



**MODEL 970  
HART PROTOCOL  
PRESSURE TRANSMITTER  
INSTALLATION MANUAL**

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# **SECTION 1 – INTRODUCTION**

## **USING THIS MANUAL**

This manual describes the setup and operation of Viatran's Model 970 SMART Pressure Transmitters. It is intended for the average user who will be making pressure measurements. This manual does not desire to get into the construction and programming of a software system to perform these operations. It is targeted at the user who desires to utilize the HART Communicator or another commercially available computer interface product to operate the Model 970 SMART Pressure Transmitter. Although there are two different HART Communicators, the Model 268 and the Model 275, this manual will deal only with the more current Model 275 HART Communicator. It is important to note that the Model 970 must be wired in a standard current loop and will operate as a typical 4-20 mA device.

## **ABOUT YOUR MODEL 970 PRESSURE TRANSMITTER**

The Model 970 SMART Pressure Transmitter is a precision instrument that utilizes the HART (Highway Addressable Remote Transducer) protocol and specification. It is capable of offering service through a digital computer interface or a standard 4 to 20 milliamp process loop connection.

The Model 970 SMART Pressure Transmitter is available in an assortment of ranges and materials. It is capable of precision measurement from a range of 0 to 100 psi thru 0 to 15000 psi depending upon the particular unit purchased.

### **SMART**

The term SMART for field device is used in the sense of "intelligent", to describe a device which includes a microprocessor and the software to control it. This implies functionality above that provided in a similar non-microprocessor based device. A SMART field device usually needs a communicator for setting up and controlling the instrument and for processing the measurement signal to produce an output.

### **What is HART?**

HART is a computer communications protocol and specification tailored to the needs of the sensor industry in general. The HART Transducer is capable of simultaneous 4 to 20 milliamp current loop operation and digital computer communication. This combination technique is achieved by superimposing a Bell 202 type frequency shift keying communications AC signal over the normal 4 to 20 milliamp DC current loop signal. The average value of the AC component of the signal is zero thereby imposing no change to the DC signal carrying the current loop communications. The transmitter (slave) and the Communicator (master) communicate digitally using their built-in HART modems. In essence, a HART smart field device will allow the analog and digital signals to co-exist on the same pair of wires without disrupting either signal.

### **Communicating With the Model 970 SMART Pressure Transmitter**

The Model 970 SMART Pressure Transmitter communicates with a Master System through the use of the HART Protocol. Reading the measured variable digitally preserves accuracy by eliminating the digital-to-analog conversion of the 4 to 20 mA signal. However, the time taken to communicate the message adds an extra delay to the measurement, which could adversely affect a fast control loop. The analog signal, however, is available and can be used for control purposes in these situations.

## **Primary and Secondary Masters**

The HART protocol has provisions for two master communicators to be present simultaneously. The designation of primary and secondary master is arbitrary and provides a mechanism for arbitrating the digital communications on the service loop or highway. The HART Communicator is a secondary master and most other systems are configurable to either be primary or secondary. The primary master has a slightly shorter waiting period between messages that the secondary master is allowed. Thus, the secondary master can only initiate communications with a slave device, i.e., Model 970, when the primary master has released the highway bus for a sufficient period of time for the secondary master to gain momentary control. By allowing two masters in the control loop, the HART Communicator can be taken into the field and used on the current loop while it performs calibration or configuration services without interfering with the operation of the control system.

## **Working with the CORNERSTONE Configurator or Base Station**

Applied Systems Technology, Inc. offers the Cornerstone series of HART master devices for interfacing with HART compliant slave devices. The Cornerstone programs are Microsoft Windows™ hosted programs which can be used for calibrating, operating, configuring, and monitoring HART slave devices such as Viatran's Model 970 SMART Pressure Transmitter. The complete operations of the Cornerstone programs are covered within their respective User's Manuals. The Cornerstone programs are user configurable to provide service as either primary or secondary masters.

## **Working with HART Master Controllers from Other Manufacturers**

Although the HART Communicator and the Cornerstone Programs are widely used, there are many other sources of Software and Control Systems that may be used to interface with the Model 970 SMART Transmitter. Interfacing with the Model 970 Smart Transmitter may be accomplished by using a program which is capable of reading a HART DDL or a computer program which has been custom tailored to utilize the command structure specified by the Viatran Model 970 Command Specification, ES0702, which details all of the interface requirements for communicating with the Model 970 SMART Transmitter.

## **DDL's**

A DDL, Device Description Language, is a HART interfacing utility program or driver which can be loaded into a HART master device so that the master device can properly interface with the HART slave device, i.e., the Viatran Model 970 SMART Transmitter. DDL's may be obtained from the HART Communication Foundation, Inc. for most HART compliant devices.

## SECTION 2 – STARTUP AND COMMISSIONING

### GENERAL CONSIDERATIONS

Before putting the Model 970 into service the instrument should be commissioned, which consists of testing the transmitter and loop, and verifying transmitter configuration data. The transmitter may be commissioned either before or after installation. If you want to commission after installation, refer ahead to Section 3 – Installation, and then return to this section. It may be advantageous, however, to commission the transmitter on the bench prior to installation. This will ensure that all transmitter components are in good working order, as well as allowing some familiarity with the instruments operation. Refer to Figure 2, Section 3 for instrument connections. A load resistance of at least 230 ohms is required for digital communications. For information on changing transmitter configuration data, refer to Section 4 – Configuration.

### STARTUP

When first connecting a Model 970 Transmitter to a current loop, the first operation which a master device will perform is to attempt to communicate with the Model 970. A series of messages are sent to the transmitter to obtain the address, manufacturer, range, serial numbers, date of last calibration, TAG, polling address, mode of operation, write protect mode status, and many other items of information necessary for operation. This process may take as long as a minute and during this time the transmitter will for all intents be unavailable for other queries. It will however continue to provide pressure output information during this time also.

### ANALOG OUTPUT

The Model 970 Analog Output typically follows 4-20 mA output for normal measurement conditions. Occasionally other levels of output can be seen when the transmitter is indicating special condition as in the following table.

Condition	Level
Normal Operation	3.90 mA thru 20.80 mA
Saturation Low	3.90 mA
Saturation High	20.80 mA
Alarm Low	3.75 mA
Alarm High	22.00 mA

### Failure Mode Alarm

The Model 970 SMART Transmitter may be software configured for several Failure Mode Alarm operations depending upon your particular needs. The allowed failure mode alarm setting are:  
Primary Variable Output HIGH, transmitter output will rise to 22.00 mA;  
Primary Variable Output LOW, transmitter output will drop to 3.75 mA;  
Primary Variable Output HOLD LAST VALUE, transmitter output will remain fixed at the last reading performed prior to the alarm condition.  
These outputs are displayed until the instrument is reset, either by power cycling or software command.

## COMMISSIONING TESTS

Testing of the Model 970 SMART Pressure Transmitter will verify that the transmitter and the loop are working properly. Testing is recommended whenever you suspect a problem with loop performance or faulty components.

### Transmitter Test

The transmitter test will verify the performance of the transmitter and will initiate a more thorough test set than the routine test performed by the unit while operating normally.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **2 Diagnostics & Service**.
3. From the Diagnostic & Service menu, select **2 Test Device**.
4. From the Test Device menu, select **2 Self Test**.

### Loop Test

The loop test allows you to verify the output of the transmitter, the integrity of the current loop, and the operation of any and all devices within the loop. During initial installation of any equipment within the loop, you should initiate this test to verify performance.

1. From the **Online Menu**, Select **1 Device Setup**.
2. From the Device Setup menu, select **2 Diagnostics & Service**.
3. From the Diagnostics & Service menu, select **3 Loop Test**.

### Reviewing Configuration Data

It is advisable to periodically review the configuration data contained within the transmitter. This information can change and a result of calibration, maintenance or factory service and the parameters contained within the unit should be compared with those expected for the device in the installation it performs within.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **5 Review**.
3. The display will then step through the transmitters configuration data.

### Security

The Model 970 SMART Transmitter offers the user the security afforded by a password that may be placed into the Model 970's non-volatile memory. When the password feature is activated, all configurable inputs are fixed in memory and cannot be changed without first unlocking the write protect mode by entering the proper password. When the user activates write protect mode, he must supply a password of up to 8 upper case characters, numbers, and/or spaces. This password will be in effect until the write protect mode is inactivated by supplying the same password to the device again. Write protect mode is a toggled operation with the same command being used to both set and unset it. Each time the Model 970 is released from write protect mode, the password is cleared from memory so that it is gone forever. This feature allows the user the opportunity to select a new password or the same password whenever he wants. It is very important that the password which activates a write protect operation not be lost or forgotten as there is no way of retrieving the password from the Model 970. If write protect mode is activated and the password lost, there is an emergency means by which the Model 970 may clear the write protect operation and erase the unknown password, but it is only available by calling the factory service line and obtaining the Factory Master Password.



## SECTION 3 – INSTALLATION

### GENERAL CONSIDERATIONS

Mount the Model 970 SMART Pressure Transmitter close to the process and use a minimum of piping to achieve the best accuracy. During installation, also afford adequate access to the transmitter to satisfy the safety of personnel, allow access and field calibration, and to exclude or minimize the effects of vibration, shock, and temperature fluctuations.

