

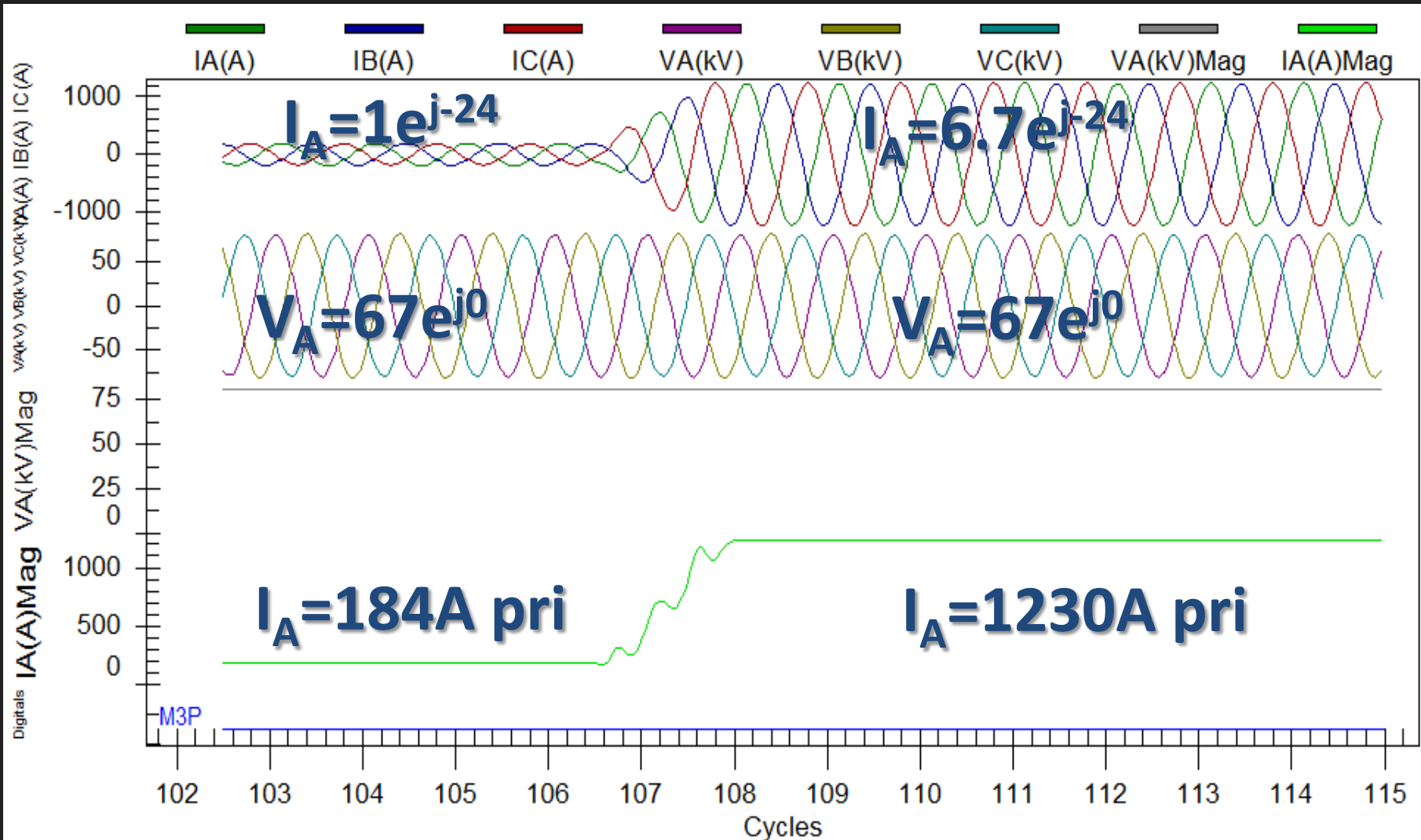
Distance Element Testing – Back to Basics

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Question 1

$Z_{app} = |V_A| / |I_A| < Z_{3P} \dots$ Why Doesn't Relay Trip?



Question 2

ZxP Setting Range is 0.05 – 64 Ohms Secondary.

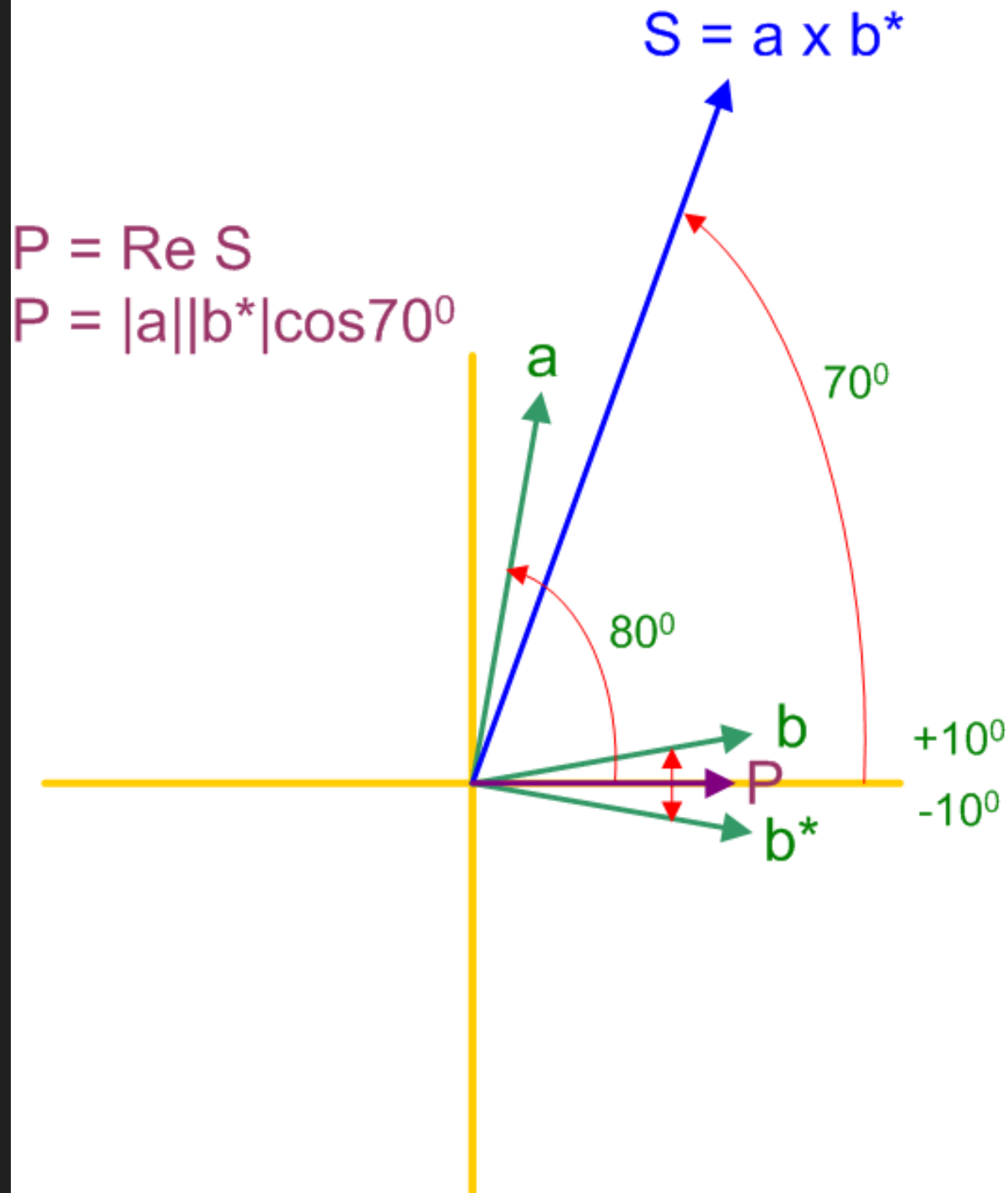
What is the *smallest* impedance
the relay can measure?

