

## WIRELESS COMMUNICATION ADAPTER FOR FIELD DEVICES

### BACKGROUND

In industrial settings, control systems are used to monitor and control  
5 inventories of industrial and chemical processes and the like. Typically, the  
control system performs these functions using field devices distributed at key  
locations in the industrial process and coupled to the control circuitry in the  
control room by a process control loop. The term "field device" refers to any  
device that performs a function in a distributed control or process monitoring  
10 system including all devices currently known, or yet to be known, used in the  
measurement, control, and monitoring of industrial processes.

Some field devices include a transducer. A transducer is understood to  
mean either a device that generates an output signal based on a physical input or  
that generates a physical output based on an input signal. Typically, transducers  
15 transform an input into an output having different form. Types of transducers  
include various analytical equipment, pressure sensors, thermistors,  
thermocouples, strain gauges, flow transmitters, digital valve controllers,  
flowmeters, flow computers, positioners, actuators, solenoids, indicator lights,  
and others.

20 Typically, each field device also includes communication circuitry that is  
used for communicating with a process control room or other circuitry over a  
process control loop. In some installations, the process control loop is also used  
to deliver a regulated current and/or voltage to the field device for powering the  
field device. Process control loop also carries data, either in an analog or digital  
25 format.

Traditionally, analog field devices have been connected to the control  
room by two-wire process control current loops with each device connected to  
the control room by a single two-wire control loop. Typically, a voltage  
differential is maintained between the two wires within a range of voltages from  
30 12-45 volts for analog mode and 9-50 for digital mode. Some analog field  
devices transmit a signal to the control room by modulating the current running

through the current loop to a current that is proportional to the sensed process variable. Other analog field devices can perform an action under the control of the control room by controlling the magnitude of the current through the loop. In addition to, or in the alternative, the process control loop can also carry digital  
5 signals used for communication with field devices.

In some installations, wireless technologies have begun to be used to communicate with field devices. Wireless operation simplifies field device wiring and setup. However, the majority of field devices is hardwired to a process control room and does not use wireless communication techniques.

10 Industrial process plants often contain hundreds or even thousands of field devices. Many of these field devices contain sophisticated electronics and are able to provide more data than the traditional analog 4-20 mA measurements. For a number of reasons, cost among them, many plants do not take advantage of the extra data that may be provided by such field devices.  
15 This has created a need for a wireless adapter for such field devices that can attach to the field devices and transmit data back to a control system or other monitoring or diagnostic system or application via a wireless network.

In order to operate an industrial process plant, field devices must often carry hazardous location approval ratings. There are different types of ratings  
20 and, to be widely adopted, a wireless field device adapter should be able to attach to each such field device without compromising the hazardous location approval rating of that field device.

One of these approval ratings is known as an explosion-proof or explosion-protected rating. The purpose of an explosion-proof enclosure is to  
25 contain an explosion should flammable gas enter the enclosure and ignite. If the enclosure fails to contain the explosion, it could ignite surrounding gases with catastrophic results. One challenge facing wireless device manufacturers is how to propagate a wireless signal through an enclosure capable of withstanding explosive pressures. Such enclosures are often large and made of metals such as  
30 steel or aluminum. Currently available wireless transmission techniques include

thick glass antenna radomes or explosion-proof coaxial feed-throughs with energy limiting circuitry and fitted with relatively fragile “rubber duck” antennas. Plastic radomes alone are not believed to be capable of withstanding explosive pressures nor are they believed to meet the chemical, environmental, and impact resistance requirements of the approval agencies.

Another type of approval rating is known as intrinsic safety (IS). An intrinsically safe device prevents ignition of flammable gases by limiting the amount of energy present in the electronics and by ensuring that electronic components are spaced far enough apart to prevent arcing in the event of an electrical fault. The heat generated by electronic components is also controlled. Making the electronics of a device intrinsically safe tends to drive up the number of components as well as increase circuit board size. This also poses a challenge when the form factor of a device must be minimized.

