Transmisson Line Protection Using Static Impedance Relay

Mr. Nilesh Pangare, Mr. R. S. Desai

***Abstract*— The increase in the line lengths and power transmitted has introduced a number of new problems in relation to protection. New techniques have become necessary to tackle these problems and the stringent requirements associated with them. Firstly it has become necessary to see that these lines are not unnecessarily disconnected, but at the same time shorter operating times for protective relays are demanded on faulted section sections to preserve the system stability. Moreover, extreme variations of fault current are often encountered with long lines necessitating the protective relays to take this aspect into account. Two major types of transmission line protection that have been developed extensively to meet modern requirements are distance and carrier current systems. Pilot wire system of protection are not applicable to long and overhead transmission lines because of high cost of pilots and the unreliability of overhead pilots in case of overhead lines this is specially true in a large country like India where the majority of lines are overhead and are also of long distance The transmission line demo panel is designed to demonstrate the fault clearing process on transmission line using distance (impedance) relay. The principle of operation of these relays depends on the fault current and power factor under fault conditions. As a matter of fact such relays are designed to operate according to the impedance of the line up to the fault point or ratio of voltage to current under fault condition. As the fault impedance is proportional to the distance of line from location of relay to the fault point, the rely indicates the distance over which the fault has been occurred. A transmission line demo panel comprises a line model per phase basis having a length 400 km and voltage of 220 KV is designed for demonstration purpose. Fault simulation switches are provided to create fault condition. The switches are used for fault simulation. The impedance relay senses the fault current, voltage and gives trip signal to the circuit breaker if fault impedance is less than set value. The circuit breaker isolates the transmission lines from the supply.**

***Index Terms*— Transmission lines protection ,line lengths and power transmission ,protective relays, design of transmission line demo panel , operating instruction,working of demo panel observation**

I. INTRODUCTION

The increase in the line lengths and power transmitted has introduced a number of new problems in relation to protection. New techniques have become to tackle these problems and the stringent requirements associated with them. Firstly it has become necessary to see that these lines are not unnecessarily disconnected, but at the same time shorter operating times for protective relays are demanded on faulted section sections to preserve the system stability. Moreover. extreme variations of fault current are often encountered with long lines necessitating the protective relays to take this aspect into account.

Tow major types of transmission line protection that have been developed extensively o meet modern requirements are distance and carrier current systems. Pilot wire system of protection are not applicable to long and overhead transmission lines because of high cost of pilots and the unreliability of overhead pilots in case of overhead lines this is specially true in a large country Ilk-e India where the majority of lines are overhead and are also of long distance.

The operation of all systems of distance protection depends on the basic fact that on the occurrence of a fault, the distance b/w any point in the power system and the fault in proportional to the ration of voltage to current i.e. impedance at that point -in an interconnected network the voltage to current ration is a maximum at power station and decreases along the various feeders to the fault where it IS almost zero. Relays responding to this voltage / current ratio can therefore be used at various points on the system to give a of distance or length of line to the fault. And by arranging the relays such that those nearest to the fault operate quicker than those at a farther distance, discriminative tripping of the circuit breakers controlling the various feeders can be obtained.

A variety of distance relays are used m protection schemes and all such relays am of the high speed type Time distance of fault from the relay being used in this project.

II. TRANSMISSON LINE PROTECTION

There are several methods of protection of transmission lines. These can be into two groups:-

A. NON UNIT TYPE PROTECTION:-

Non type of protecting which includes:-
l. Time graded over current protection
2. Current graded over current protection
3. Distance protection
Such non — unit type protection do not have pilots. The discrimination is obtained by coordinating the relay setting

B. UNIT TYPE PROTECTION:-

Unit type of protection which includes:
1. Pilot wire different protection
2. Carrier current protection based on phase comparison etc.

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Distance relaying is employed where time and graded current relaying is too slow or selectivity is not obtainable from them, i.e. where time lag cannot be permitted

In distance relays there are three main types of measuring unit, namely,

l. Impedance Relay
2. Reactance Relay
3. Mho type distance Relay

Each type has certain advantage and disadvantages for very short lines reactance
type is preferred because it is practically unaffected by are resistance.

C. OVERCURRENT PROTECTION:-

Over current protection is that protection in which the relay picks up when the magnitude of current exceeds the pick-up level. The basic element in over current
protection is an over current relay. Over current relays are connected to system
normally by means of CT.'s.

