6.11 Fieldbus and Smart Valves

J. BERGE (2005)

Partial List of Suppliers: (Intelligent Positioners):	ABB (www.abb.com/) Biffi (www.tycovalves.com/) Dresser (www.dresser.com/) Emerson (www.emersonprocess.com/) Flowserve (www.flowserve.com) Foxboro (www.foxboro.com/) Metso (www.metso.com/) Samson (www.samson.de/) Siemens (www.siemens.com/) SMAR (www.smar.com/) Tyco (www.tycovalves.com/) Westlock (www.westlockcontrols.com/) Yamatake (www.yamatake.com/) Yokogawa (www.yokogawa.com/)
Electric Actuator:	EIM Controls (www.eim-co.com/) Emerson (www.emersonprocess.com/) Rotork (www.rotork.com/) Flowserve (www.flowserve.com) Ledeen (www.dresser.com/)
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INTRODUCTION

The impact of fieldbus and smart technology on the design of control valves is profound. It changes how valves are installed, commissioned, set up, maintained, and operated. Ultimately, many benefits and savings can be achieved from using digital communication for valves.

The brains of an intelligent control valve are in the digital valve positioner. An intelligent control valve is therefore primarily an issue of using digital valve positioners. For a basic introduction on positioners please refer to Section 6.2, for a discussion of intelligent valves and positioners see Section 6.12, and for a discussion of valve diagnostics and predictive maintenance, refer to Section 6.8.

The brains of an on/off valve are in the discrete valve coupler (DVC). Therefore, using an intelligent on/off valve is an issue of using a discrete valve coupler. A Foundation™ Fieldbus or PROFIBUS-PA valve receives the command signal over the digital data highway or network.

A smart control valve receives the signal via 4–20 mA but also provides digital communication for auxiliary functions. Actually, in the case of Foundation Fieldbus more often the control is done in the positioner itself, and the positioner receives the process variable from the transmitter over the fieldbus.

Valve instrumentation based on HART, Foundation Fieldbus, and PROFIBUS-PA includes

- Control valve positioner
- Valve coupler
- Electrical actuator
- Fieldbus to current converter

Fieldbus to pneumatic signal converter
Fieldbus remote I/O
Position transmitter

BENEFITS AND SAVINGS

For valve users who spend too much effort and resources on maintenance, and see too much variability in product quality, network-enabled valves can significantly reduce the cost of operation. Unlike traditional hardwired valves, networked valve packages have microprocessors, which also allow for digital communication.

Networking of valves and microprocessors has enabled several technological breakthroughs that in turn can result in savings. This is because all information can be accessed remotely and because all functions are performed in device firmware instead of hardware: flow characterization, soft limit switch, feedback, and automatic setup.

HART, Foundation Fieldbus, and PROFIBUS-PA

In Foundation Fieldbus-based systems all valves have a permanent network connection to the engineering tool and to the asset management tool (Figure 6.11a). The digital communication works across the same single pair of wires that is used for the desired valve position. "Always on" communications means that interrogation for monitoring, parameterization, and diagnostics can conveniently be done any time.

Unlike in the past when smart valves, using HART communication, used temporarily connected handhelds, smart valves should have permanent communication with the control system in order to leverage the smart capabilities. A permanent communication link between valves and software enables on-line asset management. Operators can get on-line feedback of the control valve's true position and can monitor all critical parameters in real time without having to go into the field.

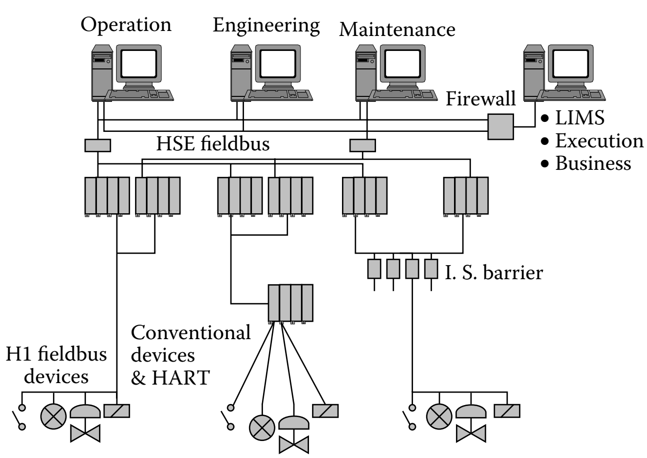

FIG. 6.11a
Illustration of a networked system architecture, which is "always on."

A fair amount of data can be accessed also from a smart HART-based valve positioner. However, fieldbus with its higher speed and standardized data formats enables positioners to provide more diagnostics, and faster. Fieldbus-based positioners therefore can bring more diagnostics to the user than their smart counterparts.

Digital valves can be configured remotely across the bus from a handheld or software tool. This makes it possible to adjust tuning, without having to leave the control room. A single type of digital valve positioner or discrete coupler can be configured for all control and on/off valves, respectively.

