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An Experimental Setup for Power System Protection in Electrical Engineering Laboratory

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Abstract: **The protective systems are essential for the Protection of Power distribution and Radial Feeder System. In this paper we have discussed a various protective schemes with testing electromechanical relay. Through this practical set-up, the students can get familiar with the fundamentals of protection and can learn how different protection schemes are wired and how they operate in a real power system.**

Keywords: **Radial feeder, Protective Relay, power system protection, over Current, Earth fault, Time Setting Multiplier (TSM), Plug Setting Multiplier (PSM).**

1. INTRODUCTION

The function of protective relaying is to cause the quick removal from service of any element of a power system when it suffers a short circuit and over current, or when it starts to operate in any abnormal manner that might cause damage or otherwise hold up with the effective operation of the rest of the system. A secondary function of protective relaying is to provide indication of the type of failure [2]. This paper will focus on the function of protective relay and different protection schemes are wired and how to they operate in real power system. Power system network consists of generators, transformers, circuit breakers, relay and transmission line and distribution circuits. Fault occurs on any part of this system, it must be quickly detect and disconnect from the system. There are two principle reasons for it

1.1 Over Current:

Over current is the condition where the current in amperes is greater than the set current of the equipment or conductors, resulting from an overload, short circuit, or ground fault. An over current protection device protects the circuit by opening the device when the current reaches a value that will cause an excessive or dangerous temperature rise in conductors. Most over current protection devices respond to both, short-circuit or ground-fault current values as well as overload conditions [6]

1.2 Earth Fault:

Earth-fault protection scheme is used to protect feeder against faults involving ground. Typically, earth faults are single line to ground and double line to ground faults. For the purpose of setting and coordination, only single line to ground faults is considered.

2. OPERATION AND CONTROL

Standard field practices for testing of relays are can be very much useful to protection engineers. Indigenous and low-cost design of academic lab set up for relay testing can be a good aid to teachers **[4]**.For making this type of experimental set up show in below image.

