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# Integration and Management of Wired/Wireless Networks Based on the HART Concept

***Abstract***. *This paper describes integration and management of wired/wireless networks in industrial plants. First, the technical requirements that justify the need for integration of wired HART devices with WirelessHART network within a modern control system in the process industry with already installed devices are specified. Then, model of integrated wired/wireless network was designed and for the same model diagrams of communication between nodes obtained using TrueTime simulator are shown. Obtained experimental results of planning and management of integrated industrial network using Emerson's AMS Wireless SNAP-ON application, which justify the use of wireless adapter for integration HART devices with WirelessHART network, are shown at the end of the paper.*

***Streszczenie***. *Opisano zarządzanie siecią przemysłową przewodową i bezprzewodową. Do zarządzania wykorzystano interfejs HART. (**Zarządzanie przemysłową siecią przewodową i bezprzewodową z wykorzystaniem interfejsu HART**)*

**Keywords:** HART, WirelessHART, Wireless THUM Adapters, AMS Wireless SNAP-ON.
**Słowa kluczowe:** interfejs HART, sieci bezprzewodowe, sieci przemysłowe

## Introduction

Industrial communication networks have come a long way since the first attempts of networking in the industrial environment to a modern highly specialized automated networks. Nevertheless, industrial communication networks are always designed to improve efficiency and from the two main aspects:

- Efficiency in terms of transmission, ie. transfer of data.
- Efficiency in design and implementation of protocols.

These two aspects have led to the development of concepts that are very unusual when it comes to industrial communication networks and represent a fundamental differences from the LAN (Local Area Network) [1]. Process automation system is a set of subsystems that include controllers, interfaces and application processors. From the technological side, the communication medium allows further innovations. So far the focus was on the wired medium because it is the dominant solution. Optical medium is used for electromagnetically disturbed environments and for long distances because it allows greater cable lengths with a lower price. The future research that is the most promising technological development is the wireless domain.

One way to connect the HART (Highway Addressable Remote Transducer) devices with WirelessHART network is the use the conventional adapters. Gateway can also be used as an integrator. But if the safety and reliability are the main goals of integration, the use of special adapters as integrators is a better choice from the following reasons [2]:

- The adapter is designed to allow connection to multidrop architecture in which more than one device can be connected to the power loop and then to an adapter, while in the point to point architecture can be connected only one device to the power loop.
- Unlike the gateway, the adapters are portable and change in physical location does not require additional cabling.
- Adapters can be connected to any HART components, but security will be greater if the adapter is connected directly to one of the devices.
- If the gateway is used for integration its architecture is more complex and more expensive.

These reasons justify the usage of adapters for secure integration of HART devices with WirelessHART networks.

## Integration of HART devices with WirelessHART network

A large number of wired HART devices is on the market or are installed in the industry. They are digitally connected to be able to completely rely on diagnostic informations that are carried by a digital signal. Due to previous, WirelessHART protocol provides alternative support for these devices. It upgrades them with the IEEE 802.15.4 radio conection, so as not to become useless in modern WirelessHART networks [3]. With the fact that millions of HART devices are already installed on the ground their integration into WirelessHART networks is more important. In a completely new installations it can be thrown out 4-20mA cable and HART devices can be made completely wireless devices. So, the devices can be powered by: battery, solar energy, energy of plant, surrounding energy etc. Despite to all these changes on the wired devices in the control room remain the classic HART applications [4]. One of the reasons that the HART standard is commonly applied in relation to other communications between devices in the process industry is its ease of installation. With the ability to combine old and new devices, HART standard enables to be applied wireless network where it is needed or where is deemed to be simpler than wired network. WirelessHART protocol provides a straightforward, easy, reliable and secure way to integrate HART devices with WirelessHART network using adapters. Adapters are elegant and reliable solution that can be used to connect one or more HART devices with WirelessHART network.

## The WirelessHART Adapter

WirelessHART standard defines the type of device known as adapter that plugs into a standard HART device and together they act as WirelessHART device (Fig. 1). Adapter consists of the following components [4]:

- FSK (Frequency Shift Keyed) port for connection to a HART device.
- WirelessHART antenna that is used to represent the newly formed WirelessHART device in the network.
- FSK port for external connection for connecting a wired HART interface of the newly formed Wireless HART device.

