DESIGN OF AN INTELLIGENT NITROGEN INJECTION SYSTEM FOR FIRE SAFTEY OF POWER TRANSFORMER

Priya N. Gokhale[1], S.M. Bakre[2]

[1]*Professor, Department of Electrical Engineering, J.S.C.O.E., Maharashtra, India*
[2]*Executive Engineer, Major Stores Baramati, MSETCL, Maharashtra, India*

Abstract

Fire hazards occurring at power transformers and interconnecting transformer installations are the matter of serious concern. These may lead into serious consequences such as fatal/non-fatal accidents and loss of valuable assets. One Power transformer costs to Rs. 4 Crores/40 Million Dollars approximately. Moreover such types of incidences may cause fatal or non-fatal accidents to human being or stray animals. On number of occasions there is a sudden blasting of porcelain bushings . The pieces of porcelain are scattered in the switchyard with a velocity of bullet and cause damage to nearby equipments in the switchyard. The Nitrogen injection system is the traditional method of quenching fire hazards occurring at transformer installations . It is desired that reporting of such occurrences should be as quick as possible. This paper suggests a novice method for communication of such occurrences based on client-server interaction by connecting it to the traditional Nitrogen injection system. The proposed communication system is based on the notion of client server communication. Server is the process that is offering some service on receipt of request from the client. Client is the process that requests server to provide service. The socket programming based technique is found to be an effective tool for quick communication of such incidences on CMS client , smart phones and ESR terminals. It is possible to implement the proposed system on existing client-server network used for transmission of ABT data from substation/consumer installation to the Central Monitoring System. The Java embedded system can be developed as a dedicated hardware for proposed Client –server Association.

Keywords: *Power Transformer, fire Hazards, quick communication, Nitrogen Injection System, client-server network, socket programming, Integrated Development Environment (IDE), smart phone.*

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1. INTRODUCTION

Fire hazards occurring at power transformer and interconnecting transformer installations are the matter of serious concern. These installations are prone to fire because of several reasons such as internal faults , overheating , high order harmonics , failure of dielectric ,lightening etc.[1] This may result into loss of valuable assets. One Power transformer costs to Rs. 4 Crores. Moreover such types of incidences may cause fatal or non-fatal accidents to human being or stray animals. On number of occasions there is a sudden blasting of porcelain bushings. The pieces of porcelain are scattered in the switchyard with a velocity of bullet and cause damage to nearby equipments in the switchyard.

Therefore, it is highly desirable to protect transformers from fire hazards. The traditional means of protecting transformers from fire hazards is providing a Nitrogen Injection System.

Figure 1 shows a pictorial view of Nitrogen Injection System installed at power transformer. As per standard code , the components of this system are shown by red color. Therefore, pipelines, cubicles, valves and other components of this system are painted by red color. [2]

In the event of occurrence of fire hazards , the system actuates and abolishes fire quickly. Nitrogen injection fire protection system designed for oil filled transformers shall prevent tank explosion and the fire during internal faults resulting in an arc, where tank explosion will normally take few seconds after arc generation and also extinguish the external oil fires on transformer top cover due to tank explosion and /or external failures like bushing fires, OLTC fires and fire from surrounding equipment's. The system shall drain a pre- determined quantity of oil from the tank top through outlet valve to reduce the tank pressure and inject nitrogen gas at high pressure from the lower side of the tank through inlet valves to create stirring action and reduce the temperature of top oil surface below flash point to extinguish the fire. Conservator tank oil shall be isolated during bushing bursting, tank explosion and oil fire to prevent aggravation of fire. Transformer isolation shall be an essential pre-condition for activating the system. The system shall be designed to operate automatically. However it shall be designed for manual operation, in case of failure of power supply.

The system shall consist of following equipment's. 1. Fire extinguishing cubicle placed on a plinth at about 5-10 meter away from the transformer. 2. Control box placed in the control room. 3. Necessary valves in the conservator pipe. 4. Suitable fire sensing components to be provided prefer in/on the tank cover. 5. Signal box suitably placed.

