WirelessHART Communication based protocol for petrochemical complex

Sreejith Menon, Harikrishnan D, Remya Gopalakrishnan, Sujith Menon

Abstract –A petrochemical plant requires close supervision over each and every tank, vessels and pipes in order to avoid any hazardous or catastrophic situation. Wired communication was the mode of communication used to control these so called field devices till now in most petrochemical industries. But owing to various drawbacks of such wired form of communication, which will be discussed in the upcoming pages, and wireless communication supporting greater flexibility than wired devices also less maintenance of network cables or connectors led to this huge step of replacing the wired network with a wireless one .Wireless communication has been successfully used in several industrial automation applications for over 3 decades. In the last decade, standardized wireless technologies like Wireless LAN / WLAN (IEEE 802.11), IEEE 802.15.4 and Bluetooth technology (IEEE802.15.1) have become the emergent technologies for industrial wireless applications. Wireless LAN, Bluetooth technology and IEEE 802.15.4 as well as many proprietary technologies of the respective companies are being used. The adopting of wireless communication in an industrial environment will be a slow process.

Index terms- *WirelessHART, Petrochemical, Communication, Network.*

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I. INTRODUCTION

Our aim is to convert a wired communication into a flexible and reliable wireless mode of communication. With the arrival of Internet and new e-business models, industries have to adopt different strategies for doing business and to be competitive in the market.Wireless technologies are the natural evolution that will allow to collect new information flows (not available at the moment) and, in addition, to improve the existing ones.The WirelessHART standard is the first open wireless communication standard for measurement and control in the process industries. It uses wireless mesh networking to communicate between the devices on field, as well as other innovative technologies that is proprietary held by a company , to provide safe and reliable digital communication that would meet the stringent requirements of such hazardous industrial applications. Control application requirements for various parameters such as sampling intervals, jitter, and latency are specifically addressed and placed into the WirelessHART technology. In fact, control action performance with WirelessHART is comparable with that of a typical wired system that uses traditional field buses. WirelessHART was designed especially to support the wide range of process and manufacturing industry application that ranges from simple monitoring to closed loop control loop action. Testing and field trials with several wireless devices has showed that the communication stability, accuracy, performance, and overall reliability can easily meet the demands of several industrial process monitoring and control applications .Our network design takes into consideration various factors such as safety, geographical condition, climatic condition, chemical reactions etc to design an efficient wireless communication for the petrochemical complex.

II. SITE SELECTION

We have to choose a plant suitable for trying out our design. Many factors have to be taken into account while selecting a plant for this design. Some of the critical factors which we took into account was

1) The geographical location.
2) Line of sight from the tanks in the plant to the control room.
3) Number of tanks/vessels that requires close monitoring.
4) Importance of the plant for the Organization.

Based on all of the above factors, we circled our choice as a caprolactum production plant in a petrochemical industry.It houses more than 100 tanks, vessels and pipes which require a close monitoring on temperature, pressure , level, volume etc during its production phase. It is also one of the most profitable plant of the organization, hence the chances of the plant decommissioning in the future also does not hold true, thereby making our design an added advantage to the plant. A rise in level of a substance, pressure, or the temperature would lead to failure of production or disastrous situation.

III. GAUGING SYSTEM

Our Wireless System is based on IEC 62591, it is the industry accepted standard for wireless networks. The reduced wiring in fields leads to large savings in infrastructure cost, design and labour required for installation and commissioning. No hardcore work is generally required and production time is minimised. Also, compared to other systems, the time between starting a project and an up-and-running wireless system is reduced drastically. The only challenge we have in front of us is to have a close control loop system that is working in real time with continues monitoring.

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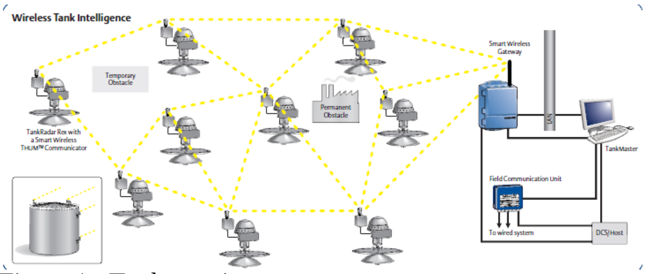

Figure 1 : Tank gauging system

The above diagram shows a typical layout of how our wireless communication network would look like, in the caprolactum plant. Tank Radar is placed on top of each tank, vessels or pipes whose parameters are to be measured. The network is designed based on various rules(which will be discussed later) and other considerations such as temporary and permanent obstacle. The signal from the adapter is given to a wireless gateway and from the gateway to the tank master(which is a system software used to monitor on the computer and then to a DCS host. Some of the characteristics of this network and protocols are

a. Self-Organizing, Adaptive Mesh Routing. No wireless expertise is required, devices automatically find the shortest communication paths. It.Supports both star and mesh topology.
b. Network continuously monitors paths for degradation and repairs itself.
c. Smart adaptive behaviour provides reliable operation and simplifies the network deployments, expansion and finally the reconfiguration.
d. It is an Industrial Standard Radio that supports Channel Hopping, Standard IEEE 802.15.4 radios GHz ISM band, which is broken into 16 radio-channels that Continuously "jumps"/"hops" across various channels to avoid interference and hence increase reliability . Direct Sequence Spread Spectrum (DSSS) technology therefore delivers very high reliability in challenging and hazardous radio environment.
e. It is a Self-Healing Network ie if an obstruction is introduced into our mesh network, then the devices will automatically find an alternative communication path that will be best for the system.
f. It integrates almost with all existing hosts. Transparent and seamless integration is one the biggest advantage of this protocol. Gateways can also be connected using this industry protocol.

IV. COMPONENTS

Wireless Gateway : The Smart Wireless Gateway enables communication between wireless devices ie the tank, vessels and pipes of caprolactum plant which are under supervision and host applications. Each gateway will manage its own unique wireless network.

Wireless Adapter : The Smart Wireless Adapter acts as a wireless data link between the level gauge and a Smart Wireless Gateway in a *Wireless*HART network. The THUM Adapter is connected to the TankRadar level gauge which is connected to the tanks, vessels and pipes.