Experimental set-up

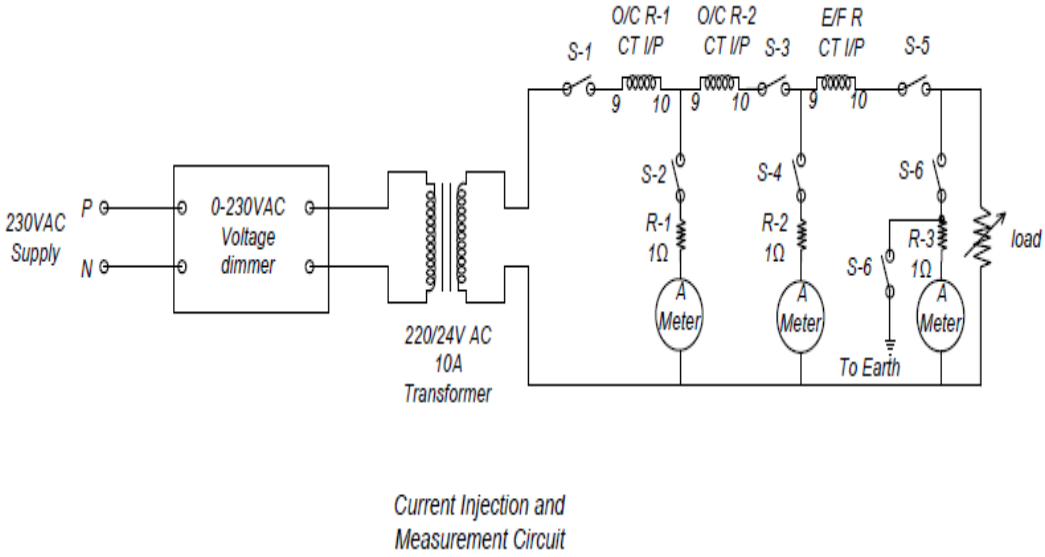


Fig.1: Circuit Diagram

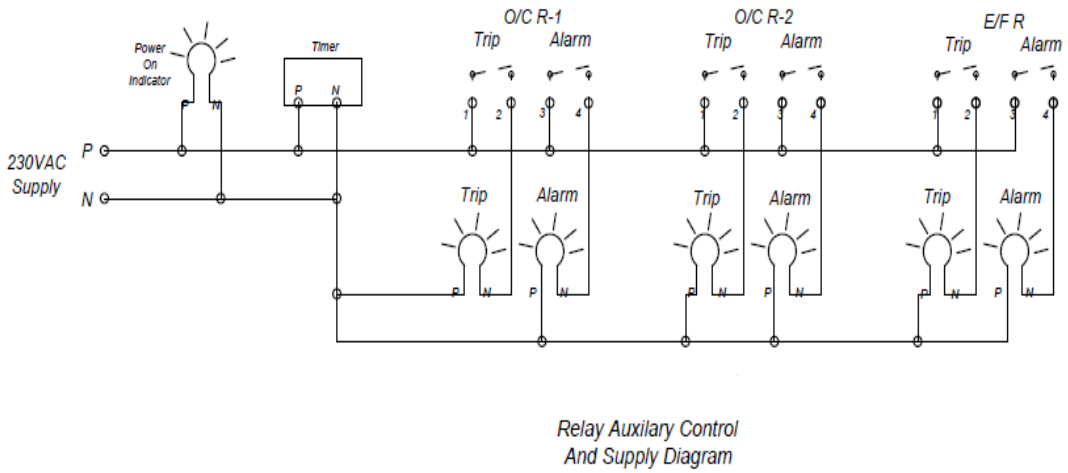


Fig.2: Panel diagram

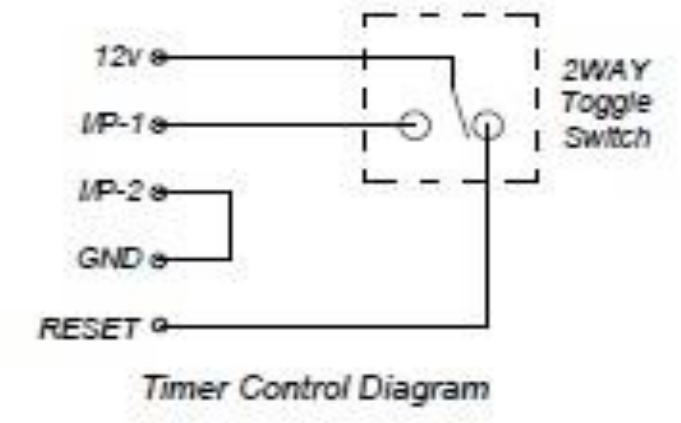


Fig.3: Timing control diagram

Here,

O/C R1→ over Current relay

O/C R2→ over Current Relay

E/F R→Earth fault relay

A meter→ Ampere Meter

R1, R2,R3 →1 Ω Resistor

S1…S6→Toggle Switch

Trip→Tripping Indication and Tripping Contact of each relay

Alarm→Alarm Indication and Alarm Contact of each relay

Hence as we can show in Fig.1 current injection in Radial Feeder this is connected to electromechanical relay. Here the Fault will occur in relay O/C R1 by operating the Switch S1, S2, and S3. The Conditions of S1,S2 and S3 should be set under below for to make a fault in relay R1. And this condition of switch will prevent the current flowing in others relay.

S1→Open, S2→Open, S3→Close

After completing the switch positions we have to increase the Current by Current Injection Kit (Fig-1). If the current will increase then Set Current in Relay, the Relay will trip and it will change the positions of its Auxiliary contacts from NO to NC. and the one contact will give the alarm indication and other will give the trip Indication.(Fig-2)Here the Fault will occur in relay O/C R2 by operating the Switch S1, S2, S3, S4 and S5. The Conditions of S1, S2, S3, S4 and S5 should be set under below for to make a fault in relay R2. And this condition of switch will prevent the current flowing in Relay E/F R. In this case the current will flow through Relay R-1due to this the R-1 will work as a backup protection for Relay R2.Because if the R-2 will not trip due to any problem in R-2 the R-1 will trip and protect the whole circuit. If the current will increase then set current in R-2 the circuit will trip and it will give the alarm and trip indications by its auxiliary contact.

