GPRS BASED DISTRIBUTION TRANSFORMERS MONITORING SYSTEM

Babak Mohammadi
Zanjan EDCO – Iran
babak58m@yahoo.com

Ali Eslami
Zanjan EDCO – Iran
eslami_ali63@yahoo.com

Akbar Bayat
Zanjan EDCO – Iran
a_bayat@znu.ac.ir

ABSTRACT

Transformers are one of the most important equipments in distribution networks. Under abnormal circumstances, due to the great delay in detection of improper operating equipments such as overload operation of transformers and lack of online connection to emergency alarms of protective relays like Buchholz and thermometer, these equipments sometimes encounter distribution companies with unpredicted heavy costs. In this paper we propose a GPRS (General Packet Radio Service) based monitoring and control system which is able to reduce the cost of damaged transformer replacement. Furthermore, the method is capable to improve reliability, create the unity and coordinated management of substations. With that motivation, several prototypes of the proposed monitoring system are successfully employed in Zanjan distribution network. The contributions are observed to be highly effective.

INTRODUCTION

As an inseparable part of electric power system, electrical distribution systems (EDS) play an important role in connecting electric power generation and the consumers. Recent innovations in power electronics and diagnostics components are changing fundamental abilities and characteristics of EDS. Distribution Transformers are considered as one of the most vital and costly equipments which play an important role in the stable power supply of EDS.

Transformers are generally reliable pieces of plant and cover a vast range of sizes on power stations. However, the outage of any transformer may be catastrophic especially for the important and high rating power transformers that supply large number of loads. Faults are often difficult to diagnose or locate in transformers due to complicated winding structures, but a multi- parameter continuous condition monitoring approach gives valuable data to diagnose the fault and suggest its location. Where in-situ repairs can then be made, both downtime and costs can be significantly reduced. Condition monitoring can prevent transformer unplanned outages and catastrophic failures cause by faults. It allows ageing of the plant to be monitored and therefore controlled and possibly predicted and extended [1].

One of the most applied procedures for detention of incipient faults in power transformers, such as partial discharges, electrical arcing and overheating, is the analysis of the concentration of gases dissolved in the isolating mineral oil. This analysis usually is carried through in a laboratory. Although it presents trustworthy results the chromatography brings some inconveniences as the need of a periodic sampling along with the distance from the laboratory to the substation of electric energy [2]. One of the most important features of the control equipment for measurement and carry through this analysis in the field is its capability for remote control and monitor. Thus, an Internet procedure based on GPRS technology was developed. The use of the GPRS for remote communication made possible the development of equipment more independent, capable to transmit and receive commands from different substation of electric energy [2].

To state the matter differently, even though having a well designed distribution network with many maneuverable switches for reconfiguration and restoration purposes, deterioration of a transformer might impose a considerable outage in a part of network which in turn decrease reliability and increase undistributed energy rates. Thus, as an economic solution, simultaneously monitoring of heavy-loaded and vital transformers can be performed by the aid of inexpensive communication environment which consequently, prevents numerous abnormal operating conditions capable of damaging transformers. That could be as simple as sending a short message from the heavy-loaded transformer to Control-Center so that they can inform and manage the crew on duty to mitigate the load of the transformer by transferring some parts of loads to the adjacent feeder.

The selection of candidate distribution transformers was based on their price and with the gradual advent of power quality concerns and the outline of electric industry, other important parameters such as modifying operation indices, outlets, reducing the deterioration expenditure, replacing traditional ways of maintenance with remote monitoring capabilities and so on are taken into account. As an example, consider a very hot summer day in which due to a failure in air conditioner of a substation, operating temperature rises and lack of online status monitoring of protective relays like Buchholz and Thermometer result in damaging transformer and de-energized area. This is especially the problem of EDS on tropical area which frequently impose heavy costs. Therefore, additional GPRS based connection and monitoring allows for real-time control, information and data gathering, optimizing system reliability, asset utilization, and security.

Nevertheless, deployment of equipment monitoring

systems is not limited to the modification on operating conditions. In some literatures, it is considered as one of fundamental requirements and primary steps towards Smart-Grid. For instance, in [3], assuming as one of inseparable part of Smart-Grid, smart transformers are studied.
Hereafter, the details of GPRS distribution transformer monitoring system will be explained

GPRS BASED DISTRIBUTION TRANSFORMERS MONITORING SYSTEM

The GPRS based distribution transformers monitoring systems are categorized into three groups.
1- Data Terminal Unit (DTU)
2- Data Transmission Network (GPRS)
3- Monitoring Center

Fig. 1 shows the way that different equipments in DTU interact together.