Tank Radar : TankRadar is a powerful radar level gauge suitable for non-contact level measurements in storage tanks and other types of tanks.

Repeater : A repeater can be any wireless device used to strengthen the wireless network or expand the distance between wireless measurements.

V. INSTALLATION PROCEDURE

1. Network Planning.
2. Installation Considerations.
3. Configure Adapter
   - Network ID and Join Key
   - Update rate
   - HART tag,
4. Configure Radar using step 3.
5. Configure repeater using step 3.
6. Mount the device.
7. Connect the device
8. Start up the device
9. Verify network design connection and status
10. Verify network design rules.

VI. NETWORK PLANNING

Since various tanks , vessels, containers and pipes of the plant are spread over a vast area, and the control room being located away from the plant, we need to plan and create a network such that there is minimum disturbances, interference and the communication takes place in a proper way as designed and expected. There are three fundamental design rules for designing a network

1. Scope : Divide the tank farm in logical parts or subsections of a tank area. By doing this, we can easily identify in which sub part error is taking place and hence debugging and troubleshooting would become more easy.
2. Design : Apply design rules to ensure optimum connectivity of the tanks, vessels , containers and pipes of the plant.
3. Fortify : Fix any potential weakness in the network.

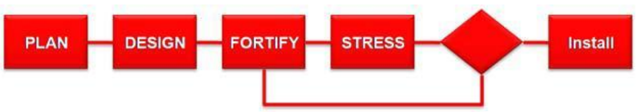

Figure 2 : Network Planning

The guidelines support design of small networks, which are less than 15 wireless devices, as well as multiple networks containing a larger number of devices. Designing a wireless network requires a scaled drawing for selecting a gateway location, arranging wireless devices and testing the layout against network design recommendations [1]. The wireless devices are located according to their tank connection. Only an approximate location on the scaled drawing is required since the self-organizing mesh technology will adapt to conditions as they exist and change from the point of installation.

Scope : Every process facility is split into process units for the purpose of organizing the people, process, work practices, and flow of data from instruments in the caprolactam plant such that debugging and troubleshooting would become easy. Every Wireless Field Network must have a unique Network ID and should be dedicated to a unique process unit so that the wireless instruments and data can leverage existing work practices and data flows. Remember, wireless instruments compliant with WirelessHART™ standards are installed and configured just like wired HART instruments using the same Field Communicators. An existing instrument location plan, equipment location plan, or aerial picture from Google Earth works perfectly fine for industrial network design.

Define the network area : We obtain a scaled drawing of the tank farm in the plant An existing location plan or aerial picture can be used from Google earth. We had made a manual sketch by surveying the plant. The tank farm often has a natural organization that can be used for scoping networks. Wireless points are ideally organized by tank groups. We divided the tank farm in logical units. We found out a suitable location of the gateway, as close to the centre of the mesh network as possible. We have placed the gateway in such a way that it is in line of sight of maximum number of adapter. We also had a detailed look at available wired infrastructure. We calculated the number of wireless devices per gateway. The wireless network gets more robust as more devices are added. 20 to 40 tanks per gateway was recommended. Look at the physical location of the critically located tanks. If an update rate of 8 seconds is required, maximum 50 wireless devices per gateway are allowed provided that the best practice design guidelines are fulfilled.

Area Density: The area density is defined by the obstruction height and obstruction density and sets the expectations for the wireless network range. We create a tank farm that has typically an area density of “light infrastructure”. A walk through this newly created tank farm would be recommended to get a good overview of the topology we are using and high buildings or obstructions that may block our communication paths [2]. We also look for a good position to place the gateway antenna and other wireless devices.

Design : There are three fundamental design rules: Rule of 5, Rule of 3, and Rule of 25% in network planning. The design rules are worked out to make sure that there is a secure margin when implementing the wireless network in plant. During commissionin, the implementation of these design rules must be verified thouroughly

I. Rule of 5

Every wireless network should have a minimum of 5 devices within effective range of the gateway [3].

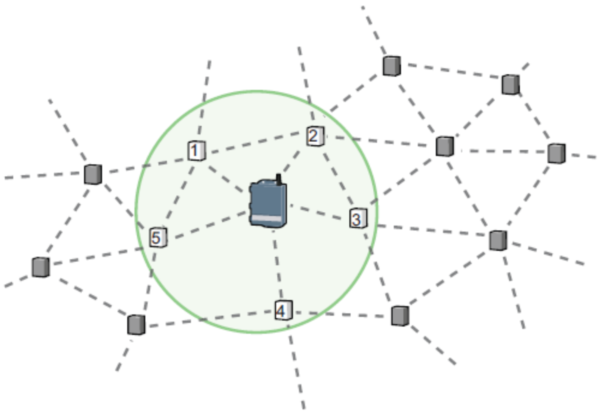

Figure 3 : Rule of 5

II. Rule of 3

When designing, every wireless device should have a minimum of 3 neighbors within effective range. This ensures there will be at least 2 possible connections once commissioned [4].

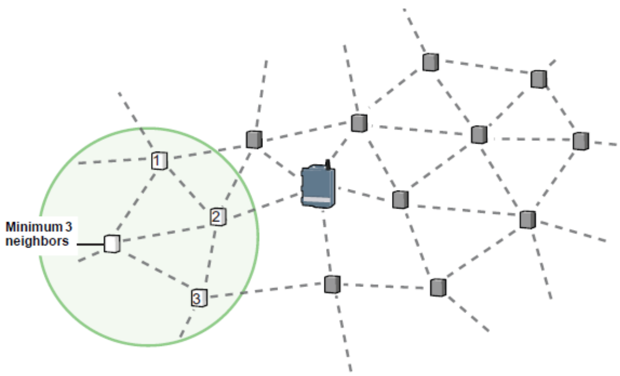

Figure 4 : Rule of 3

III. Rule of 25%

Every wireless network with more than 5 devices should have a minimum of 25% of the devices within effective range of the gateway [5].