Self-Diagnostics Digital valves have internal self-diagnostics that can be interrogated remotely across the bus from a handheld or software tool without having to go into the field. Diagnostics to this level of detail was never possible before the introduction of microprocessors and digital communication. More sophisticated valve diagnostics can be done by using on-line asset management or by utilizing proprietary software tools using information tapped from the positioner.

In the case of Foundation Fieldbus the digital valve positioner or coupler can even issue alerts when failure is detected. The user can, from a single workstation, access all the positioners and other instruments using the engineering tools. The health of any device in the plant can thus be checked easily without having to venture into the field. In the past, valve diagnostics software was connected on a single unit basis. Diagnostics was performed after the valve had already failed, "post-mortem."

Additionally, digital valves internally collect operational statistics such as total travel and the number of reversals. The operational statistics are used for condition-based maintenance schemes.

Interoperability Digital valves can be monitored remotely to see variables such as actuator pressure or torque, and to feed back actual valve position. In the case of Foundation Fieldbus and PROFIBUS-PA, the actual position feedback provided by the digital valve positioner or coupler is fast enough to be used as part of the control loop. The feedback signal travels digitally on the same wire as the desired valve position from the controller or logic, i.e., without additional wiring or external proximity switches.

The HART, Foundation Fieldbus, and PROFIBUS-PA protocols are all developed and managed by independent organizations formed by several manufacturers. This means that many valve products, control systems, and other tools that communicate by using the same protocols are therefore compatible with them. It is possible to select valve positioners, couplers, and tools independent of the control system.

All three protocols support electronics device description (DD, a.k.a. EDDL) in some form. The DD files are loaded in the configuration tool, permitting the tool to communicate with the digital valve and make all its special features accessible.

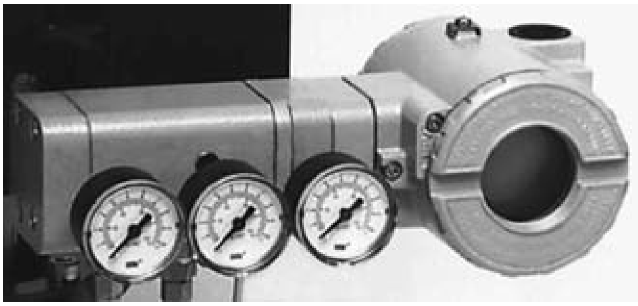

FIG. 6.11b
Digital valve positioner. (Courtesy of SMAR.)

DD for Foundation Fieldbus is very well supported in many control systems, while the DD for HART and PROFIBUS-PA is not so common. Thus better interoperability is achieved with Foundation Fieldbus, as the full set of information can be accessed from virtually any fieldbus system.

PROFIBUS-PA is also taking two other approaches to interoperability; one is device profile, which defines a common basic set of functionality providing some degree of interoperability, and the other is FDT/DTM (field device tool/device type manager). Although FDT/DTM is also not widely supported in control systems, it does have some potential advantages when it comes to sophisticated valve diagnostics. Future enhanced versions of DD may also address this capability.

Control Algorithm in Positioner A defining characteristic of Foundation Fieldbus is that it also is a standard function block diagram programming language to build the control strategy. In a modern network-based control system architecture control is often done in the field instrument (Figure 6.11b), and therefore it is possible to reduce or eliminate the number of control cards usually found in a DCS or PLC system.

Fieldbus positioners perform control in the field by executing the PID control function block. Other blocks perform functions such as split-range, flow characterization, and the positioning servo itself. It is possible to adopt decentralized control using Foundation Fieldbus programming language instead of central controllers and proprietary languages.

The failure of the electronics in the valve affects only a single loop. Diagnostics in the positioner and coupler detect loss of signal from the controller and subsequently bring the valve to its fail-safe position.

Foundation Fieldbus and PROFIBUS-PA completely do away with 4–20 mA. Valves, transmitters, and other devices are multidropped on a network. Typically up to 16 devices are connected to the same pair of wires. Theoretically it is also possible to multidrop HART devices, but the communication speed is too slow for valve applications.

Wiring Costs Using digital valves, the total installed cost can be reduced, achieving savings before the valve is even put into operation. Digital communications reduce installation cost in new construction and also in revamps.

Networked control valve positioners require less wiring than their hardwired counterparts. For example, if actual position feedback is required from an analog positioner, it is necessary to run a second pair of wires back into the control room, where the DCS or PLC will also require an analog input point (on the left side of Figure 6.11c).

For Foundation Fieldbus and PROFIBUS-PA no additional wiring is required because the feedback value is communicated on the bus together with the other values (at the center of Figure 6.11c). HART positioners also do not require an additional wire to run back into the control room. If the control system does not have native support for HART, it is possible to add a HART-to-current converter in the control room instead (Figure 6.11c right).

The converter connects to the same two wires used for the positioner to receive the desired valve position signal from the DCS or PLC, and then it uses HART to poll the positioner to get the actual position digitally (Figure 6.11d).

