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USING PROGRAMMABLE LOGIC CONTROLLERS (PLCs) TO REALIZE DISTANCE PROTECTION

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Abstract: - This paper shows how PLCs are used to realize three zone distance protection in power systems. For this purpose, a conditioning circuit was designed and tested to convert the real values obtained from current and voltage transformers to suitable values compatible with PLC inputs. Distance protection system model was designed using PLC. This model presents a three zone directional distance relay .In which the input values were the current and the voltage at the network via voltage and current transformers. Results obtained by the proposed PLC model are similar to the ones obtained by conventional relays. This model can be used in a real power system through a suitable interfacing facility.

Key-Words: - PLC, Impedance, Distance, Protection, Program, Time.

1 Introduction

Power networks control and protection circuits are undergoing serious developments to substitute the hardware protection circuits, By new flexible programmable protection means [1].The protection circuits of electrical power network have almost ended with important stage of development, when the majority of them were transformed, or partially developed from electromagnetic means of protection and control to the electronic hardware system .Nowadays, the trend in this field of industry is the implementation of programmable protection systems that can easily interface with the primary transducers from one side and the dispatch control centre from the other side [2,3].

For this reason and due to PLC advantages, as low cost, easy installation and programming [8,9], the usage of PLCs was investigated in this paper to provide distance protection in power networks. In addition to protection, PLC can be used as monitoring device for voltage, current and impedance for power lines. PLC system hardware includes in additional standard components two analog inputs and an operator terminal with key board and LCD display to provide human machine interface.

2 Distance protection with a three step characteristic

Distance protection is a widely used protective scheme for the protection of high and extra high voltage (EHV) Transmission and sub-transmission lines.

This scheme employs a number of distance relays which measure the impedance or some components of the line impedance at the relay location.

All the forms of this protection consist of a few common elements performing definite typical function [3,4] .

Figure 1. shows a simplified diagram of stepped type distance protection for one phase. The protection system includes the following elements:

-Voltage and current transformers.

-Starting element (Z3) brings the protection into action on occurrence of a fault. This element measures the impedance (distance) at the third zone of protection.

-Distance element (Z2).This element measures the distance of the second zone of protection.

-Distance element (Z1) measures the distance of the first zone of protection.

-Time delay elements t1, t2 and t3 create a time lag with which the protection operates according to the behavior of the distance elements.

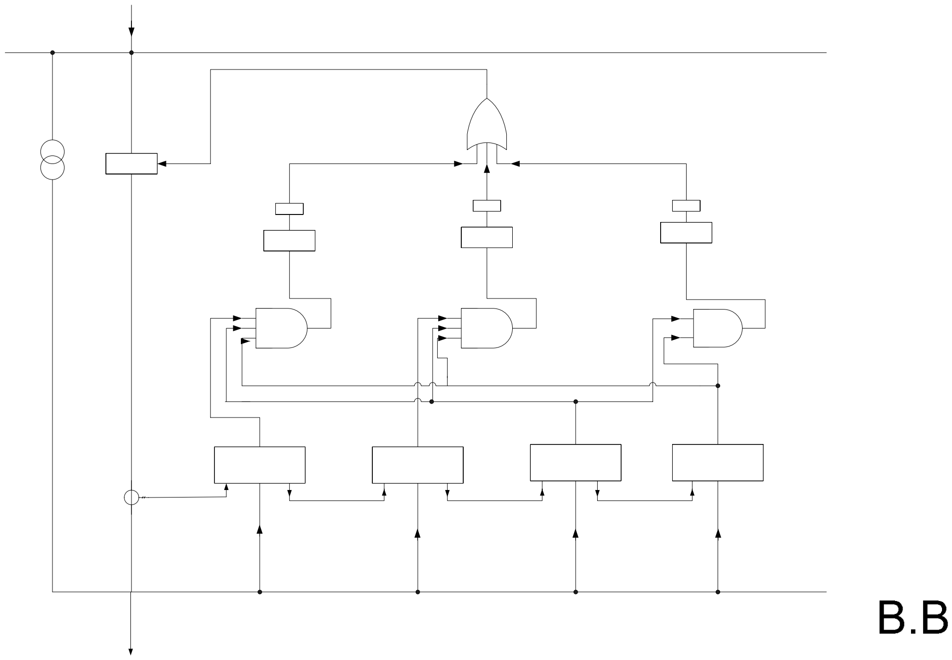


Fig 1

-Power directional element (PDR) prevents the protection to operate, when the fault power flows toward the bus bars of a substation.
-Logic gates.

If a fault occurs within the first zone ,the distance element of the first zone (Z1) operates with a high speed to form a path for disconnecting the line with a fault in the second zone ,distance element(Z1) does not operate as the impedance across its terminals is greater than the operating impedance setting of the first zone (Zr>Z1).In this case the distance element (Z2) of the second zone is brought into action and it actuates the timer (t2).After the setting time expires, a tripping signal is sent to disconnect the line . When a fault is in the third zone ,but external to the second zone , elements (Z1 and Z2)do not operate as impedances at their terminals exceed the operating impedance settings .Timer (t3) actuated by the starting element (Z3), operates after time (t3) expires , and a tripping signal is sent to the circuit breaker .

Figure 2. Shows a step time and impedance zone for distance protection.
In the illustrated system, the distance relays have three zones . Where zone 1 is set to protect about 90% of the line length and to operate with no intentional time delay.

