ORIGINAL RESEARCH PAPER

Volume-7 | Issue-9 | September-2018 | PRINT ISSN No 2277 - 8179

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

CATHODIC PROTECTION REMOTE MONITORING BASED ON IOT PLATFORM

Computer Science

Indrani Palanisamy Senior Lecturer, Department Of Computing, Middle East College, Sultanate Of Oman.

Hania Fatima Muhammad Arif Mirza* Student, Department Of Computing, Middle East College, Sultanate Of Oman. *Corrresponding Author

Khulood Sulaiman Saif Al Mawali Student, Department Of Computing, Middle East College, Sultanate Of Oman.

ABSTRACT

In oil industry, a pipeline is major infrastructure for transportation of the products from place to place. Most of the pipeline is running in the underground and submerged in the water. Soil is the corrosive medium due to the presence of air, moisture and chemical compound in the form ionic state. Pipelines are protected by coating like coal tar or polyethylene compound. Coatings are degraded owing to ageing and defects are occurred due to many reasons like poor surface preparation, mechanical damage while transporting from shop to site and then installed in the pit. Coating defect area on the pipeline acts electrochemically as an anode and corrosion will take place. Corrosion of the pipeline in soil or sea water is controlled by an electrochemical technique namely cathodic protection [1].

Cathodic protection (CP) system has been used many decades for controlling external corrosion of buried or submerged piping systems. In eighteen century, Sir Humpry Davy protects the copper bottom of the navel ship by attaching steel bock from corrosion. Since iron is more electronegative/active material than the copper and hence iron act as anode and copper become cathode. In this case, entire copper sheath receive an electron from the iron block and polarized in the cathodic direction and copper become a single potential and the techniques named as cathodic protection [CP]. Two methods for cathodic protection is sacrificial anode and impressed current system. When two different metals are coupled in a conductive media the metal which has a highly electronegative potential becomes the anodic member the other one with lesser electro negative voltage becomes the cathode. Anodes such as Zinc, Magnesium or aluminum material are used to protect iron material such as pipeline in soil/seawater medium by sacrificing the anode in the way of liberating electrons which polarize the pipeline in the cathodic polarization and prevent the corrosion. In the other way, DC power supply is to impress the electron to the pipeline, named as impressed current CP [ICCP] system to mitigate the corrosion[2].

The objective of this project is to develop IoT device using Raspberry Pi 3 module for SCADA system employed in the impressed current cathodic protection of underground pipeline. Corrosion of Oil and Gas pipeline in a soil environment is the major issues both economical and safety aspect. Cathodic protection is an electrochemical method used to control the underground corrosion of the steel structure. In impressed current CP, controlled direct current is impressed on the steel structure for polarized in the cathodic direction and also maintained at corrosion free potential. In order to monitor the CP performance polarized pipe potential is monitored along the pipeline at the interval of 500m.

In this project IoT-SCADA system and IoT-CPM was developed using Raspberry Pi 3 for controlled the corrosion as well as monitoring the level of corrosion protection respectively.

KEYWORDS

INTRODUCTION

Cathodic protection (CP) criterion of steel pipelines, −0.850V (vs. Cu/CuSO4) under CP, was first proposed by Kuhn in 1933 and has since been established and followed by globally on steel pipelines in various soils and water. The overprotection criterion is -1,200 mV vs. Cu/CuSO4 [3]. In order to maintain the polarized potential of pipeline between -850mV to -1200mV vs Cu/CuSO4, a control system was incorporated in the DC power supply. With help of insoluble anode, controlled current is impressed at one point and pipe to soil potential is measured at the interval of every 0.5km to know the level of protection. Historically, manual measurement was carried out once in a month. Layer on remote monitoring was done using multiple communication interfaces like, Radio, TETRA, RS-485, Fibre Optic, TCP/IP, etc.

