IMPLEMENTATION OF WIRELESS HART TECHNOLOGY FOR LIQUID LEVEL CONTROL AND MONITORING

HAMK
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Bachelor's thesis

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ABSTRACT

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ABSTRACT

Wireless communication is emerging from the office world to the industrial world. Since industrial communication underlies stricter conditions than office communication. It is important that some technicalities are applied by the users of wireless communication in industrial environments.

This thesis project work was about remote control of liquid levels in industrial tanks and processes of P&G Nigeria Limited, with the practical aspects implemented by Hamk University of Applied Sciences, Automation Engineering Department.

The project was brought about because of the lingering challenges the commissioning company had to correctly account for its inventory in diesel and water utility due to spillages, unsafe work processes and technical errors.

This project was planned to tackle these issues and many more by implementing systemic approaches using wireless Hart technology together with other field devices.

Pages 42 p. + appendices 9p.

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1 INTRODUCTION

The project deals with the problems encountered in accurately monitoring and controlling liquid levels in industrial processes, which could also have relevance in other fields depending on what they are used for. Considering the relevance of wireless communication which is today moving from the credence of offices to industrial processes, it is therefore an opportunity for those who know the technicalities surrounding the usage to utilize this for industrial purposes, knowing full well that the industry plays a vital role in office utilization. This documentation covers the usage of RF and radio terminology, boundary conditions for RF in an industrial environment, modern radio technology and standards, media access and networking and conditions for using wireless technologies in industrial applications.

There are some underlining fundamentals of process measurement which cannot be under emphasized. In general level measurements are typically used to determine the volumes of tanks, vessels or silos. Level measurements are used for controlling purposes. Liquid flow velocity in the emptying vessel pipe is depending on the surface level of the vessel.

“In the filling or emptying of the vessel in addition to level measurement , specific point value may be needed, it could be upper or the lower level limits in vessels or silos, these levels can be gotten by means of switches. Relatively it finds its application when the vibrating level switch is utilized.

The sensors fork vibrates at its intrinsic frequency. This frequency is reduced when immersed deeply in liquid which invariably translate to a change in frequency activating the limit switch. They could also come in the form of Mechanical float, optical, capacitive, vibrating, ultrasonic, and nuclear.”(Tikka A. 2012).

1.1 The Commissioning Company

‘‘Procter and Gamble is an American multinational consumer product manufacturer with its headquarters in Cincinnati U.S.A and branches in every continent. It was founded on the 31st of October, 1837 by William Procter, an English candle maker, and James Gamble, an Irish soap maker who was married to two sisters, Olivia and Elizabeth Norris. Alexander Norris, their father-in-law, called a meeting in which he persuaded his new sons-in-law to become business partners.’’
(P&G New Hire Employers Handbook. 2008).

Procter & Gamble is a member of the U.S. Global Leadership Coalition, a Washington D.C based coalition of over 400 major companies and NGOs that advocates for a larger International Affairs Budget, which funds American diplomatic and development efforts abroad. The Nigeria plant is classified as a part of the Middle East and Africa (MEA) section of the company. The production plant is located in Ibadan, Oyo state while the general office is located in Lagos State, South west of Nigeria. Its major function is product supply to the sub-Sahara African countries.

The Ibadan plant is divided into nine departments – Human resources, Plant Finance, Material Management Organization, Healthcare, Feminecare, Babycare, Engineering (Utility and Facility) Fabrics and Home care, Technical support Organization and Customer service.

There are about five hundred employees in the Ibadan plant and about ninety percent of them have an engineering background. The Engineering department is divided into two departments: Utility and Facility department. Utility department consistently supports operation lines with Compressed air, Power supply, and HVAC.

1.2 Terminology

- "**RF** is the word used for radio frequency, is the rate of oscillation in the range of about 3 kHz to 300GHz, which corresponds to the frequency of radio waves and the alternating current which carry radio signals, **RF** usually refers to the electrical rather than mechanical oscillations, although **RF** systems do exists. It also refers to radio to describe the use of wireless communication.'' (ISO/IEC 14443-2 Radio frequency power and signal interface).

- **DDL** stands for Device Description Language which describes specific features and functions of a device including details of menus and graphic display features to be used by host applications (including handled devices) to access all parameters and data in the corresponding device.

- **TSMP** stands for **Time Synchronized Mesh Protocol**. it was developed by Dust Networks as a communication protocol for self-organizing networks of wireless devices called motes. TSMP devices stay synchronized to each other and communicate in timeslots, also to other TDM (time/division multiplexing) systems.

- **"TDMA** stands for **Time Division Multiple Access** (TDMA) is a channel access method for shared medium networks. TDMA is used in the digital 2G cellular systems such as Global System for mobile communication (GSM)." IS-136

- **FHSS** is an acronym for **Frequency-hopping spread spectrum** (**FHSS**) is a method of transmitting radio signals by rapidly switching a carrier among many frequency channels, using a pseudorandom sequence known to both transmitter and receiver. It is utilized as a multiple access method in the frequency-hopping code division multiple access (FH-CDMA) scheme.

- **DSSS** is an acronym for direct-sequence spread spectrum (DSSS) is a modulation technique. As with other technique spread spectrum technologies, the transmitted signals that modulates the carrier or broadcast frequency. The name 'spread spectrum' comes from the fact the carrier signals occur over the full bandwidth (spectrum) of a device's transmitting frequency. IEEE 802.11" (http://en.wikipedia.org/wiki/Radiofrequency)

- **"AMS** is an acronym for Asset Manager Software it is plant asset management software of Emerson process management which provides a single application for predictive diagnostics documentation, calibration management and device configuration for managing field instrument and digital valve controllers. AMS Device is based on open communication standards, and is a core component of the plant web digital plant architecture".
  (2012 HART Communication Foundation (www.hartcomm.org))

1.3 Objectives

The utility department of P&G Nigeria Limited is facing challenges in accurately accounting for the diesel inventory involving losing money, a high inspection time in monitoring and refilling the tanks, fatigue and unsafe work processes.

The objective of this thesis was to improve the work processes, reduce the inspection time, eliminate fatigue and save on the costs of management in an industrial process by utilizing wireless network as a means of diagnosing the liquid levels in the industrial processes of P&G Nigeria Limited.

2 TECHNICAL DOCUMENTATION

2.1 Radio Frequency

"The radio waves are part of the electromagnetic spectrum, covering several other parts of radiation like light, gamma rays etc. therefore, the propagation of radio waves can generally be compared with the propagation of light. Light moves straight through space and material (glass), can be damped (either through materials like fog or simply by distance), be reflected (on mirrors), be absorbed."
(ISO/IEC14443-2:2001 Identification cards)

Radio waves can also penetrate material, be reflected or absorbed. Due to a different frequency (radio waves are of much lower frequency of light), the penetration of material is better. Radio waves can even penetrate walls if not too massive. Radio waves are damped by material and by distance, radio waves will be absorbed by massive material and do not penetrate them anymore, they are reflected on the surfaces or obstacles. In general the propagation goes undisturbed in open and damped by distance, the farther the distance the damper it becomes.
(Husu M. 2010).

Table 1 Frequency Spectrums (ISO/IEC14443-2:2001 Identification cards).

Frequency	Wavelength	Designation	Abbreviation
3-30Hz	10^4 – 10^5 km	Extremely low frequency	ELF
30-300Hz	10^3– 10^4 km	Super low frequency	SLF
300-3000Hz	10 – 10^3 km	Ultra low frequency	ULF
3-30kHz	10 – 100 km	Very low frequency	VLF
30-300kHz	1 – 10km	Low frequency	LF
300kHz-3MHz	100m – 1km	Medium frequency	MF
3 -30MHz	10 – 100m	High frequency	HF
30-300MHz	1 – 10m	Very High frequency	VHF
300MHz-3GHz	10cm– 1m	Ultra High frequency	UHF
3-30GHz	1m – 10cm	Super High frequency	SHF
30-300GHz	1mm-1cm	Extremely High frequency	EHF
300-3000GHz	0.1mm-1mm	Tremendously High frequency	THF

2.2 Radio Technology

To enable the receiver and the sender communicate properly there must be agreed frequency. This frequency will be in one of the bands reserved for radio communications. The bands are regulated by official agencies and the usage of these bands is therefore restricted. In most bands, a license must be obtained to allow usage of it. The regulations are different from country to country. The exceptions for licensed usages are ISM bands (Industrial, Scientific, Medical). In these bands anyone is allowed to send and receive according to some restriction like sending power. The only worldwide usable band for ISM is 2.4GHz.

Now, in this band single channels are established. This can either be a single frequency (like 2.45GHz) or a frequency range, e.g. 2.407 to 2.447 GHz. This is a difference of 40MHz. This range is called bandwidth. As higher the bandwidth, as more data can be transmitted. Using the higher bandwidth, one speaks also of spectrum usage. Spectrum usage can either be in sequence like FHSS, or simultaneously as FSSS uses a single frequency at a time and another frequency during the following transmission. So, the whole spectrum is used, but not for one transmission but for consecutive. Since the sequence of the single channels is unknown, it is hard to tap these transmissions and due to the short peaks of transmission, the disturbance of other radio systems is reduced.

2.3 Boundary Condition For Radio frequency In Industrial Communication

The general properties of radio frequency do of course apply in industrial environments. Three main effects have to be taken into account in industrial environments.

- Interference
- Moving equipment
- Multipath fading

Interference takes place wherever a wave is reflected or is superimposed by another wave which could either have a positive or negative effect.
The second effect is that industrial environments are not static but dynamic. Vehicles, moving equipment such as tanks, people walking through will change the environment. Therefore the propagation of radio waves is altered.

The third effect is multipath fading. Due to reflections, one wave is moving on different paths from the sender to the receiver and arrives there then lightly time shifted. This can distort the wave so the receiver does not recognize it anymore.
As a result of these three effects two main consequences must be taken into account when applying wireless communication in industrial environments.

- Range
- Reliability

The range is decreased compared to the theoretical free space propagation. Moving equipment and changing environment decrease the reliability of radio communication. A connection working at one time may not work if a truck is standing in the way and it decreases the reliability.
(Hart Communication Foundation 2012).

2.4 Modern Technology & Standard

To enable radio communication, a different common standard is mandatory. The standard makes devices of different vendors compatible to each other and enables easy to use technology. Currently, in the 2.4GHz Band there are three major known standards available.

They have been defined by IEEE in the family of communication protocols and are worldwide used.

