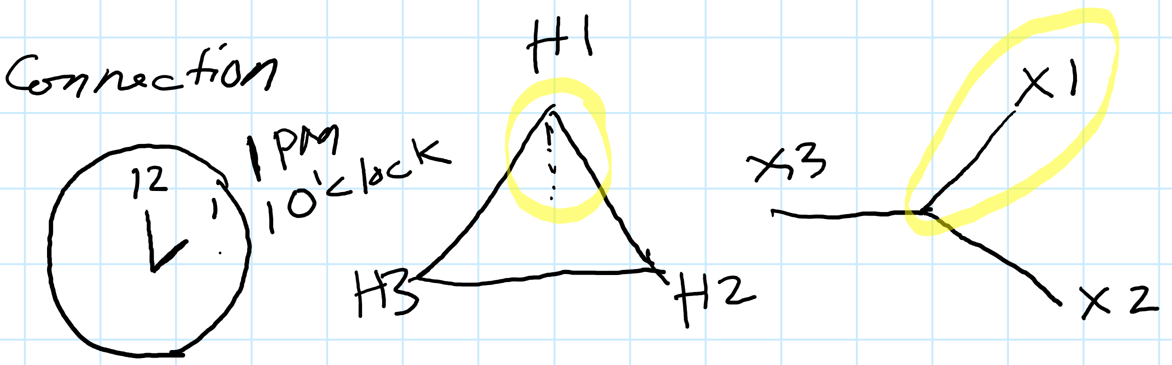
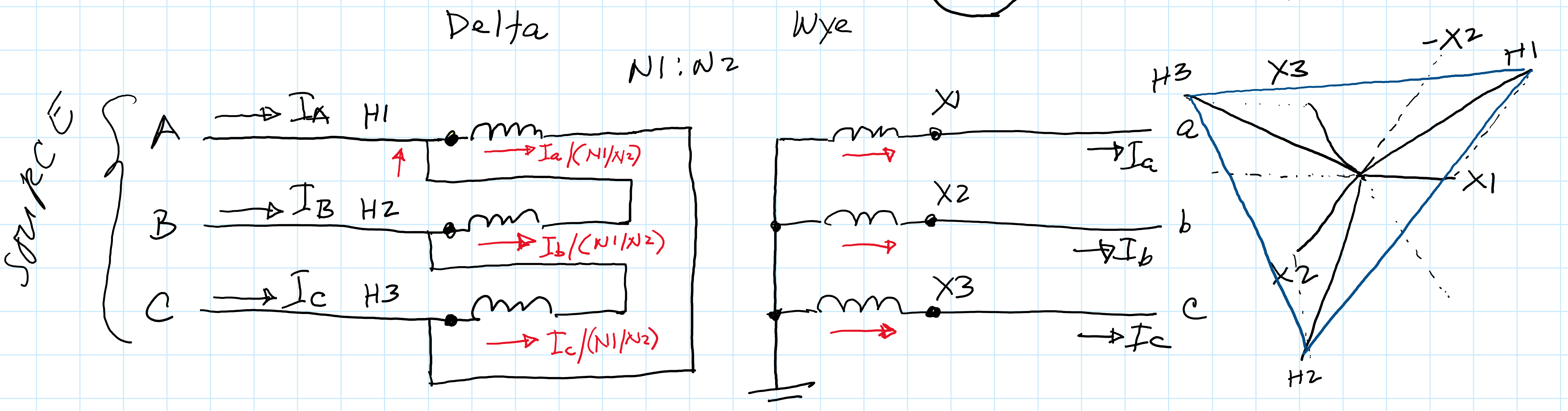
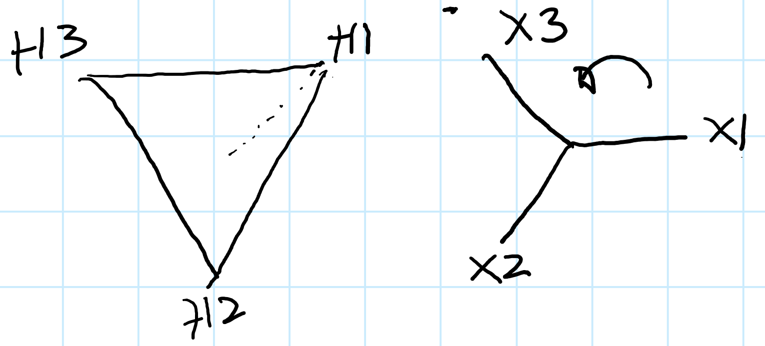
ANSI/IEEE DABY / Dy1 (IEC) Transformer Connection





Per IEEE Standard
HV must lead LV
by 30°



H1 = X1 - X2

Assuming we want to connect winding A @ HV with winding C @ HV, then at node H1:

$$I_A + I_c/(N1/N2) = I_a/(N1/N2) \longrightarrow I_A = I_a/(N1/N2) - I_c/(N1/N2)$$

$$I_c = I_a \times 1\angle 120^\circ$$

$$I_A = |I_a|\angle 0^\circ - |I_a|\angle(0^\circ+120^\circ) = \sqrt{3}|I_a|\angle -30^\circ$$

Conclusion: I_A lags I_a by 30° (Does not Comply with IEEE)

Assuming we want to connect winding A @ HV with winding B @ HV, then at node H1:

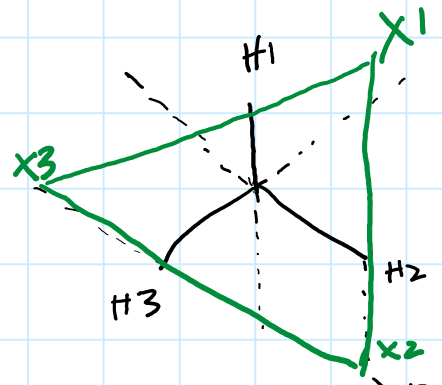
$$I_A + I_b/(N1/N2) = I_a/(N1/N2) \longrightarrow \boxed{I_A = I_a/(N1/N2) - I_b/(N1/N2)}$$

$$I_b = I_a \times 1\angle 240^\circ$$

$$I_A = |I_a|\angle 0^\circ - |I_a|\angle(0^\circ+240^\circ) = \sqrt{3}|I_a|\angle 30^\circ$$

Conclusion: I_A leads I_a by 30° (Comply with IEEE)

Ansi YDAC / Yd1 Transformer Connection



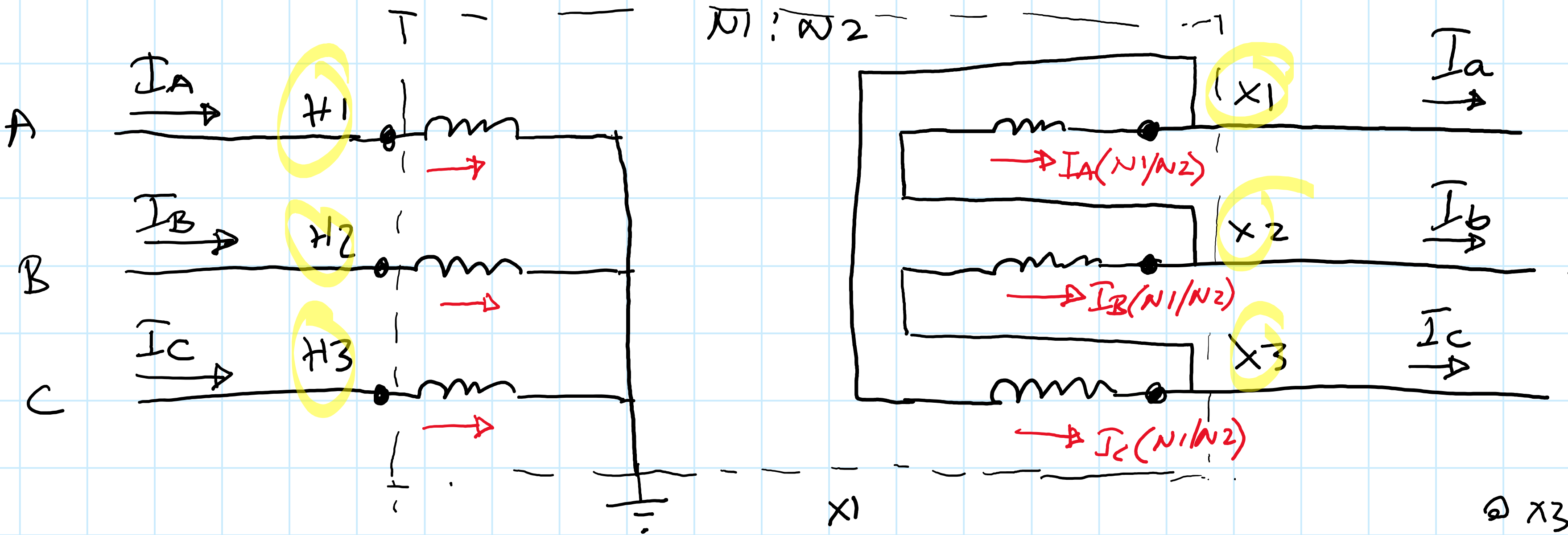
$I_B = I_A + I_b$

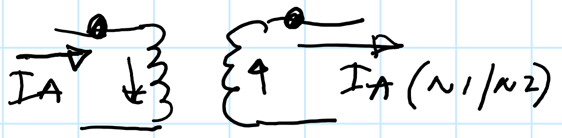
$I_b = I_B - I_A$

$X_2 = H2 - H1$

$X2 = H2 - H1$

$X3 =$

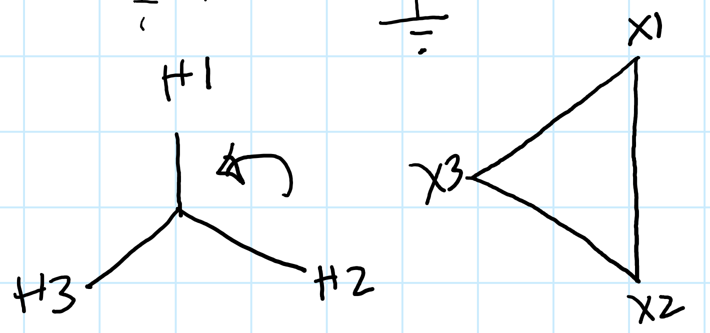




@ X3 | $I_C = I_c + I_B$

$I_c = I_C - I_B$

$X3 = H3 - H2$



Assuming we connect winding "a" @ LV with winding "b" @ LV, then @ node X1:

$$I_A(N1/N2) = I_a + I_B(N1/N2) \longrightarrow I_a = I_A(N1/N2) - I_B(N1/N2)$$

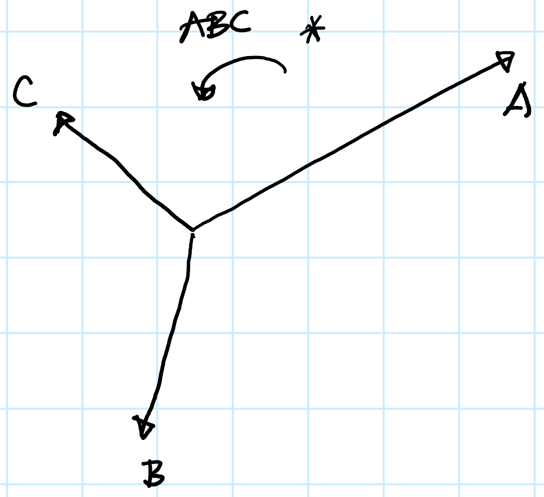
Using Wye phasor as reference: $I_A = |I_A| \angle 90°$; $I_B = |I_A| \angle (90° + 240°)$

$$I_a = I_A(N1/N2) - I_B(N1/N2) = \sqrt{3}\,(N1/N2)\,|I_A| \angle 120°$$

Conclusion: I_A lags I_a by 30° (Does not comply with IEEE)
We need to connect winding "a" @ LV with winding "c" @ LV.

Symmetrical Components

① Develop C.L. Fortescue - 1913



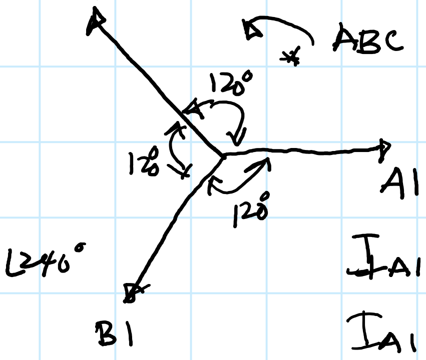
UNBALANCE

ORIGINAL NETWORK

PHYSICAL DOMAIN

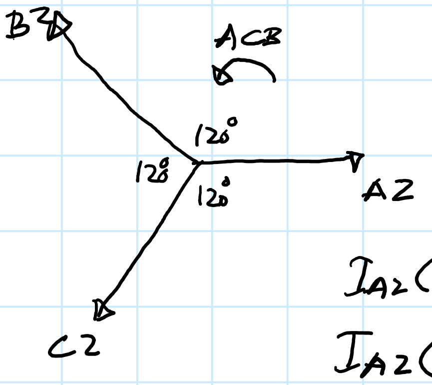
SEQUENCE DOMAIN

POSITIVE SEQUENCE (1)



+

NEGATIVE SEQUENCE (2)



$a^2 = (1\angle 120)^2 = 1\angle 240°$

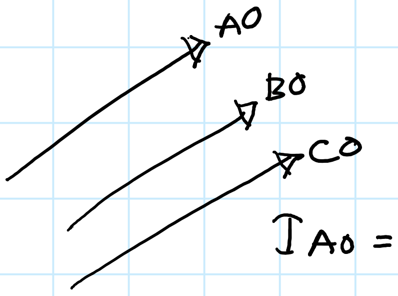
$I_{A1}(a^2) = I_{B1}$

$I_{A1}(a) = I_{C1}$

$I_{A2}(a) = I_{B2}$

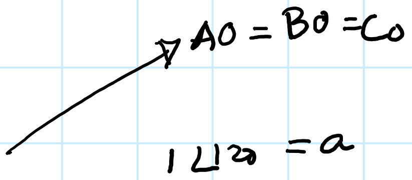
$I_{A2}(a^2) = I_{C2}$

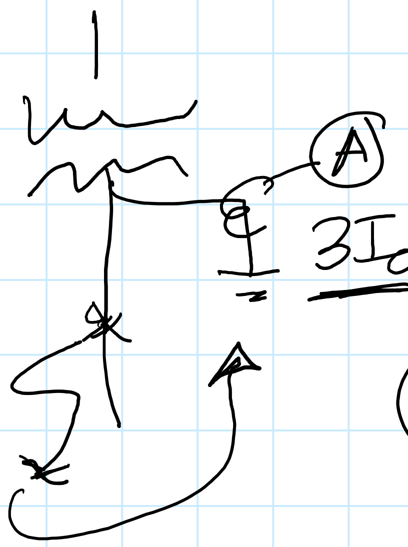
ZERO-SEQUENCE (0)



"a" operator $= \underline{1\angle 120°}$

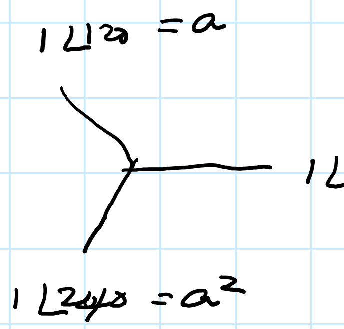
$I_{A0} = I_{B0} = I_{C0}$ $(V_{a0} = V_{b0} = V_{c0})$





$\underline{3I_0} = \underline{I_N} = I_G$

$$\boxed{I_N = I_A + I_B + I_C}$$



Dropping the "A" subscript

$$
\begin{aligned}
① \; I_A &= I_{A1} + I_{A2} + I_{A0} &&= I_{A1} + I_{A2} + I_{A0} &&= I_1 + \underline{I_2} + I_0 \\
② \; I_B &= I_{B1} + I_{B2} + I_{B0} &&= a^2 I_{A1} + a I_{A2} + I_{A0} &&= a^2 I_1 + \underline{a}I_2 + I_0 \quad \times a^2 \\
③ \; I_C &= I_{C1} + I_{C2} + I_{C0} &&= a I_{A1} + a^2 I_{A2} + I_{A0} &&= a I_1 + \underline{a^2} I_2 + I_0 \quad \times a
\end{aligned}
$$

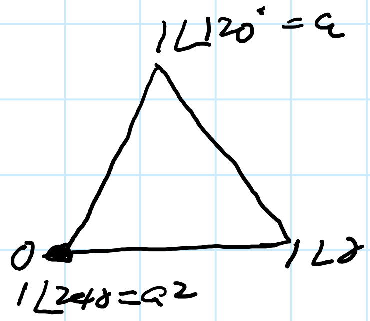
SOLVING FOR ~~ZERO~~ ZERO-SEQUENCE CURRENT:

① + ② + ③

$I_A + I_B + I_C = I_1(\cancelto{0}{1 + a^2 + a}) + I_2(\cancelto{0}{1 + a + a^2}) + I_0(\cancelto{3}{1+1+1})$

$3I_0 = I_A + I_B + I_C$

$1 + a + a^2 = 0$



SOLVING FOR POSITIVE-SEQUENCE CURRENT:

$I_A + aI_B + a^2 I_C = I_1(1 + a^3 + a^3) + I_2(1 + a^2 + a^4) + I_0(1 + a + a^2)$

$= I_1(\cancelto{3}{1+1+1}) + I_2(\cancelto{0}{1 + a^2 + a}) + I_0(\cancelto{0}{1 + a + a^2})$

$3I_1 = I_A + aI_B + a^2 I_C$

$a^3 = (1\angle 120)^3$

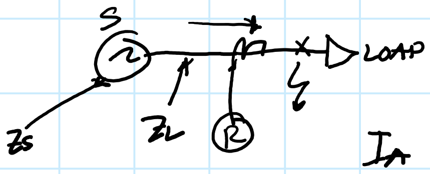
$= 1^3 \angle 3 \times 120$

$= 1\angle 360 = 1\angle 0$

SOLVING FOR NEGATIVE-SEQUENCE CURRENT:

$I_A + a^2 I_B + aI_C = I_1(\cancelto{0}{1 + a^4 + a^2}) + I_2(\cancelto{3}{1 + a^3 + a^3}) + I_0(\cancelto{0}{1 + a^2 + a})$

$3I_2 = I_A + a^2 I_B + aI_C$



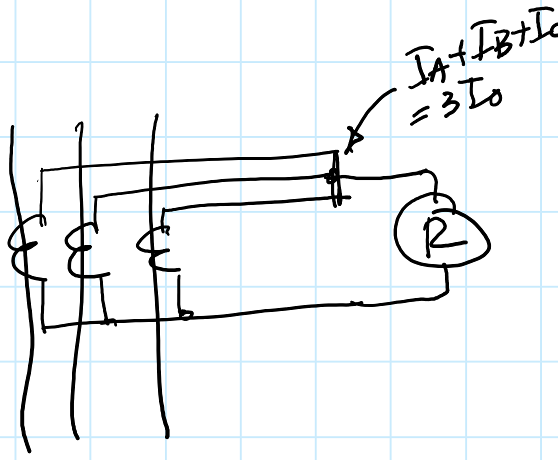
$$3I_0 = I_A + I_B + I_C$$
$$3I_1 = I_A + aI_B + a^2 I_C$$
$$3I_2 = I_A + a^2 I_B + a I_C$$

$$I_A = I_1 + I_2 + I_0$$
$$I_B = a^2 I_1 + a I_2 + I_0$$
$$I_C = a I_1 + a^2 I_2 + I_0$$

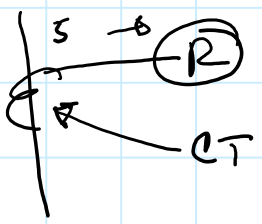
$$\boxed{\begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}\begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix}}$$