### ELECTRICAL CONSIDERATIONS

The Viatran Model 970 SMART Transmitter is a precision instrument for measuring pressure. It is diode protected at its input to prevent burnout in the event of accidental hookup backwards. It also has transient surge protection across the input leads to short high voltage transients and thus prevent damage to the Model 970. Connections to the Model 970 are made directly to the three pigtail leads coming from the unit: Red going to the positive supply, Black going to the negative supply, and Green provided a ground for those installations requiring a ground. The load resistor may be placed anywhere in the service loop.

#### Power Supply

The DC power supply should provide power with less than 2 percent ripple. The total load resistance is the sum of the resistance of the signal leads and the load resistance of the controller, indicator, load resistor, and any other related pieces in the service loop. The resistance of any intrinsic safety barriers, if any are used, must also be included.

NOTE: A minimum lead resistor of 230 ohms is required to digitally communicate with a Model 970 SMART Transmitter, and with 230 ohms of loop resistance, the transmitter will require a minimum of 16 volts to output 20 mA. If a single power supply is used to power multiple Model 970 transmitters, the power supply must be rated so as to be able to deliver at least 20 mA for each device connected. The power supply should have no more than 20 ohms of impedance at 1200 Hz.

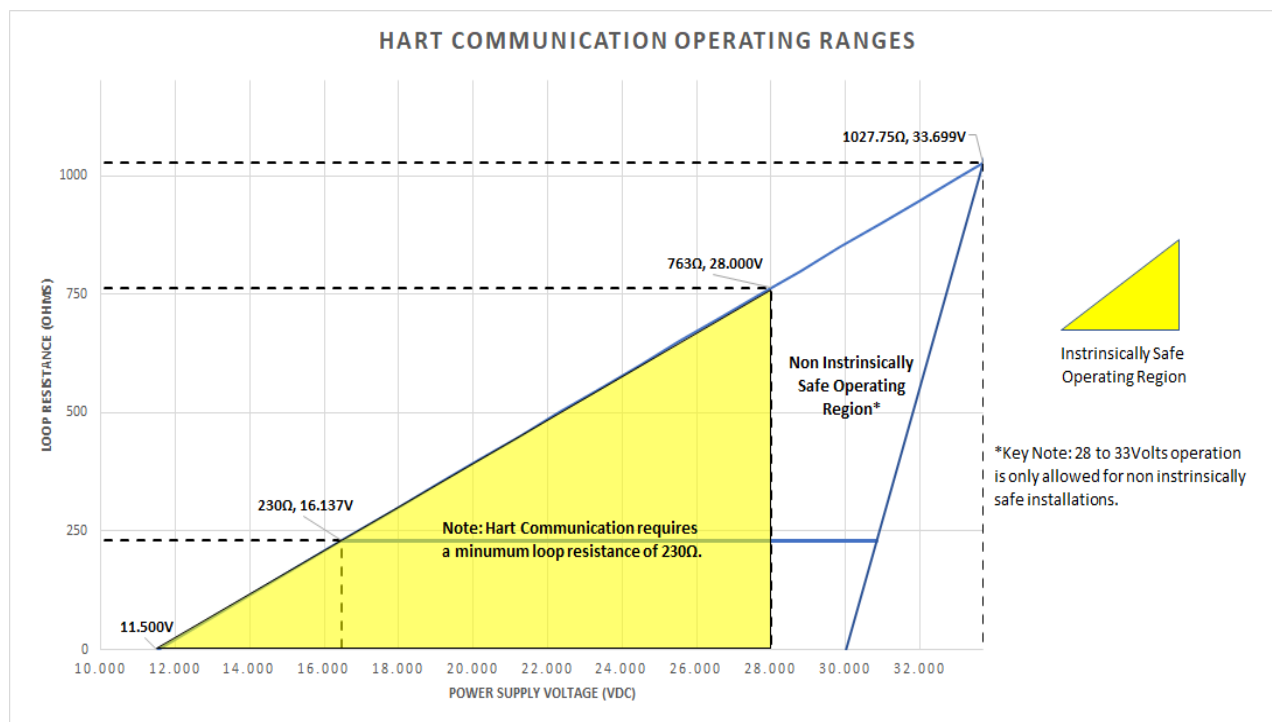


Figure 1 – Power Supply Load Limitations

## Wiring

Signal wiring need not be shielded, but twisted pair should be used for best results. In order to ensure communication, wiring should be 24 AWG or larger and should not exceed 1 mile in length. Do not run signal wiring in conduit or open trays with power wiring, near heavy electrical equipment, motors, or generators. Signal wiring may be grounded at any one point in the signal loop, or it may be left ungrounded. The negative terminal of the power supply is a recommended grounding point.

## SETTING UP A CURRENT LOOP

The minimum parts required to hookup the Model 970 and calibrate it are:

1. The Model 970 SMART Pressure Transmitter
2. A power supply or battery, voltage output at least 11.5 volts DC.
3. A load resistor (equal to or greater than 230 ohms and nominally less than 825 ohms).  
Minimum loop resistance for digital communications is 230 ohms.  
Maximum loop resistance is equal to 50 times the power supply voltage – 575, where the supply voltage can never be less than 11.5 volts.
4. A HART Communicator (and batteries).
5. Suitable current loop wiring or cabling.
6. A Bell-202 modem (only needed if using a PC based communicator program).

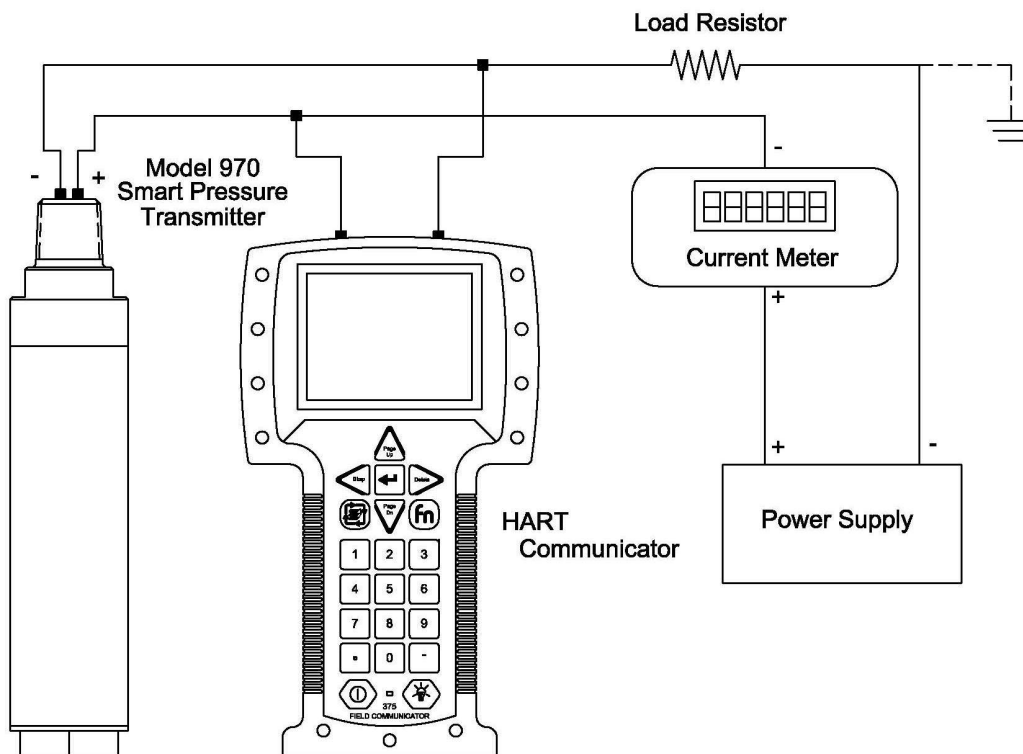


Figure 2 – Connecting the Model 970 to a 4-20 mA Current Loop

## Other Things You May Need

If you are using one of the PC based HART Master Communicator programs, you will need a Bell-202 or HART compatible modem. The Bell-202 is a US telephone standard. It uses 1200 Hz and 2200 Hz as 1 and 0 respectively. Bell-202 is full duplex communication standard using a different pair of frequencies for its reverse channel. HART uses Bell-202 signals, but is a half-duplex system so that the reverse channels are not used.

## OPTIONAL APPROVALS

970\_TJ\_(A)



CSA 03.1000784  
CL I, DIV. 2, GPS A,B,C,D;  
CL II, DIV. 2, GPS E,F,G;  
CL III, DIV. 2  
Ex nA IIC T4 at Ta = 60°C  
Type 4 End.  
DUAL SEAL



970\_TJ\_(B)

[For use with 'G' gage format]



CSA 03.1000784  
CL I, DIV. 2, GPS A,B,C,D;  
Ex nA IIC T4  
at Ta = 60°C



970\_NX\_(A)



CSA 03.1000784  
CL I, DIV. 1, GPS A,B,C,D;  
CL II, DIV. 1, GPS E,F,G;  
CL III, DIV. 1,  
Ex ia IIC T4, Ta = 50°C,  
Type 4 End.  
per drawing CD0637  
DUAL SEAL

970\_NX\_(B)

[For use with 'G' gage format  
or alt. electrical conn.]



