HART COMMUNICATION FOUNDATION

TECH NOTE

Peer-to-Peer Communication with WirelessHART

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Synopsys:

The WirelessHART standard is the first open wireless communication standard for measurement and control in the process industries. It uses wireless mesh networking between field devices, as well as other innovations, to provide secure, reliable digital communications that can meet the stringent requirements of industrial applications.

This is one of a series of papers helping users recognize the benefits of WirelessHART, as well as addressing specific questions about WirelessHART.

WirelessHART has been designed from the ground up to support a wide range of applications. These applications include monitoring, diagnostics, alarm and event detection, block transfer to support applications such a vibration monitoring and valve signature, and control. To support these applications several forms of communications are required. Although these forms of communications are largely transparent to the user, it is useful to understand that they exist. This paper describes these communication patterns as forms of peer-to-peer communications.

Peer-to-peer communication is defined as the transmission of information between participants in a network. Participants can be physical devices such as a transmitter and a valve, or they can be applications such as monitoring, control, diagnostics, and event detection. They can also be more complex applications performing calibration, a vibration analysis or a valve signature. These applications can reside in workstations, controllers, gateways, measuring devices, and final control elements such as valves.

This paper describes the various forms of peer-to-peer communication. A typical control application is used to illustrate these forms of communication.

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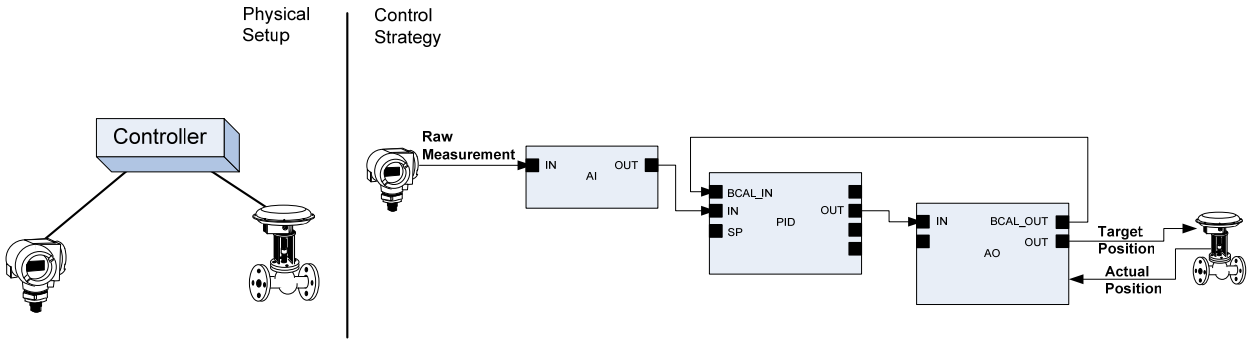
Communication patterns

When a control algorithm runs in a dedicated controller such as a Distributed Control System or a PLC, the communication is between the controller and field devices. In other cases control may be distributed between controllers and a gateway-type device in a wireless network, or between controllers, gateways, and the field devices themselves. Running control in the field devices – often called "control in the field" – can be implemented in multiple ways. One way is to wire the 4-20mA signal from the measurement device directly to the controlling device, such as a valve. Another is to distribute and run software function blocks in the devices, and communicate process variables and control signals in digital form over the communications network.

In all of these scenarios parameter values are being communicated. These communications are built on top of a communication infrastructure. The role of the communication infrastructure is to transport process variables, parameters, alarms and other values wherever they are needed. The scenarios that follow illustrate how WirelessHART supports these many forms of communication.

Base scenario

We'll use the following control loop as the starting point for these scenarios.



