American International University- Bangladesh
Department of Electrical and Electronic Engineering
EEE 4227: Power System Protection Laboratory

Title: Study of the Performance of over current relays with IDMT characteristics

Introduction:

Protection against excess current was naturally the earliest protection system to evolve. From this basic principle, the graded overcurrent system, a discriminative fault protection, has been developed. This should not be confused with 'overload' protection, which normally makes use of relays that operate in a time related in some degree to the thermal capability of the plant to be protected. Overcurrent protection, on the other hand, is directed entirely to the clearance of faults, although with the settings usually adopted some measure of overload protection may be obtained.

Theory and Methodology:

Over current Relay: A relay that operates or picks up when it's current exceeds a predetermined value (setting value) is called Over Current Relay.

Over current protection protects electrical power systems against excessive currents which are caused by short circuits, ground faults, etc. Over current relays can be used to protect practically any power system elements, i.e. transmission lines, transformers, generators, or motors. For feeder protection, there would be more than one over current relay to protect different sections of the feeder. These over current relays need to coordinate with each other such that the relay nearest fault operates first. Use time, current and a combination of both time and current are three ways to discriminate adjacent over current relays.

Primary Requirement of Over Current Protection:

- The protection should not operate for starting currents, permissible over current, current surges. To achieve this, the time delay is provided (in case of inverse relays).
- The protection should be co-ordinate with neighboring over current protection.
- Over current relay is a basic element of over current protection.

Over Current Relay Ratings:

In order for an over current protective device to operate properly, over current protective device ratings must be properly selected. These ratings include voltage, ampere and interrupting rating. If the interrupting rating is not properly selected, a serious hazard for equipment and personnel will exist. Current limiting can be considered as another over current protective device rating, although not all over current protective devices are required to have this characteristic

Voltage Rating: The voltage rating of the over current protective device must be at least equal to or greater than the circuit voltage. The over current protective device rating can be higher than the system voltage but never lower.

Ampere Rating: The ampere rating of a over current protecting device normally should not exceed the current carrying capacity of the conductors As a general rule, the ampere rating of an over current protecting device is selected at 130% of the continuous load current.

Type of Over Current Relay:

(A) Instantaneous Over Current (Define Current) Relay

(B) Define Time Over Current Relay

(C) Inverse Time Over Current Relay (IDMT Relay)

- Standard Inverse
- Very Inverse Time
- Extremely Inverse

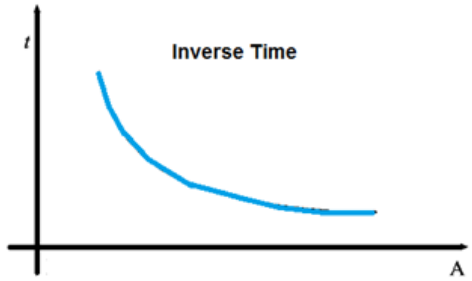
(D) Directional over Current Relay.

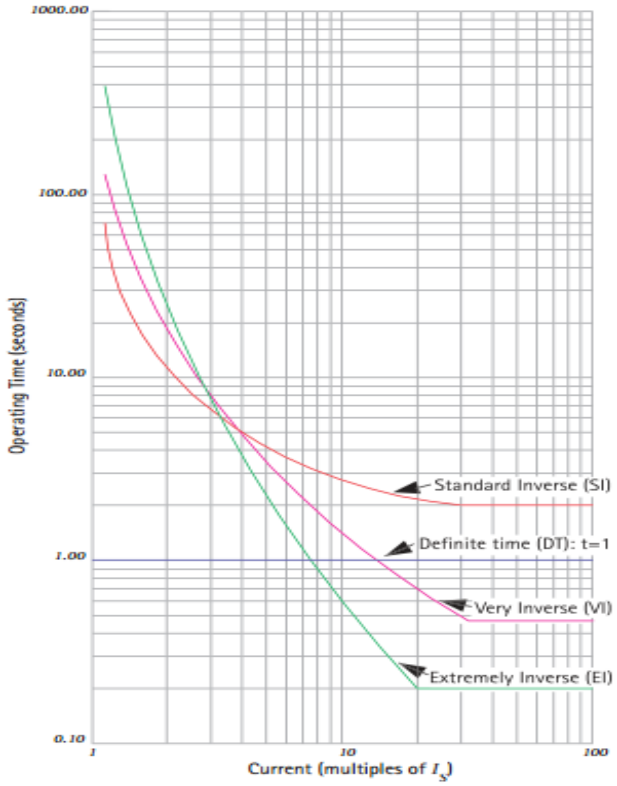
Relay Characteristic	Equation (IEC 60255)
Standard Inverse (SI)	$t = TMS \times \frac{0.14}{I_r^{0.02} - 1}$
Very Inverse (VI)	$t = TMS \times \frac{13.5}{I_r - 1}$
Extremely Inverse (EI)	$t = TMS \times \frac{80}{I_r^2 - 1}$

