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IoT Based Fault Current Monitoring and Limiting of Smart Grid System

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ABSTRACT: Smart grid is a new technology which develops high speed communication and the fault can be detected quickly through Internet of Things (IoT), to protect the electrical equipments from damage due to over current. The Wi-Fi module is used to transport data such as current and voltage. The smart grid is a two way communication which monitors accurate reading of voltage and current and it also recognize the fault occurrence on the line. The Fault Current Limiter (FCL) is used to minimize the occurrence of fault on the line. Within a second the fault line gets corrected without tripping the faulted circuit. So that, the fault can be avoided and the electrical equipments are prevented from damage. The continuous power supply can be obtained without any interruption.

KEYWORDS: Smart Grid, Internet of Things, Fault Current Limiter.

I. INTRODUCTION

An electrical grid is the large network includes generating plant, transmission lines, substation, transformers, distribution lines and consumers [1]. An electric grid is an interrelated network which delivers an electrical current from generating station to consumers. Electrical grid is a one way communication, it does not monitor the database like smart grid which sends electricity from a power plant to consumers. Smart grid is a concept of digital technology and electric power network. It offers a lot of valuable technologies that can be used in the future and also it is in use today. Electric network, digital control appliance and intelligent monitoring are all in the smart grid system. This system delivering electricity from producers to load center, control energy flow, reduce overpower and make the performance of the electric network more reliable and controllable. Within short period, a smart grid function is more efficient, while also offering considerable social benefits such as less impact on our environment.

In future, Smart Grid will connect everyone to abundant, affordable, clean, efficient and reliable electric power anytime, anywhere. It will offer the world best and most secure electric services. The existing electric infrastructure still plays a very important role in the future, such as, power transmission line and substations. The smart grid is two-way communication which monitors and controls the whole system automatically when fault occurs. In electrical grid, there are many losses occurs due to overloading of power supply. For considering the overall losses, smart grid is invested to reduce those problems. When the fault occurs, the relay will detect the faulted signal on the transmission line and it is transmitted to the circuit breaker for tripping the faulted line [2]. The purpose of using tripping circuit is to prevent the equipments from damage due to overloading of current and voltage in line. Circuit breaker is to isolate the fault and it does not recover the fault automatically, it takes some precious time to recover.

A Fault Current Limiter (FCL) is used to limits the prospective fault current when a fault occurs without disconnection. The fault current limiter is used to reduce the valuable time to recover the fault. The overloading of voltage and current can get normal condition without tripping the faulted line by using fault current limiter.

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II. FAULT CURRENT LIMITER

Fault Current Limiter is a device which limits the fault current on the system without disconnecting the faulted line. It is used to enhance the system safety, stability and efficiency of the power delivery system. It is a fully automated operation and the fault can be recovered as fast as possible to normal state [4].

(a) Operation of FCL

In power system, FCL are used to protect the main equipments like electrical generators, transformers and transmission lines from fault current. In normal operating condition, the FCL exhibits low impedance, low voltage drop and low power loss. But in fault condition, immediately impedance values and current rating get increases. The period of recovering the fault condition is fast

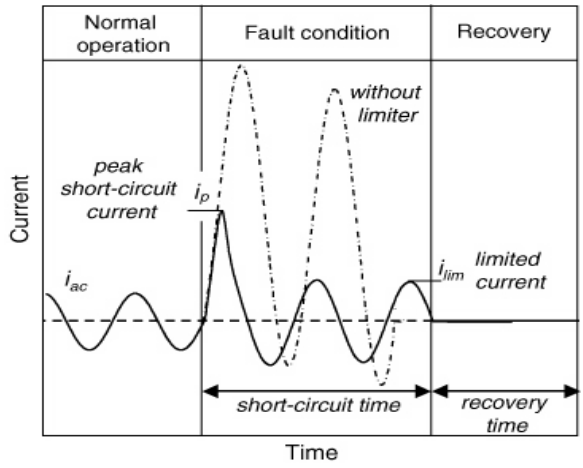

Fig.1.Generalized waveform for FCL

enough to protection from fault. The time of impedance change from 2ms to 4 ms is sufficient for the restriction of the first fault current peak and prevent over voltages [3].

III. TYPES OF FAULT CURRENT LIMITER

There is numerous kind of fault current limiter. The following classifications are in fig.2. In the power system, mostly superconducting fault current limiter is used.

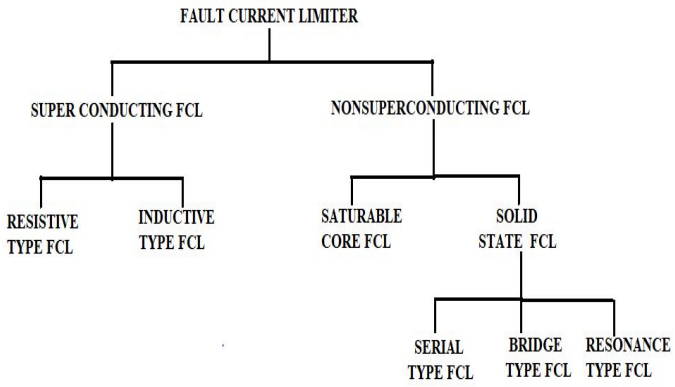

Fig.2 .Types of fault current limiter

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(a) Superconducting FCL

Superconducting fault current limiters develop a rapid loss of superconductivity above a critical combination of temperature, current density, and magnetic field[5]. The superconducting material carrying current without resistance and with negligible impedance in normal condition. If any fault occurs, the superconducting fault current limiter raises its resistance rating sharply and then the current is diverted to parallel circuits with high impedance. Superconducting fault current limiters are classified into two categories, they are resistive type and inductive type superconducting FCL.

