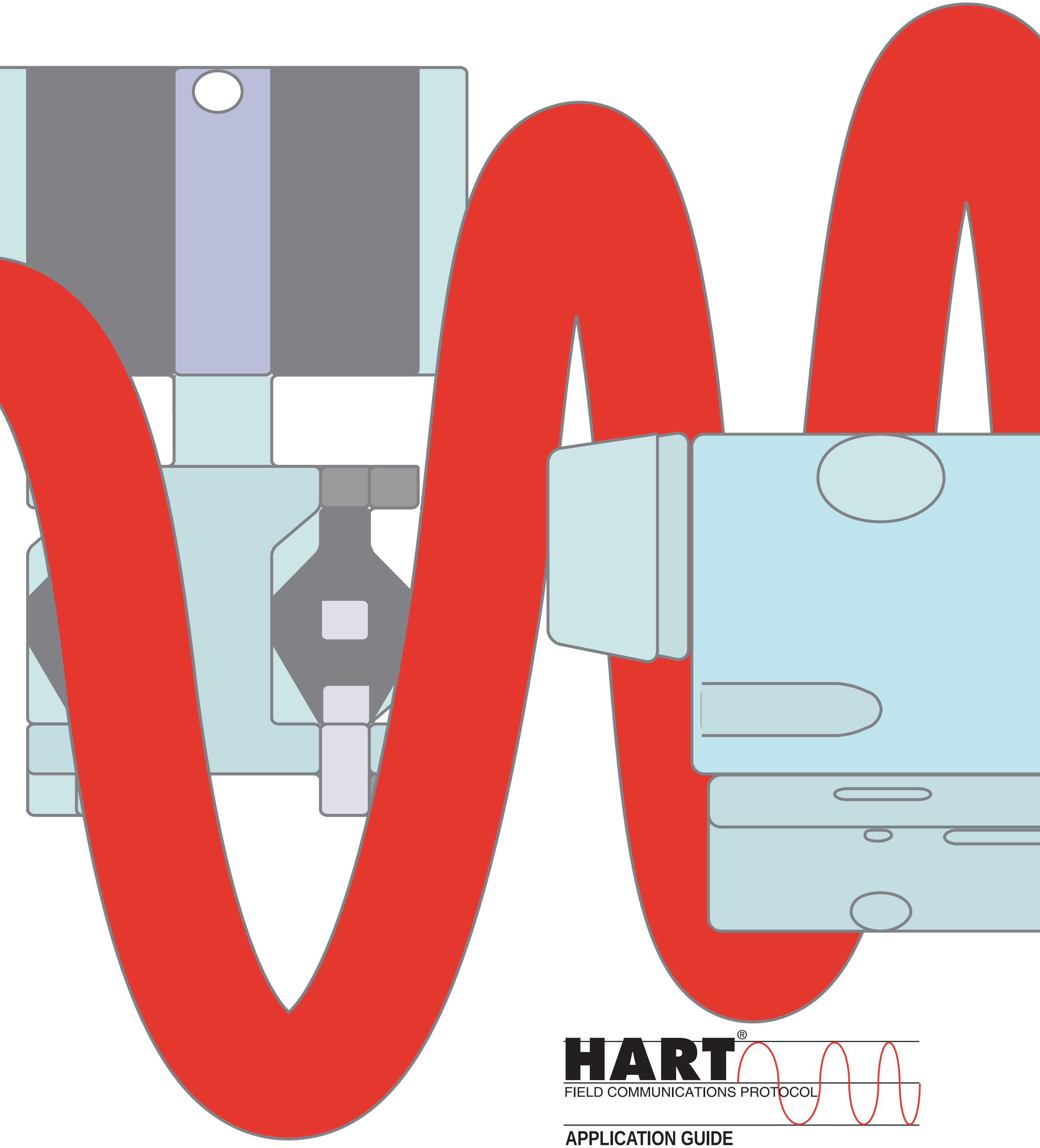


HART®

FIELD COMMUNICATIONS PROTOCOL

APPLICATION GUIDE

HCF LIT 34

For additional information contact:
HART Communication Foundation
9390 Research Boulevard
Suite I-350
Austin, Texas 78759 USA
Tel: 512-794-0369
Fax: 512-794-3904
http://www.hartcomm.org

HART Communication Protocol and the Year 2000

The HART protocol uses a 24-bit binary representation of the date. The binary format can represent every date between 1 January 1900 and 31 December 2155. The binary date format is described in *HART-SMART Communications Protocol, Universal Command Specification*, HCF_SPEC-127. While the HART protocol is year 2000 compliant, it is possible that some instrument manufacturers may offer products that are not. The HART protocol does not specify how to display the date field. The binary date representation can be displayed unambiguously in master devices to include a four-character year. For specific questions about year 2000 compliance in HART-based products, we suggest contacting product manufacturers.

Table of Contents

Table of Contents

Table of Contents

Preface

In today's competitive environment, all companies seek to reduce operation costs, deliver products rapidly, and improve product quality. The HART® (highway addressable remote transducer) protocol directly contributes to these business goals by providing cost savings in:

- Commissioning and installation
- Plant operations and improved quality
- Maintenance

The HART Application Guide has been created by the HART Communication Foundation (HCF) to provide users of HART products with the information necessary to obtain the full benefits of HART digital instrumentation. The HART communication protocol is an open standard owned by the more than 100 member companies in the HCF. Products that use the HART protocol to provide both analog 4–20 mA and digital signals provide flexibility not available with any other communication technology.

The following four sections provide you with an understanding of how the HART technology works, insight on how to apply various features of the technology, and specific examples of applications implemented by HART protocol users around the world:

- Theory of Operation
- Benefits of HART Communication
- Getting the Most from HART Systems
- Industry Applications

Theory of Operation

The following sections explain the basic principles behind the operation of HART instruments and networks:

- Communication Modes
- Frequency Shift Keying
- HART Networks
- HART Commands

Communication Modes

MASTER-SLAVE MODE

HART is a *master-slave communication protocol*, which means that during normal operation, each *slave* (field device) communication is initiated by a *master* communication device. Two masters can connect to each HART loop. The primary master is generally a distributed control system (DCS), programmable logic controller (PLC), or a personal computer (PC). The secondary master can be a handheld terminal or another PC. Slave devices include transmitters, actuators, and controllers that respond to commands from the primary or secondary master.

BURST MODE

Some HART devices support the optional *burst communication mode*. Burst mode enables faster communication (3–4 data updates per second). In burst mode, the master instructs the slave device to continuously broadcast a standard HART reply message (e.g., the value of the process variable). The master receives the message at the higher rate until it instructs the slave to stop bursting.

Use burst mode to enable more than one passive HART device to listen to communications on the HART loop.

Frequency Shift Keying

The HART communication protocol is based on the Bell 202 telephone communication standard and operates using the *frequency shift keying* (FSK) principle. The digital signal is made up of two frequencies—1,200 Hz and 2,200 Hz representing bits 1 and 0, respectively. Sine waves of these two frequencies are superimposed on the direct current (dc) analog signal cables to provide simultaneous analog and digital communications (Figure 1). Because the average value of the FSK signal is always zero, the 4–20 mA analog signal is not affected. The digital communication signal has a response time of approximately 2–3 data updates per second without interrupting the analog signal. A minimum loop impedance of 230 Ω is required for communication.

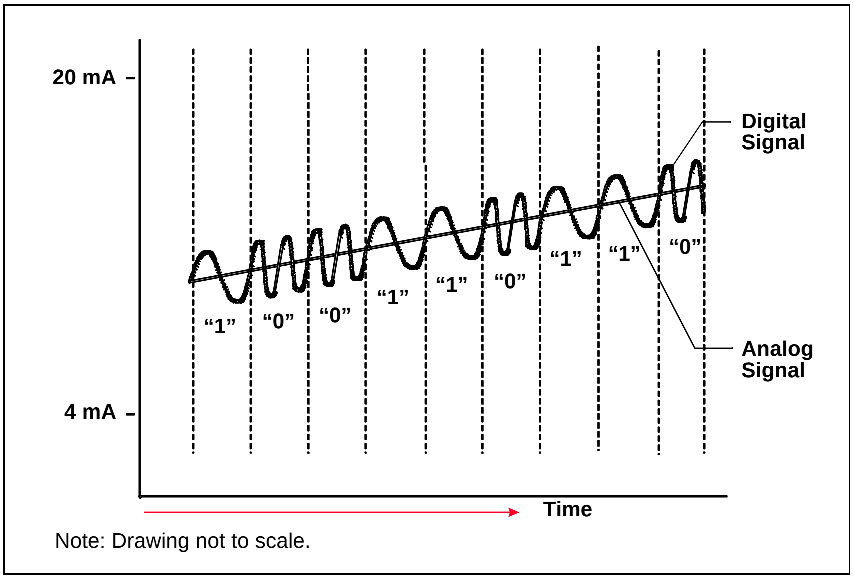


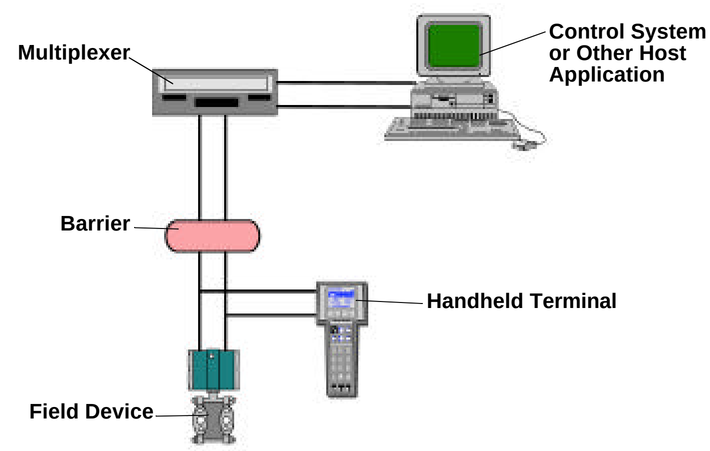
Figure 1: Simultaneous Analog and Digital Communication

HART Networks

HART devices can operate in one of two network configurations—point-to-point or multidrop.

POINT-TO-POINT

In point-to-point mode, the traditional 4–20 mA signal is used to communicate one process variable, while additional process variables, configuration parameters, and other device data are transferred digitally using the HART protocol (Figure 2). The 4–20 mA analog signal is not affected by the HART signal and can be used for control in the normal way. The HART communication digital signal gives access to secondary variables and other data that can be used for operations, commissioning, maintenance, and diagnostic purposes.



Note: Instrument power is provided by an interface or external power source that is not shown.

Figure 2: Point-to-Point Mode of Operation

HART Networks

MULTIDROP

The multidrop mode of operation requires only a single pair of wires and, if applicable, safety barriers and an auxiliary power supply for up to 15 field devices (Figure 3). All process values are transmitted digitally. In multidrop mode, all field device polling addresses are >0, and the current through each device is fixed to a minimum value (typically 4 mA).

Use multidrop connection for supervisory control installations that are widely spaced, such as pipelines, custody transfer stations, and tank farms.

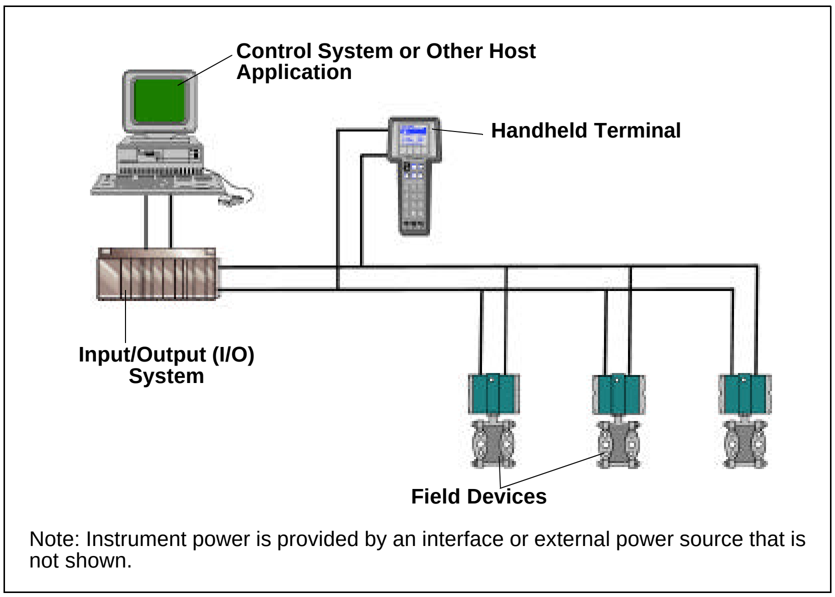


Figure 3: Multidrop Mode of Operation

HART Commands

The *HART command set* provides uniform and consistent communication for all field devices. The command set includes three classes: *universal*, *common practice*, and *device specific (*Table 1). Host applications may implement any of the necessary commands for a particular application.

UNIVERSAL

All devices using the HART protocol must recognize and support the universal commands. Universal commands provide access to information useful in normal operations (e.g., read primary variable and units).

COMMON PRACTICE

Common practice commands provide functions implemented by many, but not necessarily all, HART communication devices.

DEVICE SPECIFIC

Device-specific commands represent functions that are unique to each field device. These commands access setup and calibration information, as well as information about the construction of the device. Information on device-specific commands is available from device manufacturers.

SUMMARY TABLE

Universal Commands	Common Practice Commands	Device-Specific Commands
• Read manufacturer and device type • Read primary variable (PV) and units • Read current output and percent of range • Read up to four predefined dynamic variables • Read or write eight-character tag, 16-character descriptor, date • Read or write 32-character message • Read device range values, units, and damping time constant • Read or write final assembly number • Write polling address	• Read selection of up to four dynamic variables • Write damping time constant • Write device range values • Calibrate (set zero, set span) • Set fixed output current • Perform self-test • Perform master reset • Trim PV zero • Write PV unit • Trim DAC zero and gain • Write transfer function (square root/linear) • Write sensor serial number • Read or write dynamic variable assignments	• Read or write low-flow cut-off • Start, stop, or clear totalizer • Read or write density calibration factor • Choose PV (mass, flow, or density) • Read or write materials or construction information • Trim sensor calibration • PID enable • Write PID setpoint • Valve characterization • Valve setpoint • Travel limits • User units • Local display information

Table 1: HART Commands

Note: *Table 1 is a partial list of HART commands. See Appendices B, C, and D for more detailed information.*

-

HART Commands

ESTABLISHING COMMUNICATION WITH A HART DEVICE

Each HART device has a 38-bit address that consists of the manufacturer ID code, device type code, and device-unique identifier. A unique address is encoded in each device at the time of manufacture. A HART master must know the address of a field device in order to communicate successfully with it. A master can learn the address of a slave device by issuing one of two commands that cause the slave device to respond with its address:

- *Command 0, Read Unique Identifier*—Command 0 is the preferred method for initiating communication with a slave device because it enables a master to learn the address of each slave device without user interaction. Each polling address (0–15) is probed to learn the unique address for each device.
- *Command 11, Read Unique Identifier by Tag* - Command 11 is useful if there are more than 15 devices in the network or if the network devices were not configured with unique polling addresses. (Multidropping more than 15 devices is possible when the devices are individually powered and isolated.) Command 11 requires the user to specify the tag numbers to be polled.