Over current relays used for transmission line protection are:-

- Instantaneous over current relays.
- Inverse time over current relays.
- Directional over current relays.

D. DIFFERENTIAL PROTECTION:-

A differential relay responds to vector difference between two or more similar electrical quantities. From the above definition, it is clear that the two quantities should be similar i.e.. current / current and both magnitudes and phase angles are considered. Differential protection is generally unit protection. The protected zone is exactly determined by location of C.T's. the vector difference is achieved by suitable connection of C.T. or P.T. secondary.

E. DISTANCE PROTECTION:-

Distance relaying is employed where time and graded current relaying is too slow selectivity is not obtainable from them, i.e. where time lag cannot permitted In distance relays there are three main types of measuring unit, namely,

4. Impedance Relay 5. Reactance Relay
6. Mho type distance Relay

Each type has certain advantage and disadvantages for very short lines reactance type is preferred because it is practically unaffected by are resistance. For short line resistance is large as compared to line impedance. For medium lines, impedance relay is suitable but likely to operate wrongly on server reactive power surges. Mho type relays are used for phase faults of longer lines.

F. TYPE OF PROTECTION OF TRANSMISSION LINES

Types of Protection

a) Over current protection

- Times graded Or current graded
- Directional or Non directional
- Earth fault protection

Remark - Applied as main protection for distribution lines and backup for main lines, where main protection is of distance or other faster
type.

Inverse define minimum time relays referred for time graded Systems
Instantaneous relays for current graded Systems

Separate earth fault protection is necessary in addition to phase fault protection. Types Of earthing and magnitude of earth fault current should be considered

b) Distance protection

Pilot wire differential protection

Remark - Faster than over current protection several combinations of schemes available depending upon length of line.

For important lines of relatively shorter length (a few tens Of km)

c) Carrier current protection

Remark -Where length of transmission line is long and simultaneous opening Of circuit breakers at both ends is necessary

III. TRANSMISSION LINE MODEL:-

Transmission line model is designed for 400 km, 220 KV transmission line With four models cascaded each for 100 km ling length having the lumped
parameters. R= 4 C= 0.94 F , L = 110 mH Current capacity of model is 1 Amp. 'me transmission line model diagram is printed on front panel & terminals
are provided for every pi-model so that the connections & checking is easily
possible.

The Conductors are selected as per the current carrying capacity of the proposed transmission line. The of the conductor should be such that it can carry the rated current continuously without excessive rise of

From the standard table of ACSR IS 398-1976 we chose the conductor for the conductor design For current carrying capacity of 890A at 20 deg C and 1020A at 40deg C, the ACSR conductor with code name 'Markulla' having overall diameter 31.68mm is chosen.

The conductors of the line are placed equilaterally with each
other. The spacing between the two phases is 5 meters The maximum height of
the conductor above the ground level is 24 meters as shown in the figure.

RESISTANCE:-

The resistance of the conductor is 0.050/km.

Here we have taken resistance of the line as 40 per 100km length of the line due
to design constraints In our impedance relay.

INDUCTANCE:-

Radius of the conductor (r) =31.68 / 2 mm

=15.84 mm

Spacing between the conductors of two phases (d) =
D = 5 meters
= 5000 mm.
So,

R' = 0.7788.r
= 0.7788*15.84mm
= 12.336 mm

Inductance (L) =

CAPACITANCE :-

Capacitance (C) of a three phase line is given by
Here we have taken capacitance of the line equal to 0.94 F / 100 km.
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IV. DESIGN OF IMPEDANCE RELAY

The transmission line demo panel is designed to demonstrate the fault clearing paress on transmission line using distance (impedance) relay. The protection Of transmission line is usually done by distance protection schemes. The principle of operation of these relays depends on the fault current and power factor under fault conditions. As a matter Of fact such relays are designed to operate according to the impedance of the line upto the fault point or ratio of voltage to current under fault condition. As the fault impedance is proportional to the distance Of line from location Of relay to the fault point, (he rely indicates the distance over which the fault has been Occurred.