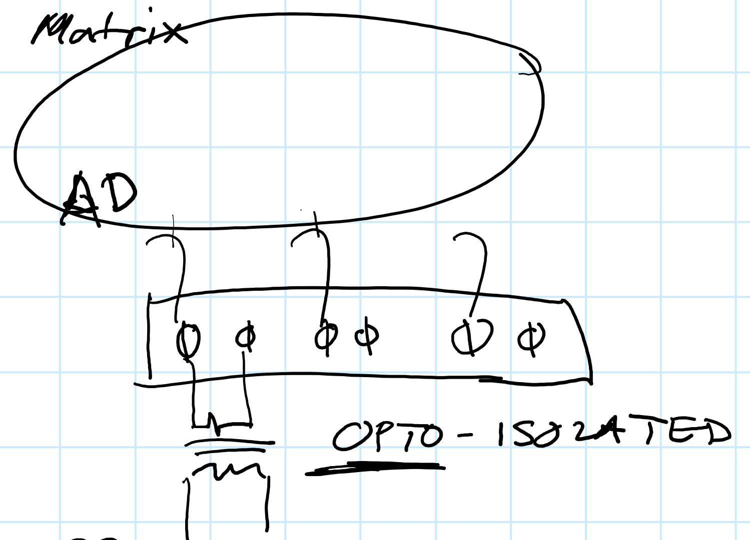
$$\begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ a^2 & a & 1 \\ a & a^2 & 1 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_0 \end{bmatrix}$$

$$[I_S] = \frac{1}{3}[A^{-1}][I_P] \qquad [I_P] = [A][I_S]$$

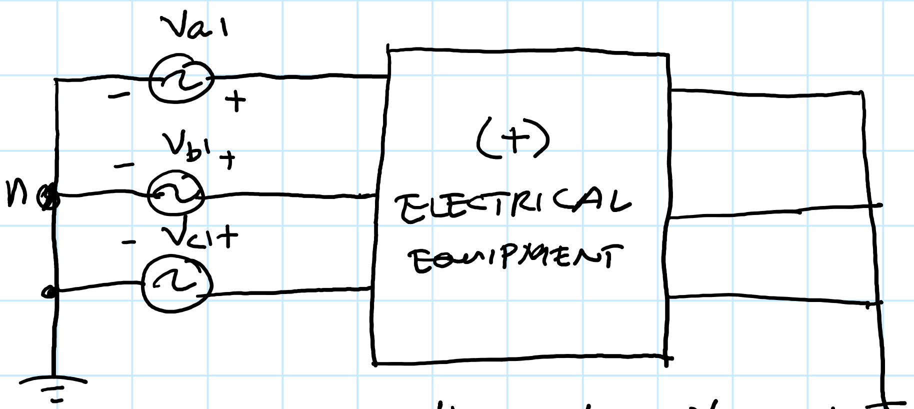


$[A]$ = Transformation Matrix



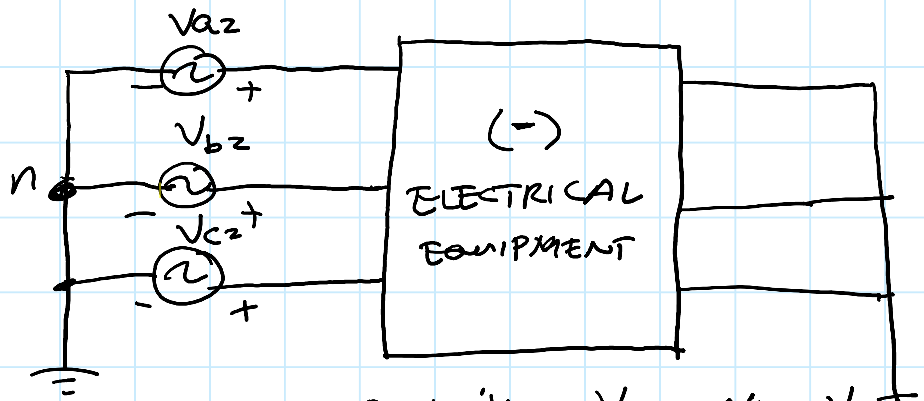


POSITIVE-SEQUENCE TEST



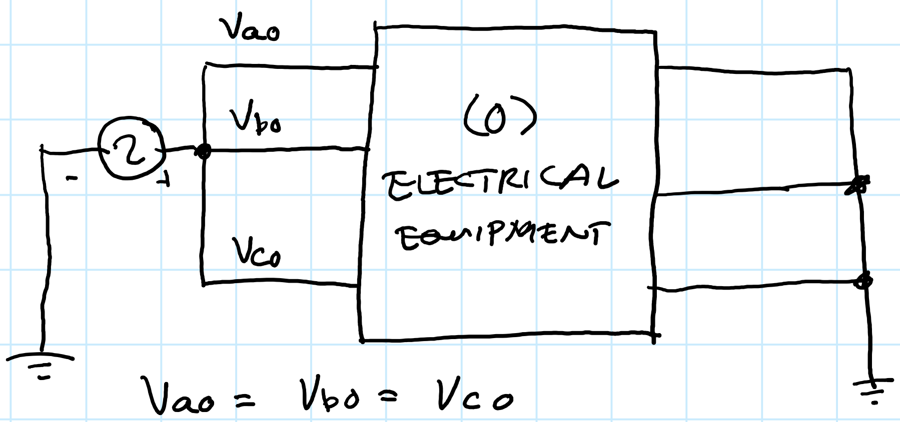
$$Z_1 = R_1 + jX_1 = \frac{V_{a1}}{I_{a1}} = \frac{V_{b1}}{I_{b1}} = \frac{V_{c1}}{I_{c1}}$$

NEGATIVE-SEQUENCE TEST



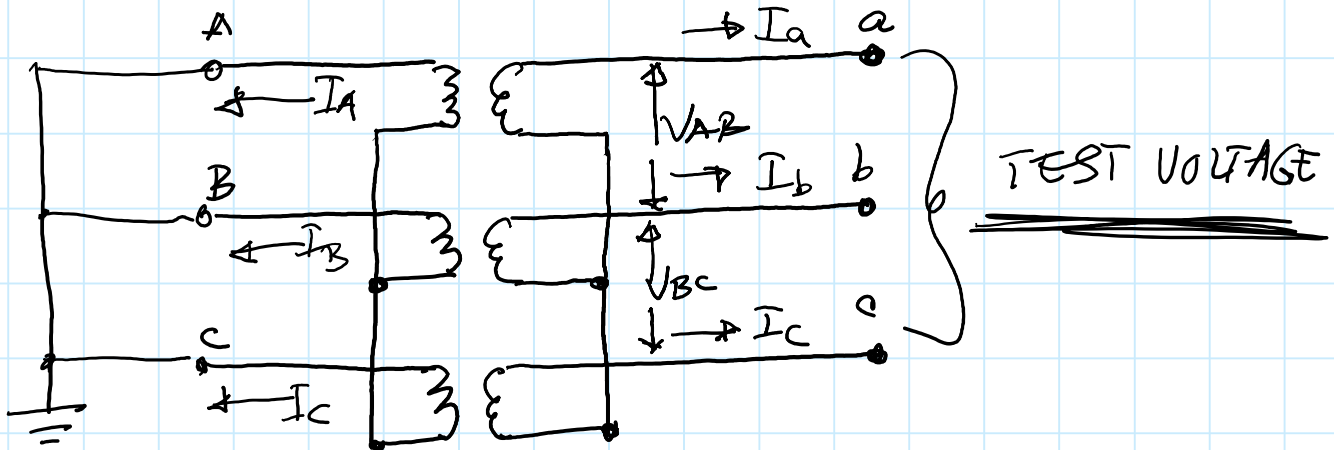
$$Z_2 = R_2 + jX_2 = \frac{V_{a2}}{I_{a2}} = \frac{V_{b2}}{I_{b2}} = \frac{V_{c2}}{I_{c2}}$$

ZERO-SEQUENCE TEST



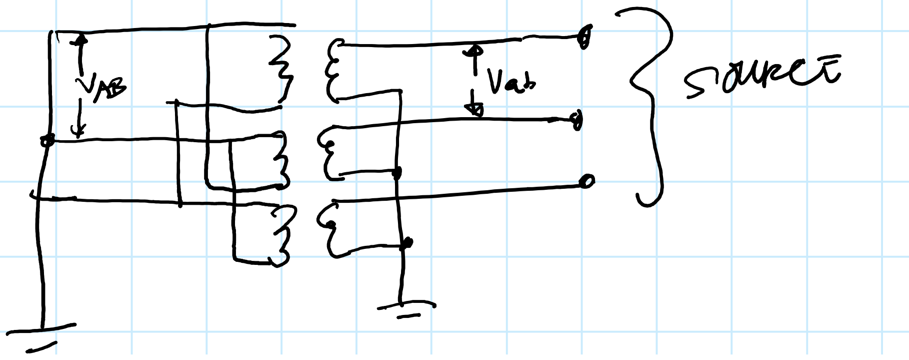
$$V_{a0} = V_{b0} = V_{c0}$$
$$Z_0 = R_0 + jX_0 = \frac{V_{a0}}{I_{a0}} = \frac{V_{b0}}{I_{b0}} = \frac{V_{c0}}{I_{c0}}$$

Wye-Wye Transformer



$3I_0 = 0$

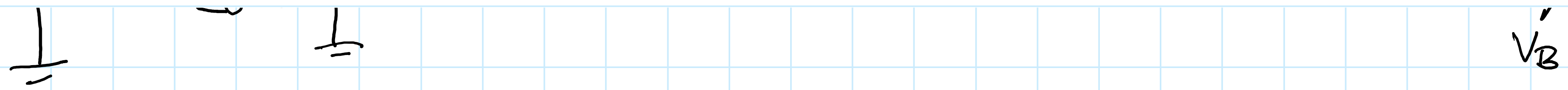
Delta-Wye Transformer



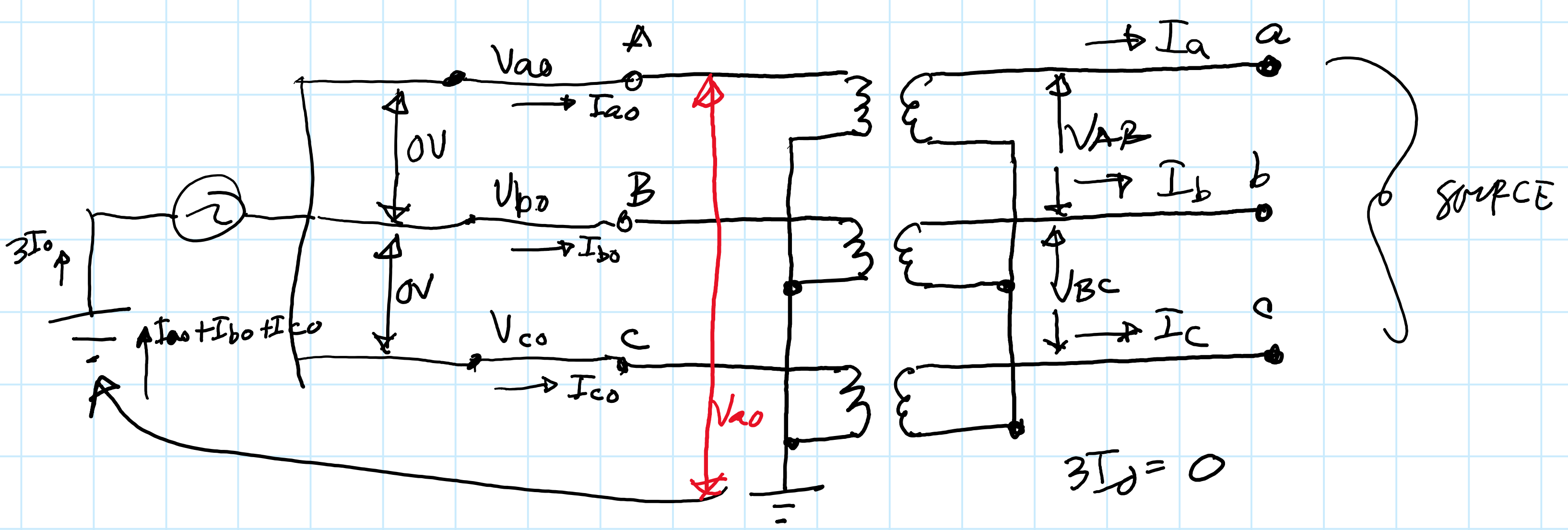
$V_A = 1\angle 0$
$V_B = 1\angle 240$
$V_C = 1\angle 120°$

$V_A = \sqrt{3}\angle 30°$

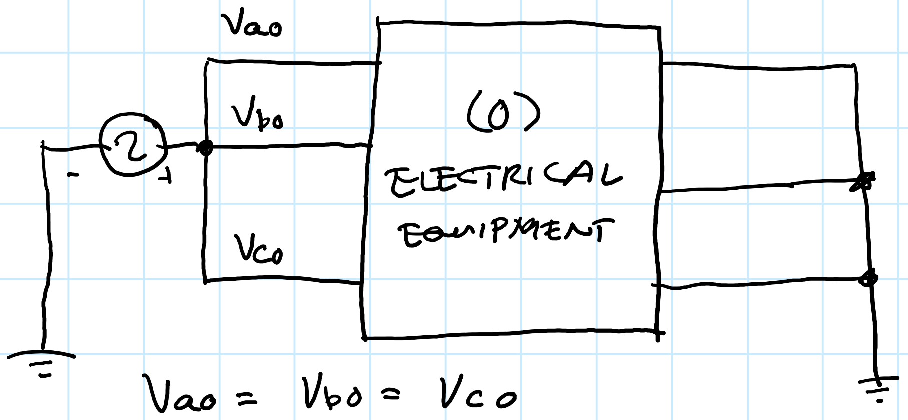
$V_{AB} = V_A - V_B$
$= -V_B$


V_B'

Wye-Wye Transformer (Zero-Sequence Test)



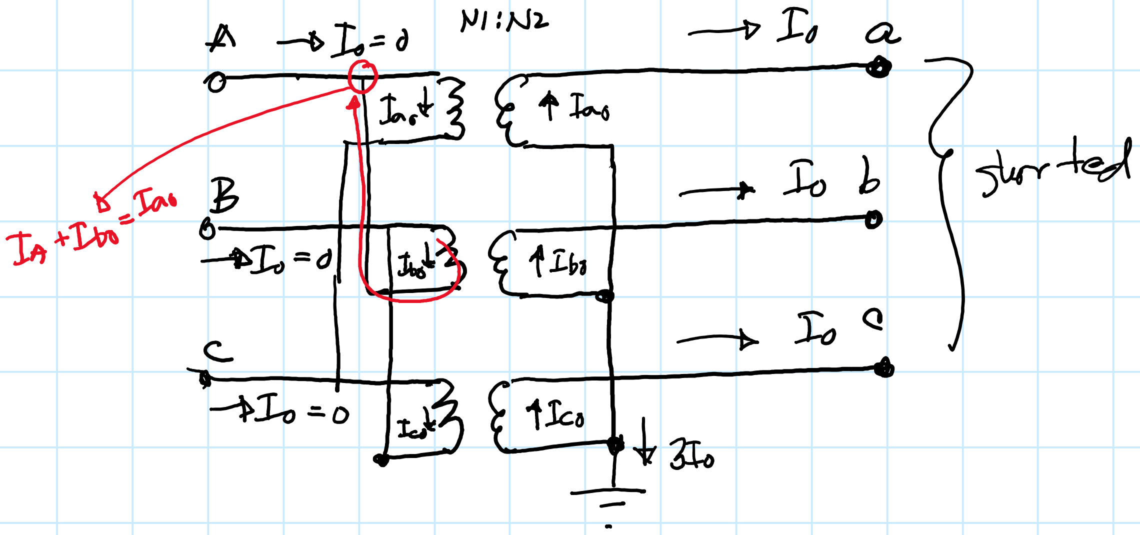
ZERO-SEQUENCE TEST



$V_{ao} = V_{bo} = V_{co}$

$Z_0 = R_0 + jX_0 = \frac{V_{ao}}{I_{ao}} = \frac{V_{bo}}{I_{bo}} = \frac{V_{co}}{I_{co}}$

Delta - Wye Transformer

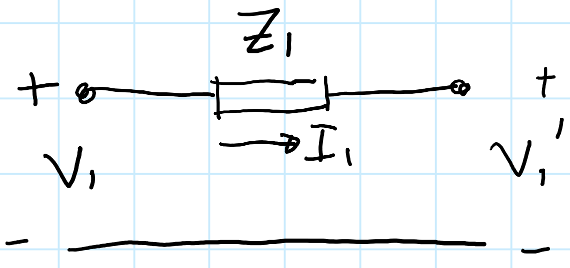


$I_{A0} = \underline{I_{a0}} - \underline{I_{b0}} \rightarrow I_{A0} = 0$

$I_A = I_{A1} + I_{A2} + \cancel{I_{A0}}^{0}$ (Delta Traps Zero-Sequence Currents)

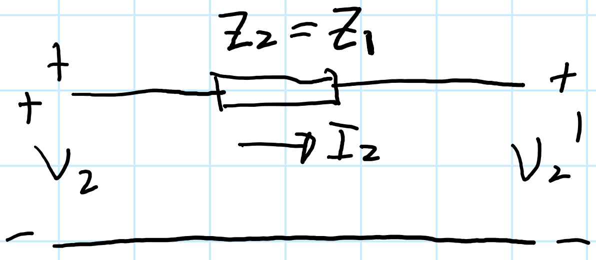
SEQUENCE NETWORK OF WYE-WYE TRANSFORMER

POSITIVE



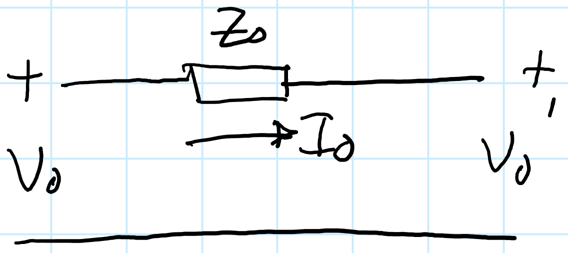
$V_1 = I_1 Z_1 + V_1'$

NEGATIVE



$V_2 = I_2 Z_2 + V_2'$

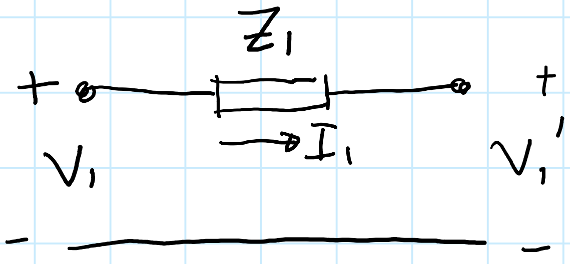
ZERO



$V_0 = I_0 Z_0 + V_0'$

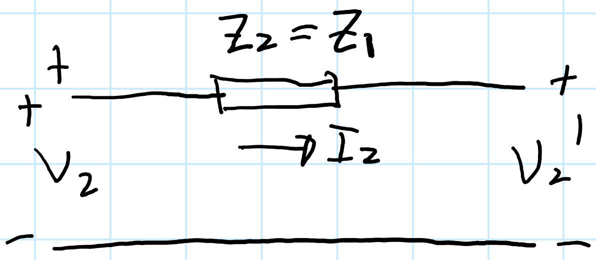
SEQUENCE NETWORK OF DELTA-WYE TRANSFORMER

POSITIVE



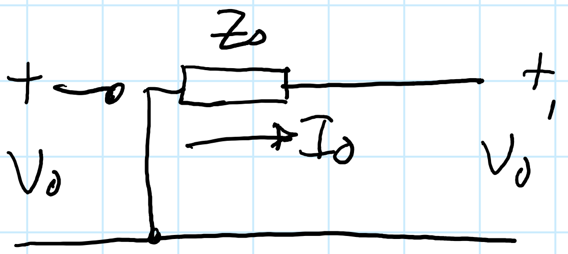
$V_1 = I_1 Z_1 + V_1'$

NEGATIVE



$V_2 = I_2 Z_2 + V_2'$

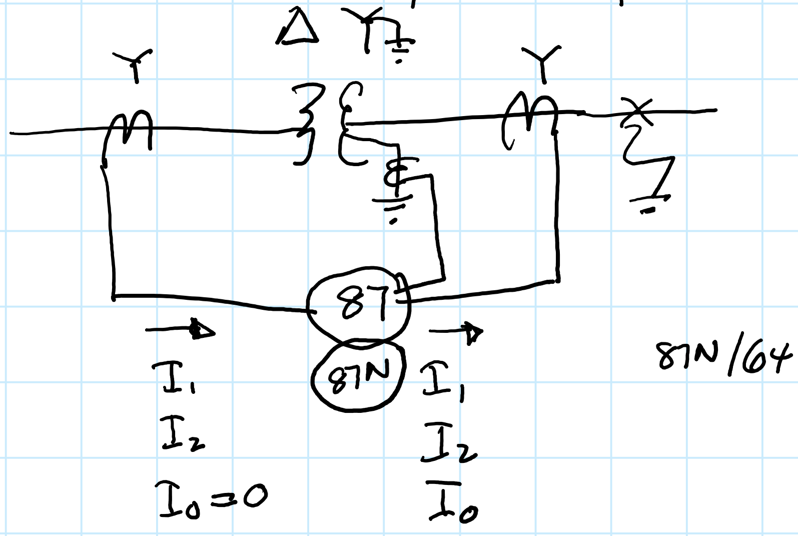
ZERO



$0 = I_0 Z_0 + V_0'$

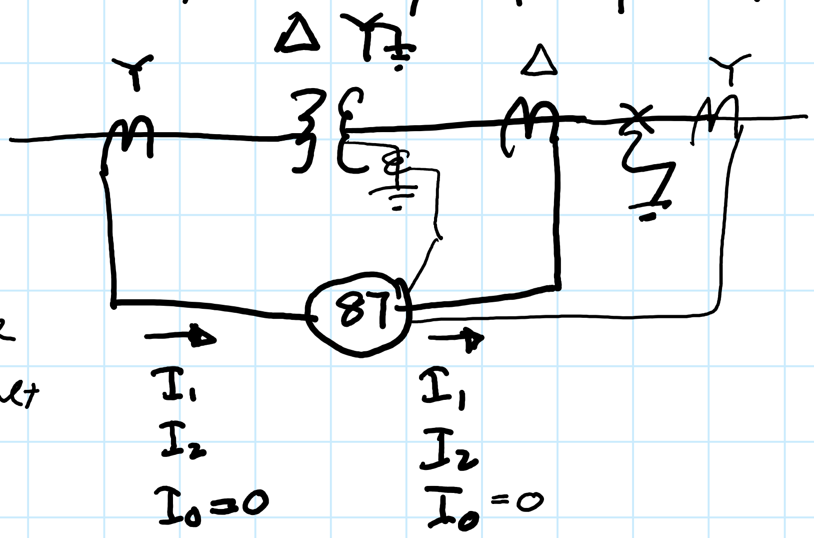
$V_1 = I_1 Z_1 + v_1'$ $V_2 = I_2 Z_2 + V_2'$ $0 = I_0 Z_0 + V_0'$

