Global Definitions

$$I := \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad ZER := \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \qquad II := \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix} \qquad ERO := \begin{pmatrix} 0 & 0 & 0 \end{pmatrix}$$

$$IT := \begin{pmatrix} 1 & 1 & 1 \end{pmatrix}$$

$$a \equiv -0.5 + 0.8660254j \qquad deg \equiv \frac{\pi}{180} \qquad BAL \equiv \begin{pmatrix} 1 & a^2 & a \end{pmatrix}^T \qquad es := 66.4 \cdot e^{j \cdot \delta \cdot deg} \qquad er := 66.4 \qquad INF \equiv 10^{10}$$

Convert +-0 to phase impedances:

$$zs(z0, z1) := \frac{2 \cdot z1 + z0}{3} \qquad zm(z0, z1) := \frac{z0 - z1}{3}$$

$$Z(z0, z1) := \begin{pmatrix} zs(z0, z1) & zm(z0, z1) & zm(z0, z1) \\ zm(z0, z1) & zs(z0, z1) & zm(z0, z1) \\ zm(z0, z1) & zm(z0, z1) & zs(z0, z1) \end{pmatrix}$$

$$XYZS2 := \begin{pmatrix} XS2 & 0 & 0 \\ 0 & YS2 & 0 \\ 0 & 0 & ZS2 \end{pmatrix} \qquad XYZS1 := \begin{pmatrix} XS1 & 0 & 0 \\ 0 & YS1 & 0 \\ 0 & 0 & ZS1 \end{pmatrix}$$

These Matrices are included to provide breaker switches at the S-End terminals

$$XYZR2 := \begin{pmatrix} XR2 & 0 & 0 \\ 0 & YR2 & 0 \\ 0 & 0 & ZR2 \end{pmatrix} \qquad XYZR1 := \begin{pmatrix} XR1 & 0 & 0 \\ 0 & YR1 & 0 \\ 0 & 0 & ZR1 \end{pmatrix}$$

These Matrices are included to provide breaker switches at the R-End terminals

$$ZS := Z(Z0S, Z1S) \qquad ZR := Z(Z0R, Z1R) \qquad ZL1 := Z(Z0L1, Z1L1) \qquad ZL2 := Z(Z0L2, Z1L2)$$

Source and line impedances to the fault

$$ZC1 := ZZC1 \cdot I \qquad ZC2 := ZZC2 \cdot I \qquad Z12 := ZM \cdot II$$

$$H11 := ZS + m \cdot ZL1 + ZC1 + XYZS1 \qquad H12 := ZS + m \cdot Z12 \qquad H22 := ZS + m \cdot ZL2 + ZC2 + XYZS2$$

$$H33 := ZR + (1 - m) \cdot ZL1 + XYZR1 \qquad H34 := ZR + (1 - m) \cdot Z12 \qquad H44 := ZR + (1 - m) \cdot ZL2 + XYZR2$$

Prefault Currents and Voltages

$$ES := es \cdot BAL \qquad ER := er \cdot BAL$$

$$ZDENOM := ZL1 + ZC1 + ZL2 + ZC2 \qquad MONEDZ := ZDENOM^{-1}$$

$$ZPRE := ZS + ZR + (ZL1 + ZC1) \cdot (ZL2 + ZC2) \cdot MONEDZ$$

$$ISPRE := ZPRE^{-1} \cdot (ES - ER) \qquad VSPRE := ES - ZS \cdot ISPRE \qquad VRPRE := ER - ZR \cdot ISPRE$$

$$IS1PRE := (ZL2 + ZC2) \cdot MONEDZ \cdot ISPRE \qquad IS2PRE := (ZL1 + ZC1) \cdot MONEDZ \cdot ISPRE$$