All already installed devices within a modern control system in the process industry in the HART network (Fig. 2) are specifically addressed as subdevices of adapter, and thanks to this device can communicate over WirelessHART network [2]. The result is that devices in a HART network

become part of the WirelessHART network with full access to information such as:

- Process variables (each instrument can provide up to 4 process variables).
- Diagnostic messages (valve operations and the status of the instrument).

Typical engineering work phases during using adapter as a network integrator in the WirelessHART network are:

- Connection of the adapter.
- Setting of parametars of the adapter

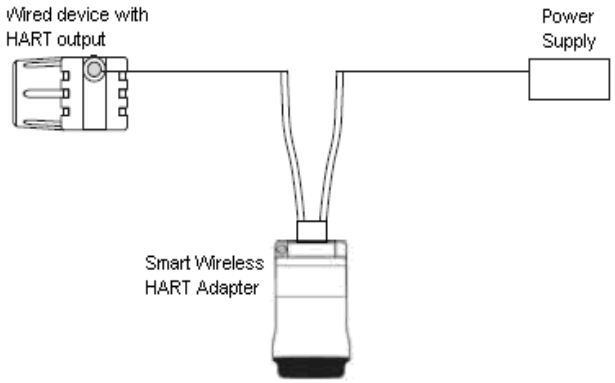


Fig. 1. The WirelessHART Adapter [5]

In the case when the adapter is used for obtaining diagnostic information, engineering work phases are very similar, but instead of instrument process variables is sent the status. When used WirelessHART Adapter and connected instrument it is necessary to set some additional parameters using the existing HART configurator or PC (Personal Computer) HART configuration program with the updated DD (Device Description) installation [2-4].

WirelessHART Adapter at the start of work communicate with a HART device to retrieve the necessary information about the device, such as ID (Identifier), tag of device, and then assumes the identity of the device and then is waiting to be initialised either through an external FSK port or from wireless network [4]. Also, it performs all wireless and wired HART commands, so that it can if necessary to send the appropriate command to HART device to retrieve additional information. If we need to develop complete WirelessHART device from plain wired device, the adapter might be part of the solution, so as to eliminate the FSK port and connect the motherboards of device and adapter into a single board and keep most of the software of adapter [4].

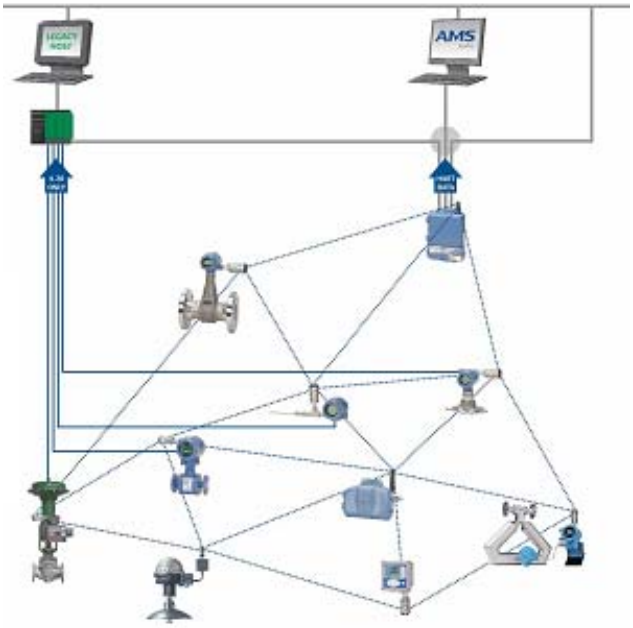


Fig. 2. Integration of HART devices with WirelessHART network [6]

**Design and implementation of model**

The model of integrated wired/wireless network (Fig. 3) was designed using the TrueTime simulator (that is freeware and can be downloaded from www.control.lth.se/truetime). The model contains three network devices, or nodes, each of which is represented by TrueTime kernel. Using True Time Network and Wireless Network Blocks [7] it is allowed wired and wireless communication between nodes.