Delta-Wye Transformer

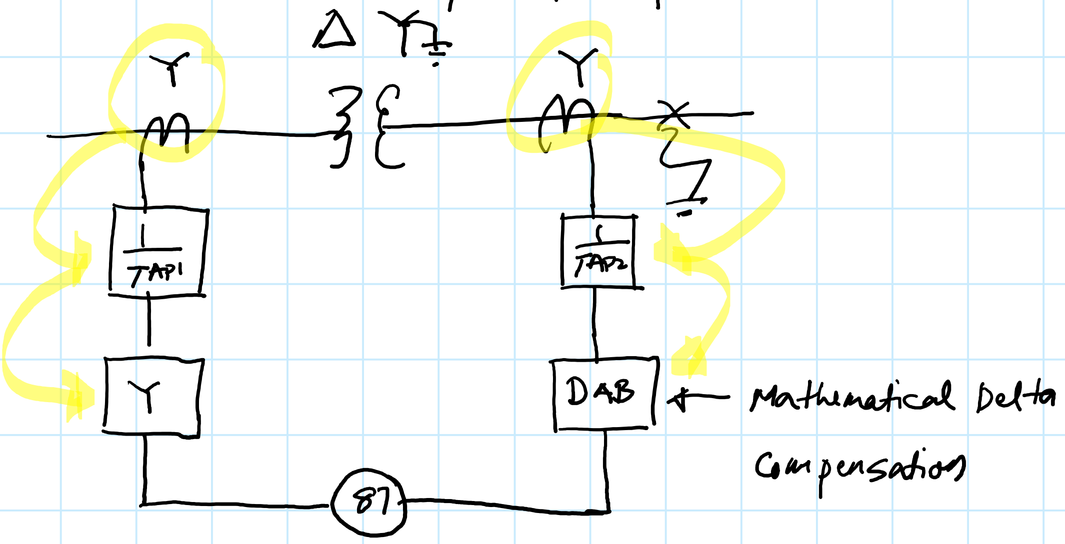


87N/64REF = Restricted Earth Fault

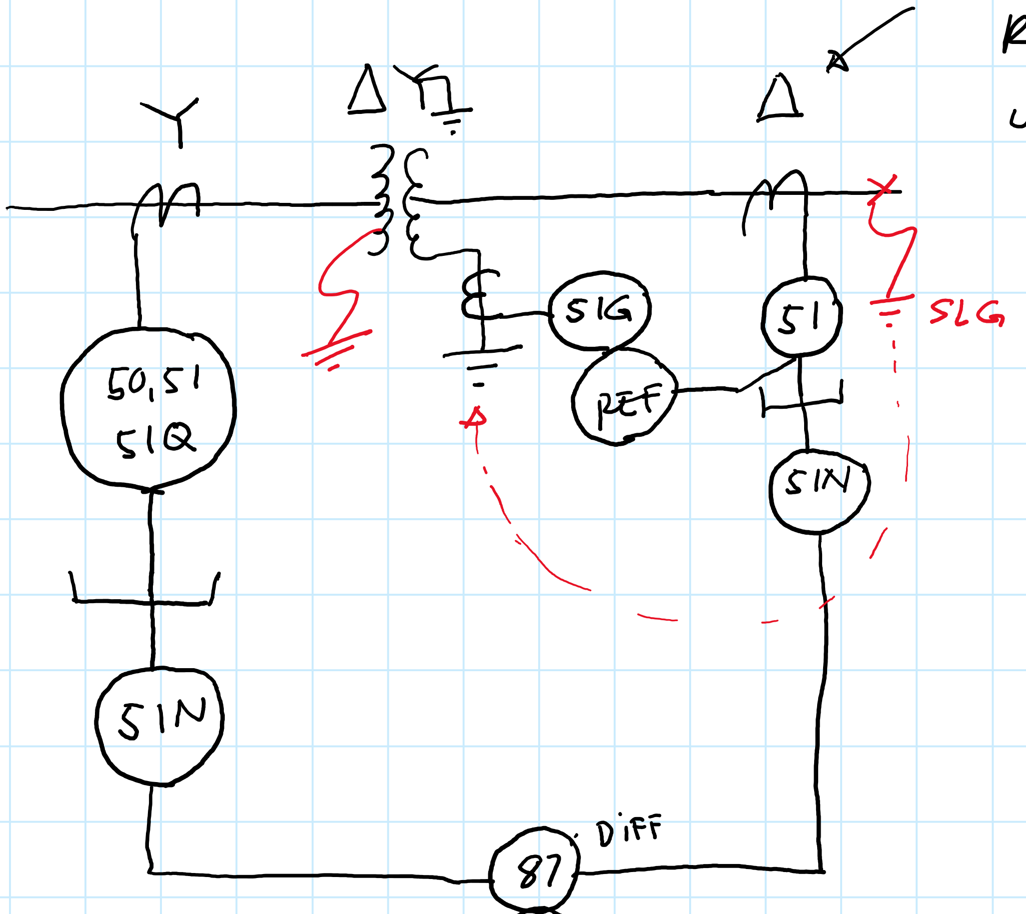
Delta-Wye Transformer



Delta-Wye Transformer



To be connected Delta when using EM Relay. Recommended to be connected Wye when using Numerical Relay

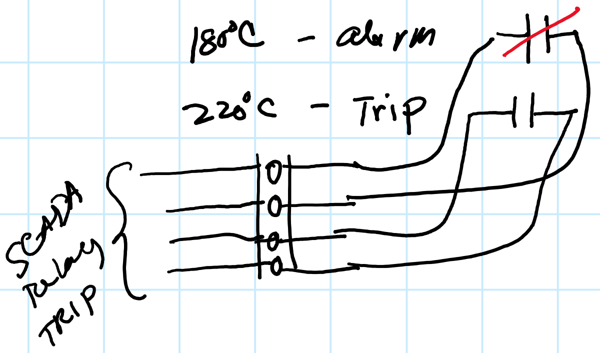


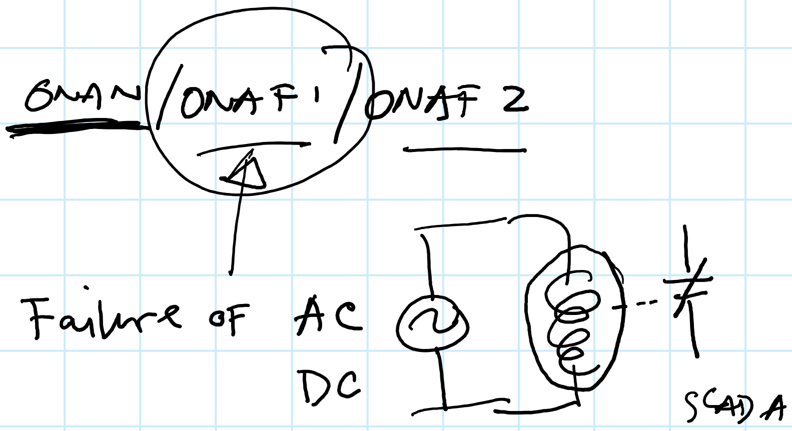
24 V/HZ

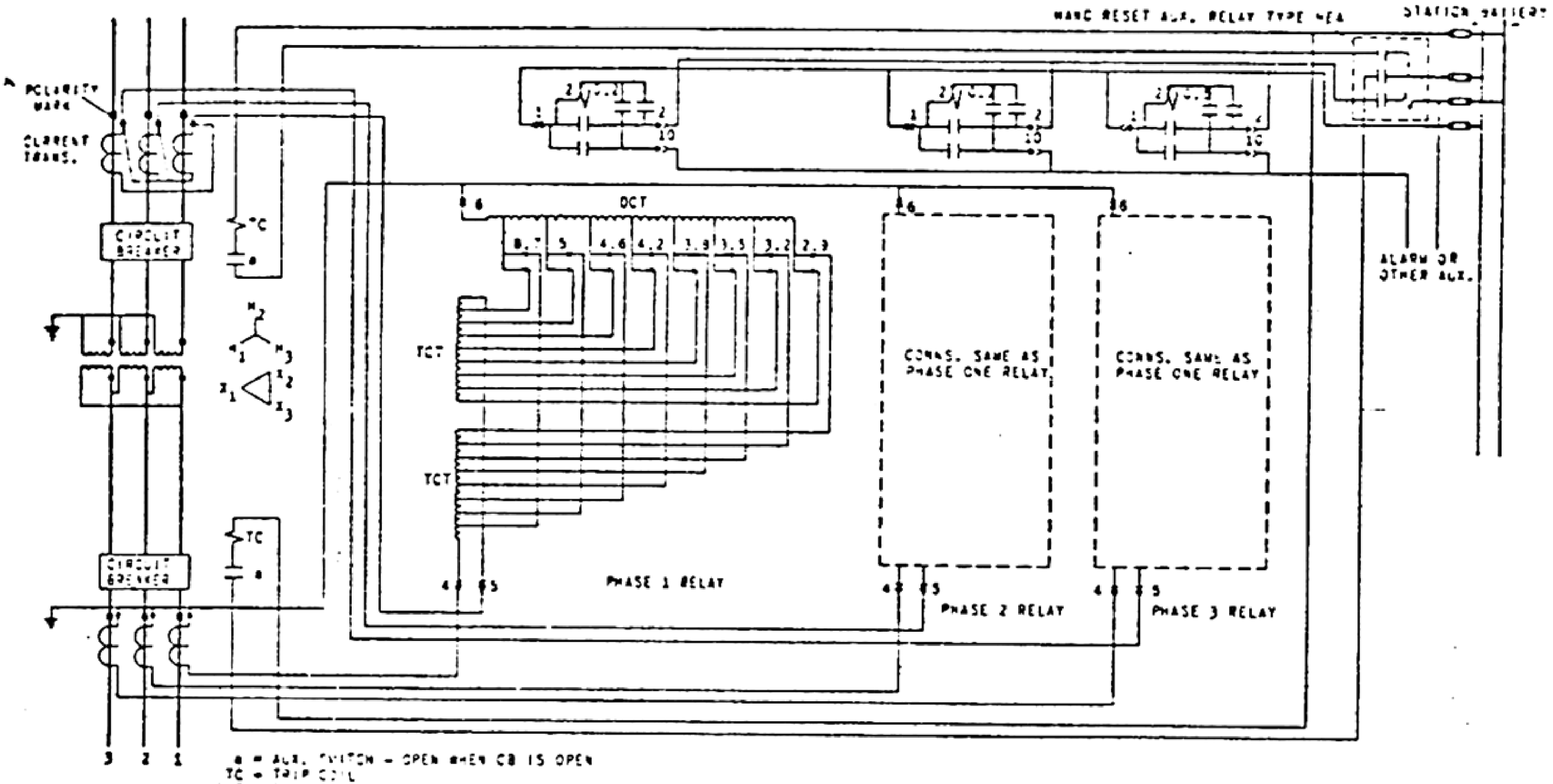
59 OV

63 Sudden Pressure (Rapid Rise Pressure Relay) ✓

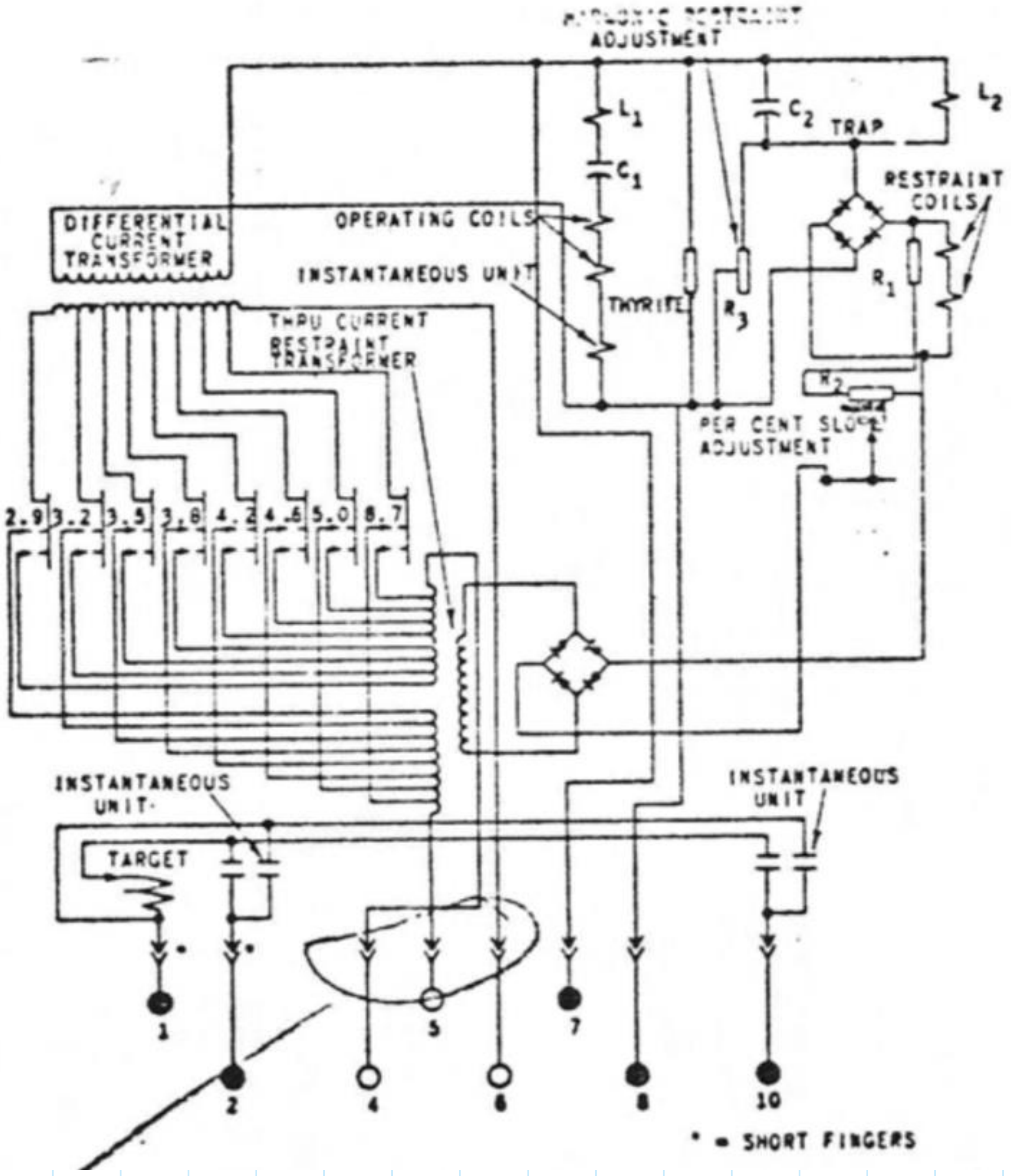
49 Thermal (RTD, WDG CT) — Typically Two Stages (Alarm and Trip)

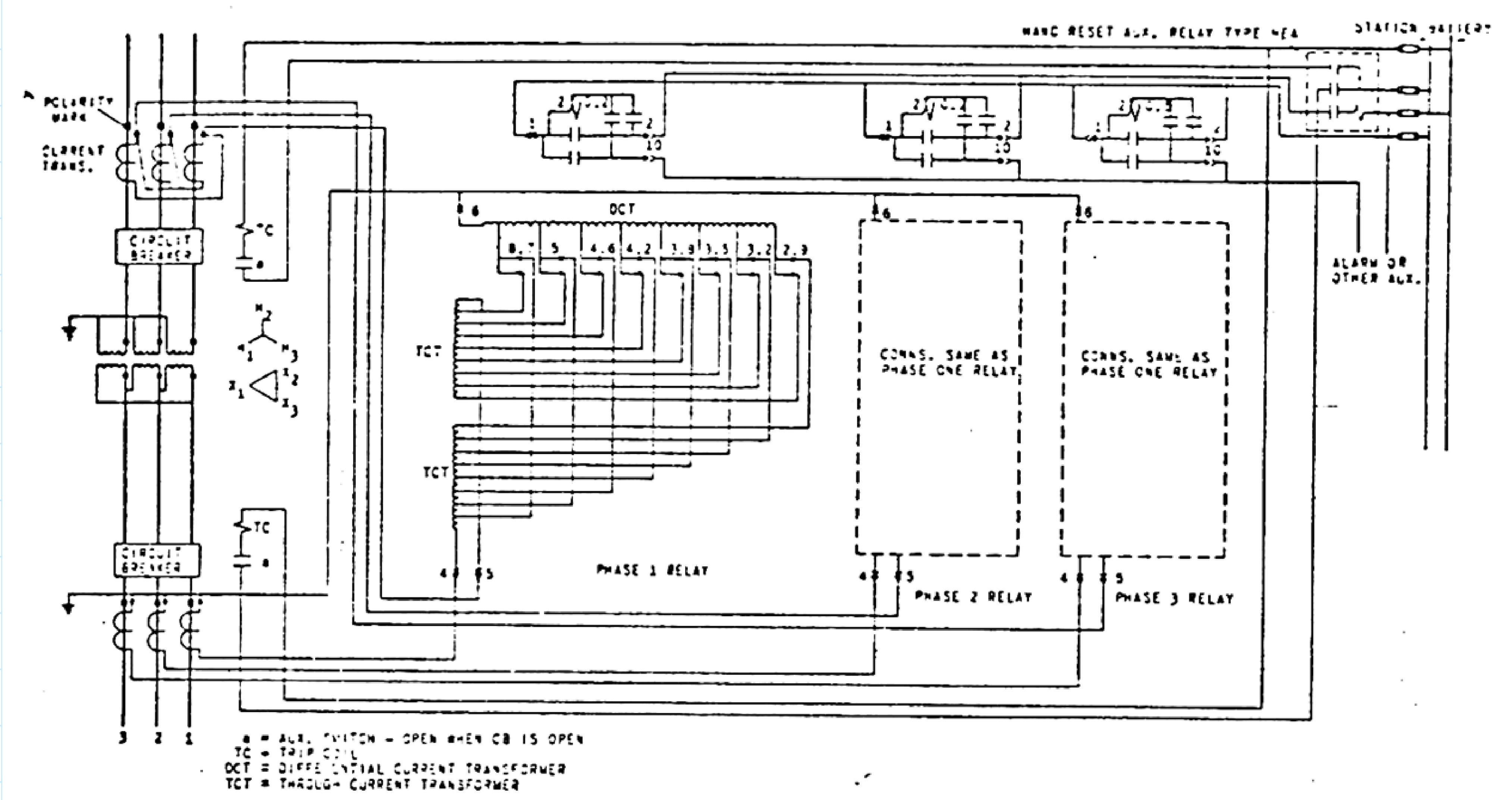


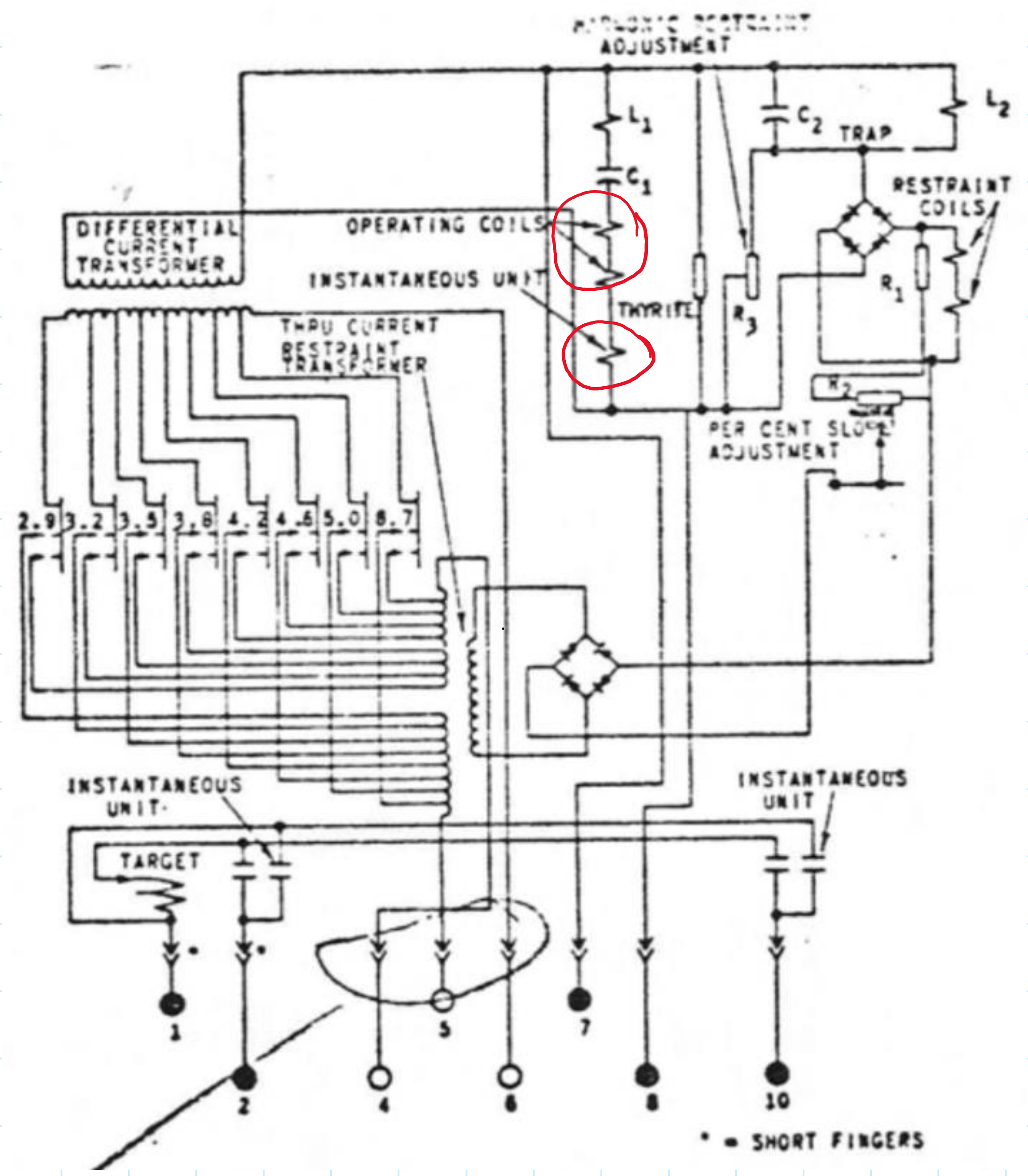




a = AUX. SWITCH – OPEN WHEN CB IS OPEN
TC = TRIP COIL
DCT = DIFFERENTIAL CURRENT TRANSFORMER
TCT = THROUGH CURRENT TRANSFORMER