In order for a wireless communication adapter to be used in explosion-proof installations, it must be explosion-protected itself and it must provide an explosion-proof barrier at the connection between the two devices. For an intrinsically safe installation, the wireless communication circuitry must be intrinsically safe as well. The ability to attach such an adapter to any device also drives the form factor. Industrial devices, such as field devices, can be installed in many configurations and are often disposed in tight spaces. This necessitates a small and unobtrusive design. To achieve this, it is beneficial for the antenna to be integral to the wireless communication adapter and for the circuit board size to be minimized. This complicates design for installations that require either explosion-proof certification or intrinsically-safe certification.

Providing a wireless communication adapter for field devices that is relatively small and unobtrusive yet still able to facilitate compliance with explosion-proof certifications and intrinsic safety would advance the art of wireless process communication.

## SUMMARY

A wireless process communication adapter is provided. The adapter includes a housing having a plurality of openings. An end cap is coupled to a first opening of the plurality of openings. A field device coupling is disposed at the second of the plurality of openings. The housing, end cap and field device coupling define a chamber therein. At least one circuit board is disposed within the chamber, the circuit board has wireless communication circuitry disposed thereon and is coupleable to a field device through the field device coupling. In one aspect, substantially all remaining volume in the chamber is filled with a solid material. In another aspect, an explosion-proof barrier is provided in the field device coupling. Combinations of the aspects are also provided.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of a process-wired field device operably coupled to the wireless communication adapter in accordance with an embodiment of the present invention.

FIG. 2 shows a simplified cross-sectional view of a field device and wireless process communication adapter in accordance with an embodiment of the present invention.

FIG. 3 is a cross-sectional diagrammatic view of a wireless process communication adapter in accordance with an embodiment of the present invention.

## DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Embodiments of the present invention generally provide a wireless transmitter that may be attached to a wired field device that is either explosion-proof or intrinsically safe without compromising approval ratings of such field device. The wireless communication adapter is configured to provide explosion protection and also preferably contain intrinsically safe electronics. The adapter

preferably includes an explosion-proof barrier at the connection point to the wired device and includes electronics that are fully encapsulated.

FIG. 1 is a diagrammatic view of a process-wired field device 12 operably coupled to a wireless communication adapter 14, in accordance with an embodiment of the present invention. While field device 12 is illustrated in FIG. 1 as a process fluid pressure transmitter, such as that sold under the trade designation Model 3051S, available from Emerson Process Management of Chanhassen, Minnesota, any suitable field device may be used. Typically, a field device includes a sensor module, such as sensor module 16, and an electronics module, such as electronics module 18. Further, as set forth above, field device 12 is often designed for compliance with explosion-proof regulations. Further, the design of electronics within field device 12 can be in accordance with an intrinsic safety requirement, such as one or more of the portions of the standard promulgated by Factory Mutual Research in October 1998 entitled APPROVAL STANDARD INTRINSICALLY SAFE APPARATUS AND ASSOCIATED APPARATUS FOR USE IN CLASS I, II, AND III, DIVISION 1 HAZARDOUS (CLASSIFIED) LOCATIONS, CLASS NUMBER 3610. Field device 12 typically includes a sensor, such as a pressure sensor, in sensor module 16 which transduces a process fluid characteristic, such as pressure, and provides an electrical indication of that process fluid variable to electronics module 18. Electronics module 18 then communicates process variable information over a process communication loop which typically couples via input 20.

As described above, it is becoming advantageous to provide additional communication abilities, such as a wireless communication ability, to process wired field devices. By providing a wireless process communication adapter, such as process communication adapter 14, additional digital information can be conveyed beyond that transmitted through the process wired connection. Such information may be communicated to a separate monitoring or diagnostic system or application for analysis. Further, the simple provision of an additional

communication resource, such as adapter 14, also allows for redundant communication. It is important for process communication adapter 14 to be coupleable to field devices without adversely affecting the assembly's ability to continue to meet explosion-proof and/or intrinsic safety requirements.