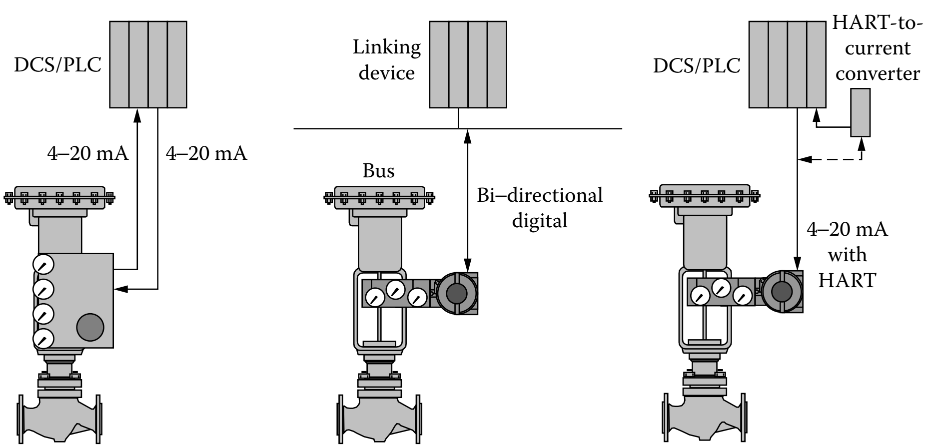

FIG. 6.11c
Wiring requirements of providing position feedback in analog (left), Fieldbus (center), and HART (right) systems.

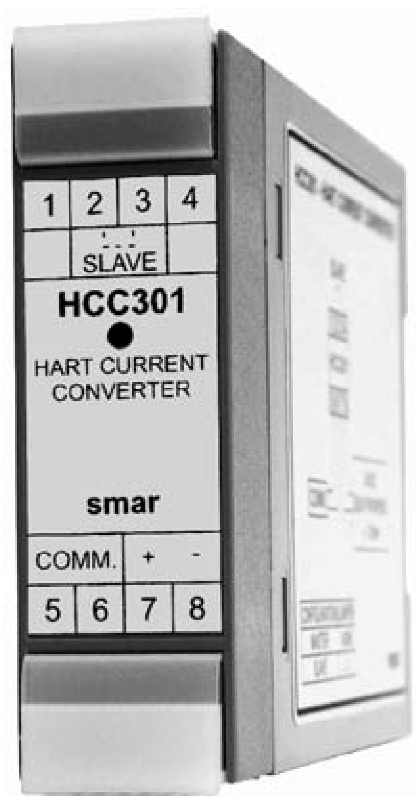

FIG. 6.11d
HART-to-current converter. (Courtesy of SMAR.)

The converter generates an analog signal accepted by the analog input card in any control system or single loop controller. Additional safety barriers are also eliminated. If discrete open/close statuses are required, these are simply detected as alarms in the control system using the actual position signal.

Similarly, networked discrete valve couplers require less wiring than their hardwired counterparts. For example, if open/close statuses are required from a hardwired valve, it is necessary to run two additional pairs of wires back into the control room, where the DCS or PLC will also require two discrete input points. However, the discrete valve coupler provides it on the same bus (Figure 6.11e).

An electric actuator may be even more extreme because the need for signals such as open/stop/close or desired valve position, shut-down, open/close statuses or actual position, local/remote, opening/closing, torque switch or torque value, and failures is not uncommon (Figure 6.11f). Using a bus, a lot of hardwire and I/O modules are eliminated.

In this case, using bus technology, it is possible to reduce by anywhere from two to ten pairs of wires per valve even if one is only considering the auxiliary functions. Needless to say, the savings in cable and controller I/O cards and all the associated costs of engineering and installation is significant.

Both Foundation Fieldbus and PROFIBUS-PA permit several devices to be connected on the same pair of wires together with other devices. Moreover, an interface module can handle as many as 64 devices, thus eliminating the need for a large number of conventional I/O modules. Significant savings in wiring and installation costs are therefore possible as compared to hardwired valves. In intrinsically safe installations the savings are even greater, because as many as four or eight devices share the same single safety barrier, depending on the scheme used. This too is a significant cost saver.

To really benefit from Foundation Fieldbus and PROFIBUS-PA multidrop wiring, the valve electronics shall draw as little power from the bus as possible. Pneumatic valve positioners that use piezo technology to drive the flapper have significantly lower power consumption than the solenoid type. Lower current draw means lower voltage drop along the wires, which translates into more devices, longer wires, and fewer barriers. Therefore, by using lower power consumption positioners, such as 12 mA, further savings are possible.

Positioners, couplers, and actuators based on HART, Foundation Fieldbus, and PROFIBUS-PA are available from multiple competing vendors. The competition among interoperable products brings prices down lower than for units using proprietary communication.

Valve Calibration and Configuration

Configuring and calibrating valves in the past required tedious mechanical adjustments. Using handheld terminal or computer software to access the valve, these tasks require less time and resources and thus result in savings (Figure 6.11g). For more detail on the subject of configuring intelligent devices, refer to Section 1.6 in Volume 1 of this handbook.

Valve instrumentation without microprocessor and communication requires mechanical and electronics adjustments at the valve in order to change the way it operates. For example, the modification of flow characteristics previously had to be done by changing mechanical cams and springs. Using digital communication it can now be done remotely through software, thereby significantly reducing cost and time, particularly during commissioning.