Recall

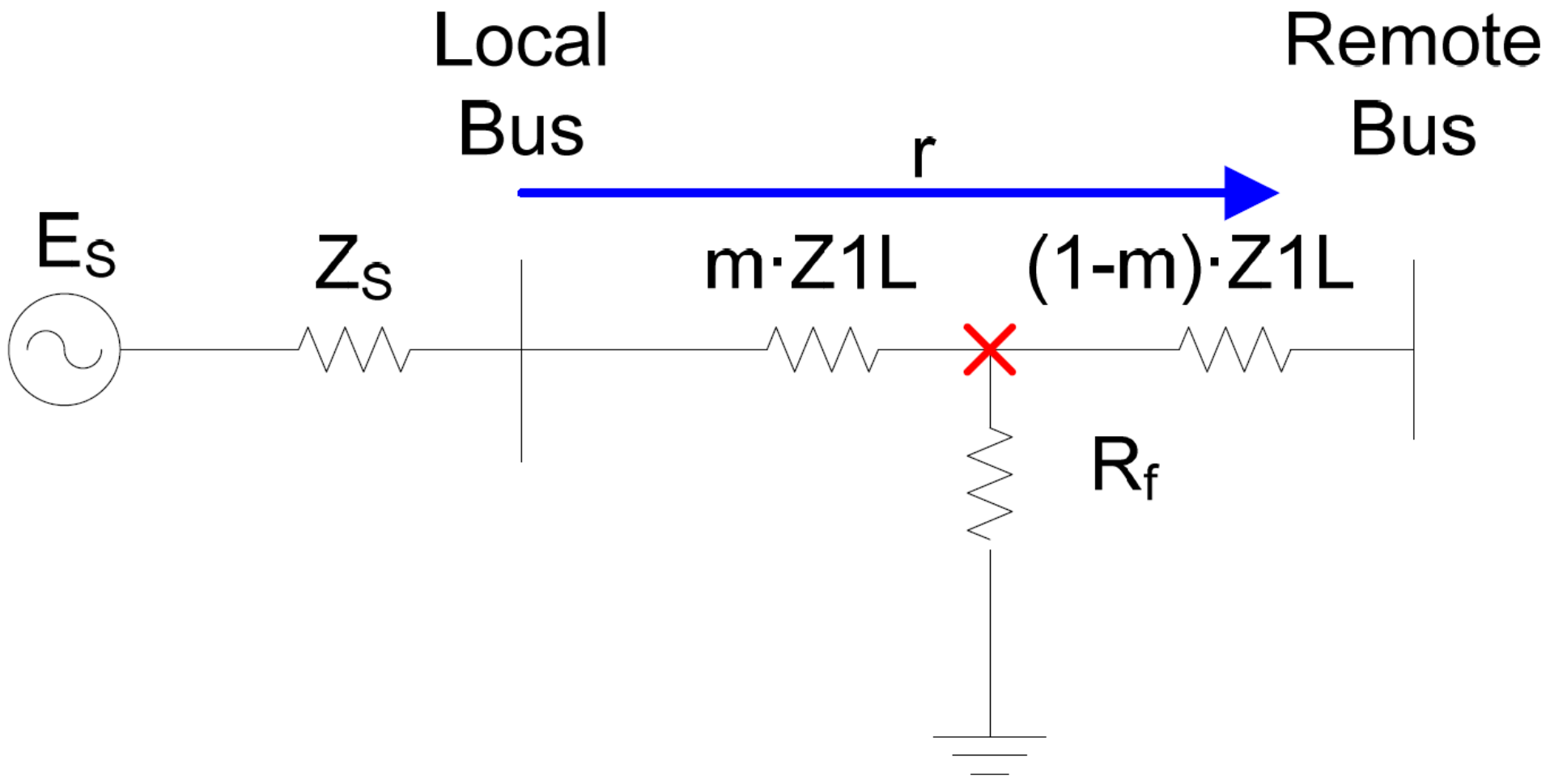
Angle of S =
Angle by which
 a leads b

P is a phase
angle
comparator

$P = +$ when
 $a \neq 0$, $b \neq 0$, and
Angle of S is
 $0^\circ \pm 89.9999^\circ$

