ISSN 2229-5518

DEVELOPMENT & IMPLEMENTATION OF LORA BASED WIRELESS COMMUNICATION SYSTEM IN PROCESS INDUSTRY

MANAS DAS

(The author is a graduate in Instrumentation Engineering from Jadavpur University,Kolkata.He has over nine years experience in desiging,tuning of various control system in Petrochemical Plants and Power Plants.Presently working as Assistant Manager in M/s HMEL(HPCL-MITTAL ENERGY LIMITED)

Abstract:*The paper explores development and application of low cost,low power wireless comminication system and its application in process industry.The paper shows the diffulicy of laying and maintaining of conventional instrumentation cable in different areas of Refinery and Petrochemical.The paper outlines complete implementation technique of proposed wireless communication technique and hook up with standard PLC and DCS..At the same time the paper provides datas and trends of practical application in a Coal Handling System of DCU .The next section of the paper deals with advantages of this solution with conventional solution.*

Key Words: LORA,Wire Less Communication,CCRD Cable,Coal Handling Unit

1.0 Introduction:

ISSN 2229-5518

Our daily life has been greatly enriched by various wireless technology like GSM(2G,3G,4G,5G),Wi-Fi,Bluetooth etc.But, the world of instrumentation in Process industry is relatively untouched by wireless technology except few pilot projects.The major reason behind this is a) Procedural barriers b) Human Latency c) Spectral Management d) High Cost e) Short Range f) Data Security. By implementing LORA wireless technology all the above mentioned problems except first two can be easily resolved.
LORA is a Long Range,Low Power wireless communication protocol. LORA is being widely used in Home Automation and IOT industry, but author has not found any significant use in the Process Industry. This paper aims how low cost LORA devices can be developed and same can be used in the process industry in a cost effective way.

2.0 LORA:Defination and Comparisons

2.1 LORA:

LoRa is a patented[1] digital wireless data communication IoT technology developed by Cycleo of Grenoble, France, and acquired by Semtech in 2012.[2] LoRa uses license-free sub-gigahertz radio frequency bands like 169 MHz, 433 MHz, 868 MHz (Europe),865-867 MHZ(India) and 915 MHz (North America). LoRa enables very-long-range transmissions (more with low power consumption.[3] The technology is presented in two parts — LoRa, the physical layer and LoRaWAN, the upper layers.In this can paper we will only consider LORA physical layer and its connectivity with DCS,PLC.

2.2 BASIC PARAMETERS:

- Link Budget 156 DB
- Data Speed: 300 bps to 5.5 kbps
- Supports:
  Secure Bi-directional Communication;
  Localization;
  Mobility;

2.3 COMPARISON WITH OTHER WIRELESS PROTOCOLS:

There are many wire less communication protocol available in the market like Bluetooth,Wi-Fi,GSM etc.Bluetooth and Wi-Fi covers short distance but it has high speed and low power consumption. On the other hand, GSM has high data speed and long range but uses more power. On the other hand, LORA has long range and low power but extremely low bandwidth. The low bandwidth will not be a problem in process instrumentation applications because dataspeed required is in between 50 bps to 4 kbps.LORA works perfectly in this bandwidth range. Moreover LORA uses very low power .As a result, firstly LORA becomes intrinsically safe for hazardous area application and secondly less battery consumption reduces operating and maintenance cost.
Another advantage of LORA uses license free ISM(Industrial,Sceintific and Medical) band for its communication.
So, it is clear from above facts that LORA is the most suitable wireless communication protocol for Process Instrumentation application.

3.0 Design and Implemention:

3.1 Brief Background of Area of Application:

Our initial area of application is Coal Handling Unit of a Petroleum Refinery.

Coal handling plant is a plant which handles the coal from its receipts from Delayed Coker Unit to transporting it to the boiler for generating the power, coke oven for making coke and store in the bunker. Coal handling refers to the movement and storage of coal from the time it arrives at the plant.