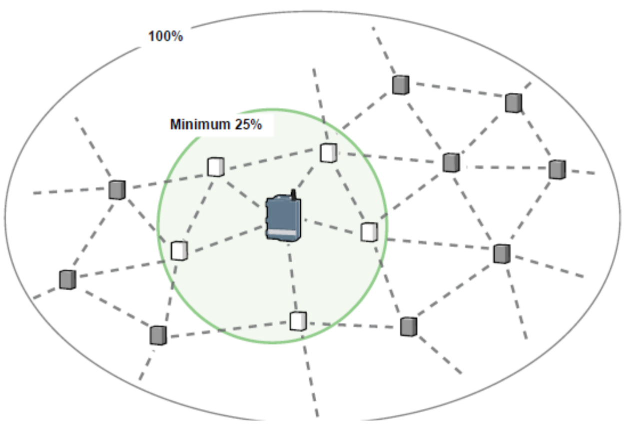

Figure 5 : Rule of 25%

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Fortify : Stress testing the network design by altering the effective range of devices is recommended to identify potential weaknesses in the network. To stress test the network, reduce the effective range of the devices in 10% increments. Then test the design rules against reduced effective ranges. For example, suppose an effective range of 150 m was used for initial design.Reducing effective range by increments of 15 m (10%) will reveal where the weak spots exist. This process builds confidence in the design [6].

When Stress Testing a Network Design:

1. The network designer is identifying the weak spot in the network by reducing the effective range against which all the design recommendations are tested. This process builds confidence in the design.

2. Our Stress Testing Result from Caprolactum plant:

a. Plant is a medium density process unit, and has effective range of 250 ft.

b. Reducing the effective range by 10% to 225 ft reveals no broken design recommendations. A 10% increase in the confidence of the design is achieved

Then we reduce the effective range by 20% to 200 ft which reveals a broken design in our network which should be recommended by experts. We then manage design risk by being satisfied with the 10% additional confidence from step 2b or choose to fortify further the network. For most process units, designing a network with 30 wireless instruments or more creates a network so strong that design recommendations can only be broken if the effective ranges for stress testing are reduced well below 50 ft, which is far in excess of typical performance in even the most dense process units

a. Fortify The Network

When stress testing a network, the weaknesses are identified. Fortify the network by resolving the weaknesses. Using repeaters is an alternative to support the fortification of a network. Instead of another wireless device with a specific measurement purpose, the repeater is used specifically for the purpose of providing more connection within the network. Repeaters should be used efficiently within our dense infrastructure, wherever necessary, they are generally placed above the infrastructure inorder to maximize the effective range of the devices . But if the network is planned in a proper way then we can avoid the use of repeaters. So below are some steps which can be done so that we can avoid using other equipments for improving the network quality.

Rule of minimum 5 can be easily resolved by adding another device within the effective range of the gateway .When rule of 3 is broken, it can be fortified by adding more devices.Rule of 25% can be resolved in several different ways. Given below there are three options available for us to fortify our network design, each having its own consideration:

1. Add more devices within the effective range of the gateway. This is probably a good solution, but there may not be much points of value within the effective range of our gateway.

2. Try moving the gateway into a more central location depending on the the distribution of our wireless field devices. In our case, there is no convenient host system integration point at the core of the network.We placed our system integration point at a very remote location, which was not at the centre of the network.

3. Add another gateway. The increased concentration of field devices within the effective range of the newly added gateway would ensure long-term, trouble-free scalability. There might still be some issue with a convenient host system integration point as we pointed out in option 2. Also since we had a limitation in the number of gateways available for our use, this point was not in our control .This overview planning a Smart Wireless Field Network is applicable to all networks where wireless instrumentation is updating at rates less than once every 8 seconds. Additional considerations should be taken when operating wireless instruments at update rates faster than once every 8 seconds

VI. RADIO TECHNOLOGY

To enable the receiver and sender of the information to communicate, both have to agree on what frequency they send. This frequency will be in one of the bands reserved for radio communications. These bands are regulated by some official agencies and the usage of such bands are therefore very restricted [7]. 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 usage are ISM bands (Industrial, scientific, medical). In these bands anyone is allowed to send and receive, following some restriction like sending power. The one and only worldwide usable band for ISM is 2.4GHz.

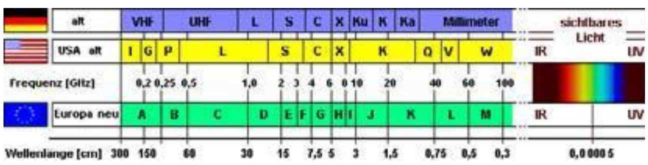


Figure 6 : ISM sub bands [8]

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 should be either be in a sequencial manner like FHSS, or should be like FSSS that uses single frequency at a time and another frequency during the following transmission , hence reducing chances of interference. 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 transmissions, the disturbance of other radio systems is reduced.

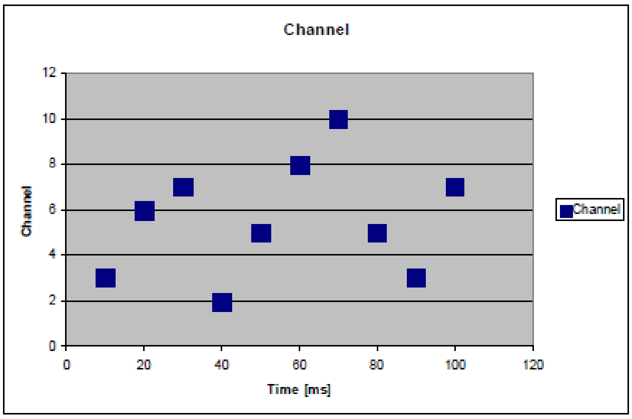


Figure 7 : FSSS

DSSS in contrary uses the entire frequency spectrum during one transmission. Therefore, the sending power can be reduced, the signal is hidden in the background noise and cannot be tapped nor jammed nor it is jamming other radio transmissions.