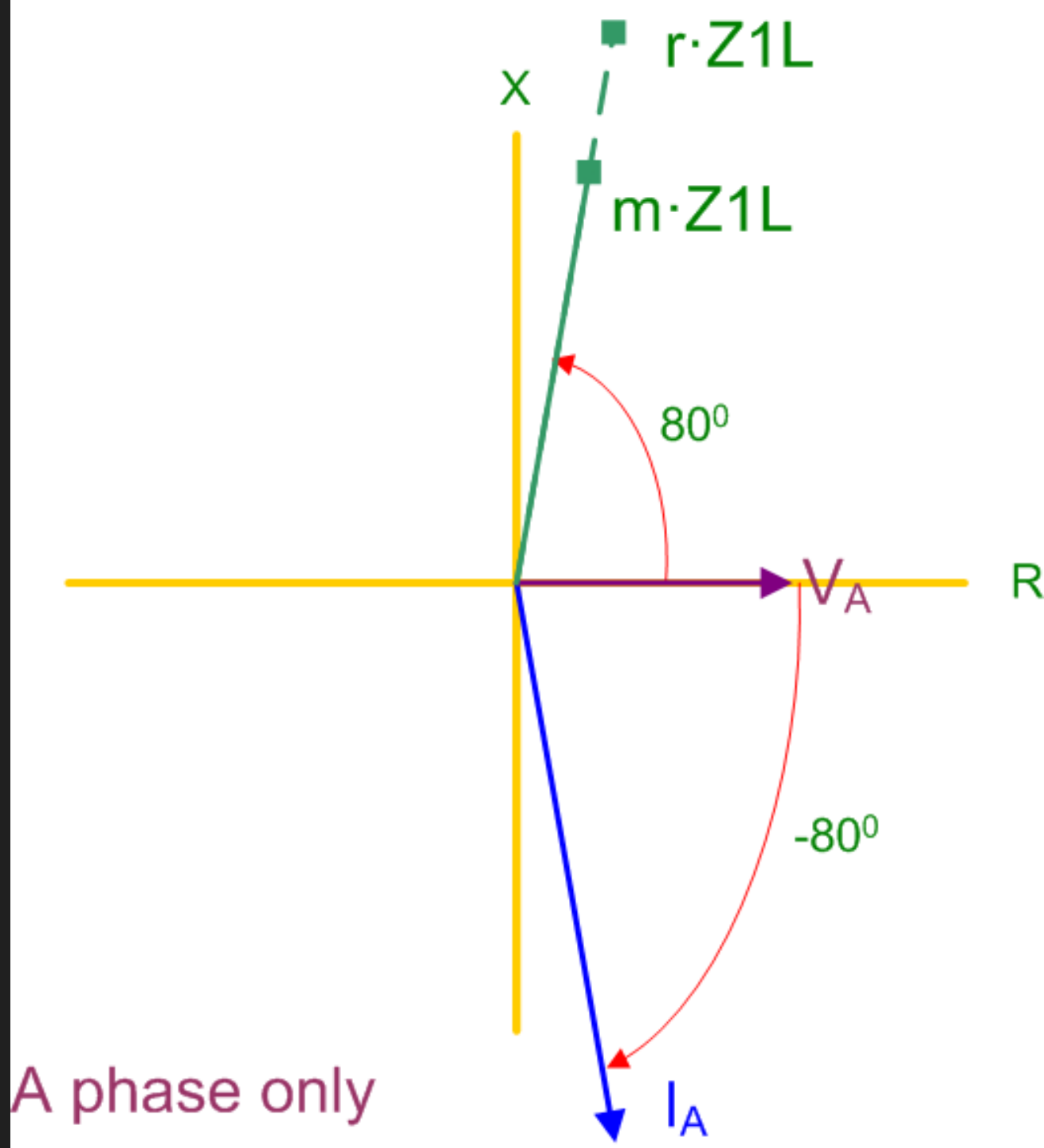


Consider a Simple Radial System

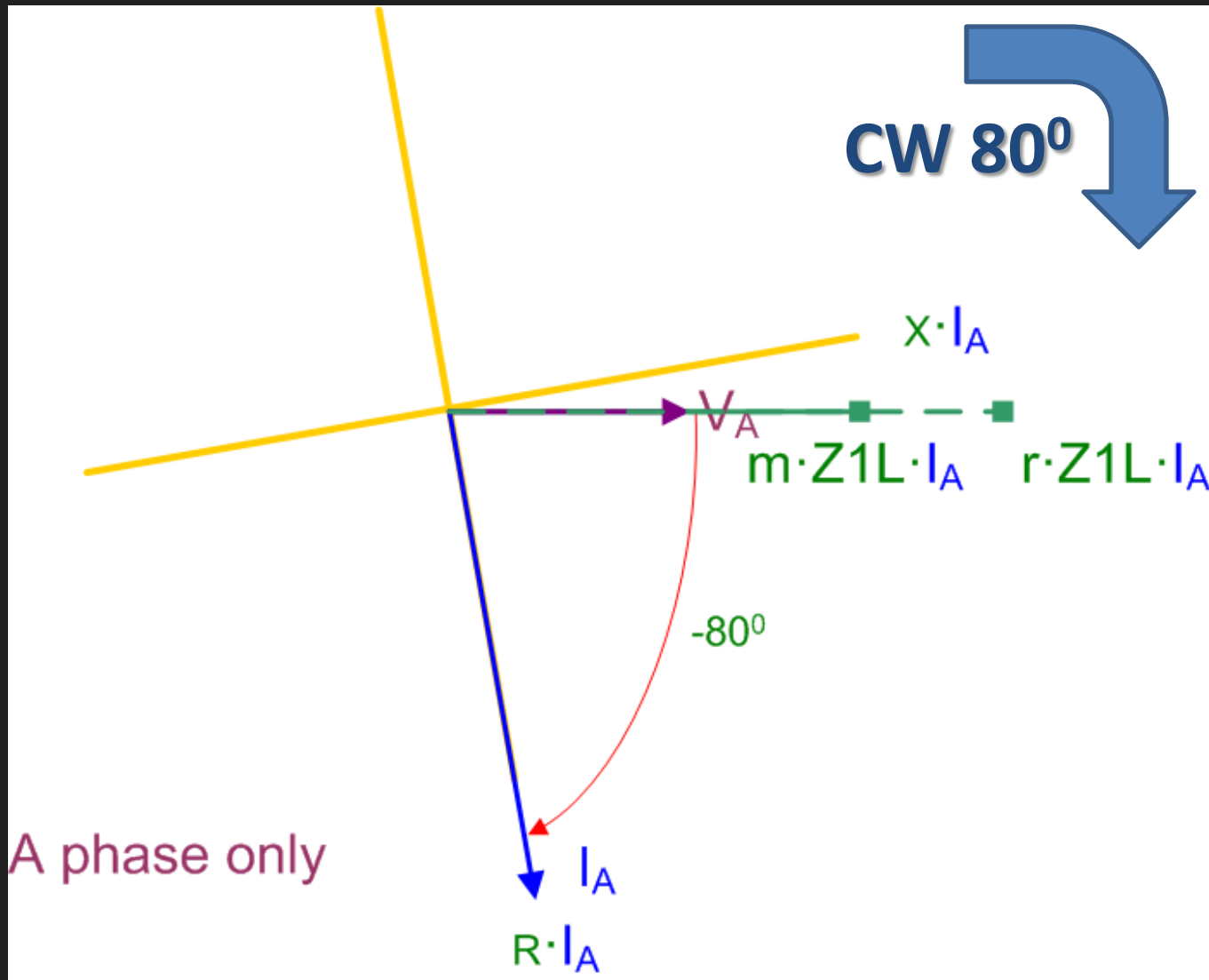


3 Phase Fault at Location m