DEVICE DESCRIPTION

Some HART host applications use *device descriptions* (DD) to obtain information about the variables and functions contained in a HART field device. The DD includes all of the information needed by a host application to fully communicate with the field device. HART *Device Description Language* (DDL) is used to write the DD, that combines all of the information needed by the host application into a single structured file. The DD identifies which common practice commands are supported as well as the format and structure of all device-specific commands.

A DD for a HART field device is roughly equivalent to a printer driver for a computer. DDs eliminate the need for host suppliers to develop and support custom interfaces and drivers. A DD provides a picture of all parameters and functions of a device in a standardized language. HART suppliers have the option of supplying a DD for their HART field product. If they choose to supply one, the DD will provide information for a DD-enabled host application to read and write data according to each device's procedures.

DD source files for HART devices resemble files written in the C programming language. DD files are submitted to the HCF for registration in the HCF DD Library. Quality checks are performed on each DD submitted to ensure specification compliance, to verify that there are no conflicts with DDs already registered, and to verify operation with standard HART hosts. The HCF DD Library is the central location for management and distribution of all HART DDs to facilitate use in host applications such as PCs and handheld terminals.

Additional information, not provided by the DD, may be required by some host applications for screen formatting and other uses.

Benefits of HART Communication

The HART protocol is a powerful communication technology used to exploit the full potential of digital field devices. Preserving the traditional 4–20 mA signal, the HART protocol extends system capabilities for two-way digital communication with smart field instruments.

The HART protocol offers the best solution for smart field device communications and has the widest base of support of any field device protocol worldwide. More instruments are available with the HART protocol than any other digital communications technology. Almost any process application can be addressed by one of the products offered by HART instrument suppliers.

Unlike other digital communication technologies, the HART protocol provides a unique communication solution that is backward compatible with the installed base of instrumentation in use today. This backward compatibility ensures that investments in existing cabling and current control strategies will remain secure well into the future.

Benefits outlined in this section include:

- Improved plant operations
- Operational flexibility
- Instrumentation investment protection
- Digital communication

Improved Plant Operations

The HART protocol improves plant performance and provide savings in:

- Commissioning and installation
- Plant operations and improved quality
- Maintenance

COST SAVINGS IN COMMISSIONING

HART-based field devices can be installed and commissioned in a fraction of the time required for a traditional analog-only system. Operators who use HART digital communications can easily identify a field device by its tag and verify that operational parameters are correct. Configurations of similar devices can be copied to streamline the commissioning process. A loop integrity check is readily accomplished by commanding the field transmitter to set the analog output to a preset value.

COST SAVINGS IN INSTALLATION

The HART protocol supports the networking of several devices on a single twisted wire pair. This configuration can provide significant savings in wiring, especially for applications such as tank monitoring.

Use HART multidrop mode to connect multiple instruments to a single cable and reduce installation costs.

Multivariable devices reduce the number of instruments, wiring, spare parts, and terminations required. Some HART field instruments embed PID control, which eliminates the need for a separate controller, and results in significant wiring and equipment cost savings.

Improved Plant Operations

IMPROVED MEASUREMENT QUALITY

HART-communicating devices provide accurate information that helps improve the efficiency of plant operations. During normal operation, device operational values can be easily monitored or modified remotely. If uploaded to a software application, these data can be used to automate record keeping for regulatory compliance (e.g., environmental, validation, ISO9000, and safety standards).

Numerous device parameters are available from HART-compatible instruments that can be communicated to the control room and used for control, maintenance, and record keeping (Figure 4).

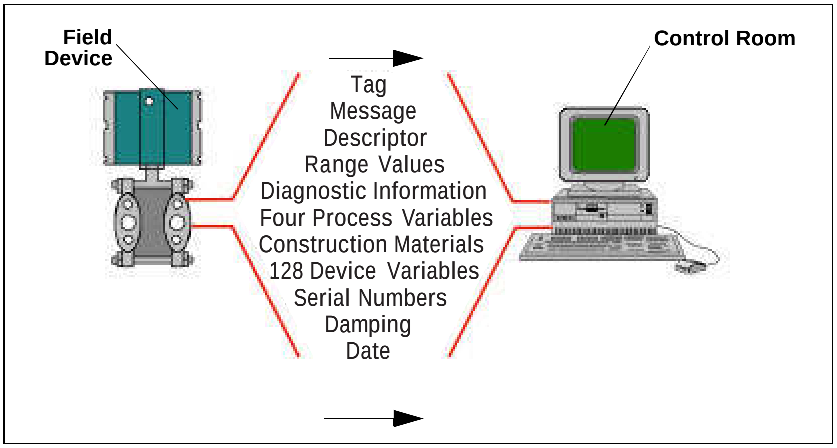


Figure 4: Examples of Device Parameters Sent to Control Room

Some HART devices perform complex calculations, such as PID control algorithms or compensated flow rate. Multivariable HART-capable instruments take measurements and perform calculations at the source, which eliminates time bias and results in more accurate calculations than are possible when performed in a centralized host.

The HART protocol provides access to all information in multivariable devices. In addition to the analog output (primary variable), the HART protocol provides access to all measurement data that can be used for verification or calculation of plant mass and energy balances.

Some HART field devices store historical information in the form of trend logs and summary data. These logs and statistical calculations (e.g., high and low values and averages) can be uploaded into a software application for further processing or record keeping.

Improved Plant Operations

COST SAVINGS IN MAINTENANCE

The diagnostic capabilities of HART-communicating field devices can eliminate substantial costs by reducing downtime. The HART protocol communicates diagnostic information to the control room, which minimizes the time required to identify the source of any problem and take corrective action. Trips into the field or hazardous areas are eliminated or reduced.

When a replacement device is put into service, HART communication allows the correct operational parameters and settings to be quickly and accurately uploaded into the device from a central database. Efficient and rapid uploading reduces the time that the device is out of service. Some software applications provide a historical record of configuration and operational status for each instrument. This information can be used for predictive, preventive, and proactive maintenance.

Operational Flexibility

The HART protocol allows two masters (primary and secondary) to communicate with slave devices and provide additional operational flexibility. A permanently connected host system can be used simultaneously, while a handheld terminal or PC controller is communicating with a field device (Figure 5).

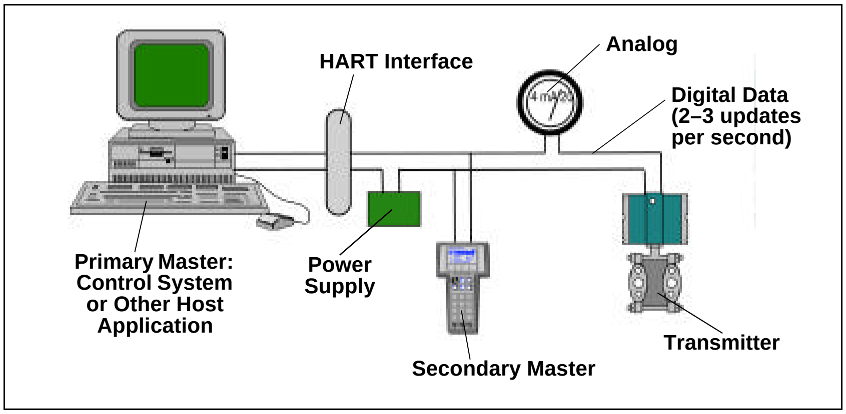


Figure 5: Multimaster System

The HART protocol ensures interoperablility among devices through universal commands that enable hosts to easily access and communicate the most common parameters used in field devices. The HART DDL extends interoperability to include information that may be specific to a particular device. DDL enables a single handheld configurator or PC host application to configure and maintain HART-communicating devices from any manufacturer. The use of common tools for products of different vendors minimizes the amount of equipment and training needed to maintain a plant.

HART extends the capability of field devices beyond the single-variable limitations of 4-20mA in hosts with HART capability.

Instrumentation Investment Protection

Existing plants and processes have considerable investments in wiring, analog controllers, junction boxes, barriers, marshalling panels, and analog or smart instrumentation. The people, procedures, and equipment already exist for the support and maintenance of the installed equipment. HART field instruments protect this investment by providing compatible products with enhanced digital capabilities. These enhanced capabilities can be used incrementally.

The HART communication protocol enables you to retain your previous investments in existing hardware and personnel.

At the basic level, HART devices communicate with a handheld terminal for setup and maintenance. As needs grow, more sophisticated, on-line, PC-based systems can provide continuous monitoring of device status and configuration parameters. Advanced installations can also use control systems with HART I/O capability. The status information can be used directly by control schemes to trigger remedial actions and allow on-line reranging based on operating conditions and direct reading of multivariable instrument data.

COMPATIBILITY OF HART REVISIONS

As HART field devices are upgraded, new functions may be added. A basic premise of the HART Protocol is that new HART instruments must behave in precisely the same manner as older versions when interfaced with an earlier revision host system.

Digital Communication

A digital instrument that uses a microprocessor provides many benefits. These benefits are found in all smart devices regardless of the type of communication used. A digital device provides advantages such as improved accuracy and stability. The HART protocol enhances the capabilities of digital instruments by providing communication access and networking (Table 2).

Benefits	HART Instruments	Digital Instruments
Accuracy and stability	✓	✓
Reliability	✓	✓
Multivariable	✓	✓
Computations	✓	✓
Diagnostics	✓	✓
Multiple sensor inputs	✓	✓
Ease of commissioning	✓	
Tag ID	✓	
Remote configuration	✓	
Loop checks	✓	
Adjustable operational parameters	✓	
Access to historical data	✓	
Multidrop networking	✓	
Access by multiple host devices	✓	
Extended communication distances	✓	
Field-based control	✓	
Interoperability	✓	

Table 2: Digital Instruments Versus HART Instruments

Getting the Most out of HART Systems

To take full advantage of the benefits offered by the HART communication protocol, it is important that you install and implement the system correctly. The following sections contain information that can help you to get the most from your HART system:

- Wiring and Installation
- Intrinsic safety
- HART multidrop networks
- Control system interfaces
- Multiplexers
- Reading HART data into nonHART systems
- Universal handheld communicator
- PC configuration software
- Commissioning HART networks
- Device status and diagnostics
- Connecting a PC to a HART device or network
- PC application development tools
- Control in field devices

Wiring and Installation

In general, the installation practice for HART communicating devices is the same as conventional 4-20mA instrumentation. Individually shielded twisted pair cable, either in single-pair or multi-pair varieties, is the recommended wiring practice. Unshielded cables may be used for short distances if ambient noise and cross-talk will not affect communication. The minimum conductor size is 0.51 mm diameter (#24 AWG) for cable runs less than 1,524 m (5,000 ft) and 0.81 mm diameter (#20 AWG) for longer distances.

CABLE LENGTH

Most installations are well within the 3,000 meter (10,000 ft) theoretical limit for HART communication. However, the electrical characteristics of the cable (mostly capacitance) and the combination of connected devices can affect the maximum allowable cable length of a HART network. Table 3 shows the affect of cable capacitance and the number of network devices on cable length. The table is based on typical installations of HART devices in non-IS environments, i.e. no miscellaneous series impedance. Detailed information for determining the maximum cable length for any HART network configuration can be found in the HART Physical Layer Specifications.

	Cable Capacitance – pf/ft (pf/m) Cable Length – feet (meters)			
No. Network Devices	20 pf/ft (65 pf/m)	30 pf/ft (95 pf/m)	50 pf/ft (160 pf/m)	70 pf/ft (225 pf/m)
1	9,000 ft (2,769 m)	6,500 ft (2,000 m)	4,200 ft (1,292 m)	3,200 ft (985 m)
5	8,000 ft (2,462 m)	5,900 ft (1,815 m)	3,700 ft (1,138 m)	2,900 ft (892 m)
10	7,000 ft (2,154 m)	5,200 ft (1,600 m)	3,300 ft (1,015 m)	2,500 ft (769 m)
15	6,000 ft (1,846 m)	4,600 ft (1,415 m)	2,900 ft (892 m)	2,300 ft (708 m)

Table 3: Allowable cable lengths for 1.02 mm (#18 AWG) shield twisted pair

Intrinsic Safety

Intrinsic safety (IS) is a method of providing safe operation of electronic process-control instrumentation in hazardous areas. IS systems keep the available electrical energy in the system low enough that ignition of the hazardous atmosphere cannot occur. No single field device or wiring is intrinsically safe by itself (except for battery-operated, self-contained devices), but is intrinsically safe only when employed in a properly designed IS system.

INTRINSIC SAFETY DEVICES

HART-communicating devices work well in applications that require IS operation. IS devices (e.g., barriers) are often used with traditional two-wire 4–20 mA instruments to ensure an IS system in hazardous areas. With traditional analog instrumentation, energy to the field can be limited with or without a ground connection by installing one of the following IS devices:

- *Shunt-diode (zener) barriers* that use a high-quality safety ground connection to bypass excess energy (Figure 6)
- *Isolators*, which do not require a ground connection, that repeat the analog measurement signal across an isolated interface in the safe-side load circuit (Figure 7 on page 19)

Both zener barriers and isolators can be used to ensure an IS system with HART-communicating devices, but some additional issues must be considered when engineering the HART loop.