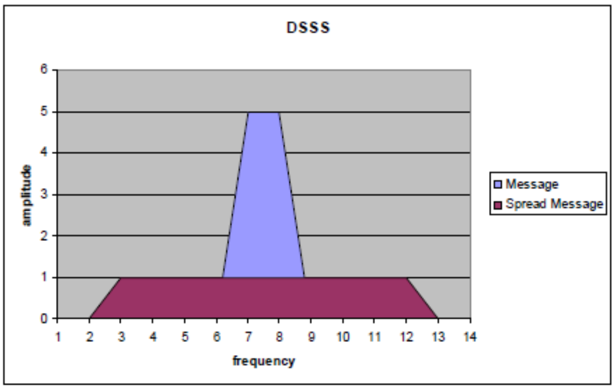


Figure 8 : DSSS

The sending power is one restriction in the ISM band of 2.4GHz. It is only allowed to send with an output power of 10mW, in some countries or regions it is allowed to send with 100mW. As more sending power is allowed, as longer the possible range is. The sending power is sometimes also describes as dB in relation to EIRP. An isotropic radiator radiates equally in all directions (like the sun). But real world antennas radiate in a different pattern, e.g. a donut like shape. So the power is not wasted to the top and bottom but more in the horizontal surface. So the 10mW are not distributed equally, but or focused which increases the sending power of e.g. 2dB (in relation to the 10mW) Another factor for the range is the receiver sensitivity. Even if the sending power is restricted, the sensitivity is not. So as better the receiving sensitivity is, as longer the range which can be obtained.

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

1. Interference
2. Moving equipment and people
3. Multipath fading

Interference happens wherever a wave is reflected or is superimposed by another wave. This can either have a positive effect or a negative effect:

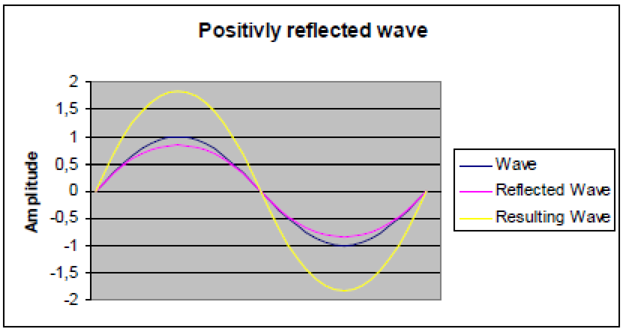


Figure 9 : Positively reflected wave

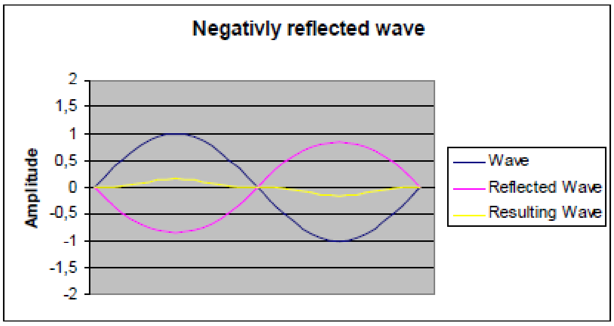
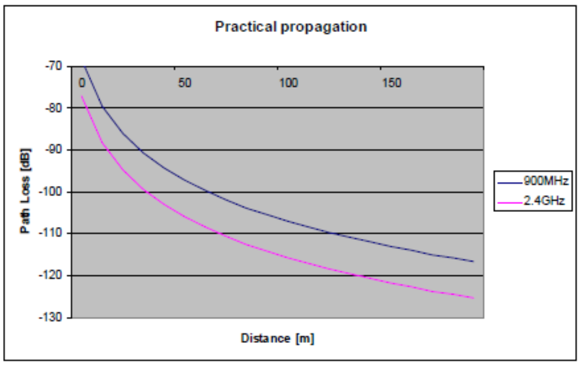


Figure 10 : Negatively reflected wave

The second effect is that industrial environments are not static but dynamic, especially a petrochemical plant. Vehicles, moving equipment like tanks, people walking through will definitely change the network environment. Therefore, the propagation of radio waves is sure to get altered. The third effect is multipath fading. Due to reflections, each wave is moving on different paths from the sender to the receiver and arrives there, then lightly time shifted from the original wave. This could distort the wave, hence the receiver would not recognize it any further. As result of those three effects two main consequences must be taken into account when applying wireless communications in industrial environments.

1. Range
2. Reliability

The range is decreased compared to the theoretical free space propagation. A practical example for industrial environment is shown below:



The moving equipment and changing environment decreases the reliability of the radio communication. A connection working at one time does not work another because a truck is standing in the way. This decreases the reliability

Modern Radio Technology and Standards : To enable radio communication, a common standard is mandatory. The standard makes devices of different vendors compatible to each other end enable 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 usable.

1. IEEE 802.11 (WiFi)
2. IEEE 802.15.1 (Bluetooth)
3. IEEE 802.15.4 (ZigBee)

One of the widest used is IEEE802.15.11, commonly known as WLAN or WiFi (even if this is not 100% correct). IEEE802.11 provides a local infrastructure for fast wireless transmission of relative amount of data over some distance like office areas or your home network. IEEE802.15.1 is known as Bluetooth. Satiating our aim to provide a wireless personal area network for replacement of cable and of other auxiliary devices such that it is able to transmit a little less data than the other WLAN over a very limited range. This is also called WPAN (Wireless Personal Area Network). IEEE802.15.4 is the basis for other prominent networks like ZigBee, where we have a very limited data to be transmitted over a medium distance through a network of knots so the covered area is extended.

Media Access and Networking:

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

1. TDMA (Time Division Multiple Access)
2. CSMA (Carrier Sense Multiple Access)

With TDMA, the data are transferred at a given time slot. So all of the participants in a network know the time slot when to send and to receive and avoid collisions with this. CSMA avoids collisions with random delay times after a free channel is recognized. So if a channel is recognized to be free, every participant waits another random time and it is very unlikely that the next send packages collide.

VII. NETWORK TOPOLOGY

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.

1. Star
2. Mesh
3. Star-Mesh or Hybrid

Using star topology, each wireless sensor end point sends data directly to the gateway. From there data is sent on 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 limited geographic range.

