

Substation Relay Protection Overview NWPPA E&O Conference 2016

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Electrical Consultants Inc.**

Presentation Overview

- *Faults*
- *Relays*
- *Instrument Transformers*
- *Correlation to Drawings*
 - One Lines*
 - AC Schematics*
 - DC Schematics*
- *Other Types of Protection*
- *Coordination of Relays*

Purpose of Protective Relaying

- *Protect Personnel*
- *Protect Equipment*
- *Isolate Fault to Smallest Affected Area*

Relay Operation

- 1) *Trip during fault*
- 2) *Trip during overload*
- 3) *Trip during over/under voltage*
- 4) *Trip during over/under frequency*

Relay Operation

- 5) *Don't trip during inrush*
- 6) *Don't trip during cold load restoration*
- 7) *Don't trip during "normal" conditions*

How do Relays Recognize Faults?

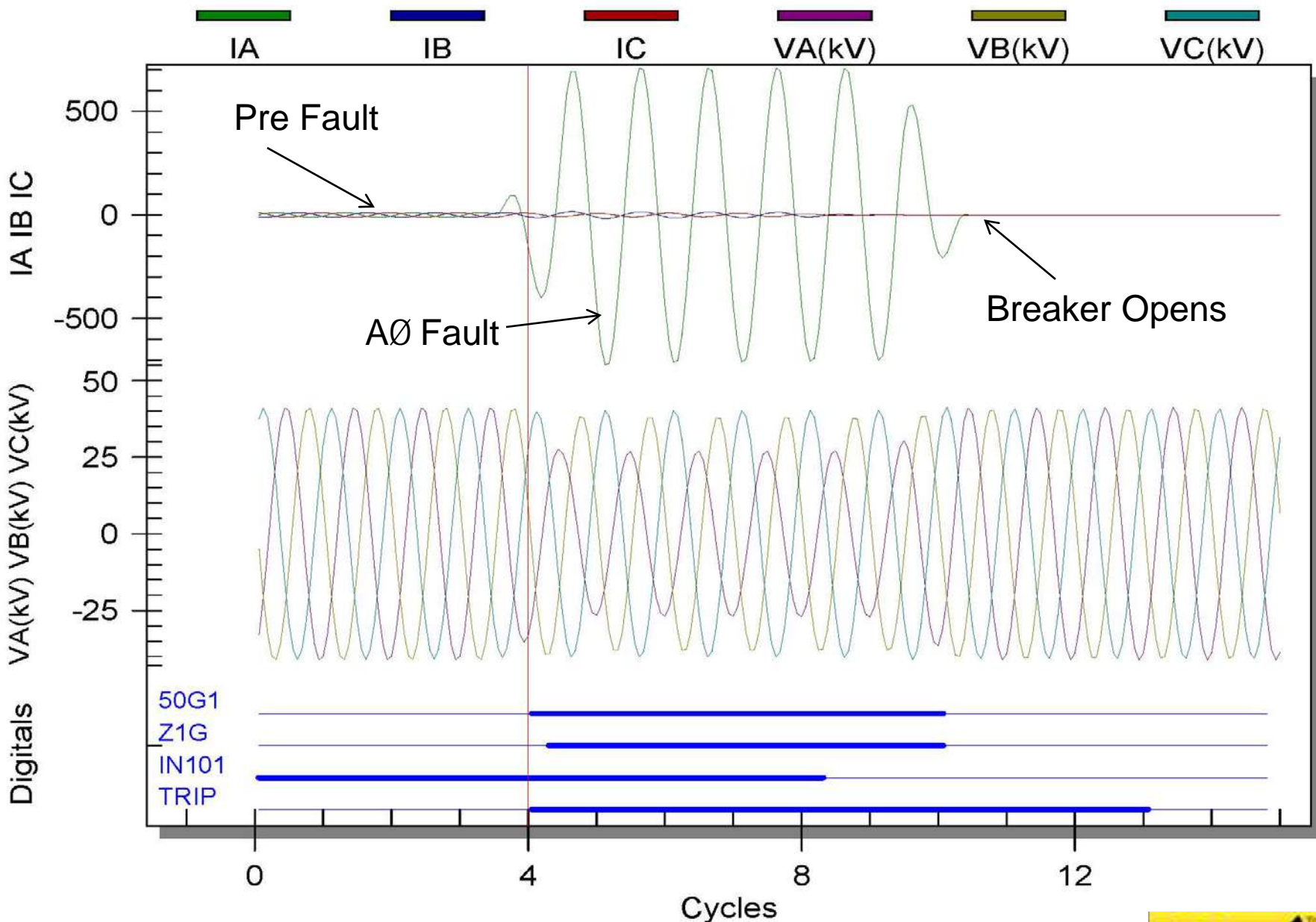
- *Abnormal Current*
- *Abnormal Voltage*
- *Abnormal Frequency*
- *Combination of any of the Above*

What does a fault look like to a Relay?

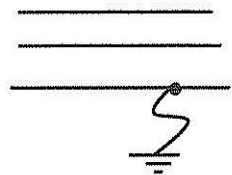
SEL-5601

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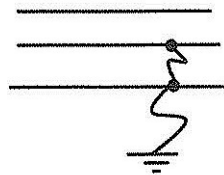
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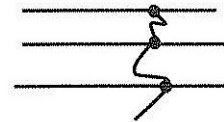
Types of Typical Faults