- **IEEE 802.11(Wi-Fi)**
- **IEEE 802.15.1(Bluetooth)**
- **IEEE 802.15.4(ZigBee)**

One of the most widely used is **IEEE802.15.11**, commonly known as WLAN or Wi-Fi (even if this is not 100% correct). **IEEE802.11** provides a local infrastructure for wide wireless transmission of relative amount of data over some distance like office areas or home network.**IEEE802.15.1** is known as Bluetooth. This provides a personal area network for cable replacement of auxiliary devices and is able to transmit some less data than WLAN over very limited range. This is also called WPAN (Wireless personal Area Network). **IEEE802.15.4** is the basic for network like ZigBee, where very limited data is transmitted over a medium distance through a network of knots so the covered area is extended.

2.5 Media Access & Networking

All the standards described above have to access the same air. If all participants access this at the same time, collisions of communication will occur. Therefore, the media access must be coordinated.
There are two principles used to coordinate media access

- TDMA (Time Division Multiple Access)
- CSMA(Carrier Sense Multiple Access)

TDMA enables the data to be transferred at a given time slot. This way all the participants in a network know the time slot when to send and to receive messages and avoid collisions.

CSMA on the other hand avoids collisions with random delay times after a free channel is recognized. So if a channel is to be free, every participant waits another random time and it is very unlikely that the next sent package collide." (HART Communication Foundation, 2010).

The other thing which is relevant in terms of the standards described above is how the network is organized. There are three basic layouts of networks.

- Star
- Mesh
- Star-Mesh or Hybrid

Using star topology, each wireless sensor end point sends data directly to the gateway as seen in Figure1. From the gateway data is sent to other systems. Star networks offer the fastest data gathering speed, but all participants must be in the communication range of the gateway. This topology suits installations that need the lowest power consumption over a limited geographical range

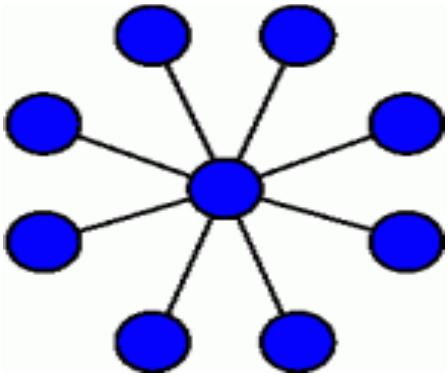

Figure 1 Star Topology.

In mesh networks, each wireless sensor acts as a router, sending and receiving data from other sensors or the gateway as seen in Figure 2. Self-

configuring networks automatically determine the best path for data to take from sensor to gateway. Data is automatically sent around failed sensor routers. This layout is good for wide area networks with high redundancy, but enough power for all participants is available to route the messages.

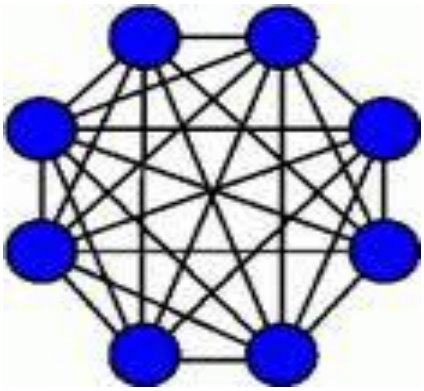

Figure 2 Mesh Topology.

Star-mesh networks combine star and mesh topologies to gain the speed of the star network with the self-repairing capability of the mesh network. As seen in Figure 3.Sensor may be either end points or routers, depending on where they are used in the system.

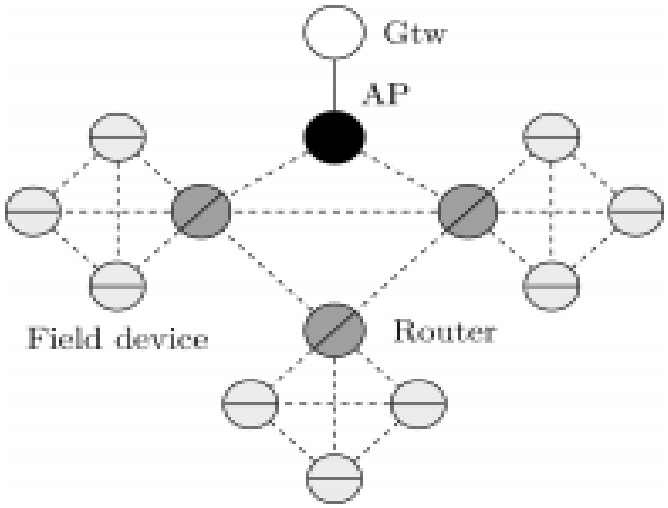

Figure 3 Star-Mesh Topology

2.6 Condition For Using Wireless Technology In Industrial Communication Application

If an office application wireless system loses a package even once in a while, it is resent and therefore the loss is not recognized by the user. Contrary to this, industrial applications rely on secure data transmission. In some cases comparisons can be made, e.g. to parameterize devoices or for asset management applications. But closed control relies on strict data transmission defined as Bit Error Rate, or how many Bits are not transmitted correctly in a number of Bits. The better the BER, the better the reliability of the data transmission. A wired transmission usually has a BER. So with correction algorithms a better BER is possible, but the algorithm needs time to find out and correct the faulty message. If the message is too disrupted, the message cannot correct the faulty message. The message cannot be reconstructed and a resending might be necessary. This delay the data transmission and a closed loop control could get out of phase. (Emerson Process Management, 2010).

2.7 Pros And Cons Of Wireless Communication

As with any new technology, wireless communications offer both advantages and disadvantages

- Mobility
  - ✓ Freedom to move about without being hindered by wires
  - ✓ Permits many industries to shift towards an increasingly mobile workforce
  - ✓ Gives team-based workers the ability to access the network resources
- Easier and less expensive installation
  - ✓ Installing network cabling in older building can be difficult, slow and costly task

- ✓ Makes it easier for any industrial relocation or modernization.

- Increased reliability
  - ✓ Networking cable failures may be the most common source of network problems

- Disaster recovery
  - ✓ In the event of a disaster, proactive relocation is easy.

On The Other Hand the Disadvantage of Wireless Communication

- Radio signal interference
  - ✓ The possibility for two types interference exits
- Security
  - ✓ It is possible for an intruder to be lurking outdoors with a notebook computer and wireless NIC with the intent of intercepting the signals from a nearby wireless network.
  - ✓ Some wireless technologies can provide added levels of security

- Health risks
  - ✓ High levels of RF can produce biological damage through heating effects
  - ✓ Wireless devices emits low level of RF while being used

(Heikkila M. 2009.)

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3 WIRELESS HART ™ DEVICES

Wireless HART ™ devices can be divided into communication and field devices. Communication devices comprise of gateway, adapter units and field devices comprising of other devices in industrial process.

- **Gateway** it enables the connections to the host network. Wireless HART and the main host interfaces such as Modbus-Profibus-Ethernet. The gateway also provides the network manager and security manager.
- **Network Manager** builds and maintain the mesh network, it identifies the best paths and manages distribution of slot time access (Wireless HART divides each second into 10msec slots) slots access depend upon the required process value refreshed rate and other access (alarm reporting-configuration changes).
- **Security Manager** manages and distributes security encryption keys. It also holds the list of authorized devices to join the network.
- **Process** includes measuring devices- the HART-enabled instrumentation.
- **Repeater** is a device which routes wireless HART messages but may have no process connection of its own. Its main use would be to extend the range of a wireless HART network or help ”go round” an existing or new obstacle(new process vessel). All instruments in a wireless HART network have routing capability which makes planning and execution of wireless network simply.
- **Adapter** is a device that conveys the instrument data through a wireless HART network by plugging into an existing HART-enabled network to the host. The adapter could be located anywhere along the instrument 4-20mA cable; it could be battery powered or obtain its power from the 4-20mA cable. Some adapter will be powered and use the same battery to power the instrument as well – in this case there will be no 4-20mA signal to the host-all process data will be reported via wireless HART.

- **Handheld Terminal** may be come in two versions. In the first case, the handheld will be a standard HART FSK configuration unit (just add new device DDs or DOF files), just like the one used for everyday tasks such as routine maintenance and calibration checks. In the case of wireless support, the handheld is used to join a new instrument to an existing wireless HART network. In the other case the handheld has a wireless HART connection to the gateway and then down to an instrument and could be used for reading PV or diagnostics.
  (Hart Communication Foundation 2012).

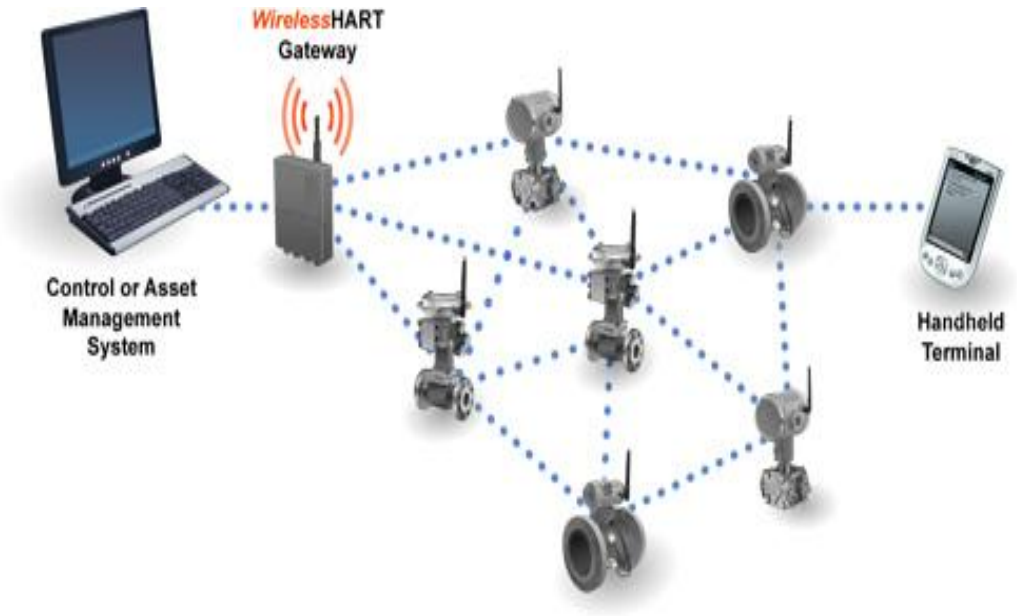

Figure 4 Wireless Hart Connections

3.1 Hart Protocol

HART is an acronym for **Highway Addressable Remote Transducer**. The HART protocol utilizes the Bell 202 Frequency Shift Keying (FSK) standards to superimpose digital communication signals at a low level on top of 4-20mA.