Other valve parameters, such as the opening and closing time of the valve, can also be set.

To align mechanical feedback systems based on leavers, cams, and potentiometers in older positioners was tedious and time consuming, especially in the field. Using digital communication, a setup command can simply be sent from a handheld terminal or software in the control system to auto-calibrate the positioner. This significantly shortens the setup time, as stroking need not be done manually, achieving reduced installation cost. Once the setup is initiated the valve automatically finds its own fully opened and fully closed positions.

A key advantage of Foundation Fieldbus is that control is also done in the field devices, typically in the valve. The decentralized architecture where control can be done in the field instruments is called Field Control System (FCS). Because control is done in the valve the number of loops in centralized controllers is reduced, and the number of

FIG. 6.11e
Discrete valve coupler incorporates solenoid and position feedback. (Courtesy of TopWorx.)

centralized controls can subsequently also be reduced. The savings achieved from the reduction in very expensive controllers are tremendous.

To enjoy maximum flexibility, the positioner can have dynamically instantiable function blocks. This allows the user to freely select from more than a dozen blocks in a library containing scores of blocks including PID, splitter, and arithmetic.

Valve Cycling and Stiction An inadequately functioning control valve will still degrade the overall loop performance and may cause the valve to wear out prematurely. Conversely, a healthy positioner ensures better control and less maintenance. The greatest savings potential for applying networked digital valves is in long-term operational costs such as maintenance and improved performance.

The push for higher valve performance has been seen particularly in the pulp and paper industries, because of their need for increasing product uniformity. Digital valve solutions have higher performance than their analog counterparts, resulting in lower process variability, which in turn translates into higher quality, less rejects, higher yield and productivity, and lower raw material and fuel consumption. Information from the digital valve may be used to fine-tune the loop for optimum production output and tighter product uniformity. The higher valve performance ultimately results in savings because of the resulting boost in production and yield.

Because aligning and calibrating analog positioners is tedious, this is often not done properly or not checked regularly. Automatic setup invoked through the fieldbus network makes sure it is done accurately, every time, so that positioning is precise. It is possible to remotely calibrate the positioner when conditions allow, e.g., while the process is down for any reason. As the valve seat and other parts wear and tear during operation, one can calibrate the valve to make sure that it operates and shuts off properly.

It is commonly seen that control valve cycling can cause the control loops to cycle and that this can destabilize production. Studies show that as many as two out of three control loops are oscillating due to the dead band of control valves. The operational statistics such as total valve travel and number of cycles that now are provided by the positioners are extremely helpful in detecting oscillation problems and enable one to eliminate them (Figure 6.11h).

FIG. 6.11f
Fieldbus electrical actuator. (Courtesy of Rotork.)

One can eliminate the sources of variability one by one. A hunting valve is easy to catch because one can see a great number of reversals counted in the positioner or coupler and communicated over the fieldbus. If this occurs, one knows that either the positioner or loop is poorly tuned. The servo gains and other parameters like the time required for opening and closing the valve can be set from a handheld or by a software tool to optimize positioner response to different valve sizes.

FIG. 6.11g
The display of a handheld tool for configuring a digital valve positioner. (Courtesy of SMAR; the screenshot is of SMAR HPC301.)

For good control loop performance a control valve must be able to respond to small steps in the control signal by matching it accurately with its stem within 1% or less. If not, a problem called "backlash" or "stiction" will occur. It is typically caused by packing friction (Section 6.5), which in turn may be a result of wear and tear.

In addition to being able to predict wear based on operational statistics, software is now available to analyze the valve's performance thanks to the improved communications capabilities to obtain data for such plots. The operational statistics may be used to more accurately predict the packing wear, as to strike the right balance of downtime due to replacement, and greater performance as a result of more frequent packing change.

Position Feedback Fieldbus positioners provide an actual position feedback value over the communication network that is fast enough to be used as part of advanced control strategies and also for true bumpless transfer and true reset windup protection based on actual valve excursion end points. Because the valve position is available over the communication network, the actual position can be put into use at a later stage, without having to modify the valve positioner, running wires, or adding any AI points to the control system, as was the case in the days of analog feedback.

Foundation Fieldbus thus makes actual position feedback possible for every control loop. This makes it feasible to provide true bumpless transfer back to the automatic control mode after the valve has been switched to manual control and was operated locally. Similarly, true integral windup protection can be provided when the valve has reached its endpoints or is unable to move. In the past this was done for some loops in conventional systems, but was not realistic for all. In fieldbus systems, this feature has no extra cost and therefore it is viable to optimize every loop and obtain the corresponding savings.

Lastly, systems and devices using Foundation Fieldbus or PROFIBUS-PA eliminate the need for D/A and A/D conversions in the transmission path, as no analog signals are used. This results in higher accuracy. Because the actual valve position is transmitted back to the workstation using digital communication, inaccuracies caused by conversion to analog are eliminated. Additional points of calibration are also eliminated.

Proactive or Predictive Maintenance For further details on valve diagnostics and predictive maintenance, refer to Section 6.8. Self-diagnostics done in the digital valves as well as using other information make it is possible to move to a proactive condition-based maintenance scheme that can lower maintenance expenses as compared to reactive or preventive maintenance schemes.

