Making smart transmitters smarter

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The use of smart loop monitors can save manpower costs and maintenance time, and prevent false shutdowns.

Thousands of smart instruments are hard at work in process plants throughout the world. Though a number of smart transmitter technologies are on the market, the most widely applied is the HART® (Highway Addressable Remote Transducer) digital communications protocol. Offered by literally dozens of manufacturers, there are smart HART transmitters available to handle nearly every type of process measurement.

The HART protocol uses the frequency shift keying (FSK) principle derived from the Bell 202 communication standard to simultaneously communicate analog and digital signals on the same two wires. The method calls for a digital signal made up of sine waves from two frequencies, 1200 Hz and 2200 Hz, to be superimposed onto 4-20 mA loop wiring. The 1200 Hz frequency signal represents bit 1, and the 2200 Hz signal represents bit 0 (*Figure 1*). The average value of the frequency signal is always zero, so the analog signal is unaffected by its presence.

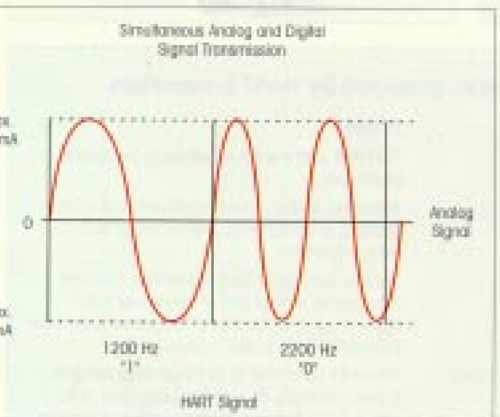


FIG. 1: HART allows both analog and digital signals to be transmitted on the same dc wires.

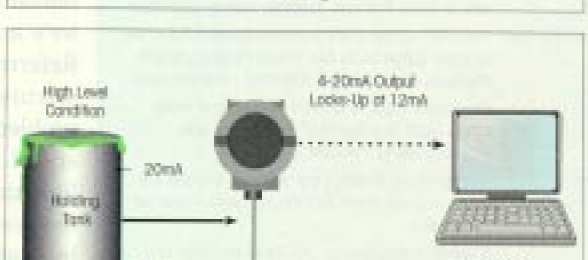
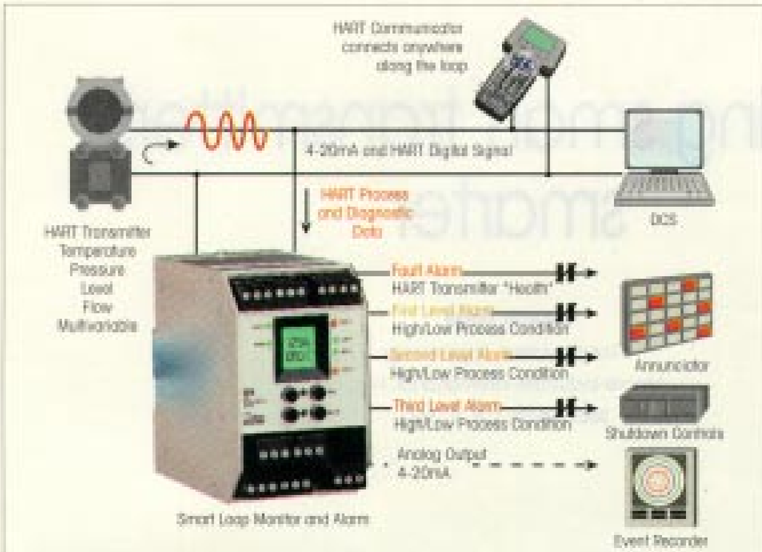


FIG. 2: When a smart transmitter's 4-20 mA output locks up, you may not know there's a problem.

Introduced in 1989, HART was one of the first industrial protocols that was capable of providing two-way digital communications between field instruments and the control room. At the time, many believed that one day it would routinely be used as an all-digital data transmission method, and eventually replace the 4-20 mA analog standard. The thinking was that digital data containing a wide array of information from multi-dropped field instruments would be sent directly to a HART-communicating control system. The information contained would include process measurements, identification information like tag numbers, configuration and calibration parameters, and instrument diagnostics.

But almost ten years after the



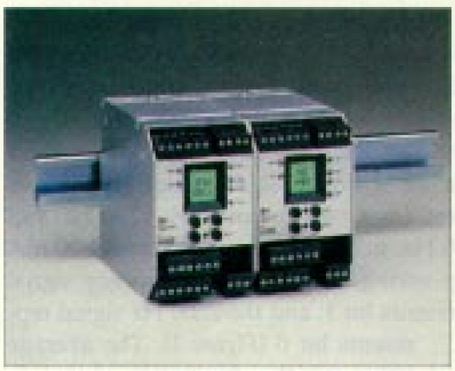


FIG. 3 (top): A smart alarm is able to monitor the constant flow of digital information that is being transmitted by a HART instrument.

