# Design and construction of a numerical Inverse Definite Minimum Time (IDMT) Overcurrent Relay using Matlab

**Abstract**–In this research, a three-phase over current relay was designed to protect the power system accompanied with the fault a high electrical current to large values lead to the destruction of electrical equipment in the power system.The research had the study of adding a load to the end of the line as (Over Load) and the fault in power system.

This paper presents the modeling of an overcurrentrelay in SimPowerSystems (MATLAB/Simulink 2010). The overcurrentrelay has the features of instantaneous, Definite Timeand inversedefinite minimum time (IDMT) characteristics. When a current in a part of a power system exceeds a pre-set value either due to a fault or a largeoverload the relay will isolate the part through sending trip signal to a circuit breaker.The overcurrent relays must have high reliability and accuracy todetect any fault currents present and determine the operation time.

**Keywords**: power system, TMS, over current Relay, IDMT.

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## 1. Introduction

An electric power system should ensure the availability of electrical energy with out interruption to every load connected to the system when the electric power supply is extended to remote village the power system would consist of several thousand km of distribution line. The high voltage transmission lines carrying bulk power could extend over several hundred km, since all these lines are generally overhead lines and are exposed there are many chances of their breakdown due to storms, falling of external objects damage to the insulators etc.[1]

These can result not only in mechanical damage but also in an electrical fault. The transmission lines of the most important part in the power systems. The transmission lines working to connect the power station with load[1], when a fault occurs on the transmission line, it is necessary to detect and separate the fault on power station [2].

Faults are classified into two types:

1. Symmetrical Faults [3]: these that occur because of the short circuit of the current of the three phasesThe appropriate percentage of occurrence of this fault – 3%.

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2. Non-symmetrical Faults [3]: they are usually several types such as and the appropriate percentage of occurrence of these faults:

i. Single phase to ground fault (SL-G) – 70-80%
ii. phaseto phase to ground fault (DP-G)– 10 -17%
iii. phaseto phase fault (DP) – 8-10%

## 2. Requirements of a Protection System

A. Reliability

The most important requisite of protective relay is reliability. They remain inoperative for a long time before a fault occurs; but if a fault occurs, the relays must respond instantly and correctly.[4]

B. Selectivity

The relay must be operated in only those conditions for which relays are commissioned in the electrical power system. There may be some typical condition during fault for which some relays should not be operated or operated after some definite time delay hence protection relay must be sufficiently capable to select appropriate condition for which it would be operated.[4]

C. Sensitivity

The relaying equipment must be sufficiently sensitive so that it can be operated reliably when level of fault condition just crosses the predefined limit.[10]

D. Speed

The protective relays must operate at the required speed. There must be a correct coordination provided in various

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power system protection relays in such a way that for fault at one portion of the system should not disturb other healthy portion. Fault current may flow through a part of healthy portion since they are electrically connected but relays associated with that healthy portion should not be operated faster than the relays of faulty portion otherwise undesired interruption of healthy system may occur. Again if relay associated with faulty portion is not operated in proper time due to any defect in it or other reason, then only the next relay associated with the healthy portion of the system must be operated to isolate the fault. Hence it should neither be too slow which may result in damage to the equipment nor should it be too fast which may result in undesired operation.[11][12]

## 3. Over current relay

An over current relay has one input in the form of ac current the output of the relay is a normally- open contact which changes over to closed state when the relay trips the relay has two settings. These are the time setting and the plug setting the time setting decides the operating time of relay while the plug setting decide the current plug setting comes from the electromechanical over current relay in these relay we have to in a shorting plug in a plug setting bridge so as to changes the number of turns of the operating coil to get a particular pick up value. The block diagram of an over current relay shown in fig.1. [9]