Build the Fault Impedance Matrix ZFLT

$$ZCC := \begin{pmatrix} A1A2 & B1A2 & C1A2 \\ A1B2 & B1B2 & C1B2 \\ A1C2 & B1C2 & C1C2 \end{pmatrix}$$

$$FZ1AG := FZ1A + FZ1G \qquad FZ1BG := FZ1B + FZ1G \qquad FZ1CG := FZ1C + FZ1G$$

$$FZ2AG := FZ2A + FZ2G \qquad FZ2BG := FZ2B + FZ2G \qquad FZ2CG := FZ2C + FZ2G$$

$$F1ABCG := \begin{pmatrix} FZ1AG & FZ1G & FZ1G \\ FZ1G & FZ1BG & FZ1G \\ FZ1G & FZ1G & FZ1CG \end{pmatrix} \qquad F2ABCG := \begin{pmatrix} FZ2AG & FZ2G & FZ2G \\ FZ2G & FZ2BG & FZ2G \\ FZ2G & FZ2G & FZ2CG \end{pmatrix}$$

$$H55 := -F1ABCG^{-1} - ZCC^{-1} \qquad H66 := -F2ABCG^{-1} - ZCC^{-1} \qquad H56 := ZCC^{-1}$$

$$M1 := augment(H55, H56) \qquad M2 := augment(H56, H66) \qquad M := augment(M1^T, M2^T)^T$$

$$K1 := augment(H11, augment(H12, augment(ZER, ZER)))$$
$$K2 := augment(H12, augment(H22, augment(ZER, ZER)))$$
$$K3 := augment(ZER, augment(ZER, augment(H33, H34)))$$
$$K4 := augment(ZER, augment(ZER, augment(H34, H44)))$$
$$K := augment(K1^T, augment(K2^T, augment(K3^T, K4^T)))^T$$

$$L1 := augment(I, augment(ZER, augment(I, ZER))) \qquad L2 := augment(ZER, augment(I, augment(ZER, I)))$$

$$L := augment(L1^T, L2^T) \qquad ZFLT := K - L \cdot M^{-1} \cdot L^T \qquad YFLT := ZFLT^{-1}$$

Calculate the Relay Currents and Voltages

$$TS1 := augment(I, augment(ZER, augment(ZER, ZER)))$$
$$TS2 := augment(ZER, augment(I, augment(ZER, ZER)))$$
$$TR1 := augment(ZER, augment(ZER, augment(I, ZER)))$$
$$TR2 := augment(ZER, augment(ZER, augment(ZER, I)))$$

$$E := (augment(ES^T, augment(ES^T, augment(ER^T, ER^T))))^T$$

$$IS1S2 := YFLT \cdot E \qquad IS1 := TS1 \cdot IS1S2 \qquad IS2 := TS2 \cdot IS1S2$$

$$IS := IS1 + IS2 \qquad VS := ES - ZS \cdot IS \qquad VCAP1 := VS - ZZC1 \cdot IS1$$

$IR1 := TR1 \cdot IS1S2$ $IR2 := TR2 \cdot IS1S2$

$IR := IR1 + IR2$

$VR := ER - ZR \cdot IR$

Outputs Prefault

$\overrightarrow{|IS1PRE|} = \blacksquare$ $\overrightarrow{\arg(IS1PRE)} = \blacksquare\ \text{deg}$ $\overrightarrow{|VSPRE|} = \blacksquare$ $\overrightarrow{\arg(VSPRE)} = \blacksquare\ \text{deg}$

$VAMEM := VSPRE_0$ $VBMEM := VSPRE_1$ $VCMEM := VSPRE_2$

$\overrightarrow{|IS2PRE|} = \blacksquare$ $\overrightarrow{|VRPRE|} = \blacksquare$ $\overrightarrow{\arg(VRPRE)} = \blacksquare\ \text{deg}$

Outputs During Fault

$\overrightarrow{|IS1|} = \blacksquare$ $\overrightarrow{\arg(IS1)} = \blacksquare\ \text{deg}$ $\overrightarrow{|IS2|} = \blacksquare$ $\overrightarrow{\arg(IS2)} = \blacksquare\ \text{deg}$

$\overrightarrow{|VS|} = \blacksquare$ $\overrightarrow{\arg(VS)} = \blacksquare\ \text{deg}$ $i := 0, 1 .. 2$ $IRS1 := \sum_i IS1_i$ $IRS2 := \sum_i IS2_i$

$IRR1 := \sum_i IR1_i$ $IRR2 := \sum_i IR2_i$

$\overrightarrow{|VR|} = \blacksquare$ $\overrightarrow{\arg(VR)} = \blacksquare\ \text{deg}$ $z1l1 := \frac{Z1L1}{|Z1L1|}$ $z0l1 := \frac{Z0L1}{|Z0L1|}$ $k0M1 :=$