FIG. 4 (above, left): Moore Industries' SPA Site-Programmable HART Alarm can monitor any combination of a multivariable transmitter's primary, secondary, third, or fourth variables.

FIG. 5 (above, right): Peek Measurement's Smart Advisor continuously monitors HART status information.

Field device status data provided by HART transmitters

Instrument status	Problem
Field device malfunction	The HART instrument is experiencing a hardware malfunction.
Cold start	Instrument power has been removed/reapplied, resulting in the automatic reinstallation of the setup information.
More status available	There is more HART fault information available than can be sent as part of the normal HART query process. Issue the HART command for more information from a HART master.
Primary variable analog output fixed	The HART transmitter is no longer responding to process changes. Its output is being held at the default value that was assigned during calibration.
Primary variable analog output saturated	The HART transmitter's output is beyond the upper or lower range limits that it was programmed to measure. It is no longer reflecting input changes.
Primary variable out of limits	The sensor input is beyond the upper or lower range limits that the HART transmitter was programmed to measure.
Nonprimary variable out of limits	A nonprimary sensor input signal is beyond the upper or lower limits that the transmitter was set to measure.
Configuration changed	A configuration change has been made by any host, or through a local OI. This is a warning to the HART Primary Master to re-read any new configuration information.

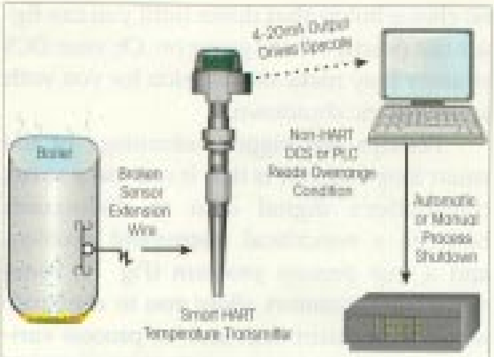
introduction of this technology into the industrial market, the vast majority of smart HART instruments are still used in a traditional point-to-point analog mode. HART's digital capabilities are relegated to providing a convenient way to periodically check and re-configure smart instruments once they are installed in the field. Digital interface with the instrument is most often accomplished when a technician connects a handheld communicator to a termination point along the current loop.

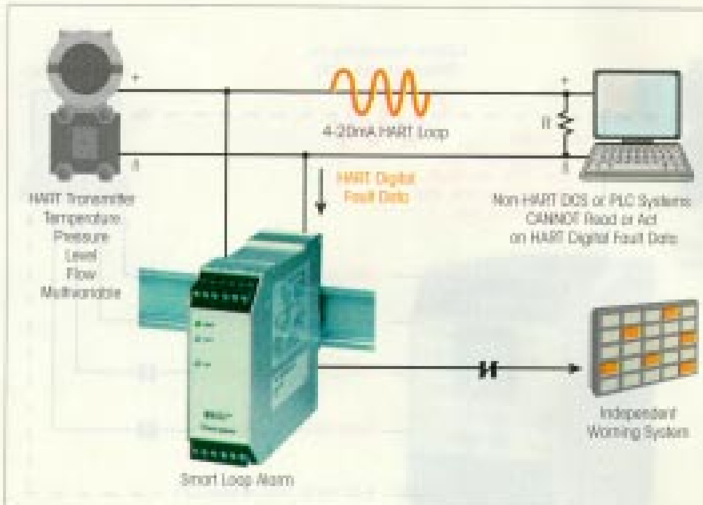
Because most control systems won't handle HART digital data, it hasn't become a widely implemented bi-directional communications strategy. And, at 1200 baud, it generally is thought to be too slow for many of these types of applications. As a result, there are thousands of smart HART instruments out there that could be delivering a lot more than a solitary 4-20 mA signal. Valuable process and diagnostic information that could, and should, be used to help protect and enhance a process never makes it out of the field.

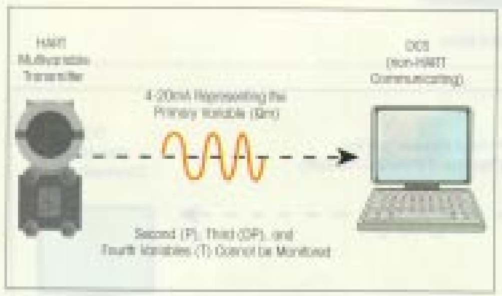
Unbottling the HART "genie"

The key to capitalizing on a smart HART transmitter's intelligence is to monitor and use the digital information that's always riding transparently on its 4-20 mA loop. Included in the digital signal is field device status data that tells you when the smart instrument, or its process input, is not behaving properly *(see Table on left).*

For example, it's not uncommon for a smart transmitter's analog output to lock up. Referred to as a transmitter seizure, latch, or freeze, this problem can be caused by a variety of circumstances such as a lightning strike, RFI/EMI interference, or a short circuit created by water flowing through conduit into the transmitter's electronics. Any of these can cause a microprocessor-based transmit-







(clockwise from top, left) ***FIG. 6:*** ***Based on a transmitter's upscale or downscale drive action, you can't tell the difference between a maintenance problem and a process problem.***

FIG. 7: A smart alarm can be used to distinguish between a noncritical maintenance problem and a true process problem.

