

# Automatic Load Sharing of Transformers using Microcontroller

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**ABSTRACT:** The transformer is a static device, which converts power from one level to another level. The aim of the project is to protect the transformer under overload condition by load sharing. Due to overload on transformer, the efficiency drops and windings get overheated and may get burnt. Thus by sharing load on transformer, the transformer is protected. This will be done by connecting another transformer in parallel through a micro-controller. The micro controller compares the load on the first transformer with a reference value. When the load exceeds the reference value, the second transformer will share the extra load. Therefore, the two transformer work efficiently and damage is prevented. In this project three modules are used to control the load currents. The first module is a sensing unit, which is used to sense the current of the load and the second module is a control unit. The last module is micro-controller unit and it will read the analogue signal and perform some calculation and finally gives control signal to a relay. A GSM modem is also used to inform the control station about switching. The advantages of the project are transformer protection, uninterrupted power supply, and short circuit protection. When designing low-voltage power system to the supply large load currents, paralleled lower-current modules are often preferred over a single, large power converter for several reasons. These include the efficiency of designing and manufacturing standard modular converters which can be combined in any number necessary to meet a given load requirement and the enhanced reliability gained through redundancy.

**KEYWORDS:** Transformer Overload, Microcontroller, Uninterrupted Power Supply

## I. INTRODUCTION

Transformer is a static device which converts energy at one voltage level to another voltage level. It is an electrically isolated inductively coupled device which changes voltage level without change in frequency. Transformer transfers ac voltage from one electrical circuit to another by the principle of mutual induction. Distribution transformers are one of the most important equipment in power system and are also known as the heart of the power system. The reliable operation of a power system depends upon the effective functioning of the distribution transformer. Therefore monitoring and controlling of key parameters like voltage and current are necessary for evaluating the performance of the distribution transformer. Thus it helps in avoiding or reducing the disruption due to the sudden unexpected failure. Transformers being one of the most significant equipment in the electric power system, needs protection as a part of the general system protection approach. Moreover the increasing population and their unavoidable demands have led to an increasing demand on electrical power. With this increased needs, the existing systems have become overloaded. The overloading at the consumer end appears at the transformer terminals which can affect its efficiency and protection systems. Due to overload on the transformer, the efficiency drops and the windings gets over heated and may get burnt. It takes a lot of time to repair and involves a lot of expenditure. Transformers are occasionally loaded beyond nameplate ratings because of existing possible contingencies on the transmission lines, any failure or fault in power systems, or economic considerations. One of the reported damage or tripping of the distribution transformer is due to

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thermal overload. To eliminate the damaging of transformers due to overloading from consumer end, it involves the control against over current tripping of distribution transformer. Rise in operating temperature of the transformer due to overloading has an influence on ageing of transformers. The accelerated aging is one of the main consequences of overloading power transformers. Thus load limitations must be implemented to operate the transformers within safe limits. Moreover on overloading the transformers voltage regulation may increase and power factor drops. The project is all about protecting the transformer under overload condition. This can be done by connecting another transformer in parallel through a microcontroller and a relay which shares the excess load of the first transformer. The transformers are switched alternatively to avoid thermal overloading. Therefore, two transformers work efficiently under overload condition and damage can be prevented. If there is a further increase in load beyond the capacity of two transformers there will be a priority based load shedding of consumers which will provide un-interrupted power supply for the hospitals, industries etc.

## II. RELATED WORK

In the power system transformers may be loaded beyond their nameplate ratings due to a fault or some emergency conditions. This type of overloading can cause either short term failures or long term failures. Increase in hot spot temperature would also lead to the accelerated ageing of the transformers resulting in transformer overload. So in order to keep the body temperature of the transformer within its nameplate rating, the transformer must be loaded efficiently in a controlled manner.

Our system aims at load sharing of transformers and priority based load shedding. The procedure of load sharing is summarised below.