The HART protocol provides two simultaneous communication channels: the 4-20mA analog signal and digital signal. The 4-20mA signal communicates with the primary measured value (in the case of a field instrument) using the 4-20mA current loop-the fastest and most reliable industry standard. Additional device information is communicated using digital signal that is superimposed on the analog signal.

The digital signal contains information from the device including device status, diagnostics, and additional measured or calculated values. Summarily, the two communication channels provide a low-cost and very robust complete field communication solution that is easily utilize and configure.

HART Technology is a master/slave protocol, which means that a smart field (slave) device gives a signal only when it receives a command from the master. The HART protocol can be used in various modes such as point-to-point or multidrop for communicating information to/from smart field instruments and central control or monitoring systems.

(Hart Communication Foundation 2012).

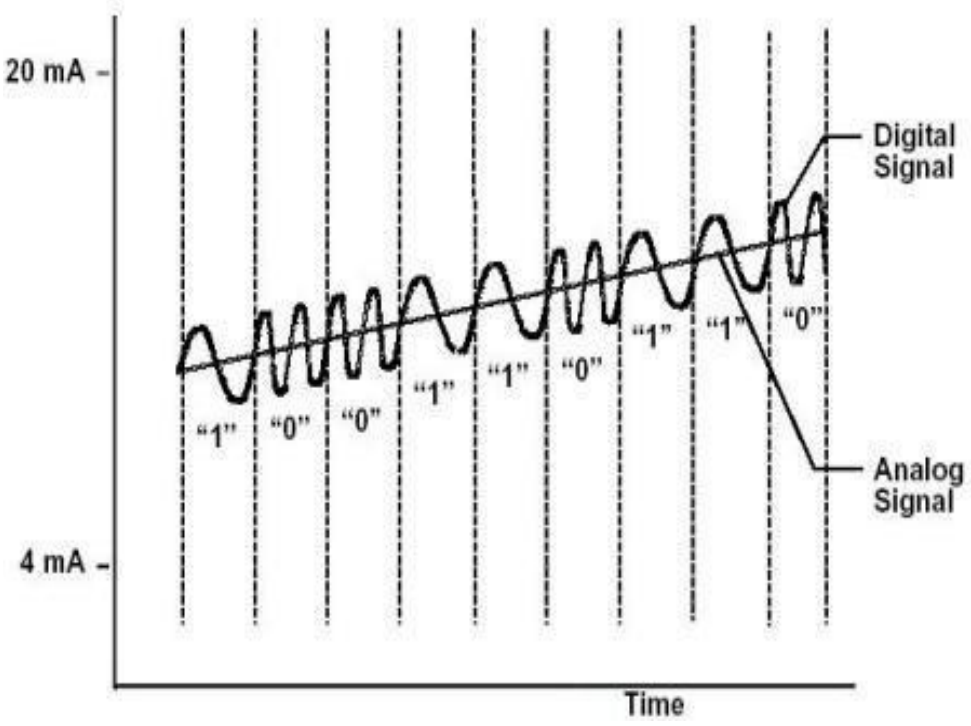

Figure 5 Frequency Shift Keying (FSK)

3.2 Protocol Structure

Wireless protocol is structured in loops, where each sensor works as a router or as a repeater. So, the range of a network does not depend only on a central gateway and allow the configuration of a wide distributed network structure. This is a proactive way to ensure that the system is reset and given alternate routes, In case of obstruction that could interrupt a communication channel, thereby enhancing network availability.

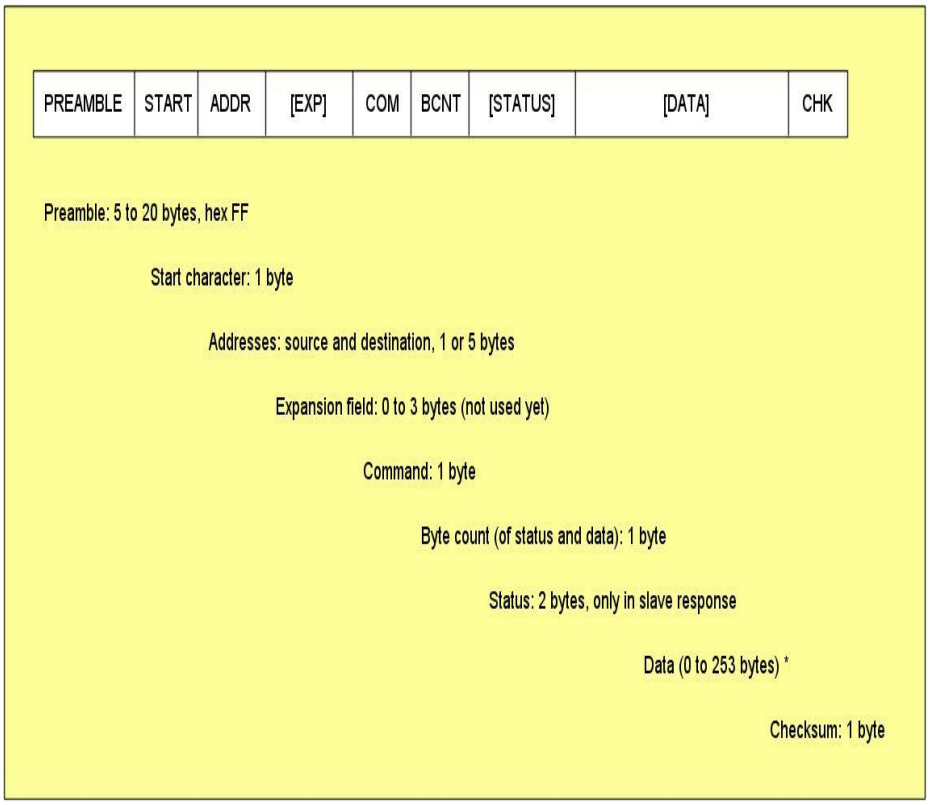

Figure 6 Hart Structure

From the above structure HART protocol uses the OSI reference model (Open System Interconnection State reference Model). As most of the fieldbus, HART use only three of the seven OSI layers of physical, transport and application layers. The layers 3 to 6 are not used, because their activities are not needed or are included in the layer 7 which is an application part.

3.3 Hart Signal

HART signal is a special features of low level modulation superimposed on the on the 4-20mA current signal which is widely used for such measurements. Because the HART signal is small and composed of sine waves, its average value is zero and does not significantly affect the accuracy of the analogue current signal, which can therefore still be used. This provides compatibility with existing systems, while allowing simultaneous digital communication for device configuration, status checking diagnostics and so forth.

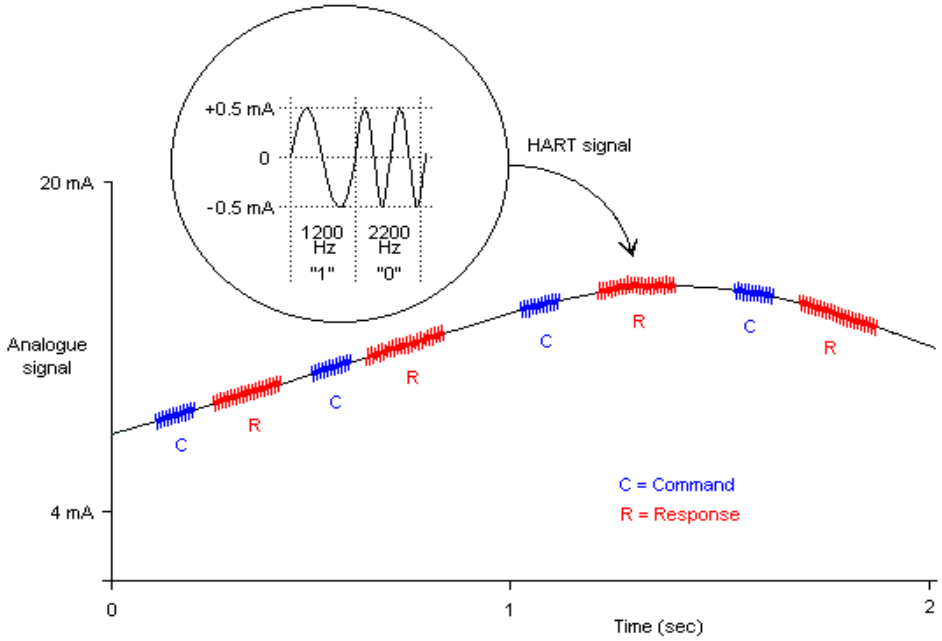

Figure 7 Hart Signal

3.4 Hart Commands

HART protocol communication consists of commands, which are divided into series of three categories: Universal, common and device-specific commands to work. Universal are in the range of 0-30bits,common practice commands are in the range of 32-126bits and device specific commands are in the range 128-253bits.common are set to HART protocol, but the device-specific commands provide the opportunity to the private parameters that occur only in certain field devices.

1. Universal commands (Universal Commands) ensure compatibility with all HART devices, regardless of manufacturer. HART protocol is the basic rule that all HART field devices must be able to respond to each other in the universal commands which include manufacturer, model, and description of the device, the device status, day vs. metric, and measurement range.
2. Common commands (Common Commands) include most types of equipment, although not all of them. Commands such as: measuring the reading of values, change the borders, calibrate and test drive.
3. Device-specific commands (Device Specific Commands) are new or peculiar functions of the device. They can be made internally control function switch, control switch, control functions, calibrate, and select different variables.

3.5 Wireless Technology

Wireless technology offers the opportunity of transferring information between two or more points that are not connected by means of electrical conductor. It offers a wide range of applications from adding measurements where they were previously out of physical or economical reach, to enable plant-wide functions such as asset and people tracking, security, and worker productivity
(Hart Communication Foundation 2012).

3.5.1 DDL

Device Description Language which describes specific features and functions of a device including details of menus and graphic display features to be used by host applications (including handled devices) to access all parameters and data in the corresponding device.

3.5.2 TSMP

Time Synchronized Mesh Protocol was developed by Dust Networks as a communication protocol for self-organizing networks of wireless devices called motes. TSMP devices remains synchronized to each other and communicate in timeslots, also to other TDM (time/division multiplexing) systems.