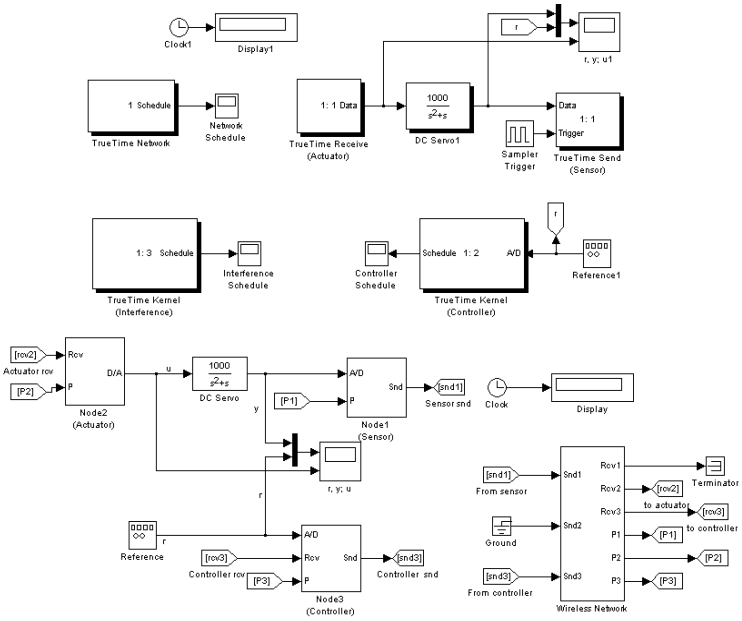


Fig. 3. Model of integrated wired/wireless network

It is necessary to ensure the user enters into the network through the user interface before simulation of the network [8]. A number of realized communication links between devices in one communication circuit is shown in Fig. 4. The meaning of individual blocks is as follows:

- The first processing block allows the user to define the number and length of each super frame in the network. All super frames are of different length.
- The second block allows the user to define the number of sensors and actuators in the network and the number of control loops in the network.
- The third block allows the definition of dependent input and output for each of the control loops. The dependent input is data obtained by the sensor device for which control signals are to be calculated.
- The fourth block is allocating to each device in the network the time slot in the appropriate super frame.
- The fifth block allows the tabular presentation of the status and details of each time slot of all super frames.
- The sixth blocks allow to view information on the allocation of the task performance of certain devices in the network, as well as on errors and warnings.

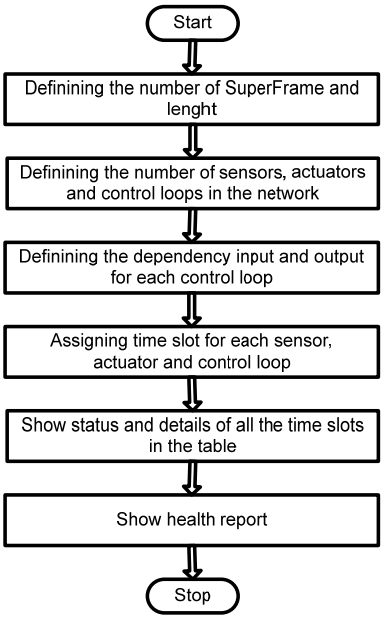


Fig. 4 User Interface Architecture

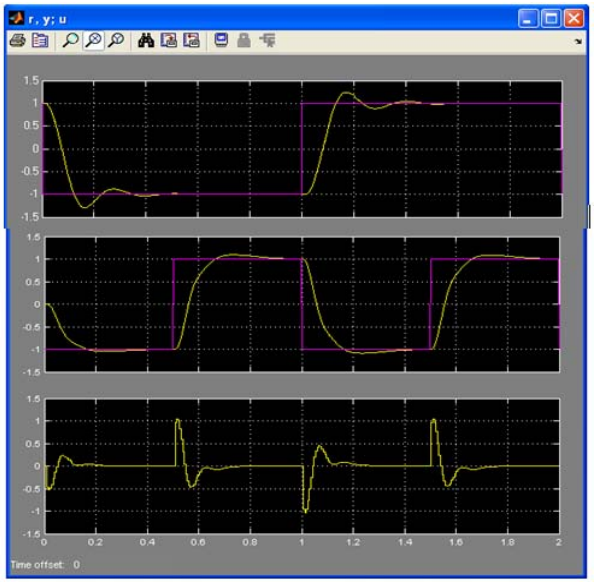

Fig. 5 Simulation results for wireless/wired communication

**The Simulation results**

It is open the window as shown in Fig. 5. if the simulator does not report errors when is started simulation by double click on the oscilloscope in the model. The new open window allows to monitor the results of the simulation of data transfer on the model of control system for wired and wireless communications.

