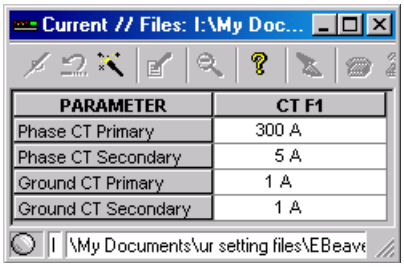
General Considerations for Using the D60 in Weak Infeed Applications

GE Publication No. GET-8406

Defining Voltage and Current Inputs

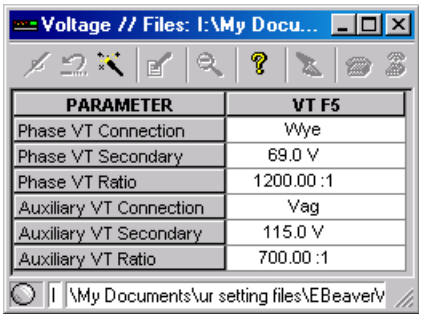
CT SETTINGS

The settings for CT primary and secondary are found under the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS** menu. The **GROUND CT** settings are not required unless the ground CT input is wired to a ground current source (transformer neutral or core balance CT).



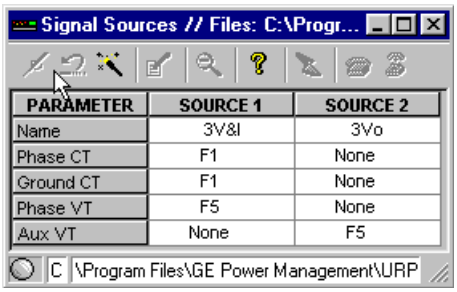
VT SETTINGS

The VT connection, ratio, and nominal secondary voltage settings are also found under the **SETTINGS ⇨⇩ SYSTEM SETUP ⇨ AC INPUTS** menu. The open-corner-delta VT input (if available) should be wired to the Vx input (F8a and F8c in the case of an F8A CT/VT module). Enter the appropriate VT ratio and nominal secondary voltage as shown:



SOURCE SETTINGS

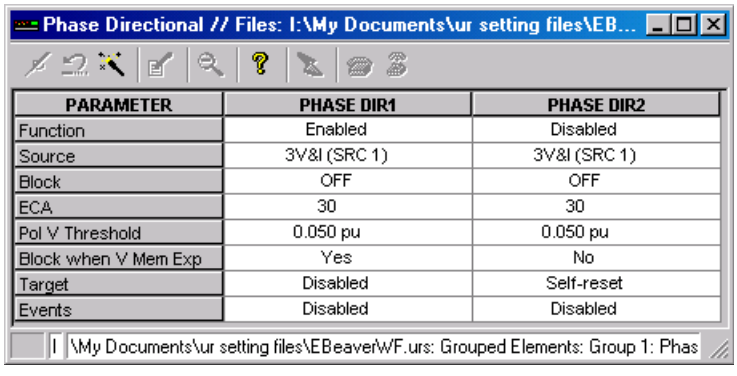
Define the two sources. Source 1 will consist of the phase voltage and current inputs to the relay and will be used by the distance, voltage, and current elements. Source 2 will be used for measurement of the open-corner-delta voltage. This source will be used for the 3V_0 element only.



Setting the Current Elements

PHASE DIRECTIONAL OVERCURRENT

The Phase Directional element is found under the **GROUPED ELEMENTS ⇨⇩ SETTING GROUP 1(8) ⇨ PHASE CURRENT ⇨⇩ PHASE DIRECTIONAL 1(2)** menu. The element function must be set to “Enabled” and the correct source must be assigned. The Phase Directional element will use the quadrature voltage for polarization (the ECA setting will be 90° ahead of the desired fault angle). If the polarizing voltage is less than the threshold setting, then the element makes use of the voltage memory until it expires. The element can be forced to block once the memory voltage expires (due to a loss of potentials to the relay) by selecting “Yes” for the **PHASE DIR 1(2) BLOCK WHEN V MEM EXP** setpoint. Select “Yes” if to disable the supervised IOC/TOC element operation when the polarizing voltage is lost. Select “No” to allow the supervised element to operate (note that directionality is lost at this point). The output of this scheme is a group of three FlexLogic™ operands (`PHASE DIR1 BLK A`, `B` and `C`). These operands can be used to provide directional control to any of the Phase IOC or TOC elements found in the relay as shown in the following section. Since this element normally only supervises other elements, Targets and Events are usually disabled.



PHASE TOC/IOC

The following URPC screen shot Illustrates the setup of a typical Phase TOC (or IOC) element. The element function must be enabled and the proper source must be assigned. The desired pickup, time dial and curve must also be entered here. The mini-

mum pickup setting is in per-unit where 1.0 pu is equal to the CT secondary nominal current (1 A or 5 A). Note that the directional overcurrent scheme FlexLogic™ operands can be assigned to the block settings to provide directional control.

Phase TOC // Files: I:\My Documents\ur setting files\EBe...

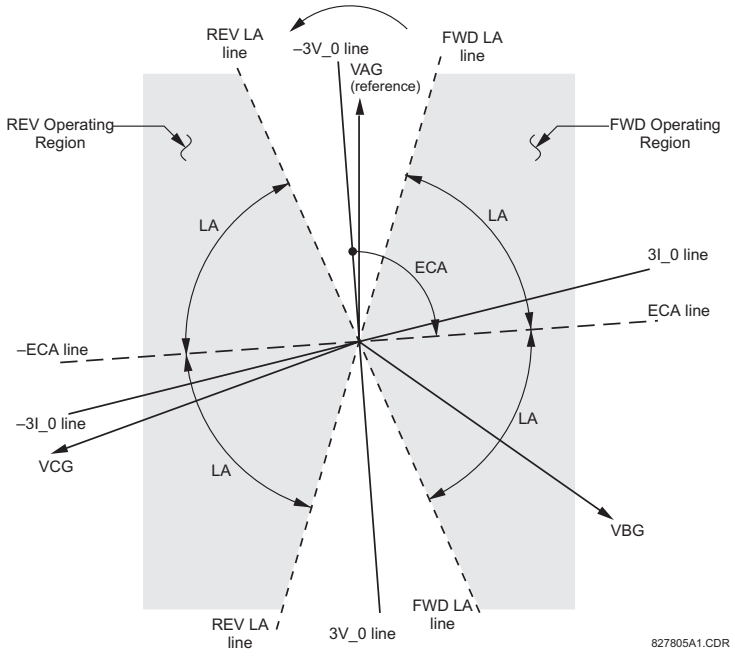
PARAMETER	PHASE TOC1	PHASE TOC2
Function	Enabled	Disabled
Signal Source	3V&I (SRC 1)	3V&I (SRC 1)
Input	Phasor	Phasor
Pickup	0.800 pu	1.000 pu
Curve	IEEE Mod Inv	IEEE Mod Inv
TD Multiplier	1.00	1.00
Reset	Timed	Instantaneous
Voltage Restraint	Disabled	Disabled
Block A	PH DIR1 BLK A	OFF
Block B	PH DIR1 BLK B	OFF
Block C	PH DIR1 BLK C	OFF
Target	Latched	Self-reset
Events	Enabled	Disabled