5           FIG. 2 shows a simplified cross-sectional view of field device 12 and wireless process communication adapter 30 in accordance with an embodiment of the present invention. Field device 12 is coupled to process communication loop 22 through input 20 and conduit 11. Examples of process communication loops include the Highway Addressable Remote Transducer (HART®) protocol and the FOUNDATION™ Fieldbus protocol. However, other wired process communication protocols are known. In the example of a process variable transmitter, field device 12 includes a process variable sensor 50 which is connected to measurement circuitry 52 to measure a process variable. Transmitter circuitry 54 is configured to receive the process variable and communicate the process variable onto the two-wire process control loop 22 using known techniques. Field device 12 couples to two-wire process control loop 22 through connection block 106. Wireless communication adapter 30 couples to two-wire process control loop 22 through connection block 106 and is mounted to the housing of field device 12, for example, through threaded connections 123 and 109. The chassis of the wireless process communication adapter 30 couples to an electrical ground connector 110 of field device 12 through wire 108. Field device 12 includes two-wire process connection block 102 which couples to connection 112 from wireless process communication adapter 30. Housing 120 of wireless process communication adapter 30 carries an antenna 126 which couples to wireless communication circuitry of the wireless process communication adapter 30. A radio-frequency (RF) transparent end cap 124 can be used to sealably couple to housing 120 to allow transmission of RF signals therethrough. In the arrangement shown in FIG. 2, five electrical connections are provided to the radio-frequency adapter, which include four loop connections along with an electrical ground connection.

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FIG. 3 is a cross-sectional diagrammatic view of a wireless process communication adapter in accordance with an embodiment of the present invention. As illustrated in FIG. 3, wireless process communication adapter preferably includes a cylindrical, metal enclosure 120 with a large opening 150 at one end to accommodate radio-frequency transparent radome or end cap 124, and a relatively small opening 152 at the other end to accommodate field device coupling 122. Electronics 154 reside within cavity 130 preferably on a pair of printed circuit boards 132, 134. The electronics preferably include wireless communication circuitry to allow wireless process communication adapter to communicate in accordance with one or more wireless communication protocols. Examples of suitable wireless process communication protocols include: wireless networking technologies (such as IEEE 802.11b wireless access points and wireless networking devices built by Linksys of Irvine, California); cellular or digital networking technologies (such as Microburst® by Aeris Communications Inc. of San Jose, California); ultra wide band, free space optics, Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS); Code Division Multiple Access (CDMA); spread spectrum technology, infrared communications techniques; SMS (Short Messaging Service/text messaging); a known Bluetooth Specification, such as Bluetooth Core Specification Version 1.1 (February 22, 2001), available from the Bluetooth SIG ([www.bluetooth.com](http://www.bluetooth.com)); and the Wireless HART® Specification published by the Hart Communication Foundation, for example. Relevant portions of the Wireless HART® Specification include: HCF\_Spec 13, revision 7.0; HART Specification 65 – Wireless Physical Layer Specification; HART Specification 75 – TDMA Data Link Layer Specification (TDMA refers to Time Division Multiple Access); HART Specification 85 – Network Management Specification; HART Specification 155 – Wireless Command Specification; and HART Specification 290 – Wireless Devices Specification.

The electronics on each circuit board 132, 134 are preferably mounted with spacing around them, and between the circuit boards, to facilitate flow of a

potting compound. With the enclosure sealed, a potting 136 is injected into chamber 130 through passageway 156 until the enclosure is full. Any suitable potting compound can be used, but it is important for the potting material itself to meet the requirements of the approval agencies, which include suitable chemical resistance, thermal endurance at hot and cold operating temperatures, as well as other relevant parameters. Radome 124, enclosure 120, and field device coupling 122 provide a weather-tight shell for potting 136.

Field device coupling 122 provides a method of attaching directly to field device 12. Feedthrough assembly 140 preferably also serves as an explosion-proof barrier at the connection point. If flammable gases enter the enclosure of the field device and ignite, feedthrough assembly 140 will contain the explosion. Wire leads 158, 160 pass through feedthrough assembly 140. The interior of the coupling is filled with a potting capable of withstanding explosive pressure. The interior of the coupling includes a shoulder 166 that helps retain the potting in the coupling. Field device coupling 122 can also include a union and/or elbow to provide adjustability, as desired. In one embodiment, the explosion-proof barrier is provided by running wires 158, 160 through a cemented joint 164 in feedthrough assembly 140. This cemented joint 164 is created by filling feedthrough assembly 140 with a potting capable of withstanding explosive pressure.

