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Transformer Theft Protection and Supervising Using Advanced GSM Technology

Aravind Panasa[1]

UG Student [4th Year], Dept. of EEE, CMR College of Engineering and Technology, Medchal, Telangana, India[1]

ABSTRACT: Distribution transformers of sub-station in rural and tribal areas experience lack of supervision and maintenance once erected for operation. Indian Power sector is experiencing huge technical, non-technical and commercial losses, in which the vandalism or theft of transformer parts, such as core (copper winding) and oil are creating enormous financial losses for both electricity department and indirectly for farmers as the transformers supplying agricultural load are more prone to thefts. Hence it is a challenging task to eradicate above stated unlawful activity through available technology. This paper proposes design of embedded circuitry and control by coordinating devices which are used to monitor and diagnose the transformer condition, such that we can observe effective results by creating an Anti-Theft circuit. The proposed system integrates the GSM technology and IR-Sensor combination to detect approach of persons near to transformer. Whenever micro-controller receives an error or return signal from IR-Sensors, it is programmed such that it initiates GSM modem. GSM inherently consist of a SIM card in which we will assign a text message which is to be sent to concerned mobile numbers.

KEYWORDS: GSM modem, IR sensors, Microcontroller, Power supplies, Automatic Change over switch.

I. INTRODUCTION

There are many Generating, Transmission and Distribution companies across the Nation which had setup their chief objectives as to generate, transmit and distribute the electrical energy with absolute reliability and satisfactory service by mitigating the any amount fluctuations in voltage, current and frequency. These companies also focused on rationalisation of tariff rates to all consumers respecting their interests by maintaining high power quality quotient of electricity [1]. Apart from objectives drafted, Indian power and energy sector is experiencing huge amount of losses [2] from their generated amount of power in the form of technical, non-technical and commercial losses, these losses are jointly deteriorating the power quality delivered to consumers. Additional to above losses there is an issue which is creating a notable amount of financial losses to the electricity department. The Financial losses are mainly due to lack of vision and maintenance on assets (viz Transformers), lack of focus and coordination between maintenance staff of power utilities.

In most rural and tribal areas, distribution transformers are subjected to lack of maintenance once they are erected for operation. As a result, these transformers are being exposed to the access of unauthorized persons, causing the inherent parts of the transformer such as cooper winding and oil to be stolen by thieves and vandals [3]. The core (copper winding) is the main part of the transformer which costs high and is a valuable article. Once these windings and oil are stolen from the transformer, they are sold to informal workers as a scrap material which will make thieves to prosper by making lot of money. The transformers which are in agriculture farm lands are more prone to these types of thefts than their distribution counter parts which are inside village/town.

In recent years, these types of cases are escalating in number and are incurring huge amount of losses to the distribution companies. Recent article explains the degree of severity of this unlawful activity [3].

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Amongst the many cases happened across the nation, most of the transformers undergone to thefts are of those which are supplying agricultural loads because they are more prone to thefts. Once the in-operation transformer is stolen, the area served by that transformer undergo power blackout. As the induction motors in agricultural farms run on power supply from the transformers. Once the transformer is stolen, farmers should make a halt for crop generation or they should run the motors by auxiliary supply sources such as by using diesel generators. Therefore, it is creating heavy financial loss for consumer and electricity department and a lot of chaos in the lives of people living nearby by effecting their irrigation system.

The James martin's [4] survey regarding consumer service from power utilities have shown adverse and poor results which reported that annually, complaints filed in rural areas are as high as 700. The shown count is only in the Punjab state alone in 1994 [2], from this situation we can imagine the adverseness of service actions to the filed complaints in rural areas.

II. PROPOSED SYSTEM MODEL

It is evident that these cases are growing in and across many rural/ tribal areas. This paper proposes a noble solution in eradicating the transformer thefts to a large extent using GSM [7] technology, IR-Sensors and other embedded devices, moreover we can make the distribution system automated regarding transformer thefts. Using GSM technology, we can supervise the transformer. The proposed system lets us know the theft occurrence by sending prefixed warning message to prefixed mobile numbers with location landmarks. Though we are supervising the transformer and other electrical apparatus and parameters through conventional methods such as PLCC (Power Line Carrier Communication), and Data Acquisition Technology and SCADA through control system algorithms, all above methods individually have their own limitations and does not provide a noble solution path to our case. On the other hand, using Sensor technology in parallel with GSM technology is a robust way of handling such problems of transformer thefts which demand constant human observation.