\My Documents\ur setting files\EBeaverWF.urs: Grouped Elements: Group 1

NEUTRAL DIRECTIONAL OVERCURRENT

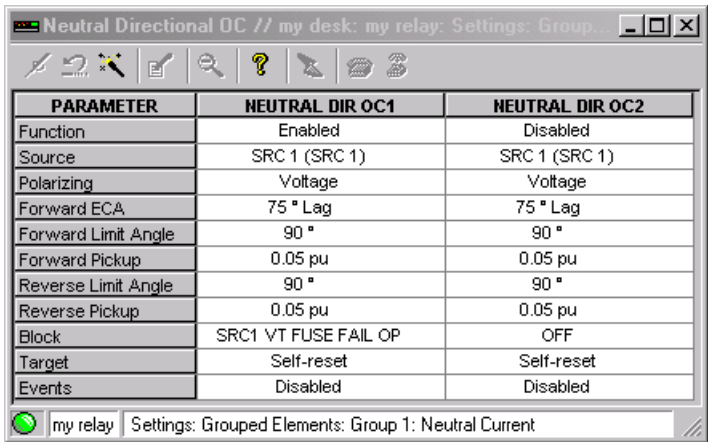
The Neutral Directional elements can be used to supervise any of the Neutral Overcurrent elements in the relay. They are also used in pilot scheme logic.

The polarizing signal can be voltage, current, or both (current polarizing requires a source of ground current; see page 1 for details). The ECA is set at the expected fault angle. The forward and reverse limit angle settings allows for reduction of the operating region as shown in the figure below. The separate settings for forward and reverse pickup allow the forward element pickup to be set higher than the reverse element for coordination purposes when used in blocking schemes.



The D60 neutral directional element has been designed for the reverse element to operate more quickly than the forward element for the same signal levels. Additionally, if a fault has been identified in the reverse direction for at least 1.25 cycles, then measurement of a forward direction fault is delayed by 1.5 cycles to ensure correct establishment of the new phasor magnitude.

The element can be supervised by the VT Fuse Failure element to prevent a maloperation for a blown fuse. Note that the element applies positive sequence restraint (1/16th of the positive-sequence current is subtracted from the zero-sequence current). This means that only system unbalances or CT errors greater than 8.25% could cause the pickup even with virtually zero pickup setting.

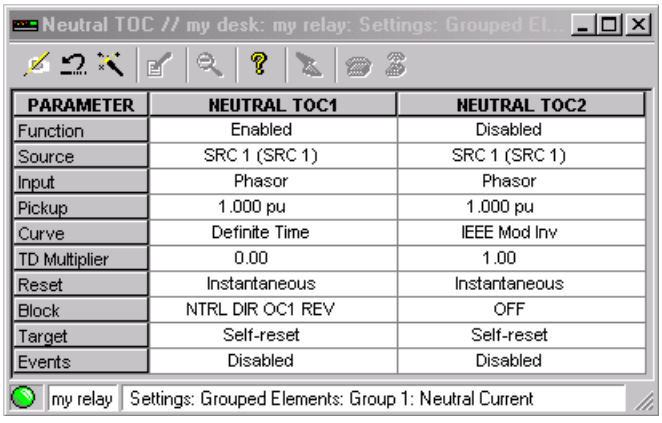


PARAMETER	NEUTRAL DIR OC1	NEUTRAL DIR OC2
Function	Enabled	Disabled
Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)
Polarizing	Voltage	Voltage
Forward ECA	75 ° Lag	75 ° Lag
Forward Limit Angle	90 °	90 °
Forward Pickup	0.05 pu	0.05 pu
Reverse Limit Angle	90 °	90 °
Reverse Pickup	0.05 pu	0.05 pu
Block	SRC1 VT FUSE FAIL OP	OFF
Target	Self-reset	Self-reset
Events	Disabled	Disabled

NEUTRAL TOC/IOC

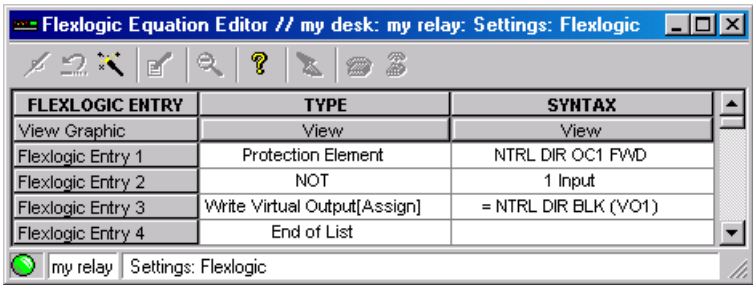
The following URPC screen shots illustrates the setup for a typical Neutral TOC element (similar for Neutral IOC). The element must be enabled and the proper source must be assigned. The desired pickup, time dial and curve is also entered here. The element can be supervised by the neutral directional element in one of two ways:

1. If there is a blown fuse, the block signal is inhibited and the element is allowed to operate (directionality is lost). The settings are shown below.

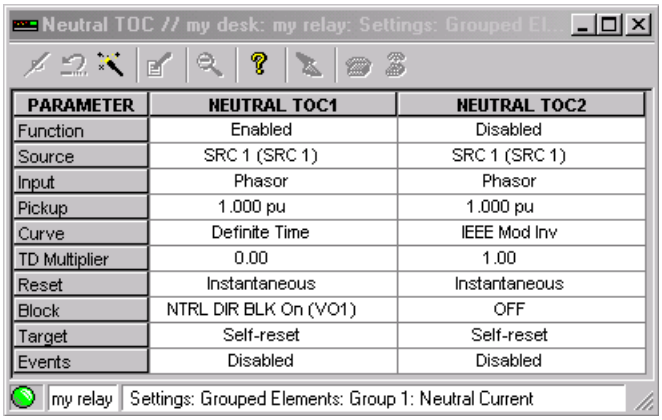


PARAMETER	NEUTRAL TOC1	NEUTRAL TOC2
Function	Enabled	Disabled
Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)
Input	Phasor	Phasor
Pickup	1.000 pu	1.000 pu
Curve	Definite Time	IEEE Mod Inv
TD Multiplier	0.00	1.00
Reset	Instantaneous	Instantaneous
Block	NTRL DIR OC1 REV	OFF
Target	Self-reset	Self-reset
Events	Disabled	Disabled

2. For the second method, a virtual output VO1 is created in FlexLogic™.



Now the element can be supervised as shown below. In this case, the supervised element is prevented for operating in all instances unless the directional element sees a fault in the forward direction.