(i) Resistive type SFCL

The resistive type SFCL is a circuit which is mainly used when the fault current occurs on the superconducting material, it rise the resistance and it limits the fault current on it.

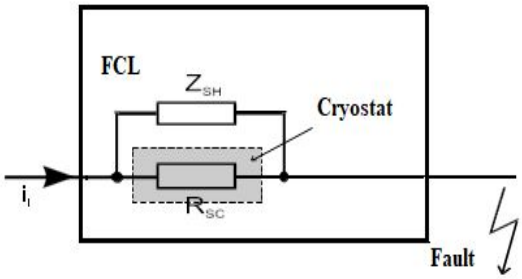

Fig.3. Resistive type SFCL

Fig.3 shows the resistive type SFCL [6]. A resistive FCL can works at either DC or AC sources. If the source is in AC, the AC losses will be removed by cryogenic system. An AC SFCL is made by non-inductive wire wound or the inductance device creates an extra constant power loss on the system.

(ii) Inductive type SFCL

The basic concept of an inductive FCL is the resistive FCL is fitted on the secondary sides of the transformer [7]. In normal operating condition, the inductance of the devices is low and there is no resistance.

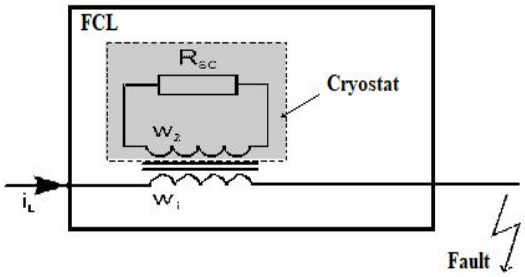

Fig.4. Inductive type SFCL

During the fault current flows, it quenches the superconductor; the secondary sides of transformer will raise the resistive and the inductance [8]. The advantage of inductive type is that there is no heat access through current leads into the superconductor, and so the cryogenic power load may be lower. In this type, the large amounts of irons are required because the inductive type is bigger than the resistive type FCL.

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(b) Solid State Fault Current Limiter

Solid state FCL using the high power semiconductor device such as SCR, GTO, IGBT to realize the FCL[9]. SSFCL will provide solution to allow delivery system to grow its capacity with increased reliability and power quality. Fig.5 shows the solid state fault current limiter . The passive current limiting elements like series inductor reduce the system stability and load flow[10]. To overcome this problem SSFCL is used for limiting the fault current instantly. Types of SSFCL are as follows.

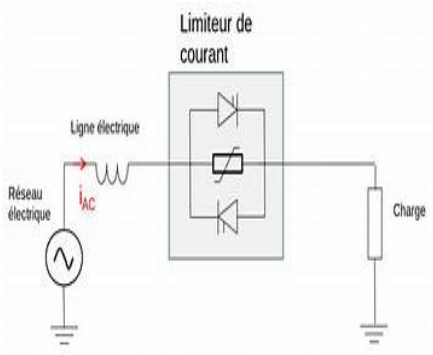

Fig.5. Solid state fault current limiter

(i).Serial type FCL
(ii).Bridge type FCL
(iii).Resonance type FCL

(c) Current Sensor

A current sensor is a device that can sense current flows through it. If the current reaches a certain threshold, then an indicator, such as an LED, will turn on [11].If it get to a certain level of current, then it gives the output in the form of analog current signal.

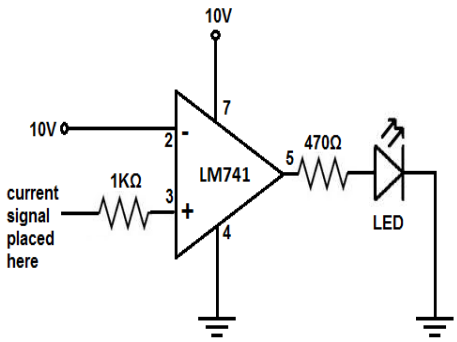

Fig.6. circuit diagram for current sensor

(d) Arduino Uno

Arduino is an electronics device that helps to embed the software and hardware [12]. The microcontroller was introduced with the purpose of making our tasks easy that comes even in a remote connection with automation in any way. Microcontrollers are widely used in embedded systems that make devices and works according to our needs and requirements. Arduino Uno is a very important technique which consists of USB interface, 14 digital I/O pins, 6 analog pins, and Atmega328 microcontroller.

