Designing Over-Current Relay Logic in MATLAB

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Abstract— Relays are being utilized for secure, reliable and convenient operation of power system. The Over-Current relay is widely used in the power system for protection of short circuit or wrong setting of system to the prespecified value. Erroneous setting of Over-Current relay in the power system causes difficulties in sending the trip signal. So it must be connected carefully in the power system. Therefore, it is important to accredit the setting of power protection equipment. This paper describes modeling of Over-Current relay logic to protect distribution system using Matlab/Simulink package. Sim Power System toolbox was used for detailed modeling of Over-Current relay, transmission line and fault simulation.

Index Terms— Over Current Relay, Power System, 3 phase fault, Mat Lab, relay logic.

1 INTRODUCTION

At present fault plays a major problem in a power system network. With the growing demand of electric power, the distribution is increasing year by year and therefore maintenance and protection of power system equipments are very important for decreasing the cost and to increas the life of the power system equipment's for reliable and uninterrupted operation. From the perspective of relay application, all this creates new engineering needs for improvements in understanding of new operating principles, determining proper way of using a given relay, calculating the settings, and finally, performing relay design and application testing. From the educational perspective, both design and application issues are important since students learn best by emulating (modeling), implementing (developing) and simulating (testing) the algorithm of a given relay. All the aforesaid needs can be met by appropriate modeling, developing and testing tools used together in one programming environment which is the primary interest of this paper [1].

2 FAULT AND ITS CLASSIFICATION

Under normal condition, a power system operates under balanced conditions with all equipments carrying normal load currents and the bus voltages within the prescribed limits. This condition can be disrupted due to a fault in the system. A fault in a circuit is a failure that interferes with the normal flow of current. A short circuit fault occurs when the insulation of the system fails resulting in low impedance path either between phases or phase(s) to ground. This causes excessively high currents to flow in the circuit, requiring the operation of protective equipments to prevent damage to equipments. The short circuit faults can be classified as:

- Symmetrical faults
- Unsymmetrical faults

2.1 Symmetrical Faults

In such types of faults, all the phases are short-circuited to each other and often to earth. Such fault is balanced in the sense that the systems remain symmetrical, or we can say the lines displaced by an equal angle (i.e. 120° in three phase line). It is the most severe type of fault in volving largest current, but fortunately it occurs rarely. For this reason, balanced short- circuit calculation is performed to determine these large currents.

2.2 Unsymmetrical Faults

Unsymmetrical faults involve only one or two phases. In unsymmetrical faults the three phase lines become unbalanced. Such types of faults occur between line-to-ground or between lines. An unsymmetrical series fault is between phases or between phase-to-ground, whereas unsymmetrical shunt fault is an unbalanced in the line impedances. Shunt fault in the three phase system can be classified as;
Single line-to-ground fault (LG).

- Line-to-line fault (LL).
- Double Line-to-ground fault (LLG).
- Three-phase short circuit fault (LLL).
- Three-phase-to-ground fault (LLLG).

3 OVER-CURRENT RELAY

A relay that operates or picks up when its current exceeds a predetermined value (setting value) is called Overcurrent Relay. Overcurrent protection protects electrical power systems against excessive currents which are caused by short circuits, ground faults, over load etc[2].
Over-Currentrelay classified as;

- Instantaneous Over-Current relay,
- Inverse time-current relay,
- Inverse definite minimum time Over-Currentrelay,
- Very inverse relay,
- Extremely inverse relay,

3.1 Instantaneous Over-Currentrelay

Instantaneous Over-Current relay is one in which no intentional time delay is provided for the operation. The time

of operation of such relays is approximately 0.1 sec. This characteristic can be achieved with the help of hinged armature relays. The Instantaneous relay is more effective where the impedance Z_S between the source and the relay is small compared with the impedance Z_L of the section to be protected.