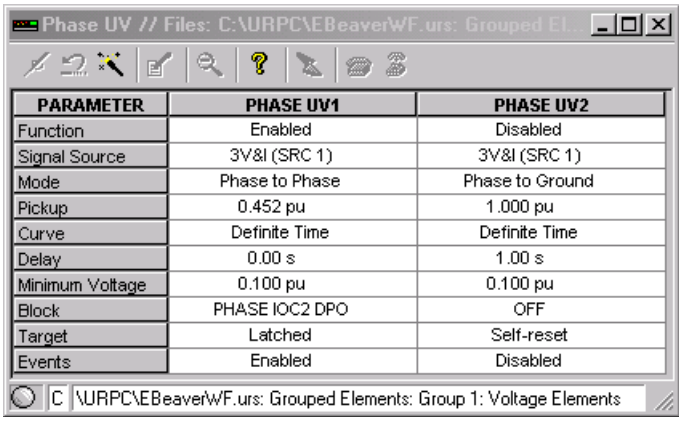


Setting the Voltage Elements

PHASE UNDERVOLTAGE

The following URPC screen shot shows the required Undervoltage element settings. This element is typically used in conjunction with the weak infeed scheme. As before, the element must be enabled and the proper source assigned. The desired pickup, curve, and delay must be entered. The pickup setting is per-unit, where 1.0 pu is equal to the VT nominal secondary voltage setting in "Phase to Ground" mode and $\sqrt{3}$ times this setting in "Phase to Phase" mode. The minimum voltage setting ensures the element does not operate for loss of potential or line de-energized conditions. Additionally, the dropout

operand of a low-set IOC element prevents operation (sending of a block) when the local breaker is open.

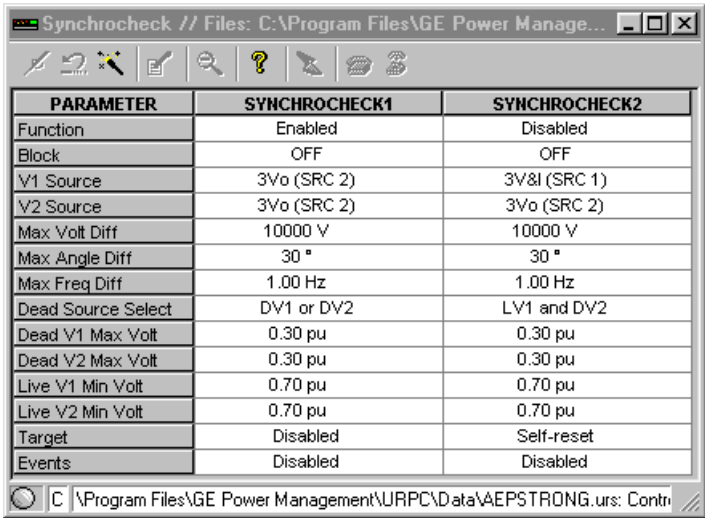


PARAMETER	PHASE UV1	PHASE UV2
Function	Enabled	Disabled
Signal Source	3V&I (SRC 1)	3V&I (SRC 1)
Mode	Phase to Phase	Phase to Ground
Pickup	0.452 pu	1.000 pu
Curve	Definite Time	Definite Time
Delay	0.00 s	1.00 s
Minimum Voltage	0.100 pu	0.100 pu
Block	PHASE IOC2 DPO	OFF
Target	Latched	Self-reset
Events	Enabled	Disabled

ZERO-SEQUENCE OVERVOLTAGE FUNCTION

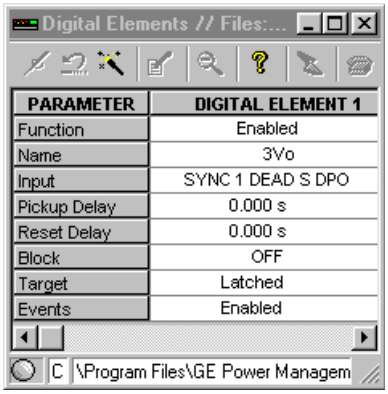
The following steps outline the settings necessary to implement a zero-sequence overvoltage function within the D60. This method is required only for firmware versions 2.6X or lower.

1. Configure the Synchrocheck element 1 for Source 2. Set the **DEAD SOURCE SELECT** setting to "DV1 or DV2". Configure the **DEAD V1 MAX VOLT** pickup setting equal to the desired 3V0 threshold (the **DEAD V2 MAX VOLT** setting is irrelevant at this point but could be set equal to the **DEAD V1 MAX VOLT** setting to minimize any future confusion on the settings). Disable the Target and Events settings.



PARAMETER	SYNCHROCHECK1	SYNCHROCHECK2
Function	Enabled	Disabled
Block	OFF	OFF
V1 Source	3Vo (SRC 2)	3V&I (SRC 1)
V2 Source	3Vo (SRC 2)	3Vo (SRC 2)
Max Volt Diff	10000 V	10000 V
Max Angle Diff	30 °	30 °
Max Freq Diff	1.00 Hz	1.00 Hz
Dead Source Select	DV1 or DV2	LV1 and DV2
Dead V1 Max Volt	0.30 pu	0.30 pu
Dead V2 Max Volt	0.30 pu	0.30 pu
Live V1 Min Volt	0.70 pu	0.70 pu
Live V2 Min Volt	0.70 pu	0.70 pu
Target	Disabled	Self-reset
Events	Disabled	Disabled

2. Create a custom protection element called "3Vo" using a digital element. Select "SYNC 1 DEAD S DPO" for the **DIG ELEM 1 INPUT** setting, where DPO refers to the element dropout. For an overvoltage condition, this operand will be asserted.

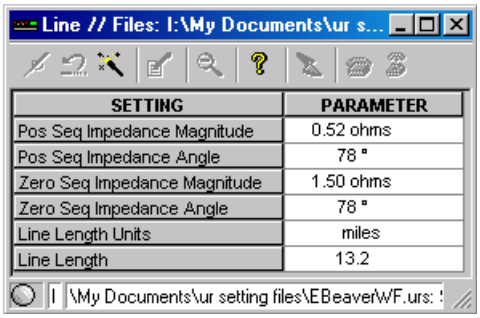


3. In the instance that a 3V0 element is not required (i.e. an auto-transformer at the weak terminal), the previous setting definitions can remain unchanged with the exception of the digital element **FUNCTION** setting. This setting would be changed to "Disabled".

Setting the Distance Elements

COMMON LINE DISTANCE SETTINGS

The common line distance settings (found under the **SYSTEM SETUP** ⇨⇩ **LINE** menu) are entered as follows:

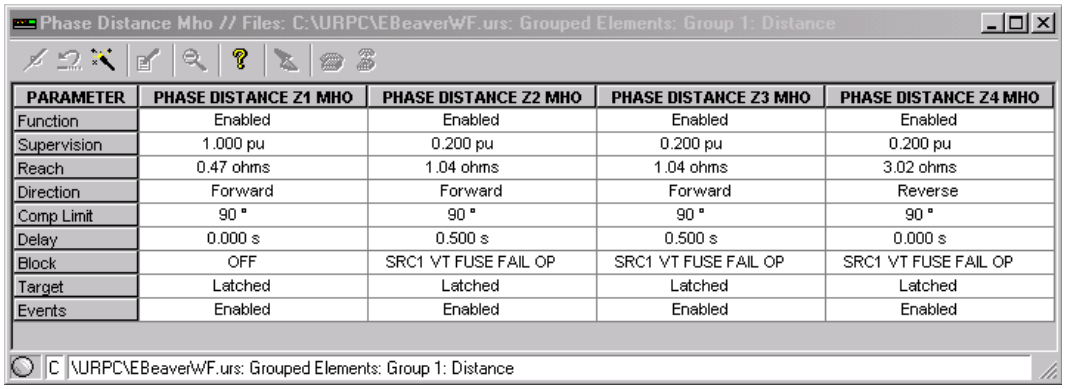


The ECA of the individual phase and ground distance elements are taken from the positive and zero-sequence impedance angles respectively. The zero-sequence compensation factor is calculated automatically from the positive and zero-sequence impedance magnitudes. The fault locator also uses this setting information.