3.5.3 TDMA

Time Division Multiple Access (TDMA) is a channel access method for shared medium networks. TDMA is used in the digital 2G cellular systems such as Global System for mobile communication (GSM). IS-136

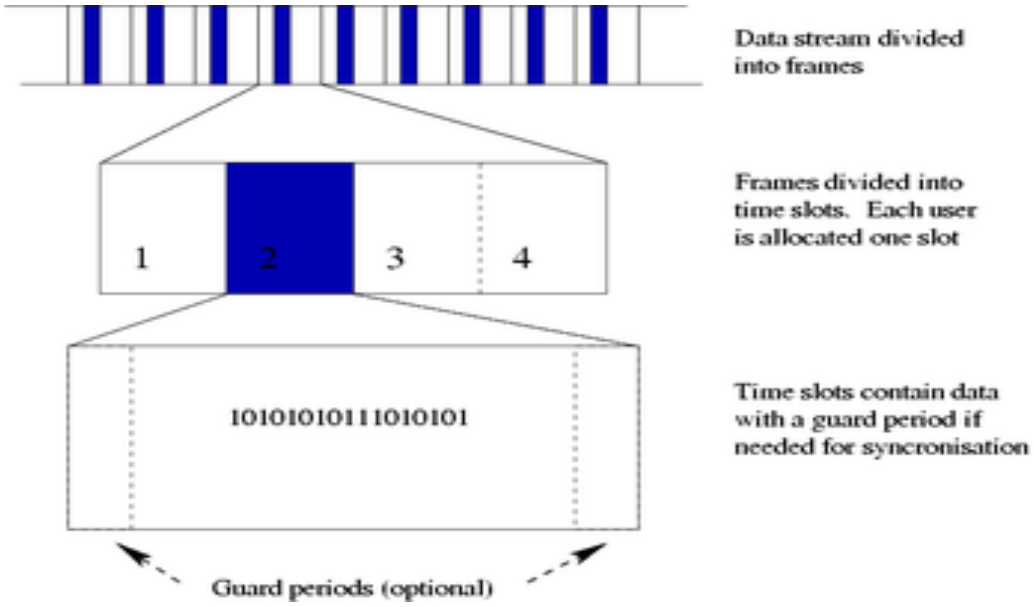

Figure 8 TDMA Data Stream.

3.5.4 FHSS

Frequency-Hopping Spread Spectrum (FHSS) is a method of transmitting radio signals by rapidly switching a carrier among many frequency channels, using a pseudorandom sequence known to both transmitter and receiver. It is utilized as a multiple access method in the frequency-hopping code division multiple access (FH-CDMA) scheme.
(Heikkila M. 2009.)

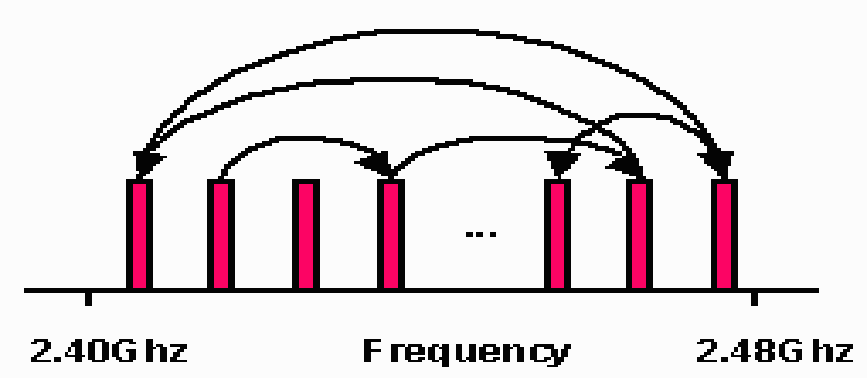

Figure 9 Frequency Hopping Spread Spectrum

3.5.5 DSSS Modulation Wireless Hart

Direct Sequence Spread Spectrum (DSSS) technology provides about 8dB of additional gain utilizing unique coding algorithms. The transmission is spread over the frequency of the channel. Devices with the correct decoding information can receive data while others see transmissions as white noise and disregard it. This allows multiple overlapping radio signals to be received and understood only by other devices in their own networks.

Direct-Sequence Spread Spectrum (DSSS) is a modulation technique. As with other technique spread spectrum technologies, the transmitted signals that modulates the carrier or broadcast frequency. The name 'spread spectrum' comes from the fact that the carrier signals occur over the full bandwidth (spectrum) of a device's transmitting frequency. IEEE 802.11

4 AMS DEVICE MANAGER

AMS Device Manager could either be used online or offline. It enables real-time access to intelligent device diagnostics and alerts, so that you can always monitor and know how devices are performing and have valuable asset health information. A predictive alert gives you an information of what is likely to fail so you can know what you need to replace and the necessary action that need to be taken at a convenient time before the failure occurs and causes costly unscheduled shutdown. It actually depend on the purpose it is been used for, but it helps to proactively act.

When online, you can see alerts of device to know how they are performing, if they are working as desired or not. In this case you can see alert of how the transmitters are working if they are out of range or sensor fails it will trigger an alert immediately. As a result the sensor will be changed or something will be done proactively to avoid shutdown. Also in the case of the valve for controlling the liquid, it alerts when a particular valve is exceeding its cycle limits, so the necessary adjustment is done to maintain consistency in process performance.

It also gives a storage database of the configuration information, given access to instrumentation process information, diagnostics status information, and automatic documentation of all instrument maintenance information while in online.

AMS Device Manager has the capability to keep record of database of connections of device on it through a system interface. In-plant operator can view the process control information in the control room while technician can view the asset management information from the plant maintenance site.

AMS Device Manager permits connections to devices like:

- In offline mode using HART Modem connect to a single device at once.
- In online mode using Interface options with DeltaV™ Ovation®, RS3, or PROVOX.
- Online mode using Rosemount 3420 Field bus, interface Module and system interface.
- Online mode using HART multiplexers and the system Interface.
- Online mode using HART over Profibus interface.
- Online mode using ROC Interface.
- **Wireless mode using the 1420 wireless Gateway**

(AMS suite Product Data Sheet Catalogue 2008-2009)

4.1 Ams suites

4.1.1 Wireless interfaces

"Wireless Interface enables an easy access to the wireless HART device through 1420 wireless Gateway with online AMS device manager, it gives easy and quick access to the health of the connected wireless device as well as the configurations, calibrations and device task documentation. Wireless Interface makes it easy to achieve cost effective solution for remote configuration and diagnostics without incurring additional cost of multiplexers and wiring. It is a cost effective means of assets management.

4.2 Hart Multiplexer

HART Multiplexer interface allows the communication between AMS Device Manager and HART devices which could be connected to any DCS/PLC .Online connection makes current configuration to be made to devices, detection and monitoring of status likewise alarms. It is just like the gateway device between the field device and the AMS Device Manager. Though it allows the connection to DCS or PLC but it is not a means of control to the device.

4.2.1 Emerson System

Emerson Host System Interface enables monitoring of process variables, continuously device status and open protocol device configuration from AMS device workstation connected. It is also with other Interfaces while on online mode.

4.2.2 Rosemount 3420

Rosemount 3420 Fieldbus Interface Module is a High-Speed Ethernet (HSE) which is utilized with AMS Device Manager to configure, diagnose fieldbus devices along with other devices and assets from a single application. This will result in reduction of installation and operation cost, filed bus networking, access to management and control in the field capabilities. The plant web makes it easier for operator because it gives alert of personnel problem with critical plant assets costly downtime can also be prevented.

4.2.3 Hart Modem

HART Modem works offline, it gives access to historical information in the plant database, it also enables single device configuration and trouble-shooting at the termination panel, it allows the communication with HART instruments using a PC, USB or PCMCIA port, and AMS Device manager."

(AMS Suite Product Data Sheet Catalogue, 2008-2009).

5 WIRELESS LEVEL TRANSMITTERS

Generally level measurements are typically used for the purpose to determine the material volume in tanks, vessels or silos. Level measurements are used for controlling purposes. Liquid flow velocity in the emptying pipe of the vessels is depending on the level of vessel. Level measurements are needed when vessels are required to be emptied or filled for controlling upper or lower level limits. These measurements depend largely on pressure and differential pressure. Hydrostatic pressure is used in such cases which is not applicable for solids. In level measurements Gauging rods, level switches are also utilized.

Level measurements in view of hydrostatics pressure to could be mathematically represented thus:
Hydrostatic pressure: $p_h = \rho gh$.

Where ρ is the liquid density is acceleration due to gravity and h is a height of liquid level.
And h is the height (level) of the liquid.
(Tikka 2012).

Wireless level Transmitters generally covers a wide range of applications technologically depending on their demands. Wireless level transmitter enables the ease of liquid level indications and control. Level transmitters cut costs and increase safety by precisions and reliable level data under most industrial process conditions and this is based on the utilization of the following kinds of level transmitters: Non-contacting radar, guided wave radar, ultrasonic, differential pressure and vibrating forks.

5.1 Differential Pressure Level

A Flexible mounting for liquid tank levels, including those with wide temperature and pressure requirements. It can be isolated by valves without interfering with vapour space changes, surface conditions, foams, corrosives fluids, internal equipment.

Figure 10 Differential level pressure Transmitter.

5.2 Non – Contacting Radar

This is a top mounted level measurement applicable for both liquids and solids including those with wide temperature and pressure requirements it can be isolated also by valves unaffected by changing process conditions. Applicable for dirty, coated and corrosive substances.

Figure 11 Non-Contacting Radar level Transmitter

5.3 Guided Wave Radar

It is also top mounted type of level measurement transmitter for liquids and solids including those with wide temperature and pressure requirements not affected by changing process conditions applicable for small spaces and easy swap older technologies.

Figure 12 Guided Wave Radar Transmitter.

5.4 Ultrasonic Transmitters

Ultrasonic is another top mounted non-contacting level measurement in open and closed tanks, vessels, wet wells and open channels flow not affected by the density, viscosity, liquid surface and corrosiveness of the liquid and good for hazardous area.

Figure 13 Ultrasonic Transmitter.

5.5 Vibrating Fork Liquid Level Switches

This is one of an efficient way to monitor and control liquid level. This was utilized in this thesis work. It indicates the high and low alarms, overall protection, pump control including a wide range of pressure and temperature requirements and hygienic applications, flexible mounting suitable for changing process conditions and most liquids.

Figure 14 Vibrating Fork Liquid Level Transmitter.

(Smart Wireless Gateway 2009).

6 IMPLEMENTATIONS

Before the proper implementations of the Wireless communication, basically there some considerations and requirements that had to be in place.

