Introduction

This document details the protection settings and logic for the SEL-311C relay installed to protect Transformer T-1000, which is located in the Dennison Pumping Station and connected to the T-2 transformer 4.16kV secondary through the T-2 BUSS.

RID = T-1000 SEL-311C
TID = Dennison Substation

This relay provides the following protection that will operate OUT101:

- Instantaneous phase overcurrent protection (50P1) for currents greater than 1140A primary, or 24.0A secondary.
- Inverse phase time overcurrent protection (51PT) for currents greater than 180A primary, or 3.00A secondary. The 51PT protection should operate in 1.24 seconds if a 12.0 A secondary phase-phase or three-phase fault is generated into the relay.
- Instantaneous residual ground overcurrent protection (67G1) for currents greater than 480A primary, or 8.0A secondary, if the phase-ground fault occurs downstream of the relay.
- Inverse residual ground time overcurrent protection (51GT) for residual ground currents greater than 36A primary, or 0.60A secondary, if the phase-ground fault occurs downstream of the relay.. The 51GT protection should operate in 0.71 seconds if a 2.4 A secondary phase-neutral fault is generated into the relay.

This relay provides the following protection that will operate OUT103:

- If the 49T relay operates IN101, OUT103 will operate with no intentional time delay, the trip LED will light up, and the front panel will indicate “49T OPERATED”. The 49T trip can only be reset via the front panel or the TRGTR command.

The following control functions are performed via the front panel display.

- The relay front panel will indicate “52-T1000 CLOSED” if the 52-T1000 circuit breaker is closed, and “52-T1000 OPEN” if the 52-T1000 circuit breaker is open.
- The relay front panel will indicate that the remote 86 relay on the secondary side of T-1000 is operated or not via “86 OPERATED” and “86 RESET”.

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1. Transformer Details

Transformer T-1000 is a Delta-Wye transformer with the following ratings:

- 1 MVA
- 4160V / 480V
- OA

$$VA = \sqrt{3} \times V_{LL} \times I_L$$

The full load rated amps of the transformer is $I_L = \frac{VA}{\sqrt{3} \times V_{LL}} = \frac{1000000}{\sqrt{3} \times 4160} = 138.79A$

The high-voltage winding CT Ratio is 300:5 or 60:1

CTR = 60

The CTRP input is not used

CTRP = 60

Potential transformers are connected to the switchgear bus and are connected in wye and are rated 4200:120V or 35:1

PTR = 35

The PTRS input is not used

PTRS = 35

2. Global Settings

The PTs are connected in wye

PTCONN = WYE

The VS input is not used and left at the default setting

VSCONN = VS

Multiple groups are not used and the settings were left at the default setting

TGR = 180

The power system is at 60Hz with ABC rotation

NFREQ = 60
PHROT = ABC

The remaining settings were left at default

DATE_F = MDY
FP_TO = 15
SCROLD = 5
LER = 30
PRE = 4
DCLOP = OFF
DCHIP = OFF

3. Relay Configuration Settings

The relay is being used in SEL-311C mode

APP = 311C

The relay is protecting a transformer instead of a line, so no line parameters are available

Z1MAG, Z1ANG, Z0MAG, Z0ANG = Default
E21P, E21MG, E21XG, E50Q, E51Q, EOOS, ELOAD, ESOTF, EVOLT, E25, E81, EFLOC, ELOP, ECOMM, E79, EZ1EXT, ECCVT, EADVS = N, ESV = N

The relay will be using latching relays and timers to receive and transmit a 49T over-temperature signal from T-1000 to trip the 86 lockout relay

ELAT = 1

Circuit breaker, lockout, and 49T status will be displayed on the front panel

EDP = 3

4. Directional Element Settings

Directional control is required for all ground overcurrent elements

E32 = AUTO

Loss of potential logic is turned on to prevent mis-operations during a PT fuse failure

ELOP = Y

Busbar PT LOP Logic is disabled

EBBPT = N

Levels 3 and 4 are disabled and left at default

DIR3 = Y
DIR4 = F

Order is set for negative sequence, then zero-sequence polarizing

OEDER = QV

5. Overcurrent Settings

The relay will be using the phase and residual ground time inverse overcurrent pickup functions

