Protection of Transmission Lines Using a Fault Locator

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Abstract

This paper presents a method for protection of transmission lines using a fault locator. Fault in a power system is defined as an electrical short circuit due to which the currents are diverted from the intended path. A fault can be cleared by protective schemes consisting of circuit breakers and various types of relays. The function of protective relays is to detect a fault and to disconnect the faulty section with the help of a circuit breaker.

Generally relays are used to detect a fault on a transmission line. A relay senses the fault but is unable to give the exact location of the fault. A fault locator gives the exact location of fault in transmission lines. Mathematical analysis of the fault locator has been carried out using transmission line model. A single-end fed lines has been assumed but it is applicable to double-end fed line too.

Keywords: Really, fault locator, Arcing fault

1. Introduction:

1.1 Need of relays

An electrical power system consists of generators, transformers, transmission lines etc. Short circuits and other abnormal conditions often occur on power systems. Heavy currents associated with short circuits/faults in power systems are likely to cause damage to equipments. Hence, for protection of power system equipments, protective relays and circuit breakers have to be provided.

Fault in a power system is defined as an electrical short circuit due to which the currents are diverted from the intended path. If a fault occurs in an element of a power system, an automatic protective device is needed to isolate the faulty equipment as quickly as possible to keep the healthy section of the system in normal operation. The fault must be cleared within a fraction of a second. If the short circuit persists on a system for a longer time period, it may cause extensive damage to important sections of the system.

A fault can be cleared by protective schemes consisting of circuit breakers and various tupes of relays. The functions of protective relays is to detect a fault and to disconnect the faulty section with the help of a circuit breaker.

1.2 Need of fault locator

The present day power systems are highly interconnected and utilize extra high voltages for bulk transmission of electrical power over very long distances. Transmission lines, being fully exposed to the vagaries of atmosphere are highly prone to faults. About 50% of faults taking place on power system equipments take place on transmission lines. In case of faults, the inspection team or lineman has to quickly reach the fault location to put the line back to service. The faster the faulty line is restored, the higher is the system dependability and security. Even in case of transient faults, the fault vulnerable spots of the line are to be inspected.. Thus fault locating equipments area absolutely necessary to find out the location of the fault form the terminal substation very accurately.

1.3 Comparison of a relay and a fault locator

Realy: It is a device which senses abnormal conditions on a power system by constantly monitoring electrical quantities of the system, which differ under normal and abnormal conditions and initiates the operation of other elements of the protective scheme.

During the normal operating conditions, the circuit breaker can be opened or closed by a station operator for maintenance. During the abnormal or faulty conditions, the relay senses the fault and closes the trip circuit of the circuit breaker, thereafter circuit breaker opens. The relay circuit is as shown in Fig.1