Figure 2 shows a transformer installation caught by fire.

Fig -1: Traditional Nitrogen Injection System

2. WORKING OF NITROGEN INJECTION SYSTEM

Fig -2: Transformer Installation caught by Fire

On such occurrence, the Nitrogen Injection system operates automatically and quenches fire. In case on non-operation of system by itself, the system is required to be operated manually. There are two modes for manual operation,
1. The lever inside the cubicle is pressed. The cubicle is provided near transformer in the switchyard. 2. One unit is provided in a control room by laying cable from the Nitrogen Injection system. See Fig 3. The glass cover provided on this unit is broken and the fire switch is closed. This option is usually preferred when the system does not operate automatically and it is risky to go near transformer for pressing lever inside the cubicle. The main parts of the system are briefly discussed below.

2.1 Sensors

The sensors are usually provided at the top side of transformer tank. These units work as temperature transducers. The temperature of transformer oil is sensed by the sensors. Any abnormal rise in temperature due to fire hazards to the control box.

2.2 Valves

The valves provided at three locations. a. Between conservator and breather. b. On oil drain pipe and c. At nitrogen cylinder.

2.3 Pipelines

Basically two pipelines are provided, one for oil evacuation and the other for nitrogen filling.

2.4 Control Box

The control box receives signals from sensors and accordingly sends command to operate the system.

2.5 Oil Pit

It is the underground pit below the soil in which the small quantity of oil is drained from transformer tank.

2.6 Outdoor cubicle

The outdoor cubicle is provided near transformer installation . It comprises of nitrogen cylinder and mechanism for operating the system.

2.7 Indoor cubicle

The indoor cubicle is installed in the control room . It is connected to the system through a control cable. It comprises of fire switch , glass cover , hammer , LED indicators , Fire alarm indicators etc. Whenever there is an occurrence of fire hazards , there is obliviously rise in temperature. This temperature rise is detected by the sensors as shown by square packets in the figure . The sensors inform abnormal condition caused because of rise in temperature to the control box. In response , the control box performs following three actions in a sequential manner. The valve provided near buckholz relay is closed. This stops circulation of transformer oil between conservator and main tank. The Oil drain valve is opened and a small quantity of oil (usually 1%) is taken from top of the tank to the underground pit as shown in the figure. This creates a small gas at top of the transformer tank. Now the nitrogen valve is opened so that the nitrogen gas is released from cylinder and gets injected inside the transformer tank. The nitrogen gas is injected at the bottom of tank. However , because of low density it goes up and fills the gap created by evacuation of the oil. The nitrogen quenches the fire immediately.

Fig. 3 Outdoor and Indoor cubicles of Nitrogen injection system

3. CLIENT SERVER BASED SOCKET PROGRAMMING SYSTEM

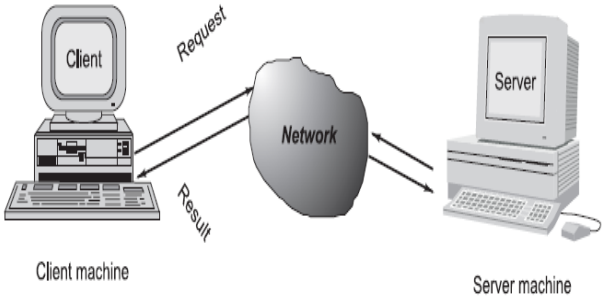

Fig. 4 Client –Server Communication

The proposed communication system is based on the notion of client server communication. Server is the process that is offering some service on receipt of request from the client. Client is the process that requests server to provide service. [3]. Generally, programs running on client machines make requests to a program (often called as server program) running on a server machine. They involve networking services provided by the transport layer, which is part of the Internet software stack, often called TCP/IP (Transport Control Protocol/Internet Protocol) stack. The transport layer comprises two types of protocols, TCP (Transport Control Protocol) and UDP (User Datagram Protocol). The most widely used programming interfaces for these protocols are sockets. TCP is a connection-oriented protocol that provides a reliable flow of data between two computers. Example applications that use such services are HTTP, FTP, and Telnet. UDP is a protocol that sends independent packets of data, called datagrams, from one computer to another with no guarantees about arrival and sequencing. Example applications that use such services include Clock server and Ping. The TCP and UDP protocols use ports to map incoming data to a particular process running on a computer.