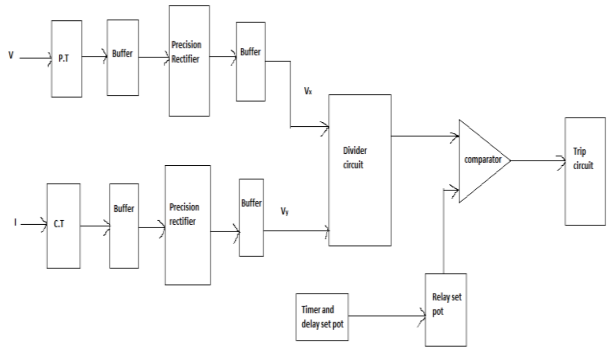
A transmission line demo panel comprises a line model per phase basis
having a length 400 km and voltage of 220 KV is designed for demonstration purpose. The lumped parameter line model with four cascaded networks each Of them is designed for 100 km parameters. Fault simulation switches are provided to create fault condition. The switches are used to short live parts of line to ground through Some fault impedance at different locations. The impedance relay senses the fault Current, voltage and gives trip Signal to the circuit breaker if fault impedance is less than set value. The circuit breaker isolates the transmission lines from the supply,

The solid state impedance relay with single element is designed to measure the fault impedance with magnitude and compares it with Set point value and gives the trip signal to circuit breaker.

The transmission line demo panel also comprises digital voltmeters, ammeters, push buttons, indicating lamps, hooter and accessories. A digital timer is used to measure time required for detection and clearance of the fault.

The demo panel provided with protective devices i.e. MCB and HRC fuses to give protection from any abnormal condition occurring during the actual demonstration and experiments.

Block Diagram Static impedance relay.



WORKING OF THE TRANSMISSION LINE PROTECTION DEMO PANEL

The transmission line demo panel consists of the following parts-

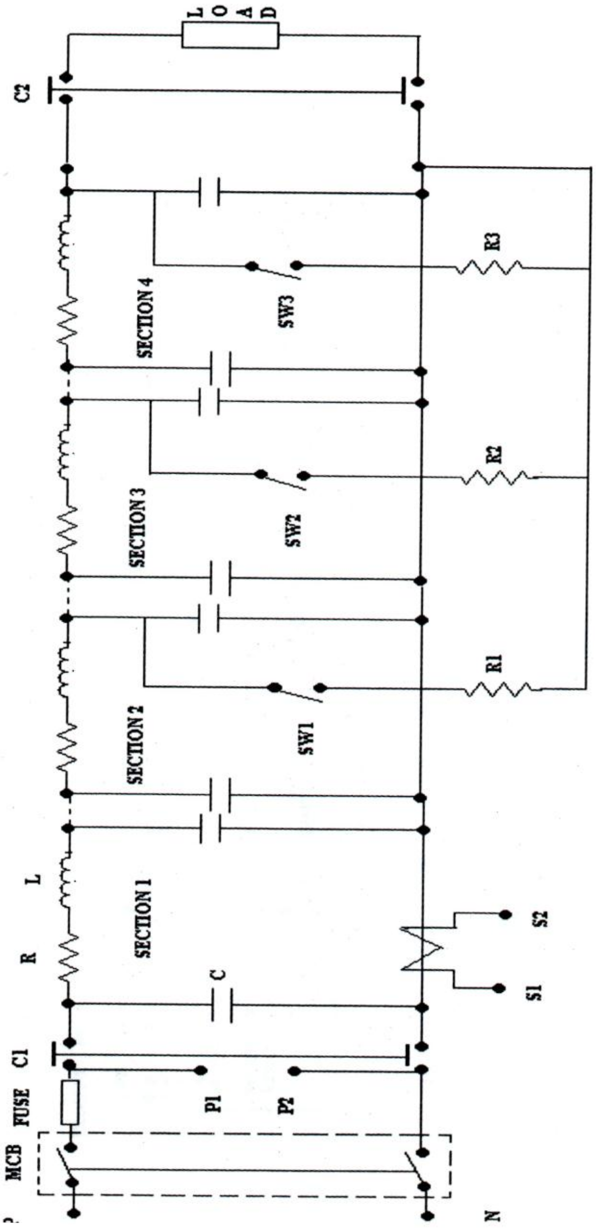
- Long transmission line model
- Contactors
- Fault simulating switches
- Bypass resistances
- Associated control circuitry

V. CIRCUIT DESCRIPTION:-

The I-ph., 220V AC input supply is given through 6A, DP MCB. The voltage is stepped down with the help of 230 / I IOV AC potential transformer and then is given to I-ph, impedance relay voltage coil whereas the current at the sending end is sensed with the help of 2 / IA CT and is fed to impedance relay. Contactors Cl and C2 acts like circuit breakers at sending and receiving ends respectively. A transmission line model having lumped parameters 40hms, I 0.94 PF per phase per 100 km line length and four I-I —networks are cascaded for 400 km length. Switches SWI, SW2 and SW3 are used to create the phase to earth fault at a distance 200 km. 300 km and 400 km from the sending end respectively

When the supply is switched on with the help of a 6A, DP MCB, MAINS ON indication will be given by indicating lamp. When PBI is pressed, the coil of contactor Cl gets energized. The NO contact of Cl is used as a hold on contact. Thus the input supply is given to the transmission line model. KIT ON indication is given through indicating lamp. When push button PB3 is pressed, contactor C2 gets energized. The NO contact of C2 IS used as a hold on contact. The load gets connected to transmission line and LOAD ON Indication is given.