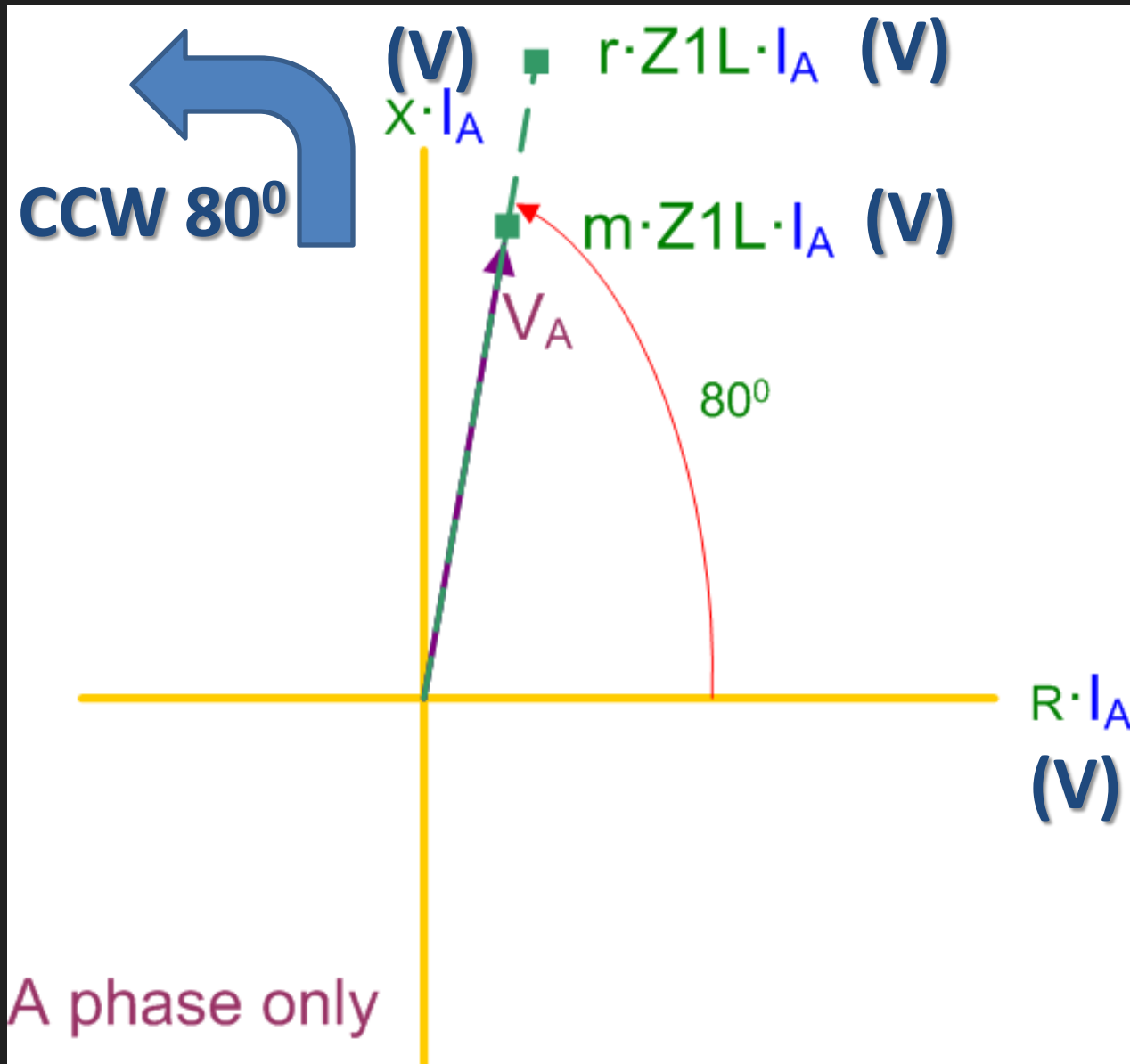
$r = \text{reach}$



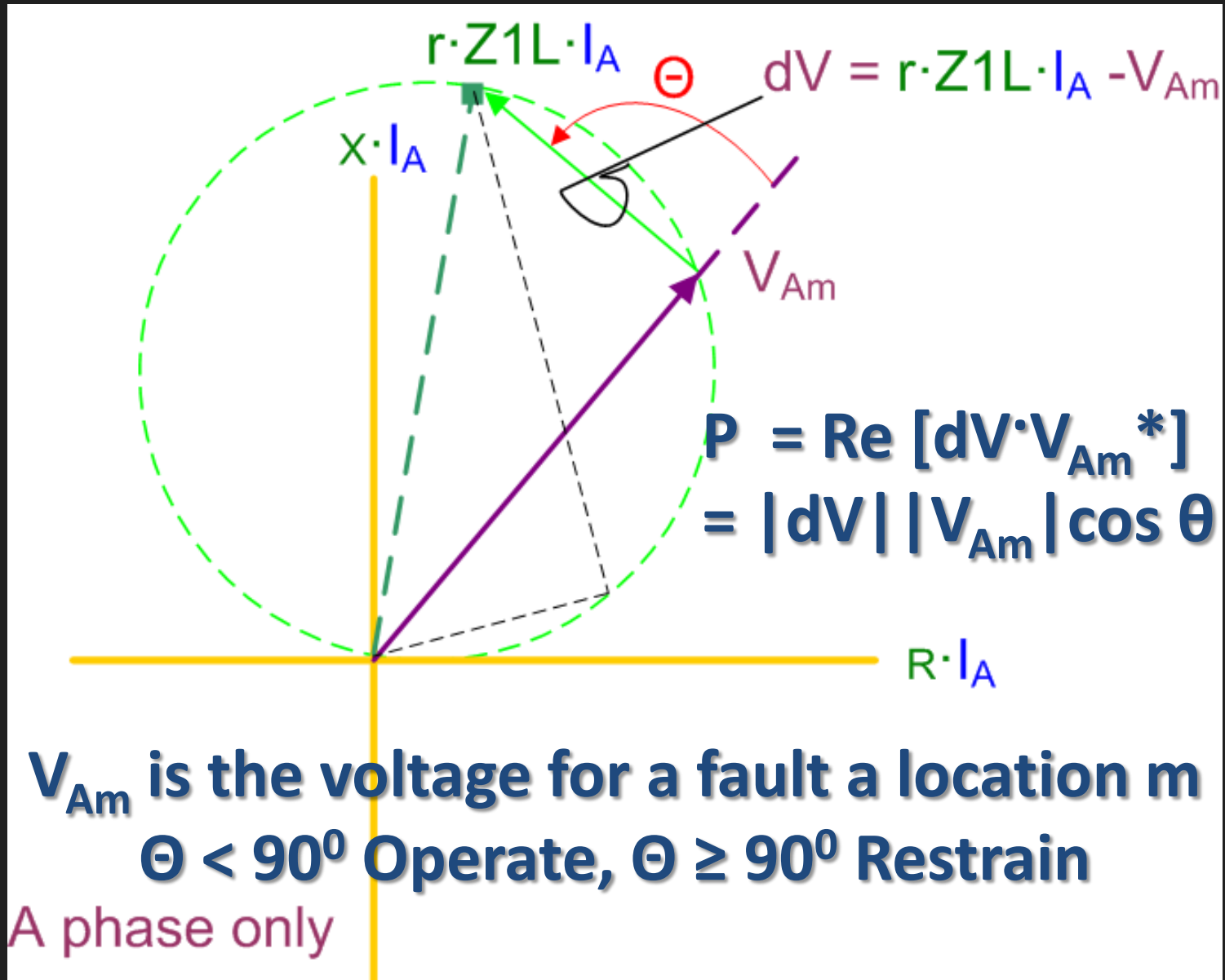
Convert Axis and Z1L to Voltages by Multiplying by I_A