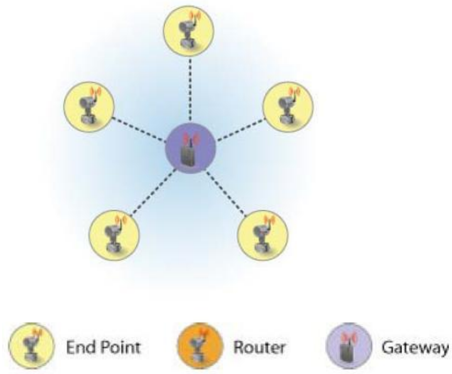


Figure 12 : Star Network

In mesh networks, each of the wireless sensors is a router, sending and receiving data from other sensors orelse the gateway. Self configuring or self healing networks automatically determines the best path for data to take it from sensor to gateway. Data is automatically sent around again in failed sensor routers. This layout is very good for wide area networks with high redundancy, but enough power is required for all participants that is available to route the messages.

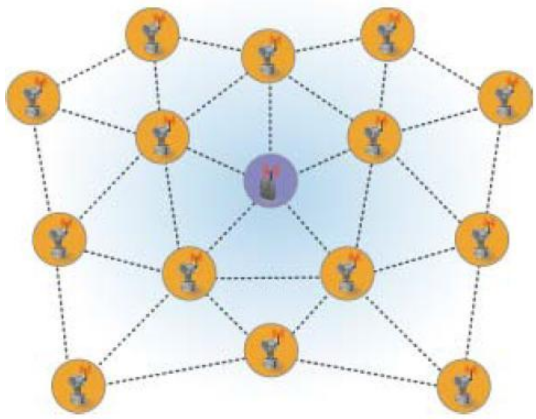


Figure 13 : Mesh network

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Star-mesh networks combine the benefit of both star and mesh topologies to gain the speed of the star network with the self-repairing and healing capability of the mesh network. Sensors may be either end points or routers, depending on where and how they are used in the system

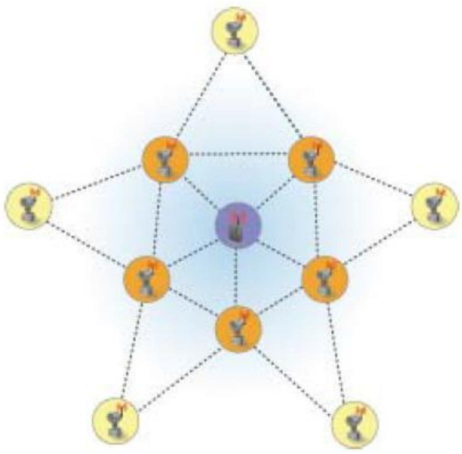

Figure 14 : Star mesh network

Using wireless technologies in industrial application is surely possible, but some restrictions must be considered.

1. Radio technology uses a shared medium and does not guarantee transmission reliability as a wire
2. Radio waves are damped absorbed and mirrored by obstacles and therefore not everywhere is a connection possible
3. License free bands have just limited range, also other wireless systems might make use of the band and cause coexistence issues.

VIII. WIRELESS RADAR LEVEL TRANSMITTER

Measuring the level of the tanks, pipes, vessels and containers is one of the most common and important application in any production plant, especially a petrochemical plant. This radar is used to measure the levels of such tanks.It is a guided wave radar. Radar Transmitter is a smart, two-wire continuous level transmitter that is based on Time Domain Reflectometry (TDR) principles for variable measurement. We send low power nano-pulses, which are guided along a probe immersed in the process media. When the pulse reaches the surface of the material inside the vessel it is measuring, part of the energy is reflected back to the transmitter after hitting the material, and the time difference between the generated pulse and reflected pulse is converted into a distance, in the transmitter, from which the total level or interface level is calculated [9]. The reflectivity of the product is a key parameter for measurement and performance. A high dielectric constant of the media gives better reflection and a longer measuring range.

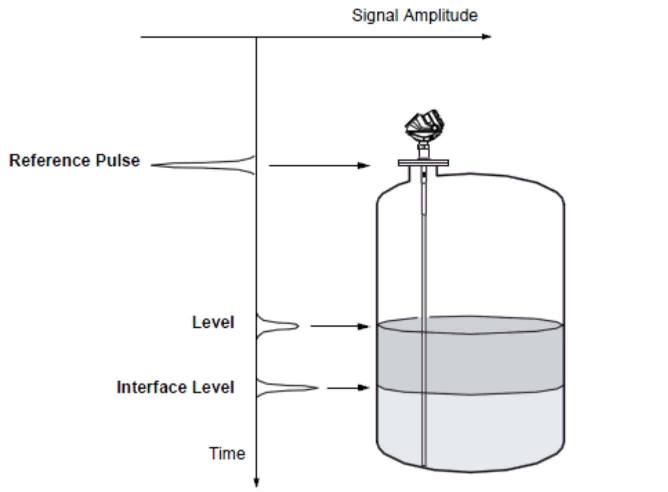

Figure 15 : Radar Measuring level

Radar Transmitter program is suited for aggregate (total) level measurements on most solids, semi-liquids, liquids, and liquid/liquid interfaces. Guided microwave technology generally offers highest reliability and precision, over other technologies, which ensures measurements are unaffected by pressure, temperature, density, vapour gas mixtures, bubbling/boiling, low level, turbulence, varying dielectric media, pH, and viscosity. Guided wave radar technology when used in combination along with advanced signal processing makes the transmitters suitable for a wide range of applications. The measuring range of such transmitters depends on probe type and properties of the product, and is usually limited by the Upper and Lower Transition Zones. In these zones measurements may have reduced accuracy. The Upper Transition Zone is the minimum measurement distance between the upper reference point and the product surface. At the end of the probe the measuring range is reduced by the Lower Transition Zone [10]. The Transition Zones vary depending on probe type and product.

