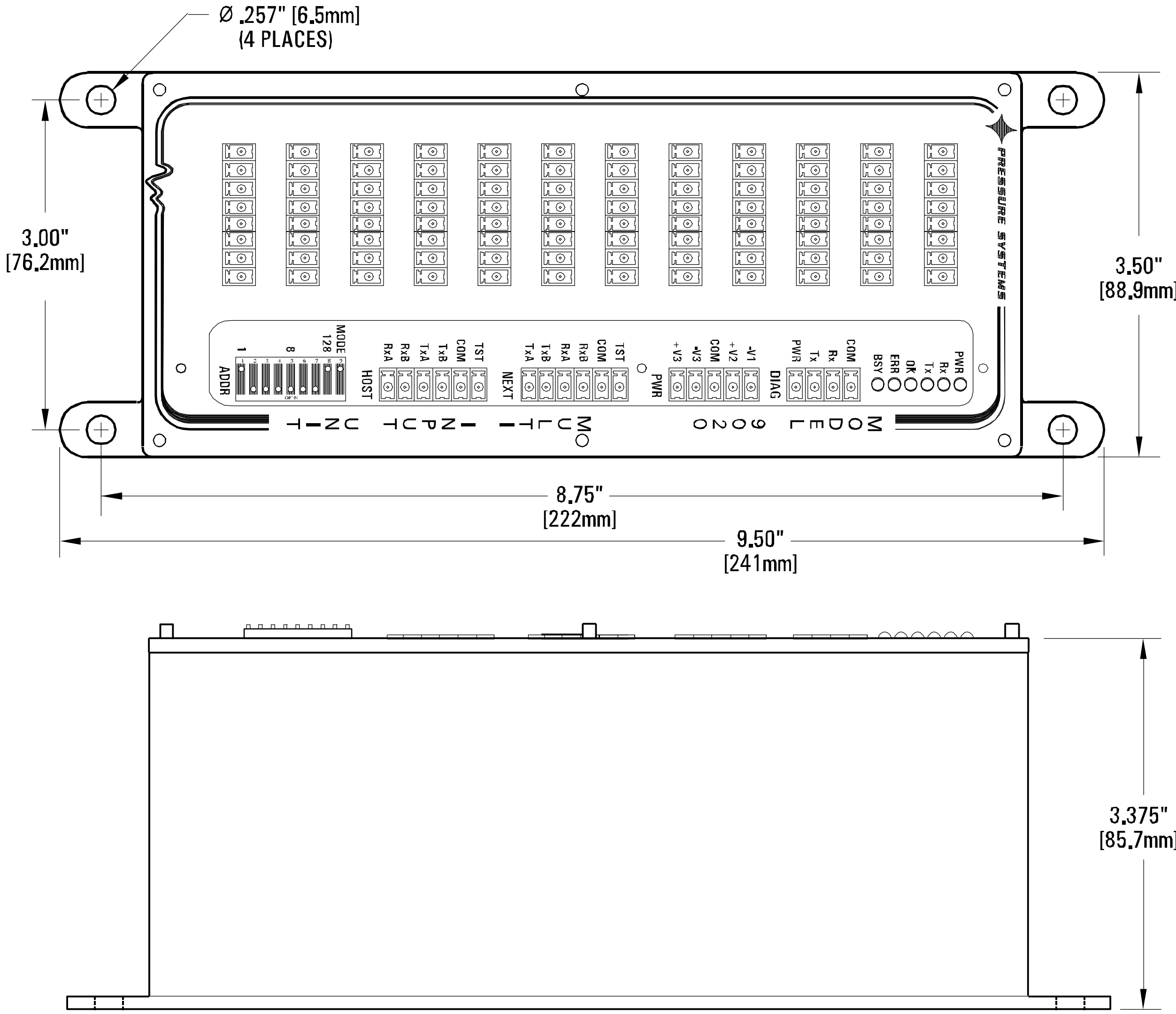
Mounting Dimensions



9010/15 Mounting Dimensions



9016 Mounting Dimensions



9020/9021 Mounting Dimensions

Appendix I

9000 Range Codes

The following range codes are stored in each DH200 and digital 9400 and 9401 pressure transducer. The range code of each transducer can be read through the Read Internal Coefficient (‘u’) command.

Range Code	**Full Scale Pressure**	**Minimun Calibration Pressure**
1	±.360 psi (±10" Water Column)	-0.360 psi
2	±.720 psi (±20" Water Column)	-0.720 psi
3	±1 psid	-1.0 psi
4	±2.5 psid	-2.5 psi
5	±5 psid	-5 psi
6	10 psid	-5 psi
7	15 psid	-5 psi
8	30 psid	-5 psi
9	45 psi	0 psi
10	100 psi	0 psi
11	250 psi	0 psi
12	500 psi	0 psi
13	600 psi	0 psi
14	300 psi	0 psi
15	750 psi	0 psi
16	10 psid	-10 psi
17	15 psid	-12 psi
18	30 psid	-12 psi
19	45 psid	-12 psi
20	20 psid	-12 psi
21	20 psi	0 psi
22	15 psi	0 psi
23	15 psid	-10 psi
24	5 psi	0 psi
25	10 psi	0 psi
26	30 psi	0 psi
Range Code	**Full Scale Pressure**	**Minimun Calibration Pressure**

27	50 psi	0 psi
28	100 psi	0 psi
29	100 psia	2.5 psi
30	250 psia	25 psi
31	50 psia	2.5 psi
32	500 psia	25 psi
33	750 psia	25 psi
34	30 psia	2.5 psi
35	15 psia	2.5 psi
36	125 psi	0 psi
37	35 psid	-12 psi
38	150 psi	0 psi
39	200 psi	0 psi
40	22 psid	-12 psi
41	60 psid	-12 psi
42	375 psi	0 psi
43	150 psi	0 psi
44	75 psi	0 psi
45	150 psi	0 psi
46	650 psi	0 psi