Single Line
to Ground



Two-Line
to Ground

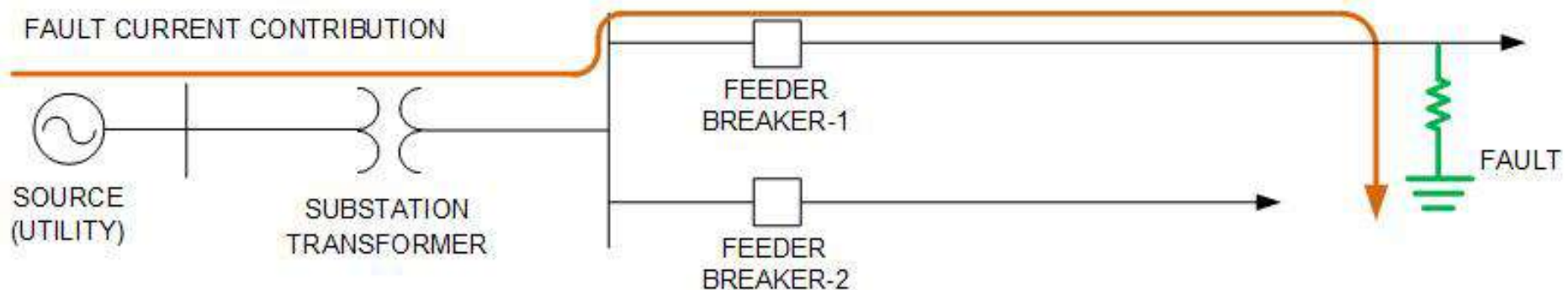


3-Phase

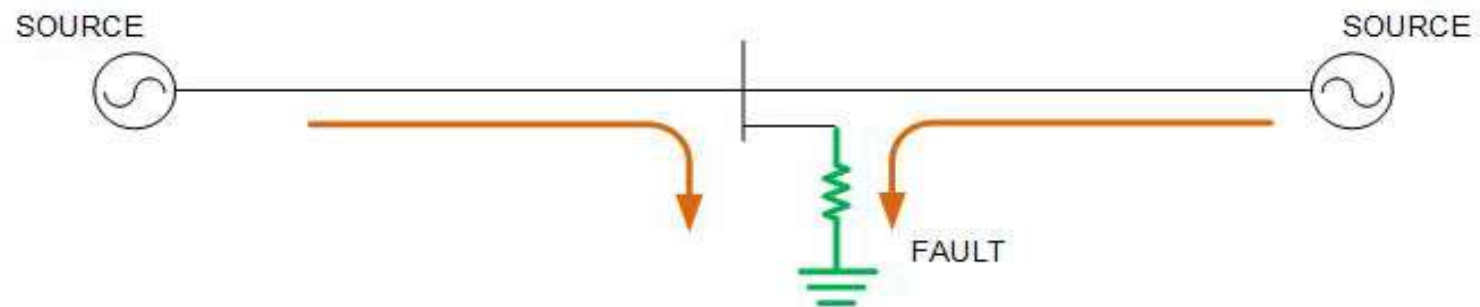
Cause of Faults

- *Grounding Cables*
- *Trees*
- *Splices*
- *Terminations*
- *Weather*

Simplified Overall System Schematic (Radial System)



Looped System



What is a Relay

- *Continuously Monitors Power System*
- *Sends a signal to Trip Circuit Breaker or Recloser during abnormal conditions (faults)*

Common Types of Relays Located in Substation

- *Line (Distance and Differential)*
- *Transformer (Differential)*
- *Bus (Differential)*
- *Feeder (Overcurrent)*

Line

187L-P PRIMARY
LINE DIFFERENTIAL RELAY
SEL-311L

SERIAL
PORT F

EN	TRIP	TIME	COMM	B7	50/S1	RECLOSER
A	B	C	G	1	2	RS
FAULT TYPE			ZONE/LEVEL			LO
						BTCH
						FAIL

TARGET ADSET	METER	EVENTS	STATUS	OTHER	SET	CTRL	GROUP
LAMP TEST	CANCEL	EJECT	←	→	▲	▼	EXIT

SEL-311L
LINE CURRENT DIFFERENTIAL
PROTECTION AND AUTOMATION SYSTEM

SEL SCHWEITZER ENGINEERING LABORATORIES

187L-P CURRENT & POTENTIAL
TEST SWITCH 1TS1

Va Vb Vc Ia Ia* Ib Ib* Ic Ic* Vn

187L-P RELAY CONTROL
TEST SWITCH 1TS2

1CB-1TC+ 1CB-1TC- 1CB-1TC2+ 1CB-1TC2- 1BTPT+ 1BTPT- 1BTST+ 1BTST- 1CB-1BP+ 1CB-1BP-

187L-P RELAY CONTROL
TEST SWITCH 1TS3

Va 1CB-1R2+ 1CB-1R2- 1CB-1R2C+ 1CB-1R2C- Vn

87T1P
PRIMARY XFMR DIFFERENTIAL RELAY
SEL-387A



87T1P RELAY 138 kV WINDING CURRENT
TEST SWITCH 2TS2

$$I_a \quad I_a^* \quad I_b \quad I_b^* \quad I_c \quad I_c^* \quad I_{HO} \quad I_{HO}^*$$

87T1P RELAY 34.5 KV WINDING CURRENT
TEST SWITCH 2TS3

la la* lb lb* lc lc* l_{x0} l_{x0}*

87T1P RELAY CONTROL
TEST SWITCH 2TS4

NETP14	NETP15	13B15F4	13B15F5	TWNETT	TWNETT	TWNETT	TWNETT	13B15F4	13B15F5
--------	--------	---------	---------	--------	--------	--------	--------	---------	---------