1. Loads are supplied from a single transformer under normal condition and a standby transformer is connected in parallel through a circuit breaker.
2. A current transformer measures the load current continuously and feeds it to the controller by converting it to a corresponding D.C value in order to compare with the reference value set by the user.
3. Whenever the load current exceeds reference value, the controller sends a high signal to the relay which energises the relay coil. The relay coil thus sends a tripping signal to the circuit breaker of the standby transformer.
4. Thus the load is shared by the transformers equally as the transformers are identical. The current transformer still measures the load current and compares it with the reference value.
5. Whenever the load current falls below reference value one transformer is shut down and this is done in an alternative manner to avoid thermal overloading.
6. If the load value increases further beyond the capacity of two transformers, load will be cut-off from the main supply based on the priority level set by the user. This is done to provide un-interrupted power supply to higher priority loads.
7. Each of the process is informed to the controller by a GSM and the load parameters are continuously displayed in the LCD.

This algorithm is followed whenever the transformer is working and the program is executed in a loop function so that the algorithm repeats itself.

## III. BLOCK DIAGRAM

Figure 3.1 shows the block diagram of automatic load sharing of transformers using microcontroller. The various components in the system are described below.

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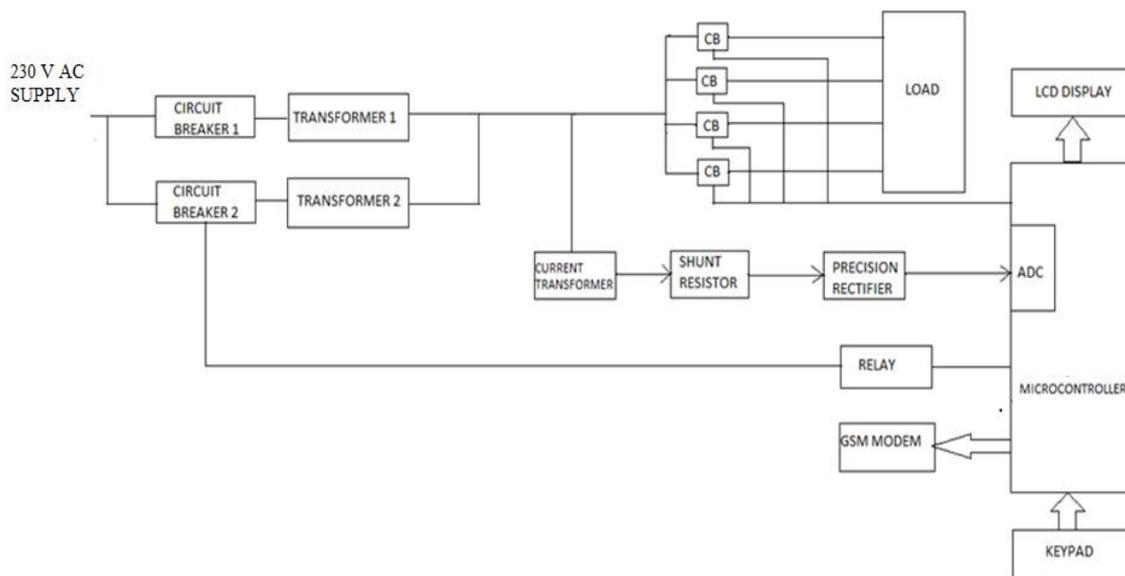


Fig 3.1 Block Diagram

In the block diagram circuit breakers are used to make and break the connections to the transformers. A relay is used to send a tripping signal to the circuit breakers and they are energised on receiving a signal from the microcontroller. The current transformer is used for measurement purpose.

### Circuit breaker

A circuit breaker is used to isolate the faulty point of the power system in case of abnormal conditions such as faults. It is a protective device which energizes and de-energizes a circuit and provides over-current protection. Circuit breakers operate on receiving a signal from relay.

### Transformers

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. Transformers convert AC voltage from one level to another level with a little loss of power. A transformer operates on the principals of “electromagnetic induction”, in the form of mutual induction. The transformer used here is a step-down transformer so that it can be directly fed to the measuring devices by rectification.

### Microcontroller

The microcontroller is used to compare the load current with reference value. Atmega328 is the controller used for this purpose and it also provides a provision for GSM module and in built ADC.

### Relay

Relays are components which allow low power circuit to operate high current application circuits. It is an electrically operated switch and is used where it is necessary to control a circuit by a low-power signal with complete electrical isolation between control and controlled circuits, or where several circuits must be controlled by one signal. The relay used here is of electromagnetic type.