In this control system it is only one loop in which sensor sends readings off to gateway which is responsible for communication with the controller using the protocol for the wire data transfer and for the sending control signal to the actuator using the wireless network.

As it is shown in Fig.6., in the first time period sensor (S) sends readings off to the gateway (GW) and in the second time period gateway sends the control signal to the actuator (A). Controller (C) executes the command between time periods of duration of tasks of sensor and actuator [9].

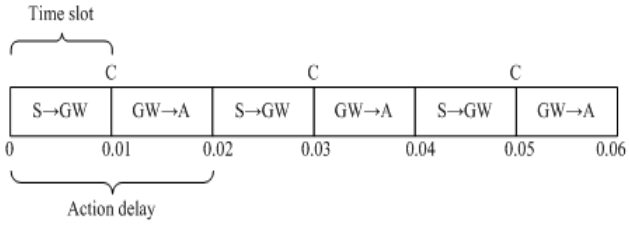


Fig. 6 Illustration of communication [9]

From the Fig. 6. it can be noticed that the controller is not needed time space for the execution of task. That is because of the fact that the controller with gateway communicates across the wire. If it is the run time of task of controller equal to the total time period (10 ms), the best is to give one free period between the reading off and reaction in order to enable that the controller finishes its calculations [9].

**Planning and managing of integrated industrial network**

By incorporating an open WirelessHART protocol and industrial Wi-Fi (Wireless-Fidelity) standard in Emerson's AMS Wireless SNAP-ON$^{TM}$ Application it is obtained insight that provides to achieve control performance assessment of industrial plants [10]. Contrary to most approaches to wireless networks in plants that require a direct line of sight between the instruments and communication devices, Emerson's Smart Wireless approach ensures the highest integrity of the network allowing all devices communicate with each other. AMS Wireless SNAP-ON$^{TM}$ Application gives a comprehensive presentation of self-organizing network and helps identify potential problem places such as obstacles between the transmitters and signal loss, and the communication link in that case is realized through other neighboring device [10]. After completing the planning of industrial network, the AMS Wireless SNAP-ON$^{TM}$ Application checks the integrated wired/wireless network of installation and graphicaly displays variations of the parameters that are set to the following values:

- 25% of wireless devices in the range of the gateway.
- Minimum of 2 wireless devices in the network.
- Any device with an external antenna has two wireless devices in range.
- Each Smart Wireless THUM$^{TM}$ Adapter has two wireless devices in range.

To network be correct, as shown in Fig. 7, within the range of each wireless device should be placed at least two devices to meet the planned parameters that also dictate the number of redundant paths in case of lose of the signal. As this are self-organizing networks, which are specific in that it is more wireless devices in the network, it expands easier because there are more available lines for additional

communication. In other words, the network simple notices that the new device is connected to the network and routing algorithm in the device and the gateway automatically finds the best path to destination [4].