87T1S
SECONDARY DIFFERENTIAL RELAY
SEL-387A



Bus Differential

87B1
34.5 kV BUS #1 DIFFERENTIAL RELAY
SEL-587Z

PORT F

EN	67	50	51
A	B	C	G
FAULT TYPE			

TARGET RESET	METER	EVENTS	STATUS	MAINT	SET	CTRL	DOT
LAMP TEST	CANCEL	SELECT	◀	▶	▲	▼	

SEL-587Z
HIGH-IMPEDANCE DIFFERENTIAL RELAY

SEL SCHWEITZER ENGINEERING LABORATORIES

87B1 RELAY CONTROL
TEST SWITCH 2TS11

Ia Ia* Ib Ib* Ic Ic*

87B1 RELAY CONTROL
TEST SWITCH 2TS12

8B11 8B12 13B13 13B14 13B15 13B16

94T1 & 94T2 RELAY CONTROL
TEST SWITCH 2TS13

34T1 34T2 34T3 34T4 34T5 34T6 34T7 34T8

Relay Testing





How to Measure Current, Voltage and Frequency :

Instrument Transformers

- *PTs*
- *CTs*







CT

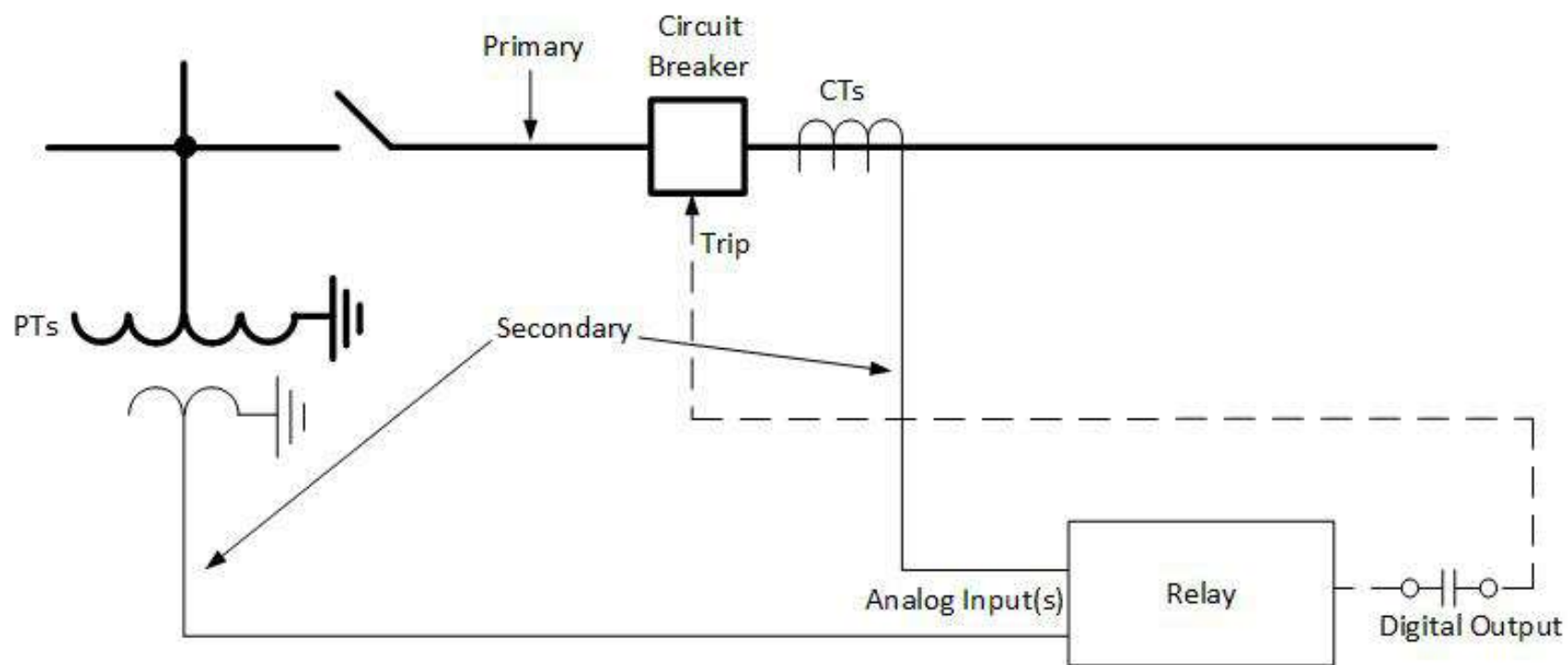
CT

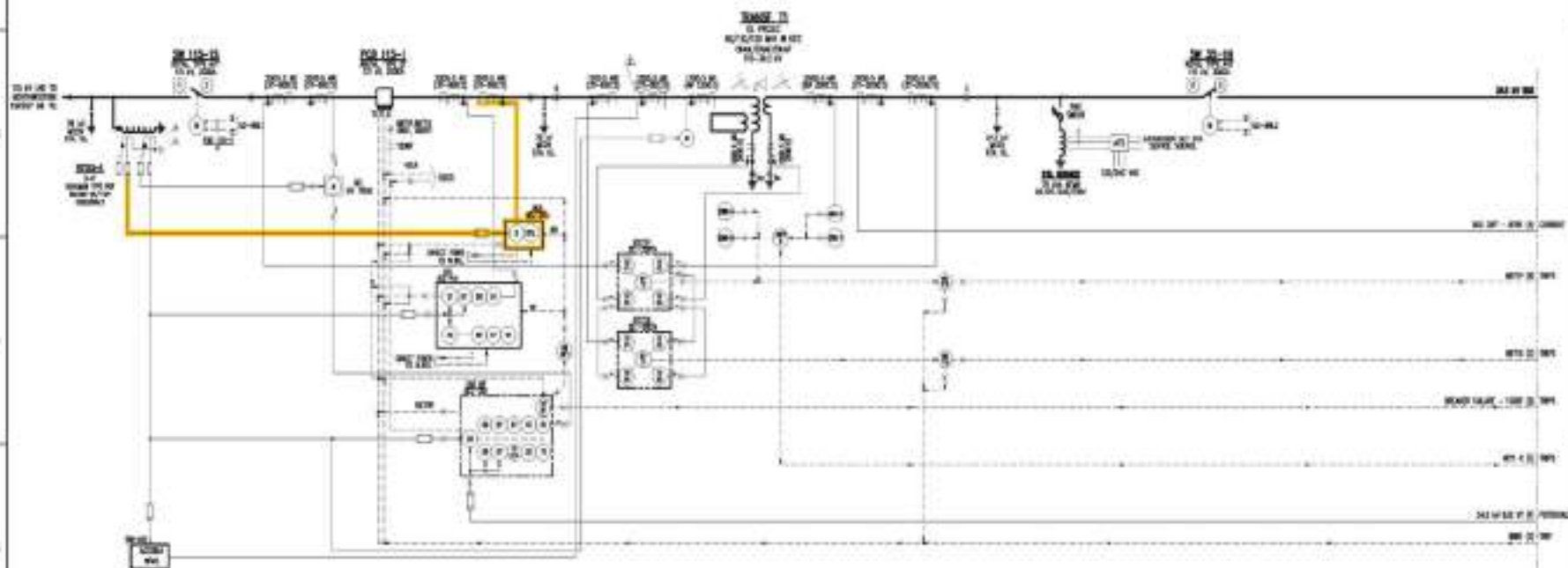


Correlation to Drawings

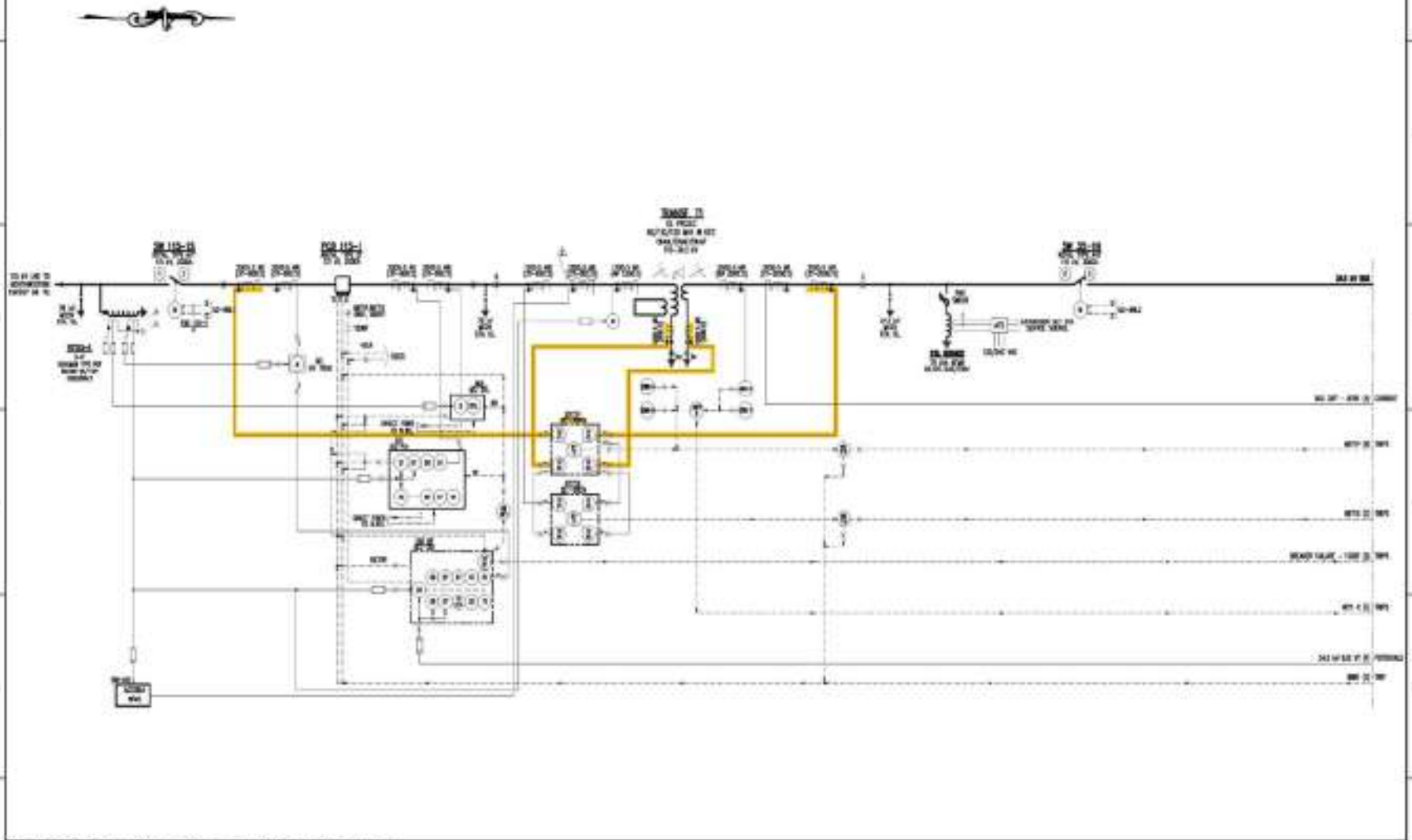
One-line Diagrams

Primary vs. Secondary





Transformer Differential



Drawn by: [Name] Checked by: [Name] Date: [Date] Scale: [Scale]