CSA 03.1000784  
CL I, DIV. 1, GPS A,B,C,D;  
Ex ia IIC T4, Ta = 50°C,  
per drawing CD0637

970\_NY\_(A)

[All product ≥300 PSIA/A]



APPROVED  
EXPLOSION PROOF FOR USE  
IN CL I, DIV. 1, GPS A,B,C,D  
CL II/III, DIV. 1, GPS E,F,G  
CL I, ZN 1, AEx d IIC  
T5 at Ta=88°C NEMA 4X, HAZ LOC  
Factory Sealed, Conduit Seal not Required  
DUAL SEAL  
for Process Temps -40°F to 300°F

970\_NY\_(B)

[All product (All Ranges) PSIG/PSIV/TB Option]



APPROVED  
EXPLOSION PROOF FOR USE  
IN CL I, DIV. 1, GPS A,B,C,D  
CL II/III, DIV. 1, GPS E,F,G  
T5 at Ta=88°C NEMA 4X, HAZ LOC  
Factory Sealed, Conduit Seal not Required  
DUAL SEAL  
for Process Temps -40°F to 300°F

970\_NY\_(C)

[All product <300 PSIA/A]



APPROVED  
EXPLOSION PROOF FOR USE  
IN CL I, DIV. 1, GPS A,B,C,D  
CL II/III, DIV. 1, GPS E,F,G  
CL I, ZN 1, AEx d IIC  
T5 at Ta=88°C NEMA 4X, HAZ LOC  
Factory Sealed, Conduit Seal not Required

970\_NZ\_(A)

[All product except as  
noted in labels 970NZ(B-D)]



APPROVED  
NONINCENDIVE FOR USE IN  
CL I, II & III, DIV. 2, GPS A,B,C,D  
CL I, ZN 2, GP IIC  
T4 at Ta=60°C,  
NEMA/TYPE 4X, HAZ LOC  
DUAL SEAL  
for Process Temps -40°F to 300°F

970\_TF\_(A)

[All product except as  
noted in labels 970TF(B-D)]



APPROVED  
INT. SAFE (IS) FOR USE IN  
CL I,II,III, DIV. 1, GPS A,B,C,D,E,F,G  
CL I, ZN 0, AEx ia IIC T4 at Ta=60°C,  
NEMA/TYPE 4X, HAZ LOC  
INSTALL PER CD0636  
DUAL SEAL for Process Temps -40°F to 300°F

970\_TF\_(B)

[G' Gage format  
and/or TB option]



APPROVED  
INT. SAFE (IS) FOR USE IN  
CL I, DIV. 1, GPS A,B,C,D,  
CL I, ZN 0, AEx ia IIC T4 at Ta=60°C,  
INSTALL PER CD0636  
DUAL SEAL for Process Temps -40°F to 300°F

970\_TF\_(C)

[All product <300 PSIA/S/V]



APPROVED  
INT. SAFE (IS) FOR USE IN  
CL I,II,III, DIV. 1, GPS A,B,C,D,E,F,G  
CL I, ZN 0, AEx ia IIC T4 at Ta=60°C,  
NEMA/TYPE 4X HAZ LOC  
INSTALL PER CD0636

970\_TF\_(D)

[All alternate  
electrical connections]



APPROVED  
INT. SAFE (IS) FOR USE IN  
CL I, DIV. 1, GPS A,B,C,D,  
CLS I, ZN 0, AEx ia IIC T4 at Ta=60°C,  
INSTALL PER CD0636

970\_NG\_

[For use with 'S' sealed format  
or 'A' absolute format only]



Ex db IIC T6...T4 Gb  
T6...T4: -20°C < Ta < 60°C

PRESAFE 16 ATEX 8250X



970\_NK\_



Ex ia IIC T4 Ga  
(-20°C < Ta < 50°C)  
Ui=28V, Ii=200mA  
Li=1.2uH, Ci=14.1nF, Pi=1W  
Baseefa 03 ATEX0054



970\_TW\_



TC RU C-US.BH02.B.00653/18  
0Ex ia IIC Ga  
T4: -20°C < Ta < 80°C  
T5: -20°C < Ta < 40°C  
1Ex d IIC Gb  
T6: -20°C < Ta < 40°C  
METROLOGY CERT:  
OC.C.30C001.A No 73774

970\_NJ\_



970\_NZ\_(B)

[G' Gage format  
and/or TB, ZU options]



APPROVED  
NONINCENDIVE FOR USE IN  
CL I, DIV. 2, GPS A,B,C,D  
CL I, ZN 2, GP IIC  
T4 at Ta=60°C,  
DUAL SEAL  
for Process Temps -40°F to 300°F

970\_NZ\_(C)

[All product <300 PSIA/S/V]



APPROVED  
NONINCENDIVE FOR USE IN  
CL I, II & III, DIV. 2, GPS A,B,C,D  
CL I, ZN 2, GP IIC  
T4 at Ta=60°C,  
NEMA/TYPE 4X, HAZ LOC

970\_ME\_



CERTIFIED EXPLOSION  
PROOF FOR  
CL I, GPS A,B,C,D;  
CL II; GPS E,F,G; CL III  
HAZ LOC, Type 4 End.  
Dual Seal

## SPECIAL CONDITIONS FOR USE

Certificate	Type	Special Instruction
Presafe 16 ATEX 8250X	ATEX Flameproof	The pressure transmitters are constructed with permanently connected unterminated conductors and unprotected bushing. The external part of the bushing and the conductors terminated outside the flameproof enclosure shall be protected with one of the types of protection listed in EN 60079-0.
1000784 (LR 34272)	CSA Explosion Proof	Transmitter must be powered by an approved SELV source, in accordance with CSA standard C22.2 No.1010.1, Annex H
1000784 (LR 34272)	CSA Intrinsically Safe	Connect per installation drawing. Transmitter must be powered by an approved SELV source, in accordance with CSA standard C22.2 No.1010.1, Annex H

## SECTION 4 – CONFIGURATION

### ONLINE CONFIGURATION

Online Operations consist of setting parameters that determine how the Model 970 SMART Transmitter operates and reading the outputs received back from the transmitter during operation.

#### Re-Ranging the Transmitter

One of the most common changes to the configuration of the Model 970 SMART Pressure Transmitter involves re-ranging the transmitter 4 and 20 mA points. DO NOT re-range the transmitter such that the 4 and/or 20 mA range points are outside the normal high and/or low digital sensor trim values. To optimize performance, the digitally trimmed span should be equal to or slightly greater than the 4-20 mA span utilized by the transmitter. The range points refer to the “Upper Range Value” (URV), and the “Lower Range Value” (LRV).

#### Selecting the Damping

Changing the damping value of the Model 970 SMART Pressure Transmitter forces the output of the transmitter's 4-20 mA output to not change faster than allowed by the time constant associated with the damping value. The allowed values of damping are: 0.00, 0.30, 0.60, 1.20, 2.40, 4.80, 9.60, 19.20, 38.40 and 76.80 seconds. Any other value entered will be changed, either upward or downward, to the closest allowed value, (i.e., 0.50 sec will be changed to 0.60 sec, and 2.5 sec will be changed to 2.40 sec). The user will want to select the damping value which best suits his particular process or needs. The transmitter will always report back, digitally, the setting that was actually sent.

#### Changing Non-Output Related Transmitter Information

The Model 970 contains many items of information that do not directly affect the transmitter function. The items encompass such information as transmitter construction materials, calibration dates, TAG information, message, descriptor, revision numbers, etc. Most of these items can be user reconfigured or re-written, while several, such as serial number and manufacturer, cannot.

## OFF-LINE OPERATIONS

Off-Line Operations are those procedures and data exchanges which do not have a direct impact upon the Analog Signal which the transmitter outputs or reports and which do not affect the measurement data transmitted digitally by the transmitter.

### Specifying a TAG

The "TAG" is an important item recognized by the transmitter in many non-standard transmitter installations. It appears as a top-level option in the multidrop display and is used to initiate communications. Since many transmitters may be on the same current loop and at times, one or more of them may be removed or replaced for maintenance or during calibration, the "TAG" allows the replacing transmitter, if it is similarly tagged, to be recognized by the system as being the replacement for the replaced transmitter. Without this feature, each unit would have to be separately identified and noted by the operators and its locations identified through an external bookkeeping operation.