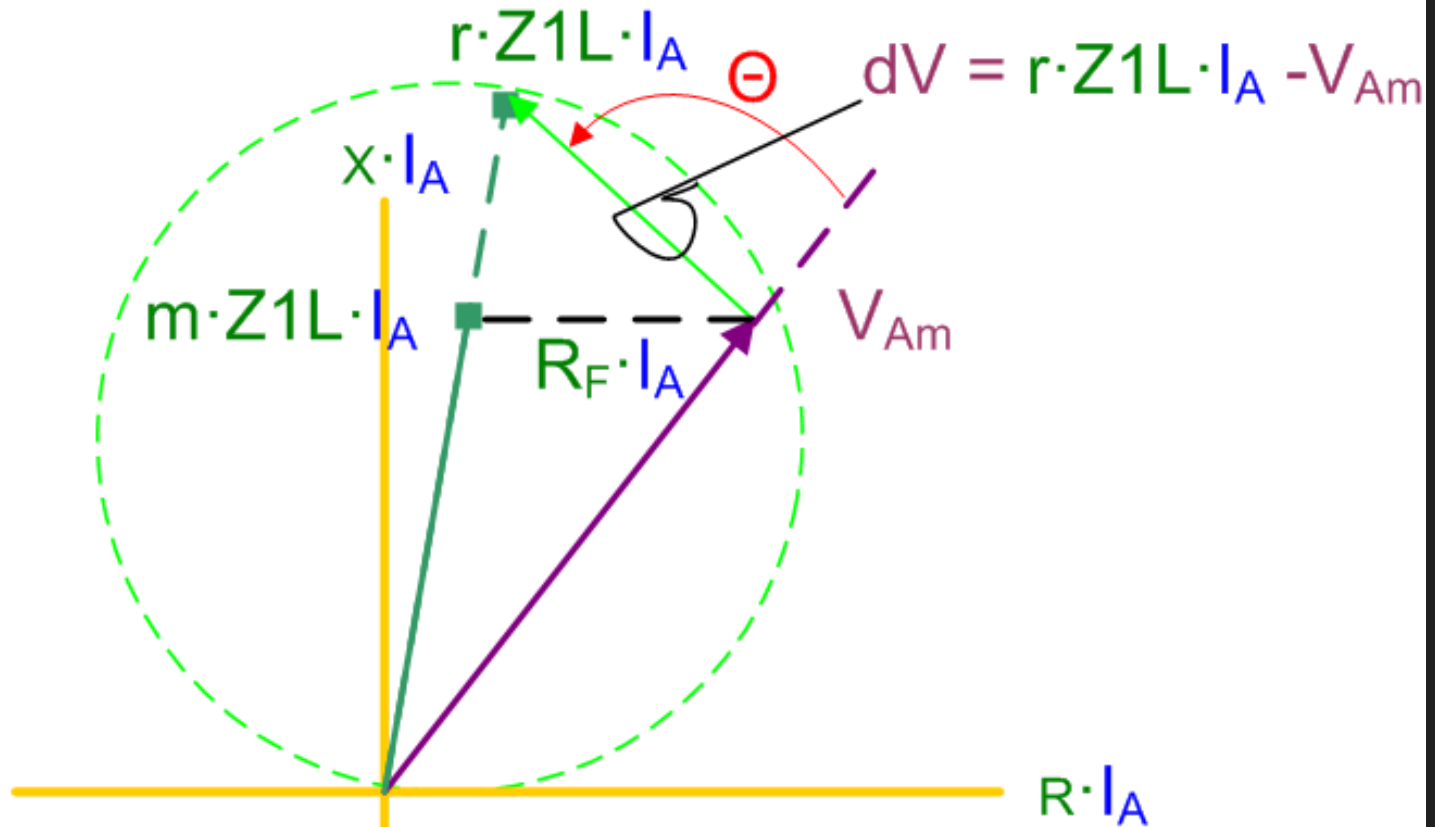
Rotate Back to a Familiar Reference



$\theta = 90^\circ$ Defines Point on a Circle



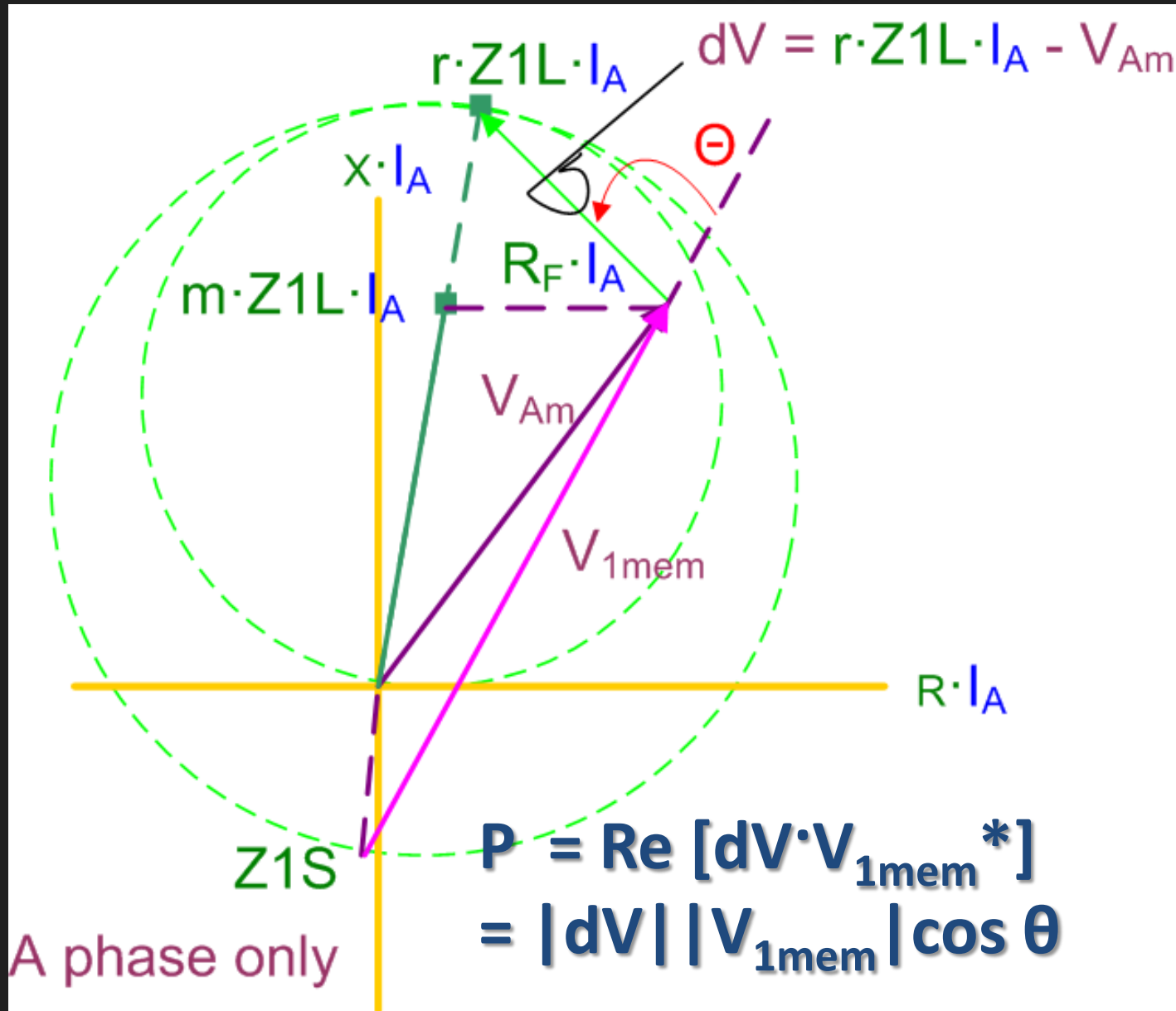