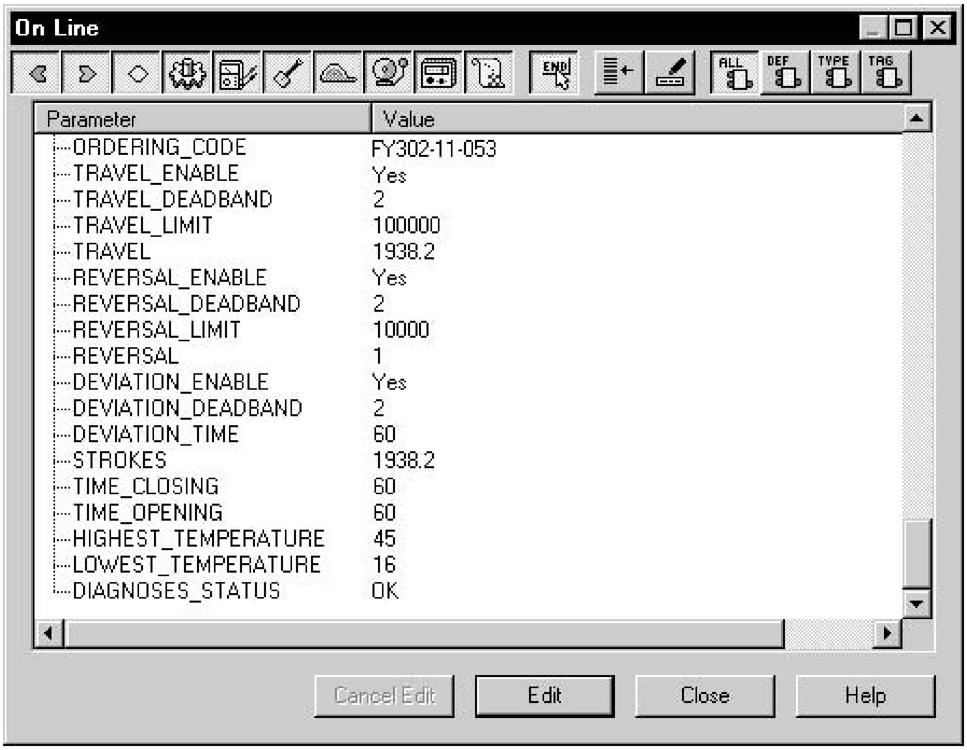

FIG. 6.11h
Operational statistics, such as listed here, is easily reviewed and can trigger alarms notifying the operators that the valve is due for service. (Screenshot is courtesy of SMAR Syscon.)

Asset management software can continuously poll digital valves over the network to find out their health immediately. This means that failed valves can be found faster and problems pinpointed with greater accuracy, making repair quicker and easier. Fewer resources spent means savings. For example, if the supply air to the positioner is lost, the operator is immediately notified.

The operational statistics such as total valve travel and number of cycles that now are provided by the positioners are leading indicators of wear and tear. The operational statistics are used for proactive maintenance to determine the optimum time for valve overhaul. Based on valve manufacturer recommendation for stem packing change, alarm limits for these statistics can be set, notifying the technicians that maintenance is due. Spares can be ordered in advance, several valves can be fixed all in one shutdown, and maintenance can be done before the valve fails. Fewer unscheduled shutdowns mean higher productivity. Major maintenance savings are possible.

In the past, many valves were removed, brought to the workshop, and torn down only to find nothing was wrong. Remote diagnostics reduce such unnecessary work by allowing the technicians to check the general health of the valve from the host before even going into the field. Valve instrumentation can be managed without having to leave the workstation. The cost that can be saved by not having to bring one valve into the workshop is substantial. Users can instead target their maintenance resources to the valves that really need attention.

It primarily is the asset management software that allows technicians to find out what is really wrong, and based on the valve condition it is possible to schedule maintenance only when really necessary, prioritizing the most immediate needs. Rather than running until essential equipment fails, maintenance can be carried out when needed, and only when needed. Maintenance efforts can be focused on problem valves, not the healthy ones.

Spare Parts and Flexibility The interoperability of HART, Foundation Fieldbus, and PROFIBUS-PA means that plants have many alternative third parties from which to obtain their replacement positioners and couplers. This ensures that spare prices will be market based, and not inflated, as was the case when proprietary protocols were used.

To achieve maximum flexibility and enable the same positioner or coupler to be used with any pneumatic control valve or actuator in a plant, more and more functions are performed in software as opposed to hardware, making it easier to adjust and adapt to the application. Users can standardize on one positioner or discrete valve coupler for all different kinds of control valves, keeping spares and training to a minimum.

Safety and Pollution

Apart from the direct economical benefits, digital technology can also enhance safety and protect the environment. An important part about the actual position interlocks in Foundation Fieldbus is that they are handled by the PID and AO blocks, without the user having to configure separate logic for interlocks and reset windup protection on actual position, as was done in old DCSs.