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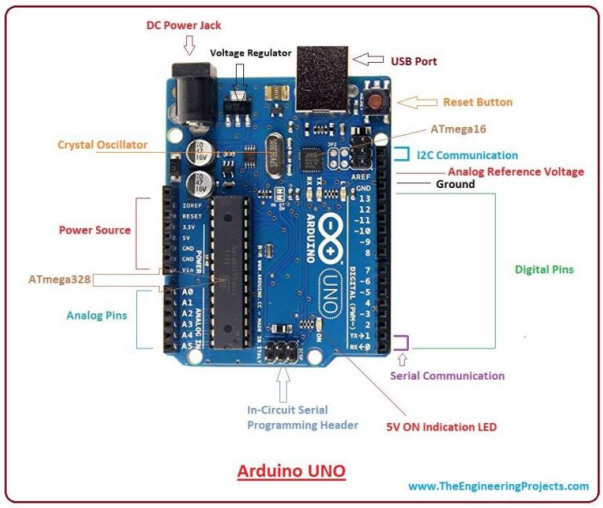

Fig.7. Arduino Uno

There are 14 I/O digital and 6 analog pins incorporated in the board that allows the external connection with any circuit with the board [13]. These pins provide the flexibility and it can be easily connected to the external devices through these pins.

IV. BLOCK DIAGRAM

This block diagram contains the many components such as voltage and current sensor, Arduino Uno and fault current limiter. Operation of these components is explained in below.

(a) Operation

In smart grid voltage and current is measured continuously by using three phase voltage and current sensor. Analog output of the voltage and current sensor is send to the Arduino uno. Arduino uno collects the data to detect the fault by storing the program in it. Corresponding voltage and current readings are displayed in LCD at every time. By using IoT text message is send to the corresponding authority to their smart phone. If the current rating exceeds the particular range then the fault occurs. Due to the overloading of current the fault current limiter is used to detect the fault and it automatically limits the current within few seconds without tripping the Circuit.

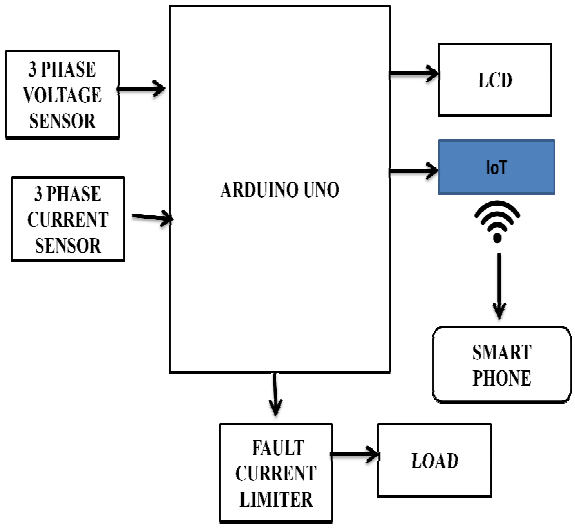

Fig.8. Block Diagram

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Finally the power supply continuously flows to the load. In this system occurrence of fault can be detected within few seconds without destroying the any equipment in smart grid. The fig.9 shows the hardware setup of this project. The AC power from the line is sensed by using potential transformer and it is step-down to 5V.

Fig.9. Hardware Setup

The current flowing through the circuit is sensed by the resistive type current sensor and it is flow to the Arduino at the rating of 5A. If the overloading of current passes through the circuit, the FCL circuit will turn on to limit the fault current within 20 nano seconds without tripping the line. The sensed reading of voltage and current on the line is transmitted to the clouds through Wi-Fi modules for every 20 seconds.

(b) Advantages

By using the fault current limiter it limits the fault current without tripping the circuit. In smart grid it takes the minimum amount of time to recuperate the fault current so it saves the time. In this system circuit will not tripped so, there is no need of manual work to reclaim the tripped circuit. During the occurrence of fault, the electrical demand from the distribution side can be reduced by using the fault current limiter and also it helps to protect the equipments from the damage. By using the IoT current and voltage data's are sending to the particular person for each and every second. The mobile number can be changed at any time and there is no need to monitor the data from the relay room. The system can be monitored and controlled from anywhere in the world.

(c) Application

- Power grid
- Factories
- Industrial area
- Home automation
- Railway

V. RESULT AND DISCUSSON

The monitoring of power from the line and limitation of the fault current circuit is done by the Arduino. The Arduino is very important for the operation of this project. The current from the line is stepped down to 5A because the Arduino will operate the voltage. This work limits the fault in transmission line without tripping the circuit. It reduces the time duration of recovering the fault and continuously monitoring the exact data in this system. In this system it

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prevents from the occurrence of damage to the equipment. In smart grid by using the fault current limiter the time to recovering the faulted line can be minimized and also the demand from the distribution sides gets reduced.

VI. CONCLUSION

In conclusion the design of an efficient system will provide to detect the fault and monitoring the exact data in the line with the help of IoT terminals. This work limits the fault in transmission line without tripping the circuit. It reduces the time duration of recovering the fault and continuously monitoring the exact data in this system. In this system it prevents from the occurrence of damage to the equipment. In smart grid by using the fault current limiter the time to recovering the faulted line can be minimized and also the demand from the distribution sides gets reduced.

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