$\theta < 90^\circ$ Means Operate



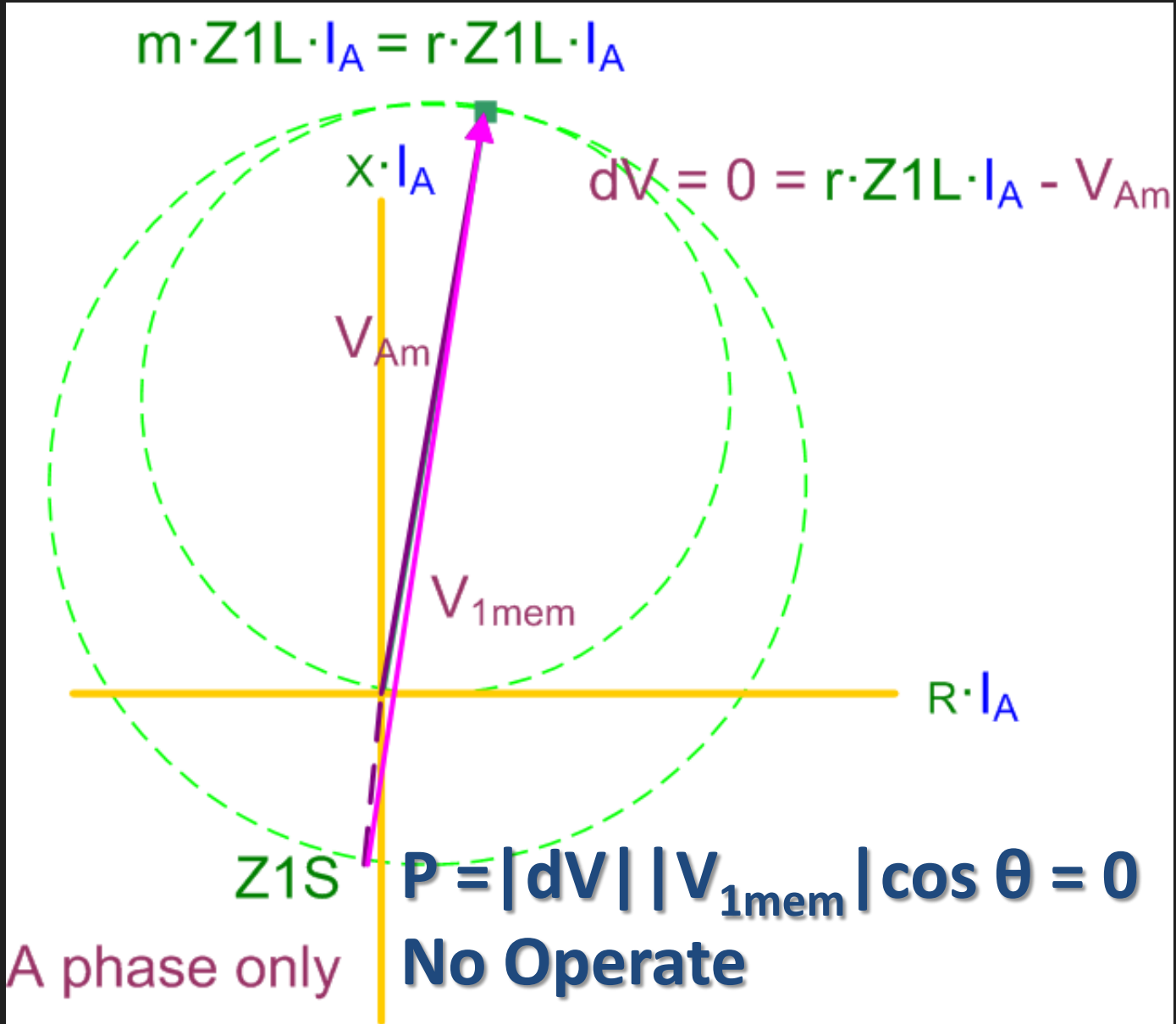
$$P = \text{Re} [dV \cdot V_{Am}^*] = |dV| |V_{Am}| \cos \theta$$

