

# Distance – Voltage Transformer (VT) Supervision

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# VT Supervision

- VTS is to tackle **voltage signal failure** condition due to **VT fuse burnt** or **operation of MCB** in which impedance cannot be measured  $Z = V / I$ .
- It does not result in trip with  $V = 0$  and  $Z = 0$  with the **superimposed current phase selector / guard**. Yet, it may lead to unwanted operation with subsequent disturbance.
- Hence, VTS in general blocks **voltage dependent tripping** (distance, directional) and issue a **VTS alarm** with a delay.
- Reset of VTS in general relay on **3 phase volt healthy**. Depending on VTS detection mechanism, VTS can be reset with earth fault current, i.e.  $I_N > I_{N, SET}$ .
- Some distance relays also include **other detection element** such as zero sequence current detector ( $I_0 > I_{0, SET}$ ) in which it can still be operative in OCEF manner.

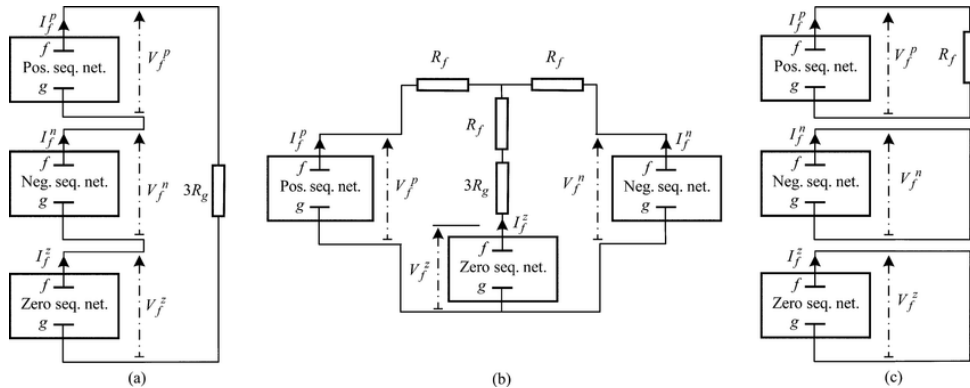
# Recall for Detection Element

Matrix Conversion:

$$\begin{bmatrix} I_a^0 \\ I_a^+ \\ I_a^- \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

$$\mathbf{I}_S = \mathbf{A}^{-1} \mathbf{I}_{abc}$$

$$I_N \text{ (neutral current)} = I_A + I_B + I_C = 3I_0 \leftarrow I_0 \text{ (calc)}$$



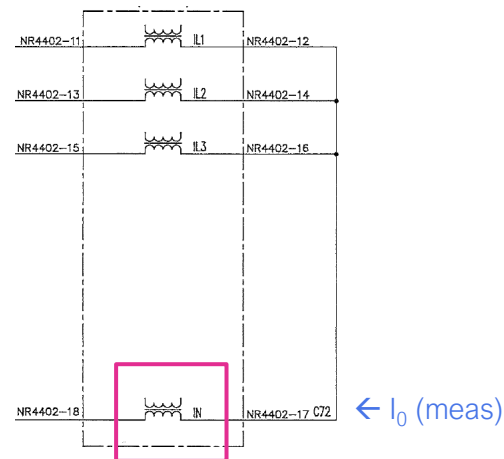
(a) Single Line to Ground Fault (SLG)

$$I_{af}^0 = I_{af}^+ = I_{af}^- = \frac{V_f}{Z_{a\Sigma}^0 + Z_{a\Sigma}^+ + Z_{a\Sigma}^- + 3z_f}$$