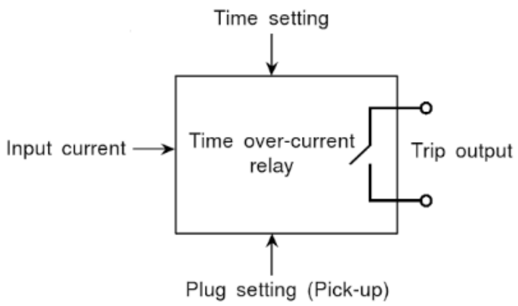
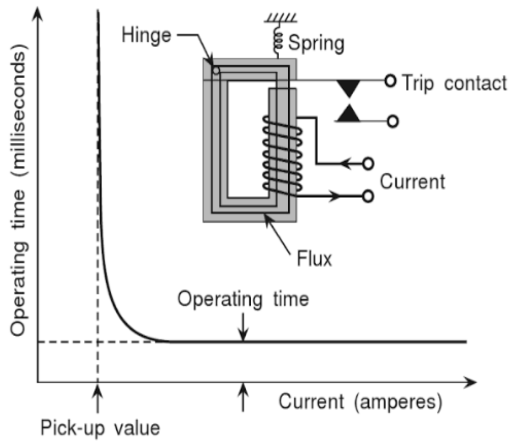



**Fig.1**The block diagram of over current relay.

Types of Over Current RelayDepending upon time of operation, there are various types of OC relays, such as[5]

### i. Instantaneous over current relay:

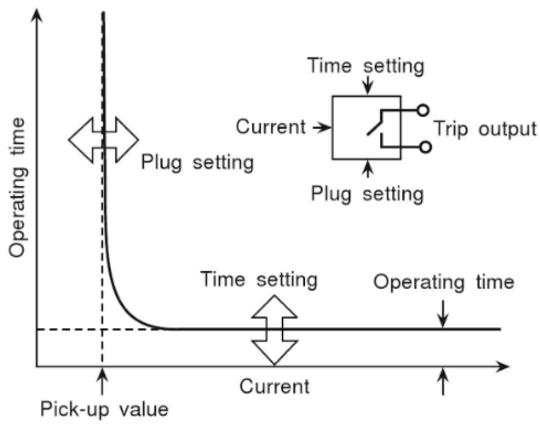
These relays instantaneously send a trip command to the breaker as soon as the fault is detected (input current greater than the present value).They do not have any intentional time delay. They are usuallyimplemented close to the source where the fault current levelis very high and a small delay in operation of relay can causeheavy damage to the equipment. So an instantaneous relay isused there to detect and respond to a fault in few cycles.[5]




**The Fig.2** Instantaneous over current relay characteristic

### ii. Definite Time Overcurrent Relay:

This type of over- current relay is used for backup protection (e.g. back up protection for transmission line where primary protection is distance relay). If the distance relay does not detect a line fault and does not trip the breaker, then after a specific time delay, the overcurrent relay will send a trip command to the breaker. In this case, the overcurrent relay is time delayed by a specific time which is just greater than the normal operating time of the distance relay plus the breaker operation time.[6]




**The Fig. 3**Definite time over current relay characteristic

### iii. Inverse Definite Minimum Time (IDMT) Overcurrent Relay:

This relay has an inverse time characteristic. This means that the relay operating time is inversely proportional to the fault current. If the fault current is higher, the operating time will be lesser .It can be graded for a very large range of operating times and fault currents .The characteristics of

