Advanced Differential Protection Scheme Using Microcontroller

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***Abstract*- This paper describes a differential protection with a controller based on the differential protection, and studies its performance through simulation results. Multisim/Simulink is the simulation tool, used in the study, development, and performance evaluation of the differential protection scheme The simulations are carried out for difference between CT output at healthy and faulty condition. The differential protection scheme allows only for internal fault and proposed scheme provides stability against external faults, presenting a good dynamic and steady-state performance, as it can be observed in the simulation results.**

***Keywords*- Microcontroller, Differential Protection , Multisim.**

I. INTRODUCTION

The generator, transformer and bus bar form the major components of a power system. Protection of these components against any type of abnormal condition is essential. A simple, but most reliable, protection scheme for these elements is a differential protection because of the ease of connections at its terminals. The differential relay operates on the principle of circulating current. It involves a direct comparison of the magnitudes and phase of the current entering and current leaving the protected equipment / section. To accomplish this; current transformers having suitable ratios of transformation are interposed in the circuit at both ends of the protected equipment. Ideally for the normal power flow condition, the current in the operating relay (I1-I2¬) should be zero.

However, due to the various factors such as unequal C.T. saturation, magnetizing inrush current etc. such an ideal condition may not be obtainable. So, differential relay should be characterized by its ability to distinguish between internal faults requiring isolation of faulty section and an external fault requiring non-operation of the relay. Thus the internal fault characteristics and external fault characteristics should be carefully considered in differential relay. The application of Microcontroller to protective relay is resulting in the availability of faster and more accurate and reliable relaying units.

The increased growth of power systems both in size and complexity has brought about the need for fast and reliable relays. To protect major equipment and to maintain system stability, the conventional protective relays are either of electromagnetic or static type. The electromagnetic relays have several drawbacks such as burden instrument transformer, high operating time, contact problems etc. Also static relays suffer from a number of disadvantages e.g.

inflexibility and improved performance over conventional relays. All the above advantages can be achieved in a Microcontroller based relays.

In a Microcontroller based differential relay the various incoming and outgoing currents are obtained by the CTs. These current signals, with required signal conditioning are applied to the Microcontroller assembly. The Microcontroller then compared these actual signals and determines the internal fault and then trip signal is given depending on the abnormal condition.

Thus a Microcontroller based differential relay has a programming facility and is flexible one and the pick-up values can be altered very easily.

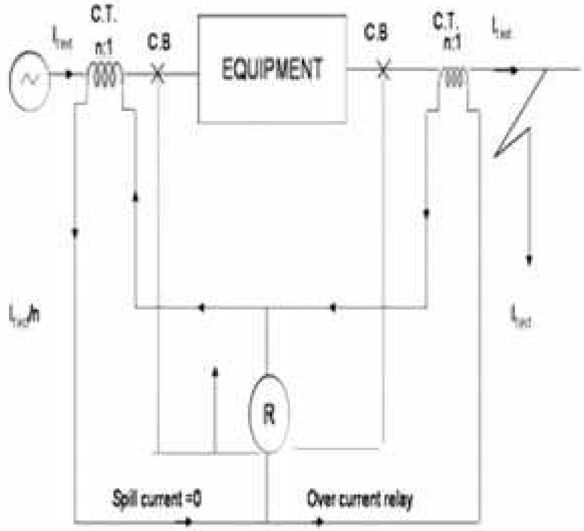


Fig.1 Simple Differential Protection Scheme Remain Stable on External Faults

II. INSTANTANEOUS DIFFERENTIAL THEORY

In simple differential scheme the current entering and leaving the equipment to be protected, are stepped down with the help of CT's on either side. Careful attention must be paid to the dots marked on the CT's. The rule to be applied in order to trace the currents in the circuits is when current enters the dot mark in primary then the current must leave the similarly marked dot on the secondary side.

For the operating condition of normal load flow is shown in figure2.1. The currents transform by two CT, being equal in magnitude as well as equal in phase, just circulate on secondary side. There is no tendencies for the current to spill in the over current relay. The over current relay connected in the spill path is wired to trip the two circuit breakers on either side of the equipment being protected.

