2018 3rd International Electrical Engineering Conference (IEEC 2018)
Feb, 2018 at IEP Centre, Karachi, Pakistan

SHORT CIRCUIT AND OVERLOAD CURRENT SENSING FOR POWER CONVERTERS USING INDIRECT CURRENT SENSING

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Abstract: All power semiconductor devices have limited operating capabilities. Reliable use of power devices has always been challenging. Traditionally, relays and fuses are used to detect the fault current and high speed switches are used to remove the fault current. However, for high speed sensitive environments the reaction time of these devices is too high to sense fault current. In this research, high speed digital detection technique is implemented using indirect current sensing to sense the short circuit current (SCC). This technique detects the fault current efficiently in small time as compared to other techniques. The result shows that our proposed system takes 20-30ms to detect the fault and 10-15 ms to system resume.

Keywords: **Converters, Overload Current, Fault Current, Indirect Current Sensing**

I. INTRODUCTION

Rapid grow in the field of power electronics is shown in last few decades due to the requirement of high reliability and performance of micro grids such as renewable energy system, telecommunication systems and industries [1-3]. DC power systems are much reliable than AC systems, when high power is required [4]. Protection and control are the major challenges to sense and mange the fault conditions [5-6].

In AC Power systems relays are widely used to sense the fault current and also reliable to isolate the fault with the help of Circuit breakers [7]. Power semiconductor devices such as MOSEFT, IGBT, and GTO are extensively used in medium and high power system applications. These devices are acceptable to less sensitive environments, but for high speed sensitive circuits, the reaction time of these devices is excessively high to detect and distinguish fault current in time [8-11].

To maintain the power system reliability, faults in power converters and methods of fault handling should be investigated. In this research, high speed digital detection technique is implemented using ohmic method to calculate the fault current. This technique sense the fault current efficiently in very small time as compared to the other systems. It also coordinates with the digital circuit breaker. Successful implementation of sensing and removing fault current using digital technique has been implemented.

The rest of the document is organized as follows: in section II Related work is described briefly. Section III consists of Methodology. The Results of our experiment presented in section IV, and finally conclude the paper in section V.

II. OVERVIEW OF PROTECTION SYSTEM

There are several devices used for protection of power systems.

A. Fuses

Fuse is a device through which the load current flow, but when the short circuit occurs and large current flow through the fuse for a certain period of time then it breaks the path. Fuses are usually used for low voltage system but can also be used in the medium voltage applications. These are not a good choice of high voltage system. Fuse can be classified in two types on the basis of fault current limitation. First cannot limit the current and second limit the fault current. According to the above mentioned types, fuses can limit the first peak of fault current. So fuse is good device for limiting the fault current with some handicaps which restrict their use.

The load current flow directly through fuse which increases the losses. These losses are directly proportional to the square of the current. For sensitive systems these losses are not acceptable.

Some time it is also difficult to coordinate fuses with the power system and other protection installation.

B. Circuit Breaker

Circuit breaker is device which can be used for all power systems. The basic principle of circuit breaker is that it is dependent on input and output current. When the input and output currents differs the magnetic settings of the internal coil change. The terminals of the circuit breaker are open. There are several circuit breakers which work on zero-crossing method. So when the fault current flows through the breaker the contacts of the breaker are opened, causing an arc until it reaches its natural zero-crossing. If the arcing channel is not cool properly then the current will not be interrupted until the next natural zero-crossing. This is the main disadvantage of circuit breaker.

The other disadvantage of the circuit breaker is that the protection depends on the zero crossing because it is very difficult to protect system from the mechanical forces which are due to the first fault current peak. There is no solution even if the protection time becomes smaller to protect the system from the first peak because the operation is based on the zero crossing.

III. SIMULATION SETUP

A. High Low Current Ranging

This current limiting technique has been implemented using two TL6101 precision amplifiers. One amplifier give value of lower current level and the other amplifier give value of higher current level. The sensitivity, resolution and measurement of given circuit is 10 times greater with low current. Where LTC1540 detect high current flow through system and switch sense high current circuitry. BAT54C are used to detect arc during fault current and its output value is compared with comparator to shutdown system if comparator value is high.