A stacker is a large machine used in bulk material handling. Its function is to pile bulk material such as coal, limestone, and ores onto a stockpile. They normally travel on a rail between stockpiles in the stockyard. A stacker can usually move in at least two directions: horizontally along the rail and vertically by luffing (raising and lowering) its boom. Luffing of the boom minimizes dust by reducing the distance that material such as coal needs to fall to the top of the stockpile. The boom is luffed upwards as the height of the stockpile increases. Some stackers can rotate the boom. This allows a single stacker to form two stockpiles, one on either side of the conveyor.
A reclaimer is a rail-mounted machine used in bulk material handling applications. A reclaimer's function is to recover bulk material such as ores and coals from a stockpile through the scraper shuttle which is taken up the material by endless mounting scraper chains and the blade fastened to them and is feeding onto a belt conveyor that runs laterally along the piles.

3.2 Problem with Conventional Data Communication technique:

Normally Cable from Control Room comes to a JB near Stacker in the grade level. A special type of cable called CCRD cable is laid between the grade level JB and Stacker Boom. Due to the movement of boom the cable comes under high tension. This causes the cable to be damaged repeatedly. The consequence is shutdown of plant,downtime.

3.3 System Architecture of LORA coomunication:

To overcome this problem a new communication system architecture envisaged.

