Over current Protection of Transmission Line using GSM and Arduino

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Abstract *— This Project is about designing the controls of an Over current relay using a microcontroller. The relay is an electrical switch which operates depending upon the value of current through it. It works on the principle of electromagnetic induction to operate. When the current through the Over-current Relay rises or passes beyond a particular value then the relay operates to send a tripping signal to the circuit breaker.*

Microcontroller based relays have found their importance growing day-by-day since it is much more efficient in its working than the mechanical relay conventionally used. They have been observing a growing popularity because of its high speed of operation. In such type of relays, there are generally following components present responsible of its working which are: current transducer, a controller, current transformer and a circuit breaker.

The microcontroller used in the relay provides much flexibility of operation through the use of above-mentioned components in the electrical system. A simple relay wouldn't contain such characteristics. Microcontroller based relays use the controller to read the load current. The load current is read via a current transformer used in the circuit (C.T.), a current transducer and an Analog-to-Digital Converter i.e. the current is converted from Analog to Digital form and fed to one of the digital pins of the microcontroller. If the current is greater than the pickup value, then the relay is being sent a signal which then operates to send a tripping signal to the circuit breaker which then opens the circuit. IDMT characteristics of the relay can also be realized.

Keywords — *Over-Current, Microcontroller, Relay, Arduino.*

I. INTRODUCTION

Relays are being used in the electrical network for the purpose of its safety and increased security against damages which can occur due to various factors like over current in any part of the electrical network. Thus, relays find themselves in the category of crucial equipment used, which decide whether a network performs stably under certain hitches/disturbances occurring in the circuit. Increased reliability of operation is one of the major factors, which makes the use of relay important in the power system.

One such type is an over current relay which is governed by the principle of increment of current beyond a particular value, also known as a current threshold or maximum value of current, after which the relay operates. If the current in the power system increases beyond a safe value (for stable operation), then the relay sends a tripping signal to the circuit breaker which effectively opens the circuit so as to prevent it from some serious damage.

The Over current relays generally have two settings namely, time setting multiplier and plug setting multiplier, which determines the operational time delay and the pickup current for the OC relay respectively. These two settings are the reason why OC relay has found its significance in such harsh conditions.

All the relays ever made are intended to serve one general purpose i.e. recognition and rectification of fault. Faults as the name itself say are defects occurring in an electrical system which not only changes the path of the current in the circuitry but also disturbs both the steady state and transient stability of the system. Their causes can be many like huge stresses, mechanical failure of the system etc. The currents developed due to faults tend to be high in value since the fault impedance is generally low. Due to faults, the power flows in the direction of the fault, which affects the supply of power in the adjacent zones of the power system.

This imbalance of power causes the voltage imbalance to occur in the circuit as a result of which the transient stability of the system is affected. Thus the system efficiency is reduced to a large extent incurring a huge cost if the fault is large enough to cause severe damage. Use of microcontroller can enhance the time response of the system so as to recognize huge faults occurring for short period of time. Also, it can help to regulate the system in a better way.

In this project, we use an Arduino microcontroller ATMEGA328 in our demonstrative circuit. The whole attention of the circuit lies in the use of a GSM Module, which is used to send the status of the circuit to the operating personnel, as well as make the circuit controllable from his/her side. Thus, if the system is encountered with a fault, the microcontroller sends a signal to the relay. The relay then operates to send a tripping signal to the circuit breaker depending upon the amplitude of the fault that means higher the fault, lower will be the time of operation of the relay, which is sensible as higher faults can cause severe damage even for the significantly lower time. Thus the microcontroller is coded accordingly to prevent the circuit from severe

damage. Also at the same time, the microcontroller sends a signal to the GSM Module, which effectively sends SMS to the personnel regarding the condition/status of the circuit. If the fault is rectified either naturally or through some manual efforts within a particular period of time, then the code is made intelligent enough to restart the circuit, however, if that isn't the case then it also depends on the personnel whether or not to start the system. If he sends a signal to switch the circuit on (in our case it's 'LOAD ON') then the circuit will restart. However, if the current in the circuit is still high enough to be called as fault current, then the microcontroller again switches the circuit off within a particular time interval.