A phase only

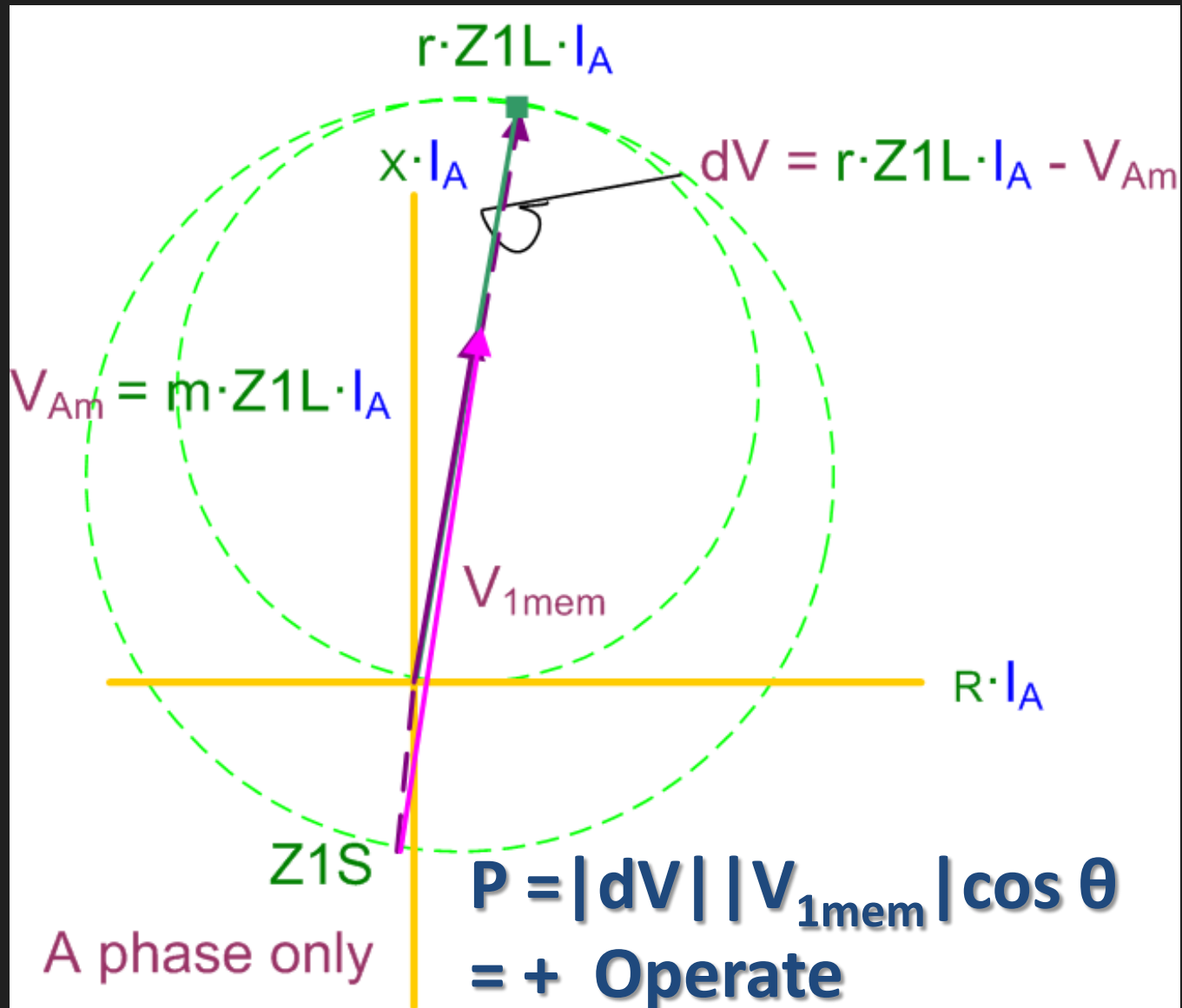
Self Polarized vs. V_{1mem} Polarized



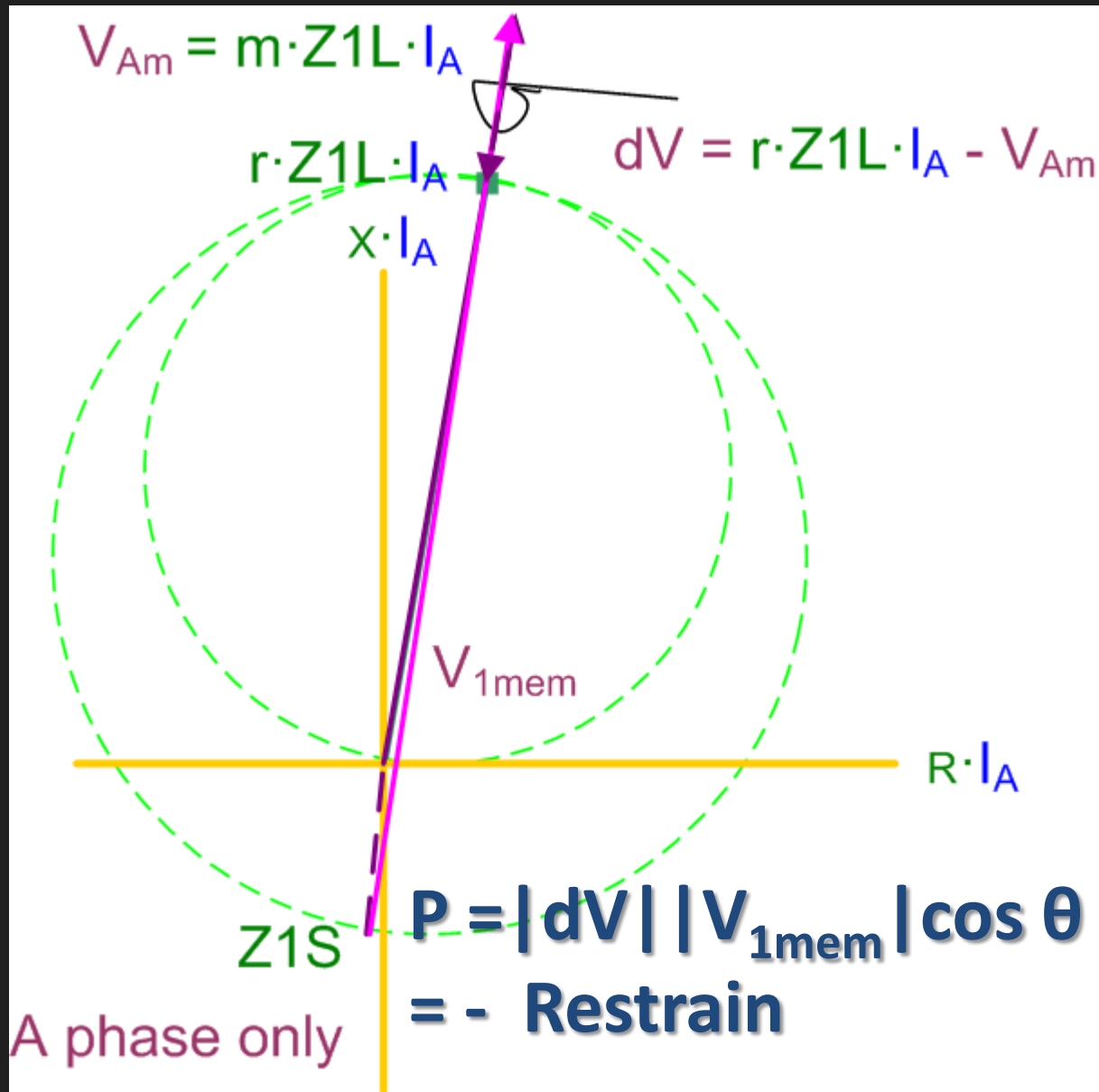
Fault at $m = r$



Fault at $m < r$



Fault at $m > r$



$$V_{\text{FAULT}} = V_{\text{PREFault}}$$

$$P = |dV| |V_{1\text{mem}}| \cos \theta$$

$$dV = 12.6e^{j72^\circ} \bullet 6.7e^{j-24^\circ} - 67e^{j0^\circ} = 64e^{j100^\circ}$$