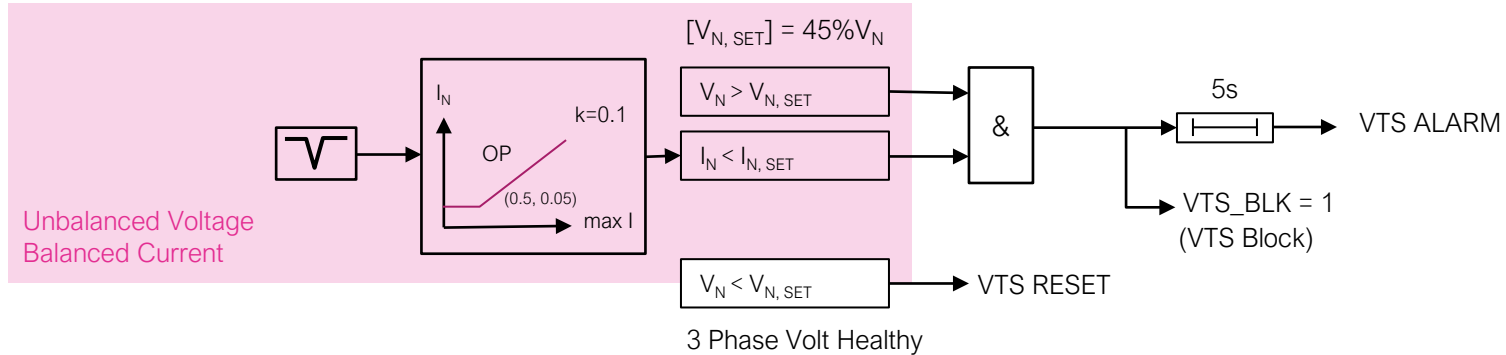
(b) Double Line to Ground Fault (DLG)

$$I_{af}^0 = -I_{af}^+ \left[ \frac{Z_{a\Sigma}^-}{Z_{a\Sigma}^- + Z_{a\Sigma}^0 + 3z_f} \right]$$

(c) Three Phase to Ground Fault



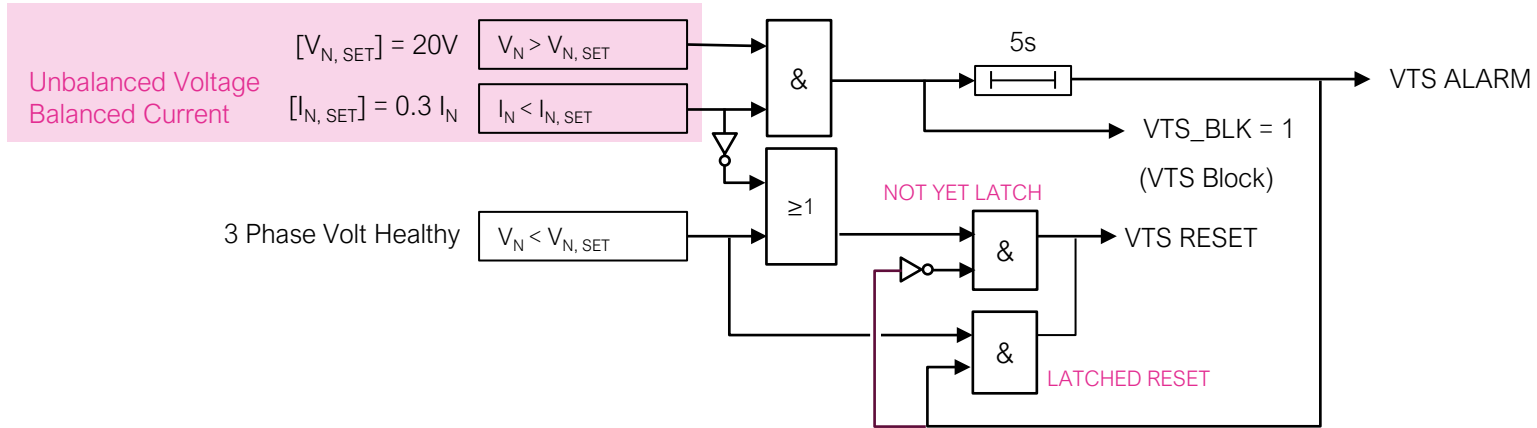
# Distance Relay 1: Alstom LFZR



Note:

1. Check also – IF pole dead for 240ms OR distance/ DEF element operated, VTS will NOT operate.
2. (Optional Setting) – IF MCB operates (given signal), no delay is given to VTS alarm.
3. OC Tripping is still available.