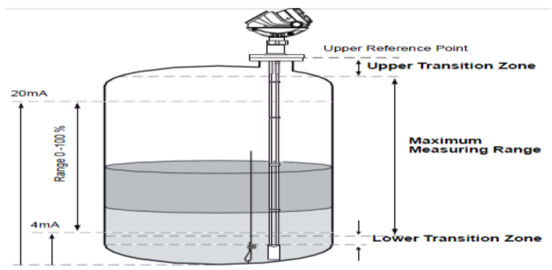

Figure 16 : Transition Zones

The Basic Configuration includes parameters for a standard configuration which is sufficient in most cases. The Basic Configuration comprises the following items:

Measurement Units

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Tank Configuration
Tank Geometry
Environment
Volume
Analog Output

Measurement Units : Measurement units can be specified for presentation of Level/Interface Level, Level Rate, Volume and Temperature values.

Tank and Probe Geometry : The basic transmitter configuration includes setting the tank geometry parameters.

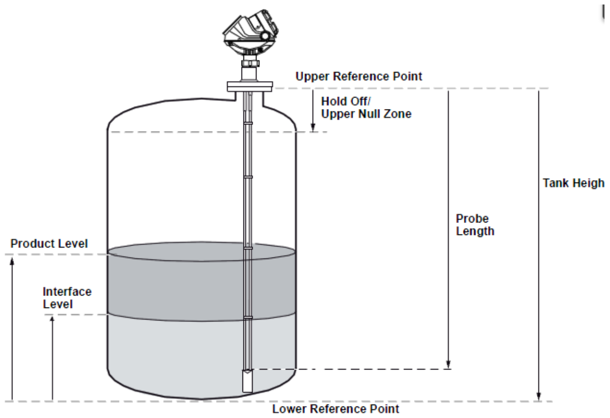

Figure 17 : Tank length

Tank Height : The Tank Height is defined as the distance from the Upper Reference Point to the Lower Reference Point. The transmitter measures the distance to the product surface and subtracts this value from the Tank Height to determine the product level. The Lower Reference Point can be set to any position in the tank simply by adjusting the Tank Height.

Probe Length : The probe length is the distance between the Upper Reference Point and the end of the probe. If a weight is used at the end of the probe it shall not be included. For Flexible Single Lead probes anchored with clamps, the probe length should be configured as the distance between the underside of the flange and the upper clamp.This parameter is pre-configured at factory. It must be changed if the probe is shortened.

Probe Type : The transmitter is designed to optimize measurement performance for each probe type. This parameter is pre-configured at factory. This value needs to be changed if the probe type is changed.

Hold Off/Upper Null Zone : This parameter should only be changed if there are measurement problems in the upper part of the tank. Such problems occur if there are any disturbing objects present, such as a narrow nozzle that hasrough walls, very close to the probe. By adjusting the Hold Off/Upper Null Zone the measuring range can be reduced.

Rapid Level Changes : Optimize the transmitter for measurement conditions where the level changes quickly due to filling and emptying of the tank.

Dielectric Constant : For interface measurements the dielectric constant of the upper product is essential in order to obtain good accuracy.If the dielectric constant of the lower product is significantly smaller than the dielectric constant of water, we may need to make special adjustments.For level measurements the Upper Product Dielectric parameter corresponds to the actual dielectric constant of the product in the tank. Normally this parameter does not need to be changed even if the actual dielectric constant of the product deviates from the Upper Product Dielectric parameter value. However, for some products measurement performance can be optimized by setting the proper product dielectric constant.

Volume Configuration**:** For volume calculations we can choose one of the standard tank shapes or the strapping option. We choose none if volume calculation is not used. For the standard tanks, a Volume Offset parameter can be specified which can be used if we don't want zero volume to correspond to the zero level. This may be useful if you for example like to include the product volume below the zero level.

Tank Type

We should choose one of the following options:

.Strap table
. Vertical Cylinder
. Horizontal Cylinder
. Vertical Bullet
. Horizontal Bullet
. Sphere
. None

Strapping Table : Use a strapping table if a standard tank type does not provide sufficient accuracy. Use most of the strapping points in regions where the tank shape is non-linear. A maximum of 20 points can be added to the strapping table.

