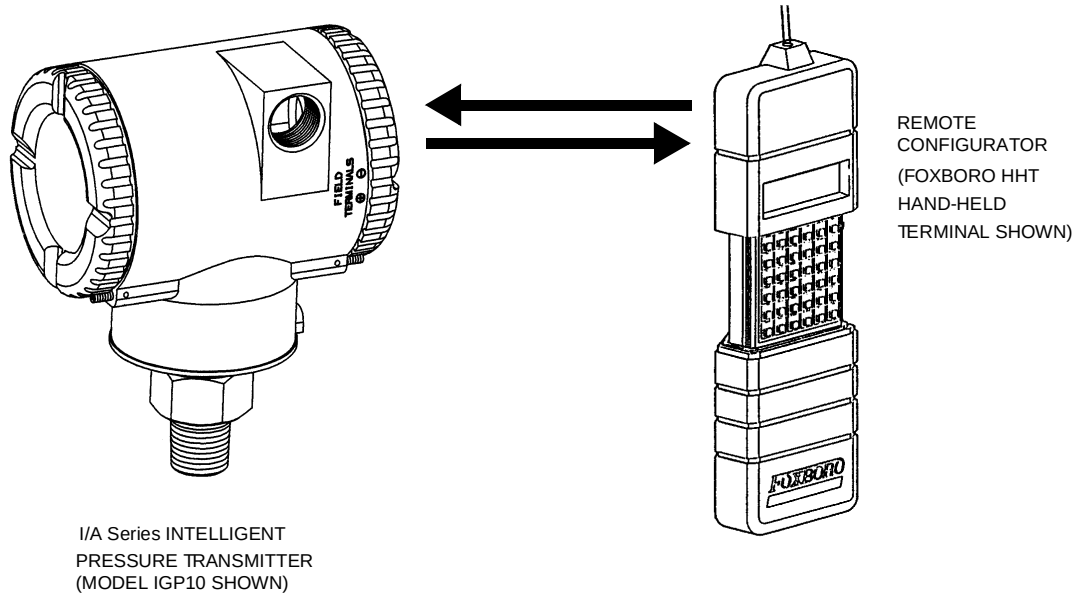
FOXBORO®

Technical Information **TI 037-096**

I/A Series®
Intelligent Pressure Transmitters (FoxCom or HART)



I/A Series INTELLIGENT PRESSURE TRANSMITTER (MODEL IGP10 SHOWN)

REMOTE CONFIGURATOR (FOXBORO HHT HAND-HELD TERMINAL SHOWN)

These compact, 2-wire Intelligent Pressure Transmitters feature outstanding measurement accuracy, high reliability, and digital communication for remote measurement, reranging, and configuration functions. The FoxCom module communicates with an I/A Series System workstation, a PC10 Personal Computer Configurator, or a Model HHT Hand-Held Terminal. The HART module communicates with a Model 275 HART Communicator. All models transmit either a 4 to 20 mA dc or digital output signal.

INTRODUCTION

The I/A Series Intelligent Transmitters combine integrated circuit sensor[1] technology with intelligent microprocessor-based electronics. The transmitter family includes seven models: Model IAP10 absolute pressure, Model IGP10 direct connected gauge pressure, Model IGP20 bracket mounted gauge pressure, Model IDP10 differential pressure, Model IFL10 flanged liquid level, Model IPS10 flush diaphragm differential pressure with remote seals, and Model IPS11 extended diaphragm differential pressure with remote seals.

The communications network allows you to reconfigure, read the measurement, rerange, and receive diagnostic data over the same two wires used for power and measurement data. In addition, the output can be set to any value to check the accuracy of other instruments in the loop. When the FoxCom electronics module is selected, these functions can be performed from remote locations using the Foxboro Model HHT Hand-Held Terminal, or a personal computer with Foxboro PC10 Configurator software and modem, or an I/A Series System Workstation. When the HART electronics module is selected, these functions can be performed from a Model 275 HART Communicator.