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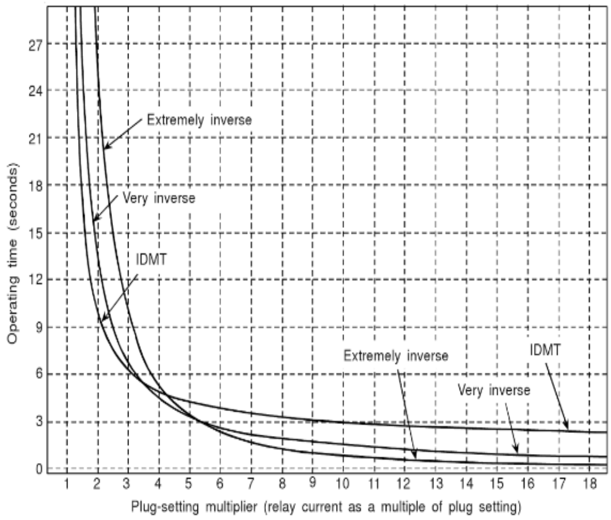
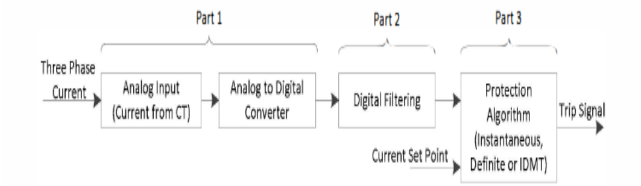
an IDMT overcurrent relay depend on the type of standard selected for the relay operation.[6]




**The Fig.4**Inverse definite minimum time over current relay characteristic (TMS=1)

The characteristicsof IDMT relays are represented with the following equation:[7]

$$T = \frac{C}{(\frac{I}{I_s})^{\alpha} - 1} \times TMS$$




**The Fig.5**Functional Block Diagram of an Overcurrent Relay

Where

T: Relay operation time.

C: Constant for relay characteristic.

Is: Current Set point.

I: Current Input to the relay.

α: Constant Representing Inverse Time Type (α> 0).

TMS: Time Multiplier setting controls the relay tripping time, the TMS in this research (TMS=0.2).

**Table. 1** TYPE OF INVERSE CHARACTERISTICS CURVES [8]

| Relay Characteristic Type | α | C |
|---|---|---|
| Standard Inverse | 0.02 | 0.14 |
| Very Inverse | 1 | 13.5 |
| Extremely Inverse | 2 | 80 |
| Long Inverse | 1 | 120 |

## 4. Representation of Power System

The system was represented by using a (MATLAB 2010) program which consists of the power system from generating station with 11Kv , frequency of (50Hz), the Transformer (50 MVA, 11KV/132KV) and linked load in the end of line with a value of (P=50 MW) and over current relay to protect power system as in fig. 6

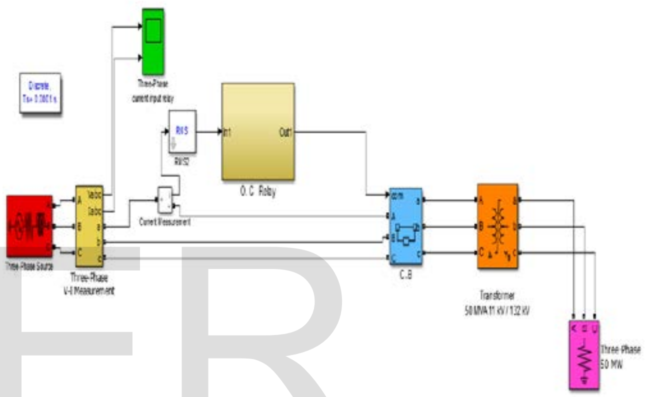



**Fig. 6**Representation of Power System by using of (Matlab/Simulink)

1. Powerstation: the voltage with11Kv the frequency 50Hz and the rated power (200 MW).
2. Over Current relay: detect the faults in the power system
4. Measurement Block: used to measure the phase voltage and current line for each phase.
5. Circuit breaker: working on the separation of the power plant whenthe fault on the power system.
6.load: the load attached at the end of the line and the value of load(P=50MW).

The below Figure shows (the Mathematical Model) for over current relay where issues a trip signal to circuit breaker.

