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Sensing of Fault Current for Auto Restoring of High Tension and Low Tension systems

Apeksha Supekar[1]
Department of Electronics & Tele-Communication Engineering
Vishwakarma Institute of Information Technology
Pune.
[1]apekshasupekar17@gmail.com

Pratik Chopade[2]
Department of Electronics & Tele-Communication Engineering
Vishwakarma Institute of Information Technology
Pune
[2]pratikchopade@viit.ac.in

***Abstract-* To protect a circuit against over (fault) current, there is a need to trip the supply from load. At Cosmic Ray Laboratory CRL, Tata Institute of Fundamental Research,(TIFR) Ooty, in photon detection system using 'Photo Multiplier Tubes' (PMT), this fault current flows through circuit if resistances get short due to climatic conditions. As the gain of the PMT is dependent on the voltage applied to it. It is necessary to provide a continuous power supply without any fault. If fault occurs power supply gets tripped and loosing of data continues till we restore power supply manually. 'Sensing of Fault Current for Auto Restoring of High Tension (HT) and Low Tension (LT) systems' aims to solve the problem of loosing data due to fault condition, leading to tripping of power supply. This system mainly deals with sensing of fault current using 'Open loop Hall effect Current Sensor' also tripping and auto restoring it using PIC Microcontroller.**

***Keywords*: CRL-Cosmic Ray Laboratory, TIFR-Tata Institute Of Fundamental Research, PMT-Photo Multiplier Tube, HT-High Tension, LT-Low Tension, V_{TL}- Low Voltage Level Threshold, V_{TH} -High Voltage Level Threshold.**

I. INTRODUCTION

Current flow in a conductor always generates heat. The greater the current flow, the hotter the conductor. Excess heat is damaging to electrical components. High levels of heat cause the insulation to breakdown and flake off, exposing conductors. For that reason, conductors have a rated continuous current carrying capacity or ampacity. Excessive current is referred to as over current. An over current may result from an overload or short circuit. An overload occurs when too many devices are operated on a single circuit or when electrical equipment is made to work beyond its rated capabilities. And a short circuit is a low resistance path for current created when bare conductors touch. Ohm's Law describes the relationship of current, voltage, and resistance, $I=V/R$. When a short circuit develops, resistance drops and current increases.

To protect a circuit against over currents, a protection device must detect a fault and automatically disconnect the electrical equipment from the voltage source. Many electrical faults are momentary in nature. Normally when fault happened, trip unit will automatically get tripped and someone has to reset it manually. In between this there might be chances of losing some important data detected by PMT. As we do not want to lose any data due to tripping we need an auto restoring system, which will restore the power supply automatically.

'Sensing of Fault Current for Auto Restoring of High Tension (HT) and Low Tension (LT) systems' is a system that is able to detect over current in the system and trip the power supply automatically also this system can detect

Whether the fault (over current or short circuit) in the system still exist or not. Once the fault is cleared, it will automatically switch ON back the breaker or switch.

II. SENSING OF FAULT CURRENT

There are two types of current sensing:

A. Direct current sensing: Works on basis on Ohms law. By placing a shunt resistor in series with the system load, a voltage is generated across the shunt resistor that is proportional to the system load current. The voltage across the shunt can be measured by differential amplifiers. Direct sensing typically is used when galvanic isolation is not required. The shunt resistor also dissipates power, which may not be desirable. Fig.1 represents the direct current sensing method.

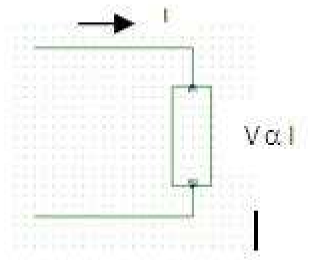


Fig.1 Direct Current Sensing.

B. Indirect current sensing: Indirect current sensing is based on Ampere's and Faraday's laws. By placing a coil around a current-carrying conductor, a voltage is induced across the coil that is proportional to the current. Since there is no direct connection between the sensing circuitry and the system, the system is inherently isolated. Fig. 2 represents the indirect current sensing method.