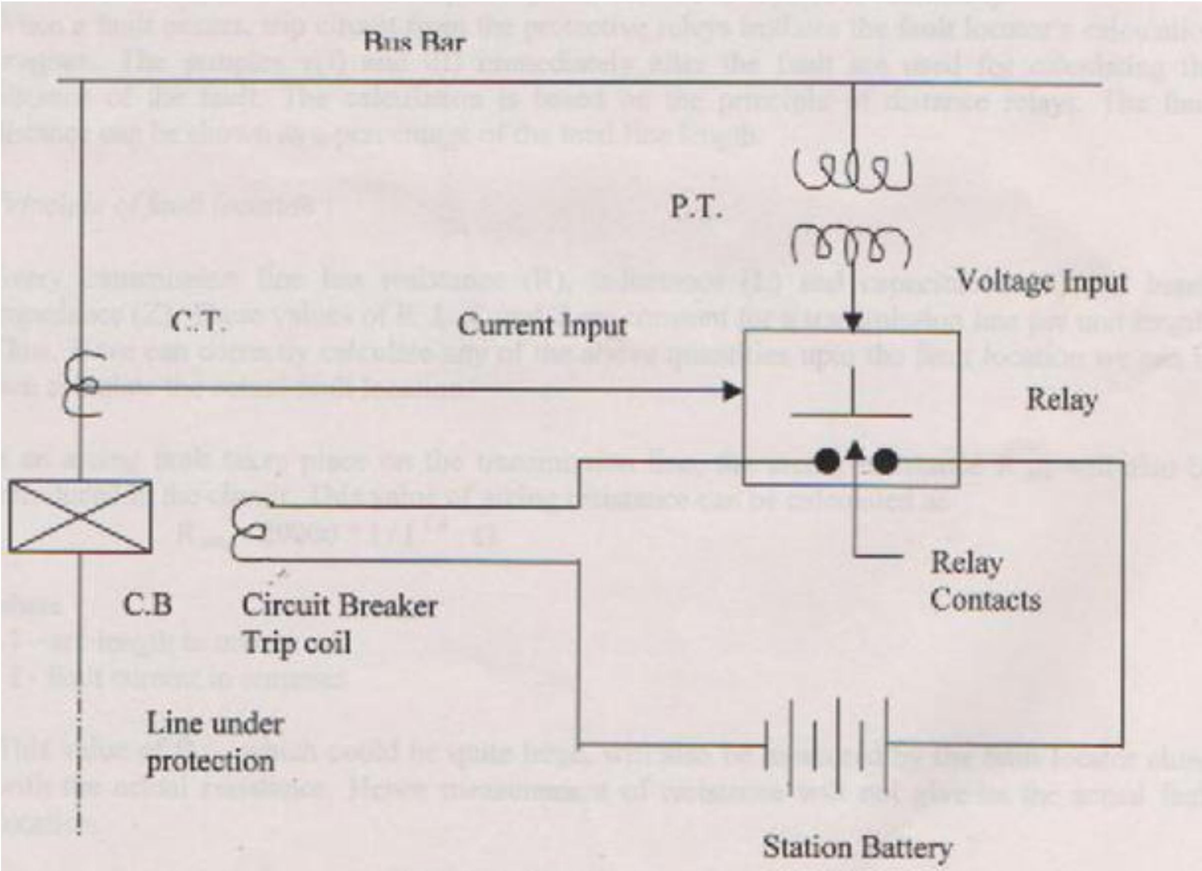

Fig. 1 Relay Circuit

When a fault occurs in a circuit, the relay, fed by the CT and PT, gets activated and closes its contacts. Current flows from battery in the trip circuit. Thus, as the trip coil of the circuit breaker is energized, the circuit breaker opens the circuit.

Thus, under abnormal conditions, the relay senses the fault and the circuit breaker trips the circuit. In case of permanent faults, the inspection team has to inspect the entire length of the transmission line, locate the fault and restore the power supply. But this is a very time consuming process. Thus, we need an equipment to locate the fault very accurately, which is nothing but a fault locator.

Thus the fundamental difference between relay and fault locator is that relay just sense the fault while a fault locator locates its exact position.

Fault Locator: It is an essential complement to distance relays for transmission line protection Fault locators are installed on distance protection scheme. This scheme measures and indicates accurately the distance between the substation and point of fault.

Fault locators can also be combined with the fault recorder and printer, for recording the distance to the fault and fundamental component of fault current, before and after the fault. Fault locator is energized by CT and PTs of the line, just like distance relay.

Under normal conditions the fault locator monitors three phase currents, the ground currents and voltage input signals continuously. The input analog signals are converted to digital signals in an A/D converter and stored in memory for specific number of cycles continuously.

When a fault occurs, trip circuit form the protective relays initiates the fault locator's calculation program. The samples v(t) and i(t) immediately after the fault are used for calculating the distance of the fault. The calculation is based on the principle of distance relays. The fault distance can be shown as a percentage of the total line length.