IoT-SCADA system:
An automatic control CP system consists of three modules:

- Control Unit or Remote Terminal Unit [rtu]
- Monitoring Unit
- Communication Network

Control unit

The function block of the RTU contains of numerous elementary parts such as, a microprocessor, memory device, buffers, decoders, clock and an ADC converter block [5]. The block diagram of typical SCADA system for Cathodic Protection is shown in Fig 1.

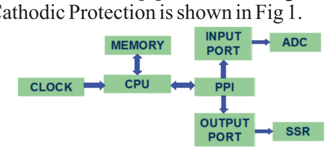

Fig 1. Block diagram of a control unit of RTU

CPU executes the program stored in the memory and generates the suitable signals to their input and output ports. An ADC module converts the analog voltage of the sensor output and stored in the memory module. CPU computes the difference between measured sensor data and a set voltage, the pulse with a necessary duty cycle is generated at the output port. Fig. 2 shows the wave form of the control signal.

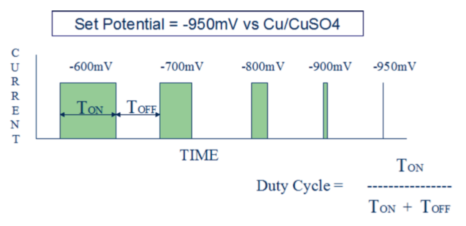

Fig.2 Schematic representation of a typical Pulse with control signal of the RTU

In the phase controlled CP rectifier, the output is fed with pulses of energy. The filter at the output section cleans up these pulses quite well when the duty cycle (on time) is high. However, when the duty cycle is low, the filter cannot do a good job of cleaning up the pulses into a pure DC voltage. The result is a high amount of AC voltage (or ripple) superimposed on the desired DC output. This high value of AC creates instability in the feedback control and as a result, this type of rectifier cannot properly control current and voltage at low output values. Also for this reason, this type of rectifier cannot be used for accurate off potential control at low output levels. By definition of CP criteria, the control system is operated based on a true polarized potential of the pipeline with free of IR- drop voltage. The IR drop error starts from the resistance of the electrolyte to the structure. IR drop error can be eliminated by interrupting the current instantaneously during a measurement of sensor data.

Fig 3 shows a block diagram of the output module in which SCR device is replaced with a SSR-solid state relay. The key components of a relay SSR is an optoisolator that contains a photo sensitive device, infrared and LED light source within a single case. The optoisolator separates the input from the output.

Fig 3. Block diagram of the output module of an RTU

SCADA was designed over the Raspberry Pi3 module integrated with ADS1256, 8ch 24bit high-precision ADC, 30ksps sampling rate, interfaced through SPI protocol. The Raspberry Pi 3+ has a Broadcom BCM2837 system on a chip (SoC), which includes a 1.4 GHz 64-bit quad-core ARM Cortex-A53 processor with 512 KB shared L2 cache. It uses an SD-Card for booting and persistent storage. It has a 40-pin GPIO pinout for a peripheral interface. The Foundation provides rasbian Linux OS and Arch Linux ARM distributions for download. It features dual-band IEEE 802.11b/g/n/ac WiFi, Bluetooth 4.2, and Gigabit Ethernet [6,7]. Python as the main programming language, tools are available for coding [8,9].

Sensor Cu/CuSO4 was employed for measuring the polarized potential of pipe under CP envisaged condition. The solid state relay was installed between positive terminal DC power supply and ICCP anode (Graphite anode). The schematic diagram of the impressed current IoT-SCADA system is shown in figure 4.