$VAS := VS_0$ $VAR := VR_0$ $IAS1 := IS1_0$ $IAR1 := IR1_0$

$VBS := VS_1$ $VBR := VR_1$ $IBS1 := IS1_1$ $IBR1 := IR1_1$ $IBR2 := IR2_1$

$VCS := VS_2$ $VCR := VR_2$ $ICS1 := IS1_2$ $ICR1 := IR1_2$ $ICR2 := IR2_2$

$IAS2 := IS2_0$ $IBS2 := IS2_1$ $ICS2 := IS2_2$ $IAR2 := IR2_0$

$IABR1 := -(IAR1 - IBR1)$ $IBCR1 := -(IBR1 - ICR1)$ $ICAR1 := -(ICR1 - IAR1)$

$IABS1 := IAS1 - IBS1$ $IBCS1 := IBS1 - ICS1$ $ICAS1 := ICS1 - IAS1$

$VABR := VAR - VBR$ $VABS := VAS - VBS$ $VA1RM := VRPRE_0$ $VB1RM := VRPRE_1$ $VC1RM$

$VBCR := VBR - VCR$ $VBCS := VBS - VCS$ $VAB1RM := (VRPRE_0) - VRPRE_1$ $VBC1RM := (VR$

$VCAR := VCR - VAR$ $VCAS := VCS - VAS$

$VA1SM := VSPRE_0$ $VAB1SM := (VSPRE_0) - VSPRE_1$ $V0S := \left(\frac{1}{3}\right) \cdot (VAS + VBS + VCS)$ $I2S2 := \left(\frac{1}{3}\right) \cdot (IAS2$

$VB1SM := VSPRE_1$ $VBC1SM := (VSPRE_1) - VSPRE_2$ $V0R := \left(\frac{1}{3}\right) \cdot (VAR + VBR + VCR)$ $I2R1 := \left(\frac{1}{3}\right) \cdot (IAR$

$VC1SM := VSPRE_2$ $VCA1SM := (VSPRE_2) - VSPRE_0$ $V2S := \left(\frac{1}{3}\right) \cdot (VAS + a^2 \cdot VBS + a \cdot VCS)$ $V1S := \left(\frac{1}{3}\right) \cdot$

$V2R := \left(\frac{1}{3}\right) \cdot (VAR + a^2 \cdot VBR + a \cdot VCR)$ $I1S1 := \left(\frac{1}{3}\right) \cdot$

$I2R2 := \left(\frac{1}{3}\right) \cdot (IAR2 + a^2 \cdot IBR2 + a \cdot ICR2)$ $I2S1 := \left(\frac{1}{3}\right) \cdot$

NEGATIVE- AND ZERO-SEQUENCE DIRECTIONAL ELEMENT

$z2 := \frac{Re[(V2S) \cdot \overline{I2S1 \cdot z1l1}]}{(|I2S1|)^2}$ $z0 := \frac{Re[(3 \cdot V0S) \cdot \overline{IRS1 \cdot z0l1}]}{(|IRS1|)^2}$

BUS S: LINE 1 PHASE DISTANCE ELEMENTS

$MAB := \frac{Re[VABS \cdot (\overline{VAB1SM})]}{Re[z1l1 \cdot (IABS1) \cdot \overline{VAB1SM}]}$ $MBC := \frac{Re[VBCS \cdot (\overline{VBC1SM})]}{Re[z1l1 \cdot (IBCS1) \cdot \overline{VBC1SM}]}$ $MCA := \frac{Re[VCAS \cdot (\overline{VCA1SM})]}{Re[z1l1 \cdot (ICAS1) \cdot \overline{VCA1SM}]}$

$MABD := Re[z1l1 \cdot (IABS1) \cdot \overline{VAB1SM}]$ $MBCD := Re[z1l1 \cdot (IBCS1) \cdot \overline{VBC1SM}]$ $MCAD := Re[z1l1 \cdot (ICAS1) \cdot \overline{VCA1SM}]$

$MAG := \frac{Re[VAS \cdot (\overline{VAMEM})]}{Re[z1l1 \cdot (IAS1 + k01 \cdot IRS1) \cdot \overline{VAMEM}]}$ $DMAG := Re[z1l1 \cdot (IAS1 + k01 \cdot IRS1) \cdot \overline{VAMEM}]$ $NMAG := Re[VAS \cdot (\overline{VAMEM})]$

