*Wireless*HART™

Technical Data Sheet

*Wireless*HART is a Wireless Mesh Network Communications Protocol designed to meet the needs for process automation applications. *Wireless*HART is a key part of the HART Field Communications Protocol Revision 7 and builds on nearly 20 years of HART experience in serving the needs of the process automation industry. Like all things HART, *Wireless*HART is backward compatible with existing HART devices and applications. Existing HART applications (e.g., control systems, PLCs, maintenance tools, and asset management applications) can utilize *Wireless*HART without the need for software upgrades.

This technical data sheet is intended to provide a brief summary of *Wireless*HART capability and key technical aspects. For more information see the, soon to be published, *WirelessHART User Guide* and the HART 7 Specifications.

DESCRIPTION

*Wireless*HART is a secure and robust mesh networking technology operating in the 2.4GHz ISM radio band. *Wireless*HART utilizes IEEE 802.15.4 compatible DSSS radios with channel hopping on a packet by packet basis.

The *Wireless*HART Architecture is designed to be an easy to use, reliable and interoperable wireless mesh sensor protocol. *Wireless*HART specifies mandatory requirements that compatible equipment must support for interoperability such that wireless device types of different manufacturers can be exchanged without compromising system operation.

Furthermore, *Wireless*HART is backward compatible to core HART technology such as the HART command structure and Device Description Language. All HART devices (e.g., network managers, gateways, field devices, etc) shall support DDL.

*Wireless*HART communication uses Time Division Multiple Access (TDMA) technology to arbitrate and coordinate communications between network devices. The TDMA Data-Link Layer establishes links specifying the timeslot and frequency to be used for communication between devices. These links are organized into superframes that periodically repeat to support both cyclic and acyclic communication traffic. A link may be dedicated (e.g., to assure process data is delivered with minimal latency) or shared to allows elastic utilization of communications bandwidth.

Traditionally the HART Protocol has been a token-passing network to support both request/response traffic and publishing of process data. With the inclusion of *Wireless*HART, an additional Physical and Data Link Layer are specified: IEEE STD 802.15.4-2006 Physical and TDMA Data-Link Layers. Since *Wireless*HART allows deployment of full wireless mesh networks a complete Network Layer Specification is now provided.

*Wireless*HART supports the standard HART Application Layer and focuses on what HART does best - communications with smart, process field devices

KEY FEATURES

- IEEE STD 802.15.4-2006 compatible Physical Layer and MAC PDU
- Based on the open, industry standard HART Field Communications Protocol. Directly compatible with existing HART-enabled equipment, applications and tools.
- Specifically designed to satisfy the needs of the process automation industry.
- Supports multiple messaging modes including: one-way publishing of process and control values; spontaneous notification by exception; ad-hoc request/response; and auto-segmented block transfers of large data sets.
- Highly secure communications using AES-128 block ciphers with individual Join and Session Keys and Data-Link level Network Key.
- Highly reliable, self healing, redundant path mesh networking. Simple to install and operate.
- Clear Channel Assessment (CCA), channel hopping, blacklisting, and adjustable transmit power are supported to maximize coexistence between *Wireless*HART networks and other ISM band equipment.
- All messages have a well defined priority ensuring appropriate QoS message delivery.
- Dedicated bandwidth is used for high priority and periodic communications
- Shared bandwidth provides elasticity for event traffic and ad-hoc request/response maintenance and diagnostic messages.
- Wide-area applications (e.g., tank farms, pipelines) and small unit operations (e.g., food and beverage, pharmaceutical,) supported

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NETWORK ARCHITECTURE

*Wireless*HART enables deployment of easy to use, reliable and interoperable wireless mesh networks. *Wireless*HART specifies three principle elements:

- *Wireless*HART Field Devices (WFD) that are connected to the Process or to Plant Equipment.
- *Wireless*HART Gateways that enable communication between Host Applications and WFDs in the *Wireless*HART Network. Gateways support one or more Access Points. A Gateway and its Access Points must included in every *Wireless*HART network.
- A *Wireless*HART Network Manager that is responsible for configuration of the network, scheduling communication between *Wireless*HART devices (e.g., configuring superframes), management of the routing tables and monitoring and reporting the health of the *Wireless*HART Network. While redundant network managers are supported, there must be only one active Network Manager per *Wireless*HART Network.

In addition, *Wireless*HART supports:

- *Wireless*HART Adapters that allow existing HART field devices to be integrated into a *Wireless*HART Network.
- *Wireless*HART Handhelds support direct access to adjacent *Wireless*HART field devices using its embedded *Wireless*HART transceiver.

*Wireless*HART devices support all that users have come to expect from HART including HART's rigorous and high standards of interoperability. All *Wireless*HART equipment consist of core mandatory capabilities that will allow equivalent device types to be exchanged without compromising system operation. To this end the majority of *Wireless*HART requirements are mandatory and must be universally supported.