S1→Open, S2→ Close, S3→ Open, S4→Open, S5→Close

As similarly the E/F R (Earth fault Relay) can trip by operating the toggle switch conditions by this way

S1→open, S2→close, S3→open, S4→close, S5→open, S6→open

In this case the current will flow through R-1 and R-2 to E/F R. if the will increase then set current in E/F R the relay will trip and give the Alarm indication and Trip indication by its Auxiliary contacts. (Fig-2) In this case if any short circuit will occur in Phase-Earth or Neutral-Earth the Load resistance will increase and it will trip the relay in short time. In this

case if any problem will happened in E/F R, then the circuit will trip by R-2 or R-1 respectively. So here the R-1 and R-2 works as Backup protections for E/F R. Here load is also connected for variable load operation of circuit. In this the Fault can create by vary the Operating Load .if there is a needed a maximum fault current load should be set as full load. And if the minimum fault current will needed the load should be set as lowest load value. For performing any new operation of each Relay, the relay should be in Reset condition and the Relay can reset by operating the Reset Window. The reset window is located at in front of Relay. (Fig-4)

Here the Timer is also available for to record the operation time and tripping time of relay. The timer will start from zero second when relay disc will start to operate and after tripping the relay we have to reset the timer manually by reset toggle of timer. The wiring diagram of timer is in Fig-3. The timer is needed a 230VAC supply which is shown in Fig-2.This testing set up of Relay is only for practical purpose and Lab set up only. The range of this setup is 24V and 10 Amp.

3. RELAY SETTING

A. Current Setting:

Before operating this setup we have to set the current in Relay and current setting is referred as ratio of Pickup Current and Rated CT secondary Current .For this check the below formula.

$$Current\ setting\ = \frac{Pick\ up\ current}{Rated\ secondary\ current\ of\ CT} \times 100\%$$

Here current setting of over current relay is generally of ranged from 50% to 200% in steps of 25% and for the Earth fault Relay it is from 10% to 70% in steps of 10%.

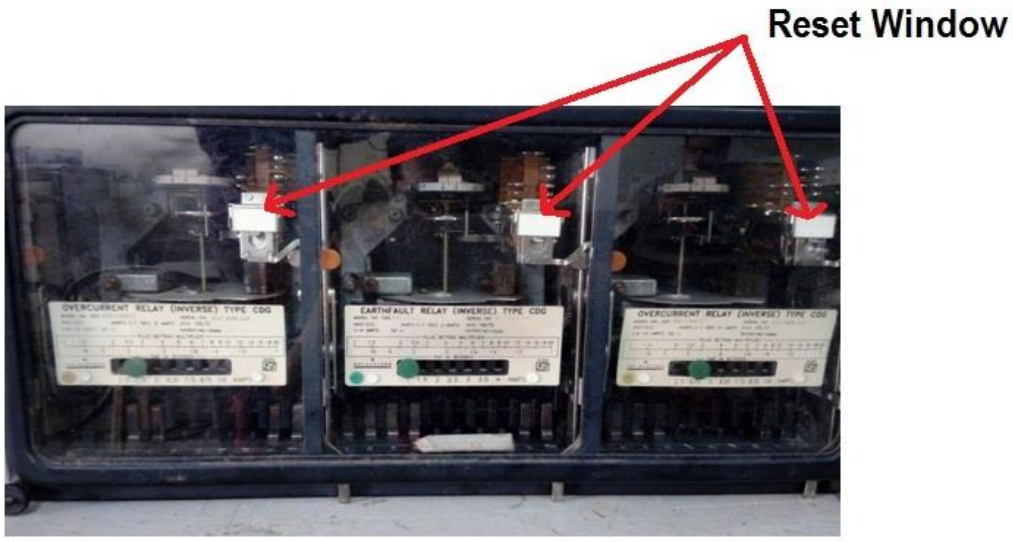


Fig.4: Electromechanical Relay

B. Plug Setting Multiplier (PSM):

Plug Setting Multiplier (PSM) is referred as ratio of current in the Relay to it's pickup current