Principle of fault location:

Every transmission line has resistance (R), inductance (L) AND CAPACITANCE (c) and hence impedance (z). These values of R, L, C and Z are constant for a transmission line per unit length. Thus, if we can correctly calculate any of the above quantities upto the fault location we can in turn calculate the actual fault location.

If an arcing fault takes place on the transmission line, the arcing resistance R_{are} will also be introduced in the circuit. This value of arcing resistance can be calculated as

$$R_{are} = 29000 * 1 / I^{1.4}\ \Omega$$

Where

1-are length in meters

I-fault current in amperes

This value of R are which could be quite large, will also be measured by the fault locator along with the actual resistance. Hence measurement of resistance will not give us the actual fault location.

The line model of the transmission line is a series R and L model. The shunt capacitances are always neglected since the voltage collapses when the fault takes place.

In the presence of DC offset in short circuit current, the impedance measured by the fault locator becomes less than the actual impedance upto the fault point. Thus knowing the value of inductance per unit length and the total inductance measured by the fault locator, the exact location of the fault can be determined.

2. Single End Fed Line

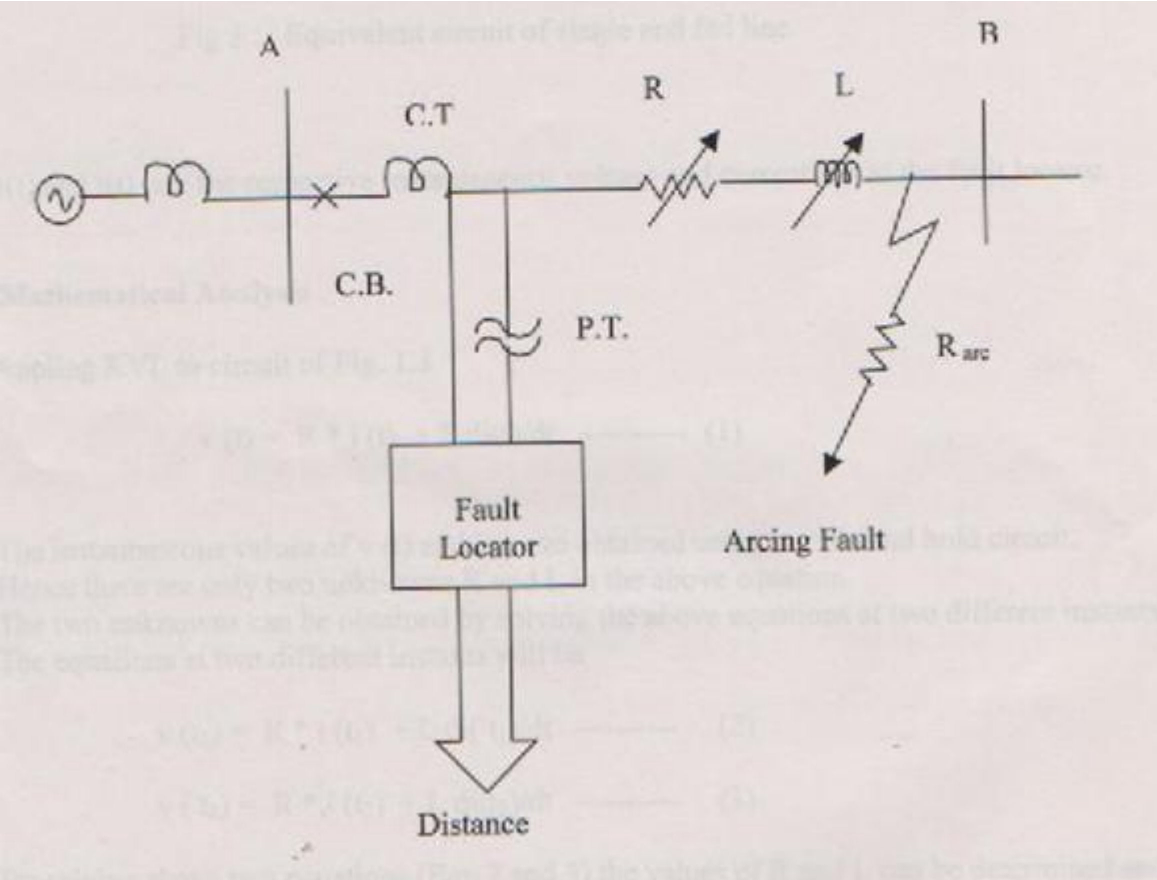

Fig. 2 Single line diagram of single end fed line

Fig 2 shows the single diagram of EHV transmission line with fault occurring at some distance from the fault locator, It is a line fed from single end only (i.e at end A only).

The equivalent circuit of a single end fed line can be drawn as shown in Fig. 3 below.

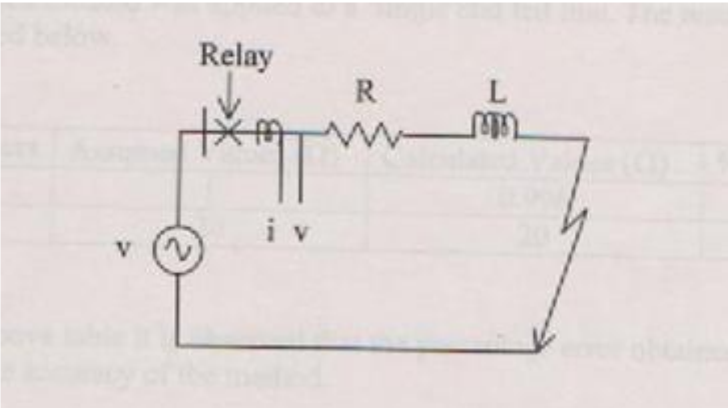

Fig 3 : Equivalent circuit of single end fed line

V(t) and i(t) are the respective instantaneous voltage and current fed to the fault locator.