1	REVISION	DATE	BY	CHK
2	REVISION	DATE	BY	CHK
3	REVISION	DATE	BY	CHK
4	REVISION	DATE	BY	CHK
5	REVISION	DATE	BY	CHK



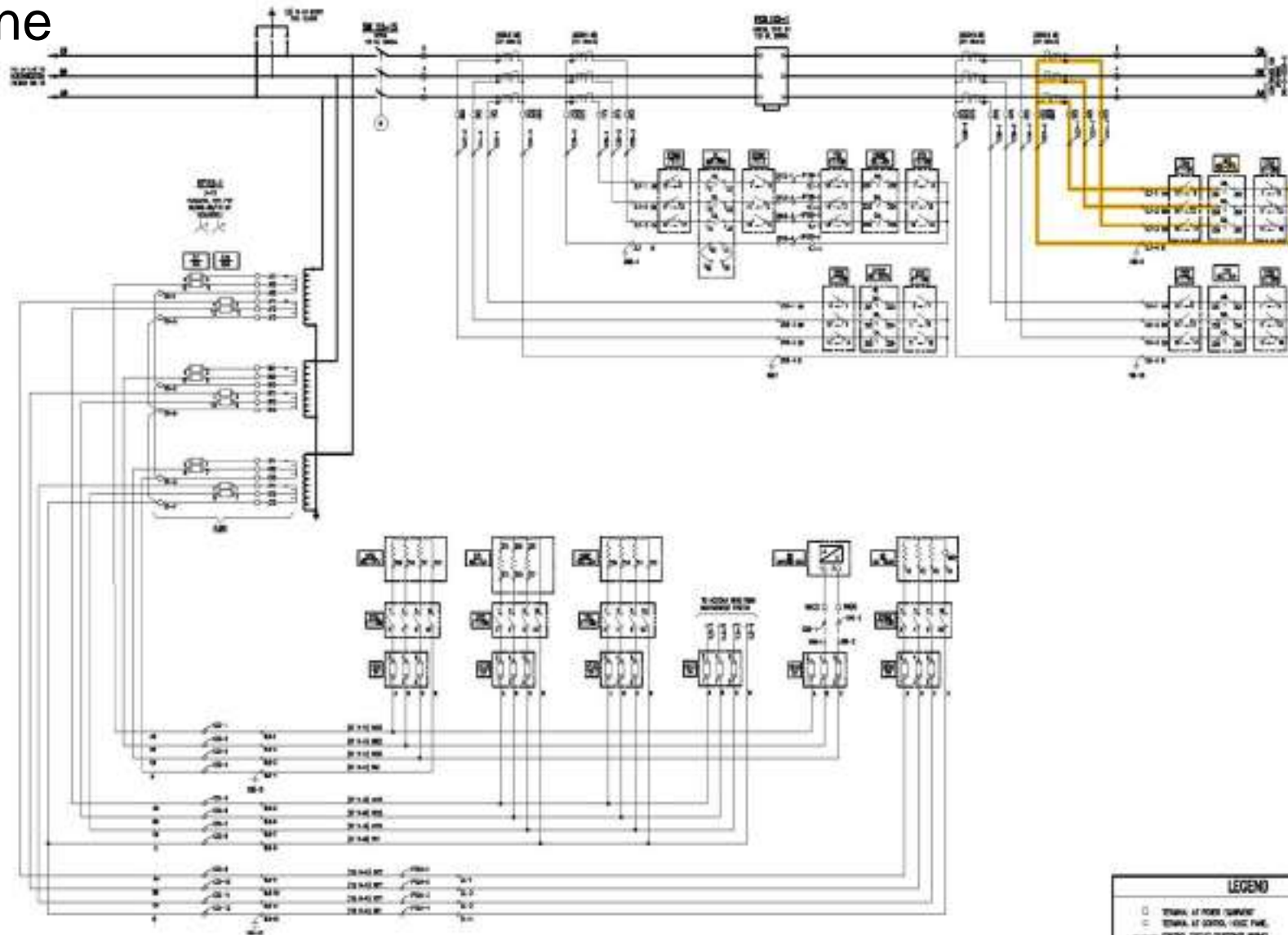
PROJECT	DATE
CLIENT	DATE
DESIGN	DATE
CHECK	DATE
APPROVE	DATE



Correlation to Drawings

Three-line Diagrams

Line

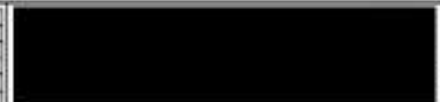


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Drawn by: [Redacted]



1. AT RKT	1/2" x 1/2"	1/2"	1/2"
2. 1/2" x 1/2"	1/2" x 1/2"	1/2"	1/2"
3. 1/2" x 1/2"	1/2" x 1/2"	1/2"	1/2"
4. 1/2" x 1/2"	1/2" x 1/2"	1/2"	1/2"