Advanced microprocessor-based electronics combined with the integrated circuit sensor provide a line of field transmitters with the following major features:

- Rangeability up to 60:1 (differential pressure -B range only) and 30:1 (pressure)
- Built-in sensor temperature and electronics temperature compensation
- Bidirectional digital communications without interrupting the output signal

1. U.S. and Foreign Patents Pending

SIEBE®

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- Continuous self-diagnostics
- 4 to 20 mA dc and digital output
- Software selectable square root output (d/p Cell only)
- Digital integration with I/A Series system (FoxCom)

PRINCIPLE OF OPERATION

I/A Series Intelligent Transmitters have two major assemblies: (1) a sensor module comprised of the process connections and sensor assembly, and (2) a two-compartment electronics housing with a terminal block and an electronics module that contains signal conditioning circuits and a microprocessor. Interchangeable electronic modules provide a choice of FoxCom or HART, as well as providing for easy transition to other communication protocols in the future. In addition, an analog output-only, 4 to 20 mA module (not covered in this TI) is available.

To ensure high performance, each sensor assembly is uniquely temperature and pressure compensated. After the basic transmitter has been assembled, it is tested throughout its input pressure range at various ambient temperatures. To provide precise temperature and pressure error compensation during transmitter operation, data from these tests is translated into compensation coefficients and entered into a memory chip in the sensor assembly. These coefficients are retained when electronics modules are changed.

Figure 1 illustrates how the primary output signal is compensated for errors caused by changes in pressure sensor temperature. An internal sensor measures temperature of the pressure sensor. This measurement is fed into the microprocessor where the primary measurement signal is appropriately corrected. This temperature measurement is also transmitted to receivers over the communications network.

GENERAL DESCRIPTION

Foxboro I/A Series transmitters use a true state-of-the-art integrated circuit sensor. Because of new precision manufacturing techniques, major breakthroughs have been achieved in diffused piezoresistive silicon chip performance characteristics and reliability.

In manufacturing, boron is diffused into the crystal lattice structure of the silicon to form a fully active Wheatstone Bridge. In this diffusion process, boron and silicon are united at the molecular level, eliminating the need for the mechanical bonding methods normally required with strain gauge sensors. This process allows Foxboro to manufacture sensors that achieve exceptional repeatability and long-term stability.

The pressure range of each silicon sensor is determined by the thickness of the silicon directly under the Wheatstone Bridge. Thickness of the silicon diaphragm is determined by chemically etching the back of each chip under the bridge to a specific depth. The finished chip is then bonded to a pyrex or alumina back plate which supports the chip and isolates it from environmental stresses. For gauge and differential pressure applications, a hole is bored through the pyrex for access to the cavity at the back of the chip. This provides an atmospheric pressure reference for gauge pressure sensors and a connecting passage to the low pressure side for the d/p Cell. For absolute pressure applications, the chip cavity is evacuated before the pyrex back plate is attached, providing a constant absolute pressure reference.

The chip is then mounted onto either a gas-tight ceramic lead frame or a glass-sealed stainless steel header and pin assembly. Gold-wire connections are made from the bridge circuitry on the silicon chip to electrical posts on the lead frame or header. The pressure sensor subassembly is then joined to the sensor assembly packaging.

Isolating diaphragms of various corrosion resistant materials are welded in place over the sensing chip, and the cavities between the diaphragms and the chip are then filled under vacuum with DC-200 Silicone Oil or Fluorinert inert fluid. This process totally isolates the