$XAG21 := \frac{Im(VAS \cdot \overline{I2S1 \cdot e^{(j \cdot T2 \cdot deg)}})}{[$ $XAG01 := \frac{Im(VAS \cdot \overline{IRS1 \cdot e^{(j \cdot T0 \cdot deg)}})}{[$

$$\mathrm{Im}\left[\left[Z1L1\cdot\left(IAS1+k011\cdot IRS1\right)\right]\cdot e^{\left(j\cdot T2\cdot deg\right)}\cdot I2S1\right] \qquad \mathrm{Im}\left[\left[Z1L1\cdot\left(IAS1+k011\cdot IRS1\right)\right]\cdot e^{\left(j\cdot T0\cdot deg\right)}\cdot IRS1\right.$$

$$RAG := \left[\frac{\mathrm{Im}\left[VAS\cdot\left(\overline{\left(IAS1+k01\cdot IRS1\right)\cdot z111}\right)\right]}{\mathrm{Im}\left[1.5\cdot\left[\left[I2S1+\left(\frac{IRS1}{3}\right)\right]\cdot\overline{\left(IAS1+k01\cdot IRS1\right)\cdot z111}\right]\right]}\right] \qquad RAB := \left[\frac{\mathrm{Im}\left[VABS\cdot\left(\overline{\left(IABS1\right)\cdot z111}\right)\right]}{\mathrm{Im}\left[\left[j\cdot\left[\left(\sqrt{3}\right)\cdot\left(a^2\cdot I2S1\right)\right]\right]\cdot\left(\overline{\left(IABS1\right)\cdot z111}\right)\right]}\right]$$

$$MBG := \frac{\mathrm{Re}\left[VBS\cdot\left(\overline{VBMEM}\right)\right]}{\mathrm{Re}\left[z111\cdot\left(IBS1+k01\cdot IRS1\right)\cdot\overline{VBMEM}\right]} \qquad DMBG := \mathrm{Re}\left[z111\cdot\left(IBS1+k01\cdot IRS1\right)\cdot\overline{VBMEM}\right] \qquad NMBG := \mathrm{Re}\left[VI\right.$$

$$XBG21 := \frac{\mathrm{Im}\left(VBS\cdot\overline{I2S1\cdot a^0\cdot e^{\left(j\cdot T2\cdot deg\right)}}\right)}{\mathrm{Im}\left[\left[z111\cdot\left[IBS1+\left(k01\cdot IRS1\right)\right]\right]\cdot\overline{e^{\left(j\cdot T2\cdot deg\right)}\cdot\left(I2S1\cdot a^0\right)}\right]} \qquad XBG01 := \frac{\mathrm{Im}\left(VBS\cdot\overline{IRS1\cdot e^{\left(j\cdot T0\cdot deg\right)}}\right)}{\mathrm{Im}\left[\left[z111\cdot\left[IBS1+\left(k01\cdot IRS1\right)\right]\right]\cdot\overline{e^{\left(j\cdot T0\cdot deg\right)}\cdot\left(IR\right.}\right.}$$

$$RBG := \left[\frac{\mathrm{Im}\left[VBS\cdot\left(\overline{\left(IBS1+k01\cdot IRS1\right)\cdot z111}\right)\right]}{\mathrm{Im}\left[1.5\cdot\left[\left[I2S1\cdot a+\left(\frac{IRS1}{3}\right)\right]\cdot\overline{\left(IBS1+k01\cdot IRS1\right)\cdot z111}\right]\right]}\right] \qquad RBC := \left[\frac{\mathrm{Im}\left[VBCS\cdot\left(\overline{\left(IBCS1\right)\cdot z111}\right)\right]}{\mathrm{Im}\left[\left[j\cdot\left[\left(\sqrt{3}\right)\cdot\left(a^0\cdot I2S1\right)\right]\right]\cdot\left(\overline{\left(IBCS1\right)\cdot z111}\right)\right]}\right]$$

$$MCG := \frac{\mathrm{Re}\left[VCS\cdot\left(\overline{VCMEM}\right)\right]}{\mathrm{Re}\left[z111\cdot\left(ICS1+k01\cdot IRS1\right)\cdot\overline{VCMEM}\right]} \qquad DMCG := \mathrm{Re}\left[z111\cdot\left(ICS1+k01\cdot IRS1\right)\cdot\overline{VCMEM}\right] \qquad NMCG := \mathrm{Re}\left[VCS\cdot\left(\overline{VCI}\right.\right.$$

