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# Remote Monitoring of Oil Pipelines Cathodic Protection System via GSM and Its Application to SCADA System

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**Abstract:** ***Nowadays, regarding the development of technology and applying the modern methods and system controls, using traditional methods and being on the site have been replaced by remote supervision that has various advantages. Therefore, an appropriate approach, using these modern methods, and applying information technology in industry seems necessary. In this paper, the authors intend to explain a device for remote sending the cathodic protection information of oil and gas pipelines and applying it to SCADA system via GMS. This device has been designed and tested in the Iranian Oil Pipelines and Telecommunication (IOPTC) of Lorestan Province for first time in Iran.***

**Keywords:** remote monitoring, GSM, cathodic protection, SCADA, pipeline

## 1. Introduction

One of the largest and most important industries in the country is the Iranian oil industry that the operating area in some of its subordinate companies covers the whole country, for instance, Iranian oil and gas pipeline companies.

These pipes are very long and costly and their uninterrupted continuous use for transport makes them very important; therefore, their protection is crucial. In industries, the pipelines in particular, protection methods have been applied from the very beginning of their production and monitoring also occurs during operation, often staying at their location form. Due to the long distance and widespread distribution of pipelines, online monitoring is usually quite difficult. Using remote monitoring offers some advantages as follows:

1. Protecting people's health and lives along roads
2. Reducing the commuting costs
3. Obtaining detailed real-time information from different sources

Generally, corrosion data are not a part of the SCADA system menu because the industry is mainly satisfied with common methods of corrosion monitoring such as Pig Operation and corrosion coupons that are not real time methods and focus on the past information. However, with the advent of new technologies in real time corrosion monitoring, operators can be equipped with the ability to detect local corrosion and the spread of corrosion, in a way that corrosion parameters can be managed and optimized to avoid costly damages and spread corrosion.

According to various modern methods of real time monitoring, it is worthy that new information be collected and integrated into the SCADA system [3]. It would be appropriate to ensure that all information about the corrosion given to the operator may be helpful. Although corrosion data are used in the analysis methods to repair and determine the objectives of the program, using these data (process parameters such as pressure and temperature) in real-time techniques can also be employed by the operator in dealing with corrosion.

Cathodic protection (CP) systems are fundamental to pipeline integrity management and are widely used on transmission and (high or intermediate pressure) distribution pipelines in gas, petrochemical and water sectors. To comply with regulatory safety standards, routine measurements of CP levels are required. Manual measurements, apart from their high costs, may only indicate problems after they have occurred, which can result in pipelines' lack of protection until the fault is discovered. Remote monitoring of CP is a new development that automates data collection process and provides operators with a proactive surveillance system. The system monitors the output voltage and current from transformer rectifiers (T/R) in order to ensure that the correct level of CP is applied. The AC supply to the T/R is also monitored so that power outages can be reported immediately. In this project, attempt has been made to build a device with SCADA remote monitoring method in cathodic protection systems using GSM system [2].

### 1.1. Advantages of Remote Motoring of Cathodic Protection system

Historically, the CP data required for compliance and operational purposes has been collected in the field manually. Pipeline operators have trained their technicians to carry out various measurements and have implemented data management schemes to record and report the data. The scale of this activity has increased in proportion to the expansion of pipeline networks over many years. T/Rs are typically spaced at 15 km intervals along a pipeline. However, they are often difficult to access or in remote locations where vehicle access may not be possible. Transport time and cost are increasing and it is not uncommon for a technician to spend half a day travelling to a remote T/R or test point.

With pressure on all companies to maximize the productivity of their labor force, manual data gathering is increasingly witnessed as a poor utilization of human resources. By identifying and reporting problems as they occur, remote monitoring ensures continuous effective CP; thus, it maintains or extends the operating lifetime of a pipeline. In Europe and the US, it has been shown to be cost-effective, with a typical payback of less than two years. It increases safety by eliminating the requirement for measurements at roadside and inaccessible locations as well as eliminating electrical hazards to technicians. Moreover, it may help companies to improve their environmental performance.