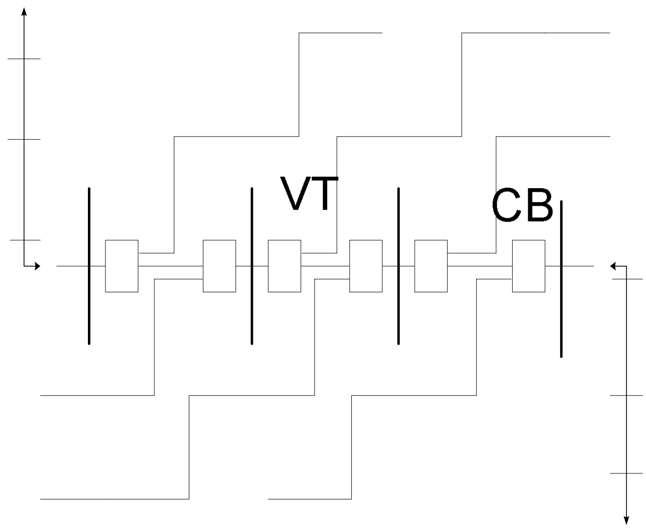


Fig 2

Zone 2 is set for 100% of the protected line plus about 50% of the shortest adjacent line, and is set to operate with time delay T2 .Zone 3 is set to reach 100% of the impedance of the first two lines and 25% of the third line , and to operate the zone 3 element with time delay T3.

Figure.3. shows a family of a three zone impedance relay characteristics in the complex Z plane

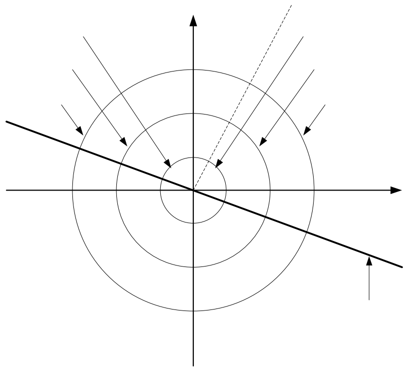


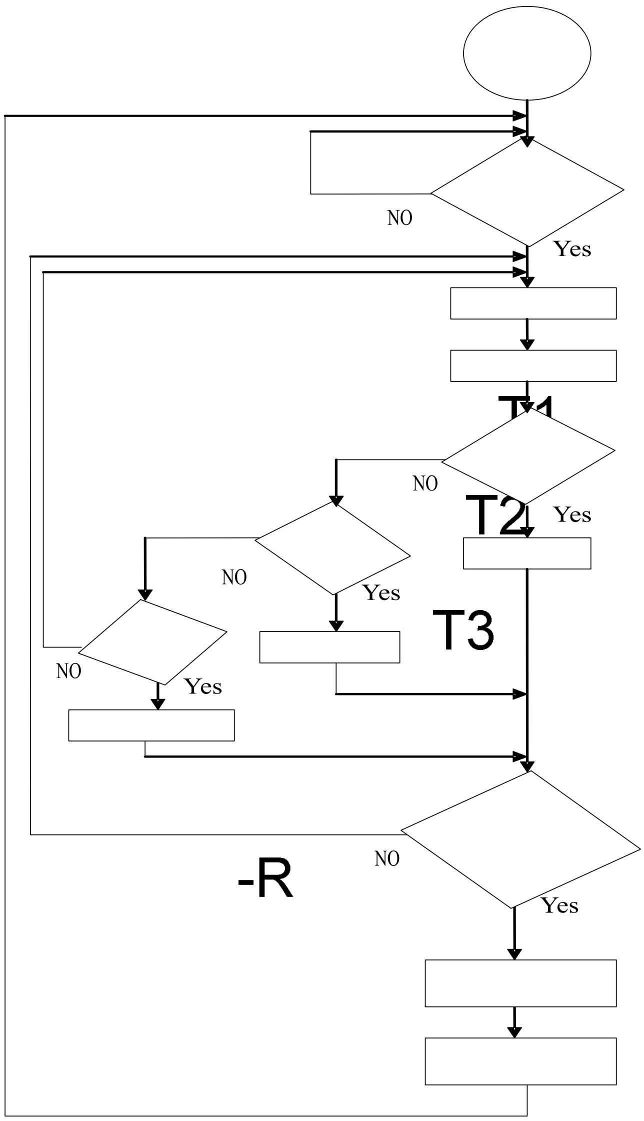
Fig. 3

Case study

A flow chart of PLC program designed for the proposed distance protection is shown in figure 4.

For different values of currents and voltages applied to the PLC, different values of the impedances (Z) are obtained. According to the value of impedance Z and time; the zones of the protection were set as follows :

Z1= 75 Ω, t1=0.06 s
Z2= 150 Ω, t2=0.3 s
Z3= 250 Ω, t3=0.8 s



+X

θ

fig. 4

3.1 Experimental measurements

Table 1

Input Voltage [V]	Input Current [mA]	Z [Ω]	Direction	Zone of operation	Time delay [ms]
10	10	1000	1	No operation	-
5	10	5000	1	No operation	-
4	20	200	1	Z_3	800
2	20	100	1	Z_2	400
1	20	50	0	No operation	-
1	20	50	1	Z_1	60

4 Conclusions

Using PLCs in distance protection circuits, all the various facilities of the PLCs are transferred to these circuits . This gives the protection circuits more flexibility and makes their integration with other protection and control circuits easier.

Distance protection system model was designed to present a three zone directional distance relay. PLC replicates conventional approach with acceptable results .

The proposed model can be used in real power system through a suitable interfacing facility .

PLC application are useful for medium voltage and high voltage networks, the benefit cost ratio favors the PLC compared to conventional method.

PLC is easily controlled and programmed to obtain desired operating characteristics.

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