## Distance Relay 2: Reyrolle Ohmega406



Note:

1. Before latching ( $< 5s$ ), VTS can be reset by 3 phase volt healthy or EF current ( $I_N > I_{N, SET}$ ). After latching ( $> 5s$ ), it can only be reset by 3 phase volt healthy.
2. Phase Fault can still be tripped by OC element or relay remains stable if VTS picks up.
3. Alternatively, negative sequence component ( $I_2, V_2$ ) can detect loss of VT fuse with higher phase-to-phase fault sensitivity.
4. Test – RY Fault 30V, 0.8A (outside Z3) → remove RY voltage & increase current to 4A (blocked tripping)

# Distance Relay: NR RCS902H

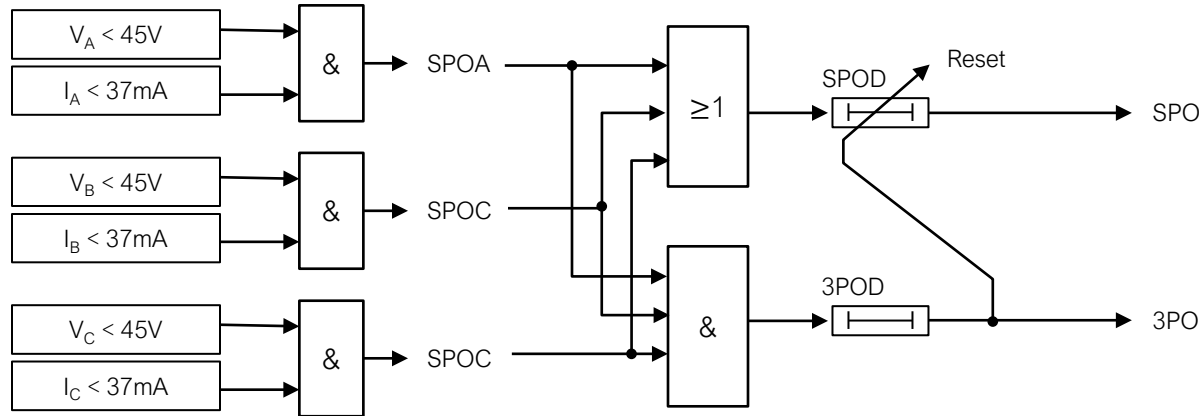
	1 or 2 Fuses Failed	3 Fuses Failed:
VTS Operate	<ul style="list-style-type: none"> <li>No fault detector picks up, &amp;&amp;</li> <li>Residual volt &gt; 8V (2-ph = 63.5V, 1-ph volt &lt; 55.5V), &amp;&amp;</li> <li>Over 1.25s.</li> </ul> <p>(Note: CB status does not affect this VTS operation for 1 or 2 fuses failure.)</p>	<ul style="list-style-type: none"> <li>Line VT in use (Setting [LVTCnc] = 1), &amp;&amp;</li> <li>CB is close (binary input BkrOff = 0 or Any Iph &gt; 8%), &amp;&amp;</li> <li>No fault detector picks up, &amp;&amp;</li> <li>Residual volt &lt; 8V, &amp;&amp;</li> <li>+ve-seq volt &lt; 33V, &amp;&amp;</li> <li>Over 1.25s.</li> </ul>
VTS Reset	<ul style="list-style-type: none"> <li>Residual voltage &lt; 8V (2 Vph = 63.5V, 1 Vph &gt; 55.5V).</li> <li>VTS will reset in 10 sec after the above condition is fulfilled.</li> </ul>	<ul style="list-style-type: none"> <li>Residual voltage &gt; 8V (2 Vph = 63.5V, 1 Vph &lt; 55.5V), or</li> <li>CB is open (binary input BkrOff = 1 &amp;&amp; All Iph &lt; 8%), or</li> <li>CB is close &amp;&amp; 3Vph &gt; 37V (+ve-seq volt &gt; 33V).</li> <li>VTS will reset in 10 sec after the above condition is fulfilled.</li> </ul>

Note:

- FD includes DPFC (half-wave integration value) or Zero-sequence current detector ( $I_0(\text{calc})$  &  $I_0(\text{meas}) > I_{0, \text{SET}}$ ).
- OCEF is provided under VTS with setting  $3I_0 > [I0VTSUF]$  or  $I > [IVTSUF]$

# Distance Relay 4: SEL421

- Pole Open Detection (without CB auxiliary contact)
- A Pole is open if the pole has no voltage AND no current.  
Single Pole Open (SPO) is ANY pole has no voltage AND no current (AND not 3PO)  
Three Pole Open (3PO) is ALL pole have no voltage AND no current