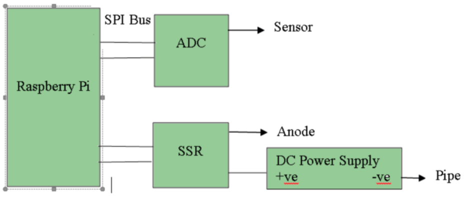

Fig 4. Schematic diagram of IoT-SCADA system

IoT-SCADA obtained pipe potential from Cu/CuSO4 sensor and controls the current output from the dc power supply through the SSR. Further, it measures the voltage between pipe to the anode, current out from the power supply using shunt resistance connected in series and stored temporarily in a file in the SD-card. Wi-Fi module in the raspberry pi sends the data file to the Dropbox cloud through the GPRS wireless modem. IoT-CPM is the raspberry pi monitoring station installed along the pipeline route at every 500m interval. It measures pipe potential with help of permanent Cu/CuSO4 sensor and uploaded periodically to the cloud storage.

RESULTS AND DISCUSSION

As an example, the designed IoT-SCADA was implemented on pipeline segment of size 8" diameter and 20 feet length, coated with coal tar, buried at the depth of 5 feet in soil. The soil resistivity was 12000 ohm-cm and chloride content was around 400 ppm with negligible amount of sulfate ions. The soil contains very low level of sulfate reducing bacteria [SRB] count. Hence control voltage was set at -900 mV vs CSE in the RTU. A TSIA (Titanium substrate insoluble anode was employed to impress the current in the order of 110mA. There are two test station was installed at both ends of the pipeline in which IoT-DCADA was installed at one end and IoT-CPN was installed at another end. At every 3 seconds, the data file was uploaded to Dropbox through TP-Link wireless modem.

Fig 5 shows the snapshot of uploaded file lists in the Dropbox account (cloud). The file name was automatically created by current date and time using string format of "yy mm dd:mm:ss.csv". Each file contains the test station number, location and pipe potential with the time stamp. A user can download the file from Dropbox by proper login username and password.

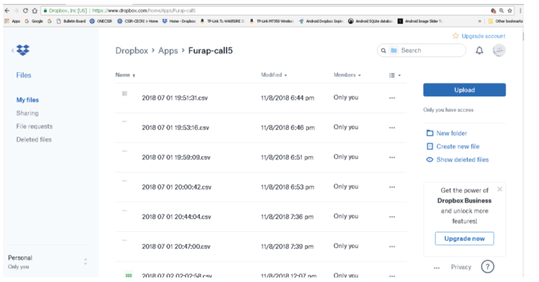

Fig 5. Snapshot of the files uploaded in the dropbox cloud

CONCLUSION

Corrosion of the underground oil and gas pipelines have the impending to cause major catastrophic happenings that not only cost millions of dollars in damages but put human lives at risk. A prototype of IoT based SCADA for impressed current cathodic protection of the underground pipeline was described. Hardware system was developed using a raspberry pi module. Solid state relay was employed as a current controller that operated in pulse with modulation. IoT-CPM monitoring system is used for continues monitoring of the pipe potential at every test station. All the data measured at the respective test stations were uploaded to Dropbox cloud and it can be viewed at anywhere using secured password login.

REFERENCES

1. Principles of Corrosion Engineering and Corrosion Control - Zaki Ahmad ISBN: 9780750659246, 2006
2. Cathodic Protection, Theory and Practixe, eds -Ashworth V and Googan CG, Ellis Horwood, New Yeark, 1993
3. Criteria for Cathodic Protection-The Journal of Corrosion and Science Engineering, Vol 3,2001 Grant T Gibson and David Scantlebur
4. Designing the Internet of Things-Adrian McEwen, Hakim Cassimally, 2016
5. Handbook of SCADA Systems for the Oil and Gas Industry -R.I. Williams, 1991
6. Raspberry Pi — Teach, Learn, and Make with Raspberry Pi- https://www.raspberrypi.org
7. https://www.wikihow.com
8. Introduction-Raspberry Pi tutorial-Python Programming Tutorials https://pythonprogramming. net/ introduction-raspberry-pi-tutorials
9. Python-Raspberry Pi Documentation https://www.raspberrypi.org/ documentation/ usage/ python/
10. Cathodic Protection Remote Monitoring Based on Wireless Sensor Network-Mohammed Sensor Network, 2012, 4,226-233,