$$RCG := \left[\frac{\mathrm{Im}\left[VCS\cdot\left(\overline{\left(ICS1+k01\cdot IRS1\right)\cdot z111}\right)\right]}{\mathrm{Im}\left[1.5\cdot\left[\left[I2S1\cdot a^2+\left(\frac{IRS1}{3}\right)\right]\cdot\overline{\left(ICS1+k01\cdot IRS1\right)\cdot z111}\right]\right]}\right] \qquad RCA := \left[\frac{\mathrm{Im}\left[VCAS\cdot\left(\overline{\left(ICAS1\right)\cdot z111}\right)\right]}{\mathrm{Im}\left[\left[j\cdot\left[\left(\sqrt{3}\right)\cdot\left(a^1\cdot I2S1\right)\right]\right]\cdot\left(\overline{\left(ICAS1\right)\cdot z111}\right)\right]}\right]$$

$$XCG21 := \frac{\mathrm{Im}\left(VCS\cdot\overline{I2S1\cdot a^0\cdot e^{\left(j\cdot T2\cdot deg\right)}}\right)}{\mathrm{Im}\left[\left[z111\cdot\left[ICS1+\left(k01\cdot IRS1\right)\right]\right]\cdot\overline{I2S1\cdot a^0\cdot e^{\left(j\cdot T2\cdot deg\right)}}\right]} \qquad XCG01 := \frac{\mathrm{Im}\left(VCS\cdot\overline{IRS1\cdot e^{\left(j\cdot T0\cdot deg\right)}}\right)}{\mathrm{Im}\left[\left[z111\cdot\left[ICS1+\left(k01\cdot IRS1\right)\right]\right]\cdot\overline{IRS1\cdot e^{\left(j\cdot T0\cdot de\right.}}\right.}$$

$$FSA60p := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq 30\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq 60\cdot deg\right) \qquad FSA60m := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq -60\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq -30\cdot deg\right)$$

$$FSA30 := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq -30\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq 30\cdot deg\right)$$

$$FSB30 := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq 90\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq 150\cdot deg\right) \qquad FSB60p := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq 60\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq 90\cdot deg\right)$$

$$FSB60m := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq 150\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq 180\cdot deg\right)$$

$$FSC30 := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq -150\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq -90\cdot deg\right) \qquad FSC60p := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq -180\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq -150\cdot deg\right)$$

$$FSC60m := \left(\arg\left(\frac{IRS1}{I2S1}\right)\geq -90\cdot deg\right)\cdot\left(\arg\left(\frac{IRS1}{I2S1}\right)\leq -60\cdot deg\right)$$

$$MABmin := \left(|MBC|\geq|MAB|\right)\cdot\left(|MCA|\geq|MAB|\right) \qquad IABmax := \left(|IBCS1|\leq|IABS1|\right)\cdot\left(|ICAS1|\leq|IABS1|\right)$$

$$MBCmin := \left(|MAB|\geq|MBC|\right)\cdot\left(|MCA|\geq|MBC|\right) \qquad IBCmax := \left(|IABS1|\leq|IBCS1|\right)\cdot\left(|ICAS1|\leq|IBCS1|\right)$$

$$MCAmin := \left(|MBC|\geq|MCA|\right)\cdot\left(|MAB|\geq|MCA|\right) \qquad ICAmax := \left(|IBCS1|\geq|ICAS1|\right)\cdot\left(|IABS1|\geq|ICAS1|\right)$$

$$IBETAM := \left[IABmax\cdot\frac{|IRS1|}{\left(|IABS1|\cdot 0.1\right)}\right]+\left[IBCmax\cdot\frac{|IRS1|}{\left(|IBCS1|\cdot 0.1\right)}\right]+\left[ICAmax\cdot\frac{|IRS1|}{\left(|ICAS1|\cdot 0.1\right)}\right]$$

RESULTS PAGE:

