SERIES TRANSFORMER BASED SOLID STATE FAULT CURRENT LIMITER

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***Abstract*— This paper studies a novel transformer-based solid state fault current limiter (TBSSFCL) for radial distribution network application. The proposed TBSSFCL is capable of controlling the magnitude of fault current .In order to control the fault current, primary winding of an isolating transformer is connected in series with line and secondary side is connected to a reactor, parallel with a bypass switch which is made for anti parallel insulated gate bipolar transistor. By controlling the magnitude of ac reactor current, the fault current is reduced and voltage of the point of common coupling is kept at an acceptable level. Also, by this TBSSFCL, switching overvoltage is reduced significantly. The proposed TBSSFCL can improve the power quality factors and also ,due to its simple structure ,the cost is relatively low. Laboratory results are also presented to verify the simulation and theoretical studies. It is shown that is TBSSFCL can limit the fault current with negligible delay, smooth the fault current waveform, and improve the power quality.*

***Keywords*— Series Transformer Based Solid State Fault Current Limiter (TBSSFCL), Power Quality (PQ),** Peripheral **Integrated Circuit (PIC),Fault Current Limiter (FCL).**

1. INTRODUCTION TO STBSSFCL

STBSSFCL is a variable-impedance device connected in series with a circuit to limit the current under fault conditions. The STBSSFCL should have very low impedance during normal condition and high impedance under fault condition.

On the basis of the above characteristic, various types of FCL have been developed. Some of these FCL are based on superconductor, power electronic switches and series transformer.

The fault current limiting technology has become hotspot in power system protection research. However, the research are concentrated on the superconducting and power electronic switches types over the last four decades, different types of FCLs have been under the spotlight in power protection research. In recent years, various types of FCL have been proposed and developed in many countries.

Series transformer type is the interest on it comes not just due to their excellent current limiting characteristics but also due to their positive contribution to the quality of supply.

Series transformer based solid state fault current limiter can be effective in reducing supply outage and mitigate voltage sag on power network.

A.PROJECT BACKGROUND

A short circuit cannot be neglected in the power system due to numerous causes. When short circuit occurs in power system, large current will flow in the system which can cause damage to the equipment due to heating effects and electromagnetic forces. Furthermore, during fault, some point in the power system network (depending on the distance of the fault point) will experience voltage sag. This problem may cause to a complete shutdown of healthy plants connected to the network. Power utilities associate that 80-90% of their customers complaining about voltage sags problem.

One of the main concerns related with the continuous growth of electricity demand is the corresponding increase in short circuit currents. This matters has been discussed since early 1960s, replacing existing switchgear with others of higher rating is certainly a solution this problem. This solution probably is the best to solve this matter which, solving the increment of the switchgear rating problem as well as providing for future growth.

However, this is the most expensive of all the other solution and also consumes a lot of time to replace all existing switchgear which leads to reduction of power system reliability for that period of time. Bus splitting is definitely a cheaper solution to this problem. This entails separation of sources that could possibly feed a fault by the opening of normally closed bus ties, or splitting the existing busses. This effectively reduce the number of sources that can feed a fault, but also reduces the number of sources that supply load current during normal or contingency operating conditions. However, this option may require additional changes in the operational philosophy and control methodology. Furthermore, splitting the bus has implication on network reliability.

B.PROBLEM STATEMENT

Recent researches show that the implementation of FCL can be used to control the short circuit capacity of power system. Thus, a study needs to be carried out to investigate the performance of power system when using FCL in various conditions;

i)Normal condition
ii) Balanced fault condition
iii) Unbalanced fault condition

C. PROJECT OBJECTIVE

The objectives of this project are mentioned in the following;

I. To review fault current limiting technologies
II. To study the power system performance with and without FCL under normal and abnormal condition
III. To compare the power system performance with and witho current limit

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D.PROJECT SCOPE

The scope of this project is limited to the following works;

I. There are two different types of FCL discussed most; Superconductor FCL and Solid-state FCL.
II. A distribution system fed from a single source radial system is used in this project.
III. Pre-fault, fault and post-fault current.
IV. Busbar voltage.

E.INDUCTOR

An inductor, also called a coil or reactor, is energy is stored temporarily in a magnetic field in the a passive two-terminal electrical component which resists changes in electric passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor, according to Faraday's law of electromagnetic induction, which opposes the change in current that created it.