# Distance Relay 4: SEL421

SPO

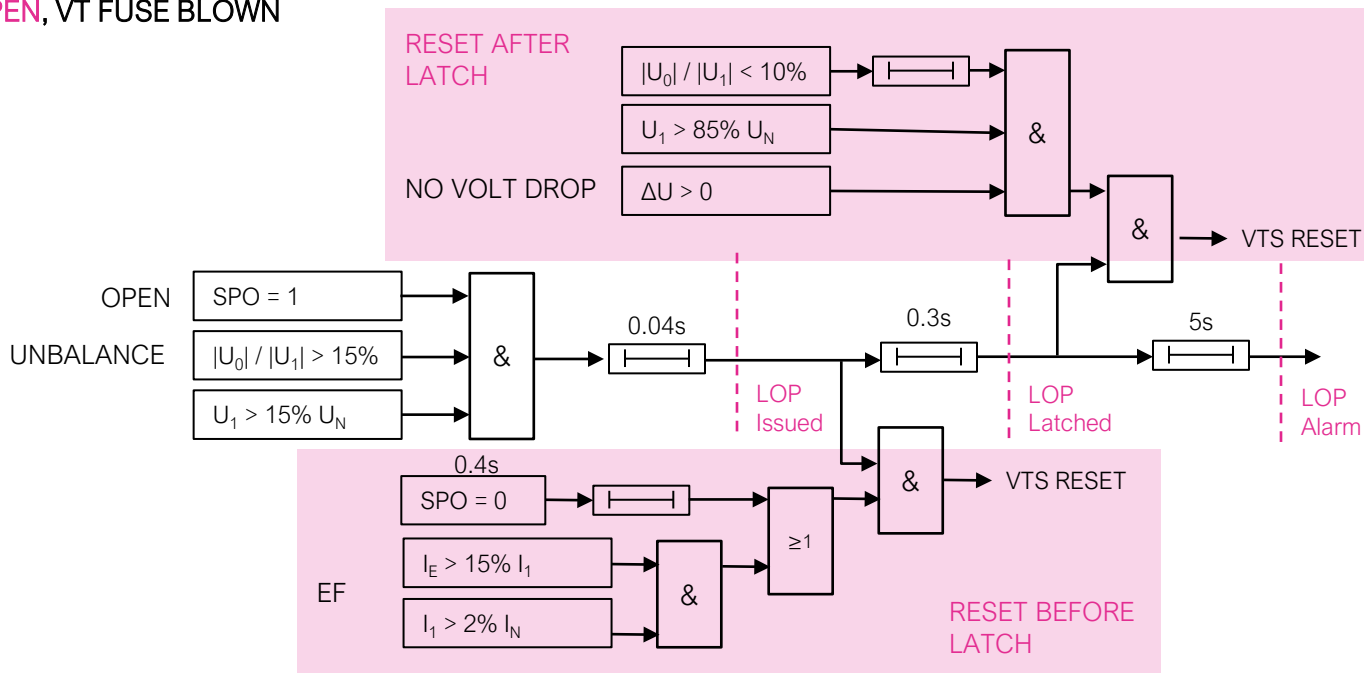
Case 1

Volt	Amp
63.5V	0A
0V	0A
0V	0A

Case 2

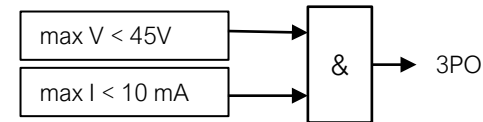
Volt	Amp
0V	50mA
0V	0mA
0V	0mA

CB OPEN, VT FUSE BLOWN

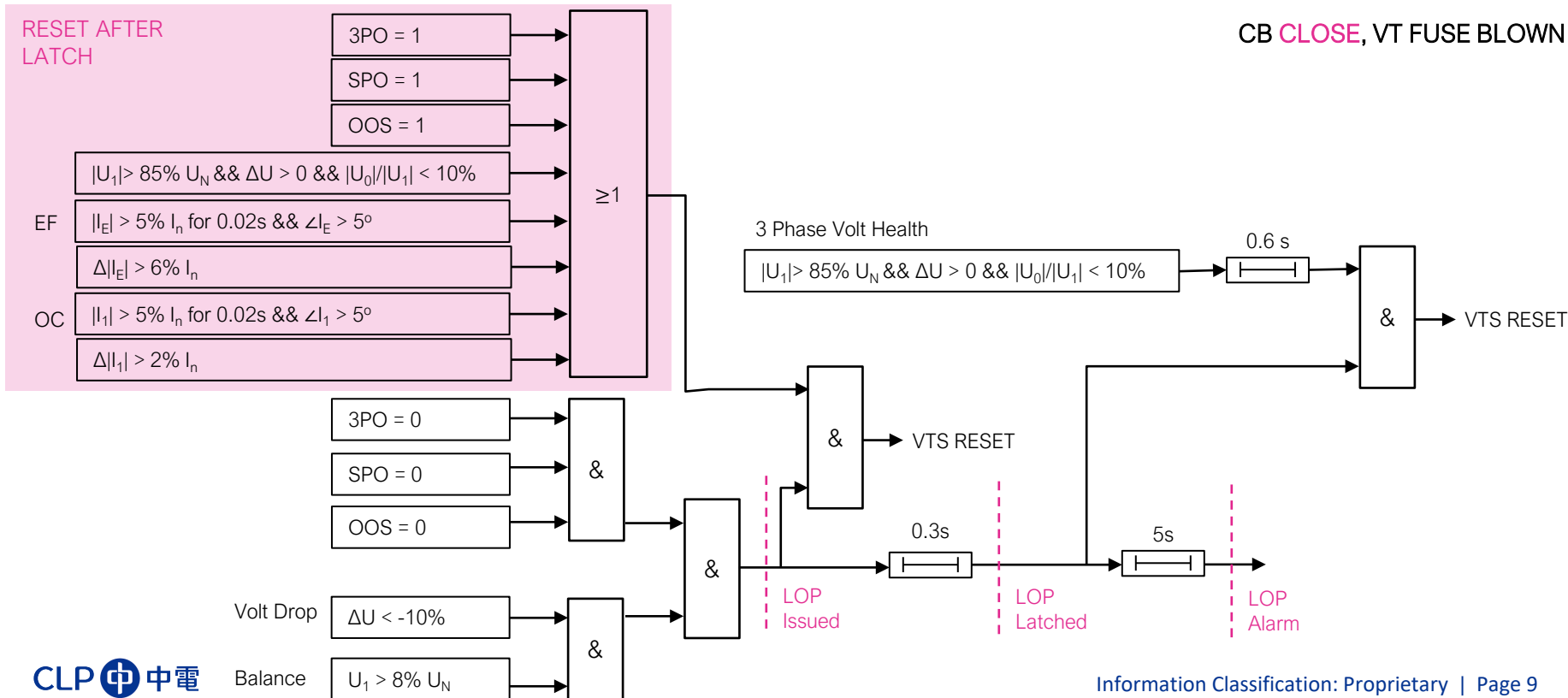




# Distance Relay 4: SEL421

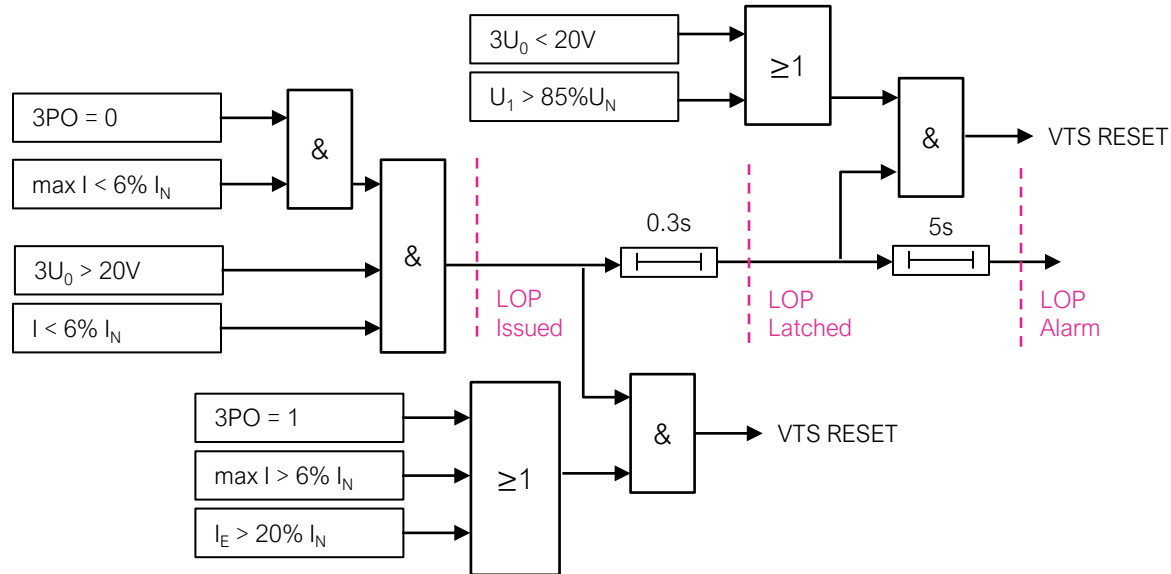


CB **CLOSE**, VT FUSE BLOWN



# Distance Relay 4: SEL421

CLP LOP – Consider  $3PO = 0$  (CLOSED),  $\max V > 45V$  &  $\max I < 10mA$  (no load condition)



DETECTION METHOD	ALSTOM - LFZR	REYROLLE - OHMEGA406	NR – RCS902H	SEL421
<b>1 or 2 FUSE BURNT</b>	✓	✓	✓	✓
$U_N > U_{N, SET}$ [residual / zero sequence voltage]	✓ [0.45 $U_N$ ]	✓ [20V]	✓ [0.08 $U_N$ ]	✓ [0.08 $U_N$ ]
$I_N < I_{N, SET}$	✓ [ $I_N$ – max I curve]	✓ [0.3 $I_N$ ]		✓ [10mA]
Fault Detector Pickup			✓ [DPFC OR $I_0$ ]	
max U < [ $U_{MAX}$ ] && max I < [10mA] = 3PO max U < [ $U_{MAX}$ ] XOR max I < [10mA] = SPO				✓
$ U_0  /  U_1  > m$ && $U_1 > n U_N$				✓ [m = 15% for 3PO] [n = 0.15 for 3PO; n = 0.08 for 3PC]
<b>3 FUSE BURNT</b> [Note: CB Open can have no volt]			✓	✓