### 1.2. Cathodic Protection Measurement Methods

Pipeline operators protect against the long term effects of corrosion by applying high quality coatings to minimize the interaction between the pipe and the surrounding soil. However, defects can occur in the coating. A secondary method of protecting the pipe metal against corrosion is therefore required. Corrosion is an electrochemical process that takes place when a metal is exposed to its environment. Corrosion normally occurs at the anode but not the cathode of the circuit. The principle of cathodic protection (CP) is to connect an external anode to the metal to be protected and to pass a positive DC current between them so that the metal becomes cathodic and does not corrode. All pipeline operators use CP extensively on their transmission pipelines. The big advantage of CP over other forms of corrosion treatment is that it is applied very simply by maintaining a DC circuit and its effectiveness can be monitored continuously. There are two main CP system types (*See* Figure 1)

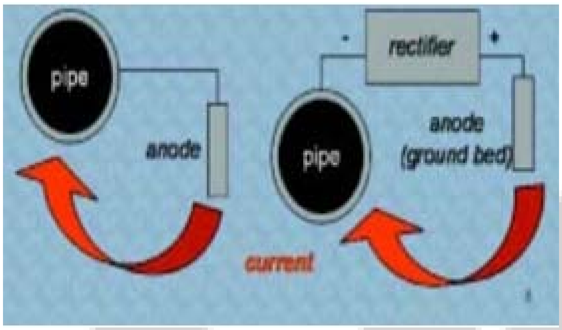


**Figure 1:** Types of cathodic protection system -- galvanic (L) and impressed current (R)

In a galvanic system, DC current arises from the natural difference in potential between the metal of the external anode (typically Zn, Al or Mg) and that of the pipe (carbon steel), to which it is electrically connected. While the pipe is protected, the anode corrodes preferentially and is referred to as "sacrificial". Galvanic systems are easy to install, have low operating costs and minimal maintenance requirements. They do not need an external power supply and rarely interfere with foreign structures. However, they offer limited protection of large structures and are mainly used for localized CP applications.

In an impressed current system, an external DC power source (rectified AC) from a transformer is used to impress a current through an external anode bed (usually inert) onto the pipe, causing its surface to become cathodic. The high current output of this type of CP system is capable of protecting long lengths of pipeline economically. However, impressed current systems rely on a continuous AC power source as well as the operation of the transformer rectifier (T/R) that energizes the system. Cathodic protection is so important in protecting a pipeline that operators are required to take and report regular measurements of CP data. Both levels of protection applied to the pipe (at the source) and the in situ levels were measured along the pipe itself. The level of CP that is applied, especially from an impressed current system, is important. Too little current will not protect the pipeline adequately. Excessive current can lead to material degradation and premature failure of the pipeline. In an impressed current system, measurements of voltage and current outputs at T/Rs must be within acceptable limits. It is also important to monitor that the AC supply is always present -- power failure immediately renders the CP system ineffective.

Figure 2 show how, in manual measurement, a multi meter is used to take spot readings of voltage potential at a test point that incorporates a physical connection to the pipe. Some or all of the measurements may be taken to confirm whether CP is being applied effectively to the pipeline. Of specific interest are:

- Drain points of T/Rs
- CP low points (often mid-way between T/Rs or at the end of a pipeline)
- Pipe crossings or other sources of foreign pipe interference
- Critical bonds and isolation joints
- Downstream of compressor stations (elevated temperatures)
- Areas of susceptibility to AC (e.g., close to overhead power lines)