### Multidropped Mode of Operation

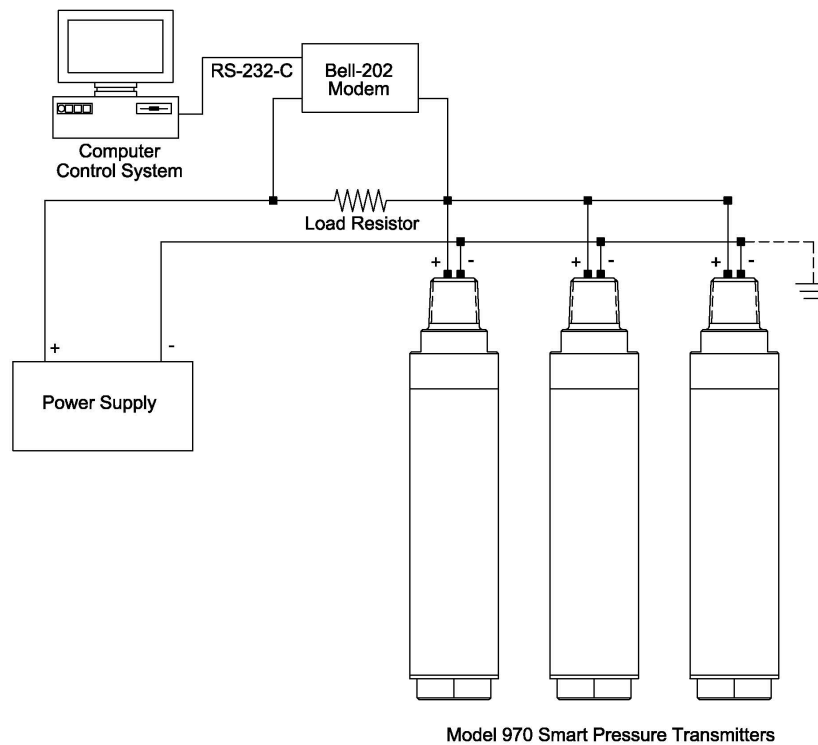
"Multidropping Mode" refers to the connection of multiple transmitters on a single communications transmission line. Communications between the control system host (or hosts) and the transmitters takes place digitally with the analog output, 4-20 mA signal, being de-activated by locking the output current to a level of 4 mA per transmitter. With the HART smart communications protocol, up to 15 transmitters can be connected on a single twisted pair of wires or leased phone lines.

The use of a multidrop installation requires consideration of the length of transmission line, the combination of transmitters and their operating characteristics and the expected update rate necessary from each transmitter. Communication with the transmitters can be accomplished with a host implementing the HART protocol and a commercially available Bell-202 or HART modem.

During multidrop operation, each transmitter is identified by a unique polling address (1-15) and responds to the commands defined by the HART protocol and the transmitter specific commands associated with each individual transmitter. The actual number of devices which may be simultaneously operated together in a multidrop system is practically limited to 15, but is actually limited by the combined capacitance of each unit and the length of the cabling in the system.

When a Model 970 is shipped from the factory, the polling address is set at "0" so that the unit will allow operation as a standard point-to-point 4-20 mA unit. To allow multidrop communications, the transmitter must have its polling address changed to a number between 1 and 15. The act of changing the polling address to a non-zero address de-activates the 4-20 mA operation mode and activates the 4 mA multidrop mode.

Communication with the transmitters can be accomplished with commercially available Bell-202 modems and a host computer system running software implementing the HART protocol. (The HART Communicator is a handheld secondary master host system with a built-in Bell-202 modem and running software that implements the HART protocol.)



**Figure 3 – Typical Multidrop Network**

### **Polling a Multidropped Loop**

Polling a multidropped service loop determines the model, address, polling address, and number of transmitters on a given loop.

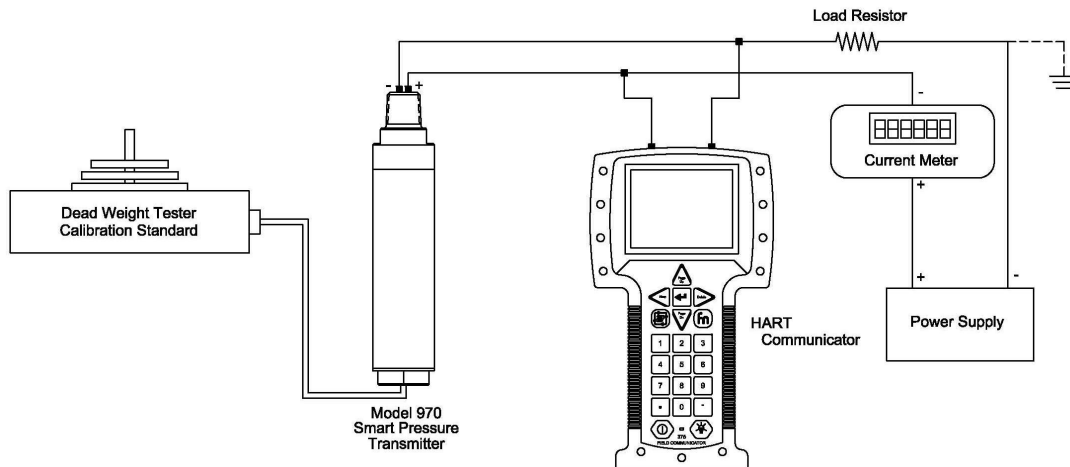
## **SECTION 5 – MAINTENANCE & CALIBRATION**

A variety of maintenance and calibration tasks are associated with the Model 970 SMART Pressure Transmitter. These include the digital trim procedures needed to trim and calibrate the transmitter's input signal conditioner and output signal conditioner. They also include hardware diagnostics and hardware maintenance. It is important to realize that the accuracy of your Model 970 SMART Pressure Transmitter is only as good as the equipment and standards used to perform any of the trim operations. If your transmitter is calibrated against an inaccurate standard, then it too will be inaccurate. If you have any doubts concerning the accuracy or precision of your calibration instruments or standards, you should return the transmitter to the factory service center for verification of your trim values. To guard against the possibility of over-trimming your transmitter, the Model 970 will accept no more than a three percent change in any zero trim or five percent of any span or full scale trim. Even with these safeguards, a clever person can over-trim the device under the right circumstances. If this happens, you can restore the unit to its original factory settings and then start over. You should consult the section on "Restoring Factory Settings" elsewhere in this guide under those circumstances.

### **Digital versus Analog Trim**

It is necessary to realize that a SMART transmitter does not function the same way a conventional analog transmitter does. The unit is not trimmed by "tweaking" the gain of an instrumentation amplifier or adjusting the zero point with a potentiometer. A SMART pressure transmitter has two separate and distinct interfaces which it must control, the sensing element and the output generator. The sensing element is characterized by comparing the inputs against known standards and then recording the settings in memory so that they may be referred to and utilized to derive a theoretical output. The output current is likewise calibrated using a precision milliammeter and its output is also recorded internal to the

transmitter. By utilizing the input and output calibrations, the microprocessor can derive and control the proper digital and analog outputs for the device while correcting for linearity and compensatable effects. The digital trim should not be confused with re-ranging, which will not affect the transmitter's interpretation of either input or output signals. With a smart transmitter you gain the ability to alter the transmitter's conversion of input to output signals such that you can create a sub-range that is measurable through the full output of the transmitter. (i.e., a 0-100 psi transmitter which is configured to output 4-20 mA for a sub-range of 20-30 psi, with 4 mA being representative of 20 psi and 20 mA being representative of 30 psi.)



**Figure 4 – Digital Trim Connections for Operation of a Model 970 SMART Pressure Transmitter**

### Sensor Trim (Calibration)

Sensor trim refers to the characterization of the input sensor by comparison to a known pressure source. During sensor trim the settings are stored in the microprocessors non-volatile memory for use during transmitter operation. There are two methods to trim the input sensor: Zero Trim and Full Sensor Trim. They vary in complexity and accuracy, and their use is often application dependent.

#### Zero Trim

A Zero Trim is a one-point adjustment typically used to compensate for mounting position effects or zero shifts caused by static pressure. A Zero Trim maintains the slope of the characterization curve. To perform a sensor zero trim you must set the pressure to zero (by removing any source of pressure) and then issue the command for the sensor to set the zero point.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **2 Diag/Service**.
3. From the Diag/Service menu, select **4 Config Sensor**.
4. From the Config Sensor menu, select **4 Trim Sensor**.
5. From the Trim Sensor menu, select **1 Zero Trim**.
6. Follow the on-line instructions.

#### Full Sensor Trim

A Full Sensor Trim is a two point process in which two accurate end-point pressures are applied and all output are linearized between them. To perform a full sensor trim you must first set the sensor zero by removing any sources of pressure from the sensor and issuing the command to set the zero point, then you must apply an accurately known pressure close to the full scale pressure range value to the input port and issue the set FSPR command. If either the zero or FSPR (full scale pressure reading), reading differs from the expected value by more than three percent (3%) in the case of the Zero or five percent (5%) in the case of the FSPR, the sensor will limit the adjustment to the maximum allowed and you must perform the trim procedure several times to finally reach the trim

point desired. You must always set the zero trim point first, see the previous section, as its adjustment will shift the upper trim point by moving it to maintain the transmitter's characterization slope. Once the Zero trim has been performed, continue on to the Gain trim to complete the full sensor trim.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **2 Diag/Service**.
3. From the Diag/Service menu, select **4 Config Sensor**.
4. From the Config Sensor menu, select **4 Trim Sensor**.
5. From the Trim Sensor menu, select **3 Gain Trim**.
6. Follow the on-line instructions.

### **Analog Output Trim (4-20 mA Calibration)**

The Analog Output Trim refers to modifying the transmitter conversion of the digital signal to an analog signal through comparison and characterization of expected output values with values actually reported by a calibrated accurate output measurement device (milliammeter).