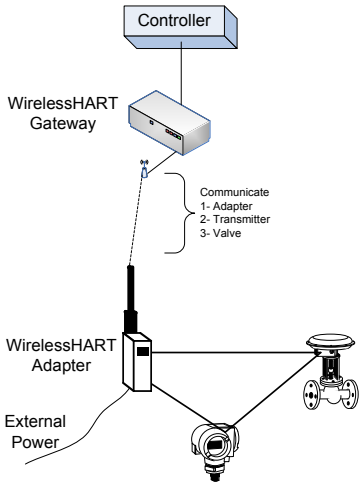
In this example loop, a raw temperature measurement from a reactor cooling jacket is converted to engineering units, filtered, and checked for violation of alarm limits using an analog input (AI) function block.*

Next, a PID function block is used to maintain the temperature about the operating target -- in this case, the reactor temperature setpoint.

An analog output (AO) function block then drives the final control element. In this example, it adjusts a valve to manipulate the flow rate through the cooling jacket.

Each of the connecting lines in the drawing represents the transfer of a parameter value and a status indicating the quality of the value. If the source and destination of the line are physically separated – for example, because they are in different devices -- then the parameter value and status must be communicated by either wired or wireless connections.

Scenario 1: Control in valve, signals communicated through current loop

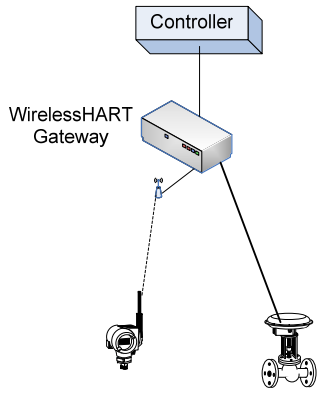


In the first scenario, the measurement and control functions are contained within the transmitter and valve, respectively. The transmitter has a physically wired 4-20mA connection to the valve, and the processed measurement value and status are communicated directly to the valve over this connection. Since the control is in the valve, the actual and target position are communicated directly between the control function and the valve.

In this scenario communication between the control system and the devices is routed through the adapter. Wireless communications are used only to monitor the control loop, adjust the setpoint in the valve, and monitor and adjust other parameter values.

* Despite their name, Analog Input (AI) and Analog Output (AO) function blocks work with the digital information used in WirelessHART communications.

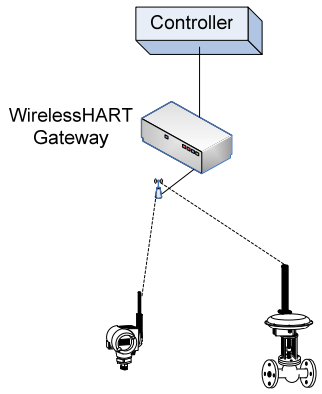
Scenario 2: Control in gateway or controller, connection to valve wired



When using self-powered wireless devices, it's important to minimize power usage in order to extend the time a device can run without needing battery replacement. One approach is to run the measurement and control functions in centralized, line-powered controllers. Putting those functions in the gateway can also provide faster response times that are required in some applications.

In this case the measurement value is communicated wireless. The valve target and actual valve position are communicated through the wired connection between the valve and the gateway.

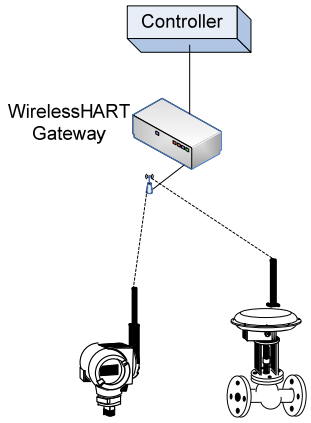
Scenario 3: Control in gateway or controller



When using self-powered wireless devices, it's important to minimize power usage in order to extend the time a device can run without needing battery replacement. The approach shown here is to run the measurement and control functions in centralized, line-powered controllers. Putting those functions in the gateway can also provide faster response times that are required in some applications.

In either case, the measurement value, the valve target, and the actual valve position are communicated wirelessly between the devices and the gateway.

Scenario 4: Control in valve, publishing through gateway



In this case it is desirable to keep the control in the field devices and create peer-to-peer communications between them. The way to do this is to publish parameter values from devices to the gateway, then republish those same values from the gateway to devices that are registered as subscribers to those parameters.