This is different from the old days, when some valves were connected to the DCS using 4–20 mA analog signals from the controller to the positioners. The DCS had no way of knowing the actual position of the valve. If the valve failed, nobody knew about it because there was no feedback or diagnostics. If somebody operated the valve by hand, nobody knew. This was very dangerous, because the operator was under the impression that automatic control was in operation, when it was not. Under these conditions, the controller can change its output, but the valve does not change, so the DCS still attempted to control even though there was no actuation.

Also, if the output of the automatic controller was 50% (12 mA), while some technician in the field has been operating the valve by hand and opened it to 75%, when the loop was switched back to the automatic controller, the valve has to jump 25% (from 75 to 50%). To avoid this, some critical loops had a 4–20 mA feedback of actual valve position from the positioner to the DCS AI module. In the DCS, then, one had to program logic to detect the deviation and in this case put the PID in manual and make sure the PID output follows the actual position feedback from the valve. That is very complex logic, but for Foundation Fieldbus valves it is all automatically taken care of.

Failure Detection Diagnostics from networked positioners and couplers detect failure in positioner, actuator, and valve including loss of supply air. Foundation Fieldbus communication will inform the operator of such events and will stop control. This allows for corrective action to be taken sooner, which might protect from dangerous situations and production loss. Thereby, Foundation Fieldbus makes systems safer.

Another example is a thermocouple failure detected by a temperature transmitter propagated to the positioner, which in response shuts the loop down to a predetermined safe state without the need for any central control action.

Another important form of diagnostics is partial stroke testing (Section 6.10). It verifies that the valve is not stuck, increasing the probability of a successful movement if called upon. This reduces the problem of valves stuck in one position.

Digital communication in conjunction with asset management software can ensure that the installed base of digital valves is maintained well and is experiencing fewer surprise failures. Thus, asset management enables plants to run uninterrupted for longer periods of time, subsequently increasing productivity, keeping costs down. Diagnostics provide an early warning for abnormal conditions and may be used as an indication of problems to come, allowing technicians to solve problems before they adversely affect the process. Users can switch to a proactive maintenance program, thereby minimizing plant downtime.

On-line Plant Asset Management

An inadequately functioning control valve will upset the overall loop performance or may cause the valve to wear out prematurely. Conversely, a healthy positioner ensures better control and less maintenance. A fieldbus control valve positioner takes a total life cycle view of the valve and is designed to enable a longer life for the valve package.

Positioners now come with built-in pressure sensors continuously monitoring the pressure at both the air supply input and the actuator chambers. This enhances simple text-based diagnostics such as loss of supply air with sophisticated chart- and graph-based analysis, such as valve signature. Thus, the valve is provided with additional on-board sensors, which determine its condition, the ambient conditions, and such external factors as the loss of supply air, and gives this information to the microprocessor.

The diagnostics is communicated to the on-line plant asset management tool using HART, Foundation Fieldbus, or PROFIBUS-PA communication. Asset management software takes the vast amount of diagnostics data in the positioner and turns it into information, which is useful to maintenance technicians. Together the asset management software and the positioners make it is easier to determine valve health and estimate their remaining life spans (Figure 6.11i).

Valve Signature The Valve Signature plot traces the actuator pressure required to put the valve in a desired position (Figure 6.11j). As was shown in Section 6.8, comparing changes in this behavior over time helps identify problem areas. Other charts include Hysteresis (a.k.a. "Positioner Signature" or "Dynamic Error Band"), step response (Section 6.9), and drive signal. It is a good idea to capture a "base line" signature for the valve package as it is new, and compare future signatures against this benchmark (Figures 6.8b and 6.10j).

By using the above described techniques, maintenance can be done before the valves fail.

DIGITAL VALVE INSTRUMENTATION

The first generation of digital valve instrumentation was an electropneumatic device enhanced with a CPU and HART communication. Few other things changed. These devices still relied on the old lever and potentiometer for the actual valve position sensing for the feedback. They had the same old pneumatic gauges. High-current-consumption solenoids were used for flapper actuation. There was not much diagnostics to speak of. However, in the second generation the technology went beyond the mere incorporation of a CPU.

Second Generation

The microprocessor is at the center of every intelligent valve (Figure 6.11k). The firmware in digital valve instrumentation