$ U_0  /  U_1  > m$ && $U_N > n$ [pu] (Balanced Voltage < )			✓ [m = 1; n = 0.08 pu]	
CB Closed OR max I > k $I_N$			✓ [BkrOFF = 0; k = 0.08]	
<b>RESET</b>			10s	0 – NOT latched 0.6s – Latched
3 Phase Volt Healthy [ $U_N < U_{N, SET}$ ]	✓	✓	✓ [RESET = 37V]	✓
Earth Fault [ $I_N > I_{N, SET}$ OR $\Delta I_N > k I_{nom}$ ]	✓ Trip by unblocking	Trip by external OC	Trip by VTS OC	✓ Trip by blocking k = 0.06
CB Open			✓ [BkrOFF = 1, min I < 8%]	[SPO by V < 45V; I < 10mA]

# Summary

- Loss of VT signal in distance protection can lead to inadvertent operation with  $V = 0$  and  $Z = 0$ . Hence, VT supervision is needed to **block tripping** of **voltage dependent element** (distance, directional).
- **Residual voltage and current** ( $V_N > V_{N, SET}$ ;  $I_N < I_{N, SET}$ ) are generally employed to detect **1 or 2 fuses burnt** cases. However, latest relays also tackle for 3 fuses burnt case, where possibly have no voltage input as 3 pole open does. Hence, **CB status** (for NR RCS902H) or **3 pole open detector** (3PO / SPO for SEL421) are employed to differentiate the case of 3 pole open or 3 fuses burnt. CLP LOP is also employed in SEL421 to tackle no load condition.
- Before the latch of VTS, **EF** ( $I_0 > I_{0, SET}$ ) can often reset VTS and unblock tripping. To ensure tripping even under VTS condition, **unblocking**, **external OC element** and **higher setting for VTS OC** can be employed. After the latch of VTS, **voltage healthy** becomes the only criteria (or + manual button reset in SEL421) to reset VTS.
- Other than zero sequence (residual) current and voltage, **negative sequence current and voltage** can also be employed for tripping, with higher sensitivity on phase-to-phase fault, and less noise with induced voltage or circulating/ charging current.
- **General fault detector** (FD) in RCS902H which includes DPFC element and zero sequence OC ( $3I_0(\text{calc}) \&\& 3I_0(\text{meas}) > 3I_{0, SET}$ ) will block issue of VTS.
- It is noted that VTS should be issued **faster** than Z1 element tripping to avoid maloperation during fuse burnt condition.