E51P = Y
E51G = Y

The relay will be using the phase and residual ground instantaneous overcurrent pickup functions

E50P = 1
E50G = 1

A) Phase Overcurrent Settings

The T-2 SEL-387 phase overcurrent settings are:

- 1200:5 CT Ratio
- 51PP = 4.2A
- 51PC = U4
- 51PTD = 9
- 50P1P = 15.5A
- 67P1D = 0.00s

The T-2 phase pickup in 4160V primary amps is

$$51PP \text{ in } AMPS_{PRIMARY} = 51PP \times CTR = 4.2A \times \frac{1200}{5} = 1.8A \times 240 = 1008A$$

$$50P1 \text{ in } AMPS_{PRIMARY} = 50P1 \times CTR = 15.5A \times \frac{1200}{5} = 1.8A \times 240 = 3720A$$

The T-1000 phase time inverse overcurrent pickup (51PP) setting is set to 130% of T-1000 FLA

$$FLA * 130\% = 138.79A * 1.30 = 180.42A$$

The 51PP setting calculation is $51PP = \frac{AMPS_{PRIMARY}}{CTR} = \frac{180.42A}{60} = 3.007A$

The 51PP setting was rounded to 3.00A

51PP = 3.00

The SEL U4-Extremely Inverse curve will be used to match the transformer damage characteristic curve

51PC = U4

The time delay was chosen to coordinate with the upstream main breaker and protect T-1000

51PTD = 3

No phase electromechanical relays are installed upstream or downstream from this device, therefore the electro-mechanical reset has been disabled

51PRS = N

The instantaneous overcurrent must be set 10x or greater than FLA to prevent the relay from tripping during transformer inrush

$$50P1 = \frac{AMPS_{PRIMARY} \times 10}{CTR} = \frac{138.79A \times 10}{60} = 23.13A$$

The setting was rounded up to 24

50P1 = 24.00A

There is no intentional time delay

67P1D = 0.00

There is no reason to block the phase overcurrent protection so

51PTC = 1
67P1TC = 1

B) Residual Ground Overcurrent Settings

The T-2 SEL-387 residual ground settings are

- 1200:5 CT Ratio
- 51GP = 1.8A
- 51GC = U3
- 51GTD = 6
- 50G1P = 14.0A
- 67G1D = 0.00s

The T-2 pickup in 4160V primary amps is

$$AMPS_{PRIMARY} = 50GP \times CTR = 1.8A \times \frac{1200}{5} = 1.8A \times 240 = 432A$$

The T-1000 residual ground time inverse overcurrent pickup (51GP) setting is set to 1% of the CT primary current $\frac{CT_{PRIMARY}}{CT_{SECONDARY}} \times 1\% = \frac{300A}{5A} \times 1\% = 0.60A$

51GP = 0.60

The SEL U3-Very Inverse curve will be used to match the transformer damage characteristic curve

51GC = U3

The time delay was chosen to coordinate with the upstream main breaker and protect T-1000

51GTD =2

Electro-mechanical relays are installed on other feeders in the system and the SEL-587 relay connected to 52-Main has the 51GRS = Y, so this relay also has 51GRS = Y to maintain coordination

51GRS = Y

We only want the ground protection to operate for faults downstream of the 52-UTL Breaker, so

51GTC = 32GF

The residual ground instantaneous protection is set 1.6x the CT nominal

50G1P = 8.00

There is no intentional time delay set for the residual ground instantaneous protection:

67G1T = 0.00

The inverse residual overcurrent elements should only operate in the forward direction

51G1TC = 32GF

The instantaneous ground overcurrent element word bit 67G1 should only operate in the forward direction based on the internal relay logic on Figure 3.29