The smart wireless gateway needs to have been installed and working properly before the Power modules are installed in the wireless field device. The field device should always be powered up among to their proximity to the smart wireless gateway, starting with the closest it aid faster and easier network installation as it takes time for them to connect generally. The Antenna position, mounting height and gateway redundancy are equally considered before the installation.

The other important requirements that cannot be under emphasis are:

- PC Requirements
  - ✓ Windows XP professional ,Service Pack 3
  - ✓ Windows Server 2003 Service Pack 2
  - ✓ Windows Server 2003 R2 Service Pack 2
  - ✓ Windows Server 2008 (Standard Edition), Service Pack 2
  - ✓ Windows Server 2008 R2 Standard Edition, Service Pack 1
  - ✓ Windows 7 Professional, Service Pack 1
  - ✓ Windows 7 Enterprise, Service Pack 1
- Applications
  - ✓ Internet Explorer 6.0 or higher
  - ✓ Mozilla Firefox 1.5 or higher
  - ✓ Net Framework 2.0 (For OPC proxy only)
- Hard Disk Space
  - ✓ AMS™ Wireless configurator: 1.5GB
  - ✓ Gateway Setup CD: 250MB

6.1 Step 1

The initial step after the data protocols code 5 has been ordered. Connection and configuration is not needed, since the gateway has already been established.

6.2 Step 2

Physical installation and connection to the gateway of control network.

A local connection is established between the PC/Laptop and the Gateway to configure the Smart Wireless Gateway.

6.2.1 Power the gateway from a 24VDC power source with at least 250mA to the power terminals.

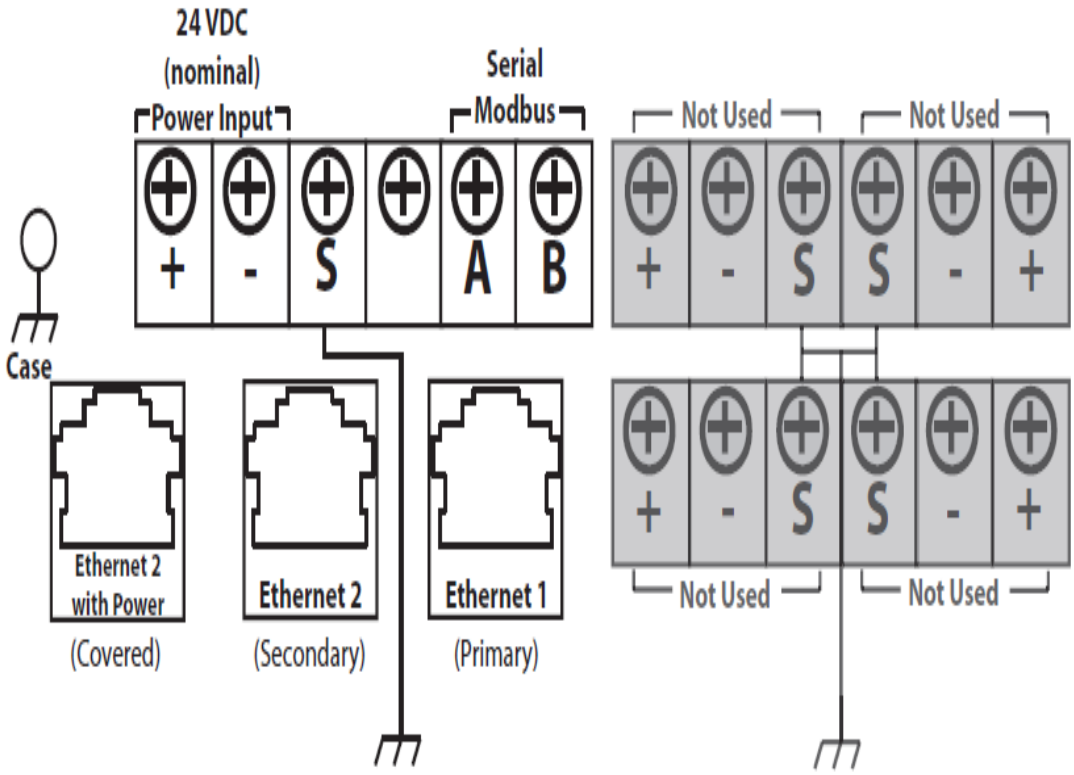

Figure 15 Gateway Terminal Diagram

6.2.2 Establishing a connection

- The PC/Laptop is connected to the Ethernet 1 (Primary) receptacle on the gateway using the provided connectivity cable.

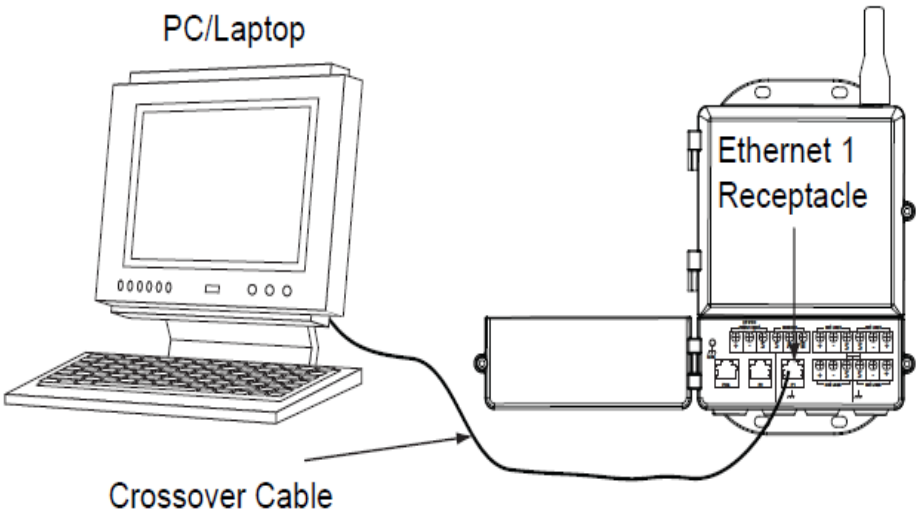

Figure 16 Gateway and PC/Laptop coneection

- PC/Laptop settings are established starting with Start>Settings>Networks connections.

  - ✓ Select Local Area Connection.
  - ✓ Right click to select properties
  - ✓ Select internet Protocol (TCP/IP), then click the properties button.
  - ✓ Select the use the following IP address button
  - ✓ Input **192.168.1.12** in the address block.
  - ✓ Input **255.255.255.0** in the Subnet Mask.
  - ✓ Select OK for both the internet Protocol (TCP/IP) properties window and the local Area Connection Properties window.

  (Smart Wireless Gateway, 2009)

Table 2 IP Address

	Gateway	PC/Laptop
Ethernet 1	**192.168.1.10**	**192.168.1.12**
Ethernet 2	**192.168.2.10**	**192.168.2.12**
Ethernet 1 (DeltaV Ready)	**10.5.255.254**	**10.5.255.200**
Ethernet 2 (DeltaV Ready)	**10.9.255.254**	**10.9.255.200**

- Proxies are disabled.
  - ✓ A standard web browser (Internet Explorer, Mozilla Fire-fox, or other).
  - ✓ Navigate Tools>Internet>Connections>LAN settings
  - ✓ Box under the proxy Server is unchecked.

6.3 Configuration of the Smart Wireless Gateway

- The default web page is accessed at https://192.168.1.10.
  - ✓ Log on as User: **admin**
  - ✓ Type in password: **default.**

Figure 17 Connection to wireless smart Gateway

- Navigate to Setup>Ethernet Protocol>Address to the network Settings.
  - ✓ Configure a static IP Address or set for DHCP and enter a Host-name.
  - ✓ Restart Application at Setup>Restart Apps.
- Power and Ethernet is disconnected from the gateway.

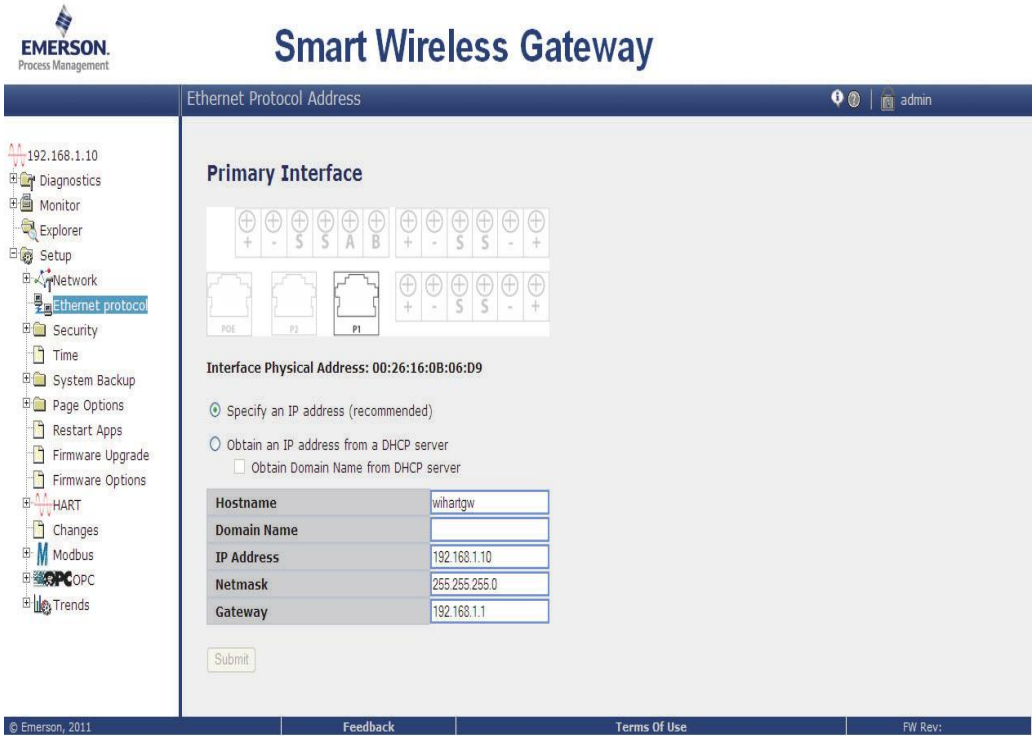

Figure 18 Smart Wireless Configuration.

- Connection to the Host System
  - ✓ Wire the Gateway Ethernet 1 (Primary) or Serial output connection to the Host system Network or serial I/O.
  - ✓ For the serial connections A to A, B to B connections is made and all terminations are ensured secure to avoid wiring connection problems.

6.4 Step 3

This is aspect of software installation, The CDs contains the security setup Utility, AMS wireless Configurations, for proper installation all windows are closed or exited while the installations are done, and it has little or no intervention, its user friendly.