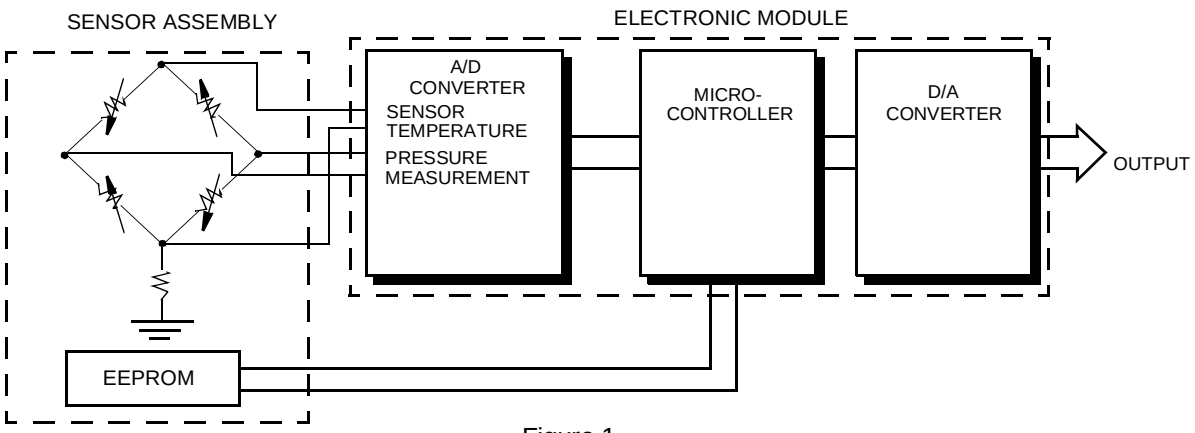

Figure 1.

silicon sensor from the process fluid without using a mechanical linkage. The isolating diaphragm also provides overrange protection for the silicon sensor in the d/p Cell.

SOLID STATE PRESSURE SENSOR BASICS

Wheatstone Bridge Strain Gauge

The solid state sensor consists of a Wheatstone Bridge circuit (see Figure 1) which is diffused into a silicon chip, thereby becoming a part of the atomic structure of the silicon. As pressure is applied to the IC chip diaphragm (see Figure 2), strain is created in the bridge resistors. Piezoresistive effects created by this strain change resistances in the legs of the bridge, producing a voltage proportional to pressure. Output from the bridge is typically in the range of 75 to 150 mV at full scale pressure for a bridge excitation of 1.0 mA.

Sensor Types

The micromachined silicon sensor is fabricated in three basic types of pressure sensors. The three types, which are shown in Figure 2, are:

1. Gauge Pressure – sensor referenced to atmosphere.
2. Absolute Pressure – sensor referenced to a full vacuum.
3. Differential Pressure – sensor measures the difference between two pressures (P1 and P2).

Because of the wide rangeability of the sensors, only four different sensor units cover the entire range of d/p spans from 3.5 inH_20 to 3000 psi (0.87 kPa to 20.7 MPa), thus reducing spare parts requirements.

An internal temperature sensor monitors temperature of the pressure sensor. This temperature is used to compensate the sensor output for the effects of temperature changes. The sensor temperature is also transmitted digitally for monitoring, alarming, and for control of transmitter heat tracing, etc.

MECHANICAL DESIGN FEATURES

Light Weight – provides ease of handling and installation, and in many cases, permits direct mounting without need for costly pipe stands.

Biplanar Construction – back-to-back process diaphragm design maintains conventional process connections and spacing, permitting easy retrofit of conventional differential pressure transmitters (IDP10).

Tangential Draining/Venting – provides full cavity draining or venting with the transmitter mounted vertically or horizontally. Optional side vents are available for vertical mounting (IDP10).

Two Process Cover Bolts for IDP10 d/p Cells – only two bolts are required to provide precise alignment of process sensor to covers and integrity of seals. The bolts are enclosed in the sensor assembly to minimize corrosion and to minimize early elongation with rapid temperature increases. This design makes it less likely for the transmitter to release process fluid during a fire.

Bolting Options for IDP10 d/p Cell:

- High strength B7 bolts are standard and provide the full 3625 psi rating (25 MPa).
- B7M (for NACE Class II requirements); refer to Foxboro for pressure rating.
- 316 ss for maximum corrosion protection; pressure rating 2175 psi (15 MPa).
- 17-4 ss for corrosion resistance; pressure rating full 3625 psi (25 MPa).

NACE Conformance – The following models/materials are available in versions to meet requirements of NACE MR-01-75:

IAP10 and IGP10:	316 ss process connector with choice of 316L ss or Co-Ni-Cr sensor diaphragm.
IDP10 and IGP10:	316L ss or steel process cover with choice of 316L ss, Co-Ni-Cr, or Hastelloy C sensor diaphragm.
IPS10 and IPS11	316 ss, Hastelloy C, or tantalum isolating diaphragm.
IFL10:	316 ss, Co-Ni-Cr, Hastelloy C, Monel, or tantalum isolating diaphragm.