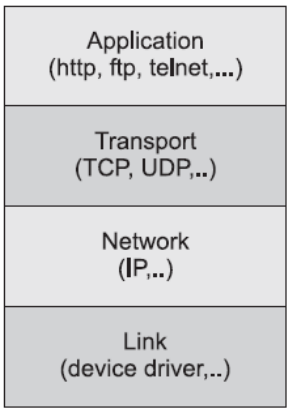

Fig. 5 TCP/IP Software stack

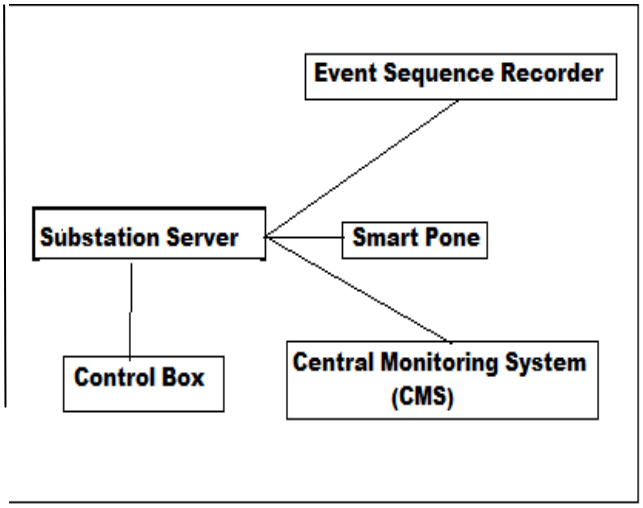

Fig. 6 Client Server Association

As shown in the Fig. 6, the server is located at substation . The controlling unit of Nitrogen cooling system is connected to this server. Various clients are located as Event Sequence Recorder (ESR) , Smart phone and Central Monitoring Station (CMS). The communication between client and server is based on polled approach. The clients continuously check whether there is ‘ Fire Hazard Occurred ‘ message. In the event of fire hazards taking place , such intimation is received by server from the controlling unit. Server then gives the message ‘ Fire Hazard Occurred ‘ to its clients. In this way the concerned engineers and authorities receive this message on their smart phone . The message is also given to CMS and ESR. The client and server processes are asymmetric . Protocol (TCP/UDP) , port number , IP address of client and server is specified in order to establish communication. The connection is done through sockets. Socket allows one process to speak with the other. The source code is written for client side and server side socket. For this purpose , Integrated Development Environment (IDE) is used. The IDE is mainly provided by Netbeans and Eclipse.