An inductor is characterized by its *inductance*, the ratio of the voltage to the rate of change of current, which has units of henries (H). Inductors have values that typically range from 1 µH (10^{-6}H) to 1 H. Many inductors have a magnetic core made of iron or ferrite inside the coil, which serves to increase the magnetic field and thus the inductance. Along with capacitors and resistors, inductors are one of the three passive linear circuit elements that make up electric circuits. Inductors are widely used in alternating current (AC) electronic equipment, particularly in radio equipment. They are used to block the flow of AC current while allowing DC to pass; inductors designed for this purpose are called chokes.

F.PIC PROGRAMMER

Programmer is used to load a program in the memory of PIC. Programmer is necessary to control ICSP.

G.LOADING FOR PROGRAM MEMORY

When assembling a source code with the assembler, HEX file is created. (The extension is .hex) The contents of this file are loaded for the program memory of PIC .To load this data in PIC, the following processing is necessary. It interprets the contents of the HEX file and it recognizes a memory address and data in the PIC. It makes the PIC program/verify mode. It makes voltage (+13v) for program/verify mode. It changes into the electric signal for which it is possible to receive the PIC.It transfers data to the PIC according to the ICSP procedure of the PIC.It checks the contents, which were loaded in the PIC.
Generally, these are done by the personal computer and the programmer software and other done by programmer

2. PROPOSED SYSTEM OF TBSSFCL

STBSSFCL is a variable-impedance device connected in series with a circuit to limit the current under fault conditions. The STBSSFCL should have very low impedance during normal condition and high impedance under fault condition.

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A.BLOCK DIAGRAM

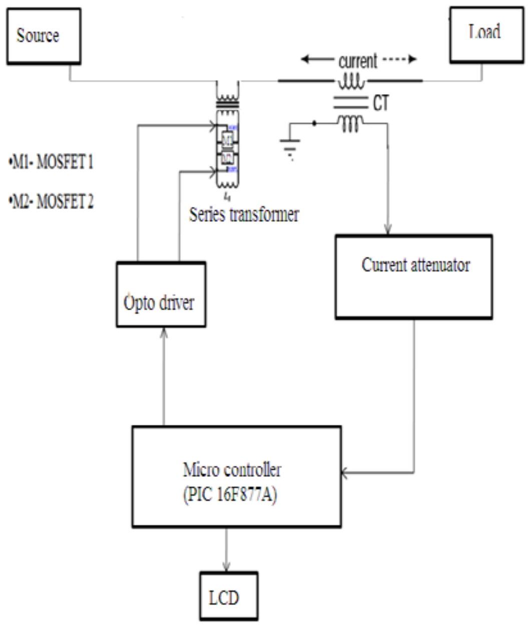

Figure.1 Block Diagram of Proposed System

B.BLOCK DESCRIPTION

1.The basic configuration of the SSFCL consisting of two connected solid state switches with Series Transformer.

2. The M1 & M2 act as the Series transformer switches.

3.Switches are connected in inversely serial manner for both branches.

4.The corresponding firing pulse is generated from the controller whenever the faulty current flows through the load. The figure 3.1 shows the block diagram of proposed system

C. CURRENT TRANSFORMER

The current transformer is used with its primary winding connected in series with the line carrying the current to be measured and therefore the primary current is dependent upon the load connected to the system and is not determined by the load (burden) connected on the secondary winding of the current transformer. The primary winding consists of very few turns and therefore there is no appreciable voltage drop across it. The secondary winding of the current transformer has larger number of turns, the exact number being determined by the turn ratio. The ammeter, or wattmeter current coil are connected across the secondary winding terminals. Thus a current transformer operates its secondary winding nearly under short circuit conditions. One of the terminals of the secondary winding is earthed so as to protect equipment and personnel in the vicinity in the event of the insulation breakdown in the current transformer.

D. CURRENT ATTENUATOR

Attenuator acts as a signal conditioning circuit. It attenuates the output of current transformer and potential transformer. OP-Amp-IC741 is used in current transformer and the load resistance (1kΩ) can drop the current and voltage reading is taken .Input resistance Rin (10KΩ) is given to OP-Amp and Feedback resistor (20kΩ) used to input charge and output gain. By using the Diode- IN4148 bring the rated voltage at constant. Pull down resistor (10kΩ) can remove the voltage noise and the Capacitor are used to remove the AC ripples.