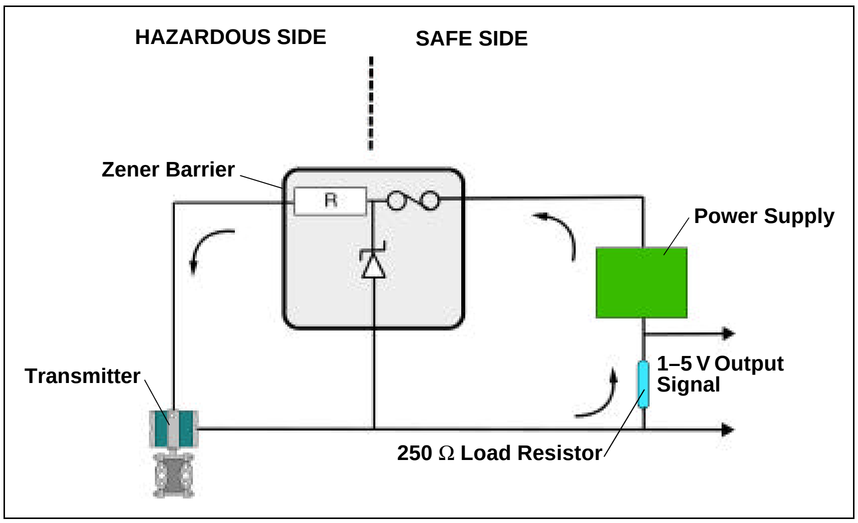


Figure 6: 4–20 mA Loop with a Zener Barrier

Intrinsic Safety

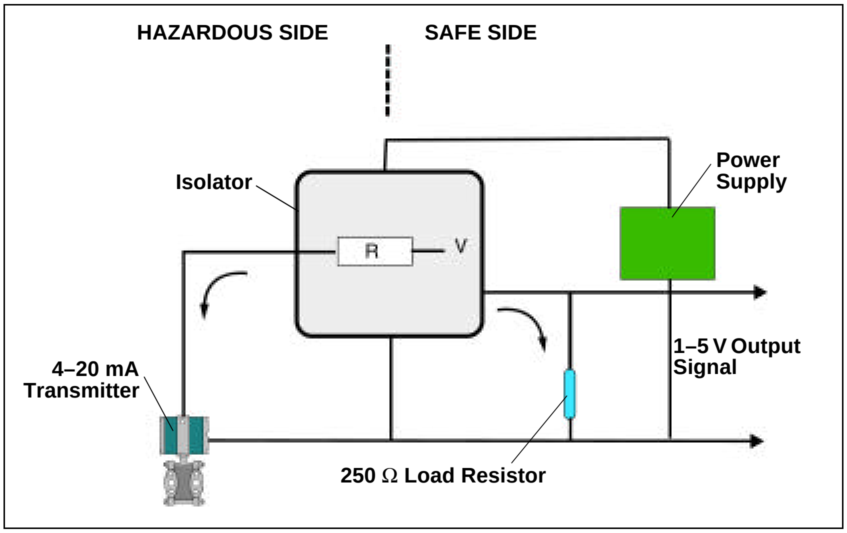


Figure 7: 4–20 mA Loop with Isolator

DESIGNING AN IS SYSTEM USING SHUNT-DIODE BARRIERS

Designing an IS direct-current loop simply requires ensuring that a field device has sufficient voltage to operate, taking into account zener barrier resistance, the load resistor, and any cable resistance.

When designing an IS loop using shunt-diode barriers, two additional requirements must be considered:

- The power supply must be reduced by an additional 0.7 V to allow headroom for the HART communication signal and yet not approach the zener barrier conduction voltage.
- The load resistor must be at least 230 Ω (typically 250 Ω).

Depending on the lift-off voltage of the transmitter (typically 10–12 V), these two requirements can be difficult to achieve. The loop must be designed to work up to 22 mA (not just 20 mA) to communicate with a field device that is reporting failure by an upscale, over-range current. The series resistance for the same zener barrier may be as high as 340 Ω. To calculate the available voltage needed to power a transmitter, use the following equation:

Power Supply Voltage – (Zener Barrier Resistance + Sense Resistance) × Operating Current (mA) = Available Voltage

Example: 26.0 V – (340 Ω + 250 Ω) × 22 mA = 13.0 V

Any cable resistance can be added as a series resistance and will reduce the voltage even further. In addition, the power supply to the zener barrier must also be set lower than the zener barrier conduction voltage. For example, a 28 V, 300 Ω zener barrier would typically be used with a 26 V power supply.

Intrinsic Safety

While it is difficult to meet the two requirements noted above for a network using shunt-diode barriers, it can be done. Following are two possible solutions to the problem:

1. Shunt the load resistor with a large inductor so that the load resistor impedance is still high (and mainly resistive) at HART signal frequencies, but much lower at direct current. This solution, while it does work, is physically somewhat inconvenient.
2. Use an IS isolator rather than a shunt-diode barrier. The output voltage on the hazardous side is usually specified as *greater than X Vdc at 20 mA* (typically 14–17 V). This value already includes the voltage drop due to the internal safety resistor, so the only extra voltage drop is that due to cable resistance. System operation at 22 mA requires reducing the 20 mA voltage by 0.7 V (340 Ω × 2 mA).

DESIGNING AN IS SYSTEM USING ISOLATORS

The implementation of HART loops in an IS system with isolators requires more planning. An isolator is designed to recreate the 4–20 mA signal from the field device in the safe-side load circuit. Most older isolator designs will not carry the high frequencies of HART current signals across to the safe side, nor will they convey HART voltage signals from the safe side to the field. For this reason, HART communication through the isolator is not possible with these older designs. (It is still possible to work with a handheld communicator or PC with an IS modem on the hazardous side of the isolator.) When retrofitting HART instruments into an existing installation, inspect the system for isolators that may have to be replaced (any isolators that will not support HART signals).

Major suppliers of IS isolators have introduced designs that are fully HART compatible. Modern IS isolators provide trouble-free design and operation and transparent communication in both directions.

IS device suppliers can assist with certification and performance specifications for their HART-compatible products. Field device manufacturers will also supply certification details for their specific products.

Intrinsic Safety

MULTIDROP IS NETWORKS

HART multidrop networks are particularly suitable for intrinsically safe installations. With a multidrop configuration, fewer barriers or isolators are required. In addition, because each field device takes only 4 mA (for a total of 16 mA in a four-device loop), plain zener barriers can be used. With a 250 Ω load, $25\ V - (340 + 250\ \Omega) \times 16\ mA = 15.5\ V$, which is well above the transmitter lift-off voltage and leaves a margin for cable resistance.

IS OUTPUT LOOPS

For output devices such as valve positioners, direct-current voltage considerations will vary depending on the drive requirements of the device. Zener barriers may be possible. If not, modern HART-compatible output isolators are appropriate.

IS CERTIFICATION CONSIDERATIONS

If the HART loop contains an IS-approved handheld communicator or modem, slight changes may be needed to meet IS installation certification rules. Handheld communicators and modems add the HART signal voltage to the voltage level coming from the zener barrier or isolator. For example, a handheld communicator typically adds a maximum of 2 V to the loop. Therefore, when used with a 28 V zener barrier, a total of 30 V may theoretically be present in the loop. The allowable capacitance must be reduced by about 15% to account for this increase in voltage.

IS NETWORK CABLE LENGTH CALCULATIONS

The cable length calculation must include the resistance of both the zener barrier and the load resistor.

HART Multidrop Networks

The HART communication protocol enables several instruments to be connected on the same pair of wires in a *multidrop network* configuration (Figure 8). The current through each field device is fixed at a minimum value (typically 4 mA) sufficient for device operation. The analog loop current does not change in relation to the process and thus does not reflect the primary variable. Communications in multidrop mode are entirely digital.

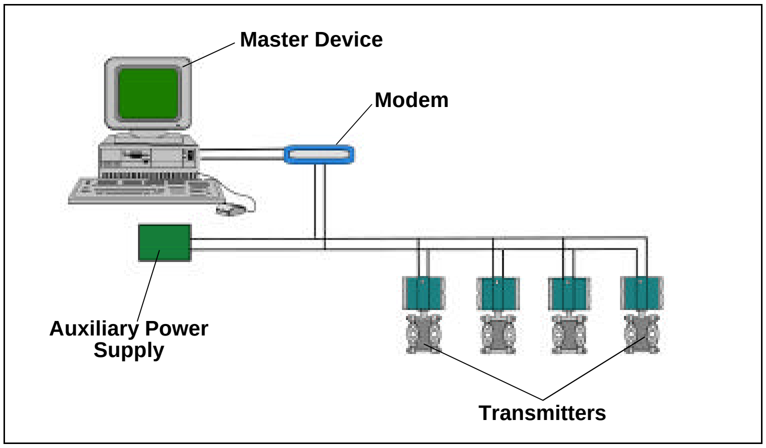


Figure 8: Multidrop Configuration

Standard HART commands are used to communicate with field instruments to determine process variables or device parameter information (see *HART Commands* on page 7). The typical cycle time needed to read information on a single variable from a HART device is approximately 500 milliseconds (ms). For a network of 15 devices, a total of approximately 7.5 seconds is needed to scan and read the primary variables from all devices. Reading information from multivariable instruments may take longer, as the data field will typically contain values for four variables rather than just one.

The typical multidrop network enables two-wire measurement devices to be connected in parallel. Two-wire loop-powered and four-wire active-source devices can be connected in the same network. If both two- and four-wire devices are used in the same network, three wires must be used to properly connect the devices (see *Water Treatment Facility Upgrade* on page 45).

HART Multidrop Networks

MULTIDROP WITH HART FIELD CONTROLLERS

HART field controllers can also be wired in a multidrop network (Figure 9). Each analog output signal from the transmitter/controllers is isolated from every other output signal, which provides a cost-effective HART network configuration. In this case, the analog signals are not fixed and are used for the output signal to the controlled device.

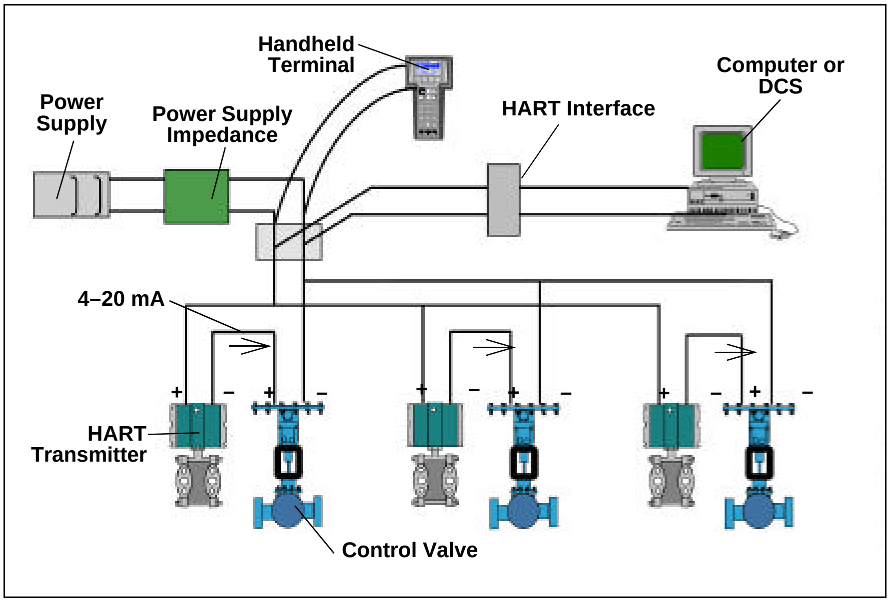


Figure 9: HART Controllers with Multidrop

APPLICATION CONSIDERATIONS

Connecting HART field devices in a multidrop network can provide significant installation savings. The total cable length in a multidrop network is typically less than the maximum cable length in point-to-point connections because the capacitance of the additional devices reduces the distance that the HART signal can be carried (see *Wiring and Installation* on page 17).

To save on installation costs, use HART multidrop networks for remote monitoring stations, tank farms, pipeline distribution systems, and other monitoring applications in which fast update rates are not required.

CONFIGURING DEVICES FOR MULTIDROP OPERATION

Using the polling address structure of the HART protocol, up to 15 devices can be connected in a multidrop network. The analog current of a HART device can be fixed by setting its polling address to a number other than zero. With the HART protocol, each field instrument should be configured with different polling addresses or tag numbers before being connected to a multidrop network—otherwise, the master will not be able to establish communication with the slave devices.

Control System Interfaces

When you change your existing control system by adding a HART interface, it is important to understand the complete functionality offered by the HART interface. While several control-system suppliers offer HART interfaces, not all interfaces provide the same functionality.

Control systems such as a DCS, PLC, or SCADA/RTU (remote terminal unit) implement only the functionality required for a given application. For example, a flow-control system may only read the primary variable of a device and provide no additional support for viewing or changing configuration information. Other control-system interfaces provide comprehensive HART support, maintaining complete configuration records for all connected devices.

Contact your system supplier for specific details on their HART interface(s). Use the form in Appendix A to obtain information from control-system suppliers to identify specific characteristics of their products.

HART I/O Subsystems

Many HART-compatible I/O subsystems have multiple analog channels on each I/O card. Suppliers choose whether to provide one HART interface per channel or to share one HART interface among several channels. The number of shared channels per HART interface impacts the frequency of data updates from a HART field device and the HART functionality that is supported.

HART I/O for Multidrop Support

For the best performance and flexibility, one HART interface should be dedicated to each I/O channel. Systems that share only one HART interface among several I/O channels may not support multidrop networks. The effective update rate of a multiplexed interface is slow enough that the performance of multiplexed multidrop networks would not be practical. Some suppliers enable multidrop support by fixing the HART interface to one specific I/O channel. However, the other channels on that card may then not be available for HART communications.

HART I/O for Burst Mode Support

Burst mode is an optional implementation in a field device. Receiving burst mode messages is optional in a host as well. To take full advantage of burst mode, the I/O system should have one HART interface for each channel. If the HART interface is shared by more than one channel, messages sent by the field device may not be detected by the control system. If the system does not have the ability to configure burst mode in the field device, a handheld terminal or other configuration tool is required.

Control System Interfaces

DATA HANDLING

All HART-compatible control systems can read the digital primary variable from a slave device. However, some system architectures may not be able to accommodate textual data (e.g., tag and descriptor fields). In these cases, the controller is able to read the process variable, but may not have direct access to all other data in the HART device.

PASSTHROUGH FEATURE

Some control systems are integrated with a configuration or instrument-management application. In these systems, the control system passes a HART command, issued by the management application, to the field device via its I/O interface. When the control system receives the reply from the field device, it sends the reply to the management application. This function is referred to as a *passthrough feature* of the control system.

GATEWAYS

Gateways can be used to bring HART digital data into control systems that do not support HART-capable I/O. Some systems support HART gateways with communication protocols such as Modbus, PROFIBUS DP, or TCP/IP Ethernet. The typical HART gateway supports all universal commands and a subset of the common practice commands. Support varies depending on the gateway supplier. Some gateways support access to device-specific information.

SCADA/RTU SYSTEMS

RTUs used in SCADA systems use a special telemetry to communicate with the control system. RTUs have the same considerations regarding multidrop and burst mode support as other systems. However, implementation is made more complex because RTUs often communicate to an upper-level host using a communication protocol other than HART (e.g., Modbus). While there are many benefits to implementing HART in an RTU (support of multidrop, burst mode, and multivariable instruments), HART data are only available to the central host system if the telemetry protocol supports the transfer of HART commands or specific HART data (see *Multidrop for Tank Farm Monitoring* on page 40).

Multiplexers

HART-compatible multiplexers are ideal for users who want to interface with a large number of HART devices. Multiplexers can be modular and are capable of supporting both point-to-point and all-digital (multidrop) HART communication modes. Communication between a multiplexer and a host application depends on the multiplexer capabilities (e.g., RS232C, RS485, Modbus, and TCP/IP Ethernet).

When installing HART multiplexer systems, the following capabilities should be considered:

- Number of HART channels supported
- Number of HART channels that share a HART modem
- Burst mode support
- Multidrop support
- Method of communication with the host computer or control system

Multiplexer as the Primary I/O System

HART multiplexers can be used as the primary I/O front end for a HART-based control or monitoring system (Figure 10). Typically, a PC acts as the host, providing the human-machine interface and performing other high-level functions. The multiplexer continuously monitors the field devices, reports the current readings and instrument status to the host, and passes HART commands from the host computer to the field devices.