III. DIAGNOSING PROCESS OF ANTI-THEFT CIRCUIT AND PROPOSED MODEL

Transformer is usually placed on a base or plinth type structure. Thieves climb on to the base and detach the input supply lines from bushings then unfastens the bolts present on surface of the transformer tank. They will lift up the core assembly and drain the oil [8] from tank.

We are placing IR sensor (Transmitter and Receiver) active type on top and bottom of the transformer tank. Sensor set-1 is placed opposite to each other on bottom of the tank area, sensor set-2 is placed opposite to each other at top portion of the tank (IR-Sensor set refers 1 transmitter and 1 Receiver). These sensors are chosen very carefully, i.e. Range of sensors and type, number of sensors required will depend on the transformer size and shape indeed.

The power supply required to drive the circuit is fed from output of the distribution transformer. The 230V transformer output is stepped down to 12V AC using stepdown transformer which is then passed through bridge rectifier circuit to be converted to DC. Rectifier output consist of pulsating DC current, and made constant by filtering through filter components and finally fed to LM7805 Voltage Regulator so that +5V DC is maintained constant for supplying components. Sometimes, it is possible that the output of distribution transformer becomes zero i.e. when supply interrupts, considering this case in view we are equipping a battery backup into the circuit to feed as source when mains source 230V-AC become zero. The changeover from ac to dc is done automatically through below shown
figure 2.

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The DC Supply through battery is fed directly to the voltage regulator, wherein normal operation happens from there. Hence by using backup DC source and automatic change over switch circuit we can run entire circuitry without any interruptions ensuring reliability in protection. If AC supply is restored meanwhile, the automatic change over switches to AC supply mode and backup DC source is no longer used. The DC battery used for backup service will be of MF (Maintenance Free) technology where frequent maintenance of battery is not essential and much lesser maintenance is required than ordinary batteries since it consists of sealed cover technology where recycling of electrolysis process happen in MF batteries.

IR sensors are selected to place at top and bottom of transformer tank because there might be a case when the signal is obstructed by an animal or bird, thereby it causes an error signal detected by microcontroller which initiates GSM for sending prefixed message though there is no threat for transformer. This can be overcome by programming the microcontroller such that it should initiate the GSM only when the error signal from 2 receivers be high, until this no further operations for gsm initiation is done. IR Sensor signals are weak that they alone cannot drive any circuit, so to enhance the signal strength we are equipping OP-Amp-LM358M and op-amp output is given to the ADC-0808. Micro controller need digital data to operate, the IR sensors output the analog values, therefore in order to convert the analog sensor output to digital data, we are using ADC-0808 which is Analog to Digital converter.

IV. BLOCK DIAGRAM OF TRANSFORMER THEFT PROTECTION SYSTEM

Below figure shows the block diagram of the proposed model for transformer protection. Input supply for LM7805 is fed from output of the distribution transformer, since most of the transformers supplying the agricultural loads are of 415 or 230 V AC output ranges and we can directly equip this level of voltage to 12V stepdown transformer. Automatic change over block and DC battery are also present before the voltage regulator block.