Assuming that the protected equipment is either 1:1 ratio transformer or say a generator winding or a bus bar, the two currents on the primary side will be equal. Hence the ratios of the two protective CT will also be identical.

The CT secondary circuit are so connected that in case the conditions are normal, the secondary currents simply circulates though the pilot leads connecting the two secondary windings. For the operating condition of normal load flow, there is no current through the spill path where an over current relay is located. Hence the over current relay will not trip the two CBS. Thus the simple differential relay meets the first and the foremost requirement that it remains stable during normal operating condition.

III. BEHAVIOUR DURING INTERNAL FAULT AND EXTERNAL FAULT

The differential relaying scheme should also remain stable for any fault which is outside its protective zone. Such faults are called external faults or the through fault. Figure 2.2 shows that external faults too, the current leaving the protected zone is same as that entering it. Assuming that the CTs transforms the two currents with the same fidelity, there will no current in the spill path and scheme remains stable.

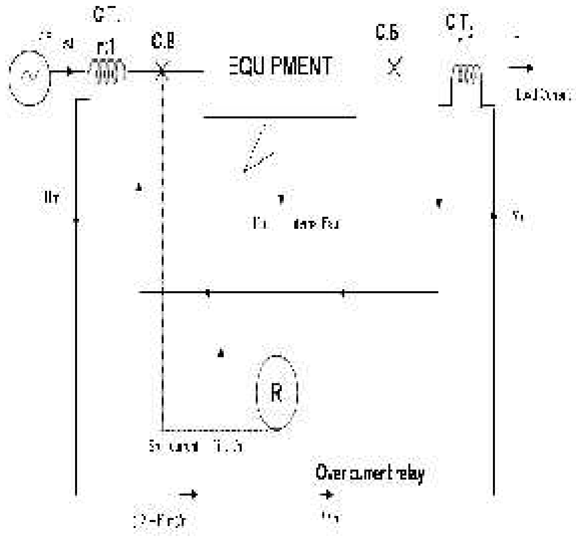


Fig.2 Behaviour during Internal Fault

Figure 2 shows an internal fault of magnitude If int. The current leaving protected zone is now I2 whereas that entering it is I1 such that I1= I2 + If int. Current in the spill path is now (If int /n) where n is the current ratio. Assuming that the current is more than the pick-up value of the over current, both the circuit breakers will be tripped out. Thus the scheme meets the basic requirements of clearing the internal faults.

The minimum internal fault current that will cause the tripping is given by,

If min = (CT ratio) (plug setting of O. C. relay) = n*Ips

IV. CIRCUIT DIAGRAM & OPERATION

Fig. shows complete circuit Diagram of our project. In this project we detect current and phase angle flowing through the entering and leaving bus bar lines. And if any one parameter such as current of entering line is greater than leaving line then microcontroller trip main supply to bus bar or vice versa condition occurs then also supply is trip. Same condition is used for phase detection. Out of these two if anyone crosses the limit level then our project can indicate it at display and at the same time it can trip main supply through relay.

For detection of this parameter we use Current transformer (C.T.) in the ratio of 5A:5mA, and for phase angle detection we make two sine to square wave converter circuit and output of this two circuit is connected to EX-OR logic gate so that at output of gate we get directly phase difference.