B. Protection Circuit

In the end protection circuit has implemented the first stage is current sensing then current to voltage converter and then decision in figure 5.6 ac RMS value is converted into dc source. Dc converted source then used as an internal source to remove effect of short circuit current due to batteries. Then there is arc detection and over current condition is handled with help of LT1122 and LT1010 in results stable dc output voltage is shown. Approximately up to 7 Amps over current condition has been handled. The protection circuit is also suitable for dc source, in case of dc source no need of RMS to dc conversion required, but an external dc source is required for power up the protection circuit.

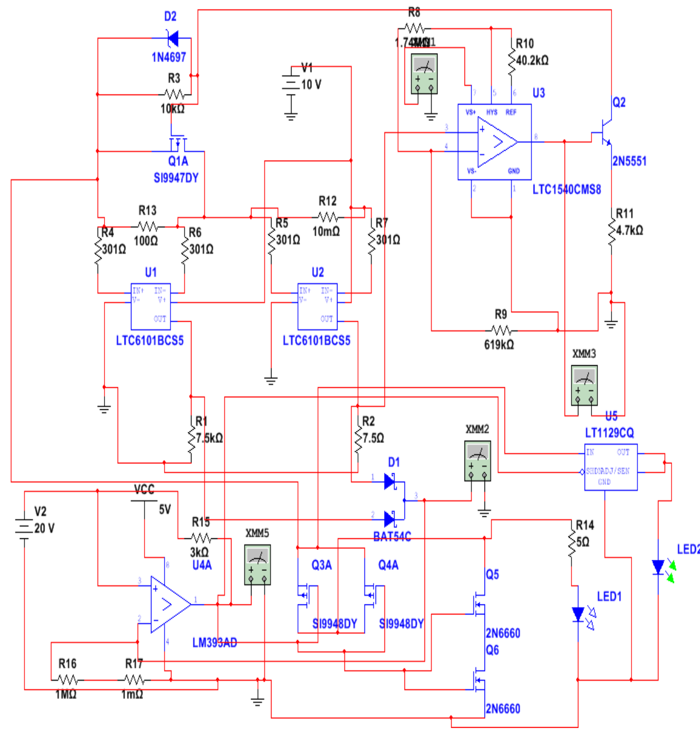

Figure 1: Protection Circuit

IV. SIMULATION RESULTS

A. DC Protection Results

The simulation of DC protection system has been implemented using direct and indirect current sensing. The protection system efficiently removes the draw backs of relays as well as the fault current. The results of the simulation of DC protection system are given below in figure 1.

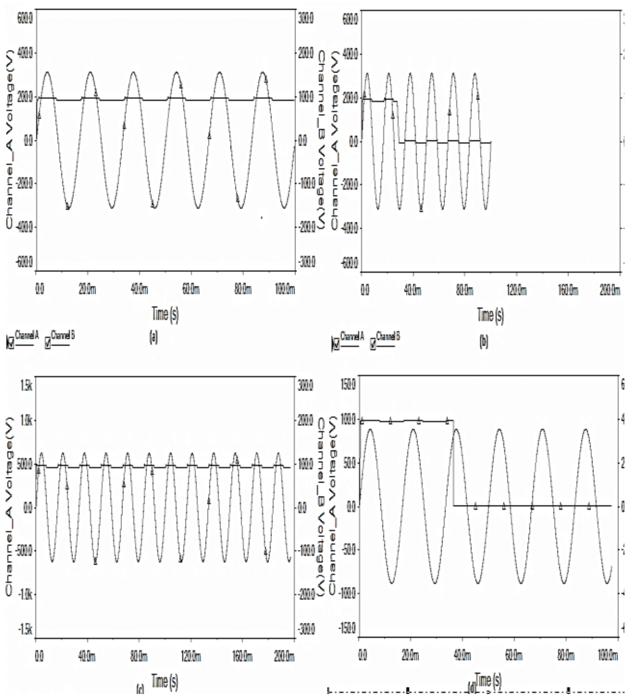

Figure 2: DC protection system results and protection during short circuit. (a) Normal operation, (b) Fault detection during negative peak, (c) Stable output during over current, (d) Fault detection during positive peak

In figure 1 (a), the general operation of the power converter are shown for 200 V. In figure 1 (b) appears that when there is an error in the electrical system, protection circuit works and clears the error. In figure 1 (c, d) the same process are tested for 500V and the protection circuit successfully removes fault current within 30 ms time spam.