3.2 Inverse Time-Current Relay

Inverse time-current relay is one in which the operating time reduces as the actuating quantity increases in magnitude. The more pronounced the effect is the more inverse the characteristic is said to be. In fact, all time current curves are inverse to lesser degree. They are normally more inverse near the pickup value of the actuating quantity and become less inverse as it is increased. This characteristic can be obtained with induction type of relays by using a suitable fault current. If the saturation occurs at a very early stage, the time of operation remain same over the working range.

Fig1 shows the over current relay characteristic

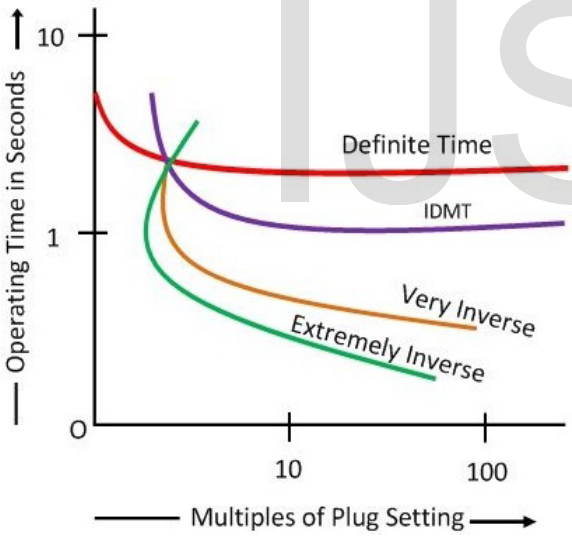

Fig.1 Relay Characteristic

3.3 Inverse Definite Minimum Time Over-Current relay

Inverse definite minimum time over-current relay is one in which the operating time is approximately inversely proportional to the fault current near pick up value and becomes substantially constant slightly above the pick-up value of the relay.

3.4 Very Inverse Relay

Very inverse relay is one in which the saturation of the core occurs at a later stage, the characteristic assume (fig1). The time-current characteristic is inverse over a greater range and after saturation tends to definite time.

3.5 Extremely inverse relay

Extremely inverse relay is one in which the saturation occurs at a still later stage.

4 MODELING TRANSMISSION LINE AND OVER-CURRENT RELAY

Matlab is powerful analysis software which has the capability of modeling power system components using Sim Power Systems toolbox inside Simulink package. In this toolbox, many available power systems components such as three-phase transformer, three-phase load, distributed parameters line, three-phase source, circuit breaker etc can be used for AC or DC applications [3]. All these components are ready to use where the users should only drag the components into model file and enter the parameter values. The transmission line and load was modeled using distributed parameters line and three-phase load block sets respectively. Fig.2 shows the developed model of transmission line and load. From Fig.3, shows the internal logic of over current relay developed using flip-flops, relational operators etc. Table1 shows the power system, transmission line and load data used in this simulation. However, the users have the capability to change these parameters.

One of the great features of Simulink package is that the developed model can be included in one block set only by creating the subsystem for the developed model. This feature minimizes the use of space inside the file for the case of complex system. Furthermore, the created subsystem block set also can be copied and pasted at any space or file and thus eliminates the multiple building of the model. Fig.4 shows the response of the phase current before and after the fault . zero magnitude current indicates isolation of faulty part from the healthy transmission line. Fig.5 indicates the overall flow chart of the overall transmission model.