Inverse Time Over current Relays (IDMT Relay):

- In this type of relays, operating time is inversely changed with current. So, high current will operate over current relay faster than lower ones. There are standard inverse, very inverse and extremely inverse types.
- Discrimination by both 'Time' and 'Current'. The relay operation time is inversely proportional to the fault current.
- Inverse Time relays are also referred to as Inverse Definite Minimum Time (IDMT) relay.
- The operating time of an over current relay can be moved up (made slower) by adjusting the 'time dial setting'. The lowest time dial setting (fastest operating time) is generally 0.5 and the slowest is 10.
- Operates when current exceeds its pick-up value.
- Operating time depends on the magnitude of current.
- It gives inverse time current characteristics at lower values of fault current and definite time characteristics at higher values
- An inverse characteristic is obtained if the value of plug setting multiplier is below 10, for values between 10 and 20 characteristics tend towards definite time characteristics.

- Widely used for the protection of distribution lines.





Pre-Lab Homework:

Co-Ordination Procedure:
Correct overcurrent relay application requires knowledge of the fault current that can flow in each part of the network. Since large-scale tests are normally impracticable, system analysis must be used.

The data required for a relay setting study are:

i. One line diagram of the power system involved showing the type and rating of the protective devices and their associated CTs.
ii. Impedances in p.u of all power transformers, rotating machines and feeder circuits.
iii. Maximum and minimum values of short circuit currents that are expected to flow through each protective device.
iv. Starting current requirements of motors and the starting and stalling times of induction motors
v. Maximum peak load current through protective devices
vi. Decrement curves showing the rate of decay of the fault current supplied by the generators
vii. Performance curve of CTs

The relay settings are first determined to give the shortest operating times at maximum fault levels and then checked to see if operation will also be satisfactory at the minimum fault current expected. It is always advisable to plot the curves of relays and other protection devices, such as fuses, that are to operate in series, on a common scale. The basic rules for correct relay co-ordination can generally be stated as follows:

a. Whenever possible, use relays with the same operating characteristic in series with each other

b. Make sure that the relay farthest from the source has current settings equal to or less than the relays behind it, that is, that the primary current required to operate the relay in front is always equal to or less than the primary current required to operate the relay behind it.

Among the various possible methods used to achieve correct relay co-ordination are those using either time or overcurrent, or a combination of both. The common aim of all three methods is to give correct discrimination. That is to say, each one must isolate only the faulty section of the power system network, leaving the rest of the system undisturbed.

Study and clear concept of relay characteristics of IDMT relay, time grading, current grading and combination of current and time grading for over curent protection by IDMT relay are required to start this experiment.

Settings of IDMT O/C relay:
The standard IDMT relay has two controls- Plug setting (PS) and Time Setting Multiplier (TSM). The PS is a device used to provide a range of current settings at which the relay starts to operate. The setting ranges from 50% to 200% in the steps of 25% of the relay rated current. The TSM is a mean of adjusting the moveable backstop which controls the travel of the disc and thereby varies the time at which the relay closes its contact for a given value of fault current.

Apparatus:

- IDMT Relay
- Current Injector
- Clamp Meter
- Stop Watch

Precautions:

- Do not touch the bare conductors or connecting junctions.
- Do not connect/disconnect anything to/from the circuit without turning off main power.
- Be careful while operating the current injector.
- Be careful of handling small equipment /instruments inside the relay device.
- Be careful when power is supplied to the apparatus and any casing is kept open.

Experimental Procedure:

The PS of the relay is set at 5 Amp. And the TSM is set at 0.5 sec (say). The current coil of the relay is connected to (0-20 A) output terminals of the current injector set. Adjust the current output at little over 5 A. Then observe the operation time of the relay. As the current in the operating coil is increased, the relay operation time is reduced. So the operating current and time are recorded in the following table.

Measurement:

Sl. No.	Current in Relay Coil (A)	Operating Time of the Relay (Sec)
1		
2		
3		
4		
5		

Table: 6.1

- Draw the TCC of the IDMT relay using the data of the table with current in X axis and time in Y axis.
- Give examples where time delayed O/C relays is applied.

Discussion:

The major advantage of IDMT relay is their ability to discriminate. As discussed earlier, without this feature faults near the source would receive large fault current but by the introduction and correct setting of the IDMT relay this can be reduced to a minimum. By correct setting of the relays only the parts of the system after the fault will suffer a loss of supply and therefore only the smallest portion of the system will be affected. By using IDMT relays in conjunction with directional relays, the protection of ring bus system can be achieved.

Conclusion:

The purpose of protection is to monitor unwanted conditions and when such conditions arise to remove the fault condition in the shortest time possible whilst leaving unaffected areas operational.

Reference(s):

1. "Electric Power Systems: A Conceptual Introduction" by Alexandra Von Meier
2. "Switchgear Protection and Power Systems" by Sunil S Rao
3. PSP previous lab sheet