FIG. 8: The newest smart transmitters are designed to simultaneously measure multiple process elements.

ter's digital-to-analog (D/A) converter to stop functioning. When it does, the output locks at a level that doesn't reflect real process conditions (*Fig. 2*). The danger here is that you may not know there's a problem. The 4-20 mA signal may be locked at a level that looks perfectly fine to you, and to the distributed control system.

The only way to head off this situation is to continuously monitor the smart instrument's digital diagnostic information. Unfortunately, most of us can't afford a new HART-communicating DCS. And dedicating a technician to watch every trouble-prone loop 24 hours a day is out of the question.

One solution is use smart loop monitors and alarms designed to continuously tap into a smart HART transmitter's hidden digital information (*Fig. 3*). Introduced to the process scene over the past year, smart loop monitors are already available in configurations ranging from a simple single point alarm trip to highly functional instruments that accommodate multiple inputs with mixed alarm and analog outputs.

Beyond analog high/low alarming

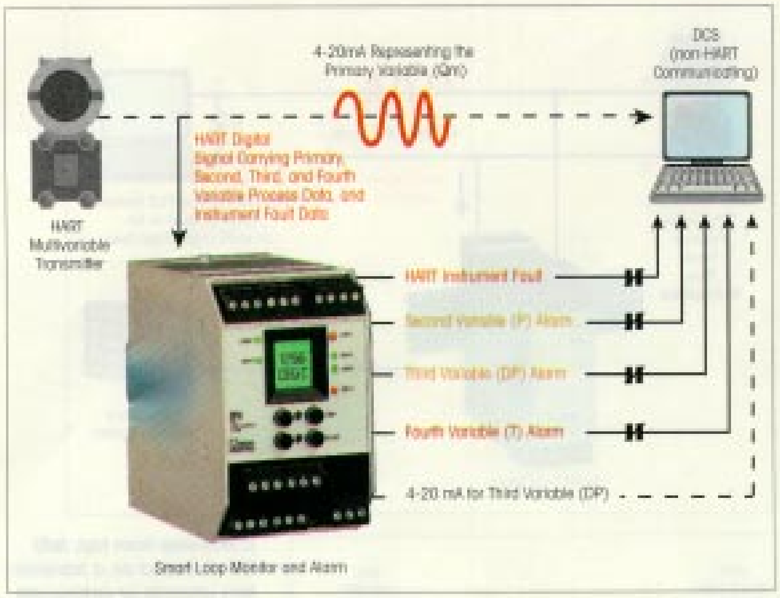
Analog alarm trips (or switches) have been used for years to monitor a loop and provide warnings and process shutdown when high or low process conditions are detected. These alarms act on a current or voltage signal, or on a primary sensor input such as an RTD. They trip when the process input exceeds high or low trip points selected by the user. Their contact closure outputs can be used to provide everything from a simple annunciator warning to complete process shutdown.

New smart loop monitors provide the same process variable high/low alarm functions, plus a lot more. Mounted transparently onto the 4-20 mA loop, their job is to continually monitor the constant flow of digital information that's being transmitted by a HART instrument.

Because they monitor a smart transmitter's digital data (in place of an analog signal), they have access to a wide range of additional process status and instrument diagnostic information (*Figs. 4 and 5*). In addition to alarming on high or low process conditions, smart loop monitors can provide contact closure outputs when instrument and input fault conditions are detected. This information can be used to detect instrument inefficiencies and malfunctions, reduce maintenance and troubleshooting time, and reduce the number of costly false shutdowns.

Avoiding false shutdowns

False shutdowns are a major source of frustration, shattered schedules, and blown budgets. A smart transmitter, like a regular analog transmitter, drives its 4-20 mA output upscale or downscale to warn that there's a problem (*Fig. 6*). At the control system, you'll know something is wrong, but you won't