$$PSM\ = \frac{Fault\ current\ in\ relay\ coil}{Pick\ up\ current}$$

$$= \frac{Fault\ current\ in\ relay\ coil}{Rated\ CT\ secondary\ current\ \times\ Current\ setting}$$

Suppose we have connected on protection CT of ratio 100/5A and current setting is 125%. Hence Pickup current of the Relay is **5*125%=6.25A.**Now, suppose fault current in the CT primary is 500A. Hence fault current in the CT secondary. i.e. In the Relay coil is

500*(5/100) =25A

There for PSM of Relay is **(25/6.25) =4A**

C. Time Setting Multiplier (TSM):

Then Time Setting Multiplier (TSM) is mainly depends upon two factors.

1) How long distance to be traveled by moving parts of the Relay cover this distance.

2) How fast the moving parts of the Relay cover this distance.

So, for the adjusting Relay operation time setting dial is calibrated form 0 to 1 in steps 0.05 sec. From time/PSM graph of relay as show in below, we can see the total operating time of the Relay is 3 Sec. that means, the 3 Seconds to travel 100% travelling distance. As the time setting multiplier is 0.1here actually the moving parts of the Relay have to travel only **0.1*100% or 10%** of the total travel distance to close the Relay contacts. Hence, actual operating time of Relay is **3*0.1=0.3** Second. i.e. 10% of 3 Second .

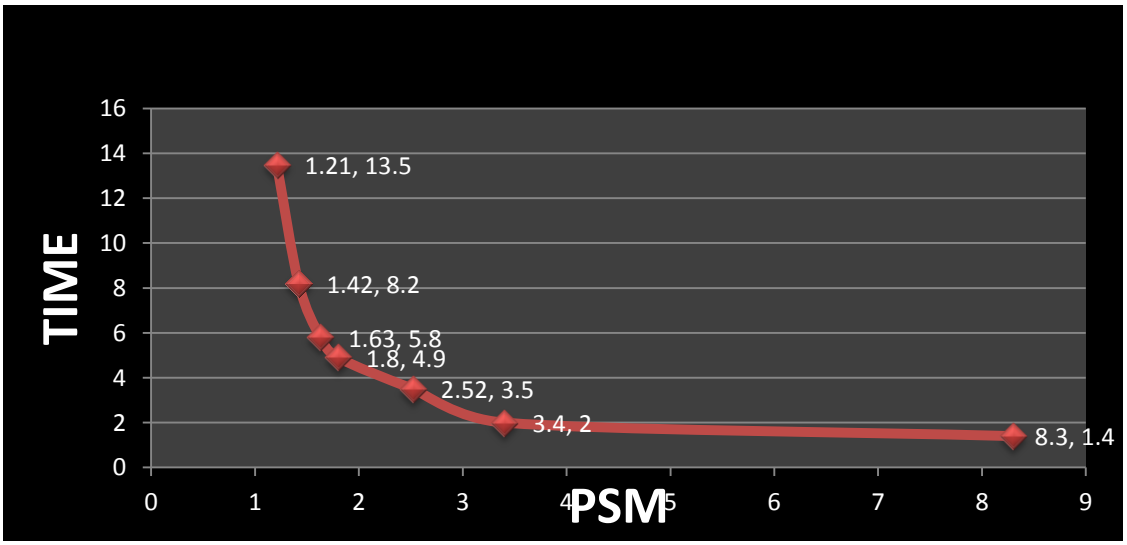
D. Time/PSM Graph:

After taking a practical trial of this set up at TSM=0.3 sec. the O/C R-1 and E/F R Relay had tripped with following readings. and its TIME/PSM Graph are as under.

table.1: is for O/C R-1 and Table-2 is for E/F R. Graph-1 is for O/C R-1 and Graph is for E/F R.