Cover Gaskets – Gaskets for d/p Cell covers are glass-reinforced ptfe (Chemloy) for virtually universal process compatibility.

Corrosion Resistance – High resistance to corrosion is provided by using Cobalt-Nickel-Chrome (Co-Ni-Cr) process diaphragms as standard. Other materials are available for special requirements. In addition, no welds are exposed to process fluids. For many process fluids, Co-Ni-Cr is superior in corrosion resistance to other common alloys. Refer to TI 37-75b for corrosion resistance information on Co-Ni-Cr and other alloys.

CENELEC – Complies with Zone 1 Flameproof (IDP10 and IGP20 only) and CENELEC Zone 0 Intrinsic Safety requirements.

FM, CSA, and SAA – Complies with FM, CSA, and SAA requirements for intrinsic safety and explosion-proof applications.

Seal Not Required – FM and CSA approved for explosionproof applications without external conduit seals. Meets requirements for “Seal Not Required”.

Secondary Containment – Transmitters have secondary containment in the sensor neck that withstands the highest pressure for which the sensor is rated. For example, the IDP10, which is rated for 3625 psi, has secondary containment to withstand the full 3625 psi pressure.

Should there be a failure of the primary seal (the process diaphragm), the topworks is not exposed to the process fluid unless there is a subsequent failure of the secondary seal in the sensor neck.

Furthermore, the secondary seal is in contact with the internal sensor fill fluid located behind the process diaphragm and this fill fluid is at the pressure of the process fluid. This provides a continual verification of the integrity of the secondary seal during normal transmitter operation.