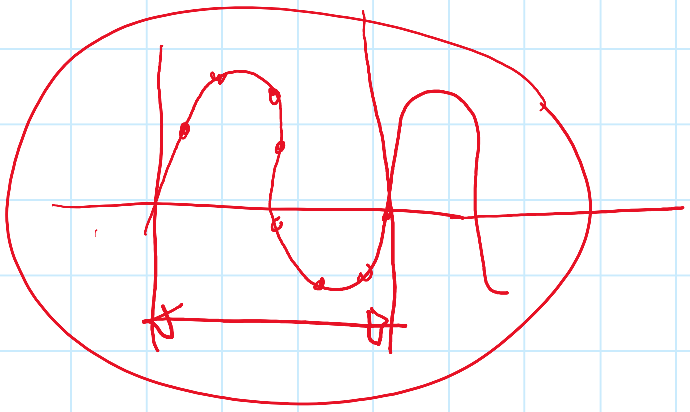
L1 } respond to fundamentel
C1 }

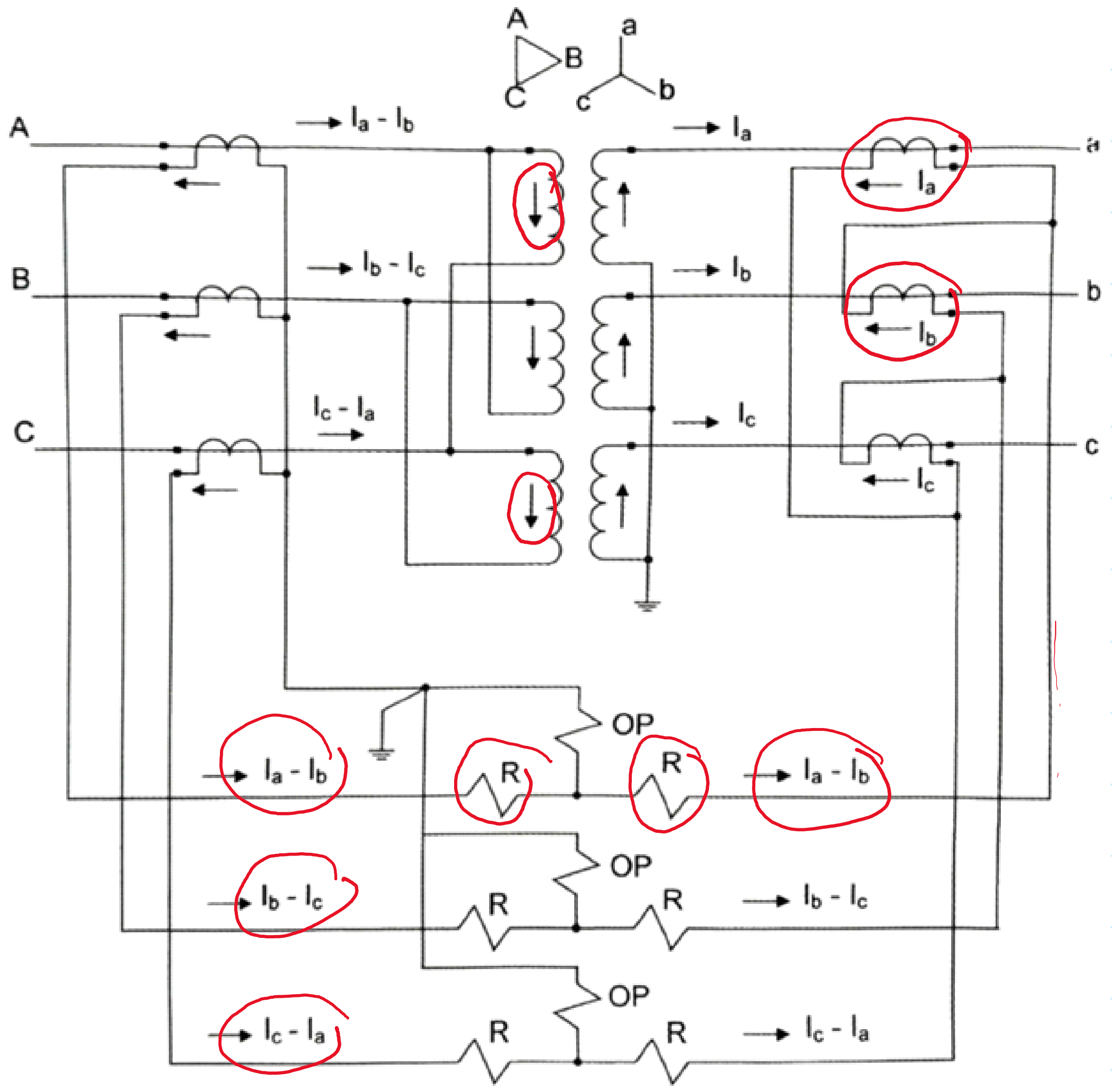
L2 } Trap/Reject Fundamental
C2 } Respond To Harmonics

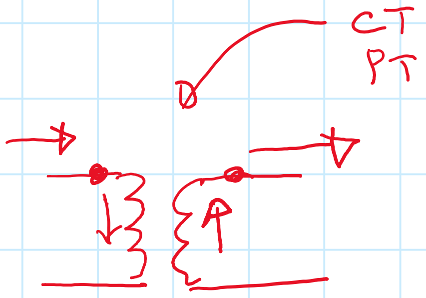
sample/cycle

16 x 60 = 960 samples/sec

60Hz   1/60 Sec

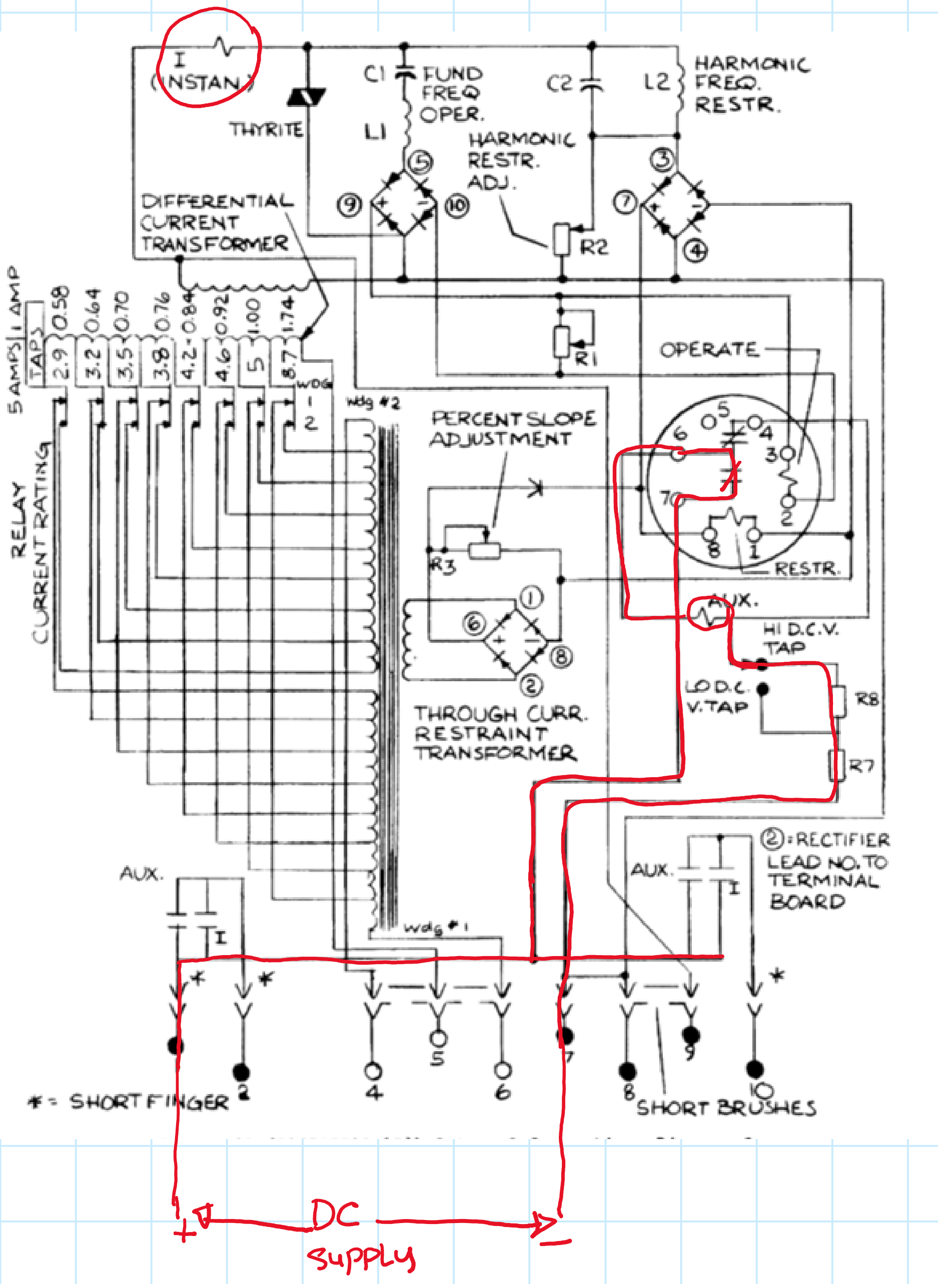


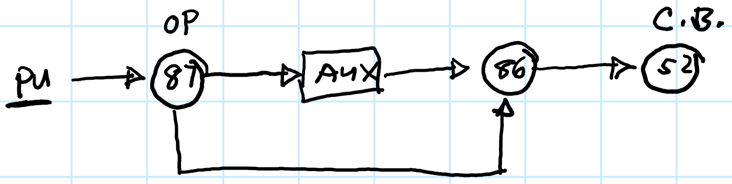


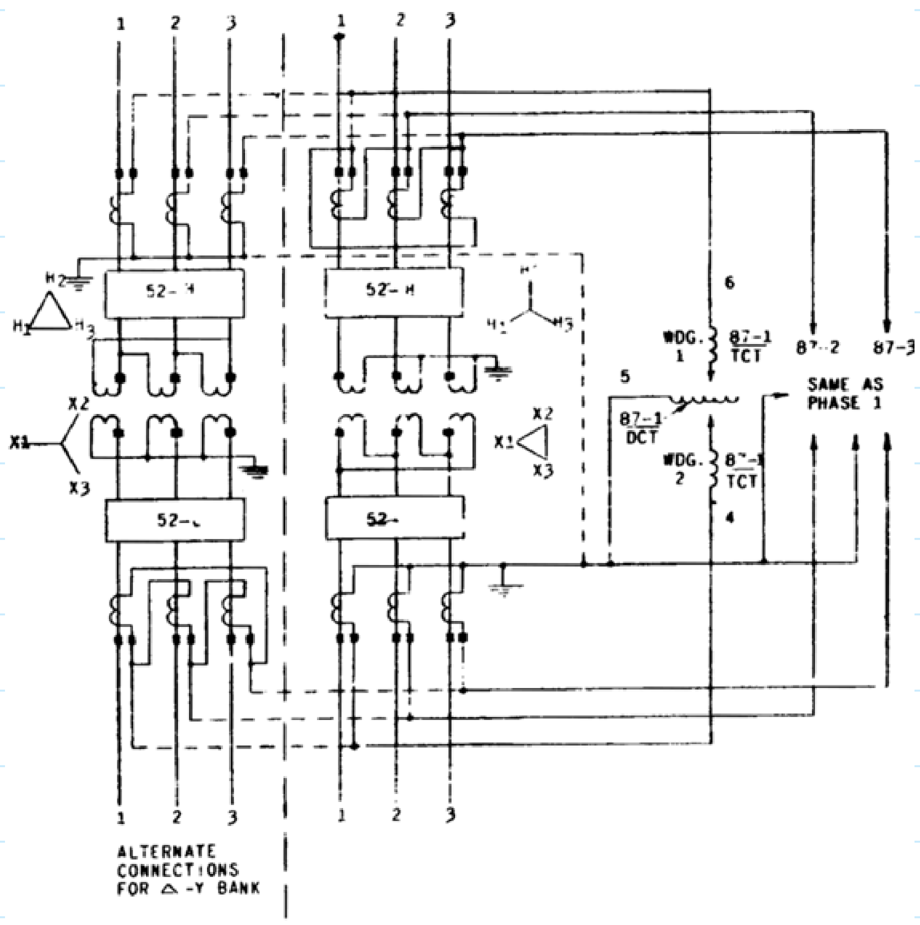


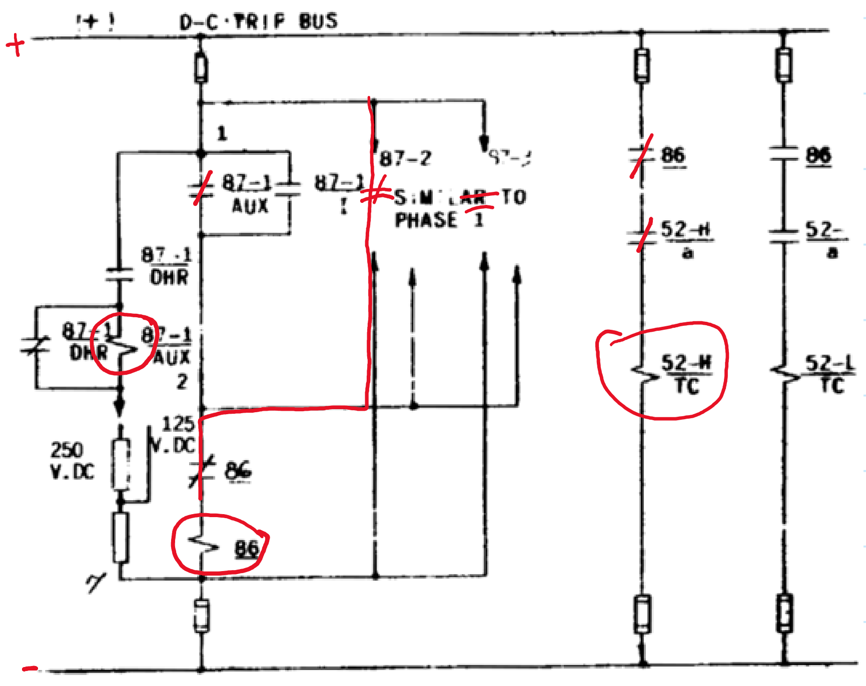
Restraining Characteristics (External Fault)

Digital Relay



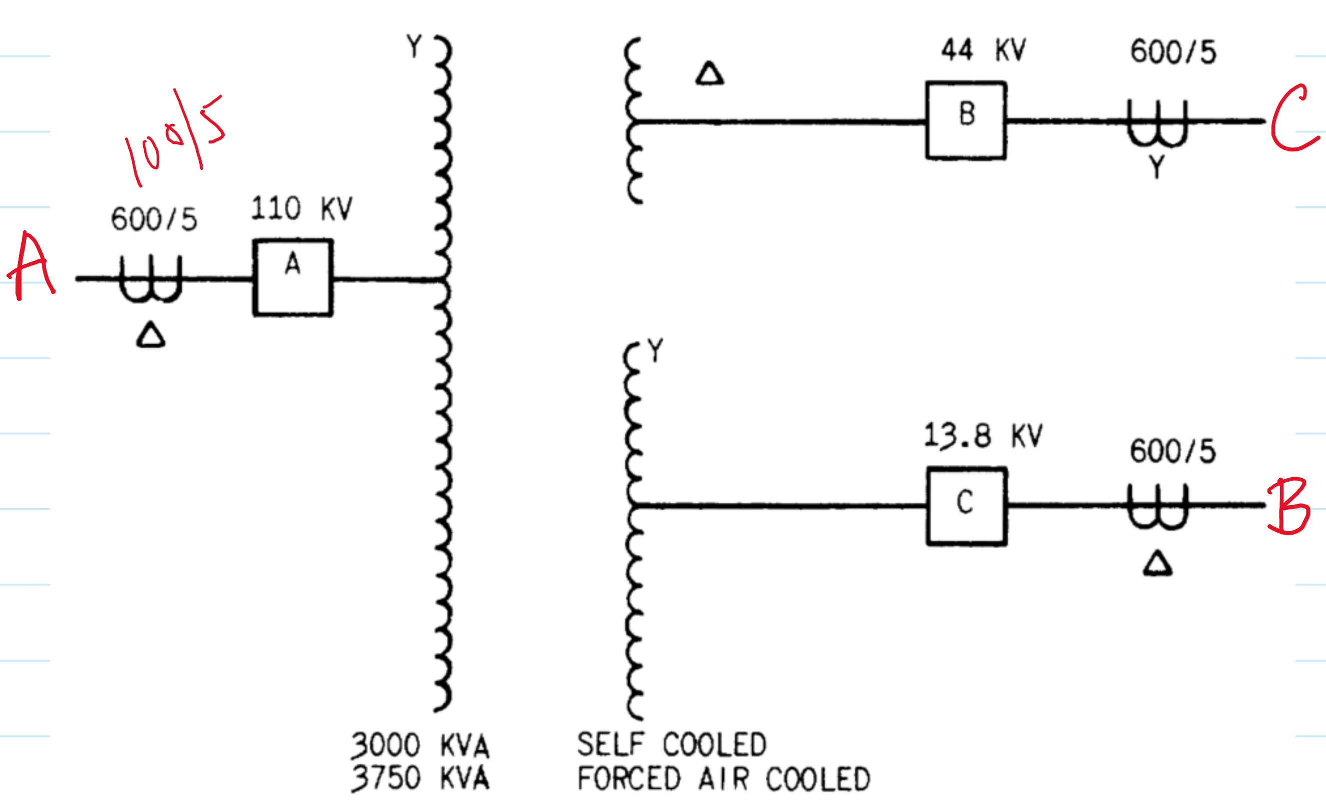






a - AUX. SWITCH, OPEN WHEN BREAKER IS OPEN
TC - TRIP COIL
DCT - DIFFERENTIAL CURRENT TRANSFORMER
TCT - THROUGH CURRENT TRANSFORMER
I - INSTANTANEOUS OVERCURRENT
DHR = DIFFERENTIAL UNIT WITH HARMONIC RESTRAINT
86 = HAND RESET RELAY TYPE HEA
52 - POWER CIRCUIT BREAKER
87 - TYPE BDD DIFFERENTIAL RELAY