PHASE DISTANCE

The desired phase distance element settings are entered as shown in the following block. The reach values are in secondary ohms. The **PHASE DIST Z1 COMP LIMIT** setting can be used to change the mho shape from circular to lens. Since the Z1 element is usually instantaneous, VT fuse failure will not prevent a false operation for a loss of potential condition. In this case, security can be provided by increasing the **PHASE DIST Z1 SUPV** setting to a value greater than the maximum load current but less than the minimum

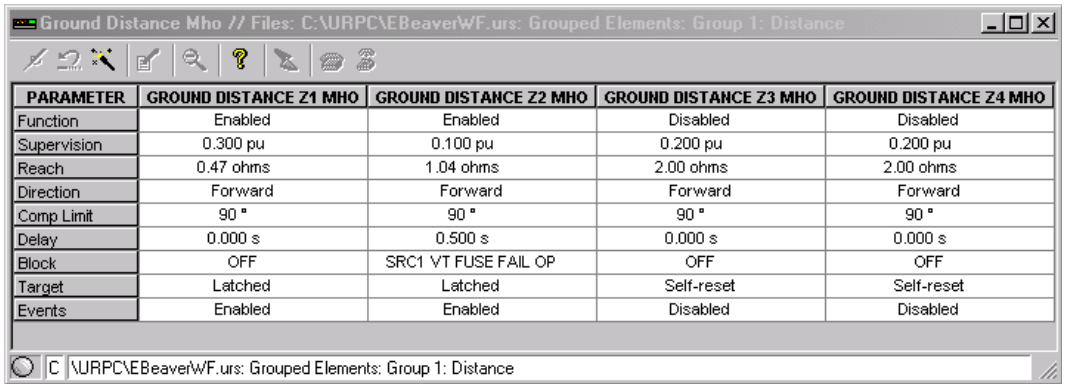
Zone 1 fault current. The minimum fault level may not be above the maximum load current for the remaining zones but since these zones are typically time delayed, VT fuse fail can be used for blocking.



PARAMETER	PHASE DISTANCE Z1 MHO	PHASE DISTANCE Z2 MHO	PHASE DISTANCE Z3 MHO	PHASE DISTANCE Z4 MHO
Function	Enabled	Enabled	Enabled	Enabled
Supervision	1.000 pu	0.200 pu	0.200 pu	0.200 pu
Reach	0.47 ohms	1.04 ohms	1.04 ohms	3.02 ohms
Direction	Forward	Forward	Forward	Reverse
Comp Limit	90 °	90 °	90 °	90 °
Delay	0.000 s	0.500 s	0.500 s	0.000 s
Block	OFF	SRC1 VT FUSE FAIL OP	SRC1 VT FUSE FAIL OP	SRC1 VT FUSE FAIL OP
Target	Latched	Latched	Latched	Latched
Events	Enabled	Enabled	Enabled	Enabled

GROUND DISTANCE

The desired ground distance element settings are entered as shown below. Positive-sequence impedance is entered for the reach. This value is adjusted internally using the zero sequence compensation factor described previously. Security against loss of potentials can be provided for Zone 1 by increasing the Supervision setting to a value greater than the maximum expected unbalanced current but less than the minimum Zone 1 ground fault current. For time delayed zones, VT fuse fail can be used for blocking



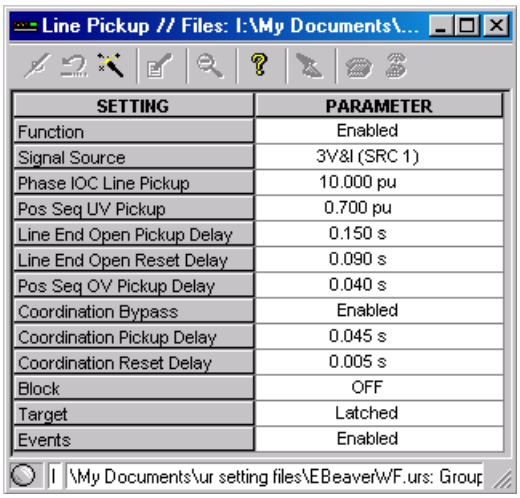
PARAMETER	GROUND DISTANCE Z1 MHO	GROUND DISTANCE Z2 MHO	GROUND DISTANCE Z3 MHO	GROUND DISTANCE Z4 MHO
Function	Enabled	Enabled	Disabled	Disabled
Supervision	0.300 pu	0.100 pu	0.200 pu	0.200 pu
Reach	0.47 ohms	1.04 ohms	2.00 ohms	2.00 ohms
Direction	Forward	Forward	Forward	Forward
Comp Limit	90 °	90 °	90 °	90 °
Delay	0.000 s	0.500 s	0.000 s	0.000 s
Block	OFF	SRC1 VT FUSE FAIL OP	OFF	OFF
Target	Latched	Latched	Self-reset	Self-reset
Events	Enabled	Enabled	Disabled	Disabled

LINE PICKUP

The Line Pickup element provides protection for switching onto a close-in fault. This scheme should not be used if the PTs are on the bus side. The settings description is as follows:

- **PHASE IOC LINE PICKUP**: Detects fault current on closing of the breaker. This should be set lower than the minimum fault current expected.
- **POS SEQ UV PICKUP**: This element is used in conjunction with the undercurrent detectors to detect that the line is opened. This should be set lower than the minimum voltage expected for a live line condition.
- **LINE END OPEN PICKUP DELAY**: This setting determines the time delay before the scheme is armed (typically 150 ms).
- **LINE END OPEN RESET DELAY**: This setting determines the time delay before the scheme is disarmed (90 ms typical).

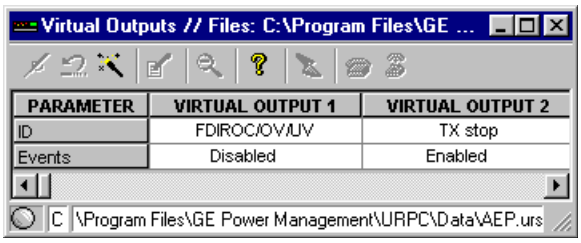
- **POS SEQ OV PICKUP DELAY**: This timer determines a minimum delay required before the line is recognized as energized. This delay is necessary to avoid spurious operation (40 ms typical).
- **AR CO-ORD PICKUP DELAY**: This timer should be used when the **PHASE IOC LINE PICKUP** setting is set below the load current and simultaneous, high speed autoreclosure is used. If used, the timer setting must be longer than the **POS SEQ OV PICKUP DELAY**. If not required, this timer can be bypassed by enabling the **AR CO-ORD BYPASS** setting.
- **AR CO-ORD RESET DELAY**: This timer can be used to seal-in the line pickup output (0 ms typical).