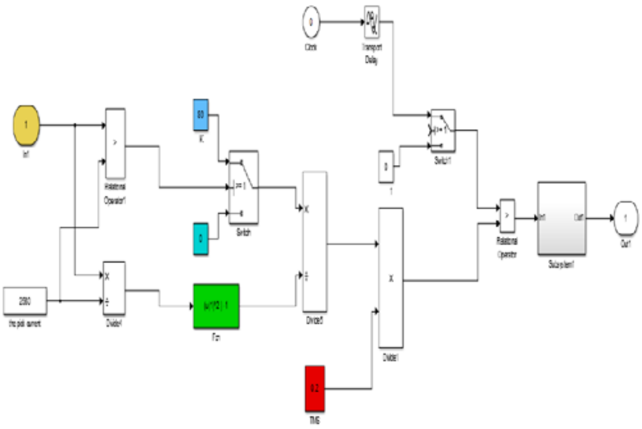


**Fig 7**Shows the mathematical model of the over current relay

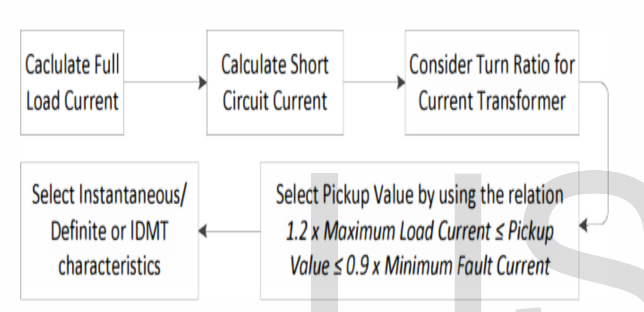



**Fig. 8** Steps Involved in Selecting Pickup Values for overcurrent Relays

The RMS value of the current is obtained, thiscurrent is fed to the over current relay protection block. Thisblock compares the current value with the pickup value. Ifthe input current exceeds the pickup value, the relay willcompute the operation time for the characteristic curve (Standard Inverse, VeryInverse, and Extremely Inverse) and send a trip signal.

## 5. Designed over current relay

For testing the designed over current relay and to ensure its ability to detect the faults in the power system.
The table (2) shows the test results of the designed over current relay where the table shows the operation time of over current relay for all the type the Inverse Definite Minimum Time (IDMT) Overcurrent Relay.

**Table 2.** Shows the test results for all typeInverse Definite Minimum Time (IDMT) overcurrent RelayWhen caseaddition load (MW) at (1 Sec) to the primaryload(50MW).

| No | addition load | Operation time for IDMT Standard Inverse | Operation time for IDMT Very Inverse | Operation time for IDMT Extremely Inverse |
|---|---|---|---|---|
| 1 | 50 MW | 2.1 | 3.02 | 5.15 |
| 2 | 70 MW | 1.75 | 2.23 | 4.1 |
| 3 | 80 MW | 1.66 | 2 | 3.5 |
| 4 | 100 MW | 1.43 | 1.65 | 2.68 |
| 5 | 120 MW | 1.3 | 1.43 | 2.15 |

**Table 3.** Shows the test results for all type Inverse Definite Minimum Time (IDMT) overcurrent Relay When casefault at (1 Sec).

| No | The fault type | Operation time for IDMT Standard Inverse | Operation time for IDMT Very Inverse | Operation time for IDMT Extremely Inverse |
|---|---|---|---|---|
| 1 | Single phase fault | 0.07 | 0.964 | 1.175 |
| 2 | Line to Line phase fault | 0.04 | 0.963 | 1.16 |
| 3 | three phase fault | 0.01 | 0.015 | 0.02 |

Trip Signal Time = Time at which fault or over load is applied (1 sec) + Operating Time.

## 6. Representation Results

The following forms show the current of the system before and after the occurrence of the faults or add load where the fault occurred at (t = 1 sec) and the trip relay signal.