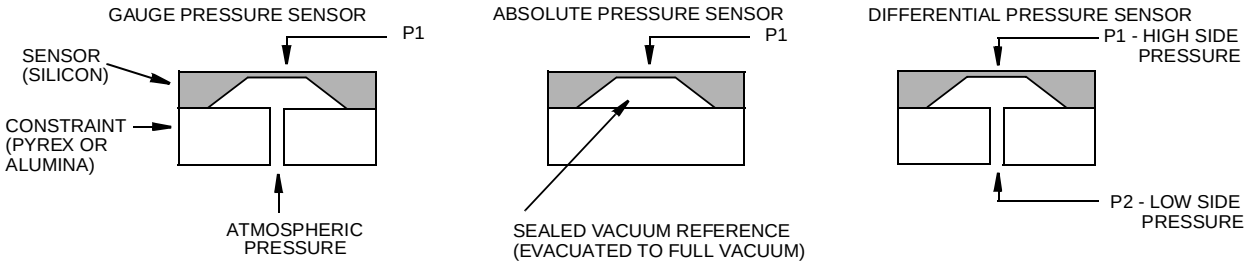

Figure 2. Types of Pressure Sensors

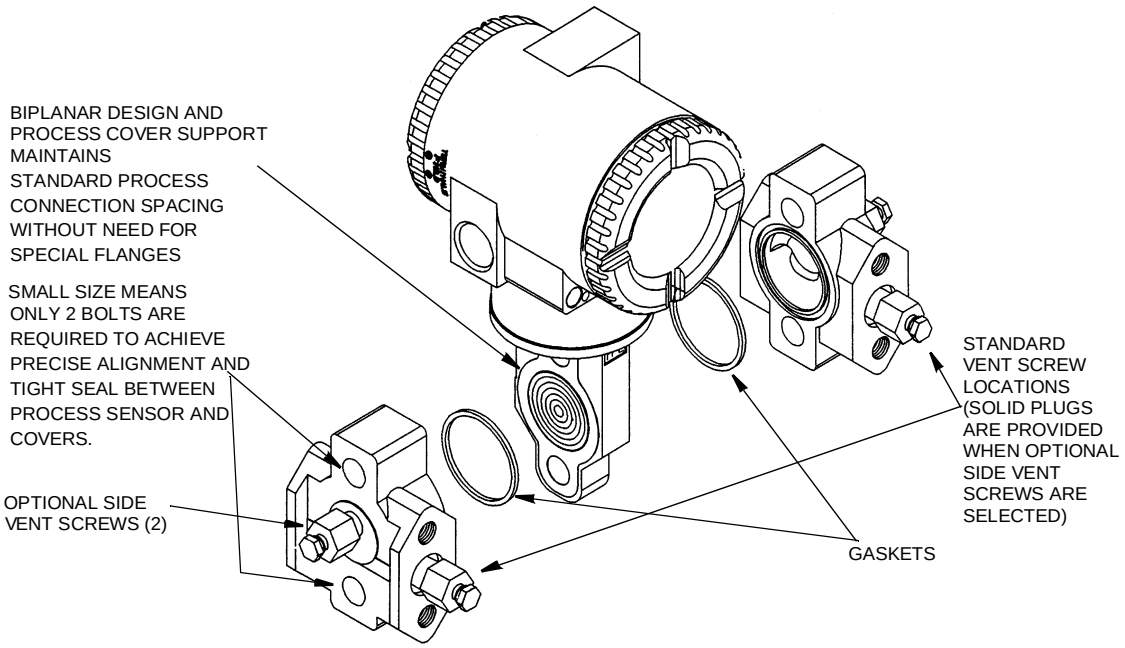

Figure 3. Mechanical Packaging Features (d/p Cell)

Topworks Design Features

Common topworks for all models, rotatable up to one full turn from fully tightened clockwise position for easy installation and alignment with conduit connections.

Dual compartment topworks provides environmental protection and isolation of the electronics module from the terminal block and conduit connection side.

Two conduit entrances offer choice of entry positions and self-draining of condensate regardless of mounting position.

The housing meets the requirements of both IP66 and NEMA 4X.

The electronics housing design includes an optional external zero adjustment for local re-zeroing of the transmitter without removing the electronics housing cover. The adjustment magnetically activates an internal reed switch through the housing wall. This eliminates a potential leak path for moisture or contaminants to enter the electronics compartment. The external zero adjustment can be disabled by a transmitter configuration action.

External Protection – Epoxy paint and clear chromate finish provide external corrosion protection, demonstrated through 500-hour salt spray lab test and thousands of field applications.