When the fault is created, impedance mlay, which measures the Impedance, if impedance is less than set value, relay operates. The hooter gives audible alarm. The NO contact of Al of relay which is connected in series with auxiliary contactor Al becomes NC. Thus Al gets energized. NO contact of Al is used as a hold on contact. The NC contact of Al which is connected in senes with contactor Cl becomes NO and thus contactor Cl gets de-energized. Thus the transmission line gets disconnected from supply. If push button PB5 (accept) is pressed, auxiliary contactor A2 gets energized, the NO contact of auxiliary contactor A2 IS used as a hold on contact. The NC contact of auxiliary contactor A2 which is connected in hooter circuit becomes NO. The coil gets de-energized. To reset system push button PB6 is pressed.



VI. OPERATING INSTRUCTIONS:-

- Connect mains cable to 230V, single phase, AC supply With proper earth connection.
- Keep SW l, SW2, SW3, MCB and all switches in OFF position.
- Connect suitable load.
- Switch ON input MCB. Check MAINS ON indication and voltage sending end is displayed on input side digital voltmeter.
- Check impedance relay supply and its DPM should be ON indicating
maximum value of impedance.
- Press push button PBI, sending end contactor (Cl) gets energized and gives
on indication and the supply is connected to the line model.
- Press push button PB3, receiving end contactor (C2) gets energized and gives
on indication and the load is connected to the line model. Voltage and current at load end and current at sending is displayed. Adjust sending end current
about I Ampere by adjusting load.
- Adjust set value on solid state relay (say 120%). Note down set point value of percent impedance.
- Keep timer at maximum position by tuning the timer Set pot,
- Create phase to phase earth fault with help of SW l, SW2 and SW3 one by one starting from SW3.
- Observe carefully the impedance value and tripping time from the impedance
meter and timer respectively on the panel and note down the readings.
- Press accept button to switch off the hooter.
- Press the reset button to reset the system.
- Now set the timer pot to maximum value and create the fault to take readings
in the similar way as stated above.
- Similarly take the readings for Other sections.
- Change the relay setting by varying the relay set pot (120%. 100%, 75%), and repeat the same process for taking readings for these set impedances.
- See the variations in tripping time and the section in which the fault is sensed
by the relay for the particular set impedance value.
- Comment on the result.

VII. OBSERVATIONS:-

Base values:-

Voltage:- 220V ; Current:- IA :
Impedance:- 2200

Impedance base value = I Pu.
100 %

Impedance value for each section = 25 %

Fault in section	**Theoretical value of Irnpedance(%)**	**Observed value of Impedance (%)**
II	50	52
III	75	76
Iv	100	108

OBSERVATION TABLE FOR TRIPPING TIME

Relay Setting (%)	Section Il Fault clearing time (Sec)		Section III Fault clearing time (Sec)		Section IV Fault clearing (Sec)	
	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin
120	2.308	0.088	4.206	0.147	10.243	0.416
100	3.192	0.137	6.275	0.277	-	-
75	5.535	0.284	-	-	-	-

Comment on observation

Tripping time is less for faults near the sending end for a particular value of delay setting Tripping occurs only when the fault impedance is less than the relay set impedance

VIII. CONCLUSION :-

The project " TRANSMISSION LINE PROTECTION USING STATIC IMPEDANCE RELAY" is basically a demo panel. It has been developed for demonstrating the working of basic distance (impedance) relay. It incorporates a static impedance relay which senses the fault current, voltage and gives trip signal to the circuit breaker if fault impedance is less than set value. The circuit breaker isolates the transmission lines from the supply. The solid state impedance relay with single element is designed to measure the fault impedance with magnitude and compares it with set point value and gives the trip signal to circuit breaker. This project demonstrates the working of distance relay. Experiments can be performed regarding the characteristics, operation and performance Of distance (impedance) relay.

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