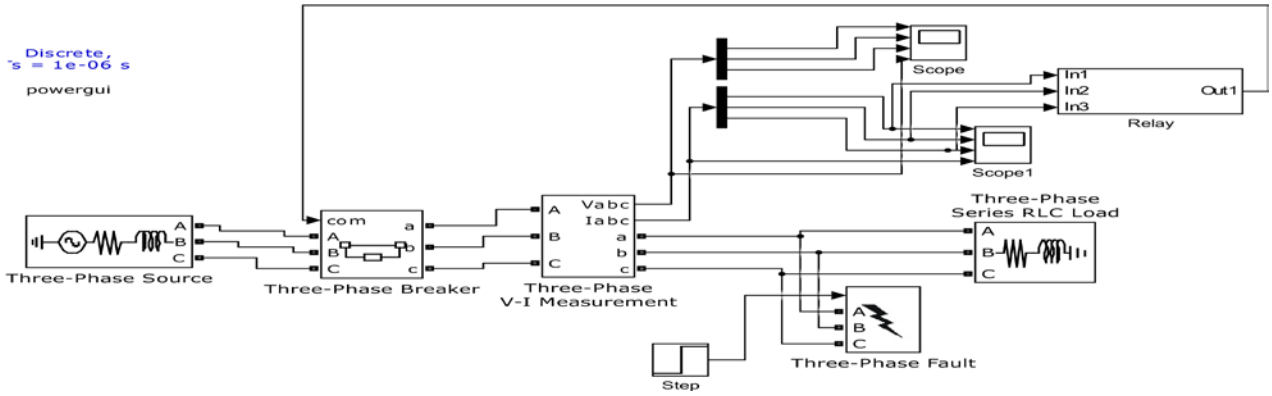

Fig.2 Overall transmission network

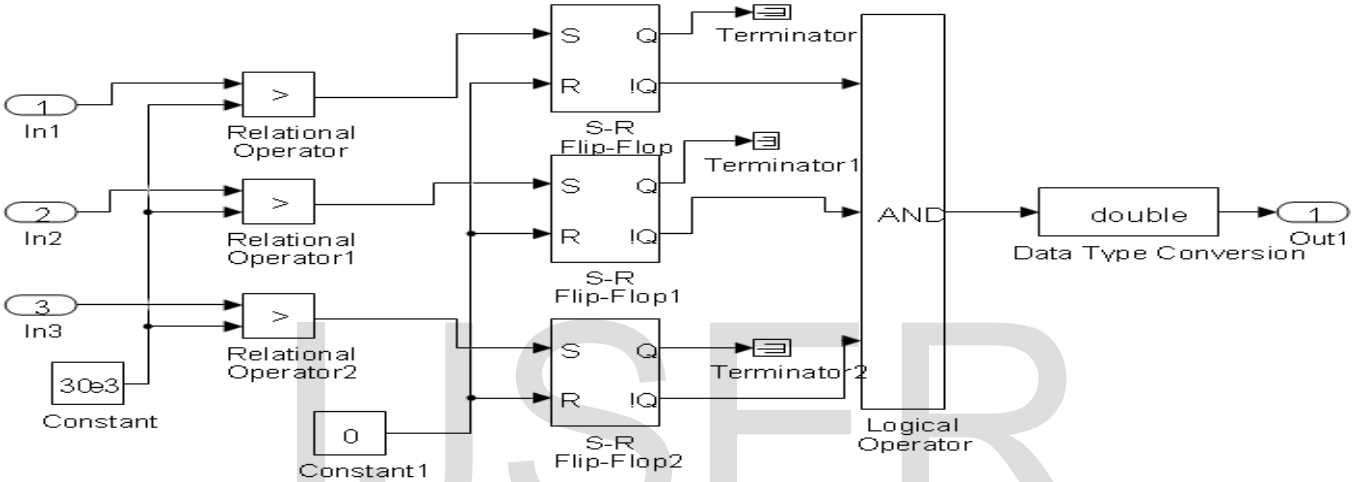

Fig.3 Internal logic Circuit

5 TABLE I. POWER SYSTEM, TRANSMISSION LINE AND LOAD DATA

Power system, transmission line and load data	Value	Unit
Power System		
Power system voltage	25	kv
Phase angle of phase A	120	degree
Nominal frequency	50	Hz
3 phase short circuit level at base voltage	100	MVA
Source X/R ratio	7	-
3 phase load		
Active power	10000	W
Inductive reactive power	100	Var
Capacitive reactive power	100	Var

6 TEST RESULT AND FLOW CHART

Fig.2 shows the overall 3-Phase model of a power system Network developed. Along with Over Current Relay Model which investigates its operation when 3-phase fault is introduced in the system. The Major Components of test Setup are 3-phase voltage Source (50 Hz, 25kv phase voltage). The 3-phase fault block introduce fault after 0.1 sec by a step signal. When fault current enter in the relay block the fault current go through the relational operator block which compare with the pre set value or if fault current increases above the pick-up value the Boolean outputs to AND gate via S-R flip flop. If the three inputs to AND gate is high, then high output from the AND gate which may be called trip signal eventually goes to 3-phase circuit breaker which will interrupt the 3-phase transmission line. As soon as the trip signal is received the faulty part will be isolated from the healthy section. If the phase current is below the pickup value, then the 3 output of S-R flip flop is low and then the output of AND gate is not high so no trip signal generates from the relay block ensuring un-interrupted supply in the transmission line.