#### **4-20 mA Trim**

A 4-20 mA trim is a two point process in which two accurate current measurements are taken at the endpoints of the loop current excursions (of 4.00 and 20.00 mA) and the output settings used to create these currents are recorded in memory for use in modifying the output equation which translates the input signals to a corresponding output current. You must ALWAYS set the zero or 4 mA trim point first since its adjustment affects the upper trim point (20 mA trim) by shifting the 20 mA point by the 16 mA span.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **4 Detailed Setup**.
3. From the Detailed Setup menu, select **3 Output Condition**.
4. From the Output Condition menu, select **1 Analog Output**.
5. From the Analog Output menu, select **D/A Trim**.
6. Follow the on-line instructions.

### **Temperature Trim**

Temperature trim characterizes the temperature sensing circuitry by referencing a known temperature. There are two methods available for trimming the temperature circuitry: temp offset trim and temp gain trim. Prior to activation of any temp offset trim command, the Model 970 Smart Transmitter should be soaked at the intended trim temperature. A soak time of at least 45 minutes is recommended.

#### **Temp Offset Trim**

As with sensor zero trim, temperature trim is a one point adjustment which maintains the slope of the characterization curve. The desired offset trim temperature must be known and should, for best performance, be at the extreme of the operating range and opposite to any temperature gain trim.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **4 Detailed Setup**.
3. From the Detailed Setup menu, select **1 Sensors**.
4. From the Sensors menu, select **2 Temperature Sensor**.
5. From the Temperature Sensor menu, select **3 Temp Low Trim**.
6. Follow the on-line instructions.

#### **Temp Gain Trim**

Temp gain trim adjusts the slope of the characterization curve. All temperature outputs are linearized according to the offset and gain set points.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **4 Detailed Setup**.



3. From the Detailed Setup menu, select **1 Sensors**.
4. From the Sensors menu, select **2 Temperature Sensor**.
5. From the Temperature Sensor menu, select **3 Temp Upper Trim**.
6. Follow the on-line instructions.

### Setting the Damping (Response Time)

Changing the damping value of the Model 970 SMART Pressure Transmitter forces the output of the transmitter's 4-20 mA output to not change faster than allowed by the time constant associated with the damping value. The allowed values of damping are: 0.00, 0.30, 0.60, 1.20, 2.40, 4.80, 9.60, 19.20, 38.40, and 76.80 seconds. Any other value entered will be changed, either upward or downward, to the closest allowed value, (i.e., 0.50 sec. will be changed to 0.60 sec, and 2.5 sec. will be changed to 2.40 sec.) The user will want to select the damping value which best suits his particular process or needs. The transmitter will always report back, digitally, the setting that was actually set.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **3 Basic Setup**.
3. From the Basic Setup menu, select **5 PV Damp**.
4. From the PV Damp menu, enter the value of the desired damping.
5. Follow the on-line instructions.

### Making the Settings Tamperproof

After making all the required and necessary calibrations and trim settings, the Model 970 SMART Pressure Transmitter may be protected from alteration by activating the Write Protect Mode of operation, so that the values cannot be changed without first removing the Write Protection from the transmitter. Write Protect Mode can be password protected to further prevent tampering by unauthorized persons.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select **3 Detailed Setup**.
3. From the Detailed Setup menu, select **4 Device Information**.
4. From the Basic Setup menu, select **5 Write Protect Info**.
5. From the Write Protect Info menu, select **1 Write Prtct Cntrl**.
6. Follow the on-line instructions.

You will be requested to supply a password to set or unset write protect mode.

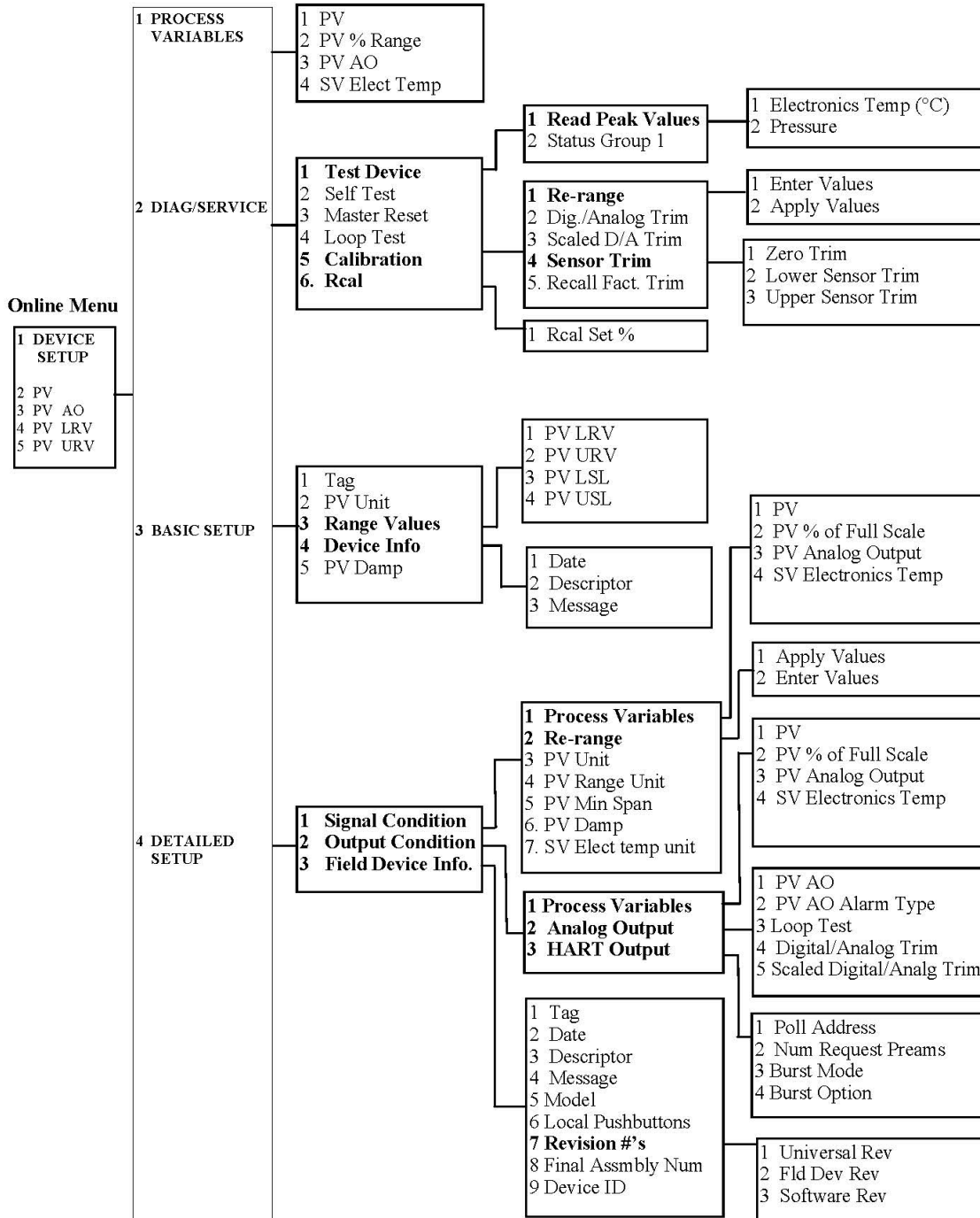
Note: A blank is allowed as a password setting if no password protection is desired.