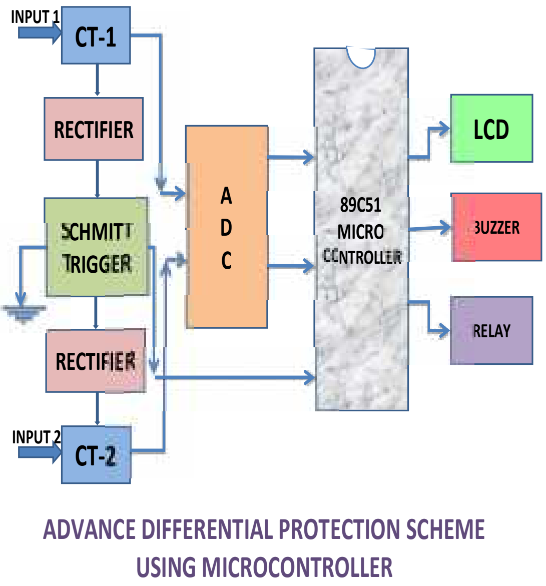


Fig.3 Block Diagram

For detection of this parameter we use Current transformer (C.T.) in the ratio of 5A:5mA, and for phase angle detection we make two sine to square wave converter circuit and output of this two circuit is connected to EX-OR logic gate so that at output of gate we get directly phase difference .This phase difference pulse we applied to timer /counter pin of microcontroller and detect the width of this phase difference pulse. Microcontroller converts this width into corresponding phase angle and make comparison.

V. SIMULATION

The block diagram of differential protection scheme can be simulated using MULTISIM SIMULINK. The inputs of the simulation are the single phase line currents. And the outputs are single phase compensating reference currents.