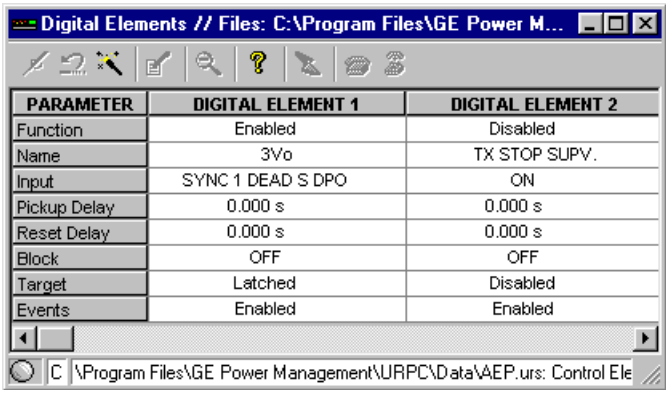
Weak Terminal Blocking Scheme Logic

The necessary steps required to implement the weak infeed logic for a weak terminal are outlined below. This same logic can also be applied if the terminal has a strong infeed. In this case, the weak infeed elements (Phase UV and 3V0) and **TX STOP SUPERVISION** would be disabled.

1. At the weak terminal, there are now two additional inputs required for tripping of the local breaker. Consequently, a virtual output will be created to combine these signals. Additionally a virtual output will be required to combine the TX block signal with a supervision signal from the Zone 4 Phase Distance element.

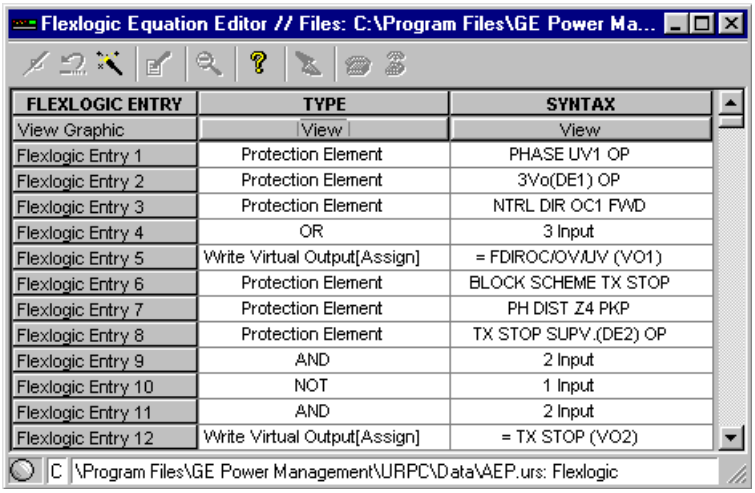


2. A digital element will be required such that Zone 4 supervision of the TX STOP can be switched out. This would be required in the case that the phase undervoltage element operates for a downstream fault at the weak terminal. When the digital element is enabled, the pickup of the Zone 4, phase distance element will prevent a carrier stop (TX STOP). When the digital element is disabled, the zone 4 phase distance element will not prevent a carrier stop.



PARAMETER	DIGITAL ELEMENT 1	DIGITAL ELEMENT 2
Function	Enabled	Disabled
Name	3Vo	TX STOP SUPV.
Input	SYNC 1 DEAD S DPO	ON
Pickup Delay	0.000 s	0.000 s
Reset Delay	0.000 s	0.000 s
Block	OFF	OFF
Target	Latched	Disabled
Events	Enabled	Enabled

3. The FlexLogic™ can now be entered.



FLEXLOGIC ENTRY	TYPE	SYNTAX
View Graphic	View	View
Flexlogic Entry 1	Protection Element	PHASE UV1 OP
Flexlogic Entry 2	Protection Element	3Vo(DE1) OP
Flexlogic Entry 3	Protection Element	NTRL DIR OC1 FWD
Flexlogic Entry 4	OR	3 Input
Flexlogic Entry 5	Write Virtual Output[Assign]	= FDIROC/OV/UV (VO1)
Flexlogic Entry 6	Protection Element	BLOCK SCHEME TX STOP
Flexlogic Entry 7	Protection Element	PH DIST Z4 PKP
Flexlogic Entry 8	Protection Element	TX STOP SUPV.(DE2) OP
Flexlogic Entry 9	AND	2 Input
Flexlogic Entry 10	NOT	1 Input
Flexlogic Entry 11	AND	2 Input
Flexlogic Entry 12	Write Virtual Output[Assign]	= TX STOP (VO2)

This logic is represented graphically as follows:

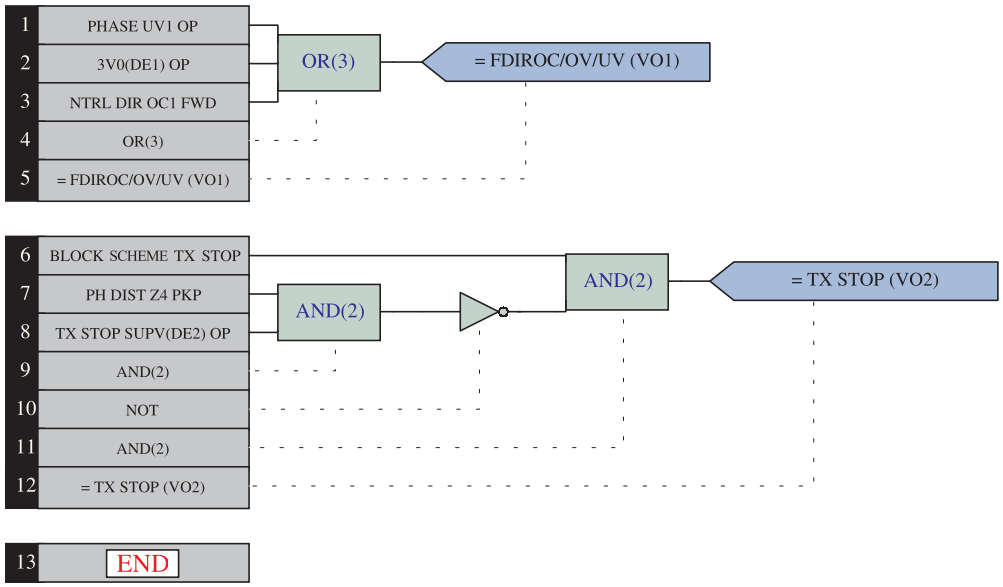
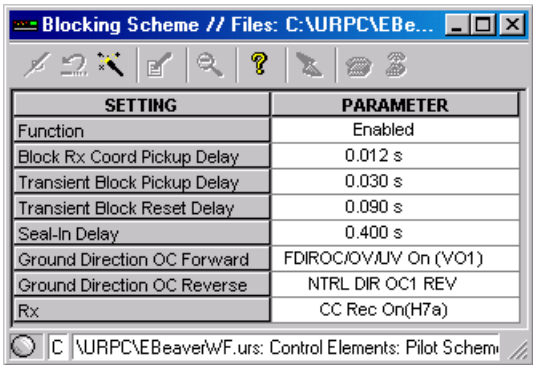