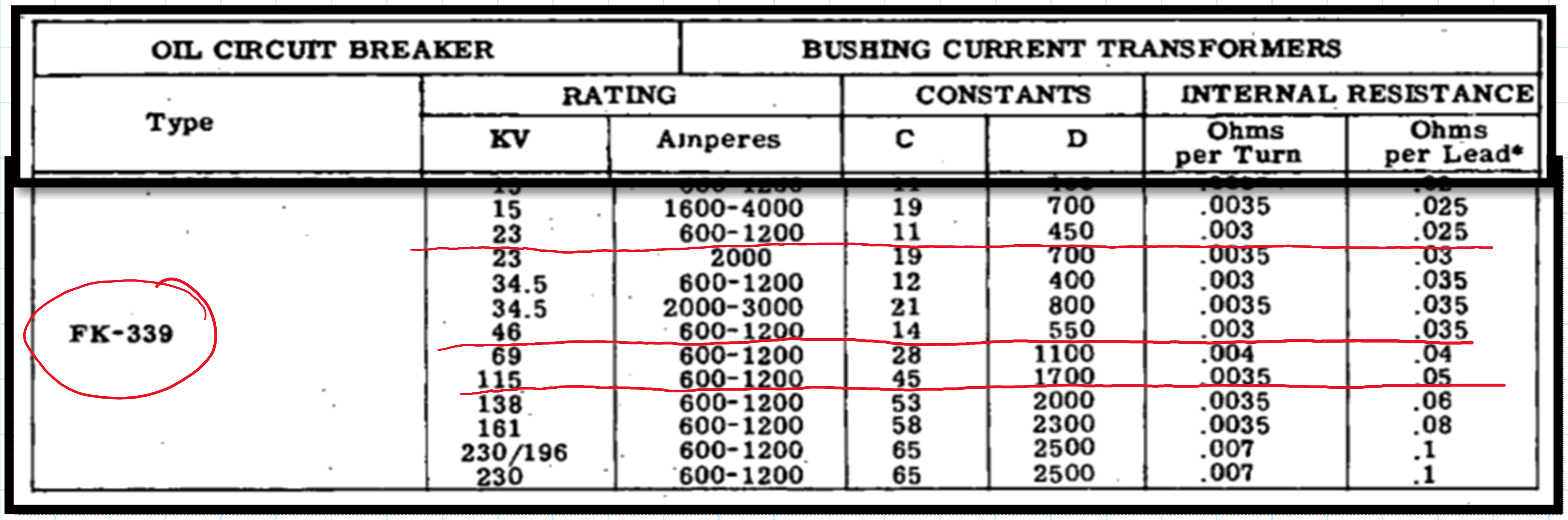
52a – open when CB is open
– close when CB is close



WYE-WYE - DELTA

$E_S = CN/20$

$I_e = D/20N$

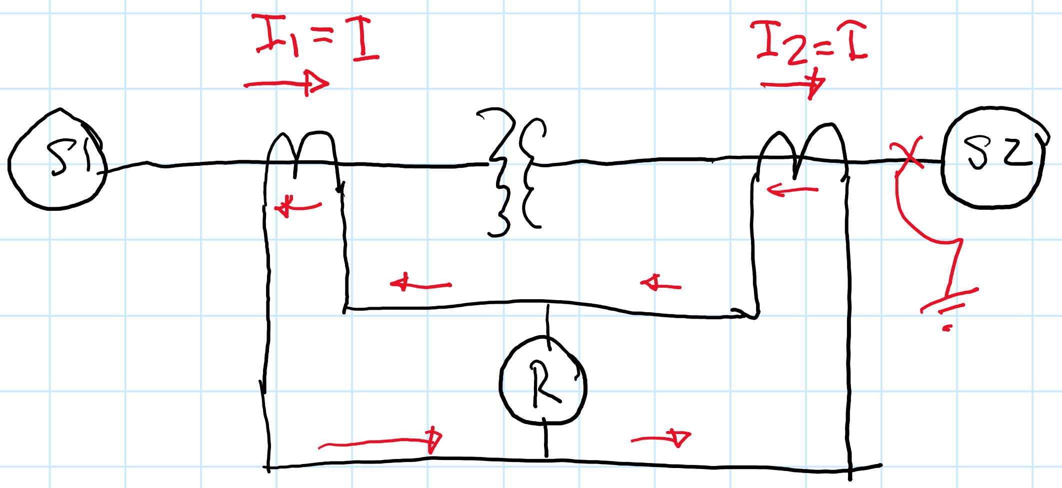


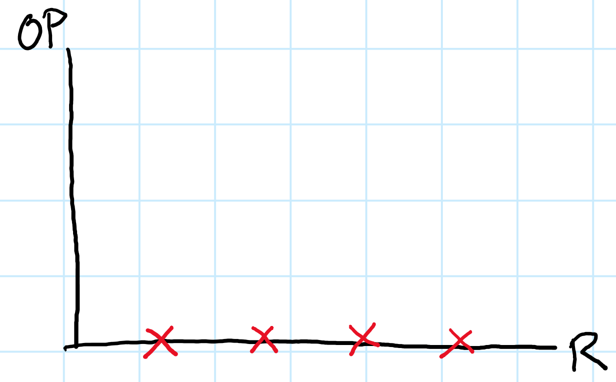
OIL CIRCUIT BREAKER	BUSHING CURRENT TRANSFORMERS					
Type	RATING		CONSTANTS		INTERNAL RESISTANCE	
	KV	Amperes	C	D	Ohms per Turn	Ohms per Lead*
FK-339	15	1600-4000	19	700	.0035	.025
	23	600-1200	11	450	.003	.025
	23	2000	19	700	.0035	.03
	34.5	600-1200	12	400	.003	.035
	34.5	2000-3000	21	800	.0035	.035
	46	600-1200	14	550	.003	.035
	69	600-1200	28	1100	.004	.04
	115	600-1200	45	1700	.0035	.05
	138	600-1200	53	2000	.0035	.06
	161	600-1200	58	2300	.0035	.08
	230/196	600-1200	65	2500	.007	.1
	230	600-1200	65	2500	.007	.1

Restraining Characteristics (External Fault)
Digital Relay

Relay Operating Current = $I1 - I2 = 0$

Relay Restraining Current = $[I_1] + [I_2] = 2I$

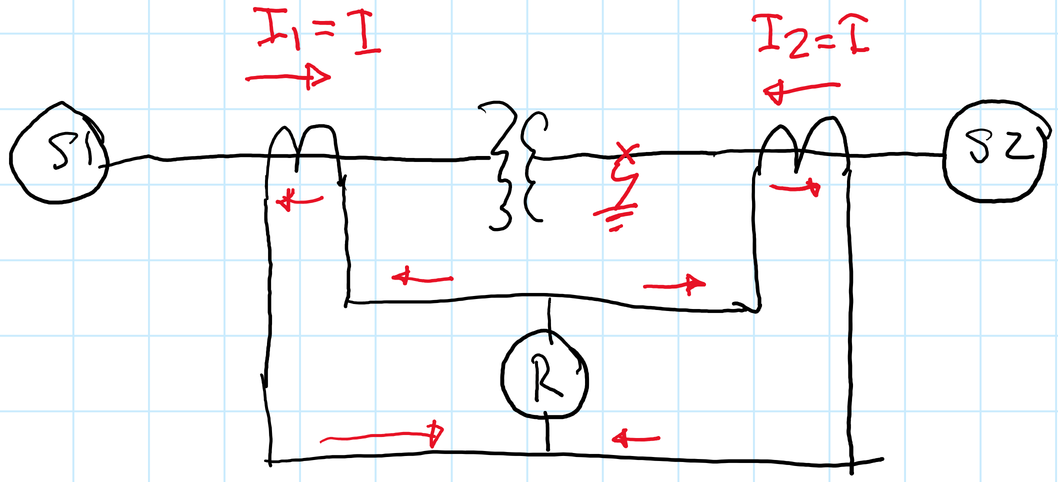


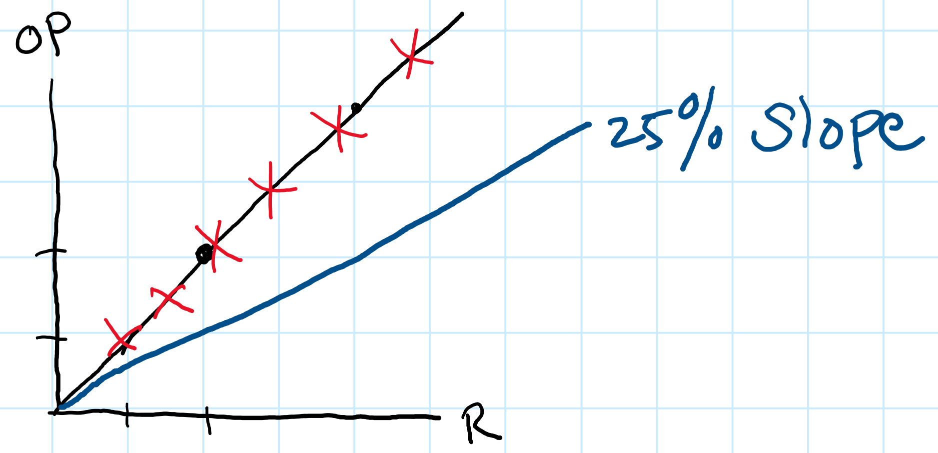


Restraining Characteristics (Internal Fault)
Digital Relay

Relay Operating Current = $I1 - I2 = I - (-I) = 2I$

Relay Restraining Current = $[I_1] + [I_2] = I + I = 2I$





Percentage Slope is determined by the sum of:

① Load control range (LTC) ←
② Mismatch of the relay taps ←

ANSI/IEEE Relay Current Transformers

Up to 10% Error at 20 times rated current

Lets say 1200/5 CT, then the 20times rated current is $20 \times 5A = \underline{100A}$

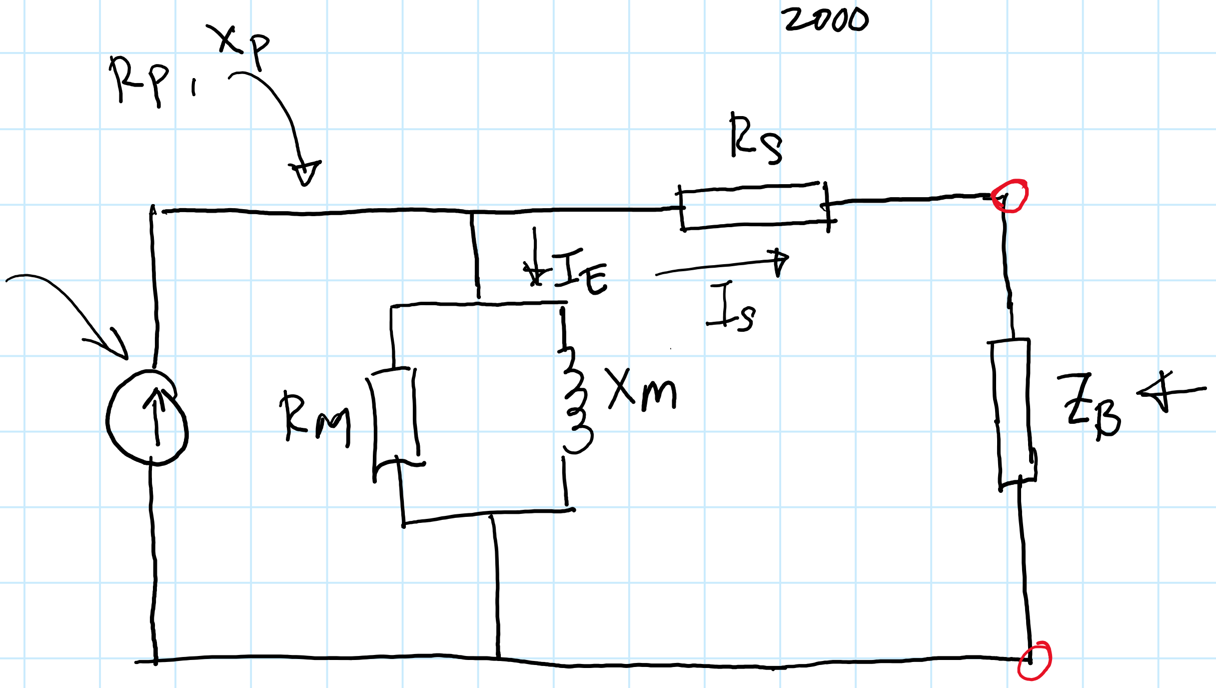
class	Z_B STD (Ω)	V STD (V)
C100	1	100
C200	2	200
C400	4	400
C800	8	800

$100/100 = 1\Omega$

Tapping a CT

2000:5, C800 tapped at 1200:5

Effective Voltage $= 800 \times \frac{1200}{2000} = 480V$



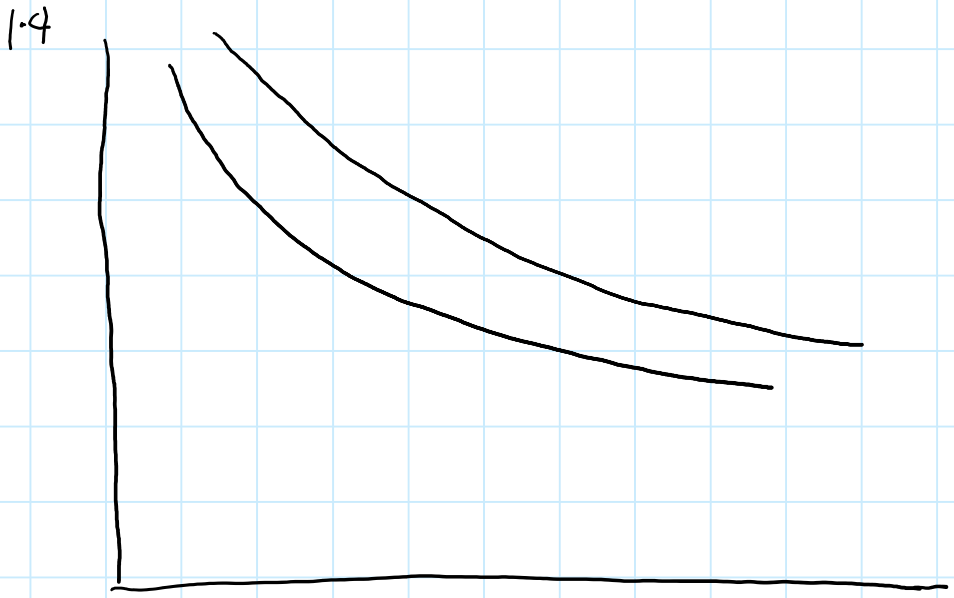
CT Composite Error $= \frac{I_E}{I_S}$

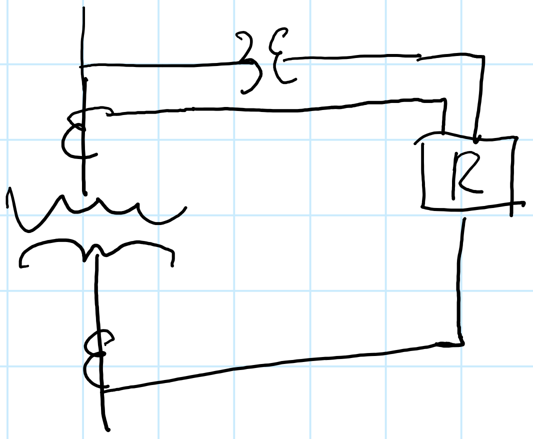
For a 100A secondary current:

$I_E = 10A$

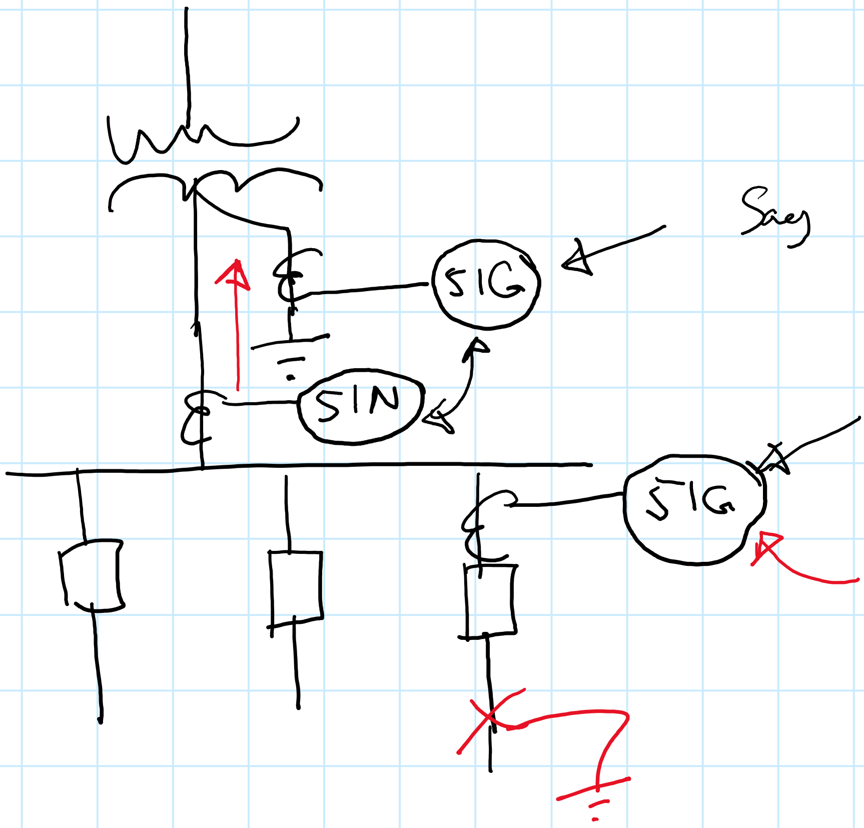
$I_S = 90A$

V/Hz





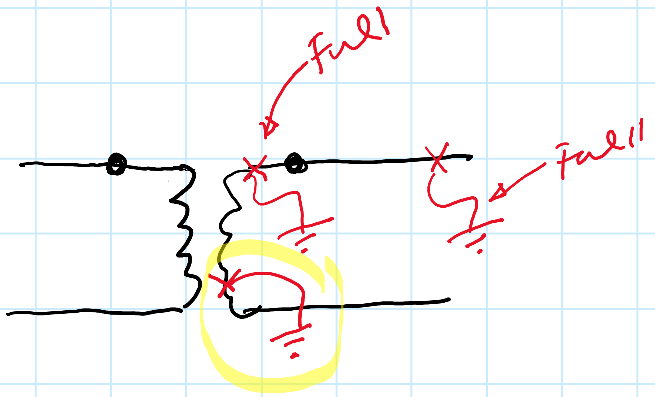
OV(59) Pu = 115% x V_{PRI} / PTR

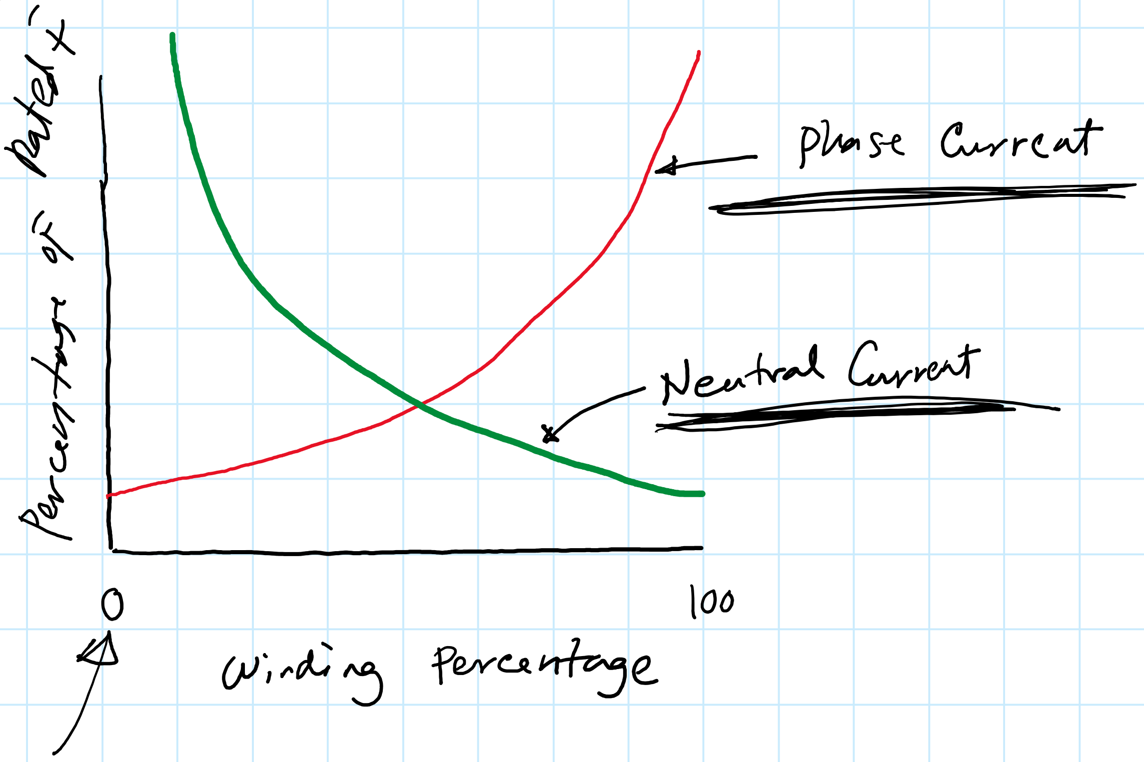


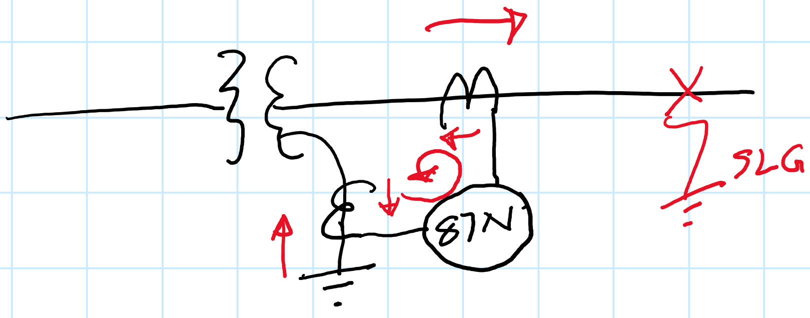
Say 8 feeders, then 51G P.U = 8X

10% - 40% x I_{FL} (or 51)