$$V_{1\text{mem}} = 67e^{j0^\circ}$$

$$\theta = 100^\circ$$

$$P = \text{negative} = \text{restrain}$$

$Z = |V| / |I|$ Does Not Make a Distance Relay

Characteristic Mapping

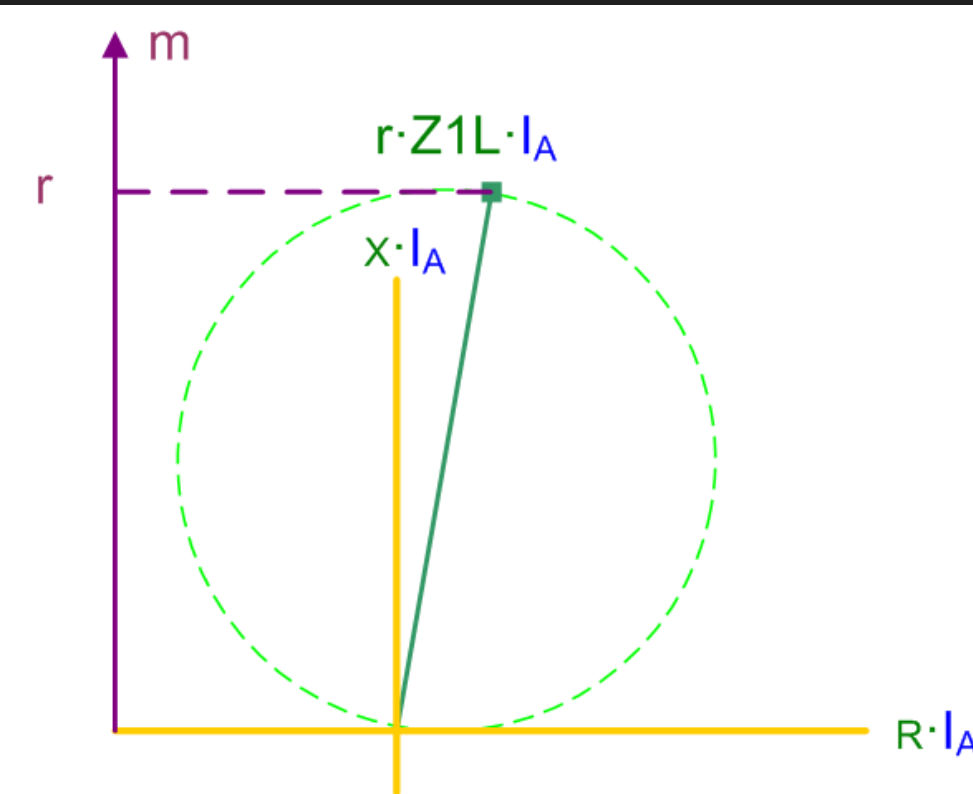
$$P = \text{Re}[dV \bullet V_{1\text{mem}}^*] = 0$$

$$r = \frac{\text{Re}[V \bullet V_{1\text{mem}}^*]}{\text{Re}[Z_{1L} \bullet I \bullet V_{1\text{mem}}^*]}$$

$$+ V_{\text{pol}} = V_{1\text{mem}}$$

$$+ \text{denominator} = 67$$

**= Reliable for
m = 0 faults**



Zero Volt Fault Test

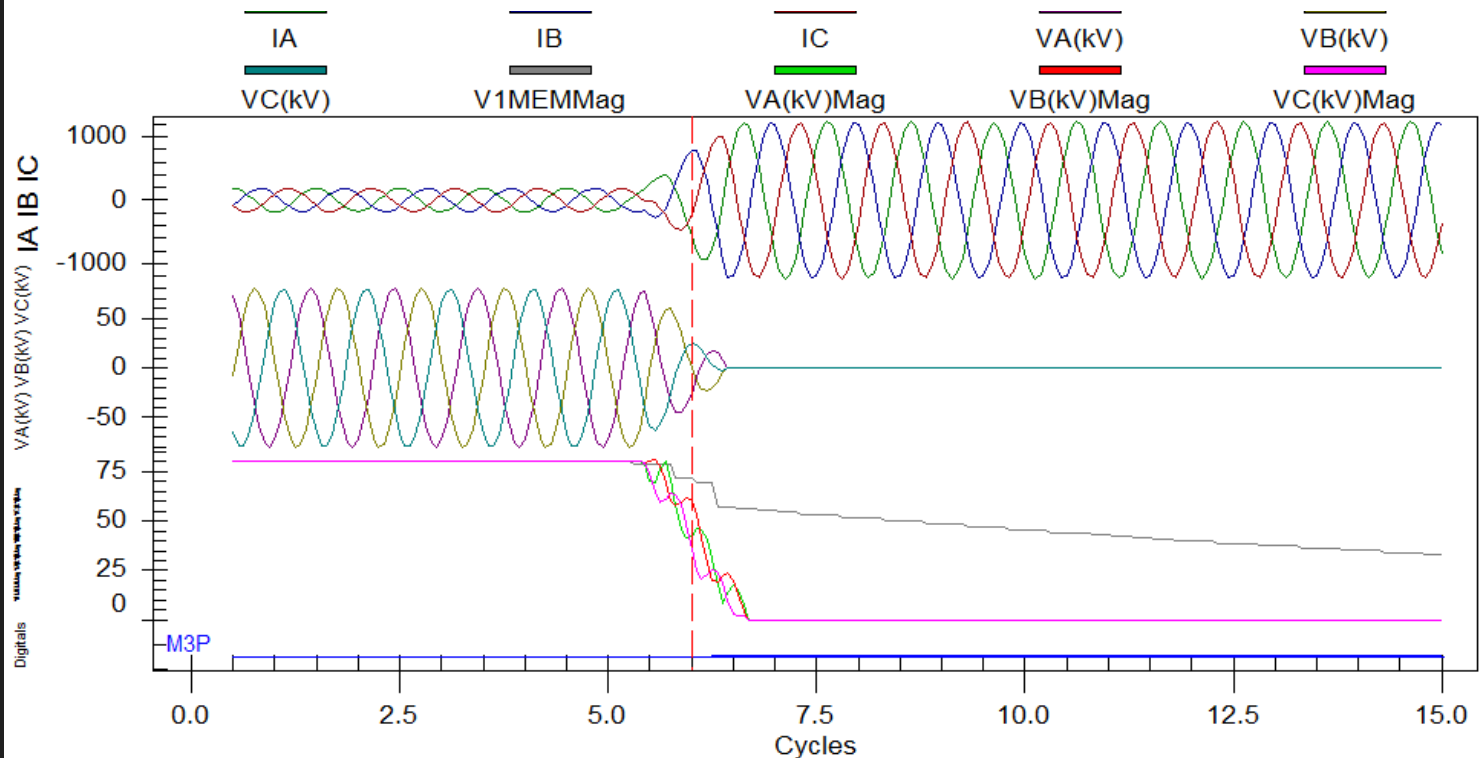
$$\underline{\underline{MABD}} := \left[\text{Re} \left[((1 \angle Z1ANG)) \cdot ((IA - IB)) \cdot \overline{(VPOLVa - VPOLVb)} \right] \right] + .00001$$

$$\underline{\underline{MAB}} := \frac{\text{Re} \left[(VA - VB) \cdot \overline{(VPOLVa - VPOLVb)} \right]}{MABD}$$

$$MAB = 0$$

$$Z3P(MAB) := \begin{pmatrix} 0 & \text{if } |MAB| > 12.6 \\ 1 & \text{otherwise} \end{pmatrix}$$

$$Z3P(MAB) = 1$$



Questions?