### Restoring Original Factory Settings

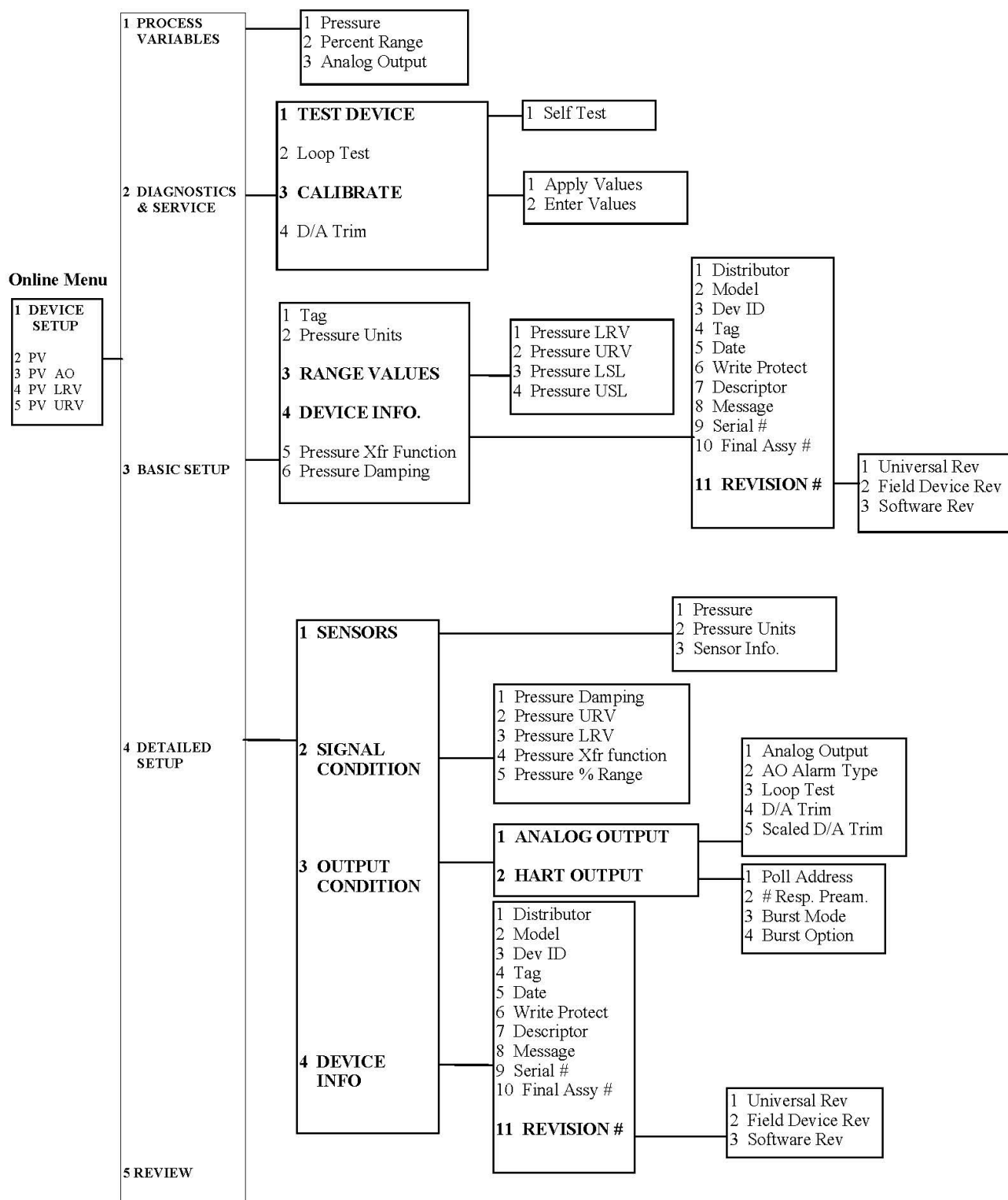
In the unlikely event that your Model 970 SMART Pressure Transmitter experiences some event which renders its adjustments unattainable or useless through improper calibration procedures or tampering by unauthorized personnel or simple careless calibration or trim procedures, you can restore all of the settings to those which were in effect when the unit was shipped from the factory. This can be especially valuable when "feeling out" the device in the beginning or when training a new person to perform the calibration and trim procedures.

1. From the **Online Menu**, select **1 Device Setup**.
2. From the Device Setup menu, select, **2 Diag/Service**.
3. From the Diag/Service menu, select **4 restr fctry set**.
4. Follow the on-line instructions.

Viatran DDL Menu Tree



Generic Device Menu Tree



## SECTION 6 – TROUBLE SHOOTING & SERVICE

### HARDWARE DIAGNOSTICS

If you suspect a malfunction of a Model 970 in the absence of any diagnostic messages, first verify that the transmitter hardware and process connections are in good working order. Always suspect the most likely and easiest to check condition first.

#### WARNING

Any time you suspect a failed transmitter, you should remove the pressure source as soon as possible. Pressure that may be present could cause serious injury to personnel if the transmitter ruptures under pressure.

#### Transmitter Does Not Communicate

1. Is the proper operating voltage being provided to the loop?
2. Is the power supply for the loop capable of providing the current requirements of the transmitter? (Many times the supply is set to current limit at too low a value.)
3. Is the proper load resistance being used in the loop?
4. Is the master controller functioning? (Does it need batteries?)
5. Is the Bell-202 modem operating properly? Is the modem hooked up backwards? Many of the available Bell-202 and HART modems are not tolerant of reverse polarity and will burn out if connected backwards.
6. Is the transmitter hooked up backwards?
7. Are all the loop connections correct? Are there intermittent shorts, open circuits, and multiple grounds?
8. Check for capacitance across the load resistor.
9. Is the unit in multidrop mode when single operation is expected?
10. Is the RS232 serial cable going from the PC to the HART modem capable of supporting hardware handshaking? The 3-wire serial cables commonly used for PC to PC serial communications will not work. The serial cables must have at least the 9 conductors which are associated with a 9-pin RS232 cable connector.

#### High Output

1. Are there leaks or blockage at the sensing element?
2. Is the pressure connection correct?
3. Is the process fluid frozen or starting to freeze?
4. Is there trapped gas in the lines?
5. Is the power supply providing the correct voltage to the loop? It should conform to the Power Supply Voltage / Load Resistance graph in the electrical specifications in Section 8.

#### Low Output

1. Check the sensing element.
2. Have there been any drastic changes in process fluid temperature?
3. Is the transmitter voltage adequate?
4. Is the mA rating of the power supply adequate to provide the current required by the transmitter and loop and all the transmitters being operated?
5. Are there shorts and/or multiple grounds?
6. Is the polarity at the signal terminal correct?
7. Is the loop impedance correct?

## Erratic Output

1. Is the connection to the sensing element correct?
2. Is pulsing of the process pressure normal?
3. Are there shorts, open circuits, or multiple grounds?

## Sluggish Output/Drift

1. Are there restrictions in the plumbing to the sensing element?
2. Are there leaks?
3. Is there sediment in the opening to the sensing element?
4. Is the process media frozen or in the process of freezing?
5. Is the damping set correctly?

# SOFTWARE ERROR AND WARNING MESSAGES

## List of Diagnostic Messages

**Access Restricted** – An attempt was made to modify or set a factory only internal setting.

**Analog Output Saturated** – The primary variable is larger than can be accommodated in the normal 4-20 mA output, and the analog output is fixed at either its upper or lower limit.

**Applied Process Too High** – The applied process which is being measured by the primary variable output would change the Upper Range Value or Lower Range Value to a value beyond the Upper Range Limit.

**Applied Process Too Low** – The applied process which is being measured by the primary variable output would change the Upper Range Value or Lower Range Value to a value below the Lower Range Limit.

**Both Range Values Out of Limits** – The transmitter was requested to change the Upper and Lower Range Values to values outside the range bracketed by the Upper and Lower Range Limits.

**Configuration Changed** – The Transmitter Configuration has been modified or changed since the last time the Configuration Changed Flag was set.

**Cold Start** – The Model 948 microprocessor has been restarted since the last time a transaction occurred.

**Device is Busy** – The transmitter is busy performing a previously requested operation such as self test, or writing a message or setting to non-volatile memory and was unavailable to act upon the current request. This situation will normally clear in a few seconds and the requested operation can be re-requested by the user. (Since the Model 948 SMART Pressure Transmitter is a low power device, writing to the non-volatile memory, EEPROM, takes a considerable amount of time since it can only record into EEPROM at the rate of approximately 10 bytes per second.)

**In Multidrop Mode** – A command which requires the unit to be in analog output mode (4-20 mA) was requested while the transmitter was in multidrop mode.

**In Write-Protect Mode** – An attempt was made to change an internal user configurable transmitter setting while the transmitter was in Write-Protect Mode.

**Invalid Transmitter Variable Code** – The transmitter does not support the variable requested.

**Invalid Selection** – A command issued to the transmitter is not supported (e.g., attempting to set a units type such as inches of water column instead of the supported psi units).

**Invalid Unit Code** – the code received by the transmitter for units was not supported by this transmitter.

**Lower Range Value Too High** – The transmitter was requested to change the Lower Range Value to a value beyond the Upper Range Limit.

**Lower Range Value Too Low** – The transmitter was requested to change the Lower Range Value to a value below the Lower Range Limit.

**Not in Fixed Current Mode** – A command which requires the unit to be in fixed current output mode was requested while the transmitter was in analog output mode. (e.g., requesting to trim the DAC zero before placing the output in fixed current mode.)

**Output Current Fixed** – An operation which requires the current to change was attempted while in fixed current mode.

**Passed Parameter Too Large** – The value passed to the transmitter is larger than that which the transmitter is capable of using. (e.g., attempting to set the upper range value of a 0-100 psi transmitter to 150 psi)

**Passed Parameter Too Small** – The value passed to the transmitter is larger than that which the transmitter is capable of using. (e.g., attempting to set the lower range value of a 0-100 psi transmitter to -5 psi)

**Primary Variable Out of Limits** – The primary variable is beyond its maximum range.

**Pushed Upper Range Value Over Limit** – As a result of setting the Lower Range Value, the Upper Range Value was pushed over the limit set by the Upper Range Limit while attempting to maintain the current Span.

**Set to Nearest Possible Value** – A value for a setting which was requested to be changed is not allowable and the value has been adjusted to the closest allowable value. (e.g., requesting the adjustment of damping to 5 seconds will require the transmitter to modify the requested setting to 4.48 seconds as the nearest available value.)

**Span Too Small** – The requested change of either the Upper Range Value or the Lower Range Value, or both, would result in the Span being less than the Minimum Span setting allowed by the transmitter as a result, the requested operation has been aborted.

**Too Few Data Bytes Received** – The message received may have been garbled or otherwise received improperly.

**Update Failed** – The transmitter was unable to perform the requested changes to its operational settings.

**Update in Progress** – The transmitter has not yet completed performing the last operation received requesting a change to the operational settings of the transmitter.

**Upper Range Value Too High** – The transmitter was requested to change the Upper Range Value to a value beyond the Upper Range Limit.

**Upper Range Value Too Low** – The transmitter was requested to change the Upper Range Value to a value below the Lower Range Limit.

