In fig.[2] above, a fault in the transmission lines 0 is cleared by CB4 and CB5, since it is in the first zone of both of them.

A fault in transformer 2 should be cleared by the instantanious actions of CB5's and CB6's

If CB5 has no istantanious element control or fails to open, then CB6 opens instantaneously and CB4 sees the fault in the second zone and trips at the second zone tripping time for the back up protection. The arrangement indicates that CB4 will provide back up protection all the way into termanials of machine 3 if CB's 8, 6, 5 all fail to opperate.

Protective Relays

(1) Current relay: overcurrent
under current.

(2) Voltage relay: over voltage
under voltage

(3) Power Relays: over power
under power

(4) Directional Relays: AC, DC.

(5) Frequency relays: Over frequency
Under frequency

(6) Temperture Relays: Operate at a predetermined temp

(7) Differential Relays: Operate according to the scaler or vectorial difference between the two quantities such as current voltage etc.

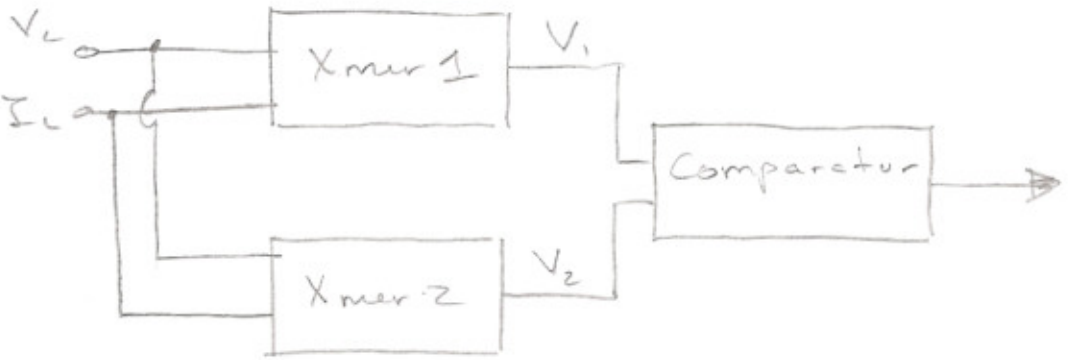
(8) Distance Relays: Operate according to the distance between the relay current transformer and the fault. Distance is

measured in terms of resistance, reactance, impedance.

We shall focus on RELAY COMPARATORS

Relay comparators can have any number of input signals, but for our purposes we shall consider 2 input comparators

Consider the following circuit:



The input to the two transformers, circuit 1 and 2 are V_L and I_L and the ouputs are V_1 and V_2 which are inputs to the comparato

These inputs (V_1, V_2), produce a trip signal whenever $|V_2| > |V_1|$ in amplitude comparison. we shall look at phase comparison later.

AMPLITUDE COMPARISON MODE

Assume that I_L laggs V_L by ϕ_L, then,

$$\bar{V}_L = |\bar{V}_L| \angle 0^\circ$$
$$\bar{I}_L = |\bar{I}_L| \angle -\phi_L^\circ$$

Impedance

$$\bar{Z}_L = \frac{\bar{V}_L}{\bar{I}_L} \quad \text{or} \quad \bar{Z}_L = |\bar{Z}_L| \angle \phi_L$$

we may write the outputs of the transformers V_1 and V_2 as linear combinations of the input quantities:

$$V_1 = k_1 \bar{V}_L + \bar{Z}_1 \bar{I}_L$$

$$V_2 = k_2 \bar{V}_L + \bar{Z}_2 \bar{I}_L$$

where

$$\bar{Z}_1 = |\bar{Z}_1| \angle \Psi_1 \; ; \; Z_2 = |\bar{Z}_2| \angle \Psi_2$$

The comparitor input voltages V_1 and V_2 are given by:

$$\bar{V}_1 = |\bar{I}_L| \{ k_1 |\bar{Z}_L| + |\bar{Z}_1| \angle \Psi_1 - \phi_L \}$$

$$\bar{V}_2 = |\bar{I}_L| \{ k_2 |\bar{Z}_L| + |\bar{Z}_2| \angle \Psi_2 - \phi_L \}$$

For amplitude comparison,

$$|\bar{V}_2| \geq |\bar{V}_1| \text{ and } |\bar{V}_2| = |\bar{V}_1|$$

is known as the threshold condition and it occurs when:

$$\left| k_1 |\bar{Z}_L| + |\bar{Z}_1| \angle \Psi_1 - \phi_L \right|^2 = \left| k_2 |\bar{Z}_L| + |\bar{Z}_1| \angle \Psi_2 - \phi_L \right|^2$$

Both sides of the above have the form

$$\left| A + B \angle \beta \right|^2 = \left| A + B\cos\beta + ; B\sin\beta \right|^2$$

$$= (A + B\cos\beta)^2 + (B\sin\beta)^2$$

$$= A^2 + B^2 + 2AB\cos\beta$$

Thus, the operating condition above can be written as:

$$(k_1^2 + k_2^2)(|\bar{Z}_L|^2) + 2|\bar{Z}_L| \{ k_1 |\bar{Z}_1| \cos(\Psi_1 - \Psi_2) - k_2 |\bar{Z}_2| \cos(\Psi_2 - \phi_L) + |\bar{Z}_1|^2 + |\bar{Z}_2|^2 \leq 0$$

The final result is an equation used for amplitude comparison relay. The choice for $k_1, k_2, |\bar{z}_1|, |\bar{z}_2|$ will provide different relay characteristics.

OHM RELAY

if we make

$$k_1 = k$$
$$k_2 = -k$$
$$\bar{z}_1 = 0$$
$$\bar{z}_2 = \bar{z}$$
$$\psi_2 = \psi$$

then our above equation reduces to:

$$\text{(A)}\quad |z_L|\left\{\cos\psi\cos\phi_L + \sin\psi\sin\phi_L\right\} \le \frac{|\bar{z}|}{2k}$$

$|\bar{z}_L|\cos\phi_L = R_L$ and $|z_L|\sin\phi_L = X_L$

we may write (A) with the equality sign (= defines threshold.)

$$\underbrace{X_L\sin\psi}_{y} = \underbrace{-R_L\cos\psi}_{mx} + \underbrace{\frac{|\bar{z}|}{2k}}_{c}$$

The above equation of a straight line

$$y = 0 \Rightarrow R_L = \frac{|\bar{z}|}{2k\cos\psi}$$

$$x = 0 \Rightarrow X_L = \frac{|\bar{z}|}{2k\sin\psi}$$

So the relay characteristics are sketched

on the X-R plane shown below