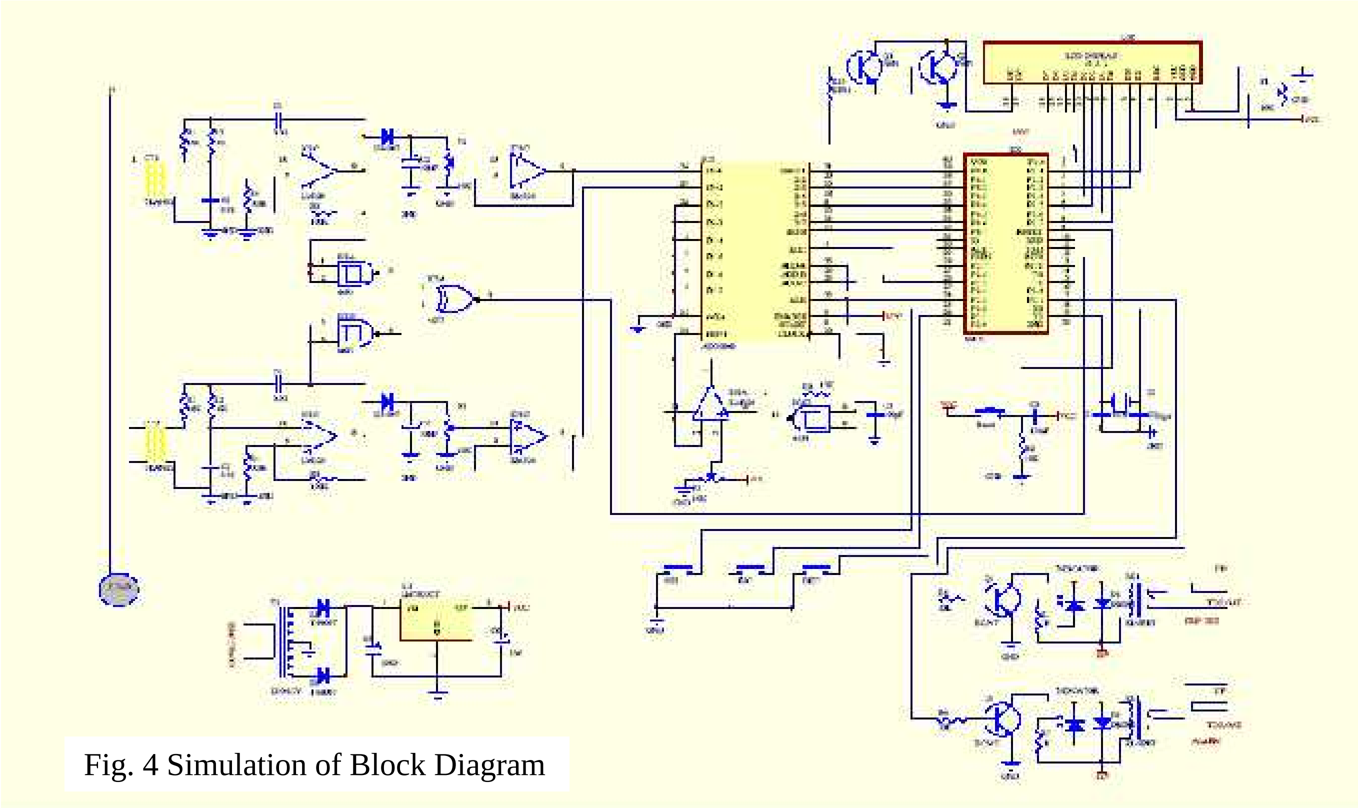


Fig. 4 Simulation of Block Diagram

In this bus bar protection system, we use two CTs of 5A/5mA as shown in circuit diagram. The primary windings of both the CTs are connected in series with the bus bar. The phase of AC supply is given to one terminal of CT 1 primary winding through relay coil.

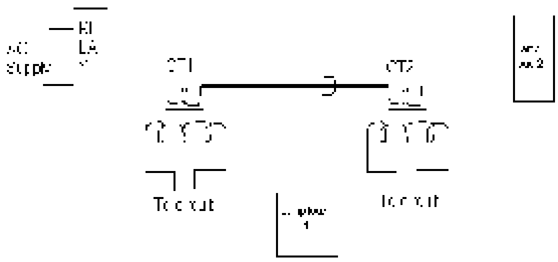


Fig.4.1 Bus bar Protection

The terminal of primary winding of CT1 is connected to the Bus bar. At the other end of Bus Bar we connect load through primary winding of CT 2 as shown in Fig. 4.1. Here we use two lamp loads. One lamp load is connected through both the CT's, it is for the creation of external fault and another lamp load is connected in between two CT, it is for the creation of internal fault on the Bus Bar.

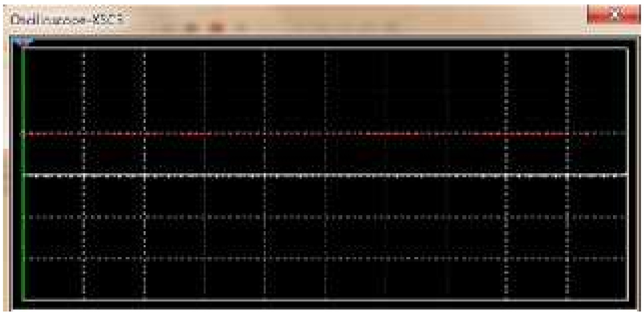
In this protection system, the output of both the CT's is given to the low pass filter which allows the 50 Hz frequency to pass towards the ADC-0808. After low pass filter, we convert AC signal to DC signal by using rectifier and filter arrangement. This DC voltage is fed to voltage follower circuit through calibration preset. The output of voltage follower circuit is the input of ADC 0808. When input current at CT is 1 A then we get 1 V at ADC input terminal. This is achieved by using 10 K preset resistance. In this way, both of the output of CT is given to the ADC.

For phase shift detection, we connect output from two CT to Schmitt trigger NAND gate. In this, we short circuit the two inputs of NAND gate and it is used as a NOT gate. The output of the two NAND gates are used as a input of EX-OR gate and the output of EX-OR gate is connected to Microcontroller. If there is no phase shift in two inputs from CT then we get low output at EX-OR gate and thus Microcontroller remains in operative. But if there is phase shift in two inputs from CT then output of EX-OR gate is high and thus, microcontroller gives trip signal to relay and hence protects the bus bar.