B. AC Protection Results

System protection used for AC system limits and removes the fault condition efficiently in 30 ms times. The fault condition has been implemented on protection system during positive and negative peaks of an input source. If the fault is removed, the system become in operation automatically with less than 5 ms times.

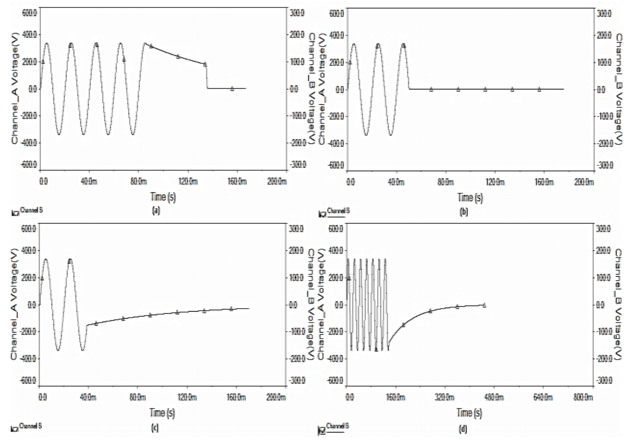

Figure 3: Short circuit current remove during positive and negative peak. (a) Positive peak fault current removing, (b) Positive peak fault current removing near zero, (c) Negative peak fault current removing, (d) Negative peak fault current removing near zero

Figure 2 Shows the simulation results in AC protection System. Figure 2(a) shws that when the fault occurs during positive peak the protection system works and power system shutdown gradually not slightly. In figure 2(b) the fault occurs near zerocrossing so the system shutdown immediately.In figure 2(c, d) same process is shown for negative peak.

In Figure 3 (a, b) it is clearly shown that the fault is current is occuringto positive and negative peaks. The system is restoring after the fault occurs to positive and negative peak.

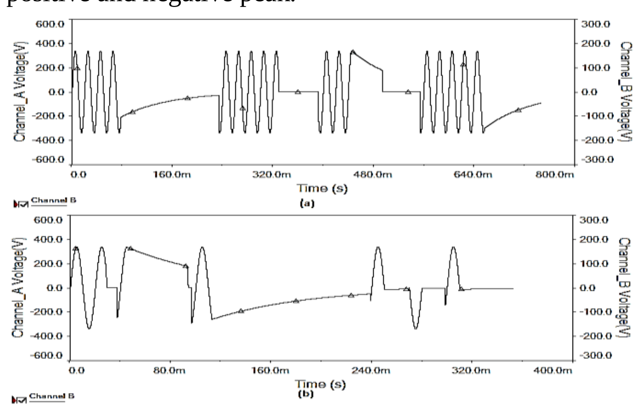

Figure 4: Fault condition sensing and system restoration. (a) Positive negative peak fault current detection and automatic system restoration, (b) Fault sensing

V. CONCLUSION

Over current and short circuit current protection design has been implemented using direct and indirect current sensing including digital protection technique and arc detection for ac and dc system during fault condition. This study involves calculation of short circuit current due to ac and dc system components and in minimum time duration to detect and remove fault current. A 600W (3A, 200V) system has been used for design simulation implementation. Fault current detection, protection and recovery times meet IEC standard 60909. The efficiency of fault current detection techniques has been evaluated on the basis of amount of current, power usage and removing output errors due to circulating current. The sensor output is also used to power up the remaining protection system, obviating the need external power sources. The digital control devices for tripping circuit use less power during fault condition as compared to the relay based protection system and tripping circuit efficiently remove first fault current peak. In summary, digital protection method requires less than 40ms to protect the load and power system from fault current.

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