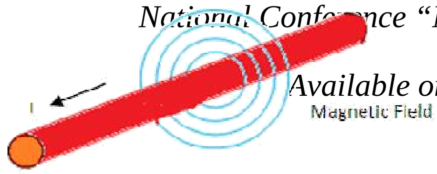


Fig.2 Indirect Current Sensing

Indirect current sensing is more accurate linear method of current sensing.

III. SYSTEM DESIGN AND MECHANISM

The block diagram of this system is as shown in fig. 3. It represents the basic building blocks of the system.

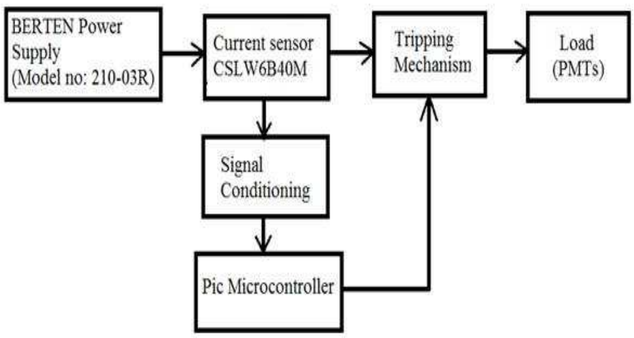
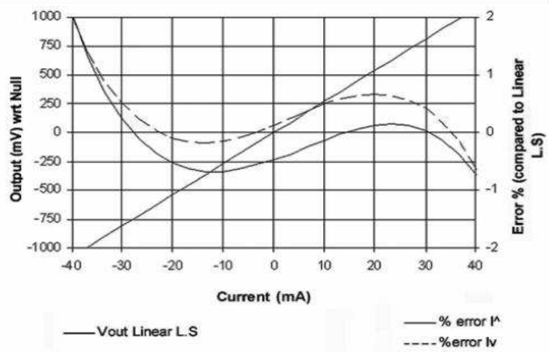


Fig. 3 Block Diagram of auto tripp and Restore System

A. BERTAN Power Supply: BERTAN (Model no:210-03R) is used as input power supply with following specifications:
   a) Input Voltage: 230Vac ±10%.
   b) Input Current: 2.5A.
   c) Output Voltage: 0 to -3KV.
   d) Output Current: 75mA.
   e) Frequency: 50Hz.

B. Current Sensor: Open loop Hall Effect ‘**CSLW6B40’** is used to sense current. The transfer function of this current is as shown in fig.4.

a)



Voltage Amplifier: To amplify the output of current sensor so that comparator can easily compare it.

b) Hysteresis Comparator: To compare change in voltage levels due to change in current through circuit. In order to make the comparator less sensitive to noise, a technique incorporating positive feedback, called ***Hysteresis***, is used. Circuit diagram of Hysteresis comparator is as shown in fig.5.

INVERTING HYSTERESIS:

$$V_{TL} = (R2 \cdot V_{REF} + R1 \cdot V_{OL})/(R1 + R2)$$
$$V_{TH} = (R2 \cdot V_{REF} + R1 \cdot V_{OH})/(R1 + R2)$$
$$HYST = V_{TH} - V_{TL}$$
$$HYST = R1 \cdot (V_{OH} - V_{OL})(R1 + R2)$$

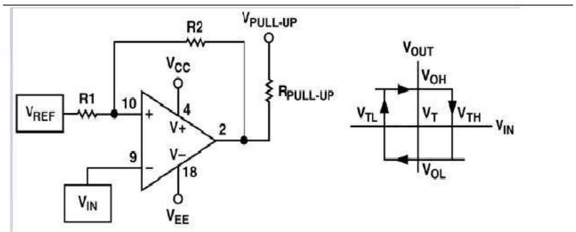


Fig. 5: Hysteresis Comparator

c) Span Zero Circuit:

D. PIC Microcontroller: This is used to check the sensor output and decide whether to trip the supply or not. If tripped, the restoration of supply is also done using microcontroller.

E. Tripping Mechanism: It includes Power MOSFET to switch ON and OFF power supply by PIC microcontroller.

IV. SIMULATION,TESTING AND RESULTS

A. To test current sensor:

CSLW6B40 Hall Effect current sensor is used to measure the current which PMTs are using. The range of current sensor is -40mA to 40mA and sensitivity of current sensor is 25.5mV/mA. Sensor V_{out} @ 0AT is 2.5V. To measure the practical sensitivity following experiment as shown in fig.8 is done. Sensor is given operating voltage of 5V DC.