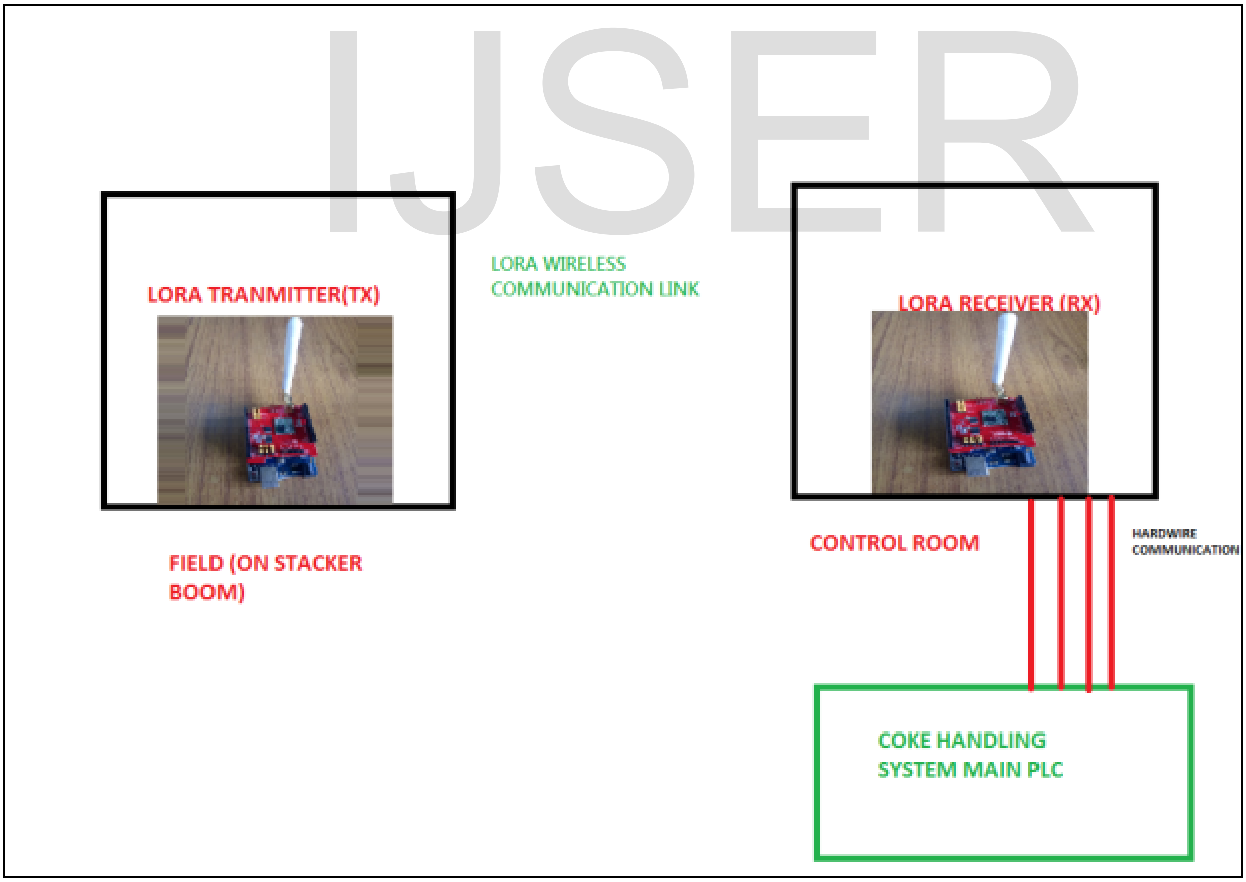


FIGURE-1

The basic communication scheme is like depicted in the diagram above. There is one LORA communication module(Transmitter) in the Stacker Boom.Another LORA module(Receiver) will be located in the CHS Control Room. The LORA receiver will be connected to the PLC with Hardware link.Field Signals will be connected LORA Transmitter module.So, field signals will be transmitted by LORA transmitter,same will be received by LORA transmitter. These signals will then further be received by the PLC through hradware link. In the PLC, these siganls will be used for necessary display and logic purpose.

3.4 Signal Details:

In this particular application we need to send following signals from field to control room.

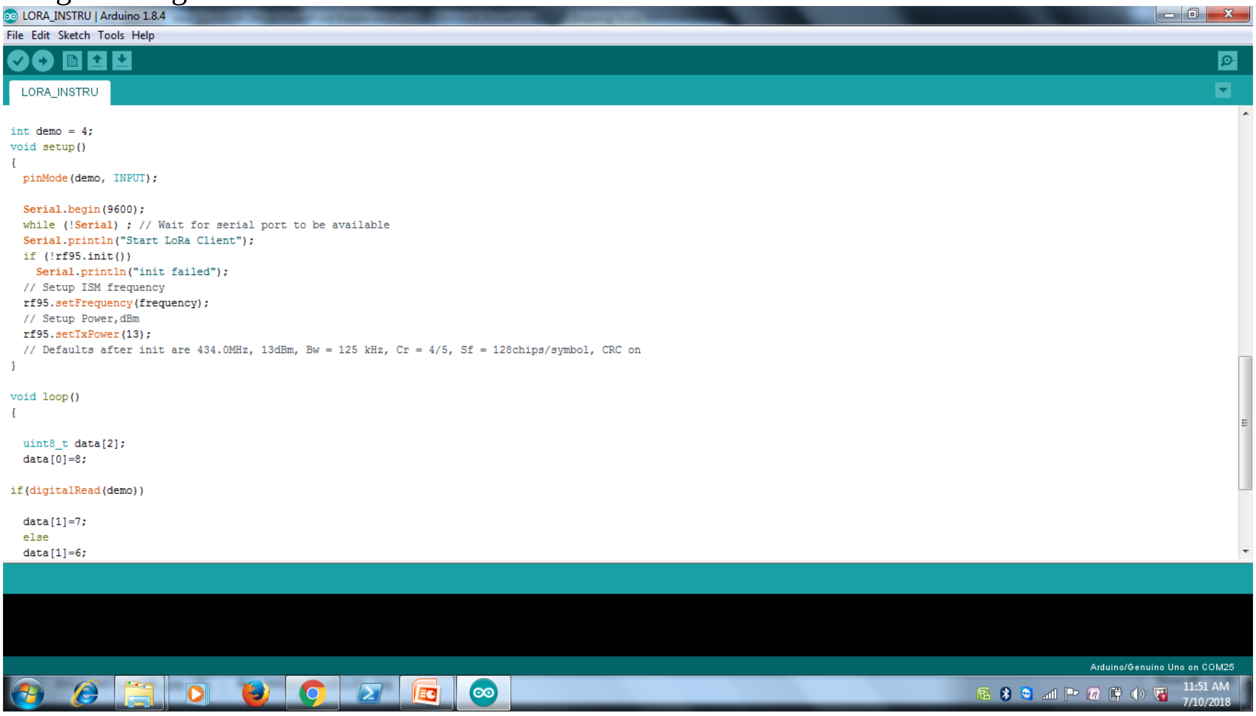
a) STACKER MACHINE HEALTHY ,DO
b) YARD CONVEYOR RUN PERMISSIVE,DI
c) TRIPPER CONVEYOR PCS_BSS_ HEALTHY,DI
d) YARD CONVEYOR RUN FEEDBACK,DI

