International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8, Issue-1S4, June 2019

# Process Control and Wireless Data Management by Constructing a Distributed Control System

**J. Sam Jebakumar, H. Rebecca Shirly, R. Aakash, Madhumitha Anand**

***Abstract---*** ***In the industrial sector, processes are mostly governed by manual methods. Therefore, industrial processes are physically wired between the controller of field device and master controller. This takes a significant portion of the total budget. Also in case of fault diagnosis, the entire plant need to be shut down and troubleshooting is tough because wires are buried underground. This paper aims at reducing the use of wires by transmitting data wirelessly. The architecture of a distributed control system for the plant will enable the control multiple actions simultaneously and only critical processes need to shut down for diagnosis. The processes are automated and controller by individual Local Control Units (LCU). The real-time data from the LCUs are transferred to master controller which is connected to a high-level human interface (computer). This method eradicates time lag and eliminates long distant wired connections. Therefore, multiple processes can be monitored and controlled from a far off master (like control room) and also instruction from master can be sent to the field device through the LCU. Furthermore, an IoT based platform will help in the remote monitoring of the healthiness of plant. The scope of this paper can extended to any type of real time process industry.***

***Index Terms--- Process Control, Distributed Control System, Wireless Data Transmission.***

## I. INTRODUCTION

In DCS incorporated process industry, individual processes are controlled by individual Local Control Units (LCUs). The important samples from all processes need to be transferred to the control room for monitoring and controlling purposes. For this, the LCU in field is connected to a master controller in the control room through shared communication facilities. These may run through kilometers of length depending on the distance between the field and control room [1-3]. The cabling cost consumes a major percentage of the total budget of plant. The cables are either overhead lines or mostly, buried underground. In case of fault diagnosis, it becomes a hectic and chaotic job to detect the presence of fault in the buriedcables. In this paper, we incorporate Distributed Control System (DCS) wherein multiple processes can to monitored and controlled through a single master [4-5]. Also, the use of cables is minimized by incorporating wireless data transmission[6-7].

Manuscript received June 10, 2019 .

**J. Sam Jebakumar,** Assistant Professor, Department of EIE, SRM IST, Kattankulathur. Chennai, T.N, India. (e-mail: jsjebakumar@ktr.srmuniv.ac.in)

**H. Rebecca Shirly,** B.Tech, Department of EIE, SRM IST, Kattankulathur. Chennai, T.N, India. (e-mail: shirley.christley0701@gmail.com)

**R. Aakash,** B.Tech, Department of EIE, SRM IST, Kattankulathur. Chennai, T.N, India.
(e-mail: aakash.ram97@gmail.com)

**MadhumithaAnand,** B.Tech, Department of EIE, SRM IST, Kattankulathur. Chennai, T.N, India. (e-mail: madhumitha_anand@srmuniv.edu.in)

Conventionally, industries used ZigBee protocol. But eventually it became out dated because of the low speed, high maintenance cost and low network stability [8]. Therefore, we go for nRF24L01 which has the similar specifications of ZigBee module. The nRF24L01 modules work on 100m Line of Sight (LOS). In case of longer distance transmission, nRF24L01 utilizes daisy chain topology wherein intermediate nodes can be made. But nRF24L01, is cheapest and has a high network speed allowing a bit rate of 2Mbps [9].However, Individual processes are automated by their respective LCUs. Individual LCUs have individual nRF24L01 modules which transmits the data to the master controller wirelessly[10]. Therefore, monitoring and controlling of processes from a faraway control station is done [11-14]. Also, processes can be controlled by changing of set point from the master is possible. The real time data is automatically updated in a file simultaneously [15]. This methodology is efficient by:

- Eliminates maximum cost spent in cables.
- Maintenance of the plant is easier.
- Troubleshooting is made efficient.
- The data transfer is faster and data loss is a rarity [16-18].

## II. METHODOLOGY

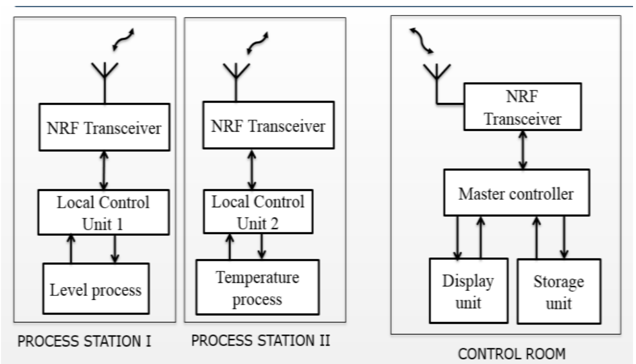


**Fig. 1: Block diagram**

The block diagram depicts the working of the DCS with wireless technology. Process station I represents the level control process. In order to maintain the level, the system utilizes a non-contact level sensor HC-SR04.

It works in the frequency of 40 KHz. The advantage of this sensor is that it incorporates a wide range from 3cm to 4m and also works on minimal global current consumption of 15mA and voltage of 5V[19].


