Calculos parcial diciembre 2015:

$U := 15$ kV $\omega := 2 \cdot \pi \cdot 50$ Hz $R := 8$ ohm

$X_{Td} := 0.07 \cdot \frac{U^2}{7.5} \cdot 1\text{j}$ $X_{Td} = 2.1\text{j}$ ohm

$X_{To} := X_{Td}$

Datos de linea 15 kV :

$Z_{Ld} := 0.57 + 0.3\text{j}$ ohm/km $L_{tot} := 3 + 1$ km

$Z_{Lo} := 3 \cdot Z_{Ld}$ $C_L := 0.17$ $\frac{\mu F}{km}$ $I_{Ctot} := 3 \left(1\text{j} \cdot \omega \cdot C_L \cdot L_{tot} \cdot \frac{U}{\sqrt{3}} \right) \cdot 10^{-3}$

$|I_{Ctot}| = 5.55$ A $I_{51N} := 2 \cdot |I_{Ctot}|$ $I_{51N} = 11.1$ A

Corrientes de cortocircuito maximo 3F en barra :

$Icc_{3Fbarra} := \frac{\left(\frac{U}{\sqrt{3}} \right)}{0.5 \cdot X_{Td}}$ $|Icc_{3Fbarra}| = 8.248$ kA $Idin := 2.5 \cdot |Icc_{3Fbarra}|$

$Idin = 20.62$ kAcr

$Icc_{3FA} := \frac{\left(\frac{U}{\sqrt{3}} \right)}{0.5 \cdot X_{Td} + Z_{Ld} \cdot 3}$ $|Icc_{3FA}| = 3.339$ kA

$I_{50} := \frac{\left(\frac{U}{\sqrt{3}} \right)}{0.5 \cdot X_{Td} + Z_{Ld} \cdot 3 \cdot 0.8}$ $|I_{50}| = 3.871$ kA

$Icc_{3FBmin} := \frac{\left(\frac{U}{\sqrt{3}} \right)}{X_{Td} + Z_{Ld} \cdot (3+1) + 40}$ $|Icc_{3FBmin}| = 0.204$ kA

$I_{51} := 0.8 \cdot |Icc_{3FBmin}|$ $I_{51} = 0.163$ kA

Impongo 200 ms de margen fusible-interruptor, curva MI:

$T_{dF} := \frac{0.21}{13.5} \cdot \left(\frac{|Icc_{3FA}|}{I_{51}} - 1 \right)$ $T_{dF} = 0.302$ seg

Corrientes de cortocircuito F-Tierra :

$$Icc_{FTmax} := \frac{3 \cdot \left| \left(\frac{U}{\sqrt{3}} \right) \right|}{0.5 \cdot \left(X_{Td} \cdot 2 + X_{To} + 3 \cdot R \right)} \qquad \left| Icc_{FTmax} \right| = 2.094 \quad \text{kA}$$

$$Icc_{FTAmax} := \frac{3 \cdot \left| \left(\frac{U}{\sqrt{3}} \right) \right|}{\left(0.5 \cdot X_{Td} + Z_{Ld} \cdot 3 \right) \cdot 2 + Z_{Lo} \cdot 3 + 0.5 \cdot \left(X_{To} + 3 \cdot R \right)}$$

$$\left| Icc_{FTAmax} \right| = 1.185 \quad \text{kA}$$

$$I_{50N} := \frac{3 \cdot \left| \left(\frac{U}{\sqrt{3}} \right) \right|}{\left(0.5 \cdot X_{Td} + Z_{Ld} \cdot 3 \cdot 0.8 \right) \cdot 2 + Z_{Lo} \cdot 3 \cdot 0.8 + 0.5 \cdot \left(X_{To} + 3 \cdot R \right)}$$

$$\left| I_{50N} \right| = 1.298 \quad \text{kA}$$

Se desea que por razones de seguridad el relé actue en no mas de 1seg
para corrientes a tierra mayores o iguales a 300 A:

$$T_{dT} := \frac{1}{80} \cdot \left(\left(\frac{300}{I_{51N}} \right)^2 - 1 \right) \quad T_{dT} = 9.118 \, \text{seg} \quad tei := 80 \cdot \frac{T_{dT}}{\left(\frac{\left| Icc_{FTAmax} \right|}{I_{51N} \cdot 0.001} \right)^2 - 1} = 0.064 \quad \text{seg}$$

$$T_{dT} := \frac{1}{13.5} \cdot \left(\frac{300}{I_{51N}} - 1 \right) \quad T_{dT} = 1.928 \, \text{seg} \quad tmi := 13.5 \cdot \frac{T_{dT}}{\frac{\left| Icc_{FTAmax} \right|}{I_{51N} \cdot 0.001} - 1} = 0.246 \quad \text{seg}$$