E. OPTO DRIVER

Opto driver is an isolation device which isolates the power side and control side of the electrically. This drives the MOSFET gate hence it is called as opto driver. Opto coupler: 4N3 is used in prototype

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3.HARDWARE DETAILS

A.CIRCUIT DIAGRAM

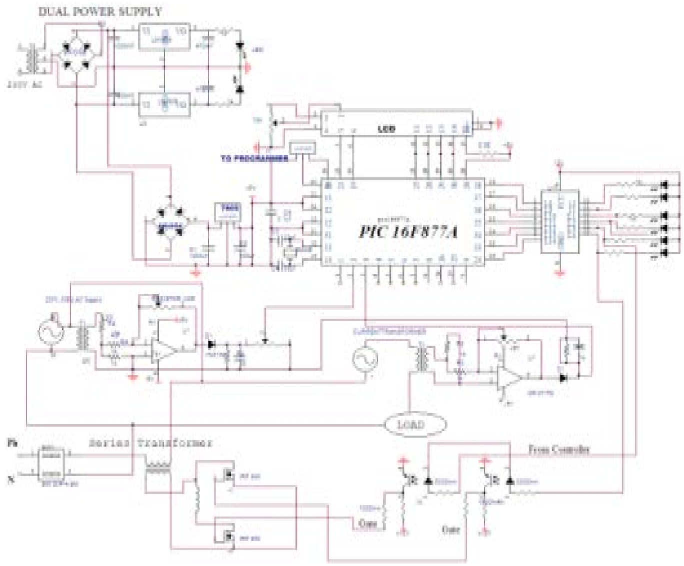


Figure.2 Circuit Diagram of Proposed System

B.CIRCUIT DESCRIPTION

The figure 4.1 shows the circuit diagram of proposed system.The proposed circuit diagram consists of our project the power supply circuit the circuit is a dual power supply (+5V,-5V). The output voltage goes to all IC's operating voltage. The line current measuring devices CT, the current transformer connect to the series of the load. Current transformer output connects to the Shunt resistor to drop the current and allow the voltage.

The voltage signals goes to IC 741 pin 2. This attenuator circuit increases the voltage. The output signals go to microcontroller. Phase current signal go to controller .The microcontroller is PIC 16f877A is using of our project. The controller input analog signals convert into digital signal.

The controller compares the input value and set value. To increase the input signal the controller output is high. As a same time the LCD display is displaying the current. The controller output signal is go to buffer. The buffer amplifies the signals. This output is connected to the opto coupler.

The Opto coupler electrically isolate the devices. Opto coupler output is connected to the MOSFET gate. The gate pulse is high, MOSFET is switched ON. Also if, SFCL switch is in ON condition means, if any fault current flows the SFCL MOSFET will be ON. And corresponding fault current will be limited through the inductive load.

C. POWER SUPPLY

Most electronic circuits require DC voltage sources or power supplies. If the electronic device is to be portable, then one or more batteries are usually needed to provide the DC voltage required by electronic circuits. But batteries have a limited life span and cannot be recharged. The solution is to convert the alternating current lose hold line voltage to a DC voltage source.

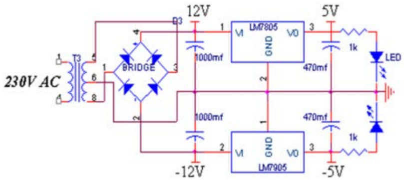


Figure.3 Power Supply

The figure.3 shows the power supply diagram.Diode-IN4007 are full wave bridge rectifier which converts Ac to Dc and filter capacitor is used to filter the AC repulse. Voltage regulator to maintain constant voltage7805-positive regulator and 7905- negative regulator. bypass capacitor are used for charging at high voltage and discharge when its low voltage. LED- to indication of power supply.

D.CIRCUIT DIAGRAM OF CURRENT ATTENUATOR

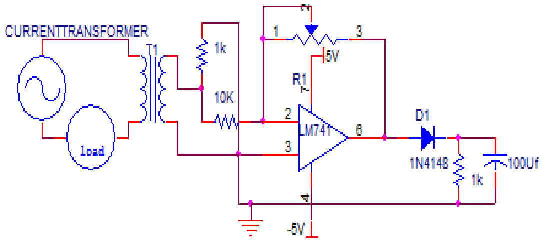


Figure.4 Current Attenuator

The figure shows the circuit diagram of current attenuator.Attenuator act as a signal conditioning circuit. It attenuates the output of current transformer and potential transformer. OP-Amp-IC741 is used in current transformer and the load resistance (1kΩ) can drop the current and voltage reading is taken .Input resistance Rin (10KΩ) is given to OP-Amp and Feedback resistor (20kΩ)used to input charge and output gain. By using the Diode- IN4148 bring the rated voltage at constant. Pull down resistor (10kΩ) can remove the voltage noise and the Capacitor is used to remove the AC ripples.