*Published By:*
*Blue Eyes Intelligence Engineering*
*& Sciences Publication*

The setup involves an 18W pump to pump in and pump out the water depending on the requirement. The LCU used is an AtMega328 microcontroller which automates the control action on the process station. The master controller can control the process station depending on the commands given which is communicated through the nRF24L01modules [20].The nRF24L01 is a single chip transceiver which operates on ultra-low power consumptions [21].

Similarly, the process station II depicts the control of temperature in the same concept of Process station I. The temperature process incorporates a digital temperature sensor DS18B20 and a 500W heater. The DS18B20 digital temperature sensor provides 12-bit measurement. The temperature measured is in degree Celsius. The DS18B20 communicates over a 1-Wire bus. It requiresone data line for communicating with microcontroller. The operating temperature range is from -55°C to +125°C with ±0.5°C of accuracy for the range of -10°C to +85°C [22]. However, there will be many such process stations spread across the industry. The data from all the LCU is segregated in the master controller using the unique node address of the each process station.The communication is not just one way. Actions like change of set point from the master to the respective LCU is done using the unique node address communication. The data transfer through wireless communication is made safer by encrypting the data in the LCU side and decrypting in the master side using random code generation technique.

## III. RESULTS

**Table 1: Level process control**

| TIME (mins) | LEVEL (feet) | MOTOR STATUS |
|---|---|---|
| 1 | 1 | ON |
| 2 | 2 | ON |
| 3 | 3 | ON |
| 4 | 4 | ON |
| 5 | 5 | ON |
| 6 | 6 | ON |
| 7 | 7 | ON |
| 8 | 8 | ON |
| 9 | 9 | ON |
| 10 | 10 | ON |
| 11 | 11 | ON |
| 12 | 12 | OFF |
| 13 | 12 | OFF |
| 14 | 12 | OFF |
| 15 | 12 | OFF |

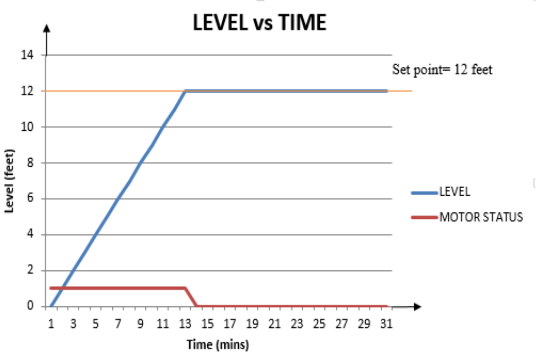


**Fig. 2: Level control process**

The Table 1 provides the real time data for the level process from the LCU. The level is maintained at its set point (i.e., 12cms). Fig 2 shows the real time plot of the same for 30 seconds.

**Table 2: Temperature process control**

| TIME (mins) | TEMPERATURE (°C) | HEATER STATUS |
|---|---|---|
| 1 | 27 | ON |
| 2 | 27 | ON |
| 3 | 27 | ON |
| 4 | 27 | ON |
| 5 | 28 | ON |
| 6 | 28 | ON |
| 7 | 29 | ON |
| 8 | 29 | ON |
| 9 | 30 | ON |
| 10 | 31 | ON |
| 11 | 31 | OFF |
| 12 | 31 | OFF |
| 13 | 31 | OFF |
| 14 | 31 | OFF |
| 15 | 30 | OFF |

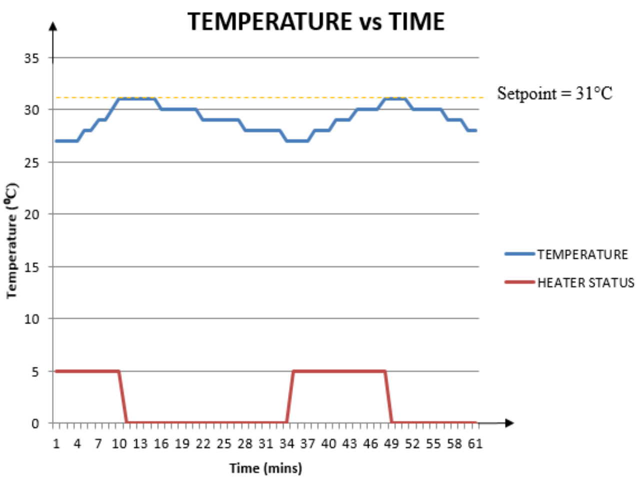


**Fig. 3: Temperature control process**

Table 2 shows that the real time temperature maintenance of the process station from its LCU. The temperature is maintained in its set point of 31°C. Fig 3 shows the plot of temperature control for 60 mins.

## IV. CONCLUSION

Wireless communication technologies are proved to be advantageous by eliminating the need of cables, which are considered as additional maintenance. Also, the speed of data transfer can be configured easily. The prototype constructed portrayed the above features.Upon constructing a DCS, it is advantageous that various processes can be controlled and monitored simultaneously. Thecollected process data are stored locally in a file. The scope can be expanded by replacing the RF protocol with industrial wireless protocols such as WirelessHART or Fieldbus.