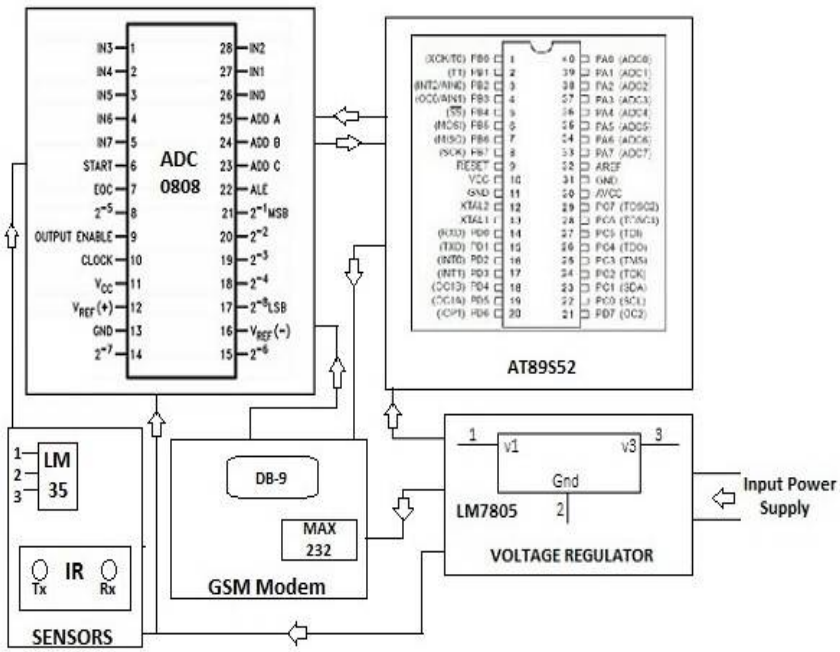

Fig. 1 *Block Diagram*

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GSM Modem and microcontroller are interfaced through MAX-232 IC so as to convert serial port signals of gsm modem to TTL signals of micro controller and vice versa. Compatible signals make data and commands to transmit between two IC's.

It is an important concept to know in detail about the automatic change over circuit which is very essential circuit for satisfactory operation of kit.

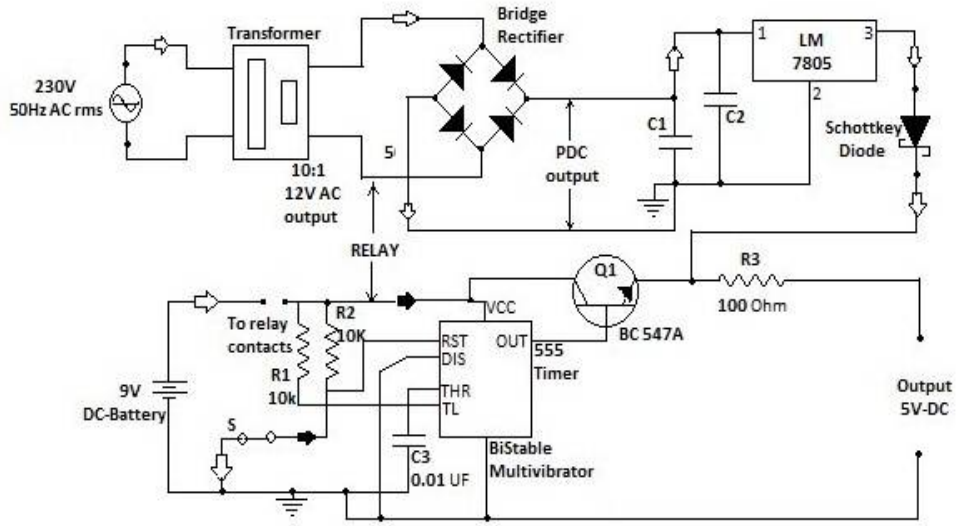

Fig. 2 *Automatic Change over Circuit.*

The circuit contains different hardware components as:

- Stepdown Transformer
- Bridge Rectifier
- Capacitive Filters
- LM-7805 Regulator
- Schottky Diode
- Bi Stable Multi vibrator with inbuilt I555 timer.

The principle operation of automatic change over circuit depends upon the operation of the Timer and Reset pins of multi -vibrator. When relay contacts are in AC circuit, reset pin of I555 timer is in active low state, hence Q is in reverse biased and cut-off region. When relay contacts are closed, i.e. when AC supply interruption occur and relay contacts are in DC circuit, trigger pin of 555 timer is grounded which make output of 555 timer to be in active high mode. Therefore, Base emitter junction of Q is forward biased which make transistor to conduct in conduction mode.

The Relay is fed through CT, the CT is connected with AC source line and the plunger is designed to hold uptight in AC circuit, when there are any supply interruptions the magnetism in plunger will get replenished and relay contacts will fall down and makes circuit with DC source. As long as the relay contacts are in DC circuit the embedded circuits run by backup DC source. Meanwhile if AC power is restored plunger contacts attracts and switches into AC circuit.

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Concluding that we can make the change over from AC to DC automatically using Relay and I555-timer. Below figure shows the schematic diagram of relay circuit.