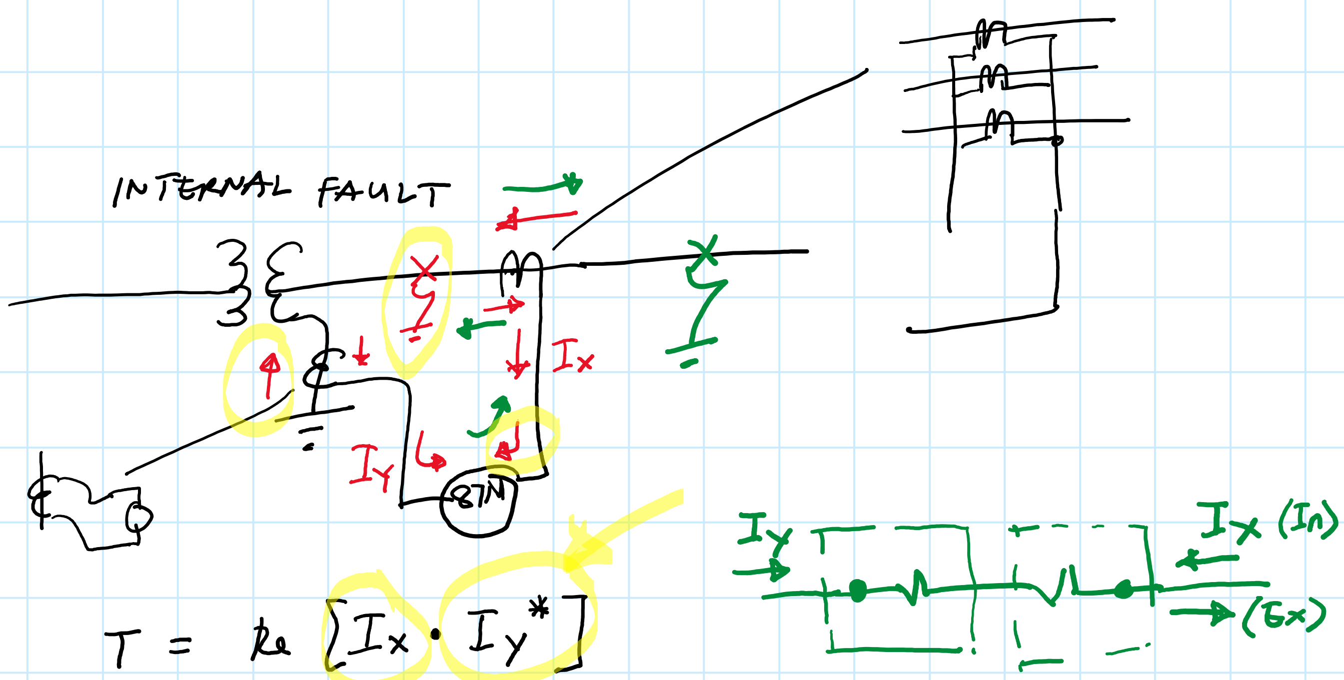
Restricted Earth Fault (87N or 64REF)







EXTERNAL FAULT



$T = \text{Re}\,[I_x \cdot I_Y^*]$

Taking I_Y as Reference : $I_Y = |I| \angle 0°$

For External Fault:

$I_Y = |I| \angle 0°$; $I_x = |I| \angle 180°$

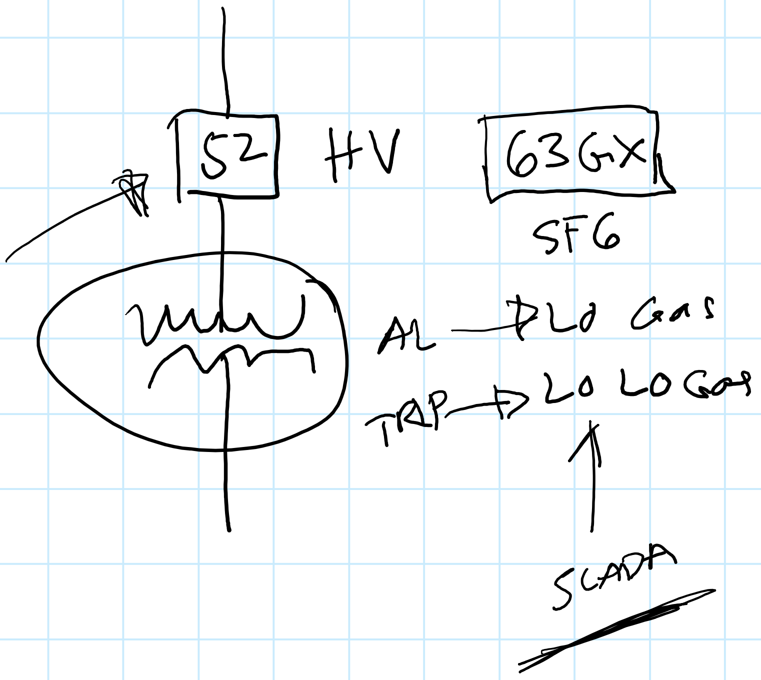
$T = \text{Re}\,[|I| \angle 180° \cdot |I| \angle 0]$ (Yields negative for Real part)

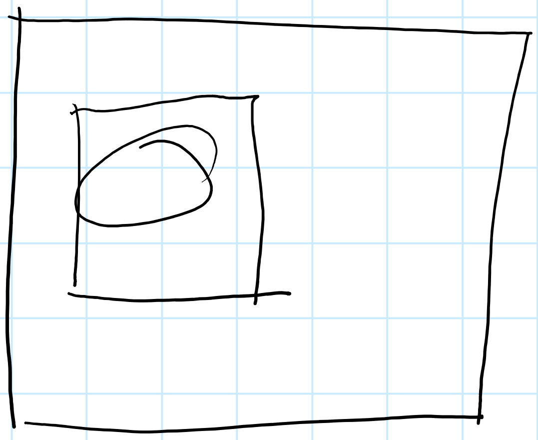
For Internal Fault:

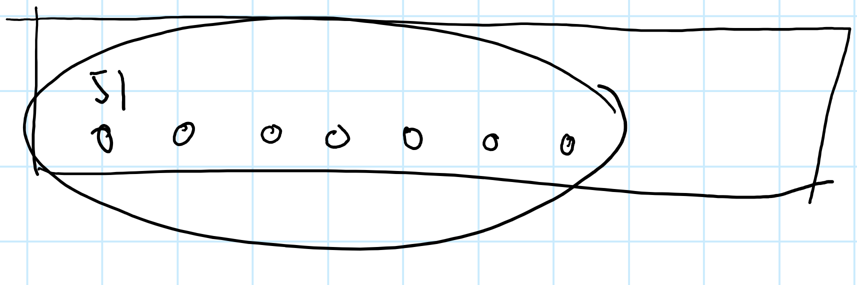
$I_Y = |I| \angle 0°$; $I_x = |I| \angle 0°$

$T = \text{Re}\,[|I| \angle 0° \cdot |I| \angle 0°]$ (yields positive for real part)

$$\text{Re} = |I| \cdot |I| \cos(\theta_x^\circ - \theta_Y^\circ)$$







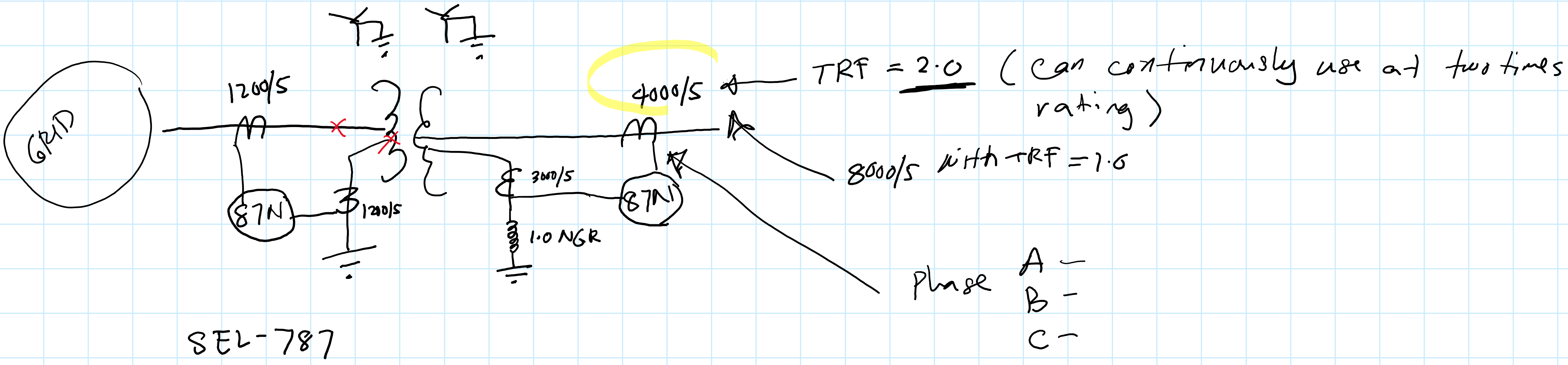
Example For 87N Setting :

Transformer Data ; 240 MVA , 345 KV , 34.5 KV , 3ϕ

I_{PRI} = 401.6 Amp

I_{SEC} = 4016.3 Amp

125% x FLA



CRITERIA : ① Must be greater than natural residual unbalance by load condition
② Must be greater than minimum value determined by the relationship of the CTRn values used in the REF function

CRITERIA #1 Evaluation :

MV SIDE (34.5 KV)

$I_{max H}$ = 401.6 A

$I_{REF H}$ = 10% x $I_{max H}$ = 40.16 A

4016.3

401.6

Secondary Amps :

$I_{REF H}$ (sec) = 40.16 / CTR_H = 40.16 / (1200/5) = 0.167 A

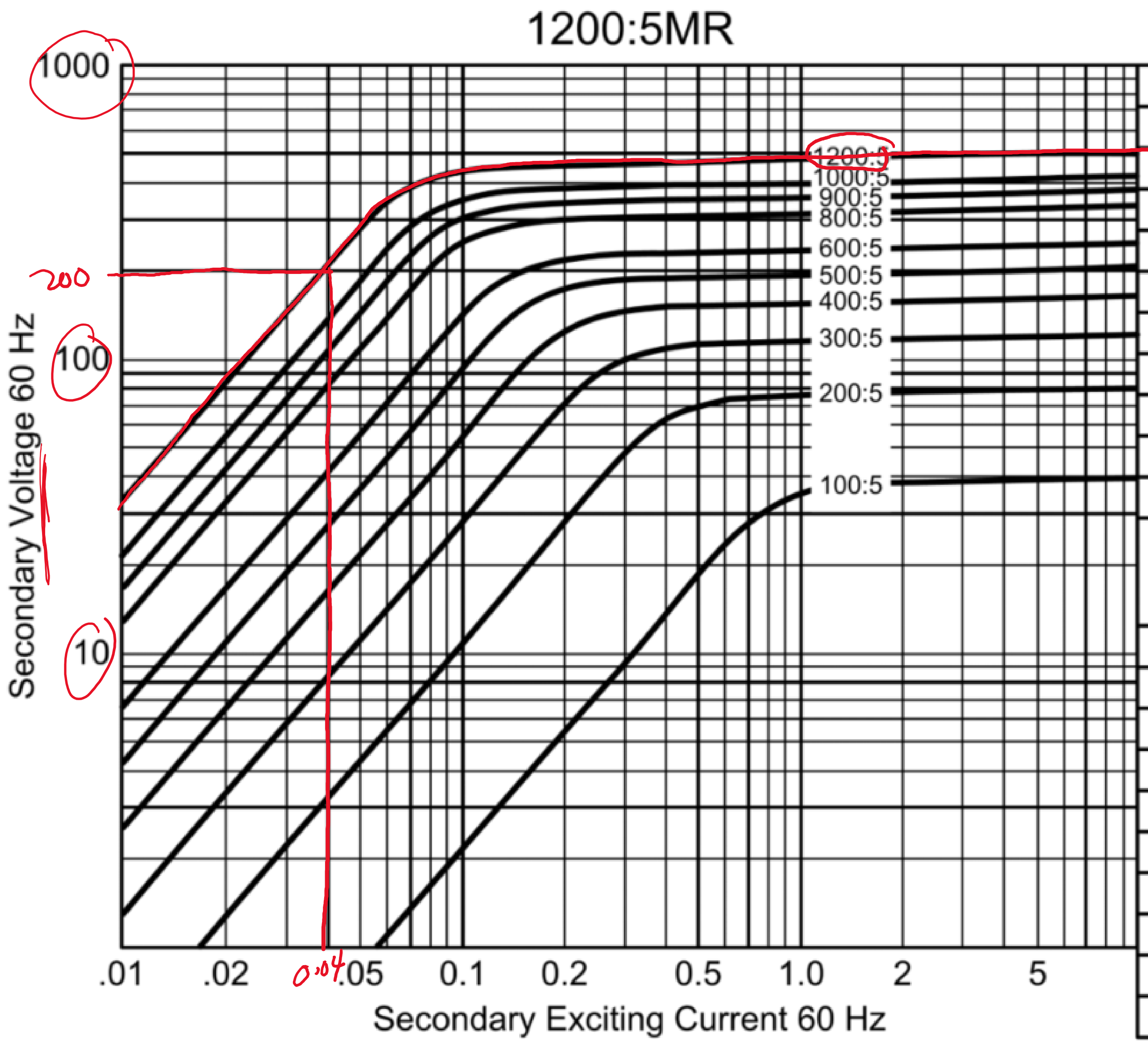
Per Unit : $I_{REF H}$ (sec) / Relay Rating = 0.167/5 = 0.033 P.U.

CRITERIA #2 Evaluation (Compare the relative sensitivity of winding CT to Neutral CT):

$$I_{REF} = 0.05 \frac{CTR_H \cdot 5A}{CTR_{HS.N} \cdot 5A} = \frac{0.05 \ (1200/5) \cdot 5}{(1200/5) \cdot 5} = 0.05 \text{ pu} \}$$

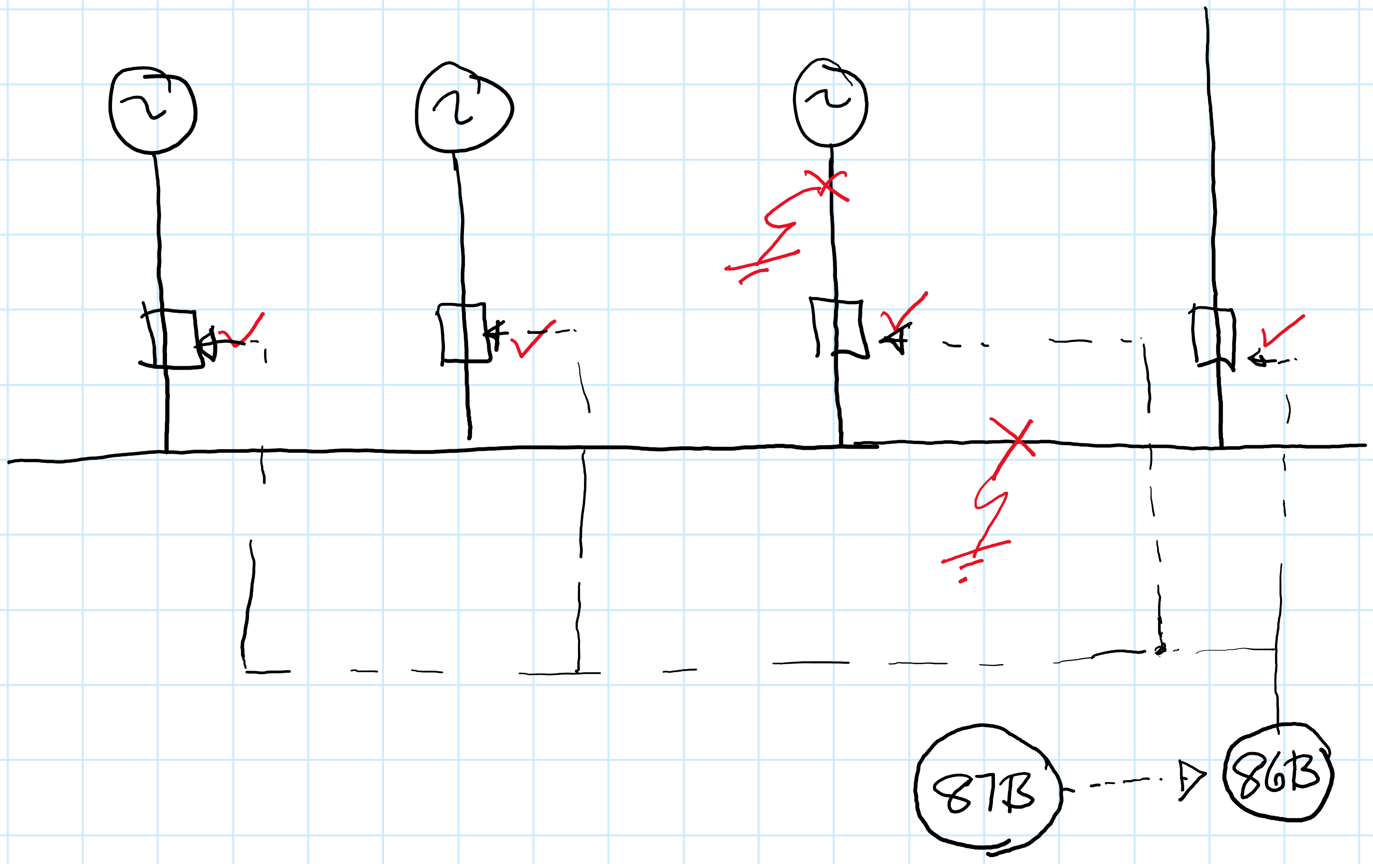
Choose ; 0.10 pu Setting For H.S. REF protection

Primary Amp ; 0.1 pu x 5 = 0.5 Amp → 0.5 x $\frac{1200}{5}$ = 120 Amp (Primary)



Ratio	Tap
100:5	X2 – X3
200:5	X1 – X2
300:5	X1 – X3
400:5	X4 – X5
500:5	X3 – X4
600:5	X2 – X4
800:5	X1 – X4
900:5	X3 – X5
1000:5	X2 – X5
1200:5	X1 – X5

Ratio	DCR Ohms at 75°C
100:5	0.088
200:5	0.177
300:5	0.265
400:5	0.353
500:5	0.441
600:5	0.530
800:5	0.706
900:5	0.795
1000:5	0.883
1200:5	1.059



NOTE : Select CTs with the same
(1) Ratio (2) Voltage class
(2) Same manufacturer

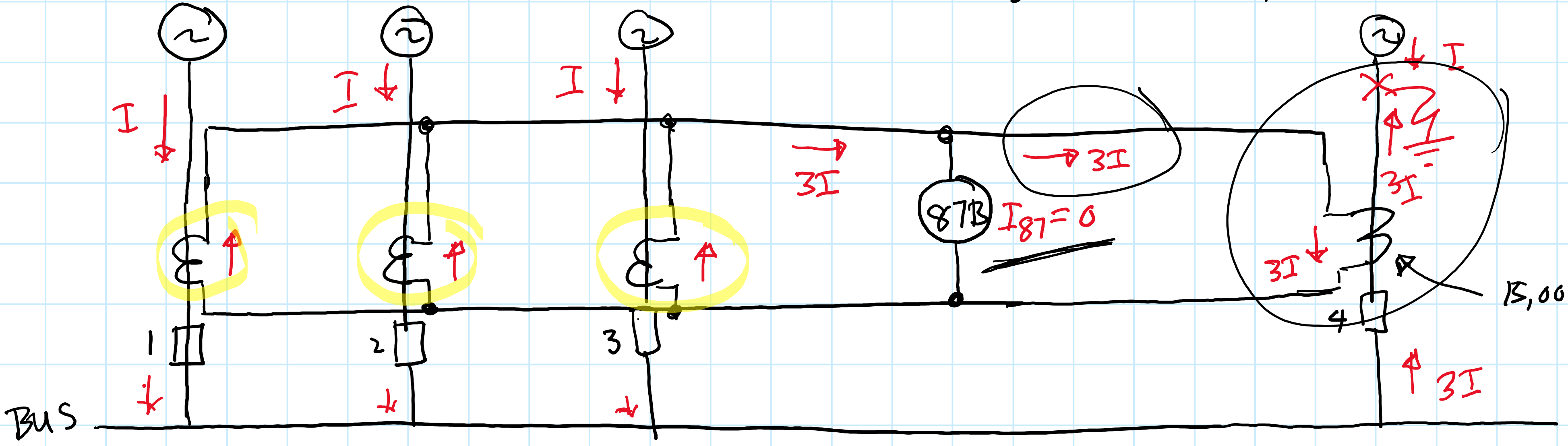
$\frac{4000}{5}$ tap @ $\frac{3200}{5}$

$R_L = 0.5\ \Omega$
$R_{CT} = 0.025\ \Omega$
$R_R = 0.5\ \Omega$
$CTR = 600/5$
$R = 10\ \Omega$