The steps involved in the project are:

a) Conversion of current to a voltage with the use of a suitable transformer.
b) Measuring of the root mean square value (RMS value) of the load current by using an Analog-to-Digital Converter.
c) Displaying of the status of the circuit like the power value at which the circuit was closed, time for which the circuit was open before finally closing to prevent damage, the sending of signal via message by GSM, whether the message was sent or not, the status of connection of GSM with the microcontroller etc., with the help of 16*2 alphanumeric LCD Display.
d) Algorithm Development for the realization of various IDMT curves.
e) The most important ones of all are the simulation of the electrical network by the use of appropriate software and the proper implementation of hardware i.e. the connections aren't loose but tight and rigid, the devices are connected as per the design and there is no overlapping of connecting wires so that one can easily monitor the connections in case he/she needs to change/reconnect something.

II. METHODOLOGY

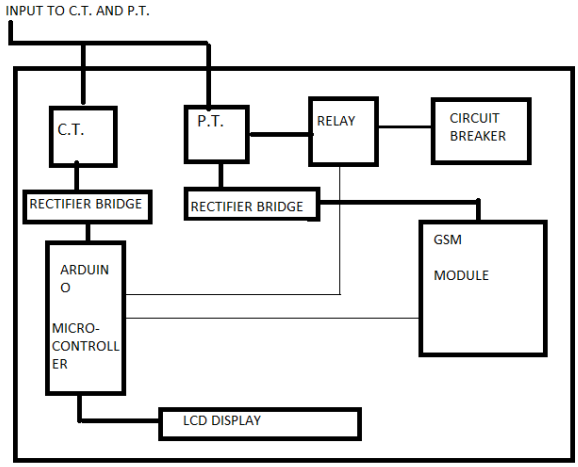

Fig. 2.1: Connection of various components

2.1 Designing of Proposed Method

Connecting a relay to the Arduino requires following steps:-

i. The first step includes the measurement of the resistance of the coil of the relay which is to be connected. This is done in order to calculate the current. On some relays, pins are labeled so we can just measure at pin 2 & 5 otherwise we have to measure at all the pins.
ii. Next is to measure the amount of current flowing. The Arduino can handle up to 20 mA but it is better to use a transistor even if the current is only 20 mA. But for the higher value of current, we would need one.
iii. In the above circuit, an NPN transistor is used in which the value of I_c should be greater than the current calculated previously and V_{ceo} should be greater than the supply voltage.
iv. Next is to calculate resistance R1 given by R1=V/ Ib. Here IB is given by $I_b=I_c$/have, where he can be found through datasheet and is already known.
v. Selection of diode is the next step. The diode is needed because the voltage will rise if we will suddenly change the voltage at the inductor.
vi. Now we should have a schematic of the working circuit.
vii. Assembling of the circuit is the next step. Before connecting Arduino we must connect a battery of suitable voltage, with its negative terminal to the ground and positive to R1.
viii. Finally, the test program is loaded as our last step.

2.2 Steps to be followed

Step 1: The current sensor continuously senses the current which is then fed to Arduino. This digital signal is compared with a present value written in our code.

Step 2: As and when the fault occurs, the current increases more than a prescribed value. This is then converted to a digital value which is more than the present value written in our code.

Step 3: To send the message we set our GSM module in text mode by sending an AT command "AT+CMGF=1". We send this command by writing this to Software serial library of the Arduino. We have written the code in serial. Print() function which has written the data in the TX pin of Arduino and is received by the RX pin of GSM module. The message is sent by using AT command "AT+CMGS=\"+91xxxxxxxxxx\"\r". The end of the SMS is shown by CTRL Z. Once these commands are received by the GSM module, the message of

warning the hike in current is sent to the number concern.

Step 4: To receive the message the AT command "AT+CNMI=2, 2, 0, 0, 0" is used. When this command is received by GSM module, after applying the delay, the user can then send the required message to Arduino which can be displayed by LCD.

Step 5: When the message is received the Arduino, it sends the signal to relay driver circuit which is used to drive the Relay. The relay is also fed through the current sensor. After receiving both the signal, the relay will send a tripping signal to the Circuit breaker.

Step 6: The circuit breaker will isolate the faulty system from the healthy system.

The figure shown above is the flowchart of the practical working model of the project. It shows how the microcontroller senses the current and if it reaches beyond the pickup value, then it sends a signal (tripping) to the circuit breaker. Also, a check of the current is made. When the circuit opens, the next process that comes into the action of SMS is also shown in the flowchart. After the message is sent, how the message is cleared from the memory is also a process of the highlight here.

A related algorithm of the following flowchart can also be made by observing the different steps involved in the flowchart.

The flowchart gives a basic idea of how the project works internally to send the required signals to the desired components at the appropriate time, for example, the operation of current sensor to sense the overcurrent, the operation of relay to immediately send a tripping signal to the breaker and similarly the checking process that comes into play if the current falls below the over-current value or the pickup value in the given amount of time.