## **A Warning Message Is Not An Error Message**

Under many circumstances or operation, the Model 970 SMART Pressure Transmitter will report a warning condition. This is just an informational message to the user that the transmitter has been commanded to perform an operation which is in conflict with other operations which may be in effect. (e.g., a command to set the current to 12 mA will be responded to with a warning message if the unit is in multidrop mode since multidrop mode is a fixed 4 mA mode and cannot assume a 12 mA output unless the polling address is first changed to "0".) Issuing a warning message is a normal operation which is not a cause for alarm.

## **IF YOU STILL HAVE PROBLEMS**

The problems/solutions presented in the Troubleshooting section of this manual are the most common ones encountered with a SMART Pressure Transmitter during installation and operation. If, however, the suggestions we've provided do not resolve your problem, you may need to call Technical Support at **1-800-688-0030**.

## **SERVICING YOUR MODEL 970**

### **Preparing Your Model 970 Pressure Transmitter for Servicing**

To preserve the integrity of the hermetic design, the Model 970 SMART Pressure Transmitter has no field replaceable or repairable parts. If a failure occurs, the transmitter must be returned to the factory for inspection and testing. Please contact the Repair Coordinator at 1-800-688-0030 for a return authorization number and/or a repair cost estimate. A nominal inspection fee is charged on all units returned to the factory which are not subsequently repaired. The Repair Coordinator will provide you with details concerning the packaging of the transmitter for return to the factory.

## SECTION 7 – THEORY OF OPERATION

The Model 970 SMART Pressure Transmitter is a microprocessor controlled device which reads an analog signal from the pressure sensing element and converts the signal using a 18 bit Analog-to Digital Converter, to a digital representation of the measurement. It then signal conditions the measurement, applying both linearization and compensation, to arrive at a desired output. The desired output is then converted back, using a 12 bit Digital-to-Analog Converter, to an analog 4-20 mA output signal. At the same time, the digital measurement and any other information requested of the transmitter is digitally encoded and superimposed on an AC carrier and added to the 4-20 mA DC signal and transmitted to the host control system. Since the small AC portion of the signal rides on top of the 4-20 mA DC signal, the average value of the AC signal is zero and is not seen by any analog control system monitoring the Model 970.

### **The Sensor Module**

The Model 970 utilizes a bonded foil strain gage diaphragm type sensor. This technology is reliable and capable of years of uninterrupted operation.

### **User Memory (EEPROM)**

The Model 970 has internal memory (EEPROM) which is used for storing the configurations and information concerning the transmitter that the user has entered or modified. This memory is electrically erasable and re-writable so that the transmitter does not lose information during any period when it does not have power applied to it. It is somewhat like a file system.

### **Permanent Memory**

The HART communications program is stored on a FLASH EEPROM within the Model 970 transmitter and cannot be erased or changed by the user.

### **Factory Settings**

The Model 970 transmitter has a second section of EEPROM memory that hold the factory set configuration and calibration and is not accessible to the user for modification. This section of memory is read by the transmitter when commanded to restore the factory settings to those originally in place when the unit was shipped from the factory. This section of memory is also used by the factory to compare the current configuration and calibration settings with those originally placed into the device before shipment.

### **Digital Communications**

The HART protocol supports both digital and analog modes of operation. The Model 970 is capable of communicating with a computer or HART communicator device and interfacing with whatever HART compatible software control system the user may desire to use. Communication is achieved through a HART modem using Frequency Shift Keying at an effective baud rate of 1200 bps. The HART modem uses a modified form of the Bell-202 specification.

### **Analog Operation**

Since the HART protocol is both digital and analog, the Model 970 SMART Transmitter can be used as a strictly analog device producing a 4-20 mA output signal and interfacing with any standard process control equipment capable of operating in this mode.

### **Span and Zero Adjustments**

The Span and Zero adjustments for the Model 970 are performed digitally through a mathematical algorithm which inputs the raw sensor measurements and adjusts the output signals, both digital and analog, to the proper output using the calibration points set into the unit by the user (initially factory set).

## GLOSSARY

<b>ASCII</b>	ASCII (American Standard Code for Information Interchange) is a widely used code defined by ANSI (American National Standards Institute). It represents the alphabet, the numeral digits, and many punctuation characters as 7-bit binary code. Packed ASCII, used in HART communications, is a 6-bit subset of ASCII which uses only upper case and omits many of the punctuation marks. It is employed so as to fit 4-bytes in a 3-byte field so that communications can be improved.
<b>Analog Output Trim</b>	A calibration operation that allows adjustment of the output electronics to establish a value of current which conforms to a standard.
<b>Bell-202</b>	Bell-202 is a US telephone standard. It uses 1200 Hz and 2200 Hz as 1 and 0 respectively, at 1200 baud. Bell-202 is a full duplex communications standard using a different set of frequencies for reverse communications. HART is a half-duplex communications standard so that the reverse pair of frequencies are not used.
<b>Bit</b>	A bit, or binary digit, which represents a single item of high/low, yes/no, or on/off information.
<b>Byte</b>	A byte is a set of bits, typically 8, which is treated as an entity. Most computers handle data bits as bytes because it is a power of two. A byte with parity is a 9 bit set used for error detection.
<b>Checksum</b>	A checksum is an additional byte or bytes of data appended to a message group containing the arithmetic sum of all previous bytes. In HART communications the checksum is a truncated to the single least significant byte.
<b>Configuration</b>	The process of setting parameters, values, and data which will determine how a transmitter will operate.
<b>Damping</b>	An analog output function that modifies the response time of the transmitter to smooth the output signal in the presence of a rapidly varying input signal.
<b>Descriptor</b>	A sixteen character text field for additional identification information about the transmitter. The Descriptor is a user settable entity.
<b>Digital Trim</b>	A combination trim operation which includes the separate operations of Sensor Trim and Analog Output Trim.
<b>Duplex</b>	Duplex communications means communications in both directions (as opposed to Simplex, which is communications in one direction only).
<b>Failure Mode Alarm</b>	A transmitter output function that drives the analog output of the transmitter to a selectable value in the event of a failure of the electronics or sensor element. The output may be driven high, low, or assume the last valid value read by the transmitter.
<b>FSPR</b>	Full Scale Pressure Range - The Design maximum value of input pressure that the transmitter is designed to measure.
<b>Full Trim</b>	A sensor trim procedure in which two accurate, end-point pressures are applied to the transmitter's sensing element and all output is linearized between the values. The end-point values should be equal to or slightly outside the Lower Range Value and Upper Range Value.
<b>HART Protocol</b>	HART – Highway Addressable Remote Transducer



<b>Lower Range Limit</b>	The lowest value of the measured variable that the analog output of the transmitter is capable of measuring. Lower Range Limit, LRL, is factory set and not modifiable by the user.
<b>Lower Range Value</b>	The lowest value of the measurand that the analog output of the transmitter is currently configured to measure. Lower Range Value, LRV, is a user settable entity.
<b>Master</b>	The communication device which controls the operation of slave devices in a communications environment. In a Master-Slave operation, the Slave device can only respond when requested by the Master device.
<b>Message</b>	A 28 character text field for additional identification information about the transmitter. The Message is a user settable entity.
<b>Modem</b>	A modem (modulator/demodulator) is a device for converting binary digital signals to and from an FSK, Frequency-Shift Keying, form. This allows communications over pathways with poor propagation characteristics.
<b>Multidrop</b>	A mode of operation for HART transmitters. Multidrop mode establishes a communication system where more than two devices are connected together on a single transmission line. In such system, each device must have a unique address. The HART protocol can be operated in multidrop mode, with up to 15 slave devices on one pair of wires. The analog (4-20 mA) signals cannot be used in this mode, since they would simply add together in this mode. With HART multidrop mode, each slave device assumes a fixed output current value of 4 mA.
<b>Off-Line Configuration</b>	Off-Line Operations are those procedures and data exchanges which do not have a direct impact upon the Analog Signal which the transmitter outputs or reports and which do not affect the measurement data transmitted digitally by the transmitter. They typically refer to operations which can be performed on the transmitter on a bench with the transmitter removed from a process control system.
<b>On-Line Configuration</b>	Any operation which is performed on a transmitter which characterizes the response of the transmitter or which modifies its configuration parameters, values or settings.
<b>EEPROM</b>	Memory contained within the Model 948 transmitter which is modifiable and which retains its information during removal of power.
<b>Parallel</b>	See "Serial".
<b>Parity</b>	Parity refers to the appending of an additional bit to a byte of information for the purposes of error detection. Parity can be ODD or EVEN by agreement between the communicating parties. For ODD parity the extra bit is a 1 or a 0, so as to make the total of the ones in the byte add up to an odd number. For EVEN parity the total would add up to an even number. HART protocol appends an ODD parity bit to each byte transmitted.
<b>Polling Address</b>	A Unique number in the range 0 to 15 used to identify a transmitter. In Multidrop operation the allowable range of values is 1 to 15. In Analog operation the only allowable value is 0.
<b>Protocol</b>	A set of rules used in generating or receiving a message to insure reliable digital or other communications. It may involve transaction rules, message structure, coding, and physical signal characteristics.