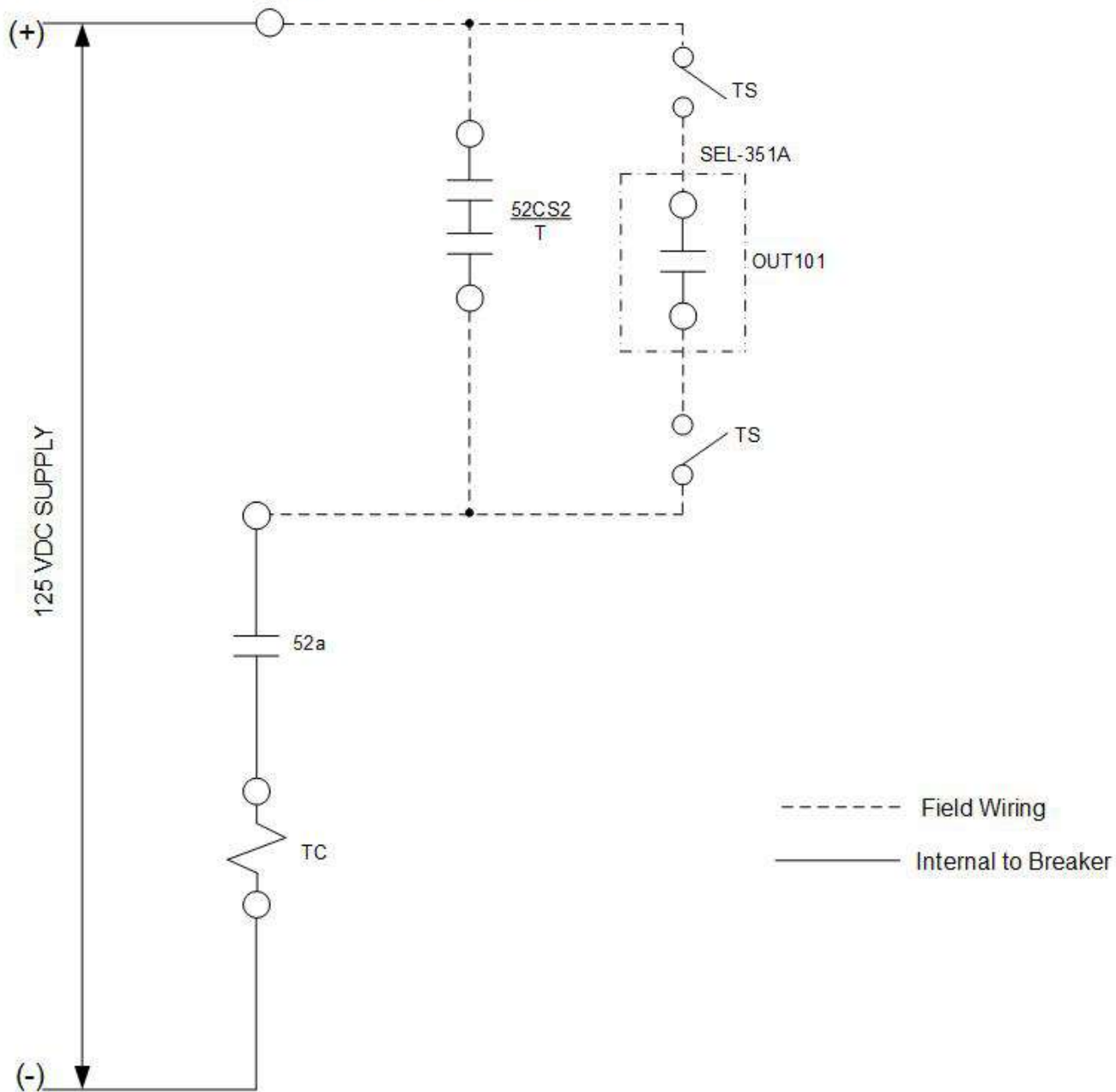
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PROJECT	12/15/00	DATE	12/15/00
REVISION	1.0	DATE	12/15/00
BY	[Redacted]	DATE	12/15/00



Correlation to Drawings

DC Schematics

Simplified DC "Trip" Schematic



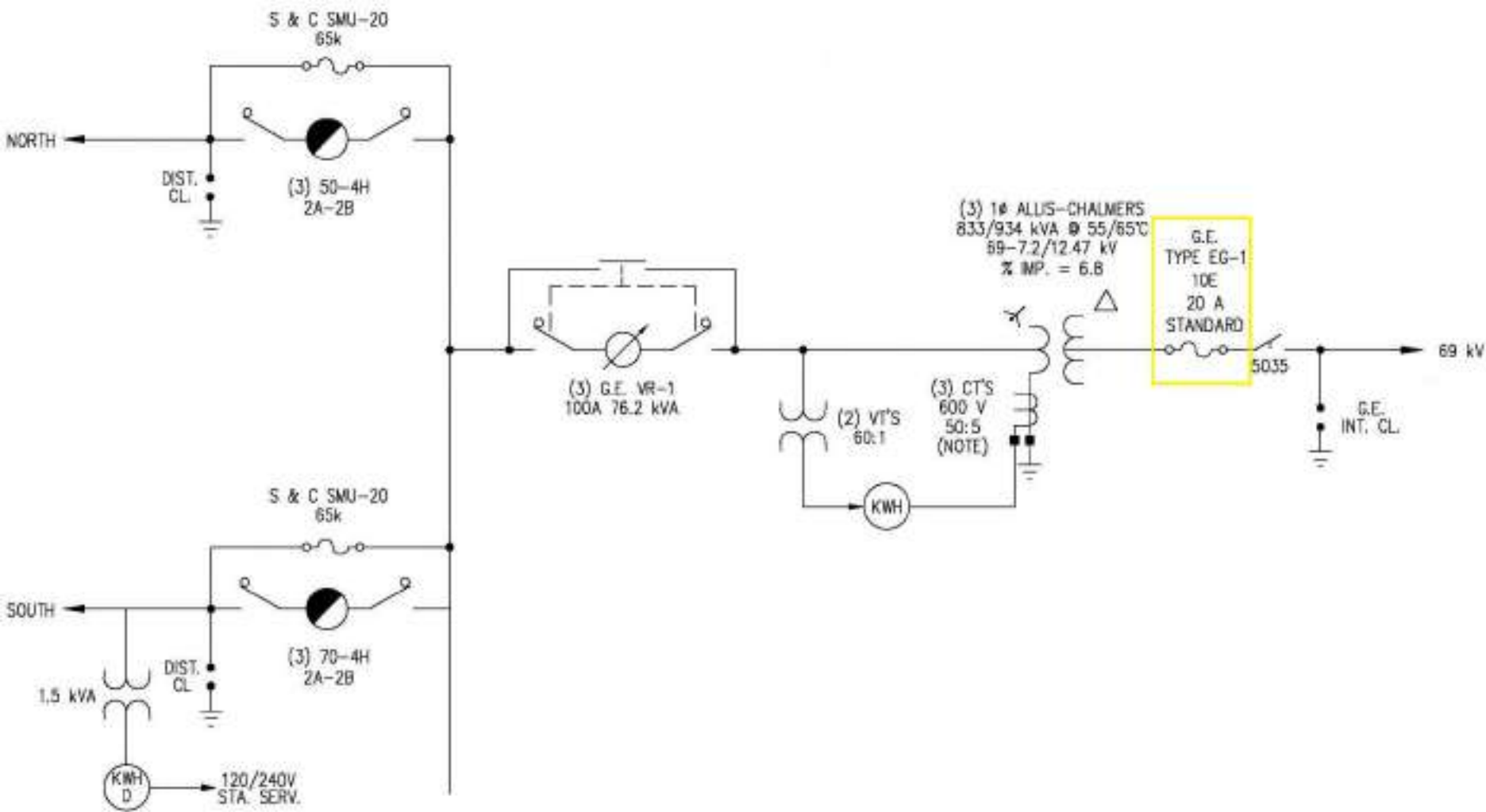
Other Types of Substation/Feeder Protection