Sensor output is very important from designing point of view. Sensor output corresponding to our threshold levels of fault and normal condition will be used to set reference for comparison

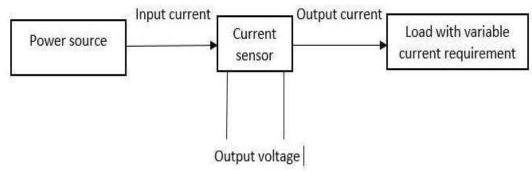


Fig. 4 Transfer Function of CSLW6B40M

C. Signal Conditioning: This block consist of three main circuits:

Fig.8 shows setup to determine sensitivity of current sensor

Following table.1 shows the results of testing of current sensor

Current(mA)	Sensor output(V)
27.02	2.005
28.03	1.982
29.7	1.948
30	1.893
31	1.895
32	1.878
33.05	1.863
34.09	1.848
35.08	1.833
36.03	1.809
37.03	1.794
38.09	1.772

Table1.Current and their corresponding sensor output

Current flowing in circuit changes, as the variable load resistance is changed. Following graph shows the variation in sensor output voltage with respect of its current.

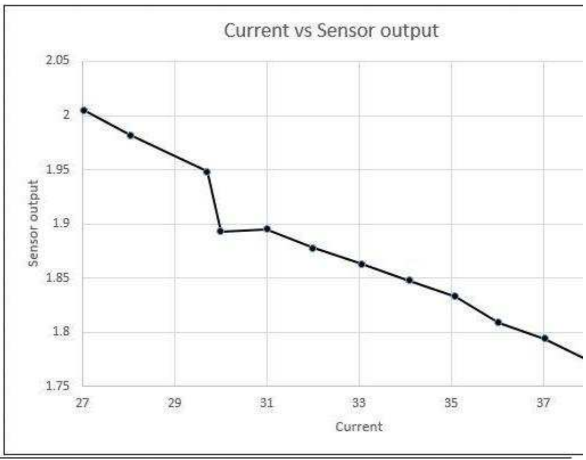


Fig.9 shows the sensor variation with respect to current

From results of current sensor it was observed that practical sensitivity of sensor is 20.36mV/mA Current to sense in circuit was varied from 0 to 40mA by using variable resistor. Let the two threshold to detect normal operation and fault operation be selected as 33mA (sensor output 1.863V) and 36mA (sensor output 1.809V) respectively for same experiment of finding the sensitivity of sensor.

B. To test amplifier and determine its gain:
Output of sensor is very low to process, hence output of sensor is given to amplifier. Gain of amplifier is selected by keeping in mind that after amplification one threshold should become higher than reference denoted by V_{TH} and other should be less than the reference known as V_{TL}. With a gain of 2, the two threshold level voltages of fault (1.809V) and normal condition (1.863V) will become 3.593V and 3.70V respectively. Output of amplifier is given

to comparator. Testing results of amplifier are tabulated in table 2. Input to amplifier is sensor output. In testing quard core LM324 is used. Amplifier is configured in non-inverting mode.

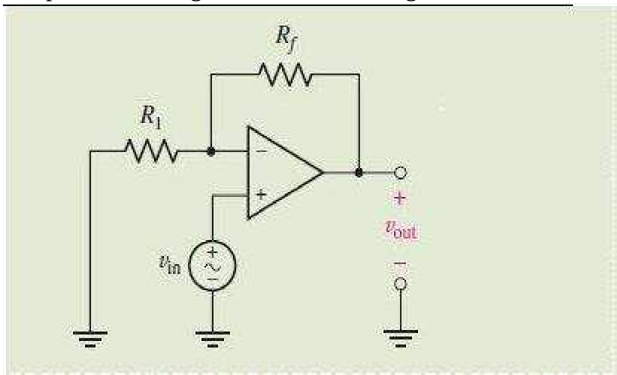


Fig 10. Non-inverting amplifier configuration

Sensor output(V)	Amplifier output(V)
2.005	3.998
1.982	3.94
1.948	3.87
1.893	3.76
1.895	3.76
1.878	3.73
1.863	3.7
1.848	3.669
1.833	3.582
1.809	3.593
1.794	3.552
1.772	3.5