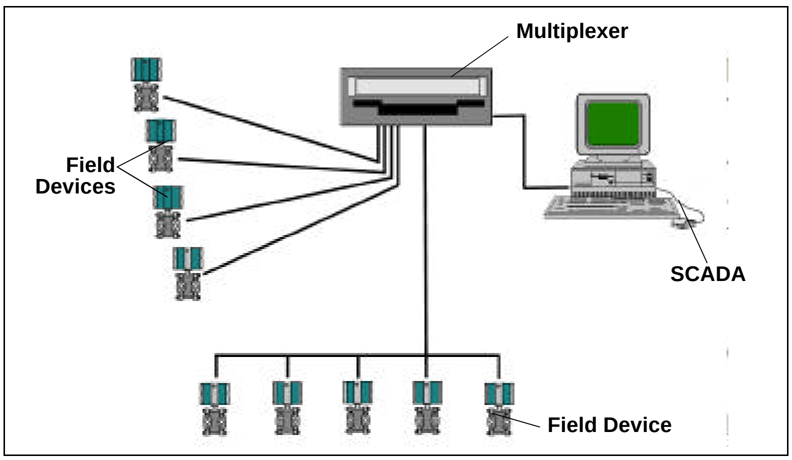


Figure 10: HART Multiplexer as the Primary I/O System

Parallel Monitoring with a Multiplexer

When a traditional 4–20mA control system is using the analog signals for measurement and control outputs, a HART multiplexer can be added to the network to gain access to the digital HART signal. Using a multiplexer enables a supervisory computer to monitor diagnostics and device status, access configuration information, and read any additional process inputs or calculations not provided by the 4–20mA signal.

Multiplexers

Use a HART multiplexer to gain access to the digital HART signal.

Two types of multiplexers are used in conjunction with a control system. A multiplexer wired in parallel with the field wiring is commonly used when the control system wiring is already in place (Figure 11).

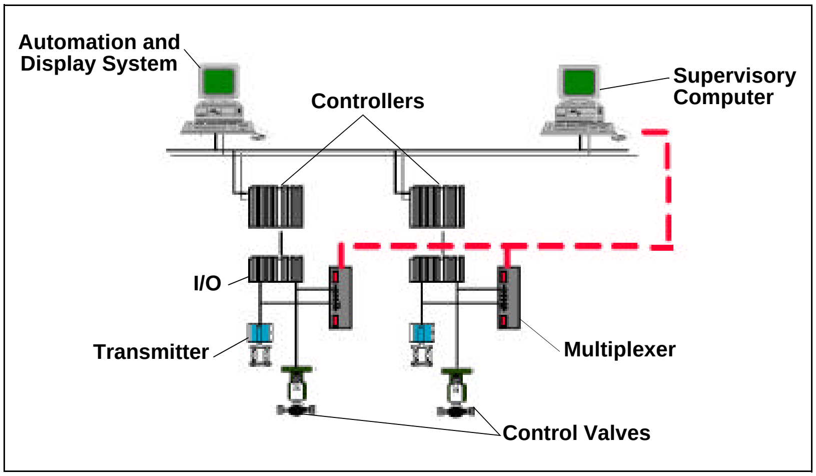


Figure 11: HART Multiplexer with Existing I/O

A multiplexer can also be an integral part of the control system as a third-party I/O (Figure 12). As an I/O system, the multiplexer can include IS barriers and other filtering capabilities and provide services to the field device, such as galvanic isolation or power. For this type of installation, no additional terminations or space are required. The multiplexer can also act as a gateway to convert the HART messages to another protocol such as Modbus, PROFIBUS, or Ethernet.

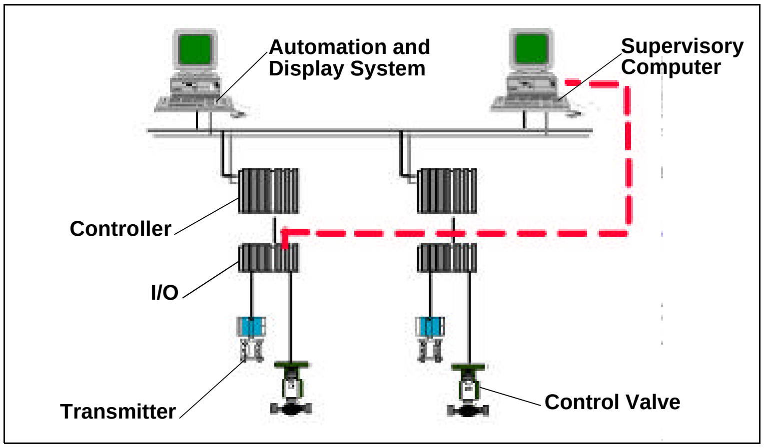


Figure 12: HART Multiplexer Integrated with I/O

Reading HART Data into NonHART Systems

Many HART products are able to perform more than one measurement or output function (e.g., make multiple process measurements, calculate process information, and provide positioner feedback information). All of this information can be easily accessed digitally. However, existing controllers or interface equipment may not have the ability to read digital HART data. Products are available that can read HART digital signals and convert them to analog or contact information, which enables any traditional analog/digital I/O to take full advantage of the benefits of HART-communicating devices. The Rosemount Inc. Tri-Loop module and the Moore Industries Site Programmable Alarm (SPA) are two such products.

HART Data-Conversion Products

The Tri-Loop module monitors a HART loop for a bursting message and converts three of the four possible variables in HART command number three to analog outputs (Figure 13). The conversion enables the field device to provide a total of four analog signals over a single pair of wires run from the field.

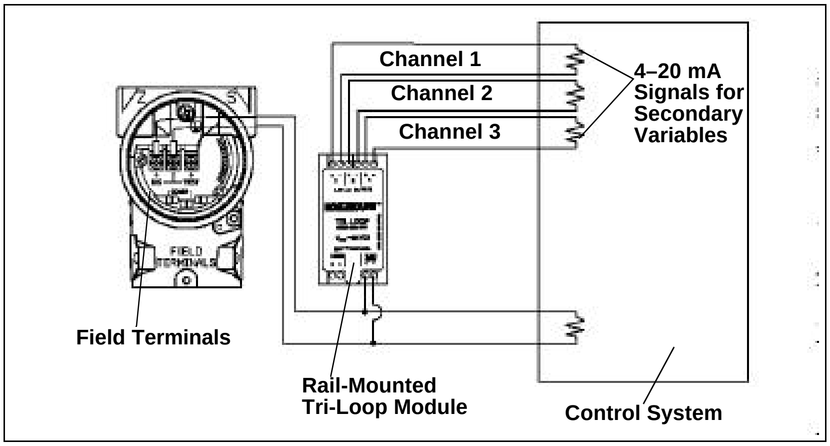


Figure 13: Tri-Loop Module

Reading HART Data into NonHART Systems

The SPA module continuously communicates with any HART-capable device and provides contact closure outputs (alarm trips) based on the information received (Figure 14). For example, the SPA can be configured to monitor the device-status information inherent in the HART communication protocol and trigger events such as local on/off applications or alarms. The SPA can also initiate emergency shutdown action if problems are detected with a field device in critical loop applications.

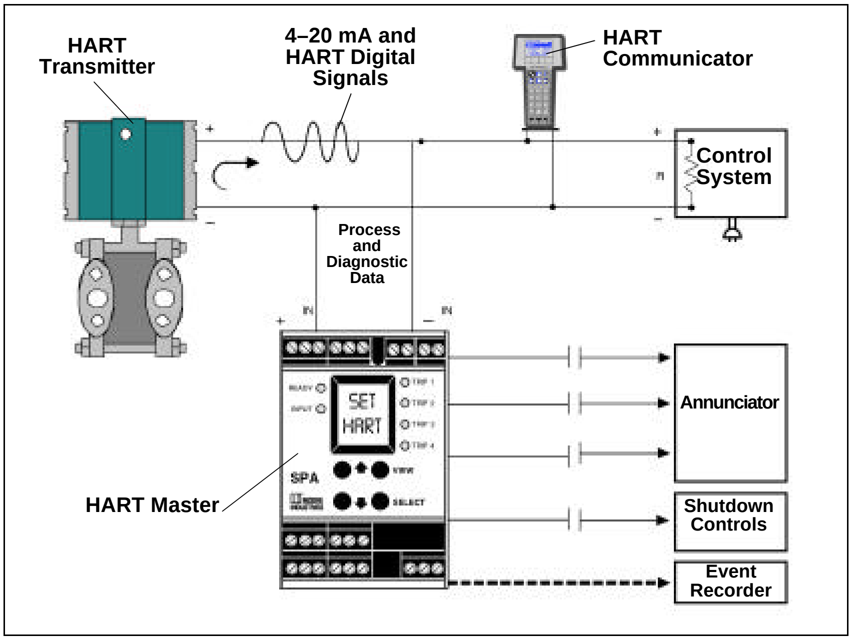


Figure 14: SPA Module

Both HART Tri-Loop and SPA provide multivariable product support on a loop-by-loop basis.

Universal Handheld Communicator

The *275 Universal HART Communicator* is available from major instrumentation suppliers around the globe and is supported by all member companies in the HCF. Using HART DDL, the communicator can fully communicate with and configure any HART device for which it has a DD installed. If the communicator does not have the DD for a particular network device installed, it can still communicate with that device using the universal and common practice commands (see *HART Commands* on page 7). The HCF provides centralized control and registration for all DDs that can be loaded into the communicator. An index of registered DDs can be found on the world wide web at <http://www.hartcomm.org>.

Use the 275 Universal HART Communicator to communicate with and configure any HART-communicating device.

Figure 15: 275 Universal Handheld Communicator

PC Configuration Software

Many instrument manufacturers, as well as some independent software developers, offer HART communication software for PCs with capabilities similar to and beyond those offered by a HART handheld communicator.

Use special software applications to continuously monitor the status of connected field devices and log status changes as they occur, which may help reduce the costs of regulatory compliance.

The software packages listed in Table 4 are used for configuration management, parameter tuning, and data acquisition with a HART device. The list is not comprehensive, and all software applications are not functionally equivalent. A number of product-specific software applications are also available for diagnostics. An RS232 HART interface or other interface device connects the PC running the HART application software to the field devices.

SUMMARY TABLE OF HART SOFTWARE

Software	Application	Manufacturer
Asset Management Solutions (AMS)	Configuration and calibration management	Fisher-Rosemount
CONF301 HART Configurator	Configuration management	Smar International
CONFIG	Configuration management	Krohne
Cornerstone Base Station	Configuration and calibration management	Applied System Technologies
Cornerstone Configurator	Instrument configuration	Applied System Technologies
H-View	Configuration management and data acquisition	Arcom Control Systems
IBIS	Configuration management	EB Hartmann & Braun
IBIS	Configuration management	Samson
K-S Series	Configuration management	ABB
Mobrey H-View	Configuration management	KDG Mobrey
Pacemaker	Configuration management	UTSI International Corporation
SIMATIC PDM	Configuration management	Siemens
Smart Vision	Configuration management	EB Hartmann & Braun/ Bailey Fischer & Porter
XTC Configuration Software	Configuration management	Moore Products Co.

Table 4: HART Software

Commissioning HART Networks

HART-based instruments have several features that significantly reduce the time required to fully commission a HART network (loop). When less time is required for commissioning, substantial cost savings are achieved.

DEVICE VERIFICATION

Before installation, manufacturers usually enter device tags and other identification and configuration data into each field instrument. After installation, the instrument identification (tag and descriptor) can be verified in the control room using a configurator (handheld terminal or PC). Some field devices provide information on their physical configuration (e.g., wetted materials)—these and other configuration data can also be verified in the control room. The verification process can be important in conforming to governmental regulations and ISO quality requirements.

The commissioning process can be further streamlined by connecting a PC configurator to each HART loop online, either by integration with the control system or by using one of the many available HART multiplexing I/O systems (see *Multiplexers* on page 26). With this centralized approach, there is no need to move the configuration device from one termination point to the next while commissioning all devices on the network.

LOOP INTEGRITY CHECK

Once a field instrument has been identified and its configuration data confirmed, the analog loop integrity can be checked using the loop test feature, which is supported by many HART devices. The loop test feature enables the analog signal from a HART transmitter to be fixed at a specific value to verify loop integrity and ensure proper connection to support devices such as indicators, recorders, and DCS displays.

Use the HART protocol loop test feature to check analog loop integrity and ensure a proper physical connection among all network devices.

AS-INSTALLED RECORD KEEPING

A HART configurator also facilitates record keeping. As-installed device configuration data can be stored in memory or on a disk for later archiving or printing.

Device Status and Diagnostics

Most HART field instruments provide both status information and diagnostic information. The HART protocol defines *basic status information* as information that is included with every message from a field device. Basic status information enables the host application to immediately identify warning or error conditions detected by the field device. Status messages also enable the user to differentiate between measurements that are outside sensor or range limits and actual hardware malfunctions. Examples of status messages are:

- Field device malfunction
- Configuration changed
- Cold start
- More status available
- Analog output current fixed
- Analog output saturated
- Nonprimary variable out of limits
- Primary variable out of limits

HART instruments can implement extensive, device-specific diagnostics. The amount and type of diagnostic information is determined by the manufacturer and varies with product and application. Diagnostic information can be accessed using the HART communication protocol. Host applications using DD files can interpret and display diagnostic information. Applications not using DD technology may require product-specific software modules to interpret diagnostic information.

Many manufacturers offer special software applications for their own products. Some modules allow you to customize for specific products. Manufacturers of valve actuators have made extensive use of this capability to provide preventative and predictive diagnostic information that greatly enhances the value of their products as compared to conventional actuators.

Several software applications are available that provide continuous communication with field devices using a HART-compatible multiplexer and HART I/O (see *Multiplexers* on page 26). These applications provide real-time monitoring of status and diagnostic information.

Connecting a PC to a HART Device or Network

PCs are commonly used for HART host applications for configuration and data acquisition. A specially designed device (Table 5) allows the HART network to be connected to the RS232C serial port or PCMCIA slot of a PC (Figure 16).