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## Current Transformer

The Current Transformer is a type of “instrument transformer” that is designed to produce an alternating current in its secondary winding which is proportional to the current being measured in its primary. Current transformers reduce high voltage currents to a much lower value and provide a convenient way of safely monitoring the actual electrical current flowing in an AC transmission line using a standard ammeter. The principle of operation of a current transformer is same as that of an ordinary transformer.

## GSM Modem

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. Here the purpose of GSM modem is to send the monitoring parameters values and faults of transformer to authorized person’s number in control room.

It is a class of wireless modem devices that is designed for communication of a computer with the GSM and GPRS network. It requires a SIM card to send the message.

## IV. SYSTEM DESCRIPTION

The system consists of microcontroller, transformers, circuit breakers, relay, Current Transformer (CT), GSM modem and LCD display. The transformers are step down transformers in which only one transformer is operating under normal condition. The input to the transformer is fed through a circuit breaker to which a relay is connected. The circuit breaker is in closed position for transformer which is operating. Here the transformer feeds five loads which are provided with individual circuit breakers for protection. A standby transformer is connected in parallel to the main transformer through a circuit breaker. In order to measure the current through the transformer a current transformer is connected to the secondary of the operating transformer. The current transformer measures the load current continuously and is fed to the microcontroller through a rectifier circuit. The output from the current transformer can also be fed directly to inbuilt ADC pins of controller, instead of using a rectifier. A GSM connected to the controller enables communication between the system and control room. The maximum load limit is entered to the controller through a keypad and a LCD display gives an indication of the same. The microcontroller continuously compares the CT value with the maximum limit entered. Whenever the current exceeds the maximum limit, the main transformer gets overloaded and the second transformer shares the total load equally. At the same time the GSM sends a message to the control room. When there is a further increase in load beyond the rated capacity of two transformers, microcontroller will give control signal to the circuit breaker of respective load to open, based on the priority level set by the user. When the load decreases and comes to normal value which is less than the maximum limit, the first transformer will shut down automatically. This type of alternative switching method avoids the possibility of thermal overloading by providing enough time for the transformer to cool naturally. Each time the transformer is overloaded or switched a message is sent to the control room about the mode of operation. Thus it enables efficient operation of existing transformer and provides un-interrupted power supply to hospitals, industries and other important areas.

## Operating principle

In the proposed system, only one transformer is operating to feed the loads. A standby transformer is connected in parallel through a circuit breaker and relay. The current transformer continuously measures the load current and feeds it to the microcontroller ADC pins. The reference value or the maximum load limit is entered by the user and priority level of the load is also set by the user or concerned authority. As the load demand increase during peak hours, a single transformer would not be able feed all the load. During this condition, when the load demand exceeds the reference value, the microcontroller will give a control signal to energize the relay coil. Thus the standby transformer will be connected in parallel and will share the load equally since the transformers are of the same ratings. Thus all the loads are fed efficiently providing un-interrupted power supply. The GSM modem will send a message to the control room about the load sharing and a display will be shown in the LCD display. When the load increases further to a value

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which is greater than the capacity of the two transformers, priority based load shedding will be implemented. The loads which have the lowest priority will be shut down by opening the respective circuit breakers. This message is also sent to the control room. When the load decreases, and comes to normal working condition, first transformer will be shut down in order to avoid thermal overloading. This is done because the first transformer operates for a longer time interval than standby transformer and its body temperature rises. By providing alternative switching, the transformers can be cooled by natural methods. Each time the GSM will send message about the active transformer thus making load sharing and load shedding efficient.

## V. CIRCUIT DIAGRAM

The circuit diagram of the proposed system is shown in figure 5.1. Here two transformers share 5 loads which can be controlled independently.