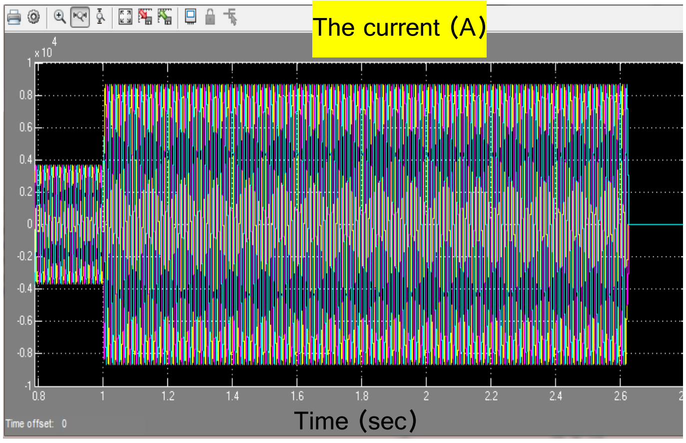



**Fig. 9** shows the currents for over load (80 MW) for over current relay with standard inverse curve

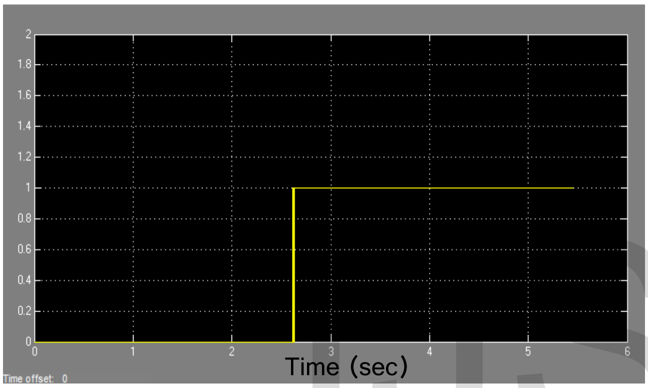



**Fig. 10**Relay Trip signal for standard inverse curve

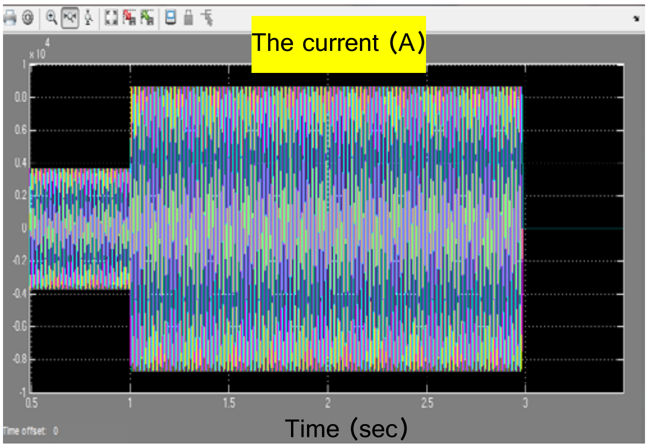



**Fig. 11** shows the currents for over load (80 MW) for over current relay with very inverse curve

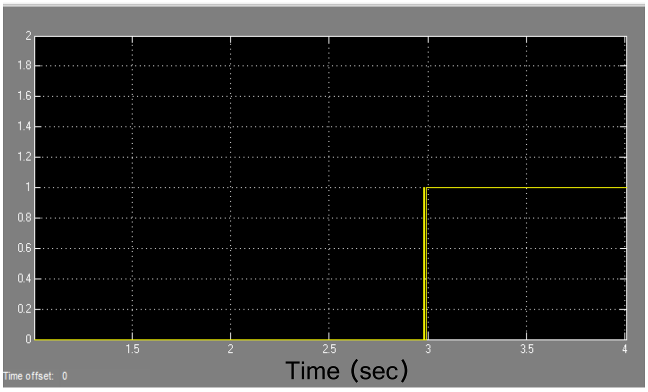



**Fig. 12** Relay Trip signal for very inverse curve

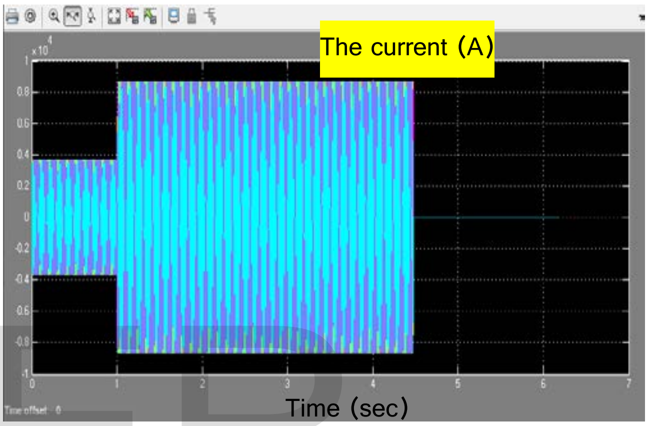



**Fig. 13** shows the currents for over load (80 MW) for over current relay with extremely inverse curve

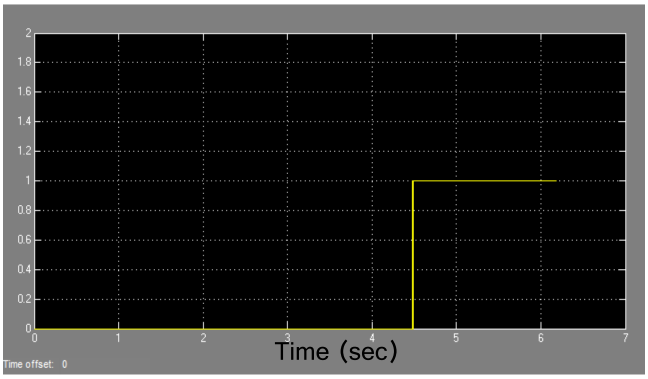