Product Name	Manufacturer
Commubox	Endress + Hauser
FSK-Modem	EB Hartmann & Braun
HT311 RS232 Interface	Smar International
VIATOR PCMCIA HART Interface	MACTek
VIATOR RS232 HART Interface	MACTek

Table 5: HART Interfaces

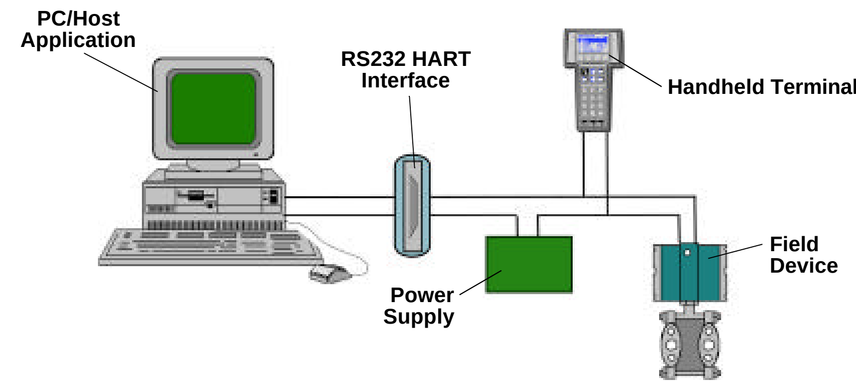


Figure 16: RS232 HART Interface

PC Application Development Tools

Software drivers are available to assist in the development and integration of PC applications with HART networks. Table 6 shows a partial list of products available.

Product Name	Description	Manufacturer
Hview	Provides DDE server	Arcom Control Systems
HRT VBX	16-bit Visual Basic driver	Borst Automation
HRT OCX	32-bit ActiveX Control	Borst Automation
HART OPC Server	OPC Server	HCF (via member companies)
HL-LinkPro	HART driver for LabVIEW	Cardiac Systems Solutions

Table 6: PC Development Tools

Control in Field Devices

Microprocessor-based smart instrumentation enables control algorithms to be calculated in the field devices, close to the process (Figure 17). Some HART transmitters and actuators support control functionality in the device, which eliminates the need for a separate controller and reduces hardware, installation, and start-up costs. Accurate, closed-loop control becomes possible in areas where it was not economically feasible before. While the control algorithm uses the analog signal, HART communication provides the means to monitor the loop and change control setpoint and parameters.

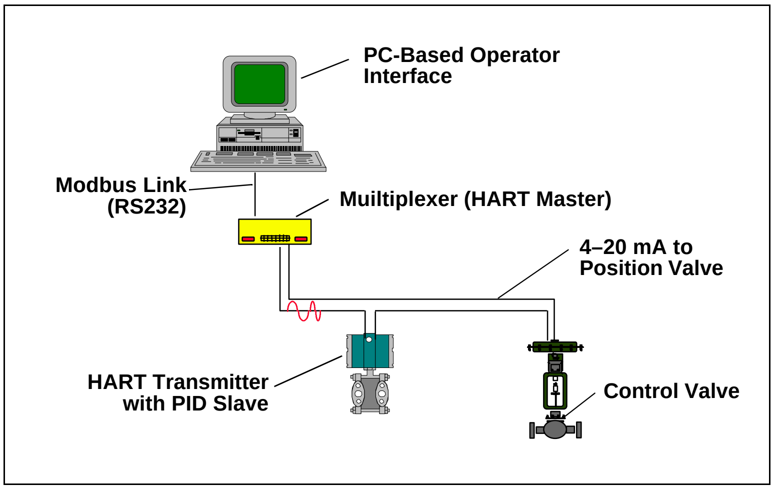


Figure 17: Transmitter with PID (HART Slave)

Placing control in the field enhances control functionality. Measurement accuracy is maintained because there is no need to transmit data to a separate controller. Control processing takes place at the high update rate of the sensor and provides enhanced dynamic performance.

Control in Field Devices

HART FIELD CONTROLLER IMPLEMENTATION

A HART field controller takes advantage of the HART protocol's simultaneous analog and digital signaling by converting the transmitter's traditional analog measurement output into a control output. The analog signal from the smart transmitter (controller) is used to manipulate the field device (Figure 18). The analog output signal also carries the HART digital signal, which is used for monitoring the process measurement, making setpoint changes, and tuning the controller.

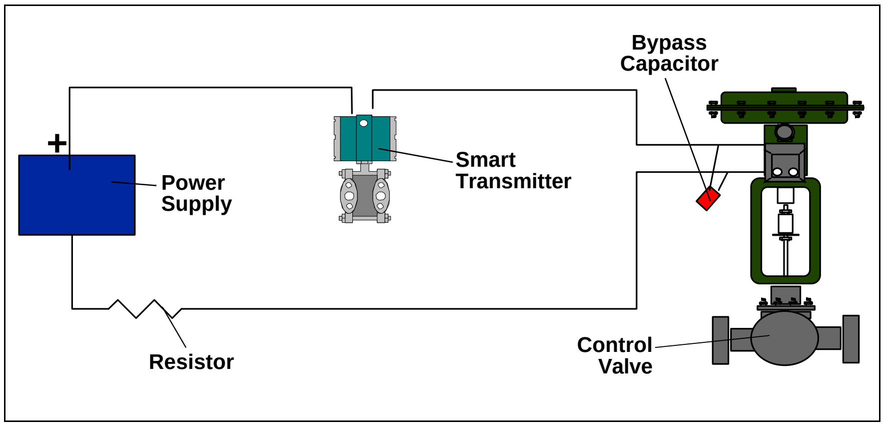


Figure 18: Smart Transmitter with PID

The communication rate of the HART protocol (2–3 updates per second) is generally perceived as too slow to support closed-loop control in the central host. With control in the field, the control function no longer depends on the HART protocol's communication rate. Instead, the control signal is an analog output that is updated at a rate that is much faster than can typically be processed in a conventional control system. Processing rates vary from 2–20 updates per second, depending on the product. The HART digital communication rate remains sufficient for monitoring the control variable and changing setpoint values.

Industry Applications

Many companies in a wide variety of industries have already realized the advantages of using the HART communication protocol. This section describes some applications in detail and outlines the tangible benefits that result. The applications have been grouped into the following sections:

- Inventory-management applications
- Cost-saving applications
- Remote-operation applications
- Open-architecture applications

Inventory-Management Applications

Accurate measurements for inventory management are essential in all industries. The HART communication protocol enables companies to make sure inventory management is as efficient, accurate, and low cost as possible.

HART MULTIDROP NETWORK FOR TANK LEVEL AND INVENTORY MANAGEMENT

Tank level and inventory management is an ideal application for a HART multidrop network (Figure 19). The HART network digital update rate of two PVs per second is sufficient for many tank-level applications. A multidrop network provides significant installation savings by reducing the amount of wiring from the field to the control room as well as the number of I/O channels required. In addition, many inexpensive process-monitoring applications are commercially available to further cut costs.

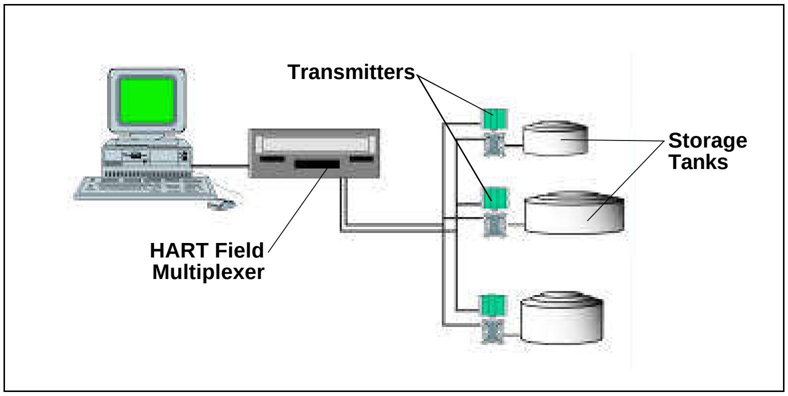


Figure 19: Inventory Management with Multidrop

One company uses a HART multiplexer to digitally scan field devices for level-measurement and status information. The information is forwarded to the host application using the Modbus communication standard. Multivariable instruments further reduce costs by providing multiple process measurements, such as level and temperature, which reduces the wiring and number of process penetrations required.

Inventory-Management Applications

MULTIDROP FOR TANK FARM MONITORING

In one tank farm application, 84 settlement tanks and filter beds on a very large site (over 300,000 m^2) are monitored using HART multidrop networks and HART RTUs (see *SCADA/RTU Systems* on page 25). The HART architecture required just eight cable runs for 84 tanks, with 10–11 devices per run (Figure 20). Over 70 individual runs of over 500 m each were eliminated. Cable savings were estimated at over $40,000 when compared to a conventional installation. RTU I/O was also reduced, which resulted in additional hardware and installation savings. The total installed cost was approximately 50% of a traditional 4–20 mA installation.

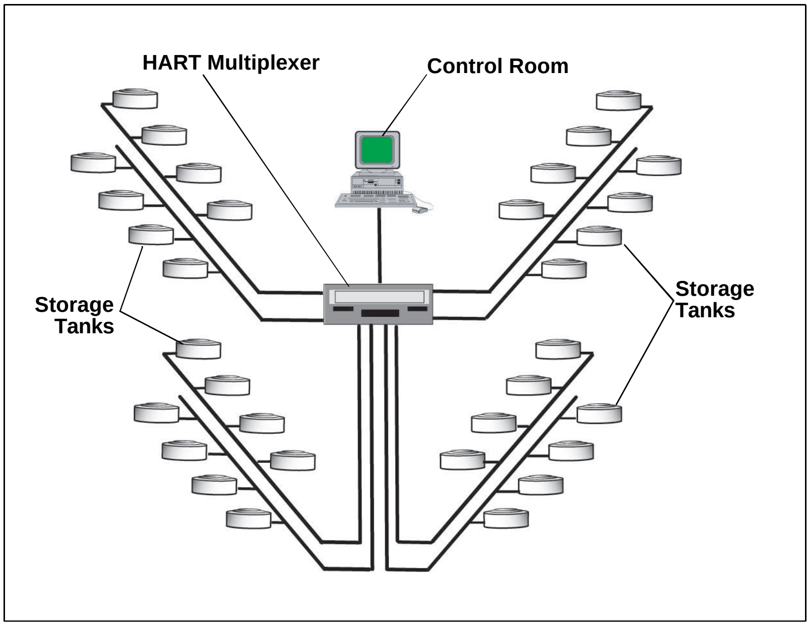


Figure 20: Tank Farm Monitoring with Multidrop

Inventory-Management Applications

UNDERGROUND PETROLEUM STORAGE WITH HART COMMUNICATION FOR ACCURACY

Underground salt caverns are frequently used for crude oil storage. One customer pumps oil from barges into the storage caverns. An ultrasonic flowmeter records the total flow. To get the oil out of the caverns, a brine solution is pumped into the cavern through a magnetic flowmeter. Brine and crude oil flowing in both directions are measured and reported to the DCS using the HART communication protocol for accuracy. The DCS tracks flow rate and total quantity to maintain a certain pressure inside the caverns (Figure 21).

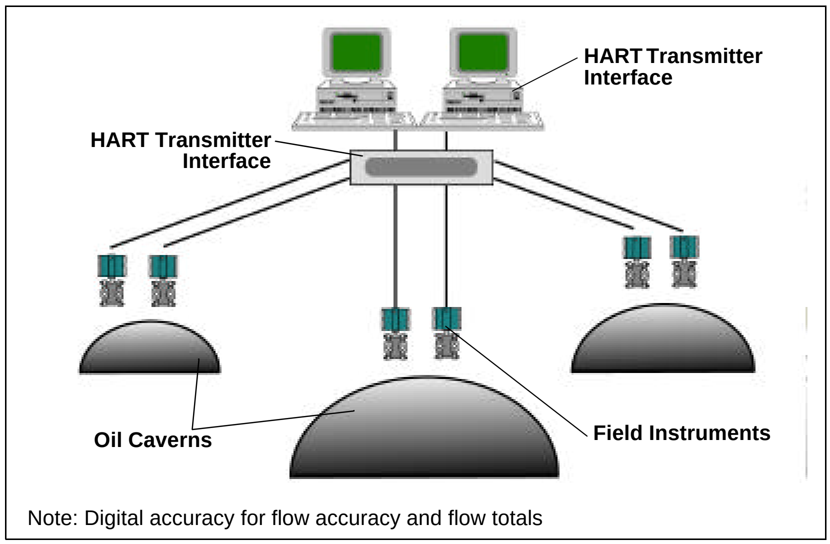


Figure 21: Underground Petroleum Storage

Cost-Saving Applications

Use HART multidrop networking to reduce installation and maintenance costs.

WASTEWATER TREATMENT PLANT UPGRADE

A Texas wastewater treatment plant replaced stand-alone flowmeters and chart recorder outstations that required daily visits for totalization with a HART system. HART-based magnetic flowmeters were multidropped into HART RTUs to create a cost-effective SCADA network. The use of HART technology reduced system and cable costs, enhanced measurement accuracy, and eliminated time-consuming analog calibration procedures.

A system of 11 HART multidrop networks was used to connect 45 magnetic flowmeters from different plant areas. Each flowmeter communicated flow rate and a totalized value over the HART network. Multidrop networks eliminated the need for additional hardware and PLC programming while providing a more accurate totalized value. Complex and costly system integration issues were also avoided—for example, there was no need for synchronization of totals between the host and field PLCs.

Multidrop networking further reduced the installation cost by reducing the required number of input cards from the traditional 45 (for point-to-point installations) to 11. Maintenance was simplified because of access to instrument diagnostic and status data.

Cost-Saving Applications

APPLIANCE MANUFACTURING WITH MULTIDROP

A consumer appliance manufacturer used the networking capability of the HART protocol to measure level, flow, and pressure. HART multidrop provided substantial wiring and installation savings as well as digital accuracy with the elimination of the analog to digital (A/D) and digital to analog (D/A) conversions of the instrument and PLC I/O. Figure 22 shows pressure transmitters connected to a PLC via smart transmitter interface multiplexers.

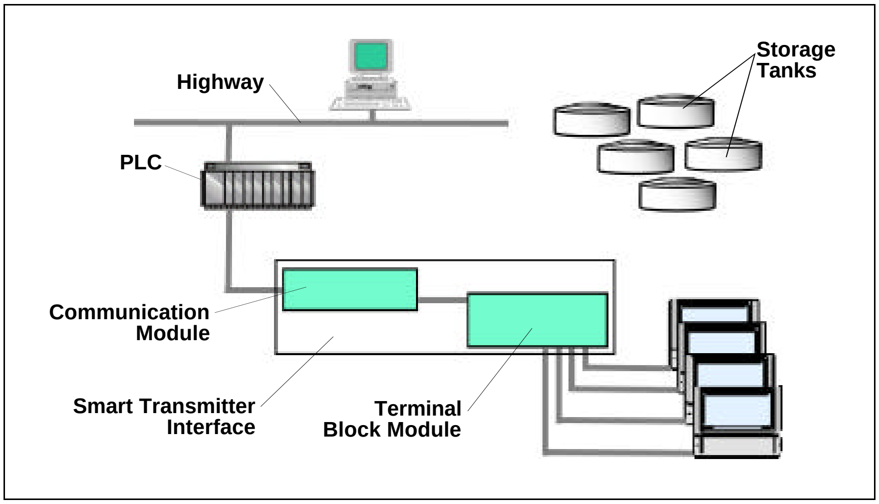


Figure 22: Multidrop Network Example

Cost-Saving Applications

REMOTE REZEROING IN A BREWERY

The benefits of remote monitoring and rezeroing of smart transmitters using the HART protocol are dramatically illustrated in this example of two smart transmitters that control the fluid level in lauter tubs in a brewhouse application. Similar benefits would be realized in any application involving a closed vessel.