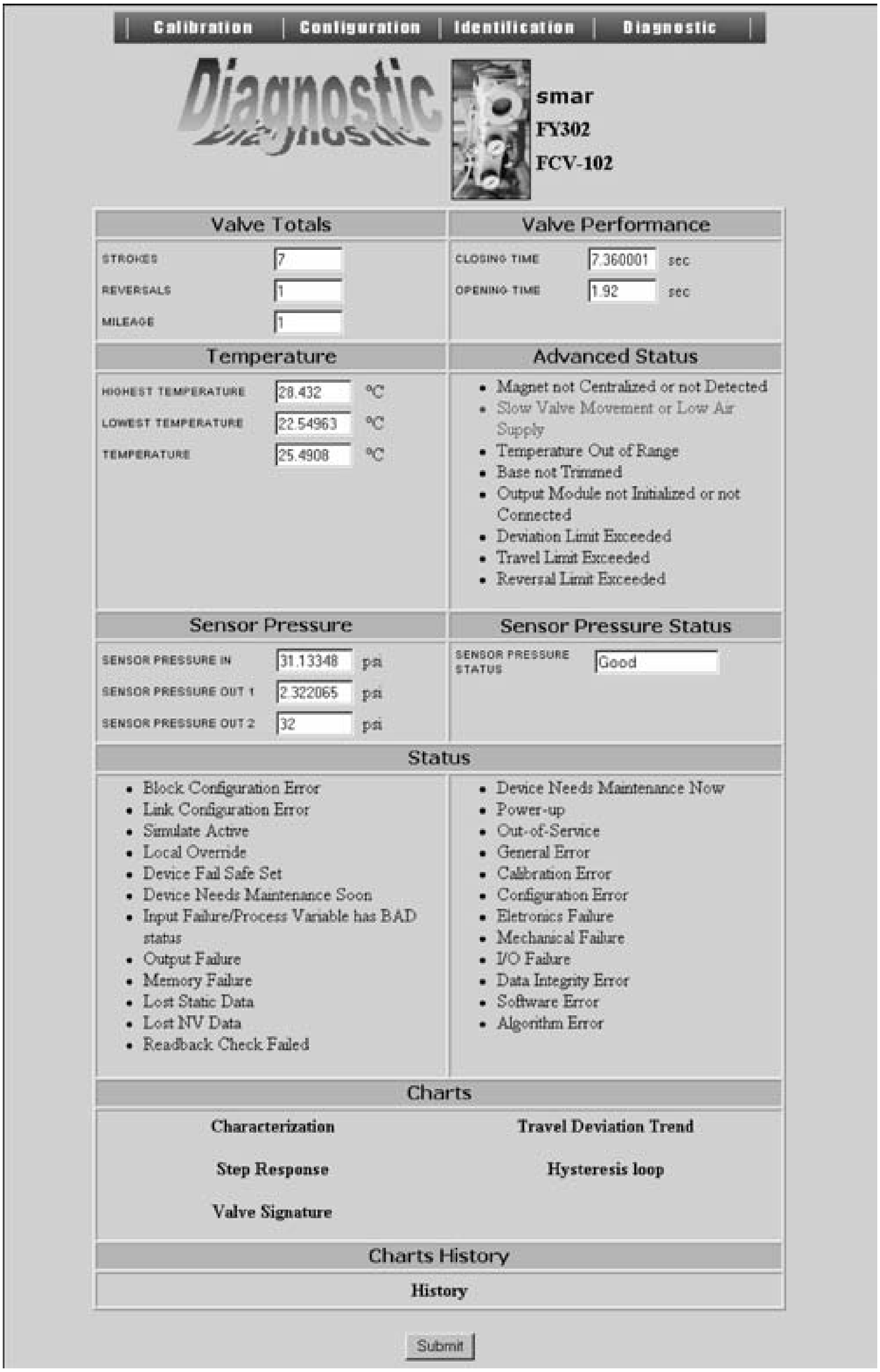

FIG. 6.11i
Fieldbus positioner diagnostics on asset management software. (Screenshot is courtesy of SMAR AssetView.)

completely controls the valve. For example, instead of cam and spring mechanics on the feedback to apply flow characterization, these instruments do the characterization in software. Error due to mechanical imprecision is avoided, further improving performance. Likewise, split-range operation, digital display, and local operation are all provided using software.

Position sensing is a key aspect of valve control and is an important means to acquire the data for sophisticated diagnostics and to tap the full potential of digital instrumentation.