3.4 Hardware Selection

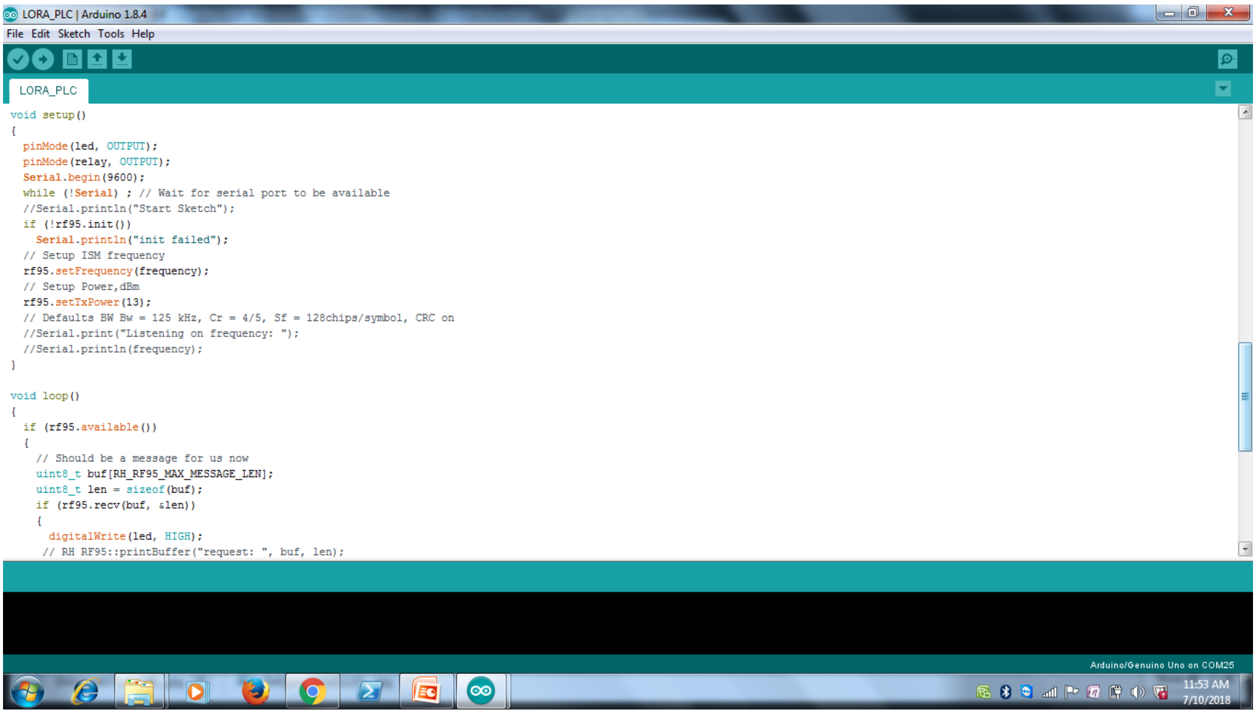
The list of hardwares required to complete one LORA module is as follows:
a) **Atmega Microcontroller :** ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.
b) **LoRa Module:** Using Semtech's patented LoRa™ modulation technique the LoRa Shield can achieve a sensitivity of over -148dBm using a low cost crystal and bill of materials. The high sensitivity combined with the integrated +20 dBm power amplifier yields industry leading link budget making it optimal for any application requiring range or robustness. LoRa™ also provides significant advantages in both blocking and selectivity over conventional modulation techniques, solving the traditional design compromise between range, interference immunity and energy consumption.
c) **Antenna:** Omni directional Antenna used with maximum gain of 2.0 dbi
d) Power: Each LORA device can either be powered by 5V battery or 230/110VAC to 5VDC converter.