Two smart transmitters are installed on each lauter tub—one on the bottom of the tank and the other about nine inches from the bottom. The bottom transmitter is ranged ±40 inH_2O; the upper transmitter is ranged 0–30 inH_2O. As the lauter tub is filled, the bottom transmitter senses level based on pressure. When the level reaches the upper transmitter, that point is marked as the new zero-level point, and the upper transmitter becomes the primary sensing instrument for the lauter-tub level. The nine-inch zero-level offset from the bottom of the tank is necessary to accommodate loose grain that settles in the bottom of the tank.

Transmitters that are coordinated and working together control fluid level in each lauter tub to within a few barrels. However, the upper transmitter requires periodic maintenance or replacement and rezeroing. An undetected false upper-transmitter level reading can cause a tank level error of up to 40 gallons.

The usual procedure for transmitter rezeroing takes about 95 minutes and has been required as frequently as twice a day. Rezeroing a transmitter using configuration software and PLC interface modules eliminates the need to locate and identify the problem at the site as well as the need for verification by control-room personnel and greatly reduces the chance for inadvertent errors. Estimated total time to rezero each transmitter is reduced to 15 minutes.

Through the configuration software's instrument-status and diagnostic capabilities, a false level indication can be automatically detected while a lauter tub fill is in progress. The affected transmitter can then be automatically rezeroed by programming logic in the programmable controller to issue the appropriate command to the instrument.

Cost-Saving Applications

WATER TREATMENT FACILITY UPGRADE

HART transmitters and a control system with HART capability were chosen to upgrade a water treatment facility. The completed installation reduced capital, engineering, and installation costs. The process dynamics of the water treatment facility allowed the HART instruments to be used in all-digital mode without compromising plant performance.

The water treatment plant is divided into two areas, each with 14 filters. Each area is controlled by a separate control system for complete autonomy. A HART network monitors each filter for filter level, filter bed differential, and filter outlet flow. The multidrop installation used a three-wire system in order to accommodate both the two-wire and the four-wire devices (magnetic flowmeters) in use (Figure 23)
(see *Multidrop* on page 6).

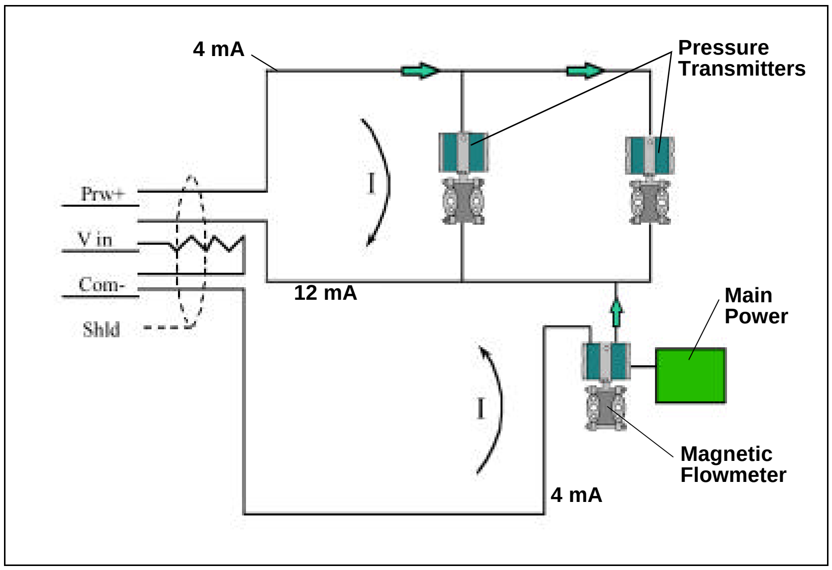


Figure 23: Multidrop Networks with 2-Wire and 4-Wire Devices

Because the water treatment facility had a modular design, the use of HART instruments allowed the configuration from the one filter network to be copied to the others, which reduced the implementation time. Engineering, system configuration, drafting, commissioning, maintenance, and documentation were simplified. A reduced I/O card count also saved money.

Cost-Saving Applications

IMPROVED DIAGNOSTICS

A cleaning materials supplier required periodic checkup of the instrument condition and configuration information as compared to the initial installation. The field transmitters provided a historical record of status changes along with current configuration information. Periodic download of this information was made possible using PLC ladder logic developed for HART instruments.

Remote-Operation Applications

UNMANNED OFFSHORE GAS PRODUCTION WITH HART NETWORKS

Choosing the HART communication protocol for all-digital communication in a wide-area network enabled one company to have real-time monitoring and control, access to diagnostics, and maintenance capabilities—all from a remote location.

Over half of the 500 transmitters on 15 platforms could be multidropped with update rates of three seconds (six devices), which resulted in substantial savings in wiring, I/O, and installation. The remaining devices (flowmeters) required a faster response and were wired point to point using digital HART communications to transmit the process data. The flowmeters used the optional burst mode, which provided an update rate of 3.7 times per second. All-digital communications provided maximum accuracy and eliminated potential errors from input scaling, conversion, and drift (see *Multidrop* on page 6).

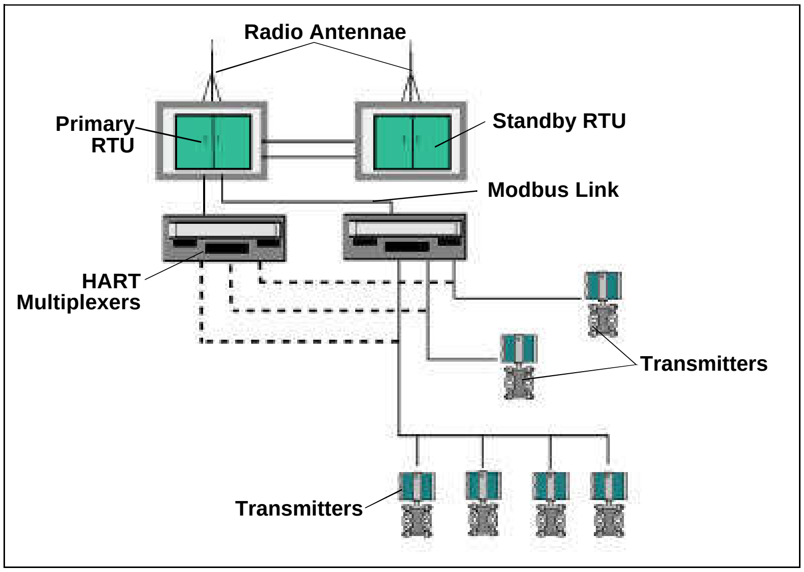


Figure 24: RTU Application

Each platform's RTU provided a link to approximately 50 temperature, pressure, and flow transmitters (Figure 24). The RTU used the multimaster capability of the HART protocol to enable the second RTU to act as a hot standby, which monitored activity and was able to take over if a failure occurred. The RTUs provided links with the emergency and safety systems and a local interface for maintenance personnel. The Modbus protocol was used for communication to the central SCADA system.

Remote-Operation Applications

VENEZUELA GAS-LIFT PROJECT

In a Venezuela gas-lift project, HART multidrop technology was used for remote operation of offshore gas-lift production wells at considerable savings (Figure 25):

- 30% decrease in installation costs
- 16:1 reduction of input modules
- Reduced cost of I/O cards in the RTU
- Remote reranging
- Remote access to the transmitter status for improved process uptime

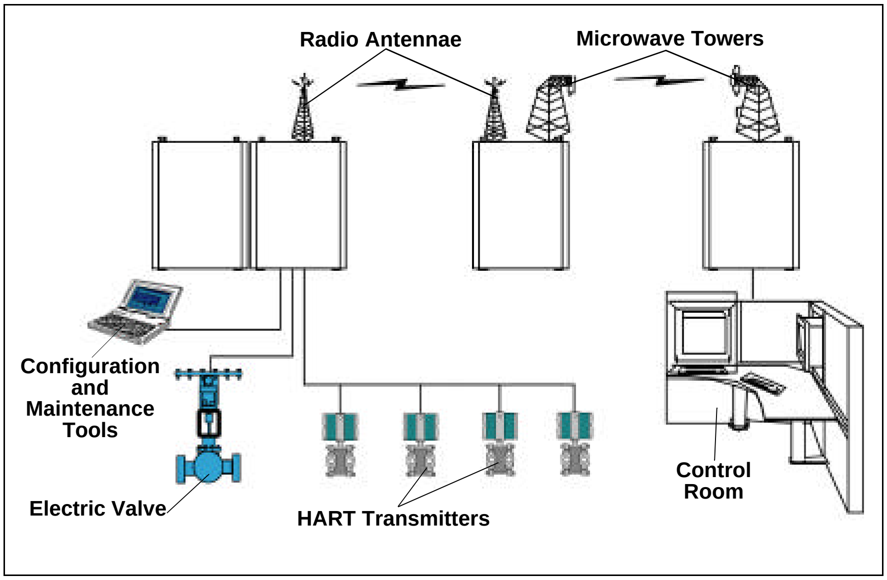


Figure 25: Offshore Gas-Lift Project

Open-Architecture Applications

OIL REFINERY EXPANSION

The best way to judge the openness of a communication protocol is by the number of products supported. By this standard, the HART protocol is perhaps the most open of any field-communication protocol available today.

In a major refinery expansion, an oil company weighed the advantages of using either a proprietary system or a HART-based system. The results indicated that the company could use HART digital instruments in 92% of their applications, compared to only 33% with the proprietary system. Choosing HART products resulted in an incremental $23,000 in savings due to commissioning efficiencies and ongoing maintenance and diagnostic capabilities.

The oil company used a traditional control system with analog I/O and supplemented the control capability with an online maintenance and monitoring system. All of the HART field devices were monitored from a central location (Figure 26).

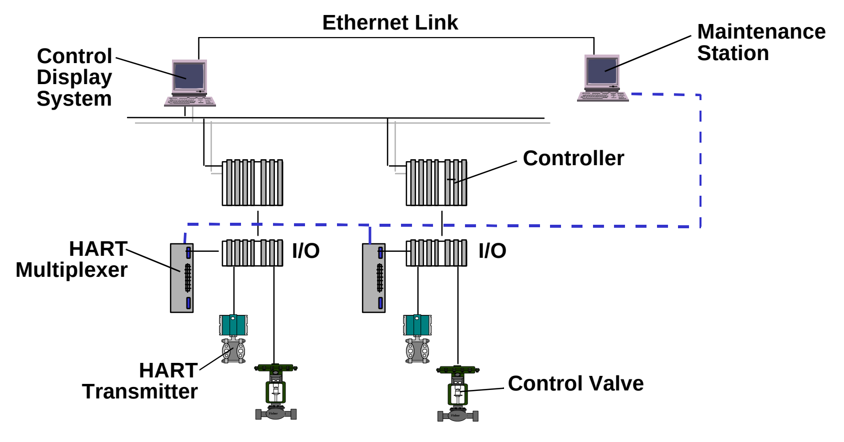


Figure 26: Online Implementation

Open-Architecture Applications

HART WITHIN A PROFIBUS NETWORK

HART field devices can be seamlessly integrated with PROFIBUS DP networks using the HART/DP Link, which enables the connection of four HART devices and facilitates the passthrough of HART commands to host applications on the DP network (Figure 27). The HART/DP Link supports IS installations.

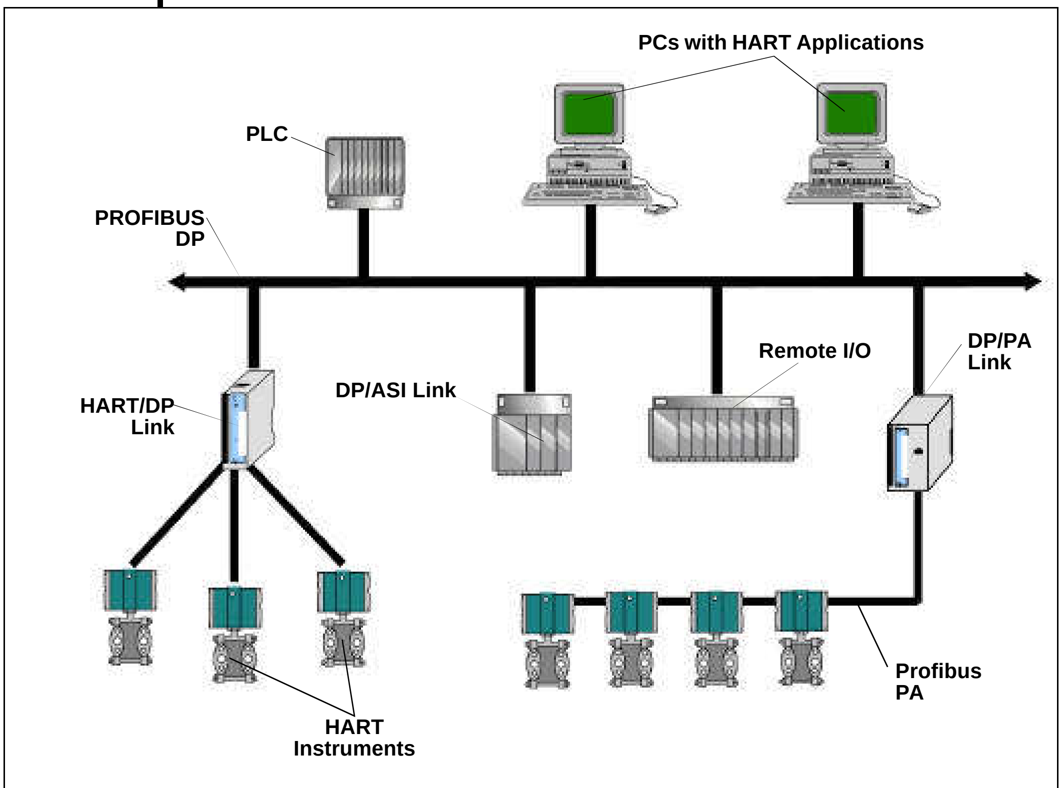


Figure 27: HART Within a PROFIBUS Network

Open-Architecture Applications

HART/DDE SERVER

Cost-effective level and temperature monitoring systems can be designed using HART multidrop networks and commercially available HART/DDE interface software. HART/DDE interface software allows any compliant application (e.g., spreadsheet) to directly read the process data and status information available in HART field devices. A HART interface module connected to the PC's serial port is needed for this HART monitoring application (Figure 28).