....Coordina bien curva MI, no la EI, ya que fusible actua a los 13 ms para esa corriente, por tanto el minimo es 213 ms y la MI da 246 ms

Si quisiera la solucion "optima", impongo margen minimo, para una curva MI (la EI nunca va a cumplir, abrira en mas de un segundo):

$$T_{dTop} := \frac{0.2 + 0.013}{13.5} \cdot \left(\frac{\left| Icc_{FTAmax} \right|}{I_{51N} \cdot 0.001} - 1 \right) \qquad T_{dTop} = 1.668 \quad \text{seg}$$

verificacion:

$$tmi\_300A := 13.5 \cdot \frac{T_{dTop}}{\frac{300}{I_{51N}} - 1} = 0.865 \quad \text{seg, menor a un segundo, verifica}$$

$$Icc_{FTBmin} := \frac{3 \cdot \left| \left(\frac{U}{\sqrt{3}} \right) \right|}{\left(X_{Td} + Z_{Ld} \cdot (3+1) \right) \cdot 2 + Z_{Lo} \cdot (3+1) + X_{To} + 3 \cdot (R+40)}$$

$|Icc_{FTBmin}| = 0.167$ kA

$$Icc_{FTAmin} := \frac{3 \cdot \left| \left(\frac{U}{\sqrt{3}} \right) \right|}{\left(X_{Td} + Z_{Ld} \cdot 3 \right) \cdot 2 + Z_{Lo} \cdot 3 + X_{To} + 3 \cdot (R+40)}$$

$|Icc_{FTAmin}| = 0.17$ kA

Cálculo umbral de tension relé sobretensión residual (59N):

$U_{59N} := 3 \cdot R \cdot |Icc_{FTBmin}|$ $U_{59N} = 4$ kV Caso acople abierto

Caso acople cerrado:

$$Icc_{FTBacopl\_min} := \frac{3 \cdot \left| \left(\frac{U}{\sqrt{3}} \right) \right|}{\left(0.5 \ X_{Td} + Z_{Ld} \cdot (3+1) \right) \cdot 2 + Z_{Lo} \cdot (3+1) + 0.5 \ \left(X_{To} + 3 \cdot R \right) + 3 \cdot 40}$$

$|Icc_{FTBacopl\_min}| = 0.181$ kA

$U_{59N} := 3 \cdot R \cdot 0.5 \cdot |Icc_{FTBacopl\_min}|$ $U_{59N} = 2.17$ kV ...elijo este porque es menor

Resumen:

$\|I_{50}\| = 3.871$	kA	$\|I_{51}\| = 0.163$	kA
$\|I_{50N}\| = 1.298$	kA	$\|I_{51N}\| = 11.1$	A
$T_{dF} = 0.302$ seg		$T_{dT} = 1.928$	seg
$U_{59N} = 2.17$	kV	$T_{dTop} = 1.668$	seg

Corriente nominal Trafos:

$In := \frac{100}{\sqrt{3} \cdot U}$ $In = 3.849$ A $Ideriv := 5 \cdot In$ $Ideriv = 19.245$ A

$I_{inrush} := 12 \cdot In$ $I_{inrush} = 46.188$ A $t_{inrush} := 100$ ms

$I_{inr\_deriv} := 5 \cdot Ideriv$ $I_{inr\_deriv} = 96.225$ A $t_{inrush} := 100$ ms

I2t de Trafo:

$5 \cdot In = 19.245$ A para t = 50 seg

$25 \cdot In = 96.225$ A para t = 2 seg

Verificación fusibles:

$I_{fus} := 15$ A $I_{3fus} := 4 \cdot I_{fus}$ $I_{3fus} = 60$ A $|Icc_{FTAmin}| = 0.17$ kA

$I_{fus} := 6$ A $I_{3fus} := 4 \cdot I_{fus}$ $I_{3fus} = 24$ A $|Icc_{FTBmin}| = 0.167$ kA