7 GRAPH & FLOW CHART

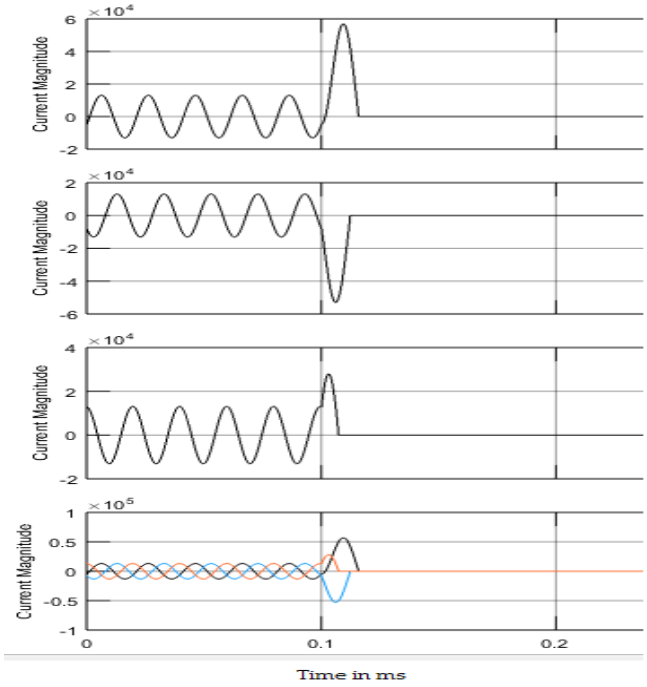

Fig.4 Phase current vs operating time

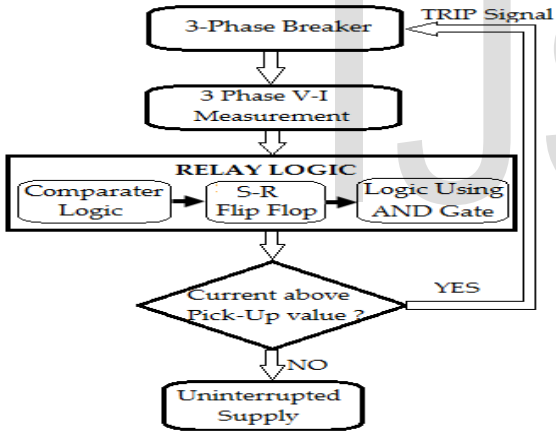

Fig.5 Flow Chart

8 CONCLUSION

In this paper over current relay characteristics are developed using MATLAB/SIMULINK. The performance characteristics of over current relay were evaluated at a location with 3-phase fault. The developed over current relay characteristics may be used for training young and inexperienced engineers and technicians [4]. The paper has presented the modeling and simulation of Over current relay on MATLAB/SIMULINK. The proposed model offer effective means for explaining the behaviors of over current relay. It is shown that these models offer effective means for explaining the functionality of over current relay under various operating scenarios. Additionally, the systematic unfolding style of model development and performance analysis means that this paper could also serves as guide to develop similar relay models and benchmark performance. The relay has good advantage in terms of their sensitivity and wide range controlling [5].

9 FUTURE SCOPE

The effect of the simulation parameters such as power system data, transmission line data, load data and fault data on fault and over current relay characteristics needs to be studied. For future enhancement, the model can be extended for other types of relay characteristic and fault types. Such as Differential relay, Impedance relay, Mho relay etc. Researcher can also think to implement relay modeling in real time system of power system.

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