FIGURE 1. Weak Terminal Infeed FlexLogic™

4. The “FDIROC/OV/UV" virtual output will be applied to the blocking scheme logic. In the case of an autotransformer at the weak terminal, The 3V0 element (Digital Element 1) can be disabled. In the case of a delta/wye transformer, the Neutral Directional Overcurrent element can be disabled. This makes the previous logic applicable for both cases. Typically the `NTRL DIR OC FWD` FlexLogic™ operand would be entered in the **GND DIR O/C FWD** setting of the Blocking Scheme logic. Now, the new "FDIROC/OV/UV" operand is entered in its place.



The complete logic for the weak terminal is shown below:

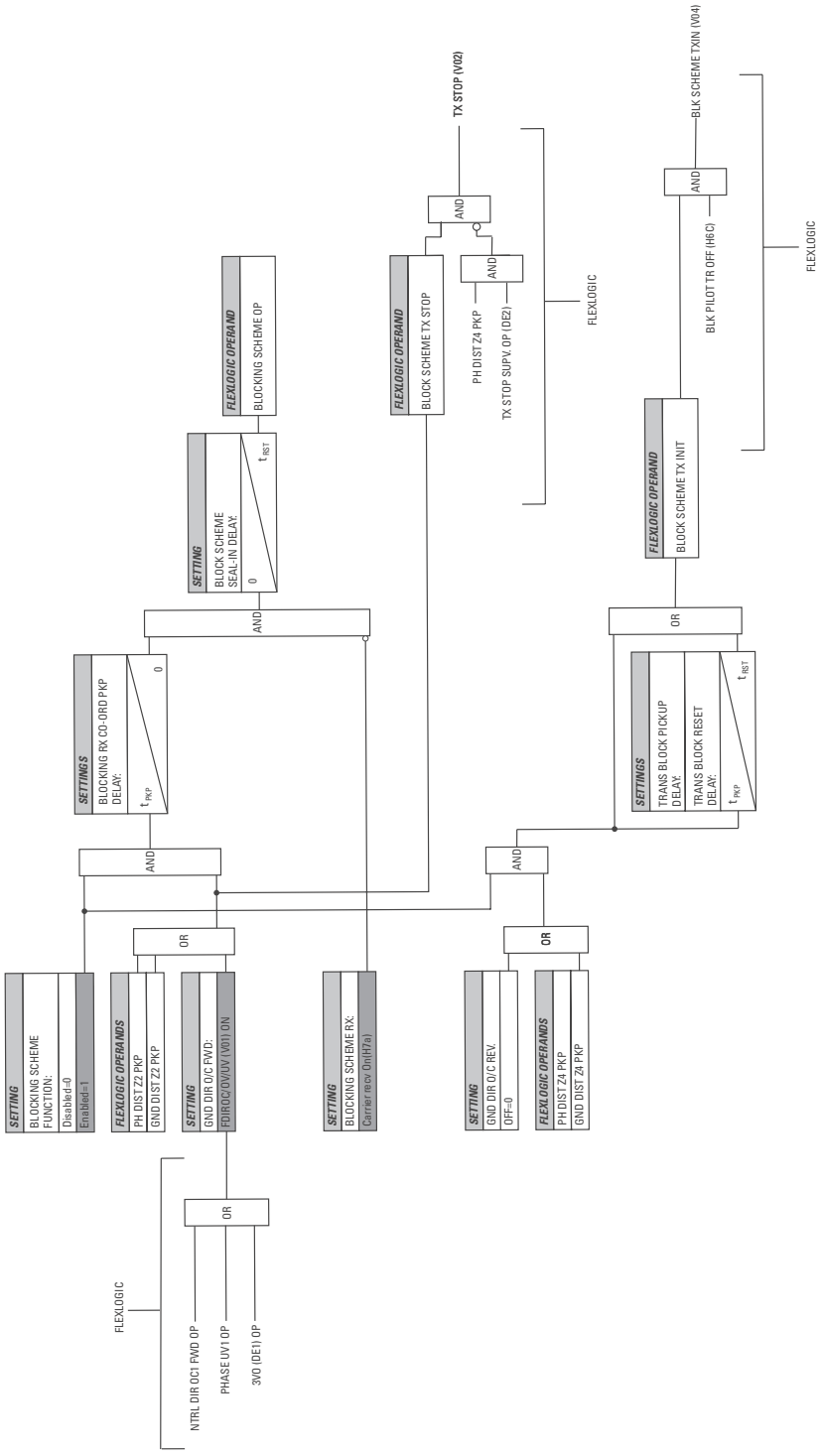
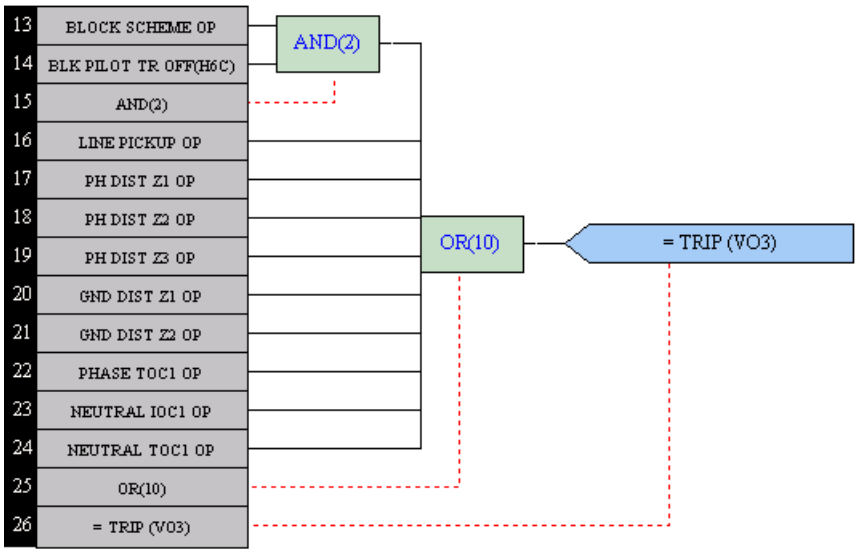