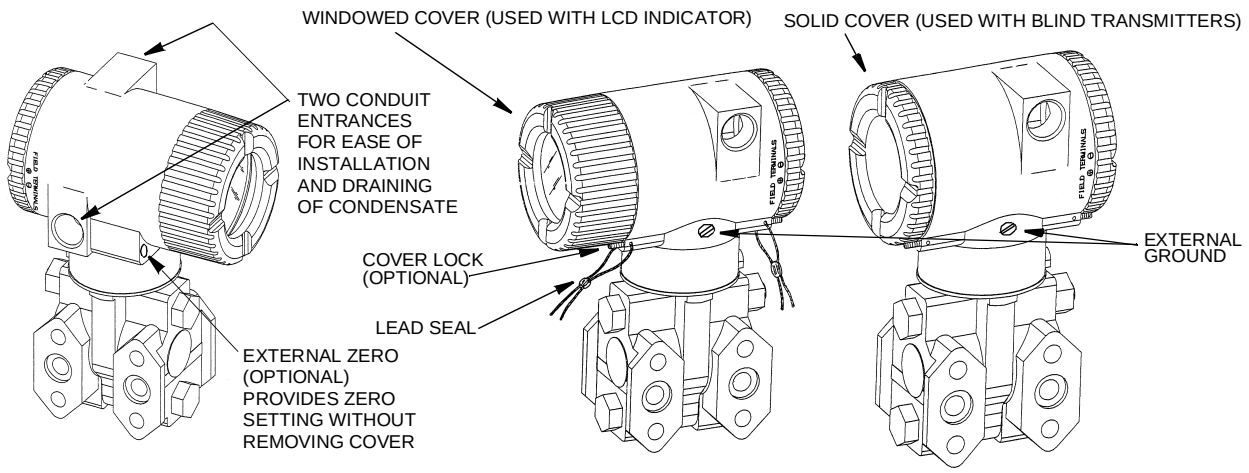

Figure 4. Topworks Design Features

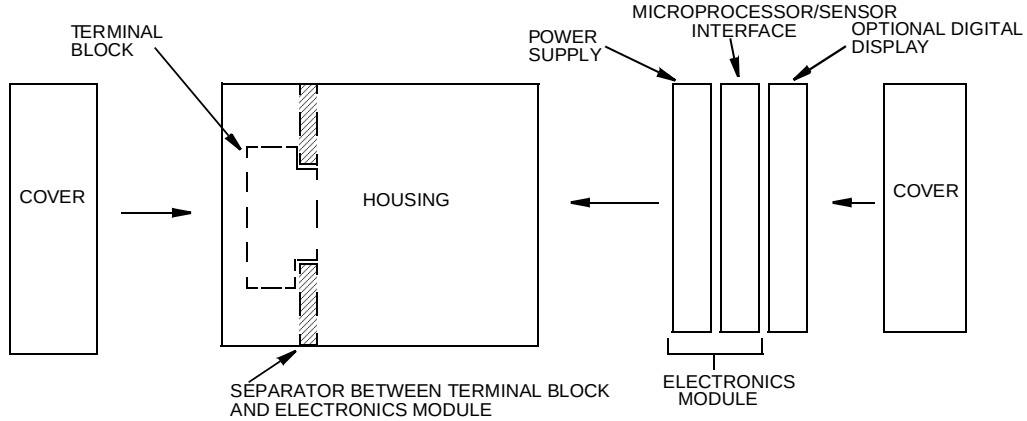

Figure 5. Topworks Design Features (Cont.)

ELECTRONICS

Interchangeable electronic modules for FoxCom or HART, as well as analog (not covered in this TI), provide easy change from one model to another. Modular design also allows for easy modular change for future Fieldbus protocols.

The transmitter carries the CE mark for approved sale in Europe. The replaceable terminal block assembly in the electronics housing can withstand a transient surge of 2000 V common mode or 1000 V normal mode without damage or calibration shift in accordance with ANSI/IEEE C62.41-1980 and IEC STD 801-5.

The transmitter complies with the electromagnetic compatibility (EMC) requirements of 89/336/EEC and NAMUR.

As the sensor coefficients are stored in a memory chip located in the sensor neck, the electronics can be replaced in the field without degrading performance or without having to save the temperature correction coefficients before replacing the electronic module.

As shown in Figure 6, an optional microprocessor-driven display with two internal pushbuttons provides local configuration and zero/span calibration functions. The display can be rotated to any one of four positions in 90° increments and is cable connected.

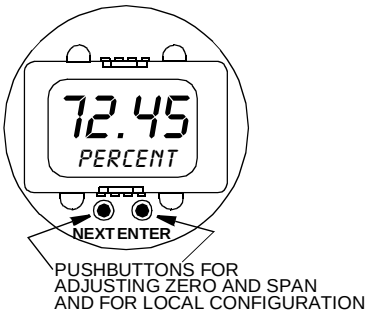

Figure 6. Optional Local Digital Display and Pushbutton Controls

COMMUNICATIONS FORMAT (FoxCom)

Digital communications is based upon the FSK (Frequency Shift Keying) technique which alternately

superimposes one of two different frequencies on the uninterrupted current signal carried by the two signal/power wires.

4 to 20 mA Output

The transmitter sends its differential pressure measurement to the loop as a continuous 4 to 20 mA dc signal. This version communicates with the HHT or PC10 at distances up to 1800 m (6000 ft).

Other specifications are:

Minimum Load – 200 ohms
Data Transmission Rate – 600 Baud
Scan frequency – 4 times/second for pressure and 1 time/second for transmitter temperature.

Digital Output

The transmitter sends its differential pressure measurement and other data to the I/A Series System Console as a digital signal. Remote communications occur between the transmitter and the HHT or PC10 and/or any I/A Series System Console up to 600 m (2000 ft) away from the Fieldbus Module (FBM).