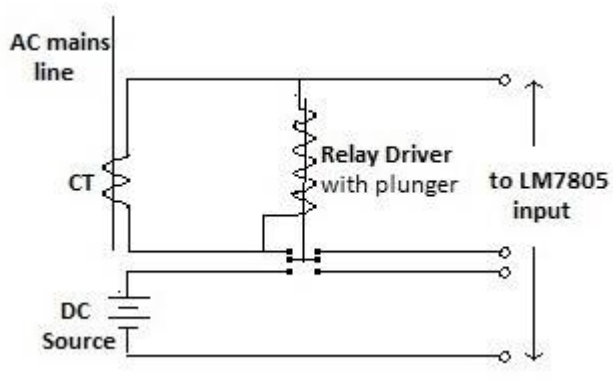

Fig. 3 *Relay Circuit*

V. HARDWARE COMPONENTS USED

1. MICRO CONTROLLER

We can term microcontroller [10] as the heart of this circuit because it instructs and commands various peripherals used according to the program we assigned. We used Atmel class AT89S52 [10] microcontroller, this type class is highly preferred for various embedded applications due to its flexible and standard features.

- It consists of 8kb ISP (In System Programmable Flash Memory)
- 5V Operating Range with 256*8 Bit internal ROM.
- It consists of three 16Bit timers/counters.
- Low power idle and power down modes with standard watch dog timer.
- 32 I/O Programmable lines.

2. GSM MODEM

We are using GSM Modem [7] to supervise the condition of transformer through wireless technology, we will program the micro controller to initiate the GSM modem and send the prefixed SMS content to indexed mobile numbers. We will use a GSM SIM which has good network coverage for reliable operation of wireless SMS data transmission. Features of GSM modem SIM-900 quad band engine.

- Quad Band GSM 900/1800/1900 MHz range.
- Built in RS-232 level connector with MAX-232
- Built in sim card holder.
- Input voltage 5V-12V DC, with -20°C to +55°C operation range.
- SMS cell broadcast, Text, PDU modes and confines to 0710 MUX, Embedded TCP/UDP, Software protocols.
- Compact Size (24*24*3MM) of 3Gms.
- It is controlled by external AT Commands, 1-0 mA Power Consumption.

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3. ADC-0808

As shown in the fig:1 Output of sensors are connected to ADC because sensors output is of Analog type and it is required to convert these Analog signals to Digital binary equivalent value to interface with micro controller. Micro controller compiles with only binary values and micro controller output is also of binary form, ADC 0808 features are

- Resolution of 8 Bits.
- +5V DC supply and consumes 15mW power.
- Conversion time=100 micro seconds, operating ranges=-40°C to +80°C.

In this project we are concentrating only on transformer and supervising using proposed technology. Additional to theft alert and cautioning, we can use the same circuit by additional peripherals and sensing elements interfaced to micro controller. There are some papers relating the same technology but used for other applications. Dr.S.P.Shukla's [5] paper discusses the transformer monitoring for internal and external faults and controlling with designed PLC system. Ms. Bhagyashree shikkelewal's[6] paper regarding transformer condition monitoring system and automated circuitry for all types of faults in a transformer. The data and other specified ratings are sent through SMS using GSM technology to maintenance and operation engineers of electricity department.

This paper confines to the study of transformers thefts and protecting them through IR-Sensors, GSM technology.

VI. CONCLUSION

Transformer is a vital device, we cannot imagine the power system operation without them from generating to distribution end, they have effective role in interchanging the voltage levels at transmission and distribution ranges, and hence it is a challenging task to protect the transformer from internal, external, incipient, transient faults and Thefts. There are different methods and systems to reduce the faults both internally and externally and we are making the transformer protected by circuit breakers, fuses and relays against the short circuits and other unpredicted faults. Many practical surveys show the poor protection [2][3] to the parts of transformer. This device cannot be operated satisfactorily without consonance and coherence of parts (core, winding and oil). We are using technology which is advanced and user friendly many electronic applications run through embedded systems and standard micro controllers for precision, accuracy in application diagnosis. By using GSM many applications, achieved positive results as there is strong mobile network structure built all over the nation wherein GSM modem work based on network availability. So as to reduce the cumulative losses for the power sector, Transformer theft protection circuit would be able to make possible solution.

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