6.5 Step 4

Verification is done through the web interface by opening a web browser from any PC on the host system network and entering the Gateway IP address or DHCP host name in the address bar, when properly installed the security Alert displays and then the log in screen.

Figure 19 Gateway Access

Then the Gateway is ready to be integrated into the host system. If the wireless field devices are bought together with the gateway, they are pre-configured with same Network Id and Join Key information, when powered the field devices appears on the wireless network and communications can be verified under the Explorer tab using the web interface. The number of field device determines the time it takes the network to form. (Smart Wireless Gateway, 2009).

7 FINAL RESULT

Basically the objective of the implementation project was to find a way to improve the work process and to save on the cost of asset management. At the end of the practical work execution in HAMK, the result achieved was that the implementation project conducted at school it is possible to solve the challenges of the commissioning company by clearly controlling and monitoring the industrial processes before a shutdown. The time interval for operator intervention was managed to prevent financial losses.

Wireless communication was in a satisfactory manner set up, it was configured and a wireless transmitter was also connected to the desired field devices. Though in the course of the practical implementation at HAMK there were some challenges when trying to set up the wireless network and to identify the field devices connected. The procedure was carefully followed up to identify the source of the problem.

8 SUMMARY

The introduction of wireless HART technology and interfaces with other field devices a Rosemount tuning fork, a pressure transmitter and a temperature sensor, which is one of the cheapest method to solve a problem.

AMS suite created a platform for the coordination of all the field devices and the gateway to effectively monitor and control liquid levels in industrial processes.

The initial idea of using Ultrasonic device posed some other challenges and a more expensive method to Emerson process, Rosemount technology which was finally implored. Despite challenges encountered the desired result was achieved. There was also room for further improvement in the project for anyone who is interested in proceeding from this point onwards.

The implementation project has the require potential to save cost, reduce inspection time and further improve industrial work processes, with a low cost of installation and setup.

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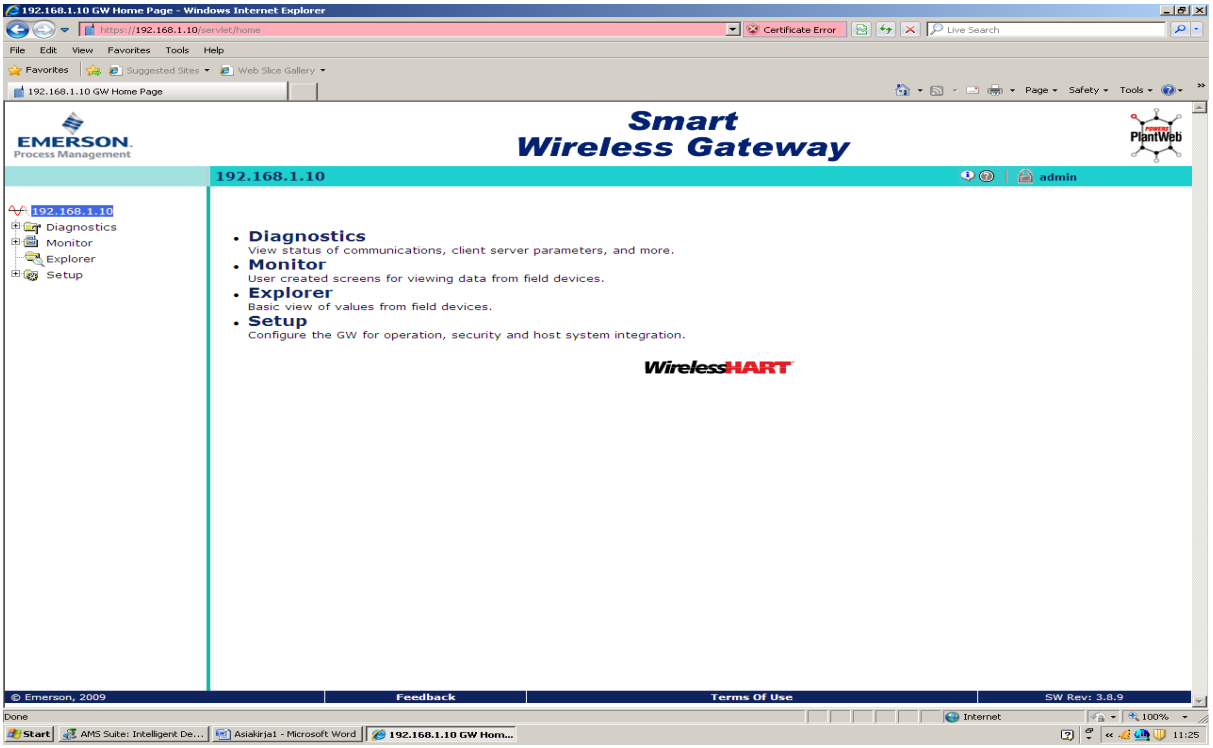
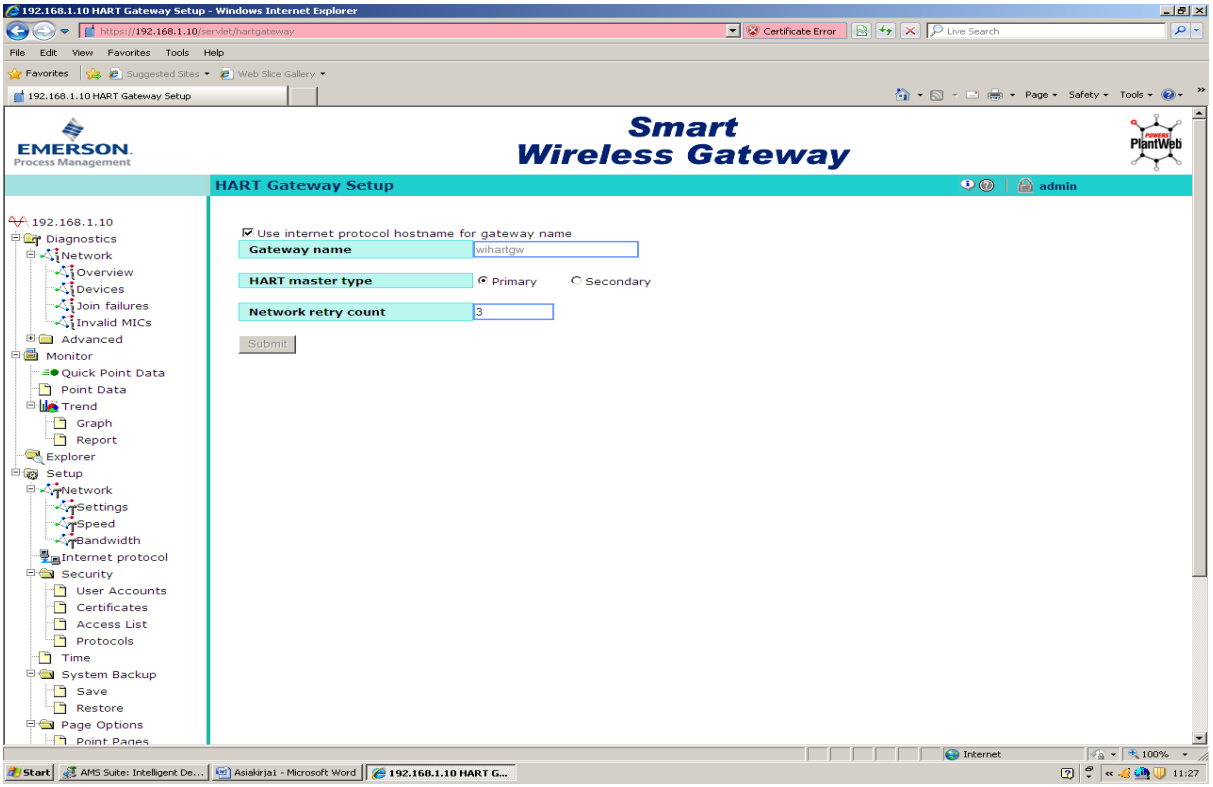
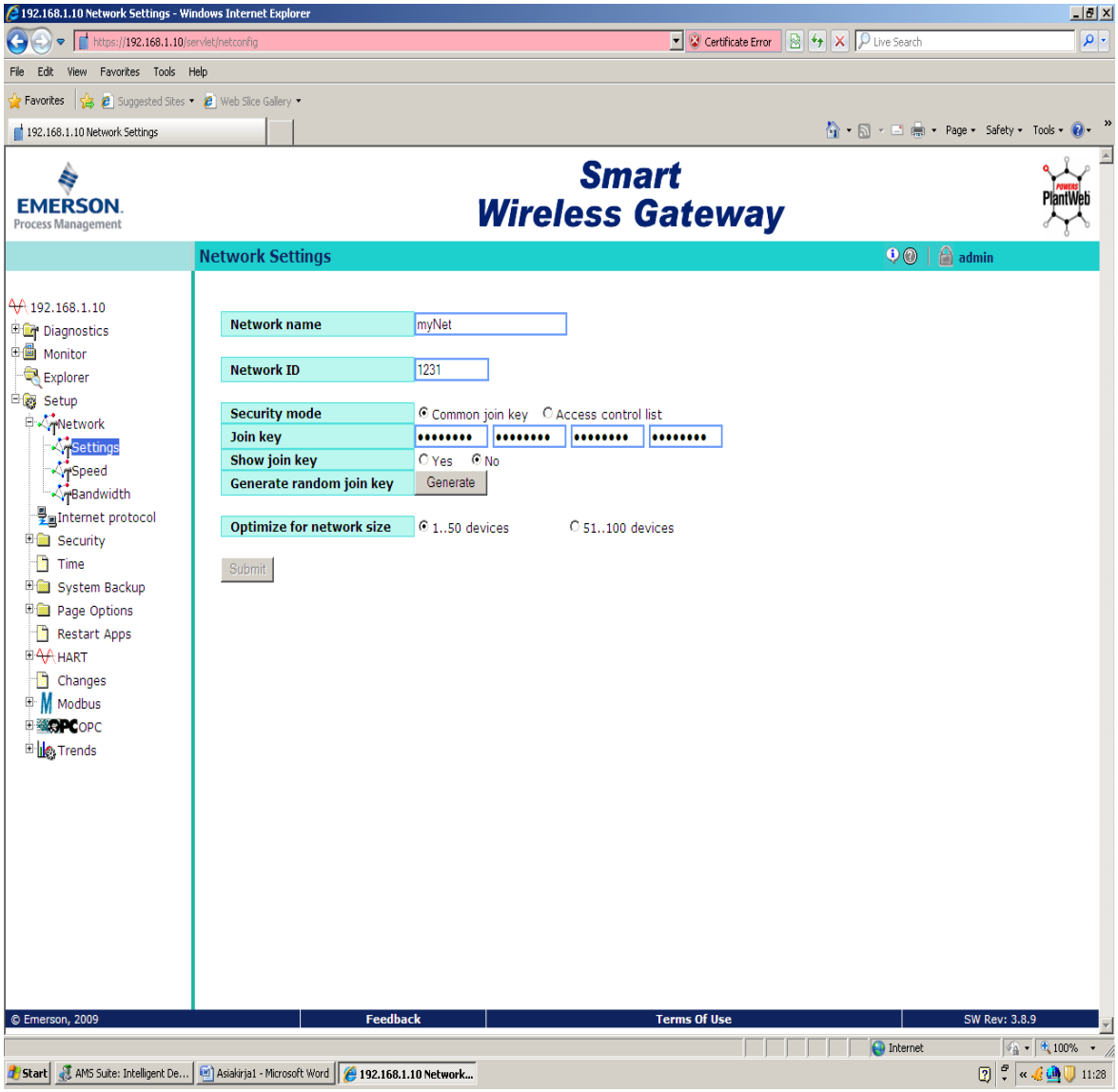
APPENDICES