Other specifications are:

Data Transmission Rate – 4800 Baud
Scan Frequency – 10 times/second for pressure and 1 time/second for transmitter temperature.

Remote Communications (FoxCom)

If the transmitter is configured for digital output and is digitally integrated into an I/A Series System, the system has full access to all of the “Display” and “Display and Reconfigure” items listed below.

Also, regardless of whether the transmitter is configured for digital output or analog 4 to 20 mA output, the Hand Held Terminal (HHT) and the personal computer-based Configurator (PC10) have full access to all of the “Display” and “Display and Reconfigure” items listed below.

As shown in Figure 7, the HHT or PC10 may be connected to the communications wiring loop without disturbing the communication signals. Plug-in connection points are provided on the transmitter terminal block.

COMMUNICATIONS FORMAT (HART)

Digital (HART) communication is based upon the FSK technique which alternately superimposes one of two different frequencies on the uninterrupted current signal carried by the two signal/power wires.

The transmitter sends its pressure measurement to the loop as a continuous 4 to 20 mA dc signal. It communicates with the Model 275 HART Communicator at distances up to 3050 m (10,000 ft) in a point-to-point mode, or up to 1525 m (5000 ft) in a multidrop (15 devices maximum) mode. See Figure 7.

Other specifications are:

Minimum Load	250 ohms
Baud Rate	1200 Baud
Transmission Level	±0.5 mA
Scan Frequency	2 times/sec max.
Measurement Updates (Internal Recalculations)	
Pressure Measurement	4 times/sec
Electronics Temperature	1 time/sec
Sensor Temperature	1 time/sec
Measurement Updates (Loop Communications)	
Primary Measurement	2 times/sec
Electronics Temperature	2 times/sec
Sensor Temperature	2 times/sec

Remote Communications (HART)

The Model 275 HART Communicator has full access to all of the “Display” and “Display and Reconfigure” items listed below.

The Communicator may be connected to the communications wiring loop as shown in Figure 7 and does not disturb the mA current signal. Plug-in connection points for the communicator are also provided on the transmitter terminal block.

“Display” Information

The information that can be displayed is:

- Model Number
- Process Measurement
- Transmitter Temperature
- Continuous Self-Diagnostics
- Day, Date, and Time
- Transmitter Serial Number

“Display and Reconfigure” Information

In addition, the following data can be remotely displayed and reconfigured:

- Output (4 to 20 mA, Digital, or 4 to 20 mA Square Root[1])
- Output Level (mA signal for Analog Loop Calibration)
- Zero and Span ReRanging
- Primary Measurement
- Secondary Measurement
- Output in Custom Units (FoxCom only)
- Last Calibration Date
- Damping
- Temperature Sensor Failure Strategy
- Failsafe (Upscale or Downscale)
- Tag Number
- Tag Name
- Address
- Location
- Calibrator’s Initials

1. With choice of cutoff to zero below 1% differential (10% flow) or active linear below 4% differential (20% flow).

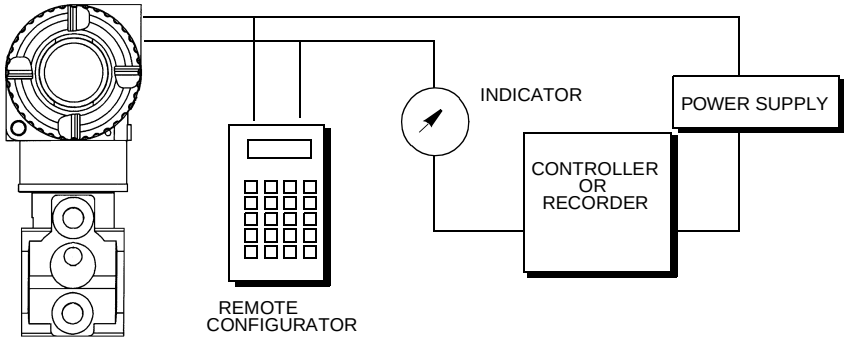

Figure 7. Functional Block Diagram for 4 to 20 mA Output (FoxCom or HART)