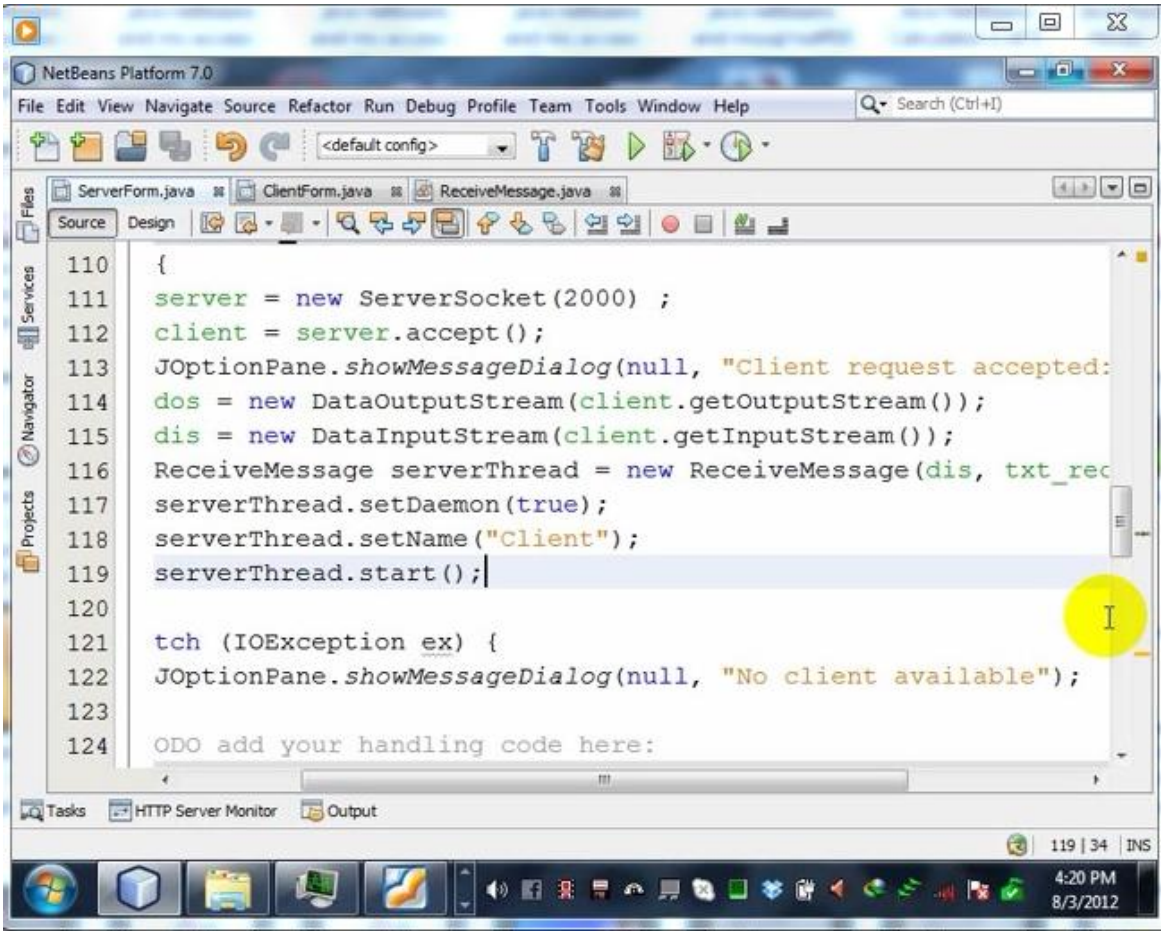

Fig. 7 Source code for server side socket programming

Fig 7 shows the source code for server side socket programming. Initially, the source code is developed in Netbeans IDE or Eclipse IDE. Later it can be embedded in an integrated circuit as a dedicated program. [4][5].

4. CONCLUSION

Safety of power transformers and interconnecting transformer installations are the matter of serious concern. Fire Hazards lead into serious consequences such as fatal/non-fatal accidents and loss of valuable assets. The Nitrogen injection system is the traditional method of quenching fire hazards occurring at transformer installations . It is desired that reporting of such occurrences should be as quick as possible. This paper suggested a novice method for communication of such occurrences based on client-server interaction by connecting it to the traditional Nitrogen injection system. The socket programming based technique is found to be an effective tool for quick communication of such incidences on CMS client , smart phones and ESR terminals . It is possible to implement the proposed system on existing client-server network used for transmission of ABT data from substation/consumer installation to the Central Monitoring System. The Java embedded system can be developed as a dedicated hardware for proposed Client – server Association . The above system can quench the fire in power transformer within one minute.

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BIOGRAPHIES

Dr. Priya N.Gokhale has professional experience of 21 years. Her research area includes power quality, reliability, sustainability.
pngokhale2003@yahoo.co.in

Dr. S. M. Bakre is having professional experience of 34 years in MSETCL and currently working as Executive Engineer at Baramati
Emailid: smbakre@hotmail.com