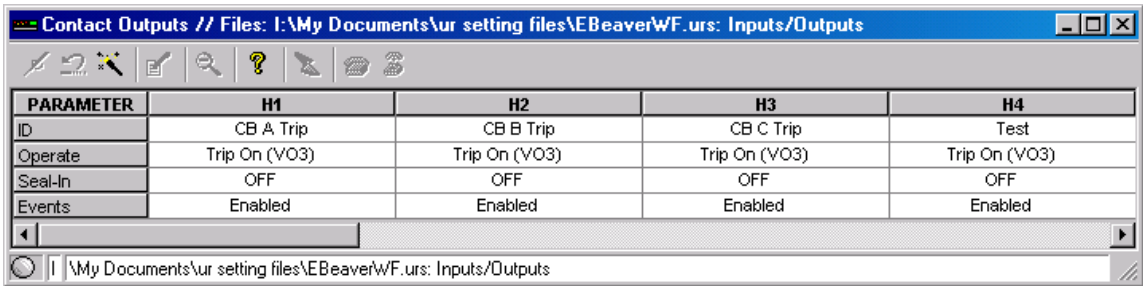
FIGURE 2. Weak Terminal Infeed Logic

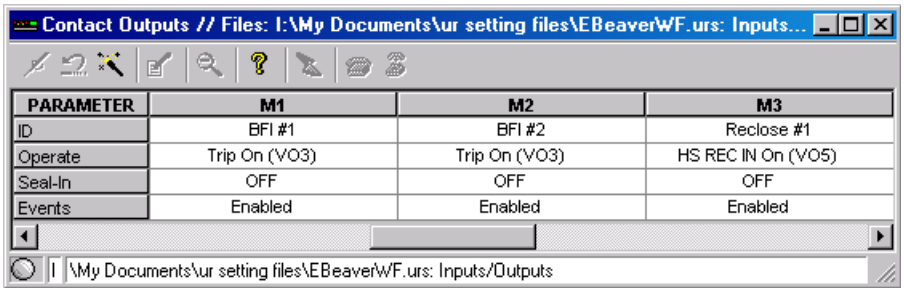
For the case of a delta/wye transformer, the Phase Undervoltage element or the 3V0 element will detect a line fault. For the case of an autotransformer, the Phase Undervoltage element or the forward, ground directional overcurrent element will detect the line fault. This signal will be time delayed to allow for the arrival of the block receive signal from the strong terminal in the instance that the fault is located beyond the remote terminal. Coordination of the voltage element settings at the strong and weak terminals will ensure correct operation for internal and external line faults. External faults located downstream of the weak terminal will be seen by the Zone 4 phase distance elements. It is assumed that the generation of the carrier start by these elements will produce a carrier receive signal which will block the operation of the voltage elements.

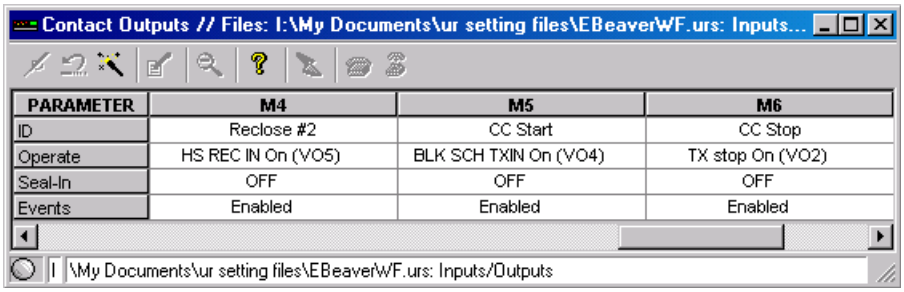
5. The output logic can now be defined. Note that a local selector switch supervises the block scheme output.



6. The output operands from the scheme logic must now be assigned to contact outputs as shown below:

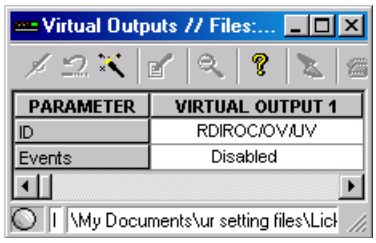




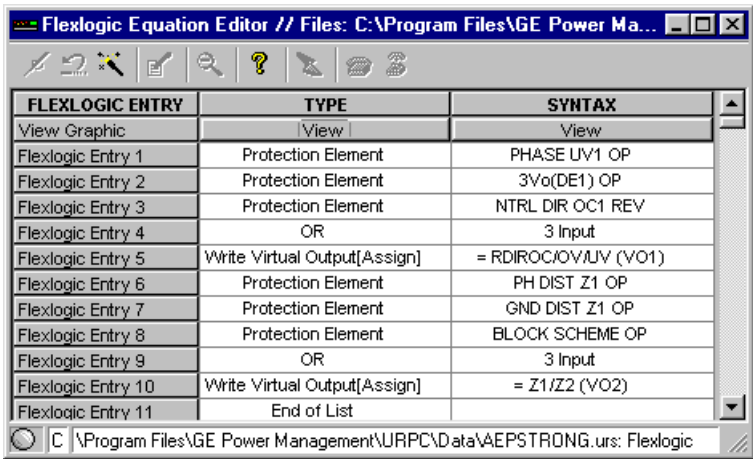


Strong Terminal Blocking Scheme Logic

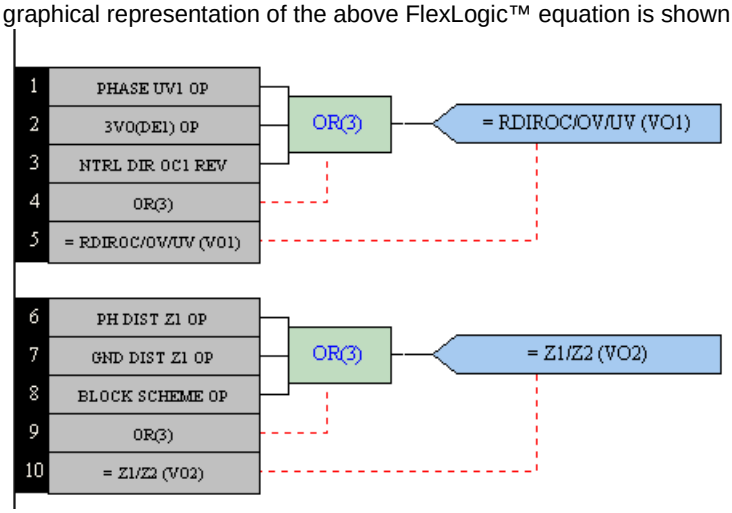
1. At the strong terminal, a blocking signal is typically initiated by the Zone 2 Phase and Ground distance elements and by a reverse looking Ground Directional Overcurrent element. In addition to this, the Phase Undervoltage and 3V0 elements must be included. A virtual output will be defined for this purpose as shown below:



2. The FlexLogic™ is entered as follows:

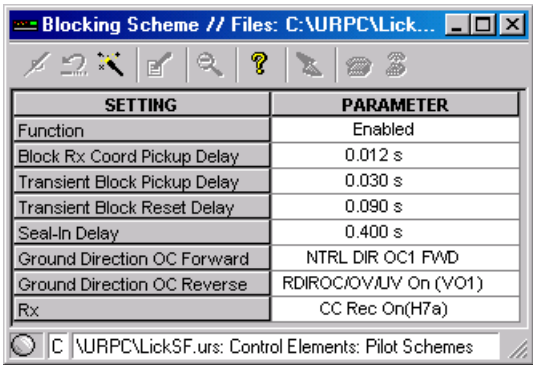


3. The graphical representation of the above FlexLogic™ equation is shown below:



This virtual output (RDIROC/OV/UV) will be applied to the Blocking Scheme logic. In the case of an autotransformer at the weak terminal, the 3V0 (DE1) element can be disabled.