Table2. Results of sensor output (i.e. amplifier input) and amplifier output

Amplifier tested averagely showed linear behavior. Average gain of amplifier was found out to 1.98. Following figure shows the output of amplifier to its input derived from sensor output

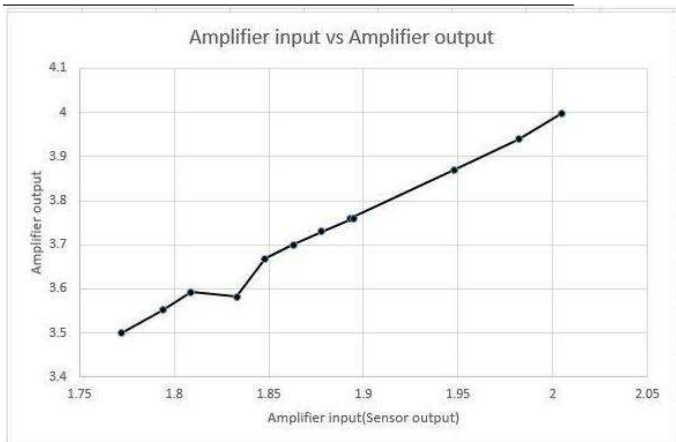


Fig.11 Amplifier input vs amplifier output

C. Testing and designing hysteresis comparator:

A small change to comparator circuit can be used to add hysteresis. Inverting hysteresis uses two different threshold voltages V_{TH} (corresponds to normal operation) and V_{TL} (Corresponds to fault operation). The input signal from amplifier must exceed the upper threshold (V_{TH}) to transition high or below the lower threshold (V_{TL}) to transition low. Hysteresis helps to avoid the false transition due to noise. Say Reference voltage is selected as 3.6V for earlier mentioned systems in *(A)* and *(B)*. Threshold of fault (VL) is 3.593V and threshold of normal operation (VH) is 3.7V. Practical values of amplifier output and hysteresis output are tabulated in table 3.

Current required by circuit is increased, hysteresis shows transition from low to high as condition changes from normal to fault

Amplifier output(V)	Hystrersis output(V)
3.998	-10.91
3.94	-10.91
3.87	-10.91
3.76	-10.91
3.76	-10.91
3.73	-10.91
3.7	-10.91
3.669	-10.91
3.582	-10.91
3.593	-10.91
3.552	-10.91
3.5	10.91

Table 3.Results of amplifier output and corresponding hysteresis output

After hysteresis Span zero matches the high output to 5V and low output to 0V.Graphical representation of hysteresis behavior is as shown in bellow figure

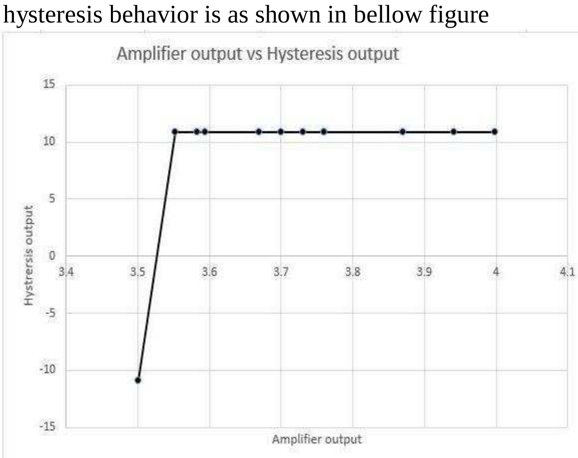


Fig.12 Graphical representation of hysteresis comparator

D. Designing of span zero:

Span zero is designed to match hysteresis high and low output levels to 5V and 0V respectively, so that they can be given to microcontroller. Intelligence system designed using microcontroller uses this signal, to decide whether the signal corresponds to fault or normal condition and take corresponding action.