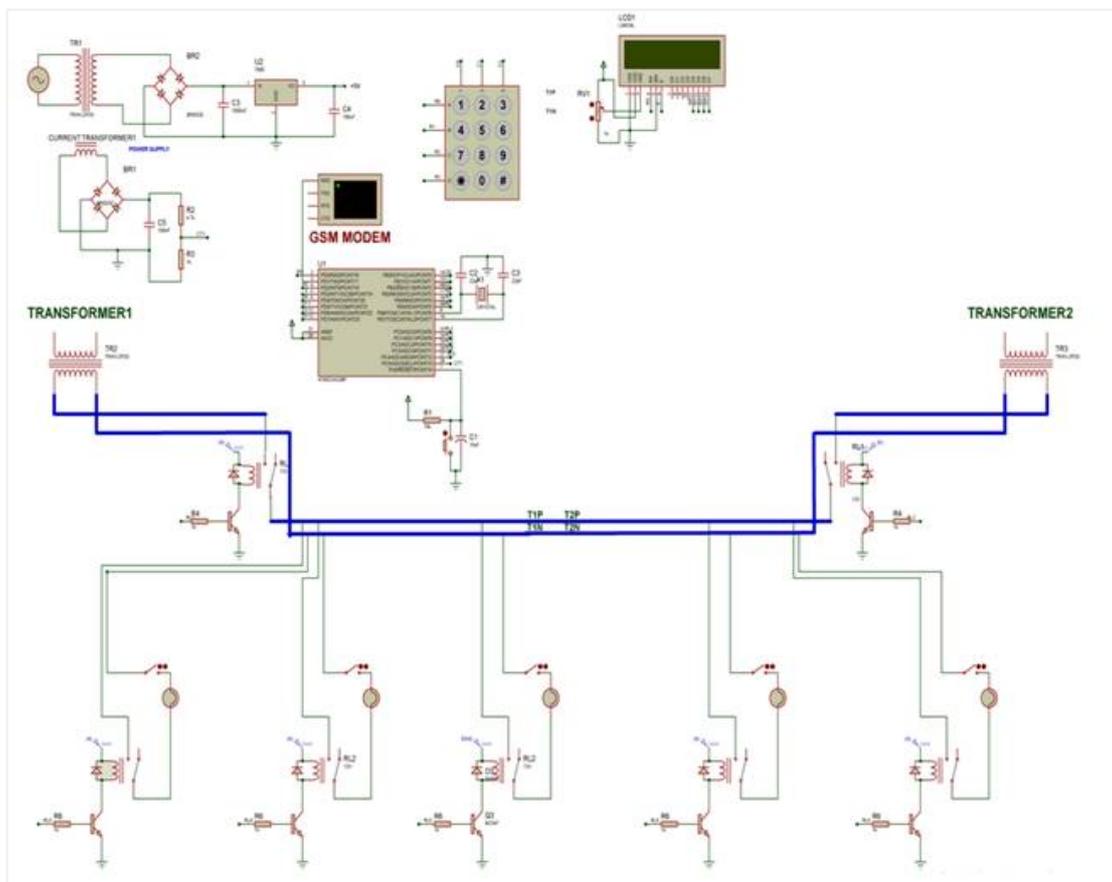


Fig 5.1 Circuit Diagram of Automatic Load Sharing of Transformers using Microcontroller

### Circuit Diagram Description

The circuit diagram consists of two transformers of which only one transformer is working under normal load condition. Each transformer is connected with a relay and the loads are connected to the secondary coil of the transformer.

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Transformers work only when the relays are latched. The transformer used here is step down transformer which converts 230V to 12V. The controller and LCD require a DC operating voltage of 5V while the relay and GSM operate at a DC voltage ranging from 9V to 12V. A power supply circuit is provided to get 12V and 5V DC from the 230V mains by a full wave bridge rectifier. A 7805 regulator ensures a regulated 5V supply to the LCD and controller. Here five inductive loads are connected to the transformer each provided with an individual relay. A current transformer continuously measures the load current of the transformer and feeds to the controller. The current transformer is connected to a zener diode in order to measure quick response. Under normal working condition relay 1 is latched and supply passes to the load through a manual switch and a relay contact. Normally the relay will be latched initially and on receiving a low signal from microcontroller the relay will be de-energized and becomes open thus interrupting the supply. The controller is programmed in such a way to send a low signal to relay when the transformers are overloaded. Thus the load cannot be operated even if the manual switch is closed. At the same time the GSM sends a message to the control room about the transformer operation. Here as the fifth load is switched on both the transformers are overloaded and in order to maintain the supply priority based load shedding is also included.

Whenever the load decreases and reaches a normal level, transformers are switched alternatively to avoid thermal overloading. The main advantage of this type of switching is that, it allows the transformer to cool by natural methods thus increasing its lifespan.