Set Up Of The Wireless Gateway Appendix 1

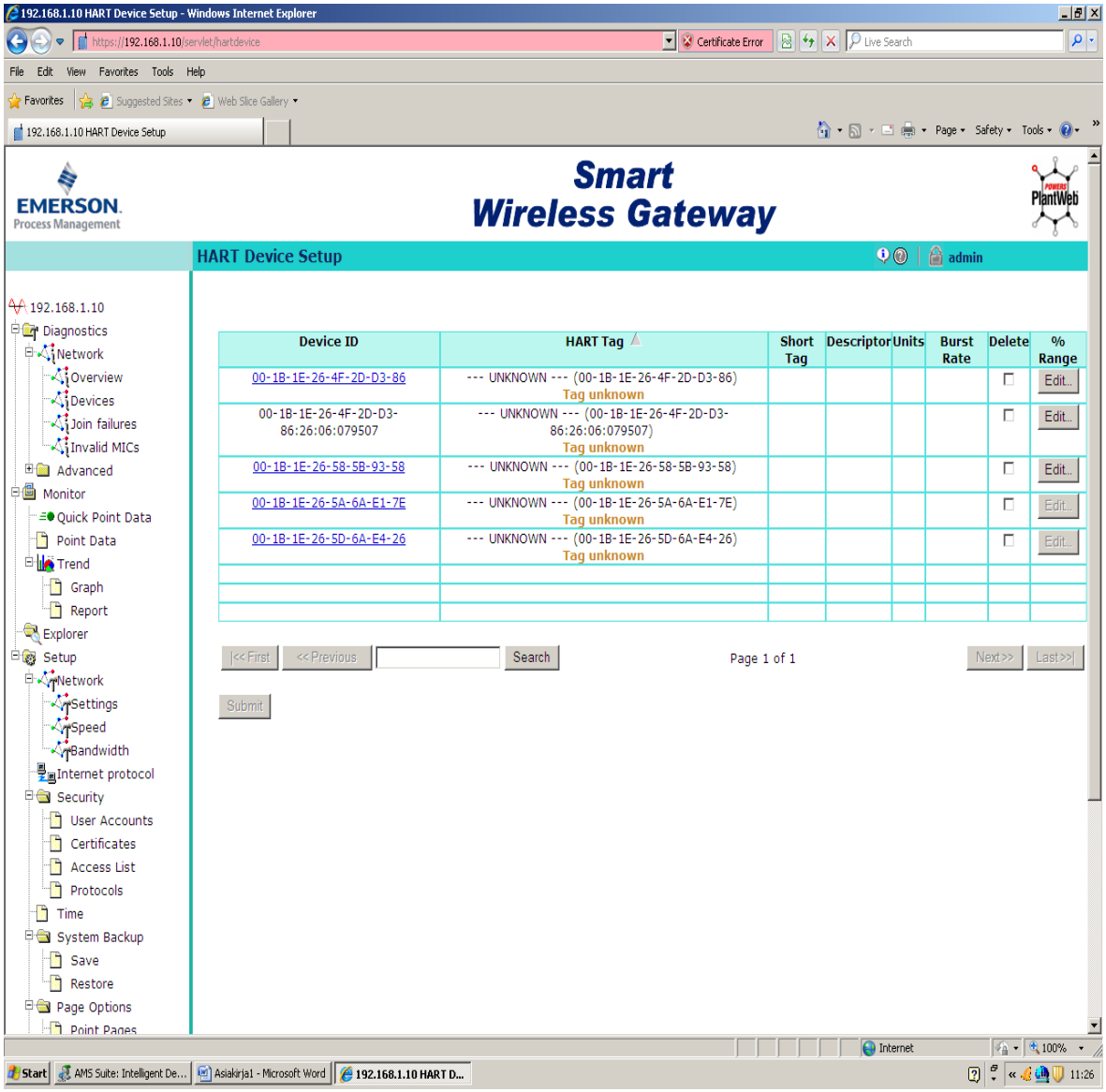




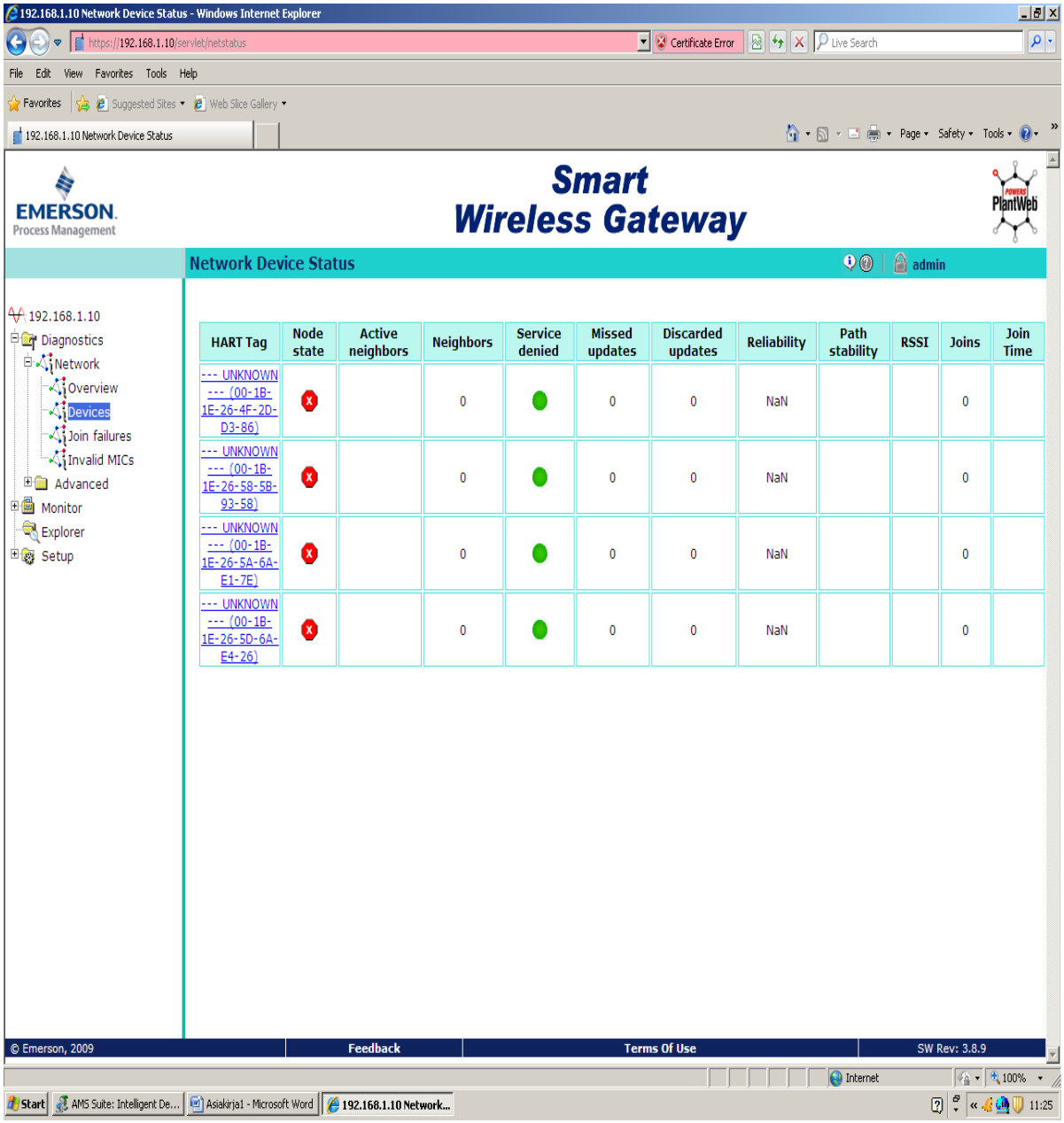
Network settings. Appendix 2



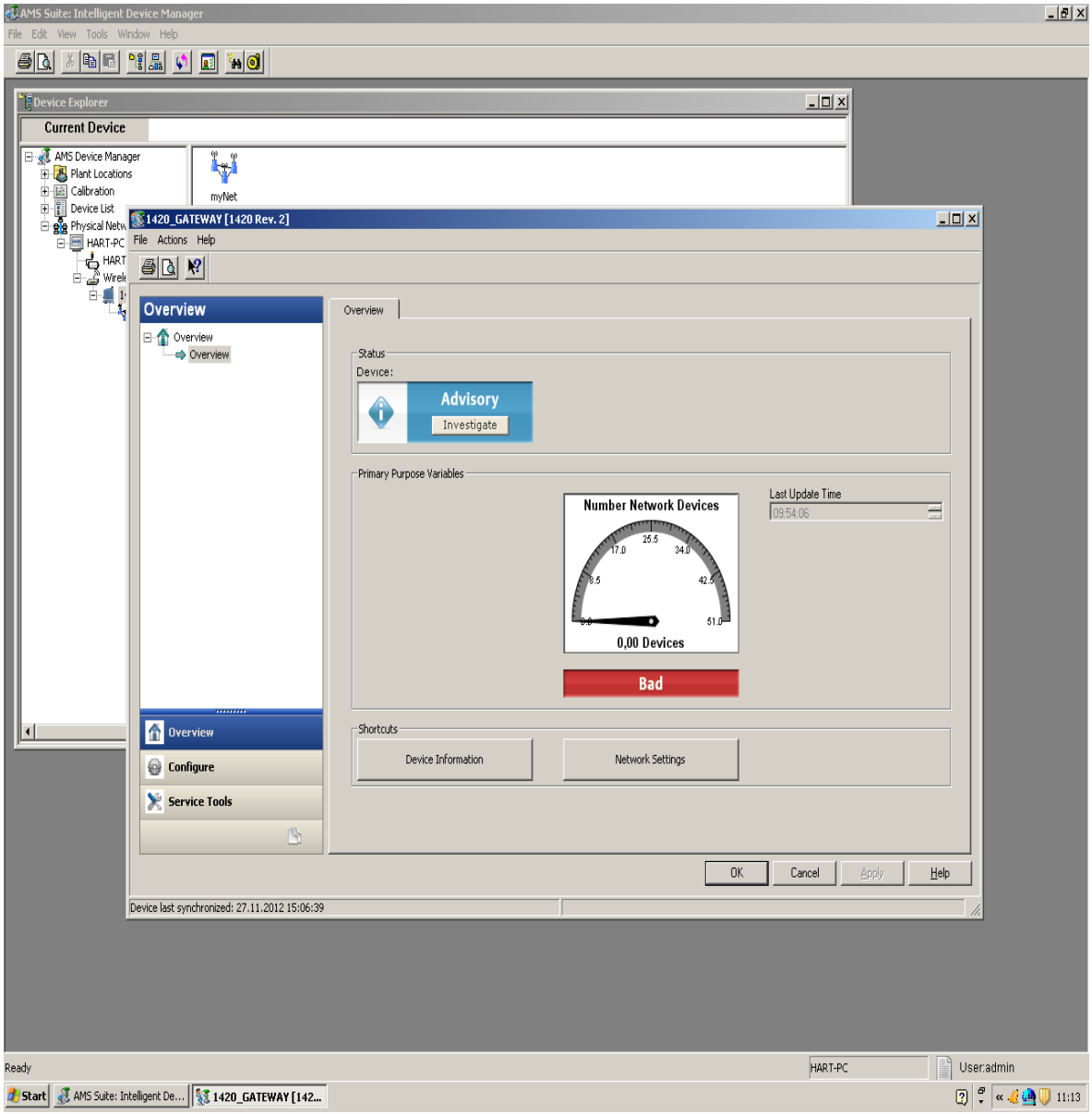
Field Device Setup. Appendix 3



Field Device Status Check. Appendix 4