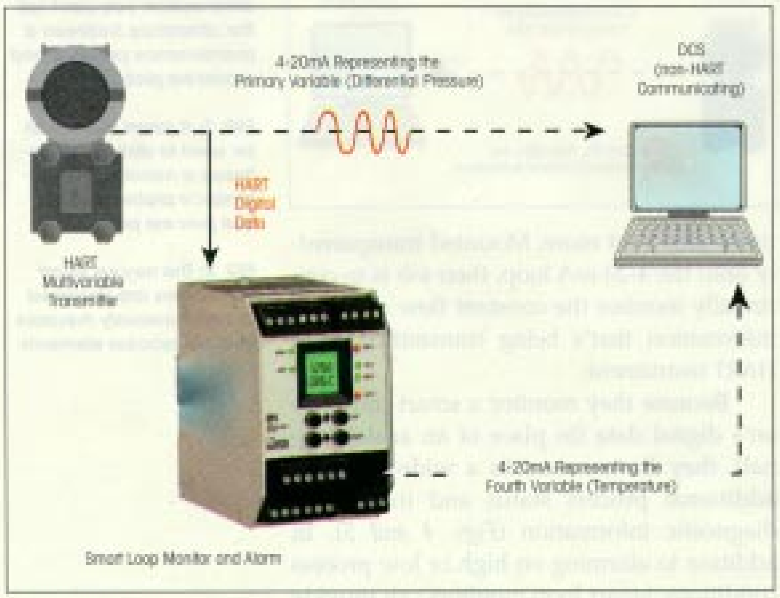


FIG. 9: Smart HART alarms can be set to trip if they sense high/low process conditions from one, some, or all of the primary, second, third, and/or fourth variables.

FIG. 10: A smart alarm can send a 4-20 mA representation of a multivariable transmitter's primary, second, third, or fourth variables to the DCS or backup systems.

know what's causing the problem. It may be a major process malfunction that warrants an emergency shutdown, but more likely it's a noncritical sensor or transmitter failure. For these types of *maintenance* problems (as opposed to the more serious *process* problems), you probably don't want an expensive and disruptive shutdown.

Unfortunately, some control systems are impossible, or very difficult, to configure such that you can easily tell the difference between a maintenance and a process problem. With these systems, to avoid a lot of wasted product, damage to equipment, or worse, a dangerous condition, you may have no choice but to shut down until you can figure out exactly what's going on. Or, your DCS strategy may make the decision for you with an automatic shutdown.

Perhaps the biggest advantage of the smart loop monitor is that it can use a smart transmitter's digital data to distinguish between a noncritical instrument problem and a true process problem (*Fig. 7*). Some smart loop monitors allow you to configure which instrument fault and/or process variable parameters you want them to alarm on and which you don't. Instead of arbitrarily shutting down on a nebulous transmitter upscale/downscale action, you can set the monitor to issue a shutdown command only on conditions that you specify. Other trips can be set to report noncritical problems, signaling that a technician should be sent out to correct the problem.

Multivariable transmitters: More than meets the eye

Some of the newest HART transmitters are designed to simultaneously measure multiple process elements such as pressure, differential pressure, and temperature. Called the second, third, and fourth variables, these measurements are often used by the transmitter to provide a compensated or calculated value, such as mass flow. The resulting value, called the HART primary variable, is the one that is sent as a 4-20 mA signal to the DCS (*Fig. 8*).

In some process applications, it may be advantageous to monitor one or more nonprimary variables. For example, if you have a process that is very temperature-sensitive, you might want to keep track of the temperature variable in addition to the calculated mass flow.

Digital information from the second, third, and fourth variables also rides on the 4-20 mA loop, along with the diagnostic information discussed earlier. Unfortunately, most systems can't read this data either, so there's no way to continually monitor it.

The solution is to use a smart loop monitor to access supplemental multivariable transmitter information. Installed onto the 4-20 mA loop, these monitors can keep track of one, some, or all of the multivariable transmitter's measurements. The more advanced monitors can be configured to trip if they sense unwanted high/low process conditions from one, some, or all of the primary, second, third, and/or fourth variables. The contact closure alarms can be sent to the DCS, or to alternate monitoring and control systems (*Fig. 9*).

If analog (in addition to alarm) signals are required, some smart loop monitors are able to convert one or more analog signals from the HART digital data. In the case of single-variable smart transmitters, this allows you to send an identical 4-20 mA measurement to two locations. For multivariable transmitters, a 4-20 mA representation of the primary, second, third, or fourth variables can be sent to the DCS, or to backup monitoring and control systems (*Fig. 10*).

A natural match

The very characteristic that has made smart HART transmitters so popular is also the foremost attribute of the new class of smart loop monitors and alarms. Like HART instruments, smart loop monitors let you capitalize on highly functional digital technology, while still providing signal types that can be readily used by existing analog monitoring and control systems. Thus, until you can go all-digital, smart loop monitors will help you get the most from the smart capabilities you have today.

About the author

Joseph Hage, vice president of engineering for Moore Industries-International, Inc., oversees new product development. For more than ten years, his speciality has been developing smart interfaces designed to bridge the gap between analog and digital technologies.

For more information...

The author, Joe Hage, will be available to answer any questions you may have about this article. He can be reached at (818) 894-7111 during normal business hours.