## Connections

The controller used is ATmega 328 which is 8 bit controller and has 20 I/O pins of which there are 14 digital I/O pins and 6 analog pins. The keypad is configured as rows and columns of which either row or column is set as input. Thus the controller reads the value by matrix arrangement. Crystal oscillator is connected to pin no. 9 and 10 of the controller which generates clock signals. Digital pins PD0 to PD7 are configured as output and all the output devices like LCD and GSM are interfaced to this port. The row pins of the keypad and the relay is connected to the port B while the column pins of keypad and CT is connected to port C of the controller. All the loads are connected to the port B through a relay which is supplied with a 12V supply. Relay contacts are shown named as RLY 1, RLY 2, and RLY 3. Of these two relay contacts corresponds to two transformers and the third relay corresponds to priority based load shedding. A crystal oscillator is used to generate clock signals to the controller. It is also possible to use internal oscillator of the controller unless the ADC pins are used. A CT is connected to ADC pin 5 of the controller and a variable resistor is used to vary the value of CT. A GSM is connected to digital pins 0 and 1 for communication purpose. In order to view the message displayed by GSM, a virtual terminal is used. A 4x3 keypad is used to set the maximum load limit and the LCD gives a visual indication of CT value and maximum load limit. For LCD display four bits of address lines are connected to the controller. RESET pin is connected to the power supply so that the controller works continuously. The controller can be reset by applying a logical low signal to RESET pin. Relays are connected with transistors which act as switches. Whenever a high signal is applied to the base of the transistor, the transistor act as a closed switch and energizes the coil of the relay which in turn latches the relay contactors. A freewheeling diode or a flywheel diode is connected across the relay coil to protect the collector terminal of transistor from the back emf of the relay coil.

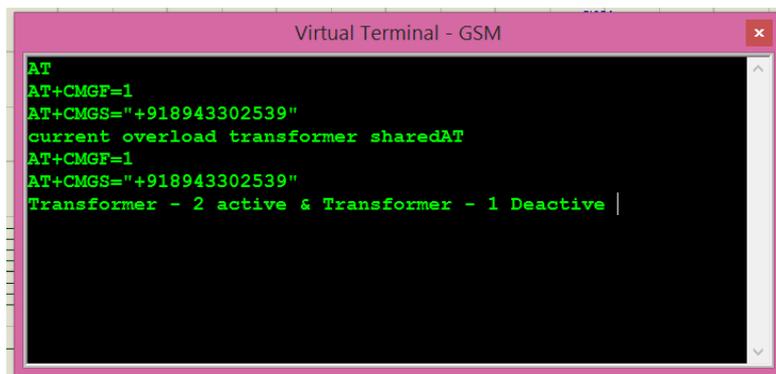
## VI. EXPERIMENTAL RESULTS

- Hardware implementation of the Automatic Load Sharing of Transformers using Microcontroller was developed using Atmega328 microcontroller.
- Simulation was done in PROTEUS ver. 7.7 and the output was verified.
- Priority based load shedding provided un-interrupted power supply to certain loads like hospitals
- load is shared by the transformers equally since the transformers were of same rating
- The message sent by the GSM was viewed by a Virtual terminal in PROTEUS as shown below.

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Virtual Terminal - GSM
AT
AT+CMGF=1
AT+CMGS="+918943302539"
current overload transformer sharedAT
AT+CMGF=1
AT+CMGS="+918943302539"
Transformer - 2 active & Transformer - 1 Deactive

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Fig 6.1 Virtual Terminal of a GSM

### VII. CONCLUSION

Transformers are one among the most generic and expensive piece of equipment of the transmission and distribution system. It is known as the heart of the power system. Due to its high cost, the protection and maintenance of the transformer is crucial. With increase in load demand day by day and with existing transformers the load demand is to be satisfied and it may lead to increase in load of each transformer. One of the best solutions of overcoming this is by connecting transformers in parallel. In this project of Automatic Load Sharing of Transformers Using Microcontroller, a technology is implemented to share the load on the transformers. This provides un-interrupted power supply and avoids blackout in particular areas where there is varying loads. With the advancement of communication technology, now it is possible to receive overload condition of transformer through GSM to the control room. During overload condition exceeding specified limits information is immediately communicated through GSM technology to the concerned authority for possible remedial actions. Hence the transformer is protected from the overload condition and uninterrupted power supply is available to the consumers

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### BIOGRAPHY



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