*Published By:*
*Blue Eyes Intelligence Engineering*
*& Sciences Publication*

## ACKNOWLEDGEMENT

We would like to thank the Department of Electronics and Instrumentation, SRM Institute of Science and Technology for extending their help and support with apparatus for the successful completion of the project.

## REFERENCES

1. Eric.J.Byres and Colin Mitchell, "Process control using fibre optic unified cabling system" IEEE industry magazine, May/June 2002.
2. GyeongMoon An, Hiesik Kim, "Optimization of the Wiring in the Sequence Control Circuit", 2016 International Conference on Electronics, Information, and Communications (ICEIC), DOI:10.1109/ELINFOCOM.2016.7563007, 08 September 2016
3. Yongsuk lee and Gyungho lee, "HW-CDI: Hard-Wired Control Data Integrity",IEEE Access, VOLUME 7, January 2019, DOI:10.1109/ACCESS.2019.2891762.
4. Liudmila V. Chernenkaya, Elena N. Desyatirikova, Vadim E. Belousov, Stanislav A. Chepelev, Svetlana I. Sergeeva, Nataliya V. Slinkova, "Optimal Planning of Distributed Control Systems with Active Elements", 978-1-5386-0777-0/17, 2017 IEEE.
5. Tuyen V. Vu, David Gonsoulin, Dallas Perkins, BehnazPapari, HesanVahedi, and Chris S. Edrington, "Distributed Control Implementation for Zonal MVDC Ship Power Systems", 978-1-5090-4944-8/17, 2017 IEEE.
6. Mark J. Nixon, Round Rock, TX (US);Terrence Blevins, Round Rock, TX(US);
7. Daniel Dean Christensen,Austin, TX (US); Paul Richard Muston, Narborough (GB); Ken Beoughter, Round Rock, TX (US), "big data in process control systems", Patent NO.: US 9,558,220 B2, Jan. 31, 2017.
8. Shancang Li,LiDaXu, and Xinheng Wang, "Compressed Sensing Signal and Data Acquisition inWireless Sensor Networks and Internet of Things", IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 9, NO. 4, NOVEMBER 2013.
9. "Disadvantages of ZigBee protocol"
10. https://www.ecstuff4u.com/2018/03/advantages-and-disadvantages-of-zigbee.html
11. "Advantages of nRF24L01"
12. http://smartmicrocontroller.com/5-reasons-to-use-2-4ghz-wireless-for-your-projects/
13. Abid Rahim, Zeeshan Ali, RaushanBharti, Syed Sabeel N.S.P., Mrs. Ramya B.K., "Design and Implementation of a Low Cost Wireless Sensor Network using Arduino and nRF24L01(+)", International Journal of Scientific Research Engineering & Technology (IJSRET), ISSN 2278 – 0882, Volume 5, Issue 5, May 2016.
14. AbdelghaniDaraiseh, Dhahran Mohamed Adnan Landolsi, "Adaptive hybrid wireless and wired process control system with hierarchical process automation field network sets", Patent No.: US 8,942,098 B2, Jan. 27, 2015.
15. Neil J. Peterson, Trevor D. Schleiss," Location dependent control access in a process control system" Patent No.: US 9.244.455 B2, Jan. 26, 2016.
16. Francisco B. Culibrina, Elmer P. Dadios, "Smart Farm Using Wireless Sensor Network for Data Acquisition and Power Control Distribution", 8th IEEE International Conference Humanoid, Nanotechnology, Information Technology Communication and Control, Environment and Management (HNICEM), December 2015.
17. Raguvaran. K, Mr. J. Thiyagarajan, "Raspberry PI Based Global Industrial Process Monitoring Through Wireless Communication", International Conference on Robotics, Automation, Control and Embedded Systems – RACE 2015, ISBN: 978−81−925974−3−0, February 2015.
18. H. Fekhar, H. Habbi, "Design and implementation of wireless system by Using microcontrollers and microcomputer with application to drive acquisition system", 978-1-5090-5987-4/17/ 2017 IEEE, Jnuary 2017.
19. Linghe Kong, Mingyuan Xia, Xiao-Yang Liu, Guangshuo Chen, Yu Gu, Min-You Wu, Xue Liu, "Data Loss and Reconstruction in Wireless Sensor Networks", IEEE transactions on parallel and distributed systems, vol. 25, no. 11, november 2014.
20. Yan Yu, Member, IEEE, Feng Han, YuequanBao, and JinpingOu, "A Study on Data Loss Compensation of WiFi-Based Wireless Sensor Networks for Structural Health Monitoring", IEEE SENSORS JOURNAL, vol. 16, no. 10, may 15, 2016.
21. "Ultrasonic HC-SR04 sensor datasheet" https://cdn.sparkfun.com /datasheets/Sensors/Proximity/HCSR04.pdf
22. "AtMega328 datasheet"
23. https://www.sparkfun.com/datasheets/Components/SMD/ATMega328.pdf
24. "nRF24L01 datasheet"
25. https://www.sparkfun.com/datasheets/Components/nRF24L01_prelim_prod_spec_1_2.pdf
26. "Temperature DS18B20 sensor datasheet"
27. https://cdn.sparkfun.com/datasheets/Sensors/Temp/DS18B20.pdf