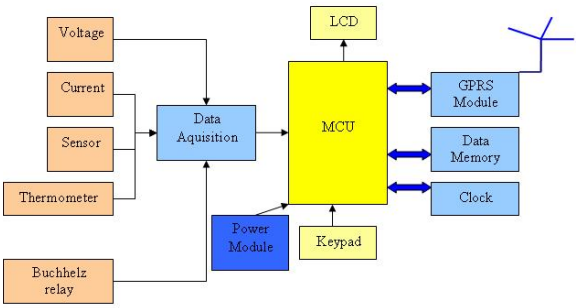

Fig. 1: Interact of DTU equipments

Some privileges obtained by the employment of distribution transformer status monitoring systems are given below:

1- Low cost requirement of GPRS (since it is an additional service for GSM (Global System for Mobile communication which is already offered by mobile operators).
2- Prevention of major damage to transformers equipped with protective relays like Buchholz and Thermometer.
3- Monitoring the status of the air conditioner for indoor distribution transformers and informing Control-Center through sending a message in abnormal circumstances.
4- Informing Control-Center in occasion of outage
5- Remote switching capability of breakers
6- Transmission of electrical parameters such as voltage, load current, active and reactive loads; thus, load profile can be simultaneously monitored.
7- The ability to show electrical parameters on GIS (Geographic Information System) maps.
8- The ability to send alarm message in case of transformer overloading.
9- Transformer status control and monitoring wherever there is an access to the Internet.
10- Reduction of the cost imposed by a critical failure of transformers due to lack or no monitoring ability in case of critical operation.
11- Modelling of different loads including residential, commercial, and agricultural.
12- Load management in accordance with load monitoring of major substations.
13- Calculation and control of power losses for a specific area.
14- Precise engineering analysis based on online load monitoring.
15- Low cost of maintenance.

PRACTICAL RESULTS WITH COST- BENEFIT ANALYZING

Zanjan Electric Distribution Company (ZEDCO) attempts to get aligned with actualizing its operational plans. Thereby, ZEDCO has installed 6 prototypes of proposed monitoring systems based on GPRS and ADSL system. Control software has also been designed which allows the Control-Center operator to pursue the transformer status, depict the load profile in a selected period, explore the information on a city map, be informed of protective relay alarms' operation and altering the switches' status.
Fig. 2 shows a prototype of the device designed and installed for the purpose of transformer status control and monitoring. The device contains four outputs well suited for the control and operation of breaker which is equipped with electrical motors.

Fig. 2: a prototype of the device designed for the purpose of transformer status monitoring and operation of breakers in case of emergency conditions

The main aim of this section is to analysis the Cost-Benefit of employing proposed monitoring and control system devices. It is noteworthy that in the majority of electric distribution companies encounter extreme costs

imposed by major damage to expensive transformers each year. However, these unpredicted costs can be prevented remarkably by using some inexpensive tools in order to early detect the heavily loaded transformer and mitigate the loads by some remote switch operation and load transfer between feeders.

According to statistics of 2011, five units of high capacity transformers were damaged due to different reasons in ZEDCO. With a further examination it was determined that three of them with the capacity higher than 800 KVA, were damaged in consequence of abnormal operating conditions which could be easily prevented by the use of GPRS based alarm notifications. Hence, in order to prevent such heavy costs due to transformer replacement, de-energized critical loads, and to establish a stable power supply, it is approved to spend 6 million Rial for the preparation and installation of monitoring and GPRS based notification systems of each substation.

The cost and benefit analysis for transformers with the capacity of 800 KVA which supply some critical downtown loads, is given in Table. 1. As it is presented, three units of transformers encountered major damage due to overloading which could be prevented by the means of monitoring and GPRS based notification and as a result, 634 million Rial saving.

Subsequent to to the analytical reports about the fault incidents led to the failure of 3 units of transformers with the capacity higher than 800KVA, the project of installing, monitoring and control devices in some of the crucial and full load substation is performed (Figs. 3&4). As seen in Table 1, accomplishments of this project can lead to save two billion Rials within a year operation.