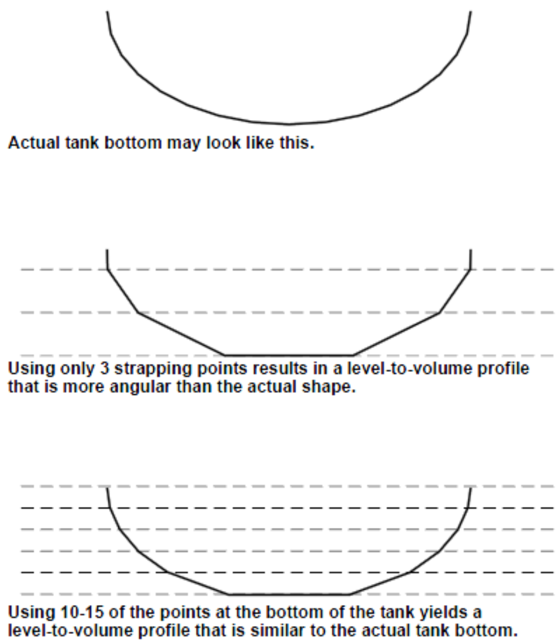

Figure 18 : Strapping table

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Standard Tank shapes

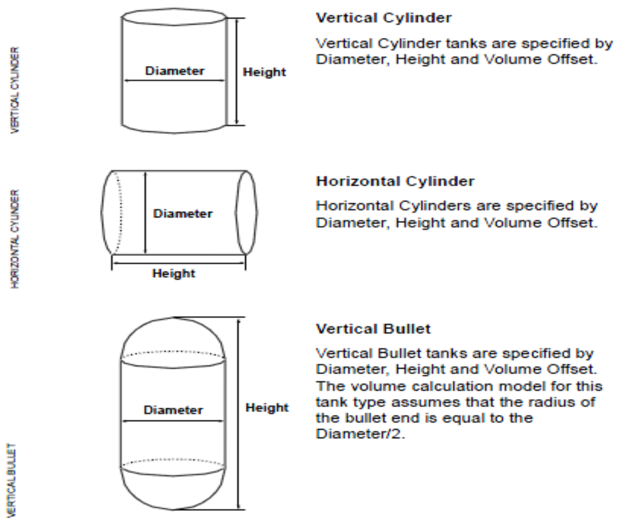
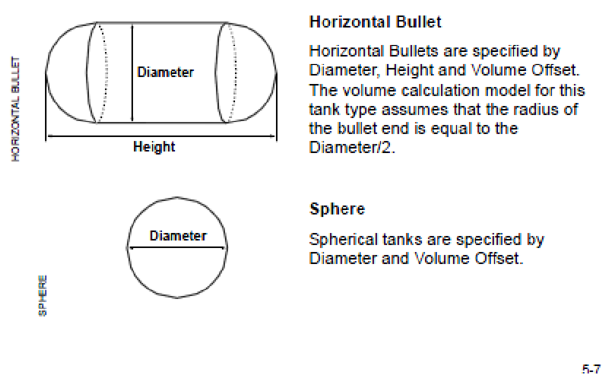


Figure 19 : Standard Tank shapes



Output Source/Primary Variable : We need to specify the source to control the analog output. Typically the Primary Value is configured to be Product Level Upper/Lower Range Value. We should enter the range values that correspond to the analog output values 4 and 20mA. It is recommended that the 4 mA and 20 mA values are set outside the Transition Zones. If a measured value goes beyond the measurement range, the transmitter

enters saturation mode (limit alarm is disabled) or alarm mode depending on the current configuration [11]. Also we should make sure that the 20 mA value is below the Upper Null Zone (UNZ). The UNZ is equal to zero in the default configuration. The 4 mA point should be above the Lower Transition Zone. If the 4 mA point is set to a point within the Transition Zone or below the probe end the full range of the analog output is not used.

Alarm Mode

The Alarm mode specifies the analog output state when there is a failure or a measurement error:

High: the output current is set to the High Alarm Limit.

Low: the output current is set to the Low Alarm Limit.

Freeze Current: the output current is set to the last valid value at the time when the error occurs.

Default settings for alarm mode:

Measurement errors: Output current=High.

Measured value out of range: transmitter enters saturation mode (if Limit Alarm is disabled)

Analog Output(HART)

Typically, the Primary Variable (PV) is configured to be Product Level, Interface Level or Volume. Other variables like Product Distance, Interface Distance, Upper Product Thickness, etc are available as well. Specify the analog output range by setting the Lower Range Value (4 mA) and the Upper Range Value (20 mA) to the desired values. The Alarm Mode specifies the output state when a measurement error occurs.

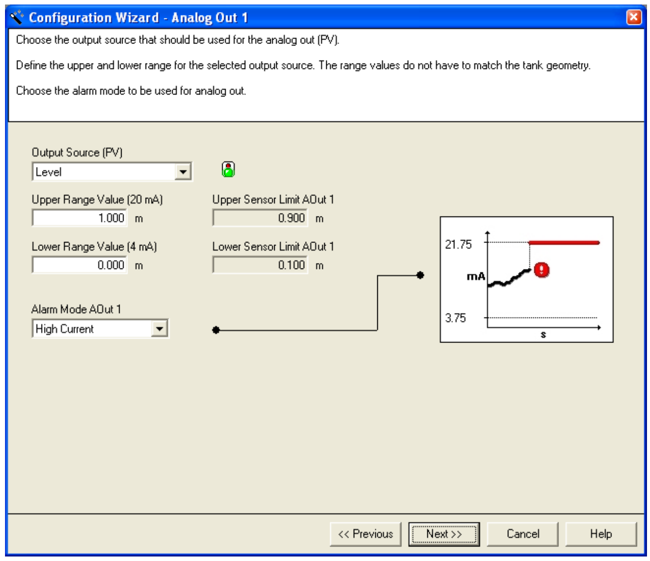


Figure 20 : Analog Output

Foundation fieldbus block operation

Function blocks within the fieldbus device perform various functions required for our process control. Function blocks performs various process control functions, such as analog input (AI) functions, as well as proportional-integral derivative (PID) functions. The standard function blocks provide the system with a common structure for defining function alarms, events, control parameters, outputs, block inputs, and modes, and combining them into a process such that it can be easily implemented within a single device or over the fieldbus network. In addition to this, function blocks and fieldbus devices usually contain two other block types to support the function blocks. These are the Resource block and the Transducer block. Resource blocks contain the hardware specific characteristics associated with a device; they have no input or output parameters. The algorithm within a resource block monitors and controls the general operation of the physical device hardware. There is only one resource block defined for a device. Transducer blocks connect function blocks to local input/output functions. They read sensor hardware and write to effector (actuator) hardware.

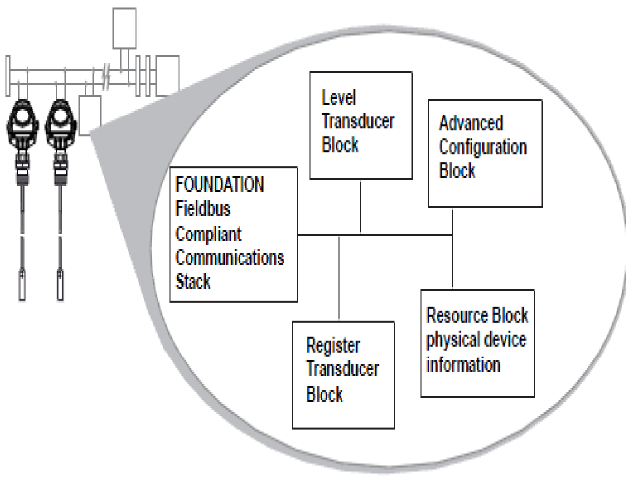


Figure 21 : Foundation fieldbus overview

Level Transducer Block

The Level Transducer block contains transmitter information including diagnostics and the ability to configure, set to factory defaults and restarting the transmitter.

Register Transducer Block

The Register Transducer Block allows a service engineer to access all database registers in the device.