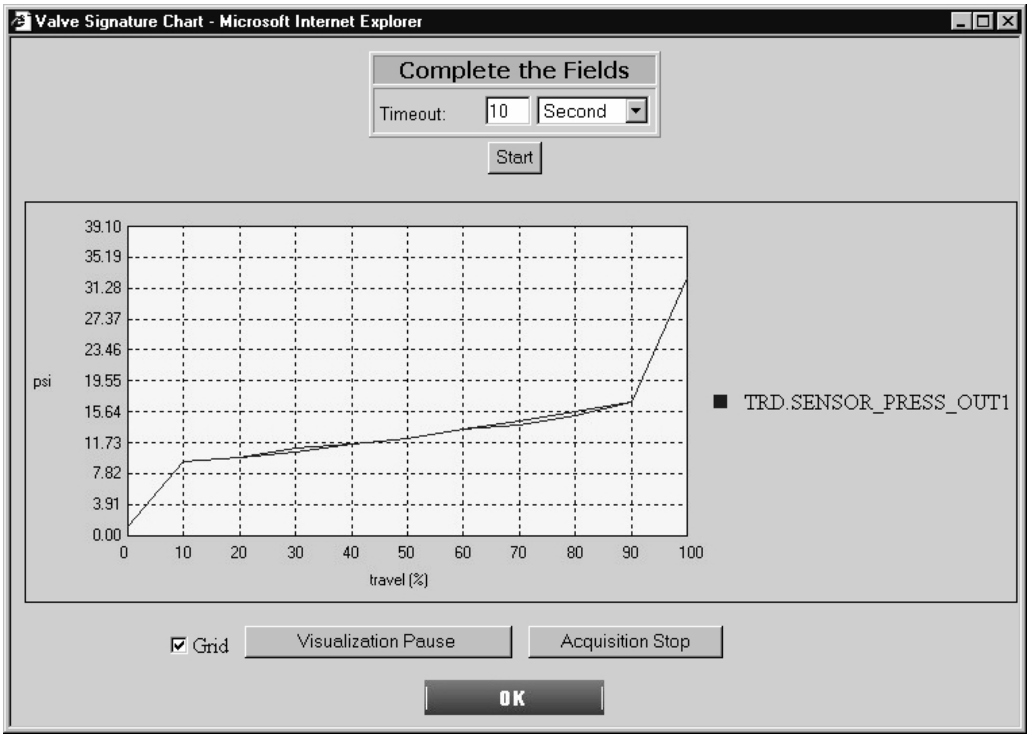

FIG. 6.11j
A valve signature. (Screenshot is courtesy of SMAR AssetView.)

See Section 7. 10 in Volume 1 of this handbook ("Linear and Angular Position Detection") for details on position sensing. Noncontact position sensing technologies such as Hall-effect eliminates linkages that can stick and gall; they are also less sensitive to vibration, thus improving hysteresis and reliability. Accurate position sensing allows the valve to be able to respond to very small demands in position change as required for tight control.

Power consumption is a key issue for digital valve instrumentation, and it is their only disadvantage as compared to analog instrumentation. For example, a traditional electropneumatic positioner has a voltage drop of only a few volts,

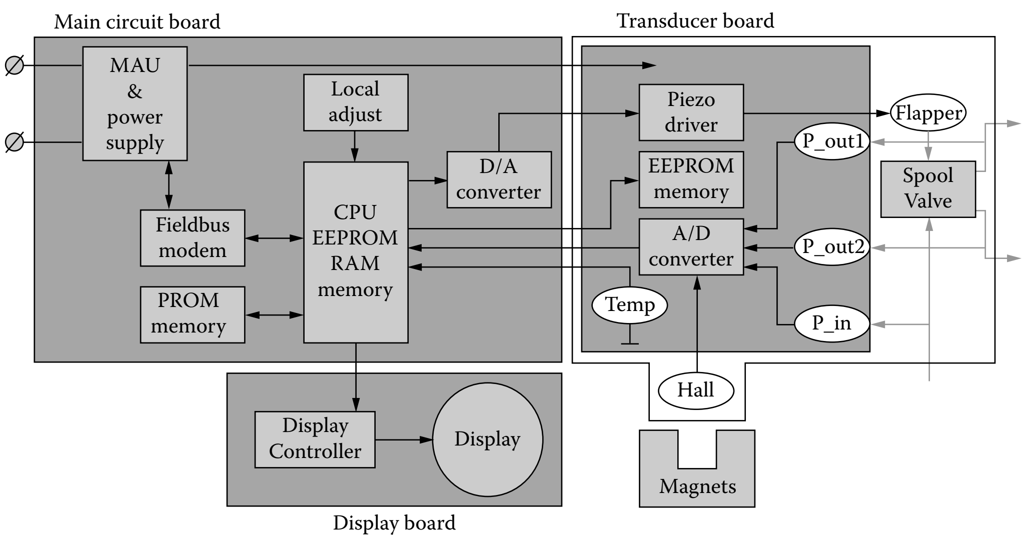

FIG. 6.11k
Block diagram of a Fieldbus pneumatic control valve positioner. (Courtesy of SMAR.)

permitting the positioner to be driven from a regular controller output over very long wires. It is even possible to put two analog positioners in a split-range scheme in series without concern.

However, smart positioners using HART typically have a voltage drop of 11 V or more and therefore Ohm's Law is putting a restriction on cable length, as controller open loop voltage may not be sufficient to drive the signal through the positioners plus cable resistance. Split-range applications generally require signal amplifiers. Current consumption is a concern in fieldbus installations where several devices are connected on the same network, causing voltage drops and restricting the number of devices on a safety barrier. Valve instrumentation that has I/P sections based on piezo technology typically have lower power consumption, making this less of a consideration.

Additional auxiliary sensors can be included in digital valve instrumentation in order to provide inputs for more advanced diagnostics. For example, they might include internal ambient temperature sensing as well as built-in pressure sensors to continuously monitor the pressure at the air supply input and at the two pneumatic outputs. The on-board sensors are dedicated to providing continuous information to the microprocessor, so that it can determine the condition of the valve assembly and ambient conditions.

CONCLUSIONS

The market for digital valve positioners in general, and for fieldbus in particular, looks very promising and is perhaps the single most important event that has occurred in the control valve industry during the past several decades.

Standards and flexible software have made it possible for users to choose third-party positioners when the positioners being offered by the control valve manufacturers cannot meet their performance requirement. With the right positioners it is very easy to upgrade an existing control valve to make it smart or fieldbus-compatible. Even when an old DCS system is converted into a fieldbus system, all the user needs to do is to remove the old 4–20 mA positioner and place a Fieldbus-compatible positioner in its place.

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