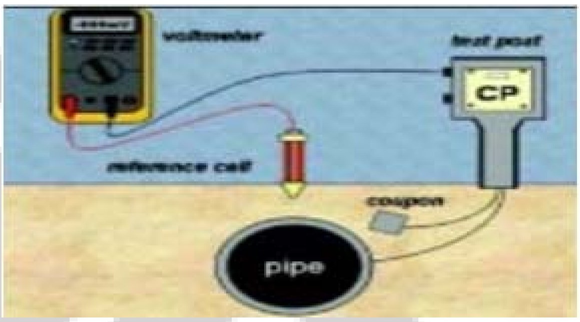


**Figure 2:** Manual CP measurements taken at a test post

The frequency of measurements at various points can be varied according to local conditions, but is generally in compliance with NACE guidelines -- monthly or bi-monthly at T/Rs and anywhere from monthly to annually at test posts, depending on the performance of the CP system and external factors such as population density, interference and third party activity. Pipeline operators must provide their national regulatory body with the evidence that their monitoring is adequate to demonstrate effective management of their CP systems. This is particularly important for pressurized pipelines containing gaseous or liquid hydrocarbons; however, CP can also be found on pipelines containing special chemicals, water and some gases, such as those used in the production of steel [1].

## 2. The Main Cathodic Protection Measurements

### 2.1 ON Potential

The potential of a pipeline at a given location (commonly known as the pipe-to-soil potential), resulting from the electrolytic reaction between the buried pipe and its surrounding soil (the electrolyte). The measurement is made while the CP system is energized.

### 2.2. Instant OFF Potential

The T/R output is briefly interrupted to produce a "true" pipe-to-soil potential, free from undesirable IR drop effects and before any appreciable depolarization occurs. This is a more significant measure of the protection afforded to the pipeline. If it is not possible to interrupt the T/R momentarily, then an alternative approach is the use of a corrosion coupon (See below).

### 2.3. Coupon Current

A coupon is a representative sample of the pipeline material, buried close to the pipe so that it is subject to the same environmental conditions and electrically connected to the pipeline. The instant OFF potential can be conveniently measured by interrupting the CP connection to the coupon. The measurement of current flow to/from the coupon can also be determined by measuring the voltage across a resistor (shunt). The surface area of the coupon allows the current density to be calculated.

## 3. Telecommunication System

CP data is transmitted from the field units to an operational center. The widely used communication methods are GSM/SMS in the areas that have cell phone coverage and satellite in the areas that do not. In either case, data is transmitted automatically and wirelessly into a software package where it is displayed, archived, and available for regulatory reporting. Alarms are generated automatically.

## 4. Advantages of GSM as Wireless Telecommunication Network

Long distance of pipelines requires the use of wireless systems. In telecommunication systems, to send data outdoors, we need radio frequency licenses from Regulatory Authority and also making communication circuits in a given frequency has its own problems. However, this device, by using the GSM system, solves all these problems completely because not only it does not require a dedicated communication channel, but also desired number of locations and different devices can be connected and there are also no security problems in sending SMS.

## 5. Project Description

Knowing the wide range of oil pipelines in Iran (about 14,000 Km), monitoring these lines is difficult at any time. In this project, attempt has been made to provide a device to measure various important parameters in protection of these pipelines and finally to send data continuously or scheduled through GSM communication system via SMS to the information center.

The idea of making the device was formed when it was seen that how corrosion engineering staff measures the applied voltage to the pipeline for cathodic protection with difficulty. One of the advantages of this device is using it in places where there are no telephone line and computer networks. Although there is no infrastructure along the pipelines due to the dispersion of the pipelines to send the information, using this machine can help us to be aware of these parameters.

This machine has two main parts (*See* Figure 3):

1. Controller and measuring part whose task is measuring the analog quantity from the related sensors and converting them into electrical quantities and also receiving some digital alterations like alarms, control process and sending to the transmitter.
2. The GSM transmitter to receive data from the controller and send them via SMS.


