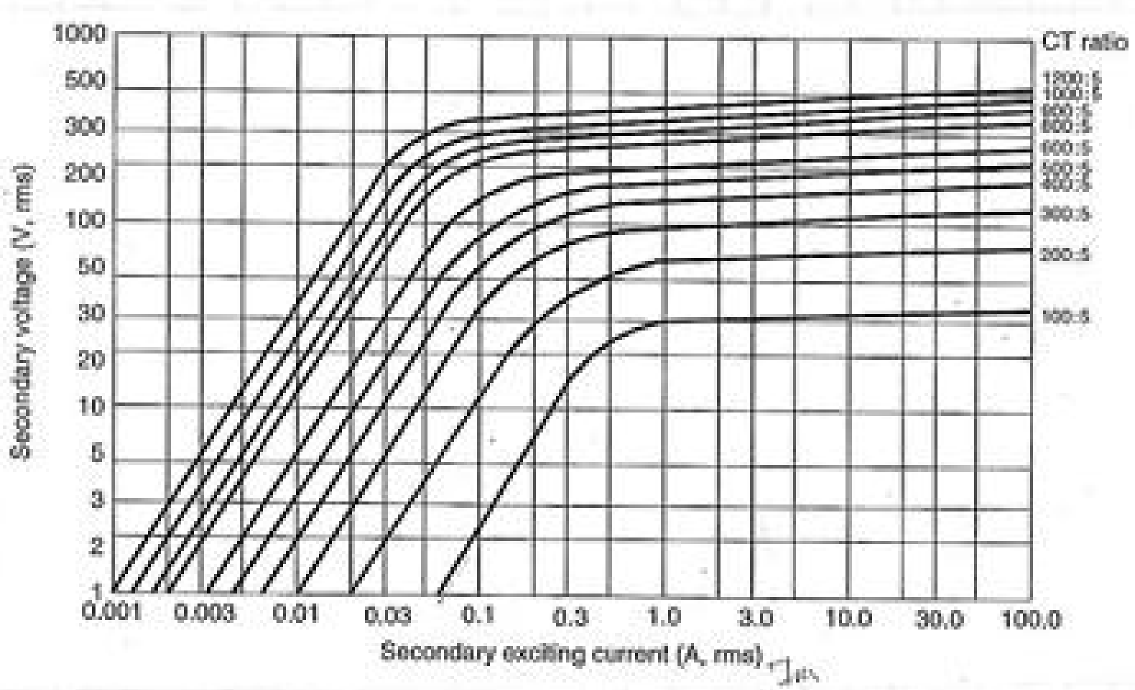
The magnetizing branch of a practical transformer is nonlinear, Z_m is not constant.

Actual excitation characteristic of TF must be taken into account in determining R.

Magnetizing characteristic of a Typical CT

(Plot of RMS magnetizing current versus RMS secondary voltage)

I_m for each E_m must be obtained from this curve, then used in previous equations.



600 : 5 MR	1200 : 5 MR	2000 : 5 MR	3000 : 5 MR
50 : 5	100 : 5	300 : 5	300 : 5
100 : 5	200 : 5	400 : 5	500 : 5
150 : 5	300 : 5	500 : 5	800 : 5
200 : 5	400 : 5	800 : 5	1000 : 5
250 : 5	500 : 5	1100 : 5	1200 : 5
300 : 5	600 : 5	1200 : 5	1500 : 5
400 : 5	800 : 5	1500 : 5	2000 : 5
450 : 5	900 : 5	1600 : 5	2200 : 5
500 : 5	1000 : 5	2000 : 5	2500 : 5
600 : 5	1200 : 5		3000 : 5

MR – Multiratio CT's.

Turns ratios for CTs have been standardized.

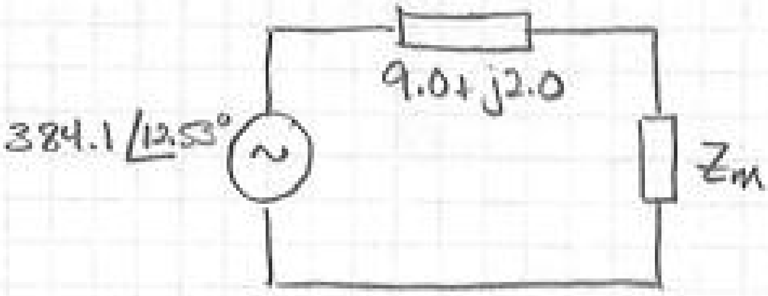
Recall: Thévenin equivalent circuits

⇒ Consists of a voltage source of

$$41.66 \times (9 + j2) = 384.1 \angle 12.53°$$

in series w/ the burden.

Thévenin equivalent.



Recall: $Z_m = |Z_m| \angle 60°$

$\cos 60 = 0.5$

$\sin 60 = 0.866$

so,

$$Z_m = |Z_m| (0.5 + j0.866)$$

Magnetizing current, I_m, is

$$I_m = \frac{384.1}{[|Z_m|(0.5 + j0.866) + (9.0 + j2.0)]}$$

$$E_2 = I_m Z_m$$

} * two equations w/ parameter Z_m

For several values of $|Z_m|$

$\lvert Z_m \rvert$	$\lvert I_m \rvert$	$\lvert E_2 \rvert$
∞	0	384.1
100	3.61	361.0
10	21.82	218.2

Superimposing these points on nonlinear curves intersects at

$$I_m = 17A \quad , \quad E_2 = 260V$$

Reworking w/ these values yields:

$$\bar{I}_1 = 41.66\angle 0^\circ \qquad |Z_m| = \frac{260}{17} = 15.3$$

so,

$$\bar{Z}_m = 15.3\angle 60^\circ$$

$$I_m = \frac{\bar{I}_1}{9 + j2.0 + \bar{Z}_m}(9 + j2.0)$$

$$= \frac{41.66\angle 0^\circ}{9 + j2.0 + 15.3\angle 60^\circ}(9 + j2.0)$$

⋮

$$= \frac{384.105\angle 12.5}{22.58\angle 42.5} = 17\angle -29.97^\circ$$

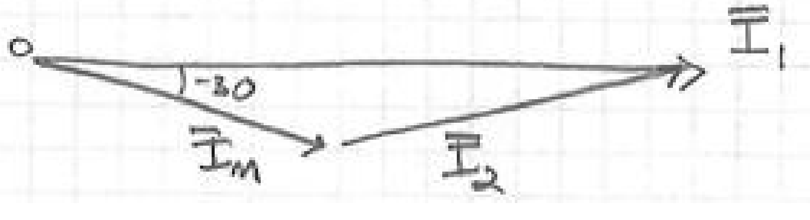
then

$$\bar{I}_2 = \bar{I}_1 - \bar{I}_m$$

$$= 41.66\angle 0^\circ - 17\angle -29.97^\circ$$

⋮

$$= 28.4\angle 17.5^\circ$$



Then,

$$\varepsilon = \frac{I_m}{I_1}$$

$$= \frac{17\angle -29.97}{41.66\angle 0^\circ}$$

$$= 0.408\angle -29.97$$

And

$$R = \frac{1}{1-\varepsilon} = \frac{1}{1 - 0.908\angle -29.97^\circ}$$

$$= 1.47\angle -17.51^\circ$$

This CT is in <u>severe</u> saturation at this current and at the burden chosen.

In practice, must be used w/ much smaller burdens to provide reasonable accuracies under faulted conditions