DIFFERENTIAL OVERCURRENT PROTECTION

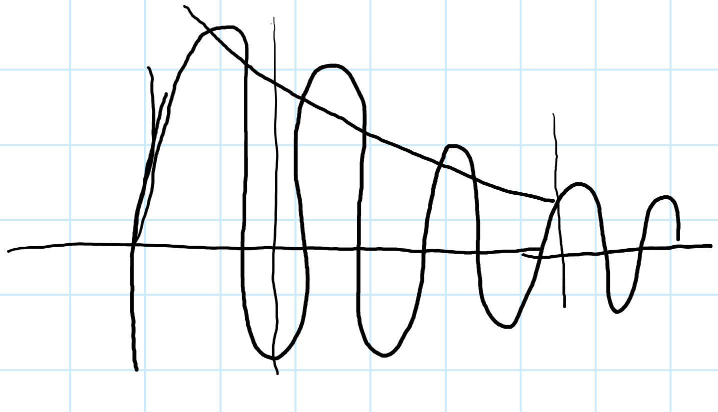
Say I = 5,000 Amps

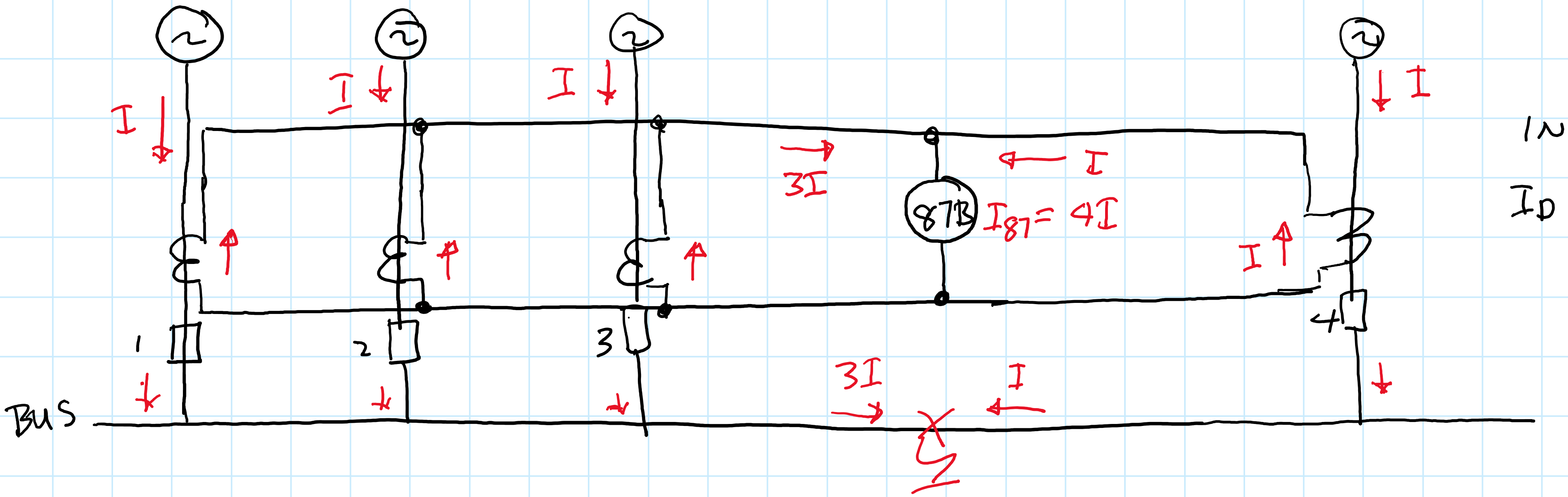
$$\left(1+\frac{X}{R}\right) I_F = Z_b$$



EXTERNAL FAULT

15,000 Amps (Can saturate)



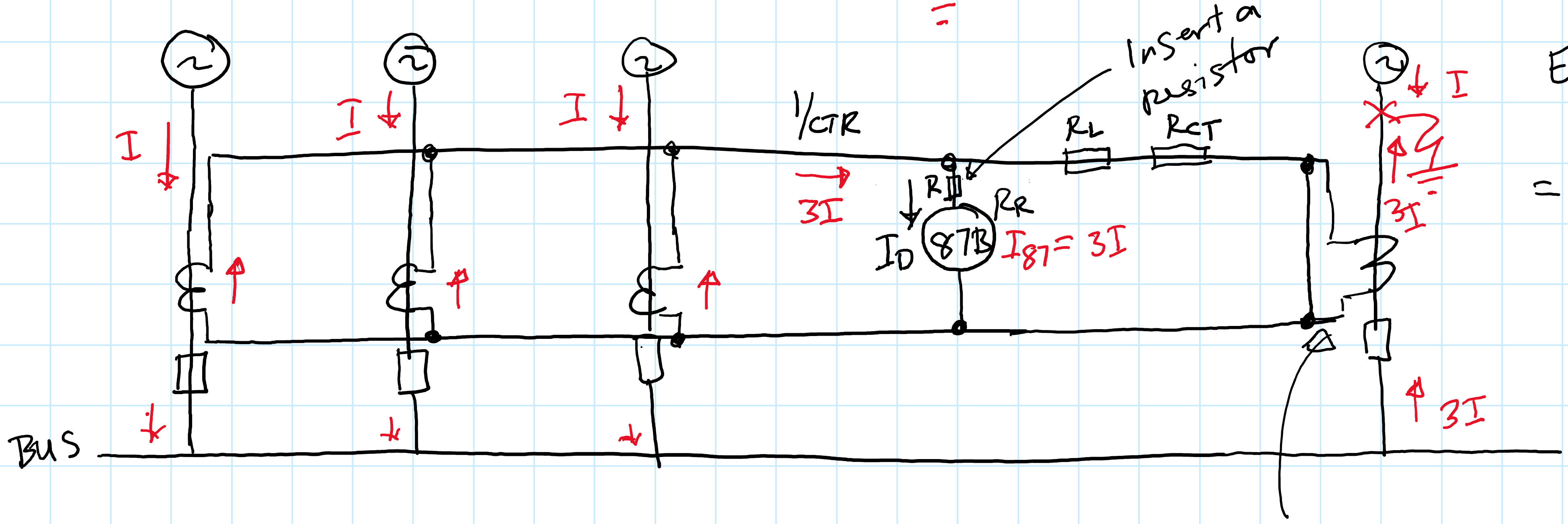


INTERNAL FAULT

$$I_D = \frac{0.5 + 0.025}{0.5 + 0.25 + 0.5} \cdot \frac{20{,}000}{600/5}$$

= 85.37 Amps

= 8.33 Amps (with R)



External Fault with Saturated CT

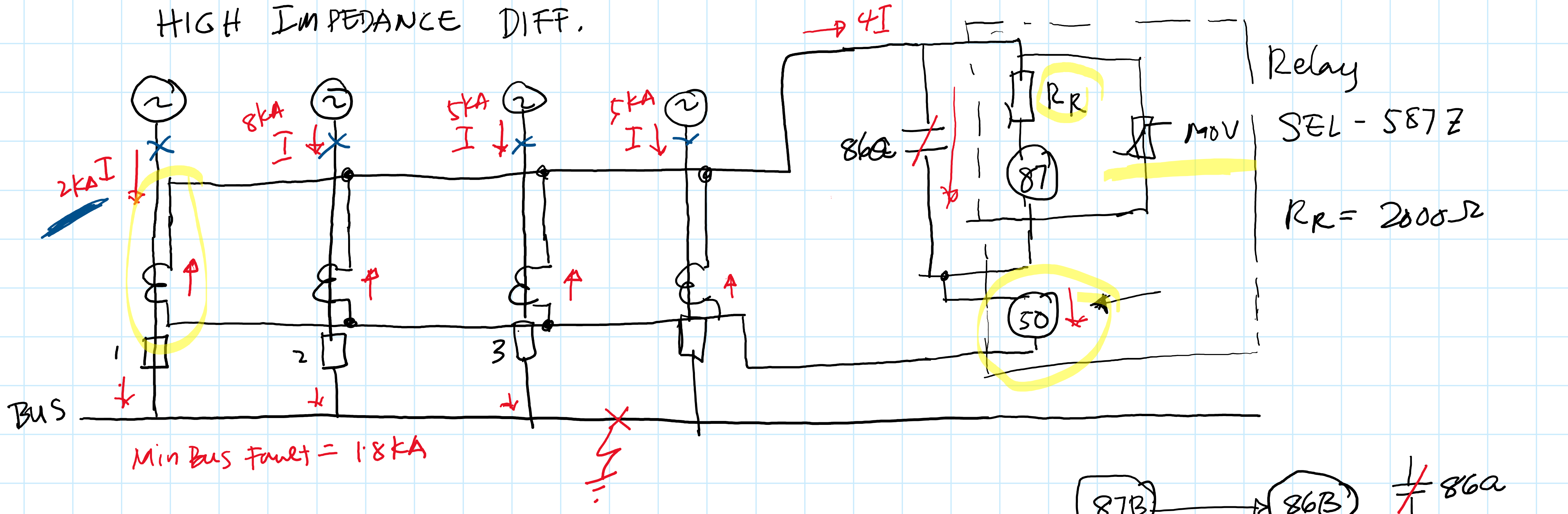
$$= I_D = \frac{R_L + R_{CT}}{R_L + R_{CT} + R_R} \cdot \frac{I}{CTR}$$

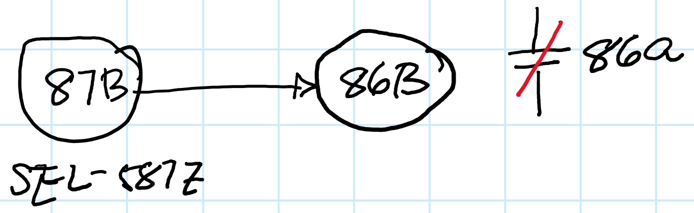
$$I_D = \frac{0.5 + 0.025}{0.5 + 0.25 + 0.5} \cdot \frac{15000}{600/5}$$

= 64.02 Amps

= 5.95 Amps (with R)

HIGH IMPEDANCE DIFF.





$$V_{pu} = K_S \cdot (n \cdot R_L + R_{CT}) \cdot I / CTR$$

K_S = safety factor (typically 1.5 to 2)

R_L = lead/conductor resistance

R_{CT} = CT secondary resistance

n = use 1 for 3φ or 2 for single-phase

$$I_{min} = (N \cdot I_E + I_{relay} + I_{MOV}) \cdot CTR$$

N = # of CTs

I_E = excitation current

I_{relay} = relay current

$$V_{pu} = K_D \cdot V_{STD}$$

V_{STD} = accuracy class of CT

K_D = security factor (0.5 to 1)

Fault Data :	3ϕ	SLG
F1	2KA	1.2KA
F2	8KA	8.8KA
F3	5KA	3.5KA
F4	5KA	3.5KA
Min Bus	1.8KA	0.9KA

CT circuits Data

$R_L = 0.4\,\Omega$

R_R (stabilizing Relay Resistor) $= 2000\,\Omega$

$R_{CT} = 1.06\,\Omega$

CTR = 1200/5

CT accuracy class = C400

④ Calculate OC element pickup setting

$$I_{pu} = K_1 \cdot \frac{I_{MIN}}{CTR} = 0.5\,\frac{900}{1200/5}$$

$$I_{pu} = 1.875\ \text{A}$$

① Calculate for Short Circuit Currents

$I_{3\phi\_INT} = 2+8+5+5 = 20KA$ } Max Internal Fault

$I_{SLG\_INT} = 1.2+8.8+3.5+3.5 = 17KA$

$I_{3\phi\_EXT} = 8+5+5 = 18KA$ } Max External Fault

$I_{SLG\_EXT} = 8.8+3.5+3.5 = 15.8KA$

$I_{3\phi\_MIN} = 1.8KA$ } minimum Internal faults

$I_{SLG\text{-}MIN} = 0.9KA$

② Calculate secure voltage setting

$$V_{pu} = K_S \cdot (n \cdot R_L + R_{CT}) \cdot I/CTR = 1.5(1\times0.4+1.06)\cdot 18{,}000/(1200/5) = 164.25V \quad (3\phi)$$

$$V_{pu} = K_S \cdot (n \cdot R_L + R_{CT}) \cdot I/CTR = 1.5(2\times0.4+1.06)\cdot 15{,}800/(1200/5) = 183.68V \quad (1\phi)$$

② Calculate dependable voltage setting

$$V_{pu} = K_D \cdot V_{STD} = 0.5 \times 400 = 200V$$

③ Calculate sensisitivity for Internal faults

$$I_{MIN} = (N \cdot I_E + I_{RELAY} + I_{MOV}) \cdot CTR = \left(4\times0.04 + \frac{200}{2000} + 0\right)\cdot\frac{1200}{5} = 62.4\ \text{Amp primary}$$

since 62.4 < 900 then sensisity is satisfied

Breaker Failure Setting

Table 4.38 Breaker Failure Setting

Setting Prompt	Setting Range	Setting Name := Factory Default
52A INTERLOCK	Y, N	52ABF := N
BRKR1 FAIL DELAY	0.00–2.00 sec	BFD1 := 0.50
BRKR1 FAIL INIT	SELOGIC	BFI1 := R_TRIG TRIP1 OR R_TRIG TRIPXFMR
BRKR2 FAIL DELAY	0.00-2.00 sec	BFD2 := 0.50
BRKR2 FAIL INIT	SELOGIC	BFI2 := R_TRIG TRIP2 OR R_TRIG TRIPXFMR

The SEL-787 provides flexible breaker failure logic (see *Figure 4.57*) for two breakers. In the default breaker failure logic, assertion of trip Relay Word bits associated with a breaker starts a BFD timer if the sum of positive and negative-sequence breaker current is above 0.02 • I_{NOM}. If the current remains above the threshold for BFD delay setting, Relay Word bit BFT will assert. Use the BFT to operate an output relay to trip appropriate backup breakers. Changing the BFI and/or 52ABF settings can modify the default breaker failure logic.

- Set BFI1 = R_TRIG TRIP1 OR R_TRIG TRIPXFMR AND NOT IN102 if input IN102 is manual trip only and breaker failure initiation is not desired when the tripping is caused by this input.
- Set 52ABF = Y if you want the breaker failure logic to detect failure of breaker/contactor auxiliary contact to operate during the trip operation as defined by the BFI setting.