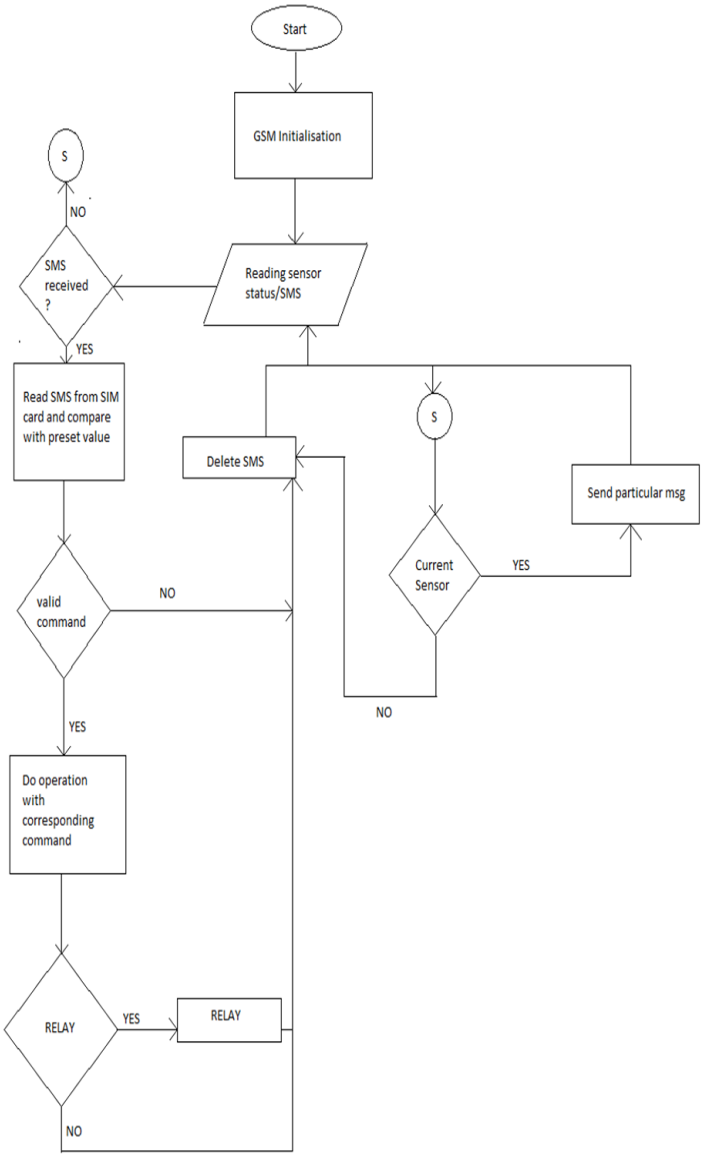

Fig. 2.2: - FlowChart

III. LOAD DESCRIPTION

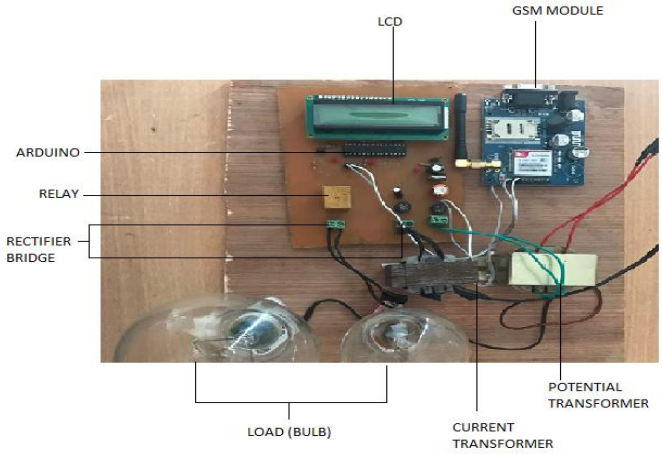

Fig. 3.1: - Top View Of The Practical Model

The load used in our practical power systems can be of different natures. Generally, they are inductive-resistive, capacitive-resistive or very rarely, simply resistive. The loads concerned with inductance and capacitance are associated with complex circuit equations which are readily used since most of the electrical power systems tend to be either capacitive or inductive in nature or both. Hence there are different equations that govern the power flow in such circuits and accordingly, we can also decide the nature and type of load to be used there.