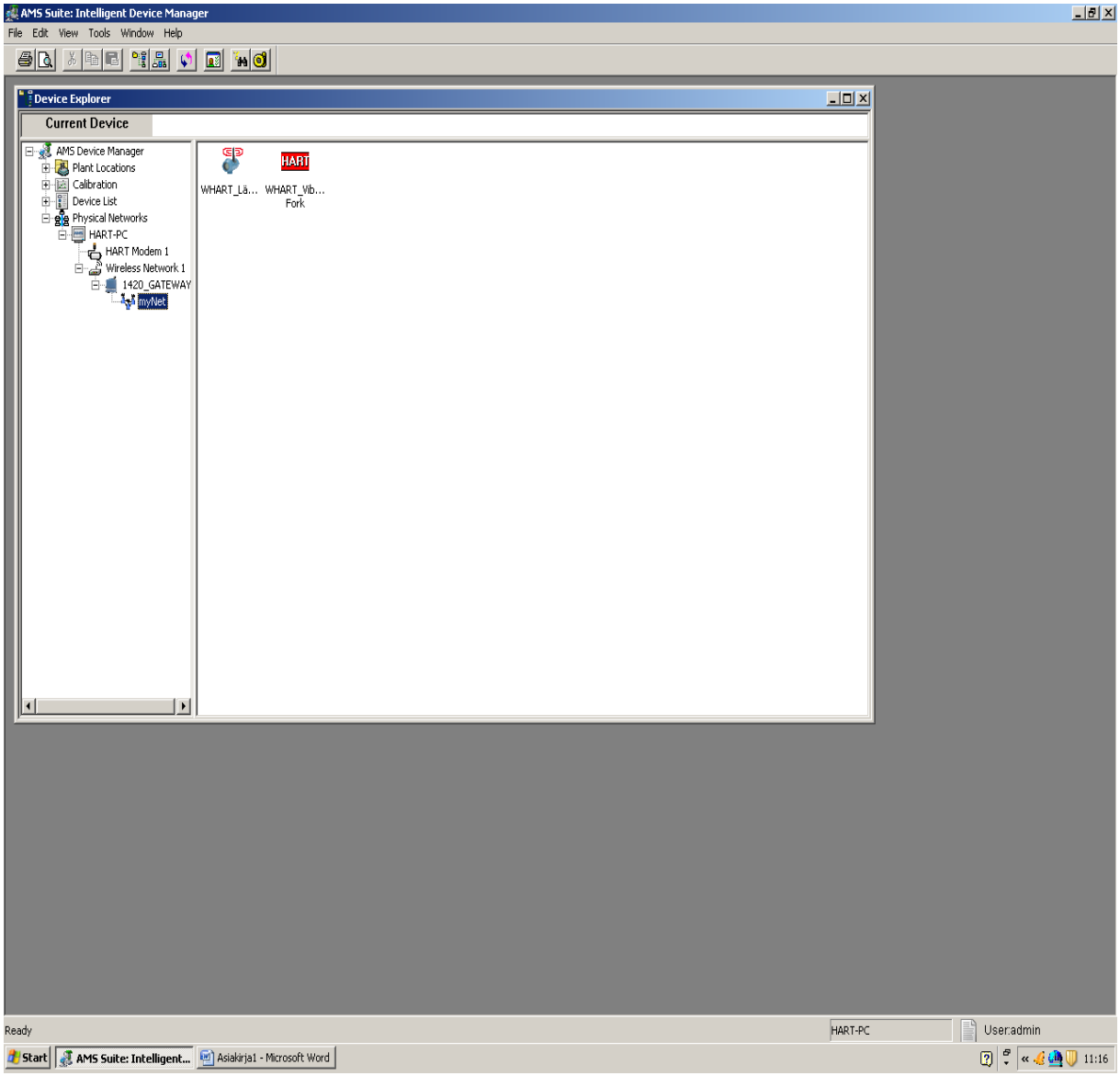


Gateway Bad Status Check. Appendix 5

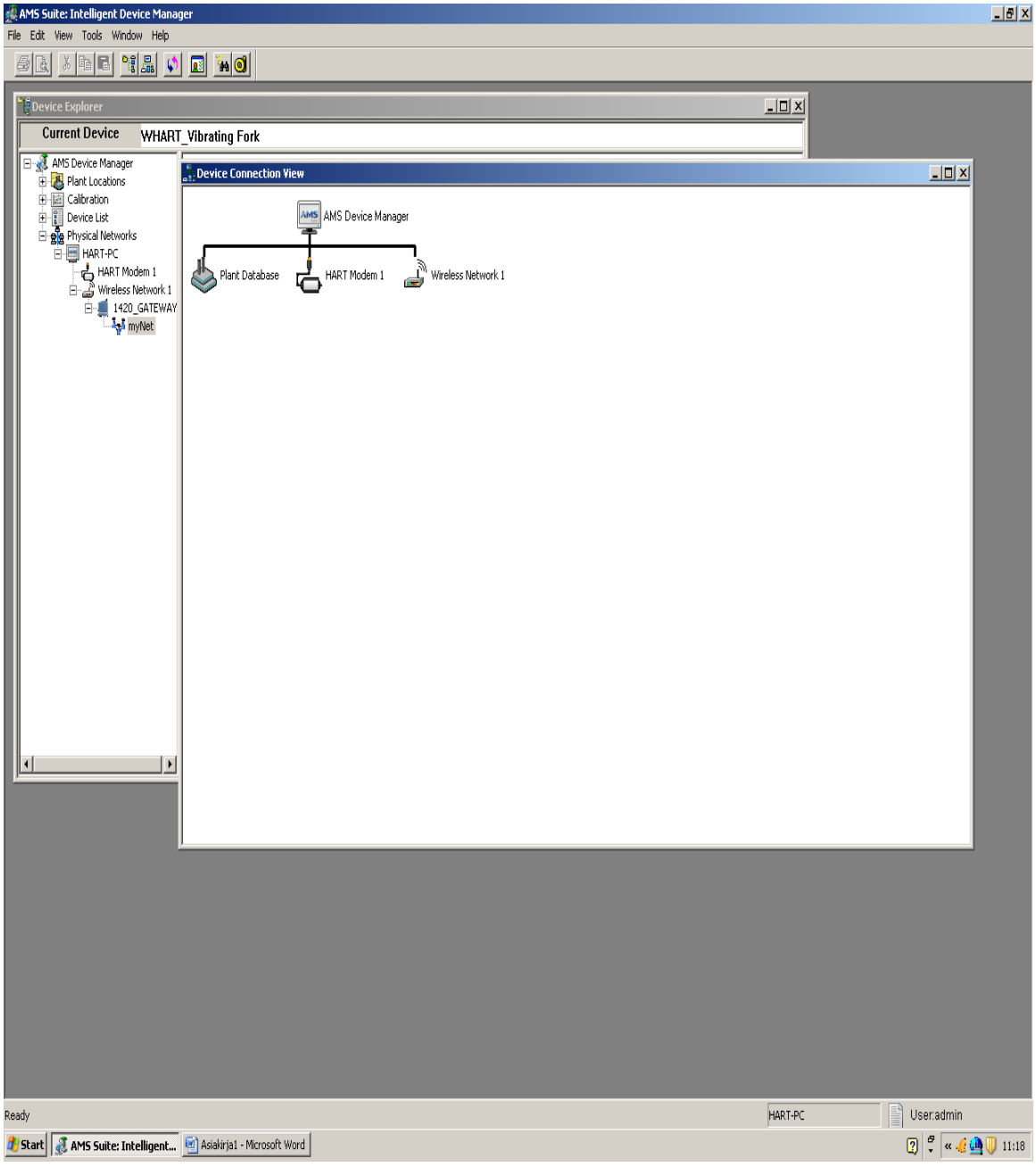


Gateway Good Status Check. Appendix 6

Device Explorer. Appendix 7



Ams Device Manager Setup. Appendix 8



Wireless Network Devices. Appendix 9