Figs. 5, 6 and 7 show the installed devices has been implemented in Zanjan GIS map which is able to make reports and display data of each device by rolling the mouse to the point and clicking on it. Frequency variation, active and reactive power diagrams of Madar substation, which are extracted through a full day's load data recording archive, has also been depicted in Figs. 5, 6&7.

Fig. 3: An image of the equipments installed on MV board of Sabzeh-Meidan substation

Fig. 4: Monitoring and control system of Sabzeh-Meidan substation

Fig. 5: Displaying device information on the city map

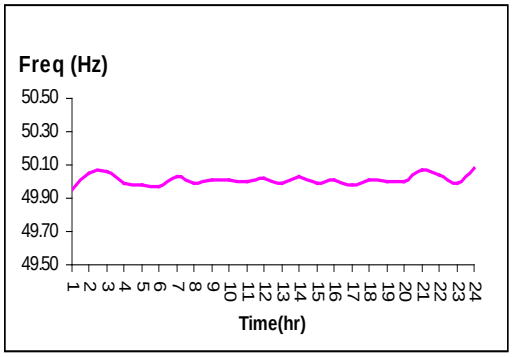

Fig. 6: Frequency variation diagram of Madar substation

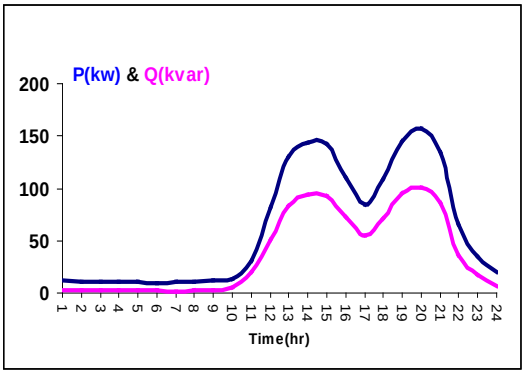

Fig. 7: Active and reactive power diagrams

of Madar substation

Table. 1: Predicted Cost of Transformer failure and Cost-Benefit Analysis

The leading cause of Transformer failure	Substation Fan's failure	Thermometer relay failure	Buchholz relay failure	Full loading	Monitoring System's installation & Operation Cost	
Number of Transformer failure	0	1	1	1		
Transformer Capacity (KVA)	0	1250	800	1000	A Monitoring System's Cost (Million Rls)	6
Transformer's and Installation's Cost (Million Rls)	0	235.3	182	214.5	Operating Cost (Thousand reels)	120
Cost of Expected Energy Not Supplied (thousand Rls)	0	1000	640	800	Number of Transformers Larger than 800 KVA	75
Total imposed Cost (Million Rls)	634.24				Total Cost (Million Rls)	459

CONCLUSION

With the abundance and rapid growth of technology in the field of communication, it is promising to use GPRS as an economic way to notify the status of critical equipment such as transformers. Transformers are commonly considered as both expensive and vital equipments of electric distribution systems. Corresponding to the prominent role of distribution transformers and as a step towards network automation, GPRS based notification method proposed in this paper to overcome the delay of informing Control-Center and prior detection of any abnormal circumstances. The GPRS environment facilitates the convey of notifications for different possible alarms including any failure in air conditioner, any noticeable rise in the operating temperature, and those of protective relays like Buchholz and Thermometer. With that motivation, the proposed method is employed in ZEDCO and some critical substation is equipped with a GPRS based connection and other devices to be monitored. The practical results demonstrate the effectiveness of the proposed method to be an economic way to improve reliability indices and prevent unpredicted heavy costs imposed by equipment failure.

REFERENCES

[1] Ahmed E. B. Abu-Elanien, and M. M. A. Alma, Fellow, IEEE "Survey on the Transformer Condition Monitoring" 2007 IEEE

[2] Marco A.M Cavaco , Mauro Eduardo Benedet, " Remote Monitoring Incipient Faults Using GPRS in Power Transformers", xix Imeko world Congree, September 6-11, 2009, Lisbon, Portugal

[3] Intelligent Transformer Substations In Modern Medium Voltage Networks As Part Of “Smart Grid” CIRED 2011

[4] R. J. Bates "GPRS: General packet radio service" Mc Graw-Hill , professional, 1St edition, ISBN 0-07-138188-0, USA, November 2002