RAG = ▪ RBG = ▪ RCG = ▪

RAB = ▪ RBC = ▪ RCA = ▪

MAB = ▪ MBC = ▪ MCA = ▪

MABD = ▪ MBCD = ▪ MCAD = ▪

MAG = ▪ MBG = ▪ MCG = ▪

DMAG = ▪ DMBG = ▪ DMCG = ▪

XAG01 = ▪ XBG01 = ▪ XCG01 = ▪

XAG21 = ▪ XBG21 = ▪ XCG21 = ▪

FSA30 = ▪ FSB30 = ▪ FSC30 = ▪

FSA60p = ▪ FSB60p = ▪ FSC60p = ▪

FSA60m = ▪ FSB60m = ▪ FSC60m = ▪

MABmin = ▪ MBCmin = ▪ MCAmin = ▪

$\delta \equiv 0.001$ $m \equiv 0.1$ $U \equiv INF$ $T2 \equiv 0.00$ $T0 \equiv 0$

z2 = ▪ $\arg(IRS1) - \arg(I2S1) =$ ▪ deg

z0 = ▪

Source R: $Z0R \equiv (0.0 + j)\cdot INF$ $Z1R \equiv (0.0 + 1\cdot j)\cdot INF$

Source S: $Z0S \equiv (0.0 + j)\cdot 3$ $Z1S \equiv (0.0 + 1\cdot j)\cdot 1$

Line 1: $Z0L1 \equiv (0.0 + j)\cdot 27$ $Z1L1 \equiv (0.0 + j)\cdot 9$

Line 2: $Z0L2 \equiv (0. + 1\cdot j)\cdot 27$ $Z1L2 \equiv (0.0 + j)\cdot 9$

Caps: $ZZC1 \equiv 0.000$ $ZZC2 \equiv 0.000$ $ZM \equiv 0.1\cdot Z0L1$

|Z1S| = ▪ arg(Z1S) = ▪ deg |Z0S| = ▪ arg

|Z1L1| = ▪ arg(Z1L1) = ▪ deg |Z0L1| = ▪ arg

|Z1R| = ▪ arg(Z1R) = ▪ deg |Z0R| = ▪ arg

$\left|\frac{Z0L1 - Z1L1}{3\cdot Z1L1}\right| =$ ▪ $\arg\left(\frac{Z0L1 - Z1L1}{3\cdot Z1L1}\right) =$ ▪ deg

Z Fault 1: $FZ1A \equiv INF$ $FZ1B \equiv 0.00001$ $FZ1C \equiv INF$ $FZ1G \equiv 4.0$ $k011 \equiv 0.66 \cdot e^{(j \cdot 0 \cdot deg)}$

Z Fault 2: $FZ2A \equiv INF$ $FZ2B \equiv INF$ $FZ2C \equiv INF$ $FZ2G \equiv INF$ $k01 \equiv k011$

Z Cross: $A1A2 \equiv 3 \cdot INF$ $A1B2 \equiv INF$ $A1C2 \equiv INF$

$B1A2 \equiv INF$ $B1B2 \equiv 3 \cdot INF$ $B1C2 \equiv INF$ $XS1 \equiv 0$ $YS1 \equiv 0$ $ZS1 \equiv 0$ $XS2 \equiv 0$ $YS2 \equiv 0$ $ZS2 \equiv$

$C1A2 \equiv INF$ $C1B2 \equiv INF$ $C1C2 \equiv 3 \cdot INF$ $XR1 \equiv 0$ $YR1 \equiv 0$ $ZR1 \equiv 0$ $XR2 \equiv 0$ $YR2 \equiv 0$ $ZR2$

VOLTAGES AND CURRENTS AT THE S-BUS, LINE 1

$\lvert VSPRE_0 \rvert =$ ■	$\arg(VSPRE_0) =$ ■ deg	$\lvert VAS \rvert =$ ■	$\arg(VAS) =$ ■ deg	$\lvert V2S \rvert =$ ■	arg
$\lvert VSPRE_1 \rvert =$ ■	$\arg(VSPRE_1) =$ ■ deg	$\lvert VBS \rvert =$ ■	$\arg(VBS) =$ ■ deg	$\lvert V0S \rvert =$ ■	arg
$\lvert VSPRE_2 \rvert =$ ■	$\arg(VSPRE_2) =$ ■ deg	$\lvert VCS \rvert =$ ■	$\arg(VCS) =$ ■ deg	$\lvert V1S \rvert =$ ■	arg
$\lvert IS1PRE_0 \rvert =$ ■	$\arg(IS1PRE_0) =$ ■ deg	$\lvert IAS1 \rvert =$ ■	$\arg(IAS1) =$ ■ deg	$\lvert I2S1 \rvert =$ ■	arg
$\lvert IS1PRE_1 \rvert =$ ■	$\arg(IS1PRE_1) =$ ■ deg	$\lvert IBS1 \rvert =$ ■	$\arg(IBS1) =$ ■ deg	$\lvert I1S1 \rvert =$ ■	arg
$\lvert IS1PRE_2 \rvert =$ ■	$\arg(IS1PRE_2) =$ ■ deg	$\lvert ICS1 \rvert =$ ■	$\arg(ICS1) =$ ■ deg	$\lvert IRS1 \rvert =$ ■	arg