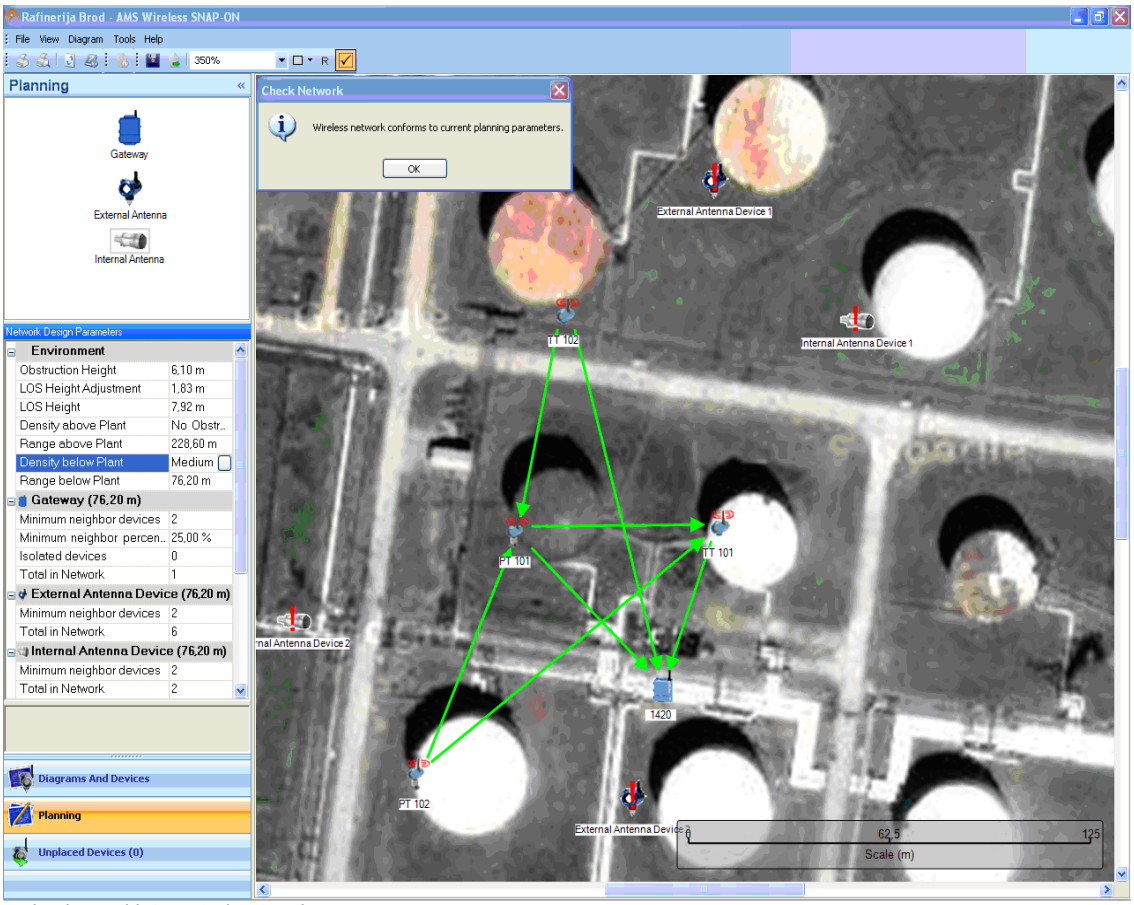


Fig. 7 Properly planned integrated network

When it is finished installation of wireless adapter for integration of HART devices in WirelessHART network, the AMS Wireless SNAP-ON™ Application gives a written message on the screen about proper planning and management of integrated industrial network [10], as is shown in Fig. 7. Finally, the resulting industrial communication network can be exported and included in project documentation.

## Conclusions

WirelessHART networks are very much rely on existing HART technologies and infrastructures so that they can perform all actions sa wired HART network. That allows a transparent integration of wireless and wired devices in the process industry or addition of wireless technology to existing or new network installation.

It can be concluded that the obtained experimental results for planning and management of integrated industrial networks justify the usage of wireless adapter for integration of HART devices with WirelessHART networks. In fact, wired HART device can communicate with conventional HART applications through the WirelessHART network. So it completly becomes member of WirelessHART network providing access to variables and parameters of installed wired HART device.

## REFERENCES


[1] Richard Zurawski, The industrial communication technology, Handbook, Taylor&Francis Group, 2005.

[2] HART Communication Foundation, WirelessHART Adaptor, HCF LIT-134, March 2010.

[3] Shahid Raza, Secure Communication in WirelessHART and its Integration with Legacy HART, Technical Report, Swedish Institute of Computer Science, Sweden, January 2010.

[4] Deji Chen, Mark Nixon, Aloysius Mok, WirelessHART: Real-Time Mesh Network for Industrial Automation, ISBN: 978-1-4419-6046-7, Springer 2010.

[5] Emerson Process Management, Avoiding HART loop interference when using the Smart Wireless THUM™ Adapter, White Paper, March 2011.

[6] Emerson Process Management, Smart THUM™ Adapter - Unlock the Value in Your Existing Field, Brochures 2009.

[7] Andersson, M., D. Henriksson, A. Cervin, TrueTime 2.0 beta—Reference Manual, Department of Automatic Control, Lund University, Sweden, January 2009.

[8] Kunjesh Shah, Design and Implementation of a simulator in support of WirelessHART-based control systems development, Masters Thesis, Jönköping University, School of engineering, Sweden, 2009.

[9] Mauro de Biasi, Implementation of a WirelessHART simulator and its use in studying packet loss compensation in networked control, Masters Thesis, Stockholm, Sweden, February 2008.

[10] Emerson Process Management, AMS Wireless SNAP-ON™ Application, Product Data Sheet, December 2008.



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