In this project, we do not use either of the two, but we choose to use the simplest kind i.e. a linear resistive load, which is the bulb. A bulb is an electrical component which converts the electrical energy flowing through it into light energy, and therefore it can be understood that the resistance associated with the bulb would also be high since the only electrical component capable of dissipating energy in the electrical power system is a resistor.

A range of resistors with different values like 60W, 100W, and 200W are used in the project. The reason for using such low values of resistance is that the power associated with our circuit is not high enough to use loads of greater values.

Generally, the security of power is concerned with the two main types: the circuit security and the load security i.e. the prevention of both the former and latter is crucial in deciding whether the circuit has a good reliability or not. It also affects the durability of the circuit if the prevention is not robust enough.

Advancements are being made in this project to make the system intelligent enough to protect both the circuitry and load from any severe damage which may occur due to large hikes in the circuit flowing through the network. Thus, when the code is written to feed in the Arduino microcontroller, different range of values of power at which the relay operates is decided during the process. The time of operation depends on the value of load i.e. higher the load attached to the circuit, lower will be the time of operation or time in which the relay operates to close-off the circuit by giving the appropriate signal to the circuit breaker.

The flexibility of changing the load is also provided here. Since the bulb is used as the load, a simple connection or disconnection from its holder will do the necessary work. Thus, it can be seen that the load used is very simple and easy to connect/disconnect.

Also given is the pictorial top view of the working model/circuit that we designed. Clearly, the circuit seen is quite simple and therefore the load associated with it is also simple and flexible enough to vary according to the needs of the person.

IV. RESULT

In today's scenario, the power system uses is much more efficient, as a result of which the reliability of various components used in the power system has increased. Use of precise control circuitry has further strengthened the capability of power system to recognize and rectify the faults

However, for the successful operation of the power system and effective rectification of faults, there must be a personnel present at the fault site, so that he/she may turn off the power circuitry in case the things go out of control, like in the case of lightning surges, heavy load dispatch etc. In this process, the time taken to cut the system out of operation state is much more as compared to that taken by our project design.

Automation used in this project helps solve the above-mentioned problem. Depending on the load, the circuit disconnects it from the power system. More the load less is the time taken for disconnection.

As a result of which, the application of the project idea in the power system, not only enhances the automation but also helps to reduce human efforts in the rectification process. The outcome thus reflects the increased capacity of the system to deal with heavy faults, in turn, protecting the power system from the major load as well as voltage imbalances, occurring in the transmission line.

V. CONCLUSION

In an integrated Power System, abnormalities can any time occur in the lifetime of the equipment used. Various reasons of worn out can be a lightning stroke, insulation failure, pollution, frequency change over or mechanical breakdown.

It is necessary to avoid these abnormal operating regions for the safety of the equipment. As well as the faulty operations of the device is also a risk to human life.

To overcome any faulty situation and protect our devices, it is necessary to react to the problem in the least possible time. This can be done by digitizing the entire circuitry and thus reducing the time of operation.

There are many ways to avoid the collapse of the power system which can occur due to abnormalities present in the system our phenomena present outside the electrical power system. One such way that can be used and that is also conventionally used in the power systems is the application of relay. They have been highly successful in overcoming this difficulty. We here simply try to introduce the feedback component of the circuitry that is applied to recognize and rectify the fault as a result of which introduction of microcontroller was being made in order to somewhat add an automotive touch to the project.

In this project, Arduino is used to controlling an over-current relay using GSM communication to protect transmission line from over-current and giving full control to the personnel concerned. Here the operation of Relay is controlled using Arduino by presenting the value of the over-current at which

it has to be operated. The relay is an electromechanical switch which is used to drive Circuit Breaker.

To conclude, it is required to monitor the system under consideration for any abnormal operating conditions thereby protecting the transmission line and saving the human lives.

VI. FUTURE SCOPE

The whole point of the "Arduino Platform" is to allow easy and fast prototyping. It is able to process the data as well as display on LCD in a matter of minutes.

The various advantages offered by Arduino are-

1. Inexpensive- It is reasonably inexpensive as compared to other versions of the microcontroller.
2. Cross Platform- The Arduino platform is easy to use for beginners yet flexible to be used by advanced users at the same time.
3. Extensible Software- The software is published on open source where the coding can be done by expanding C++ libraries as well as using AVR C programming.

Arduino has a lot of advantages over PLC's so the scope of using Arduino to protect the system and detect abnormal conditions or faults is more. Arduino increases the reliability and accuracy of the system.

The Arduino combined with GSM and Relay can be applied to almost all the things present around us, thus justifying Internet Of Things ideology. Developing various Mobile Apps related to this theory can be used as the next step.

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