E. Microcontroller:

Pic18F4550 microcontroller is used to implement the intelligence system to trip the supply and restore it. Output of span zero is given to microcontroller and on basis of this input to microcontroller decides to trip or not to trip the supply. Microcontroller is also used to keep the count of trips. Intelligence system is designed to limit the number of trip and restoring to 3 faults. Even if the fault persist, then the supply is triped, which will be manually restored

F. Switch:

Proposed idea is to use Power IGBT as switch which will be controlled by microcontroller signal. This switch will control connection of load to supply.

G. Future plan:

Till now the sensing of fault current is done. Also the program to count 3 trips and restore it and if fault still exist then to trip supply which will be restored manually is done. Now the work to trip the supply and restore it using switch is to be done in near future.

H. Simulation result of -12V with triping and restoring signal

1. Operation of system in normal mode

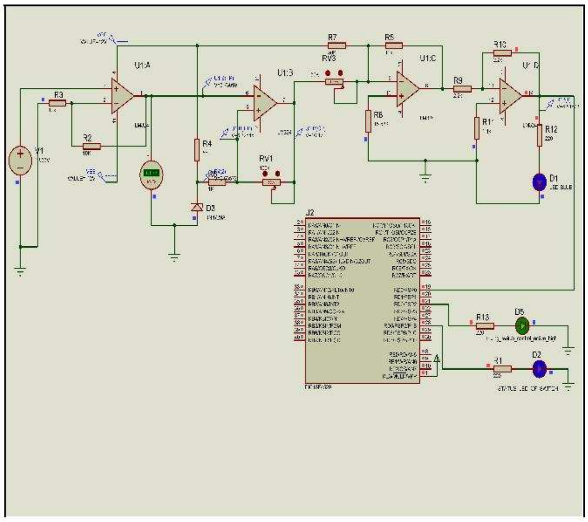


Fig.13 Simulation results of system in normal operation

2. Operation of system during fault condition.

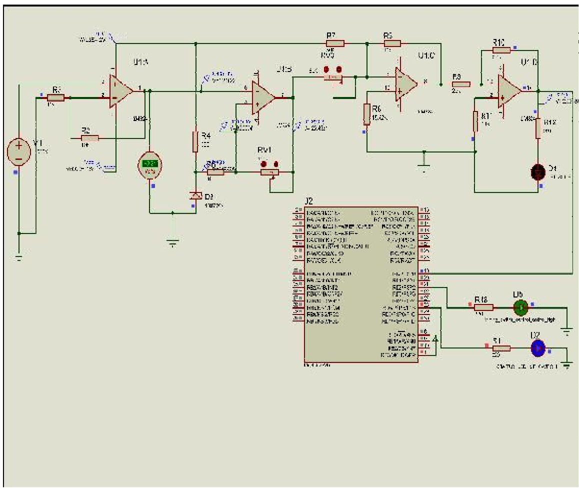


Fig.14 Simulation results of system in fault condition

From simulation it is clear that, on basis of current sensor output, load is trip and restored back.

Sensor output is amplified and then compared using hysteresis comparator. Hysteresis comparator is used after amplification. Hysteresis reference is set as 3.6 V and two threshold levels are kept as 3.7V and 3.5V. Input signal must go below 3.5V to change output to +Vsat and above 3.7V to change output to -Vsat. In simulation LED_BLUE denotes the signal which is been given to controller by span zero circuit. It is high in normal operation and low during fault condition. On basis of this signal controller detects fault and normal operation and takes the action. Controller restores the fault for 3 times and then trips it which can be restored only manually. It is planned to use signal from controller to use for restoring. Output signal from controller is given by triping_switch_active_control_high LED STATUS_LED_OF_SWITCH shows status of trip switch. Its shows one if switch is close and zero if switch is open

V. ACKNOWLEDGMENT

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REFERENCES

[4]CSLW6B40M current sensor datasheet

[5] http://www.eetimes.com/document.asp

[6] https://en.wikipedia.org/wiki/Hall_effect

[1]Engineering circuit analysis 8th edition textbook, by William H. Hayt Jr, Jack E. Kemmerly, Steven M. Durbin

[2]LM324 Op-Amp Datasheet

[3]Pic18f452 datasheet