In the example shown below, the transmitter publishes a measurement value and status to the gateway, which republishes the data to the valve – which then uses it in the control algorithm.

In WirelessHART, wireless devices are designed to support publisher-subscriber communications using multiple burst mode commands. Burst mode commands sent by the publisher (e.g. transmitter) are received by the gateway, cached, and then redistributed to the subscribing clients (e.g. valve) that are registered for notifications. One of those clients could be another WirelessHART device.

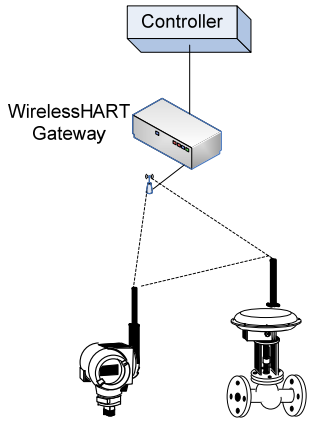
Devices receiving messages from the gateway must be preconfigured to subscribe to the measurement value and status. The subscribing field device is scheduled to periodically listen for published information and to utilize the information communicated in this manner.

When burst mode reporting is used, the data is sent on a predetermined, periodic schedule. Parameters can be sent as scheduled, or only if the value has changed by a significant amount or has not been updated within a default reporting time (report by exception).

All burst mode messages are communicated with a timestamp. The subscribing device can be designed to utilize the timestamp, such as to determine when a new value has been received.

The way the WirelessHART gateway redistributes messages has many technical advantages over other approaches. The communicated values can, in addition to being re-published back out to other devices, published to multiple client applications. Also, the gateway-to-device session keys, routing information, and network scheduling is managed automatically by the WirelessHART Network Manager.

Scenario 5: Control in valve, publishing between devices



To address some special applications, it may be necessary for field devices to form peer-to-peer sessions among themselves. In this case a device must publish directly to another device rather than through the gateway.

Such communications may be established by publishing using a burst mode operation in one device and subscribing using a catch mode operation in the other device. In this case the Network Manager can automatically allocate routes and communication resources to provide the additional session between each pair of peer-to-peer devices.

The WirelessHART specifications define the network management services required to form these types of communications. Manufacturers may use these services to allow automatic establishment of publisher-subscriber communications between devices.

Let's look more closely at what has to happen to set up this peer-to-peer communication. A good engineering or configuration system will do most of the work automatically, without the user having to worry about each of the steps outlined below.

As a starting point, consider the basic steps to set up a control strategy involving a wired field bus. The engineering tools must perform the following tasks:

- Configure parameters in the device
- Schedule function block execution with the device relative to the macrocycle
- Configure Virtual Communication Relationships in source and destination devices that have an inter-device function block link
- Configure Link Objects in source and destination devices that have an inter-device function block link
- Update Link Active Scheduler schedules in the primary Link Master device
- Update Link Active Scheduler schedules in the secondary Link Master device.

WirelessHART uses a somewhat different approach. The configuration system sorts out the control strategy, what needs to be communicated (i.e. the connections on the drawing), the communication rates (i.e. module execution rate), and the WirelessHART Network Manager takes care of the rest.

All communications in WirelessHART are reliable and secure. The WirelessHART network also allocates redundant paths for communications and automatically manages sessions for communication between devices – all communications within WirelessHART are encrypted and validated.

Conclusion

The bottom line on any technology is how well it meets users' needs. Users generally think in terms of applications such as control rather than capabilities such as peer-to-peer communications. With WirelessHART, however, those capabilities – including direct device-to-device communication -- are readily available to support the applications users care about. The WirelessHART protocol allows for secure, highly reliable, low latency control with almost no impact on the bandwidth and absolutely no impact on process performance. All of this is automatically built into the WirelessHART standard with little or no input from users. WirelessHART is simple, reliable, and secure.