Mathematical Analysis

Applying KVL to circuit of Fig. 1.3

$$V(t)= R^* i(t) + L\, di(t)/dt \ldots\ldots\ldots\ldots (1)$$

The instantaneous values of v(t) and i(t) are obtained using sample and hold circuit.

Hence there are only two unknowns R and L in the above equation.

The two unknowns can be obtained by solving the above equations at two different instants.

The equations at two different instants will be

$v(t_1)= R^* i(t_1) + L\, di(t_1)/dt$......... (2)

$v(t_2)= R^* i(t_2) + L\, di(t_2)/dt$......... (3)

By solving above two equations (Eqn 2 and 3) the values of R and L can be determined and hence the fault can be located.

3. Results And Conclusion

The proposed method was applied to a single end fed line. The results obtained

Parameters	Assumed Values (Ω)	Calculated Values (Ω)	% Error
R	1	0.996	0.4
Y	20	20	0

From the above table it is observed that the percentage error obtained is very small which confirms the accuracy of the method.

4. Further Scope

Numerical analysis of the above mentioned system can be done and hence can be compared with this method. In actual systems the line is fed form both the ends. This analysis can also be carried out on a double end fed line.

References:

(1)Jeyasura, B.J. and Smolinksi W.J.,: 'Identification of a best algorithm for digital distance protection of transmission lines', IEEE Transactions on PAS, Vol. PAS – 102, No.10, oct. 1983, pp 3358-3366

(2)Mann, B.J. and Morrison I.F.,: 'Digital calculation of impedance for transmission line protection', IEEE Transactions on PAS, Vol. 90, No.1, Jan/Feb 1971, pp. 270-279.

(3)Mason, C.R.,: 'The Art and Science of protective Relaying' , John Wiley and Sons, New York.

(4)Paithankar, Y.G.,: 'Transmission Network Protection: Theory and Practice' , Marcel Dekker Inc. New York.

(5)Paithankar, Y.G. and Bhide S.R., 'Fundamentals of Power System Protection', Prentice Hall of India Pvt. Ltd., New Delhi.