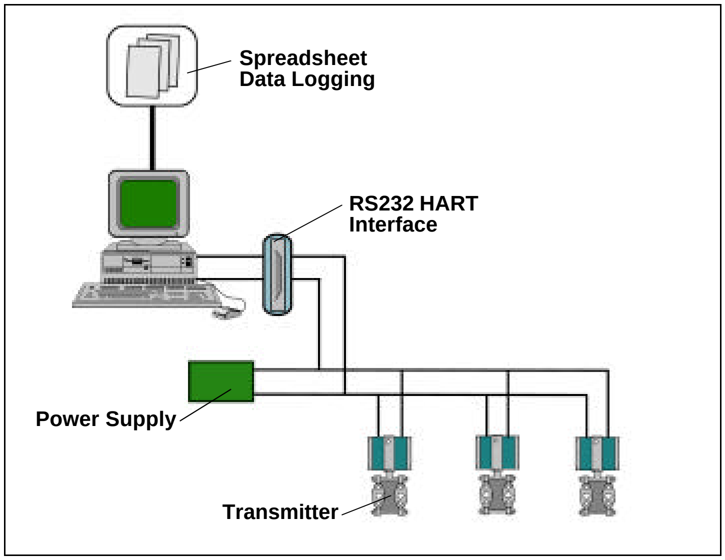


Figure 28: Multidrop Network

Where To Get More Information

WHAT INFORMATION IS AVAILABLE?

To serve the growing interest in HART-related products, the HCF publishes a library of additional documents, articles, and overviews. The following information is currently available:

- HART specifications
- Technical overview
- Application notes
- Technical assistance
- Training classes

WHERE TO FIND INFORMATION

By Mail

HART Communication Foundation
9390 Research Blvd, Suite I-350
Austin, TX 78759 USA

By Phone

Call 512-794-0369.

By Fax

Send correspondence to 512-794-3904.

By E-mail

Send correspondence to <info@hartcomm.org>.

Online

Visit the HCF website at <http://www.hartcomm.org>.

Appendix A: HART Checklist

HART HOST SYSTEM CAPABILITIES CHECKLIST

Date:____________________

Manufacturer:		
Model number/name:		
Revision or version:		
Product application (configurator, DCS, RTU, etc.):		
Function	**Commands/Notes**	**Support Provided**
How many HART I/O channels per card?		
Can the system power the devices with an internal power supply?		❐ Yes ❐ No
Which HART revisions are supported?		❐ Rev 3 ❐ Rev 4 ❐ Rev 5
Is burst mode supported on all channels?		❐ Yes ❐ No
Is multidrop networking supported on all channels? If yes, how many devices can be placed on a single network?		❐ Yes ❐ No # of devices: _____________
How are device-specific functions and features supported?		❐ Hard coded ❐ HART DDL binary files ❐ HART DDL source files ❐ Application resource files ❐ Other: ______________ ❐ Device-specific features are not supported.
Indicate the parameters that are accessed in ANY HART device.		
Manufacturer's identification	0	❐ Read ❐ Display text ❐ Display code
Device identification (device type code)	0	❐ Read ❐ Display text ❐ Display code
Device identification (unique ID)	0	❐ Read ❐ Display text
Device serial number	0	❐ Read ❐ Display text
Revision levels	0	❐ Read ❐ Display text
TAG	13, 18	❐ Read ❐ Write
DESCRIPTOR	13, 18	❐ Read ❐ Write
MESSAGE	12, 17	❐ Read ❐ Write
DATE	13, 18	❐ Read ❐ Write
Upper-range value	15, 35	❐ Read ❐ Write

Appendix A: HART Checklist

Manufacturer:

Model number/name:

Revision or version:

Lower-range value	15, 35	❒ Read ❒ Write
Sensor limits	14	❒ Read
Alarm selection	15	❒ Read
Write-protect status	15	❒ Read
Analog reading	1, 2, 3	❒ Read
Primary variable	1, 3	❒ Read
Secondary variable	3	❒ Read
Tertiary variable	3	❒ Read
Fourth variable	3	❒ Read
Change engineering units	44	❒ Read ❒ Write
Damping value	15, 34	❒ Read ❒ Write
Read device variables How many? (up to 250)	33	❒ Read
Materials of construction	Device specific	❒ Read ❒ Write
HART status information (change flag, malfunction, etc.)	Standard status bits	❒ Read ❒ Display text ❒ Display code
Device-specific status information	48	❒ Read ❒ Display text ❒ Display code
Use of status bits in control logic?	Std & 48	❒ Yes ❒ No
Use of status bits in alarm handling?	Std & 48	❒ Yes ❒ No
Setpoint (PID and output devices) Which devices?	Device specific	❒ Read ❒ Write
Support of device-specific commands/ functions: (a) for your own company's field devices (b) for other vendors' field devices		 ❒ Yes ❒ No ❒ Yes ❒ No
Rezero	43	❒ Yes ❒ No
Loop test (fix the analog current at specified value)	40	❒ Yes ❒ No
Support calibration procedures? Which products?		❒ Yes ❒ No
Calibrate the D/A converter	45, 46	❒ Yes ❒ No

Appendix A: HART Checklist

Manufacturer:			
Model number/name:			
Revision or version:			
Initiate device test	41	❒ Yes	❒ No
Clears configuration flag?	38	❒ Yes	❒ No
Read/Write dynamic variable assignments?	50, 51	❒ Yes	❒ No
Support for devices with multiple analog outputs	60–70	❒ Yes	❒ No
Set polling address	6	❒ Yes	❒ No
Text messages provided on command error responses	All	❒ Yes	❒ No
OPC Client		❒ Yes	❒ No
OPC Server		❒ Yes	❒ No
HART Command Passthrough			
Some systems have the ability to act as a conduit or router between a software application running on a separate platform and a HART field device. In effect, this ability gives the end user the functionality provided both by the system and by the application.			
Is passthrough supported?		❒ Yes	❒ No
If this is a system, what applications are available with passthrough? If this is a software application, what systems are available using passthrough?			

Appendix B: HART Revision 5

UNIVERSAL COMMANDS IN HART REVISION 5

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
0	Read unique identifier		None		0 1 2 3 4 5 6 7 8 9–11 * Bit 0 = multisensor device; Bit 1 = EEPROM control required; Bit 2 = protocol bridge device	"254" (expansion) Manufacturer identification code Manufacturer device type code Number of preambles required Universal command revision Device-specific command revision Software revision Hardware revision Device function flags* Device ID number	 (H) (B)
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) Percent of range	(F) (F)
3	Read current and four (predefined) dynamic variables		None		0–3 4 5–8 9 10–13 14 15–18 19 20–23 (truncated after last supported variable)	Current (mA) PV units code Primary variable SV units code Secondary variable TV units code Third variable FV units code Fourth variable	(F) (F) (F) (F) (F)
6	Write polling address	0	Polling address			As in command	
11	Read unique identifier associated with tag	0–5	Tag	(A)	0–11	As Command 0	
12	Read message		None		0–23	Message (32 characters)	(A)
13	Read tag, descriptor, date		None		0–5 6–17 18–20	Tag (8 characters) Descriptor (16 characters) Date	(A) (A) (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 minimum span Upper sensor limit Lower sensor limit Minimum span	 (F) (F) (F)

Appendix B: HART Revision 5

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
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 Lower-range value Damping value (seconds) Write-protect code Private-label distributor code	 (F) (F) (F)
16	Read final assembly number		None		0–2	Final assembly number	
17	Write message	0–23	Message (32 characters)	(A)		As in command	
18	Write tag, descriptor, date	0–5 6–17 18–20	Tag (8 characters) Descriptor (16 characters) Date	(A) (A) (D)		As in command	
19	Write final assembly number	0–2	Final assembly number			As in command	

Appendix C: HART Revisions 2, 3, and 4

UNIVERSAL COMMANDS IN HART REVISIONS 2, 3, AND 4 (DIFFERENCES FROM REVISION 5)

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
0	Read unique identifier		None		0 1 2 3 4 5 6 7–9	Transmitter type code* Number of preambles Universal command revision Device-specific command revision Software revision Hardware revision Device function flags Final assembly number * Revision 4 introduced the expanded device type as an option (see Rev. 5, Table 4-4), with the remaining bytes moved up by two positions.	 (H) (B)
4	Read common static data (block 0): Read message	0	Block number ("0")		0 1–24	Block number ("0") Message	 (A)
4	Read common static data (block 1): Read tag, descriptor, date	0	Block number ("1")		0 1–6 7–18 19–21 22–24	Block number ("1") Tag Descriptor Date "250"	 (A) (A) (D)
4	Read common static data (block 2): Read sensor information	0	Block number ("2")		0 1–3 4 5–8 9–12 13–16 17–24	Block number ("2") Sensor serial number Units code for sensor limits and minimum span Upper-sensor limit Lower-sensor limit Minimum span "250"	 (F) (F) (F)
4	Read common static data (block 3): Read output information	0	Block number ("3")		0 1 2 3 4–7 8–11 12–15 16 17 18–24	Block number ("3") Alarm select code Transfer function code PV/range units code Upper-range value Lower-range value Damping value (seconds) Write-protect code ("1" = protected)* Private-label distributor code** "250" * "250" or "251" in Revisions 2 and 3 ** "250" in Revisions 2 and 3	 (F) (F) (F)
5	Write common static data (block 0): Write message	0 1–24	Block number ("0") Message	 (A)		As in command	

Appendix C: HART Revisions 2, 3, and 4

Command		Data In Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
5	Write common static data (block 1): Write tag, descriptor, date	0 1–6 7–18 19–21 22–24	Block number ("1") Tag Descriptor Date "250"	 (A) (A) (D)		As in command	
5	Write common static data (block 4): Write final assembly number	0 1–3 4–24	Block number ("4") Final assembly number "250"			As in command	
11–19		***These commands did not exist before Revision 5.0.***					

Appendix D: Common Practice Commands

COMMON PRACTICE COMMANDS

Command		Data In Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
33	Read transmitter variables	0 1 2 3	Transmitter variable code for slot 0 Transmitter variable code for slot 1 Transmitter variable code for slot 2 Transmitter variable code for slot 3 (truncated after last requested code)		0 1 2–5 6 7 8–11 12 13 14–17 18 19 20–23	Transmitter variable code for slot 0 Units code for slot 0 Variable for slot 0 Transmitter variable code for slot 1 Units code for slot 1 Variable for slot 1 Transmitter variable code for slot 2 Units code for slot 2 Variable for slot 2 Transmitter variable code for slot 3 Units code for slot 3 Variable for slot 3 (truncated after last requested variable)	 (F) (F) (F) (F)
34	Write damping value	0–3	Damping value (seconds)	(F)		As in command	
35	Write range values	0 1–4 5–8	Range units code Upper-range value Lower-range value	 (F) (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 changed" flag		None			None	
39	EEPROM control	0	EEPROM control code* *0 = burn EEPROM; 1 = copy EEPROM to RAM			As in command	
40	Enter/exit fixed current mode	0–3	Current (mA)* *0 = exit fixed current mode	(F)		As in command	
41	Perform device self-test		None			None	
42	Perform master reset		None			None	
43	Set (trim) PV zero		None			None	
44	Write PV units	0	PV units code			As in command	
44	Write PV units	0	PV units code			As in command	
45	Trim DAC zero	0–3	Measured current (mA)	(F)		As in command	

Appendix D: Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
46	Trim DAC gain	0–3	Measured current (mA)	(F)		As in command	
47	Write transfer function	0	Transfer function code			As in command	
48	Read additional device status		None		0–5 6–7 8–10 11–13 14–24	Device-specific status Operational modes Analog outputs saturated* Analog outputs fixed* Device-specific status *24 bits each: LSB ... MSB refers to AO #1 ... #24.	(B) (B) (B) (B)
49	Write PV sensor serial number	0–2	Sensor serial number			As in command	
50	Read dynamic variable assignments		None		0 1 2 3	PV transmitter variable code SV transmitter variable code TV transmitter variable code FV transmitter variable code	
51	Write dynamic variable assignments	0 1 2 3	PV transmitter variable code SV transmitter variable code TV transmitter variable code FV transmitter variable code			As in command	
52	Set transmitter variable zero	0	Transmitter variable code			As in command	
53	Write transmitter variable units	0 1	Transmitter variable code Transmitter variable units code			As in command	
54	Read transmitter variable information	0	Transmitter variable code		0 1–3 4 5–8 9–12 13–16 17–20	Transmitter variable code Transmitter variable sensor serial number Transmitter variable limits units code Transmitter variable upper limit Transmitter variable lower limit Transmitter variable damping value (seconds) Transmitter variable minimum span	 (F) (F) (F) (F)
55	Write transmitter variable damping value	0 1–4	Transmitter variable code Transmitter variable damping value (seconds)	 (F)		As in command	

Appendix D: Common Practice Commands

Command		Data in Command			Data in Reply		
#	**Function**	**Byte**	**Data**	**Type**	**Byte**	**Data**	**Type**
56	Write transmitter variable sensor serial number	0 1–3	Transmitter variable code Transmitter variable sensor serial number			As in command	
57	Read unit tag, descriptor, date		None		0–5 6–17 18–20	Unit tag (8 characters) Unit descriptor (16 characters) Unit date	(A) (A) (D)
58	Write unit tag, descriptor, date	0–5 6–17 18–20	Unit tag (8 characters) Unit descriptor (16 characters) Unit date	(A) (A) (D)		As in command	
59	Write number of response preambles	0	Number of response preambles			As in command	
60	Read analog output and percent of range	0	Analog output number code		0 1 2–5 6–9	Analog output number code Analog output units code Analog output level Analog output percent of range	 (F) (F)
61	Read dynamic variables and PV analog output		None		0 1–4 5 6–9 10 11–14 15 16–19 20 21–24	PV analog output units code PV analog output level PV units code Primary variable SV units code Secondary variable TV units code Tertiary variable FV units code Fourth variable	 (F) (F) (F) (F) (F)
62	Read analog outputs	0 1 2 3 (truncated after last requested code)	Analog output number; code for slot 0 Analog output number; code for slot 1 Analog output number; code for slot 2 Analog output number; code for slot 3		0 1 2–5 6 7 8–11 12 13 14–17 18 19 20–23 (truncated after last requested level)	Slot 0 analog output number code Slot 0 units code Slot 0 level Slot 1 analog output number code Slot 1 units code Slot 1 level Slot 2 analog output number code Slot 2 units code Slot 2 level Slot 3 analog output number code Slot 3 units code Slot 3 level	 (F) (F) (F) (F)

Appendix D: Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
63	Read analog output information	0	Analog output number code		0 1 2 3 4–7 8–11 12–15	Analog output number code Analog output alarm select code Analog output transfer function code Analog output range units code Analog output upper-range value Analog output lower-range value Analog output additional damping value (sec)	 (F) (F) (F)
64	Write analog output additional damping value	0 1–4	Analog output number code Analog output additional damping value (sec)	 (F)		As in command	
65	Write analog output range value	0 1 2–5 6–9	Analog output number code Analog output range units code Analog output upper-range value Analog output lower-range value	 (F) (F)		As in command	
66	Enter/exit fixed analog output mode	0 1 2–5	Analog output number code Analog output units code Analog output level* * "not a number" exits fixed output mode	 (F)		As in command	
67	Trim analog output zero	0 1 2–5	Analog output number code Analog output units code Externally measured analog output level	 (F)		As in command	
68	Trim analog output gain	0 1 2–5	Analog output number code Analog output units code Externally measured analog output level	 (F)		As in command	
69	Write analog output transfer function	0 1	Analog output number code Analog output transfer function code			As in command	

Appendix D: Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
70	Read analog output endpoint values	0	Analog output number code		0 1 2–5 6–9	Analog output number code Analog output endpoint units code Analog output upper endpoint value Analog output lower endpoint value	 (F) (F)
107	Write burst mode transmitter variables (for Command #33)	0 1 2 3	Transmitter variable code for slot 0 Transmitter variable code for slot 1 Transmitter variable code for slot 2 Transmitter variable code for slot 3			As in command	
108	Write burst mode command number	0	Burst mode command number			As in command	
109	Burst mode control	0	Burst mode control code (0 = exit, 1 = enter)			As in command	
110	Read all dynamic variables		None		0 1–4 5 6–9 10 11–14 15 16–19	PV units code PV value SV units code SV value TV units code TV value FV units code FV value	 (F) (F) (F) (F)

Appendix E: Response Codes

STATUS

Two bytes of *status*, also called the *response code*, are included in every reply message from a field or slave device. These two bytes convey three types of information:

- Communication errors
- Command response problems
- Field device status

If an error is detected in the outgoing communication, the most significant bit (bit 7) of the first byte is set to 1 and the details of the error are reported in the rest of that byte. The second byte is then all zeros.