E. CIRCUIT DIAGRAM OPTO DRIVER

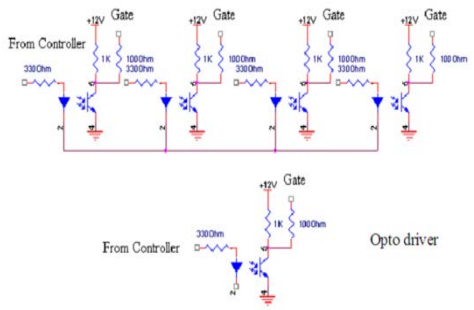
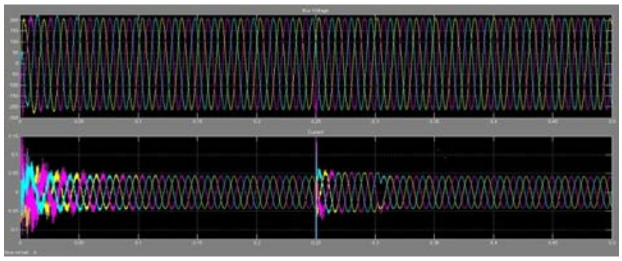


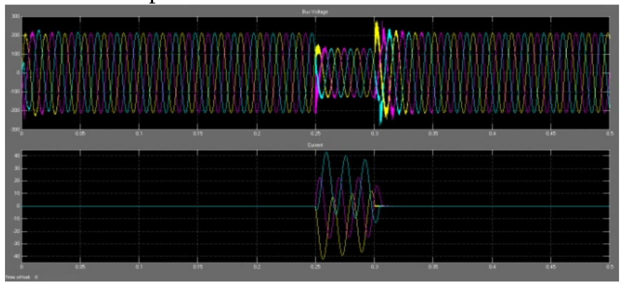
Figure .5 Opto Drive

The figure .5 shows the circuit diagram of Opto driver.Opto driver is a isolation device which isolates the power side and control side of the electrically. This drives the MOSFET gate hence it is called as opto drive.

4.MATLAB SIMULATION OUTPUT



Simulation output with TBSSFCL



Simulation output without TBSSFCL

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5. CONCLUSION

The proposed TBSSFCL is capable of controlling the magnitude of fault current. In order to control the fault current, primary winding of an isolating transformer is connected in series with the line and the secondary side is connected to a reactor, paralleled with a bypass switch which is made of anti-parallel insulated gate bipolar transistors. By controlling current, the fault current is reduced and voltage of the point of common coupling is kept at an acceptable level. so, by this TBSSFCL, switching overvoltage is reduced significantly. Current transformer will send current to the input of the current attenuator.

CASE 1: NO FAULT IN THE LINE

Current attenuator will not send signal to PIC Microcontroller. No Gate triggering current will be given to MOSFET. No Fault current Indicator LED Will glow Series transformer just sending drain to source voltage. LCD Display will give the amount of current value.

CASE 2 : WHEN FAULT IN THE LINE

Current transformer will send current to the input of the current attenuator. Current attenuator will send signal to PIC Microcontroller. Gate triggering current will be given to MOSFET.It will turn ON and secondary of the series transformer will be removed from the supply.

Series Transformer acts only in open circuit condition and dissipate excess fault like an inductance. Series transformer just sending drain to source voltage. Fault current

Indicator LED Will glow. LCD Display will give the amount of current value

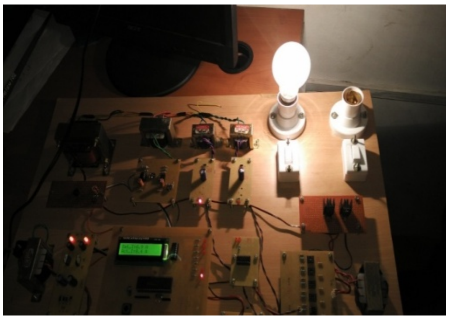

Figure .10 Normal Condition

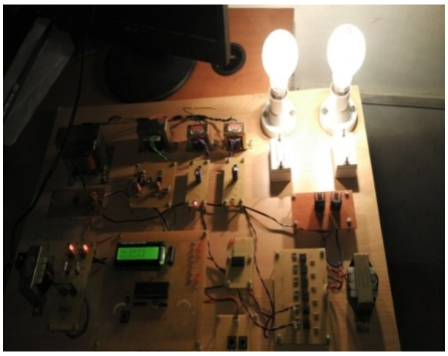

Figure .11 Fault Condition

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