<b>Re-Ranging</b>	A procedure allowing the modification of configuration values and parameters that change the transmitter 4-20 mA output settings in response to input pressure readings.
<b>RS-232-C</b>	<p>RS-232-C is perhaps the most widely used standard for serial asynchronous communications. It was originally designed for interconnection of computer equipment, terminals, and modems over distances less than 50 feet. It is specified by the Electronic Industries Association, EIA. It defines the connectors, signal types, signal voltage characteristics used and provides a standard for the handshaking and control lines. Most implementations do not make use of all of the control lines or handshaking features.</p> <p>The RS-232-C port on most computers can be used for connection to a Bell-202 modem to provide HART communications.</p>
<b>Sensor Trim</b>	A digital trim procedure which permits the adjustment of a digital process variable to a precisely known input pressure. Zero Trim and Full Trim are the two Sensor Trim functions.
<b>Serial</b>	<p>Serial communications is the transmission of digital information from one device to another on a single transmission path one bit at a time. Parallel communications provides a multipath avenue for the transmission of several, often as many as 8 bits simultaneously. The HART protocol uses serial asynchronous communications.</p>
<b>Simplex</b>	See "Duplex".
<b>Slave</b>	The communication device which is controlled by a Master device in a communications environment. In a Master-Slave operation, the Slave device can only respond when requested by the Master device.
<b>Smart</b>	A term used to describe any instrument which is microprocessor controlled and features advanced communications capabilities.
<b>Span</b>	The algebraic difference between the upper and lower range values.
<b>Tag</b>	An eight-character text field used to identify a transmitter. The Tag is stored in the transmitter and is capable of being user modified.
<b>Upper Range Limit</b>	The highest value of the measured variable that the analog output of the transmitter is capable of measuring. Upper Range Limit, URL, is factory set and not modifiable by the user.
<b>Upper Range Value</b>	The highest value of the measurand that the analog output of the transmitter is currently configured to measure. Upper Range Value, URV, is a user settable entity.
<b>Write Protect Mode</b>	A security feature employing password access to the transmitter's configuration values that can prevent accidental or deliberate changes to the transmitter's configuration data.
<b>Zero Trim</b>	A zero-based, one-point adjustment, typically used to compensate for mounting position effects or zero shifts caused by sensor drift with age.

## APPENDIX A – HART COMMAND SUMMARY

COMMAND		DATA IN COMMAND		DATA IN REPLY	
No.	FUNCTION	Byte	Data	Byte	Data
0	Read Unique Identifier		none	0 1 2 3 4 5 6 7 8 9-11 12 13 14 15	“254” (expansion) mfr’s identification code mfr’s device type code number of preambles universal command revision transmitter specific cmd revision software revision hardware revision (H) device function flags (B) device ID number common practice cmd revision common tables revision data link layer revision device family code
1	Read Primary Variable		none	0 1-4	PV units code primary variable (F)
2	Read Current and Percent of Range		none	0-3 4-7	current (mA) (F) percent of range (F)
3	Read Current and Four (predefined) Dynamic Variables		none	0-3 4 5-8 9 10-13 14 15-18 19 20-23	current (mA) (F) PV units code primary variable (F) SV units code second variable TV units code third variable FV units code fourth variable
6	Write Polling Address	0	Polling Address		as in command
11	Read Unique Identifier Associated with Tag	0-5	Tag (A)		as in command 0
12	Read Message		none	0-23	message (A)
13	Read Tag, Descriptor, Date		none	0-5 6-17 18-20	tag (A) descriptor (A) date (D)
14	Read PV Sensor Information		none	0-2 3 4-7 8-11 12-15	sensor serial number units code for sensor limits and min. span upper sensor limit (F) lower sensor limit (F) minimum span (F)
15	Read Output Information		none	0 1 2 3-6 7-10 11-14 15 16	alarm select code transfer function code PV range units code upper range value (F) lower range value (F) damping value (sec) (F) write protect code private-label distributor code

16	Read Final Assembly Number		none	0-2	final assembly number
17	Write Message	0-23	message (A)		as in command
18	Write Tag, Descriptor, Date	0-5 6-17 18-20	tag (A) descriptor (A) date (D)		as in command
19	Write Final Assembly Number	0-2	final assembly number		as in command
34	Write Damping Value	0-3	damping value (sec) (F)		as in command
35	Write PV Range Values	0 1-4 5-8	Range Unit Code Upper Range Value (F) Lower Range Value (F)		as in command
36	Set Upper Range Value (=Push SPAN Button)		none		none
37	Set Lower Range Value (=Push ZERO Button)		none		none
38	Reset "Configuration Change" Flag		none		none
40	Enter/Exit Fixed Current Mode	0-3	current (mA) (F) (0=exit Fixed Current Mode)		as in command
41	Perform Transmitter Self Test		none		none
42	Perform Master Reset		none		none
43	Set PV Zero (Trim PV Zero)		none		none
45	Trim DAC Zero	0-3	measured current (mA) (F)		as in command
46	Trim DAC Gain	0-3	Measured current (mA) (F)		as in command
48	Read Additional Transmitter Status		none	0-24	additional status
59	Write Number of Response Preambles	0	Number of response preambles		as in command
128	Write Protect Toggle	0-5	Password (A) Default password is all blanks.	0	Write Protect Code if entering WPM password is set. If exiting WPM password is cleared to all blanks.
129	Select Failure Mode Alarm	0	Alarm Select Code		as in command
130	Write Calibration Data	0-2 3-23	Date (D) Note (A)		as in command
132	Null Command		none		none
133	Read Static Data - Materials		none	0-23	Array of 24 items, each of which could have 0-255 selections.
134	Write Static Data - Materials	0-23	Array of 24 items, each of which could have 0- 255 selections.		as in command
135	Set PV Gain (Trim PV Gain)	0 1-4	PV units code Measured PV reading(F)		as in command
136	Restore All Factory Settings		none		none
137	Set Uncompensated Mode		none		none
138	Set Compensated Mode		none		none
139	Set SV Offset (Trim SV Zero)	0	SV units code (B)		as in command

	(lower ref. temp)	1-4	Measured lower ref. Temp. (F)		
140	Set SV Gain (Trim SV Full Scale) (upper ref. temp)	0 1-4	SV units code (B) Measured upper ref temp (F)		as in command
141	Write SV units	0	SV units code (B)		as in command
142	Read Compensation Mode		none	0	Compensated Mode Flag (B) (Uncomp=0xFF; comp=0x00)
143	Toggle Digital Damp Mode		None	0	Digital Damping Mode Flag (B) (Undamped=0x00; damped=0xFF)
144	Read Digital Damping Mode		none	0	Digital Damping Mode Flag (B) (Undamped=0x00; damped=0xFF)
145	Set PV Offset (Trim PV Zero)	0 1-4	PV units code (B) Measured PV Zero reading (F)	0 1-4	PV units code (B) Current PV Zero Setting (F)

## APPENDIX B – STATUS CODES

COMMUNICATION ERRORS		
BIT	FIRST BYTE	SECOND BYTE
7	Communication Error	0
6	Parity Error	0
5	Overrun Error	0
4	Framing Error	0
3	Checksum Error	0
2	(reserved)	0
1	Rx Buffer Overflow	0
0	(undefined)	0

COMMAND ERRORS		
BIT	FIRST BYTE	SECOND BYTE
7	0 = COMMAND ERROR	Device Malfunction
6	not bit mapped (see 1 <sup>st</sup> byte cmd error codes)	Configuration Changed
5	not bit mapped (see 1 <sup>st</sup> byte cmd error codes)	Cold Start
4	not bit mapped (see 1 <sup>st</sup> byte cmd error codes)	(undefined)
3	not bit mapped (see 1 <sup>st</sup> byte cmd error codes)	Output Current Fixed
2	not bit mapped (see 1 <sup>st</sup> byte cmd error codes)	Analog Output Saturated
1	not bit mapped (see 1 <sup>st</sup> byte cmd error codes)	Variable (not primary) Out of Limits
0	not bit mapped (see 1 <sup>st</sup> byte cmd error codes)	Primary Variable Out of Limits

FIRST BYTE COMMAND ERROR CODES	
CODE	MEANING
0	No Command-Specific Error
1	(undefined)
2	Invalid Selection
3	Passed Parameter Too Large
4	Passed Parameter Too Small
5	Too Few Data Bytes Received
6	Transmitter-Specific Command Error
7	In Write-Protect Mode
8	Update Failed Update in Progress Set to Nearest Possible Value
9	Applied Process Too High Lower Range Value Too High Not In Fixed Current Mode
10	Applied Process Too Low Lower Range Value Too Low Multidrop Not Supported
11	In Multidrop Mode Invalid Transmitter Variable Code Upper Range Value Too High
12	Invalid Unit Code Upper Range Value Too Low
13	Both Range Values Out of Limits
14	Pushed Range Values Out of Limits Span Too Small
15	Command-Specific Error
16	Access Denied
32	Device Is Busy
64	Command Not Implemented

B = Byte (1 Byte)

S = Short Integer (2 Bytes)

L = Long Integer (4 Bytes)

I3 = Three Byte Integer (3 Bytes)

F = Floating Point Number (4 Bytes)

A = Packed ASCII (Length Varies, 4 Bytes packed into a 3 Byte Construct)

D = Date Format (3 Bytes, dd mm yy)

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