4. Normally the NTRL DIR OC REV FlexLogic™ operand would be entered in the **GND DIR O/C FWD** setting of the Blocking Scheme logic. Now the RDIROC/OV/UV FlexLogic™ operand is entered in its place.



5. The overall logic for the Blocking scheme at the strong terminal is shown below. Operation of the voltage elements at the strong terminal will send a block to the weak terminal.

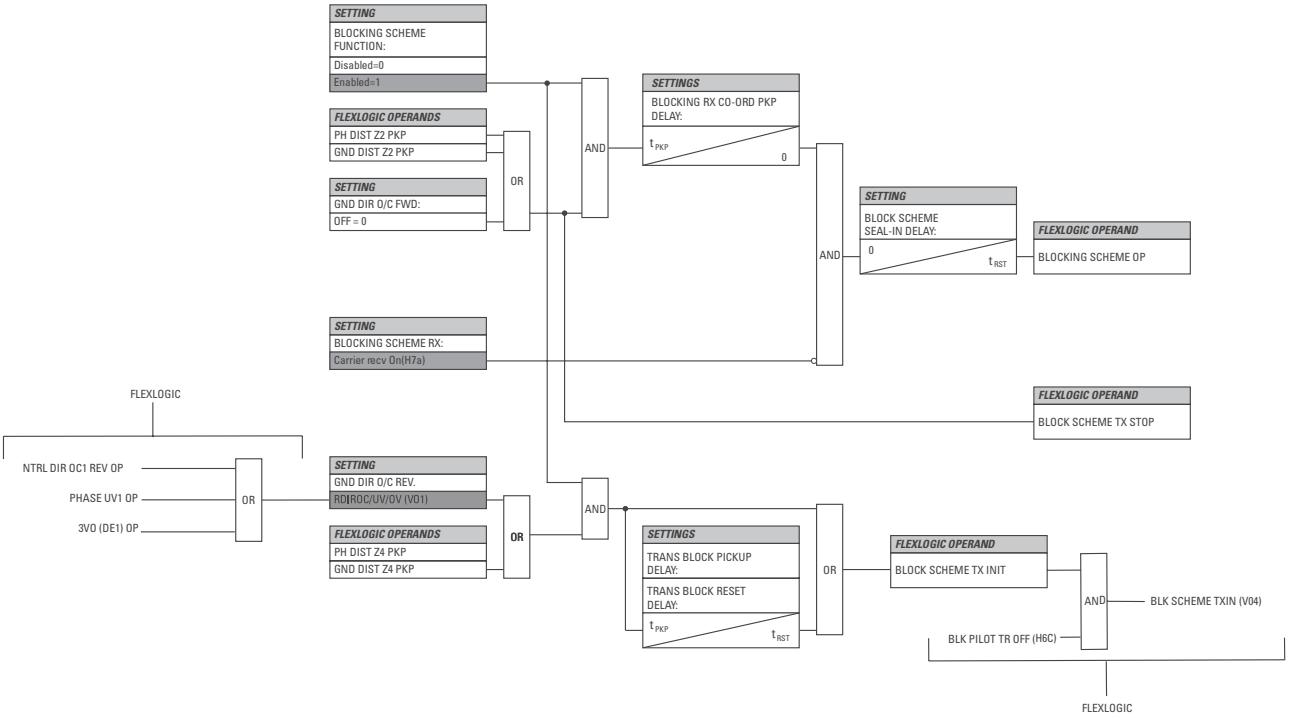
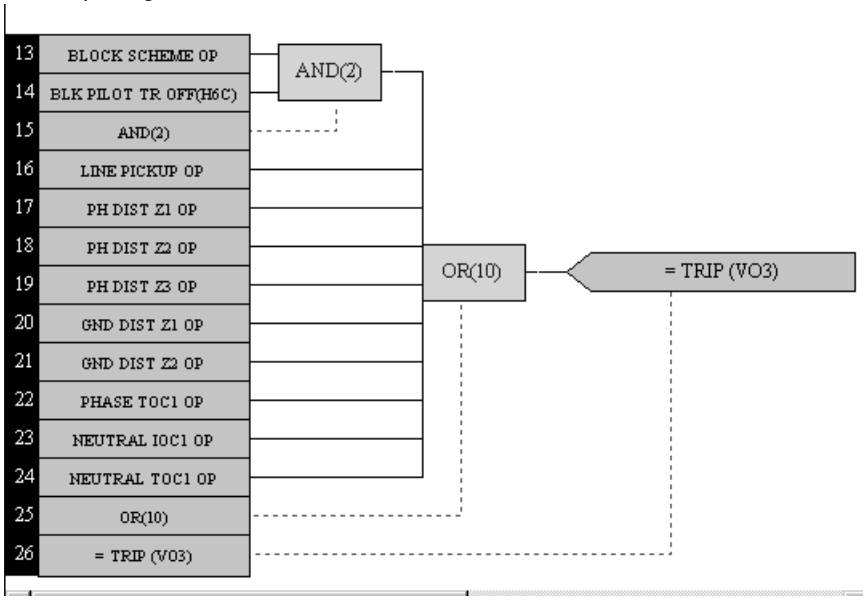


FIGURE 3. Strong Terminal Blocking Logic

6. The output logic can now be defined as follows:



7. The output operands from the Blocking scheme must now be assigned to output contacts.

Contact Outputs // Files: I:\My Documents\ur setting files\LickSF.urs: Inputs/Outputs

PARAMETER	H1	H2	H3	H4
ID	CB 105 Trip	CB 106 Trip	94TTaux Trip	Test
Operate	Trip On (VO3)	Trip On (VO3)	Trip On (VO3)	Trip On (VO3)
Seal-In	OFF	OFF	OFF	OFF
Events	Enabled	Enabled	Enabled	Enabled

\My Documents\ur setting files\LickSF.urs: Inputs/Outputs

Contact Outputs // Files: I:\My Documents\ur setting files\LickSF.urs: Inputs/Out...

PARAMETER	M1	M2	M3
ID	BFI #1	BFI #2	Reclose #1
Operate	Trip On (VO3)	Trip On (VO3)	HS REC IN On (VO5)
Seal-In	OFF	OFF	OFF
Events	Enabled	Enabled	Enabled

\My Documents\ur setting files\LickSF.urs: Inputs/Outputs

Contact Outputs // Files: I:\My Documents\ur setting files\LickSF.urs: Inputs/Out...

PARAMETER	M4	M5	M6
ID	Reclose #2	CC Start	CC Stop
Operate	HS REC IN On (VO5)	BLK SCH TXIN On (VO4)	TX stop On (VO2)
Seal-In	OFF	OFF	OFF
Events	Enabled	Enabled	Enabled

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