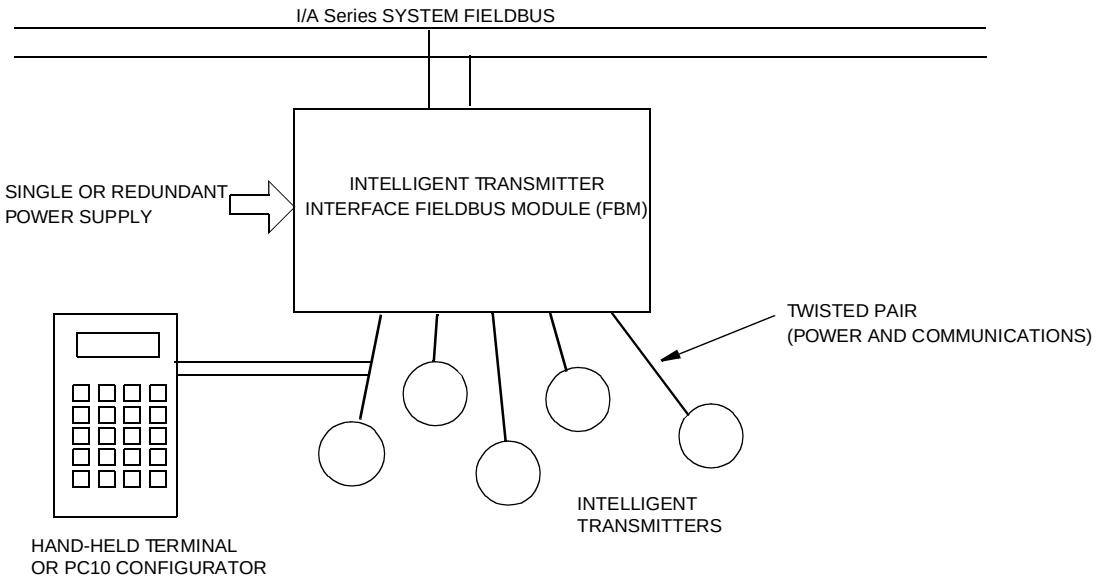

Figure 8. Functional Block Diagram for FoxCom Digital Output

SPECIFICATIONS:

For detailed specifications and further information on the I/A Series Intelligent Transmitters, refer to the following Product Specification Sheets, available from Foxboro:

PSS 2A-1C13 A	IAP10 Intelligent Absolute and IGP10/20 Intelligent Gauge Pressure Transmitters
PSS 2A-1C13 B	IAP10 Intelligent Absolute and IGP10/20 Intelligent Gauge Pressure Transmitters with HART Communications Protocol
PSS 2A-1C14A	IDP10 Intelligent d/p Cell Differential Pressure Transmitter
PSS 2A-1C14B	IDP10 Intelligent d/p Cell Differential Pressure Transmitter with HART Communications Protocol
PSS 2A-1C16 A	IPS10/IPS11 Intelligent d/p Cell Transmitters with Pressure Seals
PSS 2A-1C16 C	IPS10/IPS11 Intelligent d/p Cell Transmitters with Pressure Seals with HART Communications Protocol
PSS 2A-1C16 B	IFL10 Intelligent Flanged Liquid-Level Transmitter
PSS 2A-1C16 D	IFL10 Intelligent Flanged Liquid-Level Transmitter with HART Communications Protocol
PSS 2A-1Z3 A	Model HHT Hand-Held Terminal
PSS 2A-1Z3 C	PC10 Configurator
PSS 2A-1Z9 E	I/A Series System Intelligent Pressure Transmitters — Options and Accessories
PSS 21H-2D5 B4	I/A Series System Intelligent Transmitter Interface (FBM 18)
PSS 21H-2C4 B4	I/A Series System Intelligent Transmitter Interface (FBM 39)
PSS 21H-2D8 B4	I/A Series System Intelligent Transmitter Interface (FBM 43)
PSS 21H-2D4 B4	I/A Series System Intelligent Transmitter Interface (FBM 44)

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