**Figure 3:** Cathodic Protection measurement system schematic

The controller and measuring part consists an AVR microcontroller that usually has eight analog and 24 digital ports (which can be modified in various models of microcontroller). The former can be used in continuous measurements like voltage and current directly and measuring the pressure, temperature and flux and the explained sensors directly or indirectly. The latter can be employed in receiving commands from the switches and even sending commands to launch different actuators. In cathodic protection systems, to prevent external corrosion, a negative DC voltage is applied to pipes by transrectifier and positive pole to the earth.

Since analog ports of AVR microcontroller cannot measure the negative voltages, we use a negative inverter by up-amp. Another problem is that the resistance between the pipes and the earth is high and it causes a very low current to be flowed into measurement device and therefore AVR analog port cannot be launched. As a result, to overcome this problem, a buffer voltage op-Amp has been used to raise the input resistance of voltage measuring device before the voltage inverter. After calibration to a proper variable, which here is string, the measured voltage is converted and sent to AVR serial port in a form of serial data to be sent via SMS. In order to prepare data in the scheduled time and dial a receiving modem and finally send the considered digits, AVR program has a clock. Also, a set of points is defined so that if the voltage decreases at them, an alarm text is sent to the central unit (*See* Figure 4).

The transmitter has a GSM SIM300 module by which a phone SIM card is inserted and connected to the controller to send quantity or alarm via SMS based on a programmable time or based on an alarm set point. The connection between the transmitter and the receiver is through both software and hardware. The information is received from GSM modem via serial port and sent to the database of the SCADA software. Other advantages of using the current machine are as follows:

1. Monitoring and measuring the material flux through pipelines for leak detection material
2. Monitoring and measuring the pressure of the material along the pipelines
3. Sending commands to the actuators connected to AC rectifier transformer to change the applied voltage and current of the pipelines

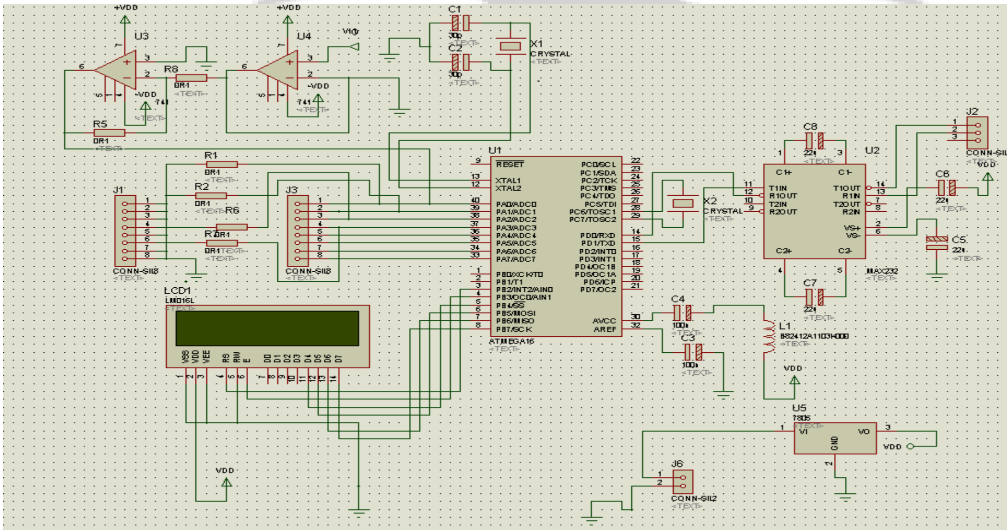


**Figure 4:** Measurement and controller system

## 6. Conclusion

Integrating the SCADA system with corrosion detection, monitoring, and prevention system is still in its early stage. However, it can be developed and applied quickly as an assistant besides the operators to prevent the corrosion and related problems. The lack of infrastructure telecommunication next to pipelines and their widespread distribution throughout the country make GSM system to be more economical and administrative. Using various modern devices and obtaining detailed data and converting them to accurate and effective graphical diagrams and finally employing appropriate alarm systems and analyzing the acquired data to predict pipeline corrosion can be the next step of this project.

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