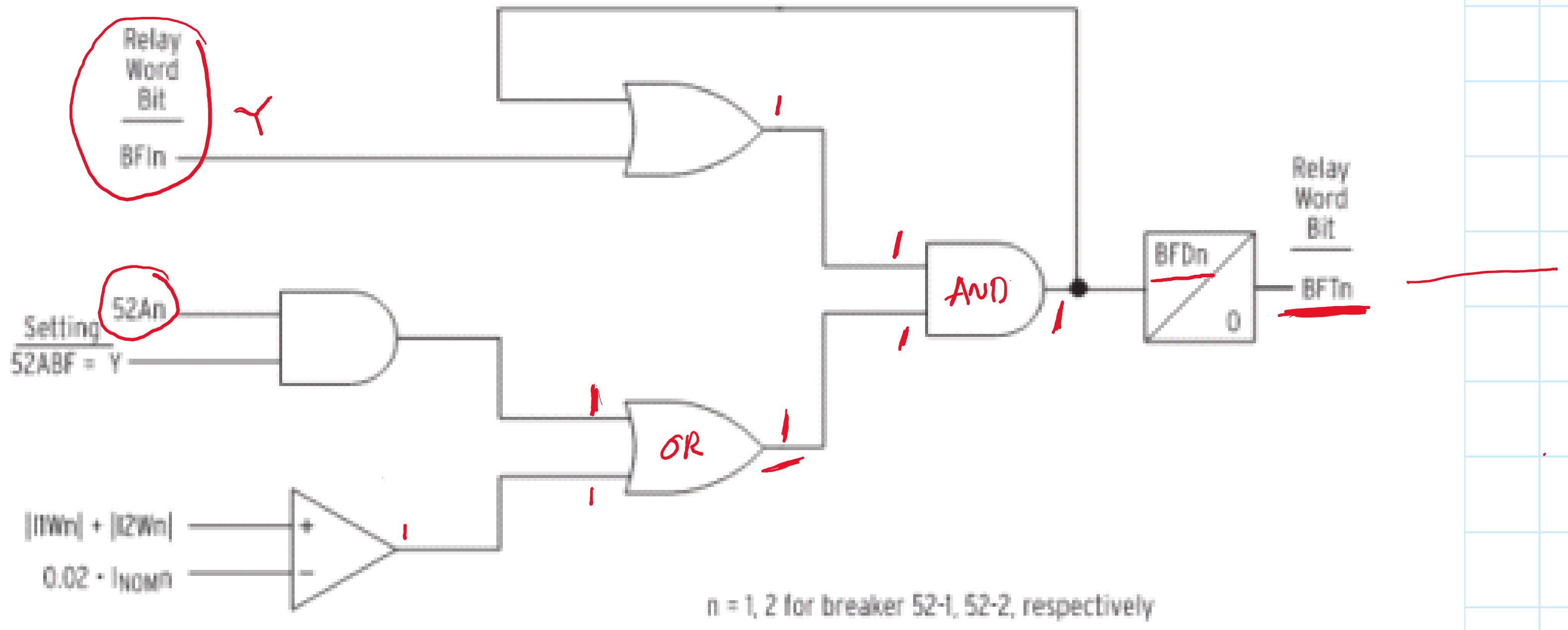


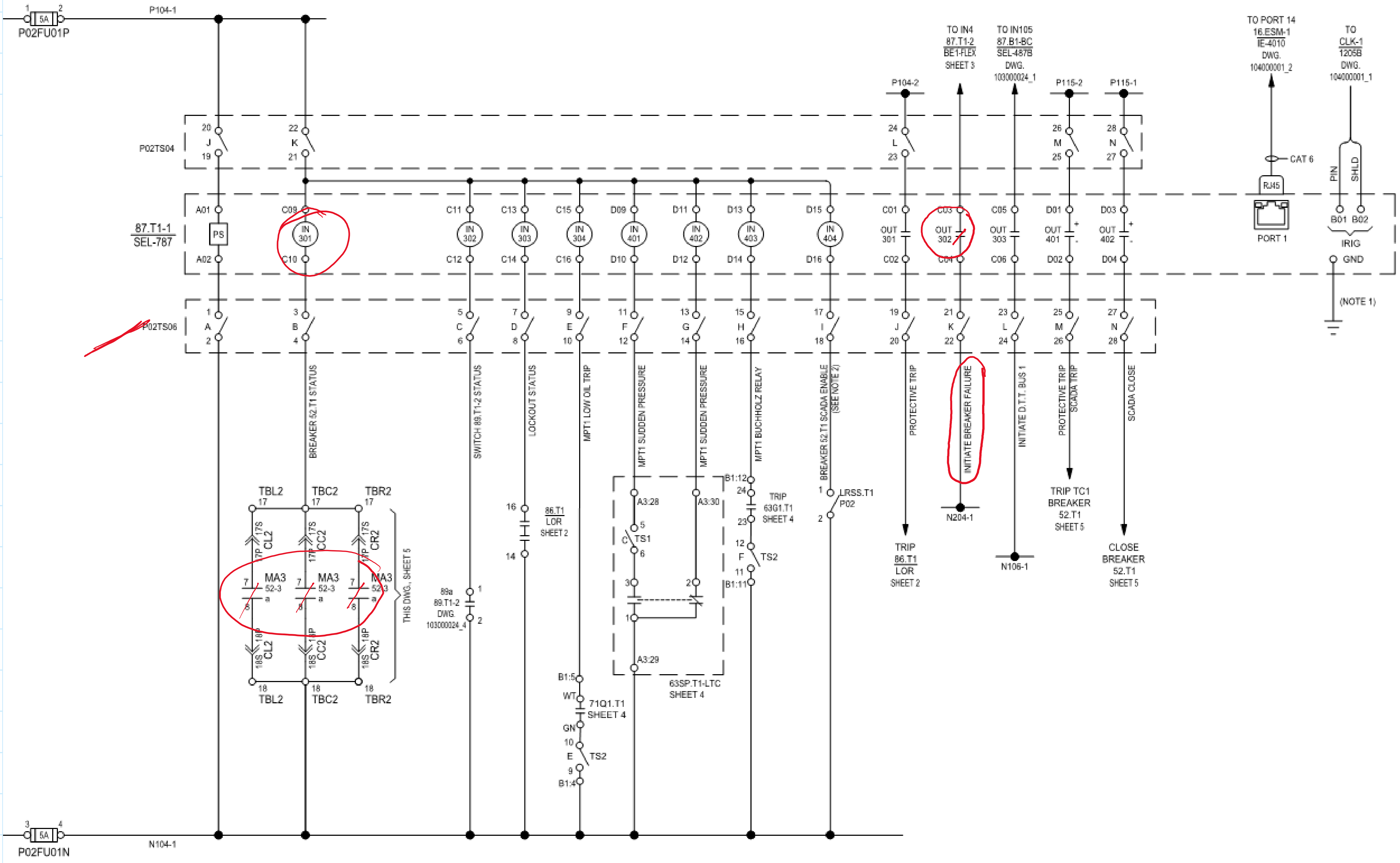
Figure 4.57 Breaker Failure Logic

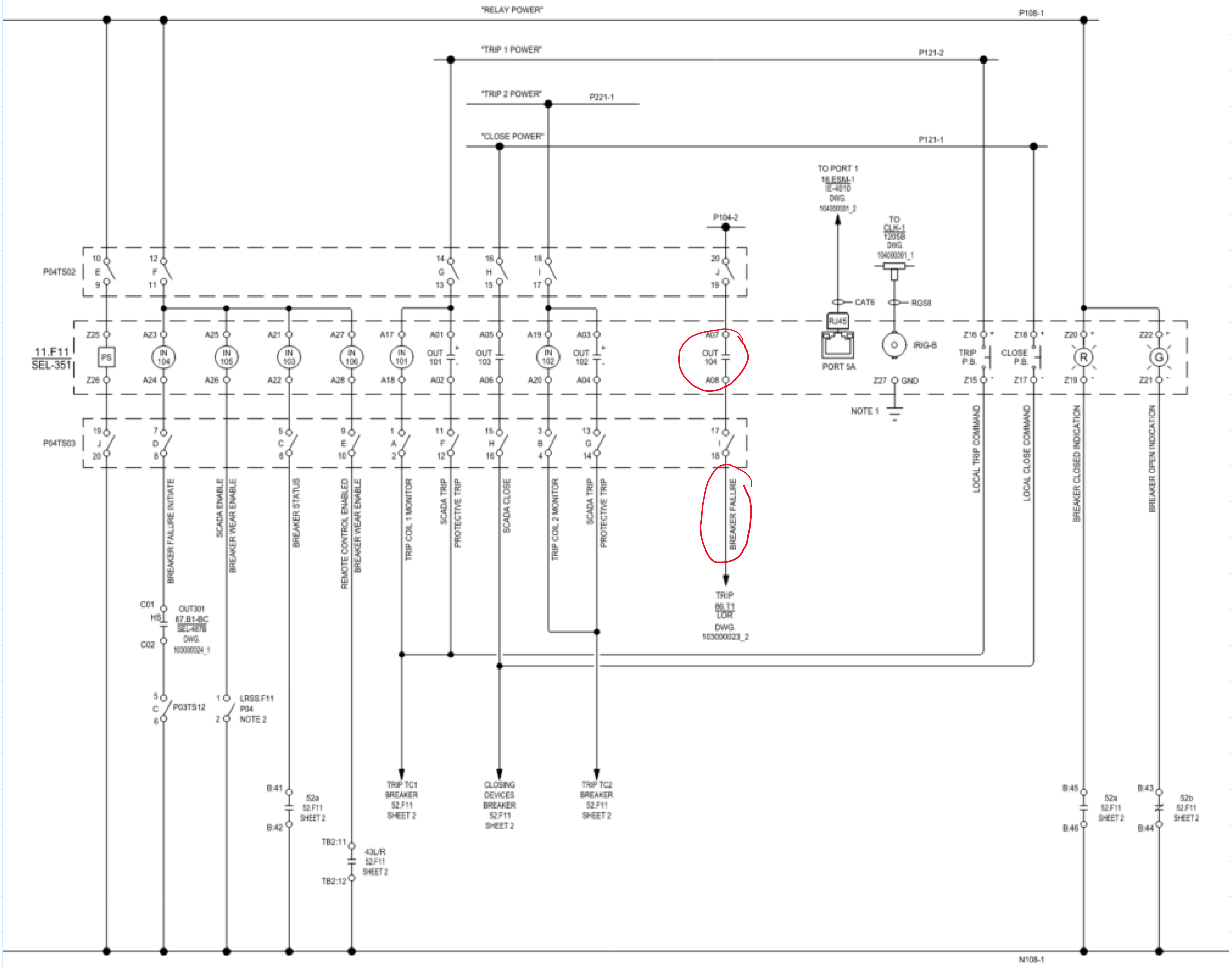
0.02·Inom

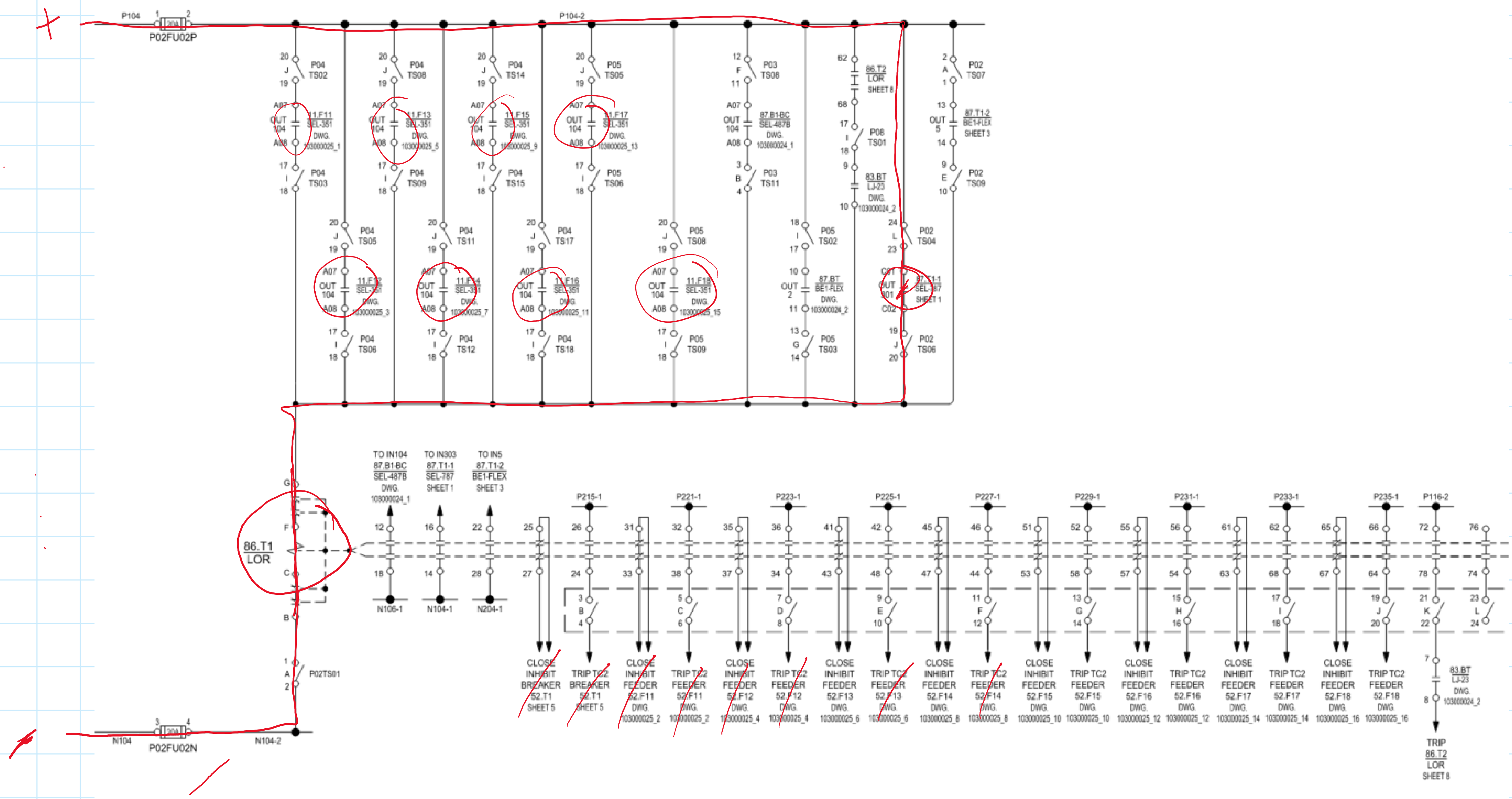
I1W1
↑
positive

I2Wn
↑
neg

52a – Breaker Aux Contact


P02FU01P
5A
P104-1
P02TS04
20 J 19
22 K 21
87.T1-1
SEL-787
A01
PS
A02
C08
IN 301
C10
C11 IN 302 C12
C13 IN 303 C14
C15 IN 304 C16
D09 IN 401 D10
D11 IN 402 D12
D13 IN 403 D14
D15 IN 404 D16
C01 OUT 301 C02
C03 OUT 302 C04
C05 OUT 303 C06
D01 OUT 401 D02
D03 OUT 402 D04
P104-2
24 L 23
TO IN4 87.T1-2 BE1-FLEX SHEET 3
TO IN105 87.B1-BC SEL-487B DWG. 103000024_1
P115-2
26 M 25
P115-1
28 N 27
TO PORT 14 16.ESM-1 IE-4010 DWG. 104000001_2
CAT 6
RJ45
PORT 1
TO CLK-1 1205B DWG. 104000001_1
PIN
SHLD
B01 B02
IRIG
GND
(NOTE 1)
P02TS06
1 A 2
3 B 4
5 C 6
7 D 8
9 E 10
11 F 12
13 G 14
15 H 16
17 I 18
19 J 20
21 K 22
23 L 24
25 M 26
27 N 28
BREAKER 52.T1 STATUS
SWITCH 89.T1-2 STATUS
LOCKOUT STATUS
MPT1 LOW OIL TRIP
MPT1 SUDDEN PRESSURE
MPT1 SUDDEN PRESSURE
MPT1 BUCHHOLZ RELAY
BREAKER 52.T1 SCADA ENABLE (SEE NOTE 2)
PROTECTIVE TRIP
INITIATE BREAKER FAILURE
INITIATE D.T.T. BUS 1
PROTECTIVE TRIP SCADA TRIP
SCADA CLOSE
TBL2 TBC2 TBR2
17
17P 17S CL2
17P 17S CC2
17P 17S CR2
7 MA3 52-3 a 8
THIS DWG., SHEET 5
18P 18S CL2
18P 18S CC2
18P 18S CR2
18
TBL2 TBC2 TBR2
89a 89.T1-2 DWG. 103000024_4
1 2
16 14
86.T1 LOR SHEET 2
B1:5
WT
71Q1.T1 SHEET 4
GN
10 E TS2 9
B1:4
A3:28
5 C TS1 6
A3:30
3 2 1
A3:29
63SP.T1-LTC SHEET 4
B1:12
24 23
TRIP 63G1.T1 SHEET 4
12 F TS2 11
B1:11
1 LRSS.T1 P02 2
TRIP 86.T1 LOR SHEET 2
N204-1
N106-1
TRIP TC1 BREAKER 52.T1 SHEET 5
CLOSE BREAKER 52.T1 SHEET 5
P02FU01N
5A
N104-1


"RELAY POWER"
P108-1
"TRIP 1 POWER"
P121-2
"TRIP 2 POWER"
P221-1
"CLOSE POWER"
P121-1
TO PORT 1
16.ESM-1
IE-4010
DWG.
104000001_2
P104-2
TO
CLK-1
1205B
DWG.
104000001_1
CAT6
RG58
RJ45
PORT 5A
IRIG-B
Z27 GND
NOTE 1
P04TS02
10 E 9
12 F 11
14 G 13
16 H 15
18 I 17
20 J 19
11.F11
SEL-351
Z25 PS Z26
A23 IN 104 A24
A25 IN 105 A26
A21 IN 103 A22
A27 IN 106 A28
A17 IN 101 A18
A01 OUT 101 A02
A05 OUT 103 A06
A19 IN 102 A20
A03 OUT 102 A04
A07 OUT 104 A08
Z16 TRIP P.B. Z15
Z18 CLOSE P.B. Z17
Z20 R Z19
Z22 G Z21
P04TS03
19 J 20
7 D 8
5 C 6
9 E 10
1 A 2
11 F 12
15 H 16
3 B 4
13 G 14
17 I 18
BREAKER FAILURE INITIATE
SCADA ENABLE
BREAKER WEAR ENABLE
BREAKER STATUS
REMOTE CONTROL ENABLED
BREAKER WEAR ENABLE
TRIP COIL 1 MONITOR
SCADA TRIP
PROTECTIVE TRIP
SCADA CLOSE
TRIP COIL 2 MONITOR
SCADA TRIP
PROTECTIVE TRIP
BREAKER FAILURE
LOCAL TRIP COMMAND
LOCAL CLOSE COMMAND
BREAKER CLOSED INDICATION
BREAKER OPEN INDICATION
TRIP
86.T1
LOR
DWG.
103000023_2
C01
HS
C02
OUT301
87.B1-BC
SEL-487B
DWG.
103000024_1
5 C 6 P03TS12
1 2 LRSS.F11
P04
NOTE 2
B:41 B:42
52a
52.F11
SHEET 2
TB2:11 TB2:12
43L/R
52.F11
SHEET 2
TRIP TC1
BREAKER
52.F11
SHEET 2
CLOSING
DEVICES
BREAKER
52.F11
SHEET 2
TRIP TC2
BREAKER
52.F11
SHEET 2
B:45 B:46
52a
52.F11
SHEET 2
B:43 B:44
52b
52.F11
SHEET 2
N108-1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P02FU02P
20A
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P04 TS02
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P04 TS06
P04 TS08
11.F13 SEL-351 DWG. 103000025_5
P04 TS09
P04 TS11
11.F14 SEL-351 DWG. 103000025_7
P04 TS12
P04 TS14
11.F15 SEL-351 DWG. 103000025_9
P04 TS15
P04 TS17
11.F16 SEL-351 DWG. 103000025_11
P04 TS18
P05 TS05
11.F17 SEL-351 DWG. 103000025_13
P05 TS06
P05 TS08
11.F18 SEL-351 DWG. 103000025_15
P05 TS09
P03 TS08
87.B1BC SEL-487B DWG. 103000024_1
P03 TS11
P05 TS02
87.BT BE1-FLEX DWG. 103000024_2
P05 TS03
86.T2 LOR SHEET 8
P08 TS01
83.BT LJ-23 DWG. 103000024_2
P02 TS04
87.T1-1 SEL-787 SHEET 1
P02 TS06
P02 TS07
87.T1-2 BE1-FLEX SHEET 3
P02 TS09
A07
OUT 104
A08
86.T1 LOR
TO IN104 87.B1-BC SEL-487B DWG. 103000024_1
TO IN303 87.T1-1 SEL-787 SHEET 1
TO IN5 87.T1-2 BE1-FLEX SHEET 3
N106-1
N104-1
N204-1
P215-1
P221-1
P223-1
P225-1
P227-1
P229-1
P231-1
P233-1
P235-1
P116-2
CLOSE INHIBIT BREAKER 52.T1 SHEET 5
TRIP TC2 BREAKER 52.T1 SHEET 5
CLOSE INHIBIT FEEDER 52.F11 DWG. 103000025_2
TRIP TC2 FEEDER 52.F11 DWG. 103000025_2
CLOSE INHIBIT FEEDER 52.F12 DWG. 103000025_4
TRIP TC2 FEEDER 52.F12 DWG. 103000025_4
CLOSE INHIBIT FEEDER 52.F13 DWG. 103000025_6
TRIP TC2 FEEDER 52.F13 DWG. 103000025_6
CLOSE INHIBIT FEEDER 52.F14 DWG. 103000025_8
TRIP TC2 FEEDER 52.F14 DWG. 103000025_8
CLOSE INHIBIT FEEDER 52.F15 DWG. 103000025_10
TRIP TC2 FEEDER 52.F15 DWG. 103000025_10
CLOSE INHIBIT FEEDER 52.F16 DWG. 103000025_12
TRIP TC2 FEEDER 52.F16 DWG. 103000025_12
CLOSE INHIBIT FEEDER 52.F17 DWG. 103000025_14
TRIP TC2 FEEDER 52.F17 DWG. 103000025_14
CLOSE INHIBIT FEEDER 52.F18 DWG. 103000025_16
TRIP TC2 FEEDER 52.F18 DWG. 103000025_16
83.BT LJ-23 DWG. 103000024_2
TRIP 86.T2 LOR SHEET 8
P02TS01
N104
P02FU02N
N104-2
+
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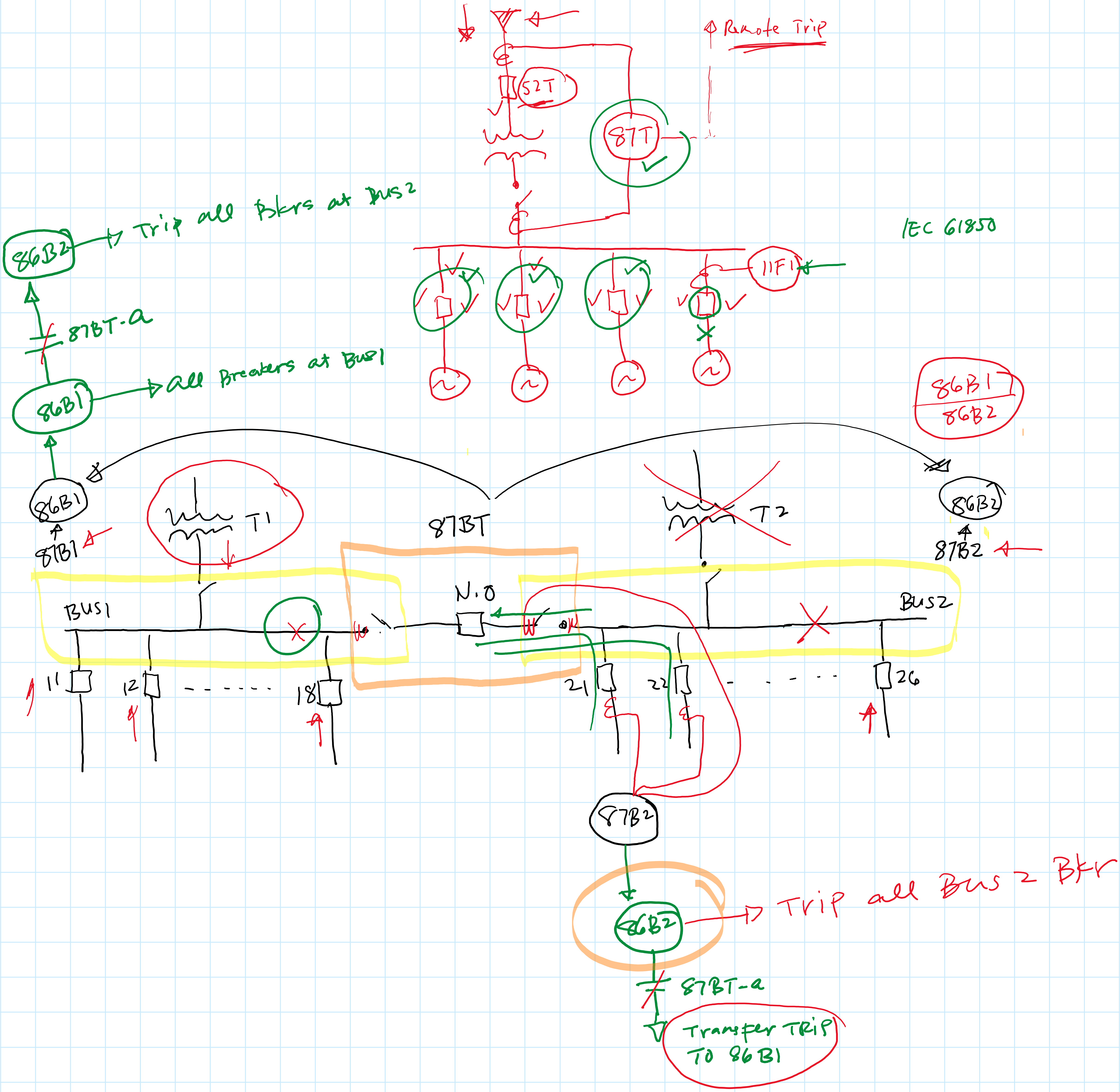
Remote Trip
52T
87T
IEC 61850
11F1
86B2
Trip all Bkrs at Bus2
87BT-a
86B1
All Breakers at Bus1
86B1
86B2
86B1
T1
87BT
T2
86B2
87B1
87B2
N.O
BUS1
BUS2
11
12
18
21
22
26
87B2
86B2
Trip all Bus 2 Bkr
87BT-a
Transfer Trip
TO 86B1