- *Transformer Fuses*
- *Reclosers*
- *Sectionalizers*

Transformer Fuse Protection



Transformer Fuse



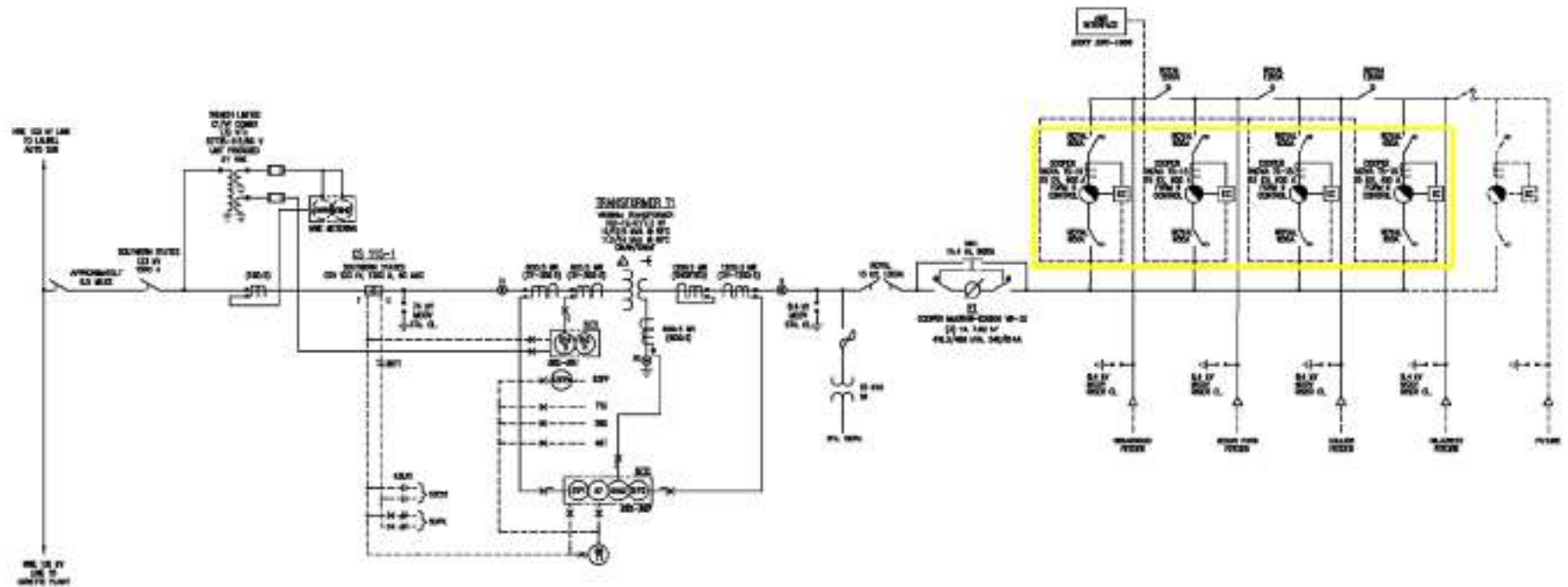
Recloser