**Fig. 14** Relay Trip signal for extremely inverse curve

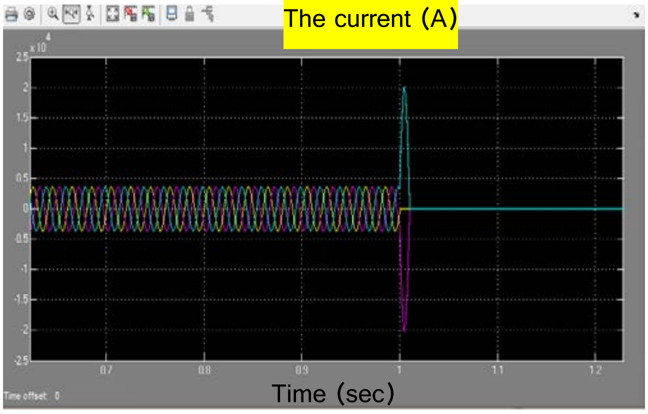



**Fig. 15** shows the currents for three phase fault for over current relay with standard inverse curve

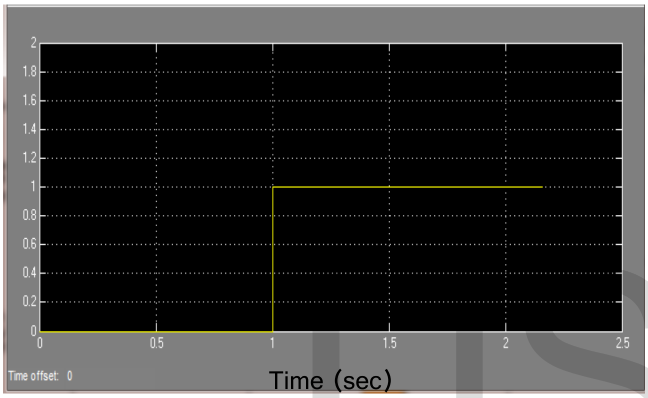



**Fig. 16** Relay Trip signal for standard inverse curve

## 6. Conclusion

The over current relay that has been designed was successful to detect the faults in the power system. Through the results, we note that in the three phase faultthe operation time is very littleCompared with the two phase and single phase fault and Whenever the over load is high the operation time is little and accreditation on the type the over current relay.

## Acknowledgements

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