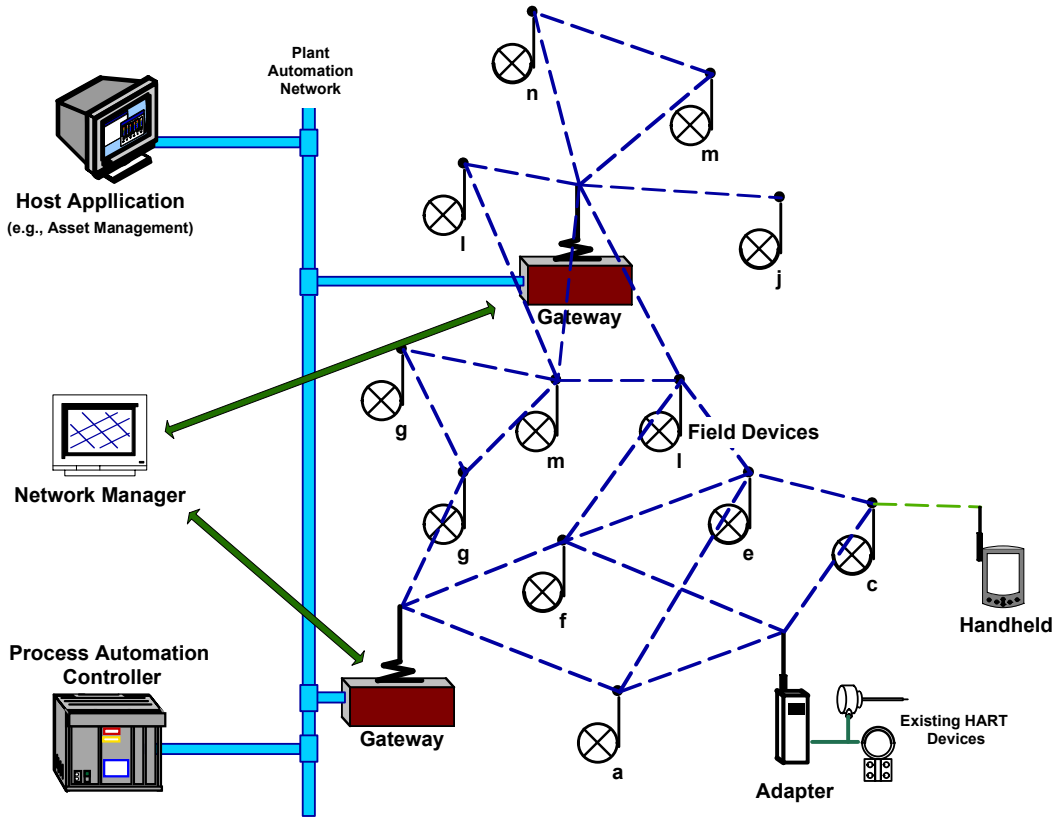

Figure 1. Elements of a Typical *Wireless*HART Installation.

DATA TRANSFER MODES

- Process data and setpoints may be published periodically, upon significant change in their value or upon crossing a critical threshold.
- Device or process status changes automatically generate a notification message to applications
- Ad-hoc Request/response traffic supported for routine maintenance, configuration, calibration.
- Auto-segmenting block transfers of huge data sets (e.g., vibration spectra or raw radar level waveforms) are supported.

PROTOCOL SUMMARY

Physical Layer

Based on IEEE STD 802.15.4-2006

- Data Rate: 250KBPS (62.5 KBAUD)
- Operating Frequency: 2400-2483.5 MHz
- Modulation: O-QPSK; Direct Sequence Spread Spectrum (DSSS)
- Transmit Power: 10dBm (Nominal) adjustable in discrete steps (e.g., 0dBM and others).
- IEEE compliant Physical Layer PDU. Maximum payload 127 bytes.

Data-Link Layer

IEEE 802.15.4 compatible MAC PDU.

- Long and short addresses. EUI-64 address based on HART Unique ID and HCF OUI.
- Additional *Wireless*HART DLPDU specifier byte identifies *Wireless*HART packet types.

Bus Arbitration: TDMA using timeslots organized into superframes:

- 100 timeslots per second
- All devices support multiple superframes with differing numbers of timeslots to allow mixing of fast (1 second), slow (minutes), cyclic and acyclic network traffic. Superframes may be enabled and disabled based on bandwidth demand.
- Communication occurs in designated timeslot and frequency channel for that message.
- Acknowledgement packets include timing information to continuously synchronize TDMA operation across entire network.

Links specified using superframe, timeslot and channel offset to enable communications between neighboring devices.

- Links may be dedicated (one source device)
- Links may be shared between multiple sources, using contention-based access. Collisions force random back-off intervals between sources.
- Frequency hopping on a message by message basis. Frequency selection based on link's timeslot and channel offset.
- Channel blacklisting supported

Message prioritization for latency management and flow control. Priority level in a device may be modified to manage traffic flow. 4 levels:

- Command (highest priority). Any packet containing Network Management payloads.
- Process Data. Any packet containing process data (e.g., Command 3 or 9).
- Normal. DLPDUs not meeting the criteria for "Command", "Process Data", or "Alarm".
- Alarm (lowest priority). Packets containing only alarm and event payload. No more than one DLPDU having "Alarm" priority buffered.