67G1TC = 1

6. Demand Metering

Demand metering is not used and set at defaults

EDEM = THM
DMTC = 15
PDEMP = OFF
GDEMP = OFF
QDEMP = OFF

7. Other Settings

The Trip outputs should stay closed for a minimum of 6 cycles

TDURD = 6.00

The remaining settings are not used and left at defaults

CFD = 60.00
3POD = 0.50
OPO = 52
50LP = 0.50

8. SELogic Control Equation Variable Timers

One latching variable is required to seal-in when the 49T connected to IN101 operates

ELAT = 1

There will be three display points for breaker status, 49T status, and 86 lockout status

EDP = 3

No SELogic equations are required

ESV = N

9. Trip and Output Logic Settings

A) Trip Logic

The relay main trips are:

- Instantaneous phase overcurrent (50P1) with no intentional delay
- Inverse time phase overcurrent (51PT)
- Instantaneous residual ground overcurrent in the forward direction (67G1) with no intentional delay
- Inverse time residual ground overcurrent (51GT) in the forward direction

TR = 50P1+67G1+51PT+51GT

There are no direct transfer trip conditions

DTT = 0

The trip output should unlatch if the current is less than the inverse time overcurrent element pickups for phase and residual ground

ULTR = !(51P + 51G)

B) Close/Reclose Logic

IN102 is connected to the 52a breaker status contact for 52-T1000

52A = IN102

No close logic is used and these settings are left at default

CL = 0
ULCL = TRIP

C) Latch Bits Set/Reset

LT1 should latch when 49T operates on IN101

SET1 = IN101

LT1 should latch when a user reads the front display and presses “TARGET REST” or “TRGTR” is sent via communication

RST1 = TRGTR

D) Torque Control Equations

The instantaneous and inverse phase overcurrent element should be non-directional

67P1TC = 1
51PTC = 1

The inverse residual overcurrent elements should only operate in the forward direction

51G1TC = 32GF

The instantaneous ground overcurrent element word bit 67G1 should only operate in the forward direction based on the internal relay logic on Figure 3.29

67G1TC = 1

E) Output Contact Equations

OUT101 is the main trip contact and is connected to 86-2

OUT101 = TRIP

OUT103 trips when the transformer 49T operates

OUT103 = IN101

OUT102, OUT103-OUT107 are all spares and not used

OUT102 = 0
OUT104 = 0
OUT105 = 0
OUT106 = 0
OUT107 = 0

F) Display Points

Display point 1 indicates 52-T1000 breaker status

DP1 = 52A

Display point 2 indicates that the 49T at the transformer operated

DP2 = LT1

Display point 3 indicates that the 86 lockout is in the tripped position

DP3 = IN103

G) Setting Group Selection

Only setting group 1 is used

SS1 = 1
SS2 = 0
SS3 = 0
SS4 = 0
SS5 = 0
SS6 = 0

H) Other Equations

All overcurrent elements should create an event report when they transition from off to pickup

ER = /51G+/51P+/50P1+/50G1

The fault light should turn on when an overcurrent element picks up or when IN101 operates

FAULT = 51G+51P+IN101

The remaining elements are not used and left at defaults

BSYNCH = 0
CLMON = 0
E32IV = 1

10. SER

All overcurrent elements should create a record in the Sequential Event Recorder when they operate

SER1 = 51G, 50P1, 51P, 50G1, 67G1, 51GT, 51PT

All outputs in-use should create a record in the Sequential Event Recorder when they operate

SER2 = OUT101,OUT103

All inputs in-use should create a record in the Sequential Event Recorder when they operate

SER3 = IN101,IN102,IN103

11. Text

The relay front panel will indicate “52-T1000 CLOSED” if the 52-T1000 circuit breaker is closed, and “52-T1000 OPEN” if the 52-T1000 circuit breaker is open

DP1_1 = 52-T1000 CLOSED
DP1_0 = 52-T1000 OPEN

The relay front panel will indicate “49T OPERATED” if the T-1000 49T relay operates

DP2_1 = 49T OPERATED
DP2_0 = NA

The relay front panel will indicate that the remote 86 relay on the secondary side of T-1000 is operated or not via “86 OPERATED” and “86 RESET”

DP3_1 = 86 OPERATED
DP3_0 = 86 RESET