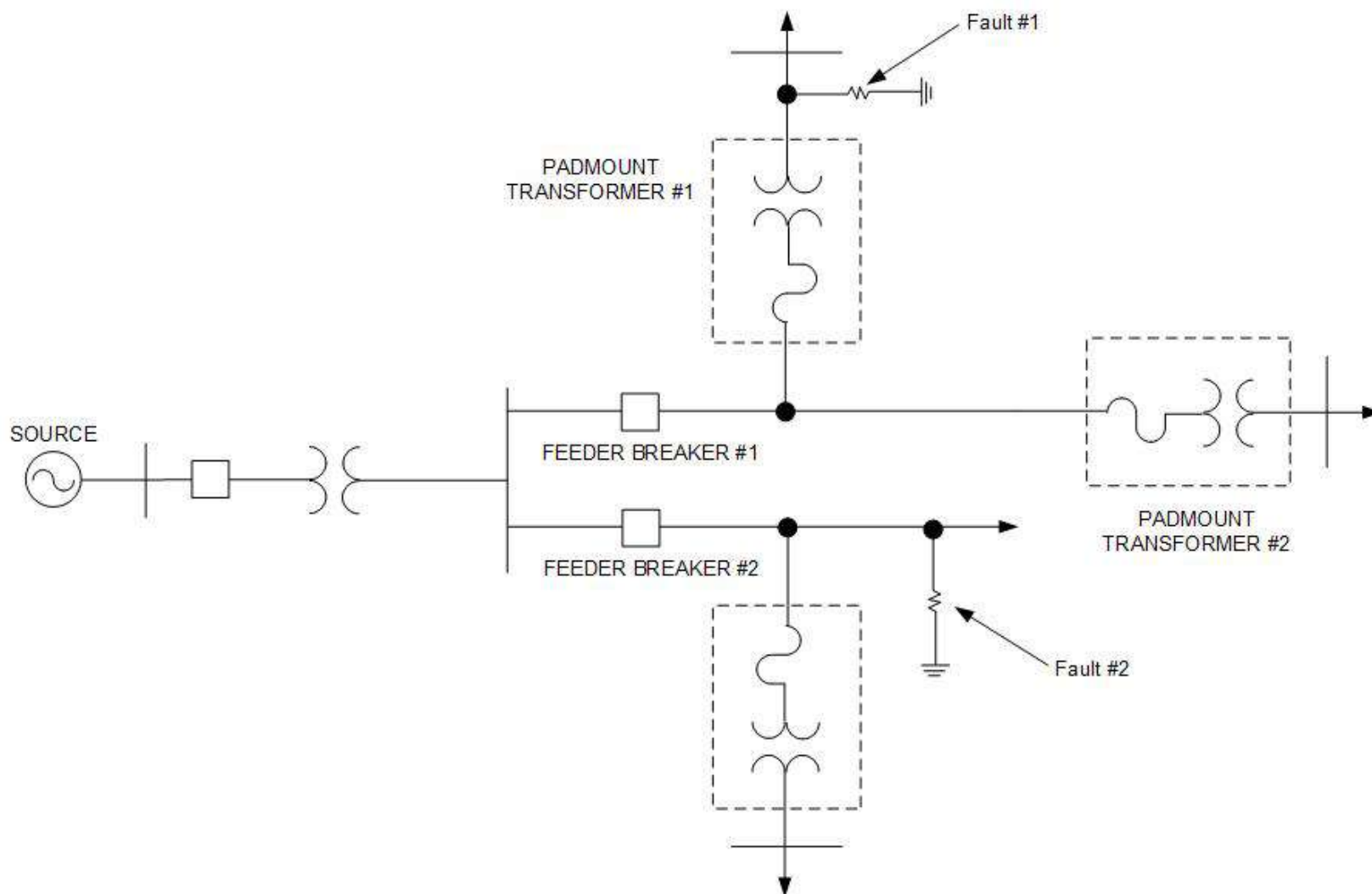
Recloser Controller



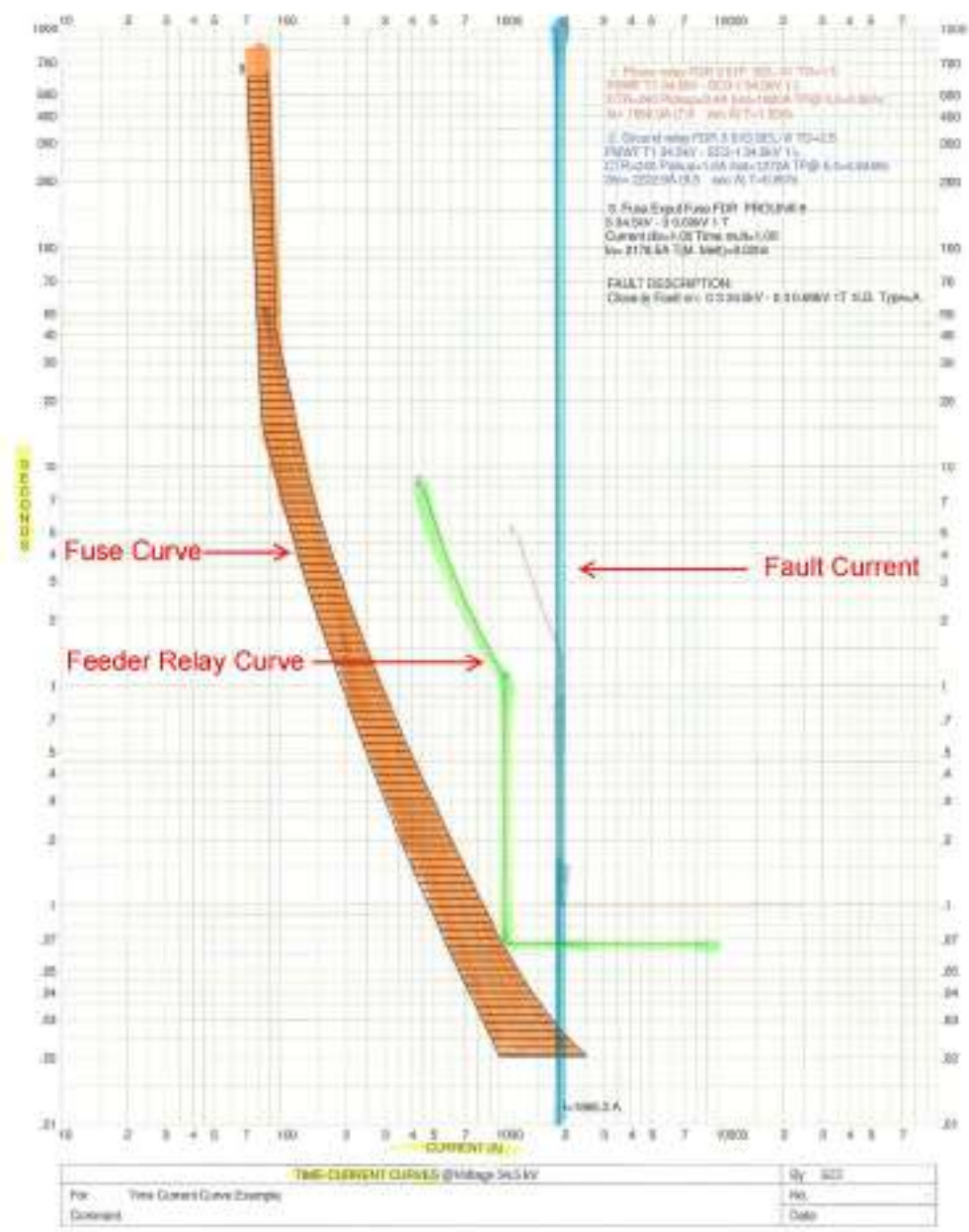
Recloser



Coordination Example



Time Current Curves





Questions?