Low priority messages declined as device buffer become full. Redundant path allow automatic re-routing around congestion.

Network Layer

Topology: Full wireless mesh network. All network devices are full function, must source and sink packets and support routing on behalf of other network devices. As the network is formed multiple redundant communications paths are established and continuously verified. Typically, reliability for a well-formed *Wireless*HART network is greater than 3σ (3-sigma = 99.7300204%) and normally greater than 6σ (99.9999998%).

Message Routing:

- Upstream and downstream graph routing. Provides redundant path routing for maximum reliability and managed latency
- Source routing for ad-hoc communications and confirmation of path viability
- Supports Broadcast, multi-cast and unicast transmissions.

Demand-driven, dynamic network bandwidth management resulting in allocation/de-allocation of superframes and links as needed:

- As field devices are configured, bandwidth is requested or released to satisfy field device communication requirements.
- If field device configured prior to joining network, communication bandwidth is obtained upon joining the network.
- Ad-hoc communications (e.g., from a DDL-enable host application) are monitored and bandwidth requested and released thus ramping up and down bandwidth use as needed.
- Shared slots are allocated to provide base bandwidth and elastic bandwidth utilization while minimizing power consumption.
- Block transfers supported by allocating high bandwidth transport pipe that is released when block transfer completes.

Simple transport layer provides un-acknowledged and end-end acknowledgement of communications. Acknowledged transmissions include automatic retries to confirm successful data transfer.

Transport layer also supports TCP-like reliable block transfers of large data sets.

- Data sets automatically segmented at source device and re-assembled at destination.
- Block transfer is transparent to upper layers.

Network performance continuously monitored, reported and network groomed:

- Each device maintains statistics (e.g., Receive Signal Level, packet counts) on communications with neighbors. Statistics routinely published.
- Devices listen for new neighbors and report discovered neighbors.
- Disconnected and dropped neighbors reported.
- Network Manager grooms network to ensure path redundancy, reduce power consumption and flatten the network.

Application Layer
*Wireless*HART uses the standard HART Application Layer. HART is command based with standard data types and procedures. Universal, Common Practice, Device Family and Wireless commands are specified. Extensive standard and device-specific status are available including quality assessment and status for all process variables. Device revision rules are specified to govern device modification and ensure backward compatibility.

In addition, several new features are added to HART 7 to better leverage wireless communication and to enhance wired HART capabilities:

- Smart Data Publishing to generate process data messages only when needed. Process values published based on time, variation of signal, or crossing a user defined threshold.
- Process data samples are time-stamped to mitigate effects of variation in latency.
- Measurements can be triggered at specified time allowing synchronized operation across multiple devices (e.g., vibration analyzers).
- Command aggregation enables multiple read commands in one transaction for faster configuration uploads

Security
Robust, multi-tiered, and "always-on" security. Utilizes industry-standard, AES-128 block ciphers with symmetric keys. Multiple key architecture:

- Separate Join key per device
- Network key to authenticate Data-Link PDUs
- Session keys encipher network payloads ensuring private, un-molested communication between end-point devices. Point-point and broadcast sessions supported.

Key management is delegated to the user and may be as simple or complex as required by plant policy.

Only trusted devices allowed to join network. Trusted device identified by Join key and standard HART Identity data (i.e., Manufacturer ID, Device Type, Device ID, Tag, etc.).

SYSTEM INTEGRATION
Compatible with existing HART tools, applications and system integration technology.

- *Wireless*HART devices transparently and seamlessly integrate with the same host and control system applications as their wired counterparts.
- Gateways support integration at all system levels (e.g., via standard HART multiplexer protocols, PROFINET or PROFIBUS-DP).
- Field devices must include a maintenance port that allows connection of existing HART tools. Access to all parameters via the maintenance port is required.
- DDL is an optional but, core HART technology. All capabilities of *Wireless*HART devices can be supported and accessed using the device's DD., DD-enabled Applications (without modification) fully communicate with WirelessHART devices.

CONNECTING TO EXISTING HART DEVICES
*Wireless*HART Adapters provide support for connecting existing HART field devices to the wireless network:

- Point-point and multi-dropped HART field devices may be attached to any adapter and access to all sub-devices must provided
- *Wireless*HART Adapters provide data publishing services on behalf of their sub-devices even if the sub-devices do not support Burst-Mode.
- To support existing HART tools, adapters must operate both as a Token-Passing Master and Slave on the sub-device network
- *Wireless*HART Gateways are required to support the WirelessHART Adapter. The Gateway and Adapter collaborate to ensure transparent routing of messages to attached devices.
- *Wireless*HART Adapter can contain its own sensors or actuators in addition to the connection to existing HART devices.

TYPICAL APPLICATIONS

*Wireless*HART establishes new opportunities for process monitoring and control applications:

- Equipment and process monitoring;
- Environmental monitoring, Energy management, Regulatory compliance
- Asset management, predictive maintenance, advanced diagnostics; and
- Even closed-loop control (when appropriate);

Start small, grow big. Adding devices to the *Wireless*HART network actually improves the network and its communication reliability.