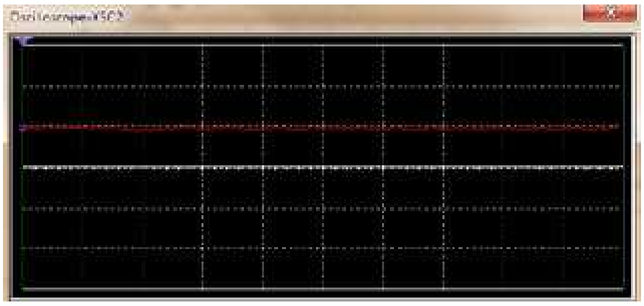
VI.SIMULATION RESULT

Simulation Results are shown below in the form of waveforms. The results are in voltage.
Figure 1 & 2 shows that the Bus Bar is in the healthy conditions, which means CT1 & CT2 output are equal.
Figure 3 shows that Relay is in [0] OFF condition.
Figure 4 & 5 shows that the Bus Bar is in the Fault condition, which means CT1 & CT2 output are not equal.
Figure 6 shows that, Relay is in [1] ON condition.

1. CT1 Waveform without internal fault

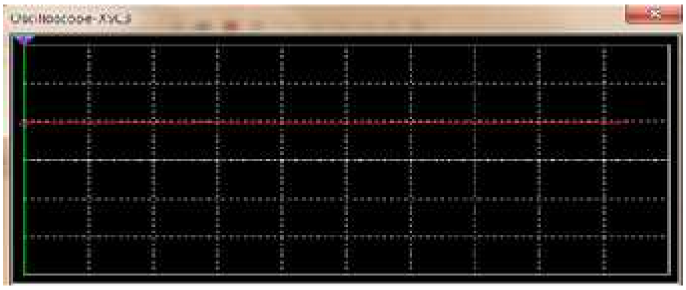


2. CT2 Waveform without Internal fault

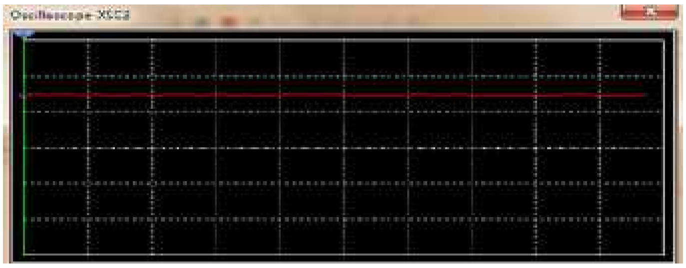


3. Relay is in OFF condition

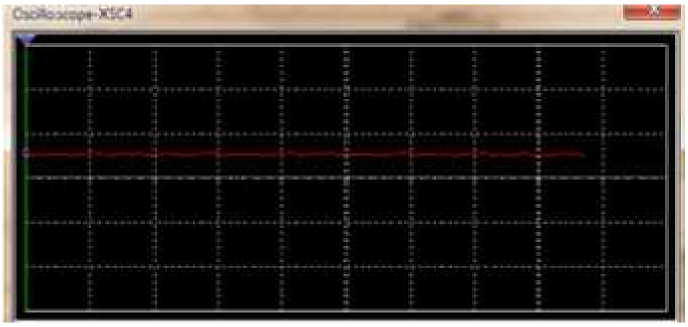
4. CT1 Waveform with Internal Fault



5. CT2 Waveform with Internal Fault



6. Relay is in ON condition



VII. CONCLUSION

The Multisim/Simulink simulation tool is used to develop a model that allowed the simulation and testing of the differential protection theory calculations, which are implemented in the controller.

The microcontroller based differential protection gives a simple and new approach to the differential protection. The protection scheme has divided into two major parts, first the hardware i.e. the power supply system and the minimum system and secondly the software i.e. programmer. The Microcontroller based differential protection given more flexibility by making desired changes in the software part and setting the desired characteristic or features. Also this scheme has proved a more reliable, accurate and faster differential protection. Also by getting the values of current and the phase angle continuously we get an additional mean for the measurement.

Repeated failures of electromagnetic relay, rapid expansion of the grid, phasing out of products by manufacturers etc. have warranted replacement of the electromagnetic differential protection by the state of the art microcontroller based differential protection to blend with the present day protection system. To ensure reliability and considering cost economics microcontroller based relays may preferred to be installed to partially retrofit electromagnetic relays.

VIII. REFERENCE

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