3.5 Programming of the Microcontroller:

The microcontroller can be easily programmed using Aurdino Software. Intially we have configured channel-4,5,6,7 to send and receive digital signal.
Programming the Receiver Side:



Programming the Transmitter Side:



3.6 Testing:

For testing the Transmitter module was placed on the stacker and the reciver module on the CHS control room. A push button was connected with channel 4 in the field side and relay was connected with channel 4 in the receiver side.

Then the push button was repaetedly pressed and released to see whether the relay is getting energised and de-energised everytime.

3.7 Hooking up with Schneider PLC:

Output of LORA module is connected to a 5V Relay. The contacts of 5V relay is connected to DI barrier of PLC.Now 4 of spare DI channels has been assigned in PLC and graphics has been configured. Now we can see the values in SCADA.

3.8 Data Security:

The LoRa protocol provides both signing and encryption for parts of LoRa packets. These are done using symmetric keys known both to the Transmitter Node and Receiver Node and are distributed in two different ways depending on how a Node joins the network .

3.8.1 Joining a Node to a LoRa network Over-The-Air-Activation (OTAA):

The first method by which Nodes are allowed to join a LoRa network is through OTAA. Here each Node is deployed with a unique 128-bit app key (AppKey) which is used when the Node sends a join-request message. The message is not encrypted, but is signed using this AppKey. The Node sends the join-request message including its unique AppEUI and DevEUI values plus a DevNonce which should be a randomly generated two byte value. The AppEUI should be unique to the owner of the device. The DevEUI should be a globally unique identifier for the device.

3.8.2 Activation by Personalisation (ABP)

ABP differs from OTAA as the Nodes are shipped with the DevAddr and both session keys (NwkSKey and AppSKey), which should be unique to the Node. As the Nodes already have the information and keys they need, they can begin communicating with the Network Server without the need for join messages.

Protection of data sent over LoRa networks:

ISSN 2229-5518

Once a Node has joined a LoRa network, either through OTAA or ABP, all future messages will be encrypted and signed using a combination of NwkSKey and AppSKey. As these keys are only known by the Network Server and specific Node, there should be no way for another Node, or a man in the middle attack to recover the clear-text data. Data Encryption Encryption of messages is performed using AES128 in Counter mode (CTR).

4.Summary:

To summarise LORA based wireless communication system designed and implemented for Process Instrumentation application in refinery.Real time trend is attached in Figure 4.

Advantages:
1.Low Cost Wireless Solutions
2.Supports Long distance
3.Can be easily hooked up with DCS or PLC
4. Secured Data Transfer

Limitation:
1. Low Bandwidth ,But this does not act as a limiation because low data requirement of Process Instrumentation.

References

1. EP2763321 from 2013 and U.S. Patent 7,791,415 from 2008
2."LoRa, LoRaWAN and LORIOT.io". *LORIOT*. Retrieved 2017-05-05.
3. Ramon Sanchez-Iborra; Jesus Sanchez-Gomez; Juan Ballesta-Viñas; Maria-Dolores Cano; Antonio F. Skarmeta (2018). "Performance Evaluation of LoRa Considering Scenario Conditions". *Sensors*.