Date: 20-4-2021

Mason: Art of Protective Relaying

Fault Current $\Rightarrow$ Load Current
Relay picks up when the value of current is more than pick up value.

\[
\begin{align*}
4A & \Rightarrow 4.5A \\
& \Rightarrow 0.5A
\end{align*}
\]

a. Protection from Overloads
   - \( I \neq V \) Temperature?
   - Insulation break down.

b. Protection from Short Circuit
   - (5 to 20 times of Full Load Current)

Devices which can be used
- Fuses (HRC)
- MCB, CB, Oil, SF6...
- Series Connected Trip Coils (Switch's device)
- CTs, PTs
- Motor starting, Transient phenomenon
- Fault X

Overcurrent relay should not operate
Time delay

Motor starting, transient phenomenon
Classification of Overcurrent Relay

A. Based on Operating Time

1. Instantaneous Overcurrent Relay
   \[ I_{on} > I_{pickup} \]
   Definite Time Relay
   \[ I^0 t = K \]
   \[ t = \text{Operating Time} \]
   \[ K = \text{Constant} \]

B. Inverse Characteristics
   \[ I t = K \]
   \[ I \propto \frac{1}{t} \]
   For more current value, operating time is less
   \[ I^1 \text{ Severe Fault Condition} \]

Examples
a. Electro Magnetic Induction Relay
b. Permanent magnet moving coil relay

\[ I^2 > I^1 \]
\[ T^2 < T^1 \]
Exremely Inverse / very Inverse

\[ I^n t = k \]

1. \[ I_1 = 2 \]
2. \[ I_2 = 5 \]
3. \[ t_1 = \frac{10}{4} = 2.5 \]
4. \[ t_2 = \frac{10}{5} = 2 \]

\[ t = 2.5 \]

\[ \text{The characteristic with inverse and definite time is known as IDMT relay} \]

\[ I = 5, 500 \]

\[ 0.2 \]

\[ \text{Instantaneous Relay (Definite)} \]

\[ \text{Inverse Relay (} n = 1 \text{)} \]

\[ \text{Very Inverse Relay} \]

\[ \text{Extremely Relay} \]

\[ n = 2 \quad - \quad 8 \]
There are two fluxes
- Alternating current \( \phi_1 \rightarrow I_1 \) and \( \phi_f \)
- Induced current and fluxes \( \phi_2, I_2 \) and \( \phi_f \)

\[ f_{net} = f(t) \]

\[ \phi_m, \phi_m, \phi_m \]

\[ \theta \]

\[ \text{Torque} \]

\[ \text{Net Torque} = \text{Operational} - \text{Restraining} \]

\[ = \text{from this point relay starts working.} \]

\[ f_{net} = \phi_2 - \phi_1 \]

Trip circuit is based upon the rotation of twin disc.
Directional Overcurrent Relay

Construction is similar to watt hour energy meter Relay. It is having direction indicating quantities Voltage and Current.

\[ P = VI \cos \phi \]  \[ \text{Power factor} \]

\[ V \theta \]

\[ \theta_1 \]

\[ \theta_2 \]

\[ I \]

\[ \phi \]

\[ \theta \]

\[ \theta_1 \times V \times \theta_2 \times I \]

\[ V \]  \[ T \]

\[ \theta_1 \times VI \cos \theta_1 \]

\[ T \]

\[ VI \sin (90 - \theta) \]

\[ VI \cos \theta \]
Till now we have discussed

1. Induction Cup/Disc relay
   → 2 magnetic coils
   \[ E, U \] → supply current

2. Net torque generation = current
   Actuating quantity = current (I)

Diagram:

- Directional Over Current Relay
- Normal Condition: Generator \( \rightarrow \) Load
- Abnormal Condition: Load \( \rightarrow \) Generation

\[ \frac{3.5}{4 \text{amp.}}  \] reverse condition

Power

E. x
Construction of Direct-acting Overcurrent Relay

1. Actuating Quantity:
   - Voltage and Current
   - Movement of disc will depend on these quantities
   - \( V \times I \cos \phi \)
   - \( P = VI \cos \phi \)

2. \( \alpha = 90 - \phi \)

Current is lagging to voltage by \( \phi \) angle

\( P = VI \cos \phi \)

\( V \times I \times \cos \phi \sin \alpha \)

\( \phi_1 \times V \quad \phi_2 \times I \)

\( V \times I \times \sin(90 - \phi) \)
1. Voltage is an actual quantity for E-shaped magnet.

2. Current is an actuality quantity for U-shaped magnet.

3. \( \cos \phi \) power factor

\[
T = \phi I \cdot \phi U \sin(\theta + \phi)
\]

\( \theta + \phi = 90^\circ \)

1. \( T \) is the angle between max. torque line and reference voltage.

2. \( \phi \) is the angle between I and U.

\( \theta + \phi = 0, 180^\circ \)

Net torque expression becomes power.

\[
T = K VI \cdot \phi U \sin(90^\circ - 2\phi)
\]

\( T = K VI \cdot \phi U \sin(90^\circ - 2\phi) \)

\[
T = K VI \cdot \phi U \sin(90^\circ - 2\phi) \]

\[
\theta = 2 - \phi
\]

\[
\Delta \theta = 90^\circ
\]

Tomorrow Morning: Ex lab class

Class Code
PSE, TSM + Overcurrent kicks Gordon
Directional Relay

Directional Earth Fault Relay is used to protect the transformer/generator/alternator from over current fault. The relay sense the fault current in only one direction, the relay does not operate when the current in opposite direction. Due to high cost, the Directional Earth fault Relays are used only of high sensitive electrical machine such as alternator & High voltage transmission lines.

For Directional Over current relay, the fault current can flow in both the directions through the relay either forward or reverse, depending upon fault location. Therefore, it is necessary to make the relay respond for a particular defined direction, so that proper discrimination is possible. This can be achieved by introduction of directional control elements. During the opposite flow of current the CT polarity reverses, the power measuring device in which the system voltage is used as a reference for establishing the relative phase of the fault current.