Advanced Configuration Transducer Block

The Advanced Configuration Transducer Block contains functions such as amplitude threshold settings for filtering of disturbing echoes and noise,simulation of measurement values and strapping table for volume measurements.

IX. ADAPTER

Over 24 million HART 4-20mA instruments have been installed over the past two decades; however, very little use has been made of the stored digital information in these instruments. Approximately 90% of the instruments are connected to analog only IO and DCS that have no HART communication capability. The digital information in HART instruments connected to analog systems is “trapped” and cannot easily be used by diagnostic, asset management, monitoring and alarming applications. Perhaps the reason for this underuse of valuable digital information is that there is a reluctance to modify an installation by placing a HART multiplexer in the 4-20mA control loop. On the other hand, a WirelessHART adaptor provides us with an alternative low cost, simple and low risk methods to access the valuable information present in existing intelligent HART instruments. A WirelessHART adaptor is wireless communications equipment used to retrofit and upgrade intelligent HART instruments in the installed base with the capability of WirelessHART communication. The adaptor provides various host applications such as diagnostic, asset management and alarm monitoring with continuous access over the WirelessHART network in the plant, to these valuable digital information that was formerly trapped in HART instruments connected to analog only IO.

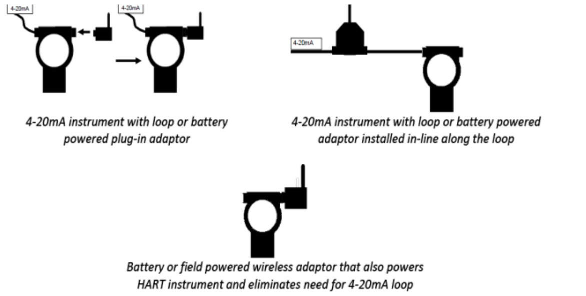


Figure 22 : Adapter configuration

The digital HART signal has rarely been used outside of commissioning and calibration, resulting in potentially valuable information not being available in the control room or maintenance area. There are of course several methods to gain remote access to HART data

1. Use Input/output (I/O) cards which provide HART pass-through
2. Install a HART multiplexer
3. Add a WirelessHART network with wireless adaptors

The options, listed above, require a certain amount of re-work on existing wiring and may also require certain loops to be shut down. The use of a WirelessHART adaptor (option 3) requires no change to our electronic marshalling rack wiring. The method of connecting the WirelessHART adaptors to the HART is similar to the method of connecting a HART hand held configurator that we use . The WirelessHART adaptor is plugged into an existing instrument via an unused instrument connection port, or using a junction box, or some other convenient location anywhere on the loop just like a hand held configurator is plugged in. The WirelessHART adaptor passes information bi-directionally ie full duplex, to and fro the installed field Instrument up to the WirelessHART network. The adaptor, in this network, acts as a wired HART master for the instrument and WirelessHART slave for the WirelessHART Gateway. When we configure it as a secondary master, the adaptor should defer to some other temporarily connected secondary master such as a hand held.

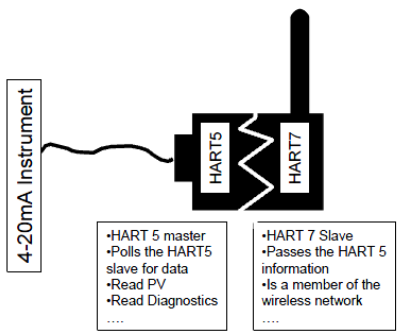


Figure 23 : Adapter configuration

X. WIRELESS GATEWAY

The Smart Wireless Gateway connects WirelessHART self-organizing networks with host systems and data applications. Modbus communications over RS-485 or Ethernet LAN provide universal integration and system interoperability [12]. Also the OPC functionality given by the Gateway, offers us a scheme to connect to newer systems and applications while providing a better set of data. The Smart Wireless Gateway also can provide us with industry leading scalability, security, and data reliability, depending upon the choice of manufacturer. Using layered security also ensures that our network stays protected. Additional field devices can be added anytime when required [13]. There is no need to configure communication paths manually because the Gateway manages our network automatically. This feature also considers that WirelessHART field devices have the most reliable path to send the data. Before the Gateway is permanently mounted and is connected to a live control network, we should configure it with an IP address for an easier access. This is usually done by forming a private network between the gateway of the network and a PC/Laptop or a workstation. The following mentioned items are needed to complete this section:

1. Gateway
2. PC/Laptop
3. 24 VDC (nominal) power supply

XI. CONCLUSIONS

In the years to come the wired form of communication will be slowly replaced by the more efficient wireless counterpart, owing to the various advantages that it holds over the typical wired communication, especially in the process and manufacturing industries. The site Carolactum plant within the petrochemical complex of our organization suited our design as it was one of the most profit making division of organization hence our implementation of wireless communication here would mean that it would not be scrapped in between due to the decommissioning. Also out design was based on HART protocol and the wired form of communication which was already commissioned here was also based on the same protocol. Hence it made our work simple.

Caprolactum plant contains several tanks, vessels and pipes. The process of manufacturing of plant has been discussed mainly because one can clearly see how important are various parameters such as volume, pressure, temperature , level etc at each stage of the process. Hence a close monitoring is required. A few seconds here or there in the control action would lead to catastrophic action. Wireless communication offers a faster communication mode for such hazardous conditions. Since we selected HART as our protocol, the many advantages of this protocol has also added more flexibility to our project. There is no need for line-of-sight between the Gateway and each device. All devices act as mesh network nodes, and can relay data. The wireless signals easily find their way around obstacles, fixed or mobile. The Smart Wireless technology from Emerson which we have used here is based on IEC 62591 (*Wireless*HART), the open communication standard that is used at thousands of industry plants all over the world. Adopting such a system is a guarantee for interoperability, which means we are not bound to a specific supplier. The range differs between devices, and is also dependent on the structure of the mesh network. If distances are long, it is possible to use a repeater device.

In short, this communication is smart enough to predict and has sufficient redundancy to work in times of failure, and hence is one of the best available technologies in such industries.

XII. REFERENCES

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