BUS S, LINE 1 FAULT LOCATOR: FLS1

$$DMAG = \blacksquare$$

$$FLBS1 := \left[\frac{Im(VBS \cdot \overline{IRS1})}{Im\left[Z1L1 \cdot (IBS1 + k01F \cdot IRS1 + k0M1 \cdot IRS2) \cdot \right.} \right.$$

BUS S, LINE 2 FAULT LOCATOR: FLS2

$$FLS2 := \left[\frac{Im(VAS \cdot \overline{IRS2})}{Im\left[Z1L2 \cdot (IAS2 + k02 \cdot IRS2 + k0M1 \cdot IRS1) \cdot \overline{IRS2}\right]} \right]$$

$$FLBS1 = \blacksquare$$

$$FLAS1 = \blacksquare$$

$$FLS2 = \blacksquare$$

$$RAG1S := \left[\frac{Re(VAS \cdot \overline{Z1L1 \cdot (IAS1 + k01 \cdot IRS1)})}{Re\left[(I2S1 + I0S1) \cdot 1.5 \cdot \left(\overline{Z1L1 \cdot (IAS1 + k01 \cdot IRS1)}\right)\right]} \right]$$

$$I0S1 := \frac{IRS1}{3}$$

$$RAG1S = \blacksquare$$

LOCAL AND REMOTE BUS SEL-311 PHASE DIRECTIONAL ELEMENTS

$$Re\left[(IABR1 \cdot Z1L1) \cdot \left(\overline{VAB1RM}\right)\right] = \blacksquare$$

$$Re\left[(IABS1 \cdot Z1L1) \cdot \left(\overline{VAB1SM}\right)\right] = \blacksquare$$

$$Re\left[(IBCR1 \cdot Z1L1) \cdot \left(\overline{VBC1RM}\right)\right] = \blacksquare$$

$$Re\left[(IABR1 \cdot Z1L1) \cdot \left(\overline{VAB1RM}\right)\right] = \blacksquare$$

$$Re\left[(IBCS1 \cdot Z1L1) \cdot \overline{VBC1SM}\right] = \blacksquare$$

$$Re\left[(ICAR1 \cdot Z1L1) \cdot \left(\overline{VCA1RM}\right)\right] = \blacksquare$$

$$Re\left[(ICAS1 \cdot Z1L1) \cdot \left(\overline{VCA1SM}\right)\right] = \blacksquare$$

$$XAG1 := \frac{Im(VAS \cdot \overline{IRS1})}{Im\left[\left[Z1L1 \cdot \left[IAS1 + \left(k01 \cdot IRS1\right)\right]\right] \cdot \overline{IRS1}\right]}$$

$$XAG2 := \frac{Im\left(\left(VS_0 \cdot \overline{IRS2}\right)\right)}{Im\left[\left[Z1L2 \cdot \left(IS2_0 + k02 \cdot IRS2\right)\right] \cdot \overline{IRS2}\right]}$$

$$km := \left(\frac{ZM}{Z1L1}\right) \qquad km = \blacksquare$$

$$XAG1M := \frac{Im(VAS \cdot \overline{IRS1})}{Im\left[\left[Z1L1 \cdot (IAS1 + k01 \cdot IRS1 + km \cdot IRS2)\right] \cdot \overline{IRS1}\right]}$$

$$XAG1M = \blacksquare \qquad XAG1 = \blacksquare$$

$$XAG2M := \frac{Im(VAS \cdot \overline{IRS2})}{Im\left[\left[Z1L1 \cdot (IAS2 + k01 \cdot IRS2 + km \cdot IRS1 \cdot 1)\right] \cdot \overline{IRS2}\right]}$$

$$XAG2M = \blacksquare \qquad XAG2 = \blacksquare$$

$$XBG1 := \frac{Im(VBS \cdot \overline{IRS1})}{Im\left[\left[z1l1 \cdot \left[IBS1 + \left(k01 \cdot IRS1\right)\right]\right] \cdot \overline{IRS1}\right]}$$

$$XBG1 = \blacksquare$$