In another embodiment feedthrough assembly 140 can be constructed from a thermoset epoxy hollow cylinder 162. Wires 158, 160 are run through cylinder 162, which is then filled with potting 164. The feedthrough assembly 140 slides into field device coupling 122 with a shoulder 166 of field device coupling 122 bearing against a surface 168 of feedthrough assembly 140. The outside diameter of cylindrical feedthrough assembly 140 and the inside diameter of field device coupling 122 as well as the length of both are tightly controlled to maintain a gap 170 that is long and narrow enough to extinguish any burning gases trying to escape. The outside diameter of feedthrough 140 also preferably includes an O-ring 172 for environmental sealing.

Wireless process communication adapter 30 thus preferably uses encapsulation and adaptation of a feedthrough assembly to provide explosion and environmental protection and to reduce the spacing required between electronic components for intrinsic safety protection. Intrinsic safety spacing requirements are less stringent when the space between the components is filled with potting. This allows the entire device to be miniaturized more effectively. Encapsulation achieves explosion protection by excluding flammable gases entirely. The electronics of wireless process communication adapter 30 are completely surrounded by potting and therefore protected from the environment.

10       The plastic and potting each have strengths and weaknesses and are used together to compensate for the weaknesses of the other. The plastic can be used to provide a rigid shell and ultraviolet and flame resistance that are not available from most potting compounds. The potting supports the plastic from within, thereby improving its impact resistance. The potting provides chemical resistance required for agency approvals and renders the watertight and dust tight ratings moot, as it is virtually impossible for water and dust to reach the electronics. The potting also makes the electronics virtually immune to vibration and the tighter intrinsic safety spacing allows for smaller circuit boards. This design results in a compact package with only one explosion-proof joint where the leads exit process communication adapter 30. Antenna 126 is kept within the device, precluding the need for an external antenna with the explosion protection that entails.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A wireless process communication adapter comprising:  
a housing having a plurality of openings;  
5 an end cap coupled to a first opening of the plurality of openings;  
a field device coupling disposed at the second of the plurality of openings;  
wherein the housing, end cap and field device coupling define a chamber  
therein;  
at least one circuit board disposed within the chamber, the circuit board  
10 having wireless communication circuitry and being coupleable to a  
field device through the field device coupling; and  
wherein all remaining volume in the chamber is filled with a solid  
material; and  
wherein the field device coupling includes an explosion-proof barrier that  
15 includes a pressure-blocking feedthrough at a connection point.
2. The wireless process communication adapter of claim 1, wherein the  
wireless communication circuitry is intrinsically safe.
3. The wireless process communication adapter of claim 1, wherein the solid  
20 material is an epoxy.
4. The wireless process communication adapter of claim 1, wherein the  
housing is shaped cylindrically.
- 25 5. The wireless process communication adapter of claim 1, wherein the  
housing is constructed at least in part from metal.
6. The wireless process communication adapter of claim 5, wherein a chassis  
of the wireless process communication adapter is coupleable to an electrical  
30 ground of the field device.

7. The wireless process communication adapter of claim 1, wherein the at least one circuit board includes a plurality of circuit boards disposed parallel to one another and separated by a gap that is filled with the solid material.

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8. A wireless process communication adapter comprising:  
a housing having a plurality of openings;  
an end cap coupled to a first opening of the plurality of openings;  
a field device coupling disposed at the second of the plurality of openings;  
10 wherein the housing, end cap and field device coupling define a chamber therein;  
at least one circuit board disposed within the chamber, the circuit board having  
wireless communication circuitry and being coupleable to a field device  
through the field device coupling;  
wherein the field device coupling is configured to include an explosion-proof  
15 barrier; and  
wherein the explosion-proof barrier includes a pressure-blocking feedthrough at a  
connection point.

9. The wireless process communication adapter of claim 1 or 8, wherein the  
20 explosion-proof barrier includes a pressure-blocking feedthrough.

10. The wireless process communication adapter of claim 9, wherein the  
pressure blocking feedthrough includes a surface that bears against a shoulder of  
the field device coupling.

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11. The wireless process communication adapter of claim 9, wherein the  
pressure-blocking feedthrough has an outer diameter that cooperates with an inner  
diameter of the field device coupling to form a gap sized to extinguish burning  
gasses.

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12. The wireless process communication adapter of claim 1 or 8, and further comprising an o-ring disposed about the field device coupling.

13. The wireless process communication adapter of claim 1 or 8, wherein the  
5 explosion-proof barrier includes a cemented joint passing conductors  
therethrough.