TABLE.1: Experiment Readings (O/C R1)

Fault Current	Plug Setting	PSM	Time
50%	2.5	1.4	8.3
75%	3.75	2	3.4
100%	5	3.5	2.52
125%	6.25	4.9	1.8
150%	7.5	5.8	1.63
175%	8.75	8.2	1.42
200%	10	13.5	1.21

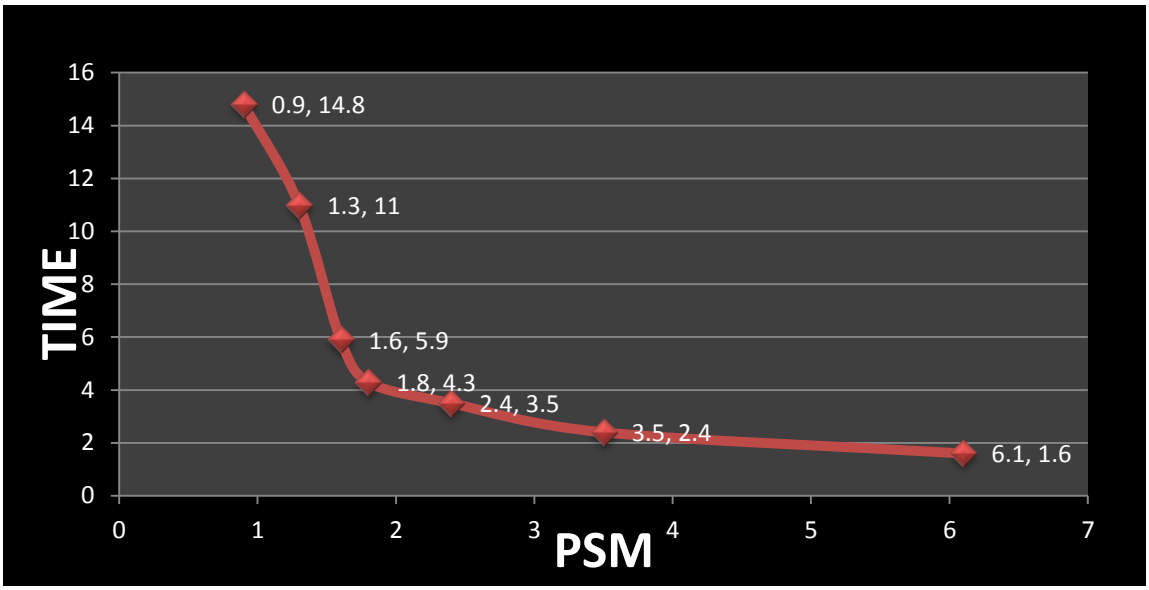


Graph.1: (O/C R1)

And at TSM=0.3 readings for E/F Relay is

TABLE.2: (E/F)

Fault Current	Plug Setting	PSM	Time
10%	1	1.6	6.1
20%	1.5	2.4	3.5
30%	2	3.5	2.4
40%	2.5	4.3	1.8
50%	3	5.9	1.6
60%	3.5	11	1.3
70%	4	14.8	0.9



Graph.2: (E/F R)

4. CONCLUSION

From this setup, we can understand and simulate the protection systems the three mostly affecting faults like over current, under current and earth fault with the use of the electromechanical relay. Also with the use of PSM (Plug Setting Multiplier) and TSM (Time Setting Multiplier), we can trip the relay by different types of timing situation and current. By this set-up, we can study and to understand the basics of terminology. In addition to outcome, the electromechanical relay has limited used purpose. But implement or used Numerical, Digital or Static relay, we can occupied the fault very accurately and make healthy the distribution system.

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