If no error is detected in the outgoing communication, bit 7 of the first byte is 0 and the remainder of the byte contains the command response, which indicates any problem with the received command. The second byte contains status information pertaining to the operational state of the field or slave device.

Communication errors are typically those that would be detected by a UART (i.e., parity overrun and framing errors). The field device also reports overflow of its receive buffer and any discrepancy between the message content and the checksum received.

RESPONSE CODES

First Byte

Bit 7 = 1: Communication Error		
Bit 6	hex C0	Parity error
Bit 5	hex A0	Overrun error
Bit 4	hex 90	Framing error
Bit 3	hex 88	Checksum error
Bit 2	hex 84	0 (reserved)
Bit 1	hex 82	Rx buffer overflow
Bit 0	hex 81	Overflow (undefined)

OR

Bit 7 = 0: Command response	
Bits 6 to 0 (decoded as an integer, not bit-mapped):	
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	Device-specific command error (rarely used)
7	In write-protect mode
8–15	Multiple meanings (see Table 4-9 in *A Technical Overview*)
16	Access restricted
28	Multiple meanings (see Table 4-9 in *A Technical Overview*)
32	Device is busy
64	Command not implemented

Appendix E: Response Codes

Second Byte

(Not Used)	
Bit 7	
Bit 6	
Bit 5	
Bit 4	All bits 0 (when a communication error is reported in the first byte)
Bit 3	
Bit 2	
Bit 1	
Bit 0	

OR

Field Device Status		
Bit 7	(hex 80)	Field device malfunction
Bit 6	(hex 40)	Configuration changed
Bit 5	(hex 20)	Cold start
Bit 4	(hex 10)	More status available
Bit 3	(hex 08)	Analog output current fixed
Bit 2	(hex 04)	Analog output saturated
Bit 1	(hex 02)	Nonprimary variable out of limits
Bit 0	(hex 01)	Primary variable out of limits

Note: *Hexadecimal equivalents are quoted assuming only a single bit is set. In reality, several bits may be set simultaneously, and the hex digits can be or'ed together.*

Appendix F: HART Field Control

HART FIELD CONTROLLER INSTALLATION

The field controller (Figure 29) is wired in series with the field device (valve positioner or other actuator). In some cases, a bypass capacitor may be required across the terminals of the valve positioner to keep the positioner's series impedance below the 100 Ω level required by HART specifications. Communication with the field controller requires the communicating device (handheld terminal or PC) to be connected across a loop impedance of at least 230 Ω. Communication is not possible across the terminals of the valve positioner because of its low impedance (100 Ω). Instead, the communicating device must be connected across the transmitter or the current sense resistor.

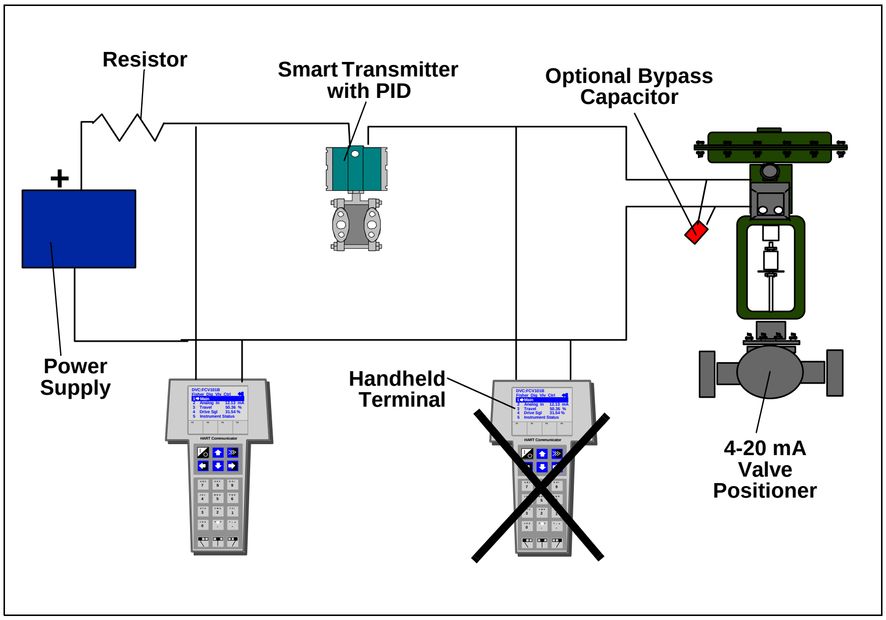


Figure 29: HART Field Controller Wired in Series

Appendix F: HART Field Control

It is also possible to use both a smart transmitter and a smart valve positioner in the loop. The control function can be in either device. The HART protocol allows one low-impedance device on the network, which is typically the current sense resistor. In Figure 26, the smart valve positioner is the low-impedance device, which eliminates the need for a current sense resistor. Communication is possible by connection across the terminal of either the transmitter or the positioner.

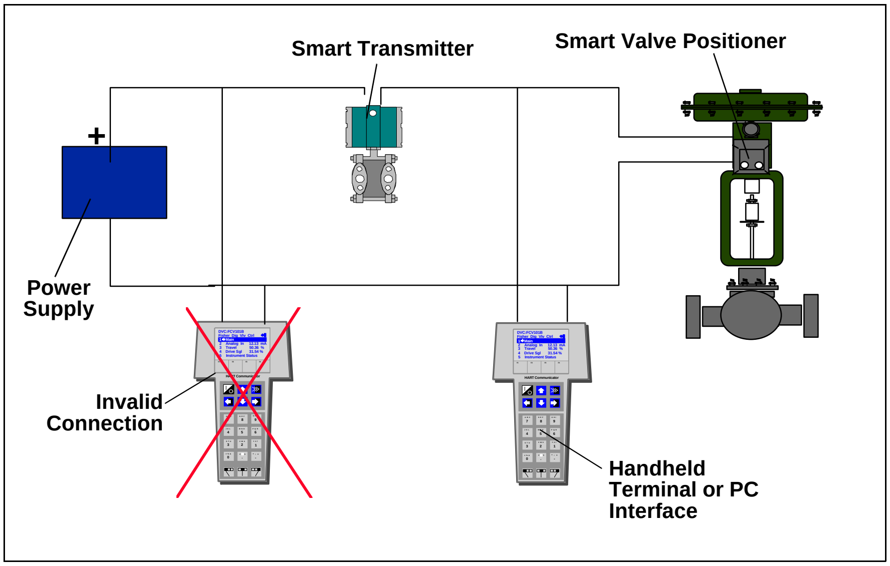


Figure 30: Field Control in Transmitter or Positioner

Appendix G: Technical Information

Communication Signals

Type of Communication	Signal
Traditional analog	4–20 mA
Digital	FSK, based on the Bell 202 telephone communication standard
Logical “0” frequency	2,200 Hz
Logical “1” frequency	1,200 Hz

Data Information

Data update rate:
- Request/response mode—2–3 updates per second
- Optional burst mode—3–4 updates per second

Data byte structure:
- 1 start bit, 8 data bits, 1 odd parity bit, 1 stop bit

Data integrity:
- Two-dimensional error checking
- Status information in every reply message

Simple Command Structure

Type of Command	Structure
Universal	Common to all devices
Common practice	Optional; used by many devices
Device specific	For unique product features

Communication Masters

- Two communication masters

Variables

- Up to 256 variables per device
- IEEE 754 floating point format (32 bits) with engineering units

Wiring Topologies

- Point to point—simultaneous analog and digital
- Point to point—digital only
- Multidrop network—digital only (up to 15 devices)

Cable Lengths

- Maximum twisted-pair length—10,000 ft (3,048 m)
- Maximum multiple twisted-pair length—5,000 ft (1,524 m)

Cable length depends on the characteristics of individual products and cables.

Intrinsically Safe

- With appropriate barrier/isolator

Glossary

275 HART Communicator
A handheld master device that uses the HART communication protocol and DDL to configure or communicate with any HART smart device

Bell 202
A U.S. telephone standard that uses 1,200 Hz and 2,200 Hz as 1 and 0, respectively, at 1,200 baud; a 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 the reverse channel frequencies are not used

Burst (Broadcast) Mode
A HART communication mode in which a master device instructs a slave device to continuously broadcast a standard HART reply message (e.g., value of a process variable) until the master instructs it to stop bursting

Cable Capacitance Per Unit of Length
The capacitance from one conductor to all other conductors (including the shield if present) in the network; measured in feet or meters

Cable Resistance Per Unit of Length
The resistance for a single wire; meausred in feet or meters

Closed-Loop Control
A system in which no operator intervention is necessary for process control

Communication Rate
The rate at which data are sent from a slave device to a master device; usually expressed in data updates per second

DCS
See *Distributed Control System.*

DD
See *Device Description*.

DDL
See *Device Description Language*.

Device Description
A program file written in the HART Device Description Language (DDL) that contains an electronic description of all of a device's parameters and functions needed by a host application to communicate with the device

Device Description Language
A standardized programming language used to write DDs for HART-compatible field devices

Distributed Control System
Instrumentation (input/output devices, control devices, and operator interface devices) that permits transmission of control, measurement, and operating information to and from user-specified locations, connected by a communication link

Glossary

Field
The area of a process plant outside the control room where measurements are made, and to and from which communication is provided; a part of a message devoted to a particular function (e.g., the address field or the command field)

Field Device
A device generally not found in the control room; field devices may generate or receive an analog signal in addition to the HART digital communication signal

Frequency Shift Keying
Method of modulating digital information for transmission over paths with poor propagation characteristics; can be transmitted successfully over telephone systems

FSK
See *Frequency Shift Keying.*

Gateway
A network device that enables other devices on the network to communicate with a second network using a different protocol

HART Command Set
A series of commands that provide uniform and consistent communication for all master and slave devices; includes universal, common practice, and device-specific commands

HART Communication Protocol
Highway Addressable Remote Transducer communication protocol; the industry standard protocol for digitally enhanced 4–20mA communication with smart field devices

HART Loop
A communication network in which the master and slave devices are HART smart or HART compatible

Host Application
A software program used by the control center to translate information received from field devices into a format that can be used by the operator

Interoperability
The ability to operate multiple devices, independent of manufacturer in the same system, without loss of functionality

Intrinsic Safety
A certification method for use of electrical equipment in hazardous (e.g., flammable) environments; a type of protection in which a portion of an electrical system contains only intrinsically safe equipment that is incapable of causing ignition in the surrounding environment

Intrinsic Safety Barrier
A network or device designed to limit the amount of energy available to the protected circuit in a hazardous location

IS
See *Intrinsic Safety.*

Glossary

Master Device	A device in a master-slave system that initiates all transactions and commands (e.g., central controller)
Master-Slave Protocol	Communication system in which all transactions are initiated by a master device and are received and responded to by a slave device
Miscellaneous Series Impedance	The summation of the maximum impedance (500 Hz–10 kHz) of all devices connected in series between two communicating devices; a typical nonintrinsically safe loop will have no miscellaneous series impedance
Modem	Modulator/demodulator used to convert HART signals to RS232 signals
Multidrop Network	HART communication system that allows more than two devices to be connected together on a single cable; usually refers to a network with more than one slave device
Multimaster	*Multimaster* refers to a communication system that has more than one master device. The HART protocol is a simple multimaster system allowing two masters; after receiving a message from a slave device, the master waits for a short time before beginning another transmission, which gives the second master time to initiate a message
Multiplexer	A device that connects to several HART loops and allows communication to and from a host application
Multivariable Instrument	A field device that can measure or calculate more than one process parameter (e.g., flow and temperature)
Network	A series of field and control devices connected together through a communication medium
Parallel Device Capacitance	The summation of the capacitance values of all connected devices in a network
Parallel Device Resistance	The parallel combination of the resistance values of all connected devices in the network; typically, there is only one low-impedance device in the network, which dominates the parallel device-resistance value
Passthrough	A feature of some systems that allows HART protocol send-and-receive messages to be communicated through the system interface
PID	Proportional-integral-derivative
PID Control	Proportional-plus-integral-plus-derivative control; used in processes where the controlled variable is affected by long lag times

Glossary

Point-to-Point A HART protocol communication mode that uses the conventional 4–20mA signal for analog transmission, while measurement, adjustment, and equipment data are transferred digitally; only two communicating devices are connected together

Polling A method of sequentially observing each field device on a network to determine if the device is ready to send data

Polling Address Every HART device has a polling address; address 0 is used for point-to-point networks; addresses 1–15 are used in multidrop networks

Process Variable A process parameter that is being measured or controlled (e.g., level, flow, temperature, mass, density, etc.)

Protocol A set of rules to be used in generating or receiving a message

PV See *Process Variable*.

Remote Terminal Unit A self-contained control unit that is part of a SCADA system

RTU See *Remote Terminal Unit*.

SCADA See *Supervisory Control and Data Acquisition.*

Slave Device A device (e.g., transmitter or valve) in a master-slave system that receives commands from a master device; a slave device cannot initiate a transaction

Smart Instrumentation Microprocessor-based instrumentation that can be programmed, has memory, is capable of performing calculations and self-diagnostics and reporting faults, and can be communicated with from a remote location

Supervisory Control and Data Acquisition A control system using communications such as phone lines, microwaves, radios, or satellites to link RTUs with a central control system

Zener Type of shunt-diode barrier that uses a high-quality safety ground connection to bypass excess energy