

VARC 953B

Power distribution process simulator

User's guide



IMPORTANT NOTICE:

The simulations may contain inaccuracies due to the approximations made in the models or due to the estimated parameters. In order to verify the results measurements with actual system are recommended when possible. Authors do not assume any liability to anyone for any loss or damage caused by any errors or inaccuracies in this study.

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1. General

This is guide for VARC 953B power distribution process simulator. This guide describe the operations of the simulator, relay connection to computer using usb port and contains also some examples about using simulator.

1.1. Simulator components

This power distribution process simulator model contains one VAMP 52 feeder and motor protection relay. Three arc sensors are installed into the simulator. The arc sensors in zone Z1 and Z2 are connected to arc input S1 of the relay and arc sensor in zone Z3 is connected to arc input S2 of the relay. Figure 1.1-1 shows the arc sensor locations and the current measurement point of the relay. On simulator display the leds indicate the position of the circuit breaker. The leds are connected to the trip output relay T1. Tripr output relay T1 must be chosen from output martrix if some protection functions are wanted to ignite the “breaker open” led when relay trips.

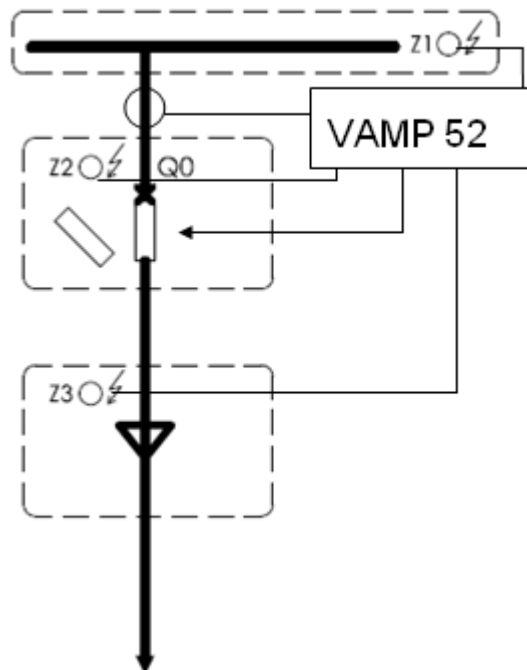


Figure 1.1-1 Connections in simulator VARC 953B

1.2. The Control Panel of the Simulator

The figure 1.2-1 shows the functions of simulator panel. Each phase current (L1, L2 and L3) can be adjusted separate by potentiometers. For simulate the earth fault situation, there is adjust for earth fault current and residual voltage. A phase shift between earth fault current and residual voltage can be adjusted with a switch. Earth fault current can be adjusted either 0 or 90 degrees phase difference with residual voltage. Three arc sensors are installed to this simulation model. Arc sensor in Z1 and Z2 zone are connected to arc channel S1 in the relay and arc sensor in Z3 area to arc channel S2 in the relay. In simulator panel have three push buttons which activates the arc channel without torch light.

The leds in the panel shows the position of the breaker. The circuit breaker (leds) can be opened and closed by switch on the panel. The leds are connected to the trip output relay T1 Simulator contains two digital input switches which can be programmed by using matrix and also for example setting groups can be changed using virtual inputs. There is leds in the panel for digital outputs.

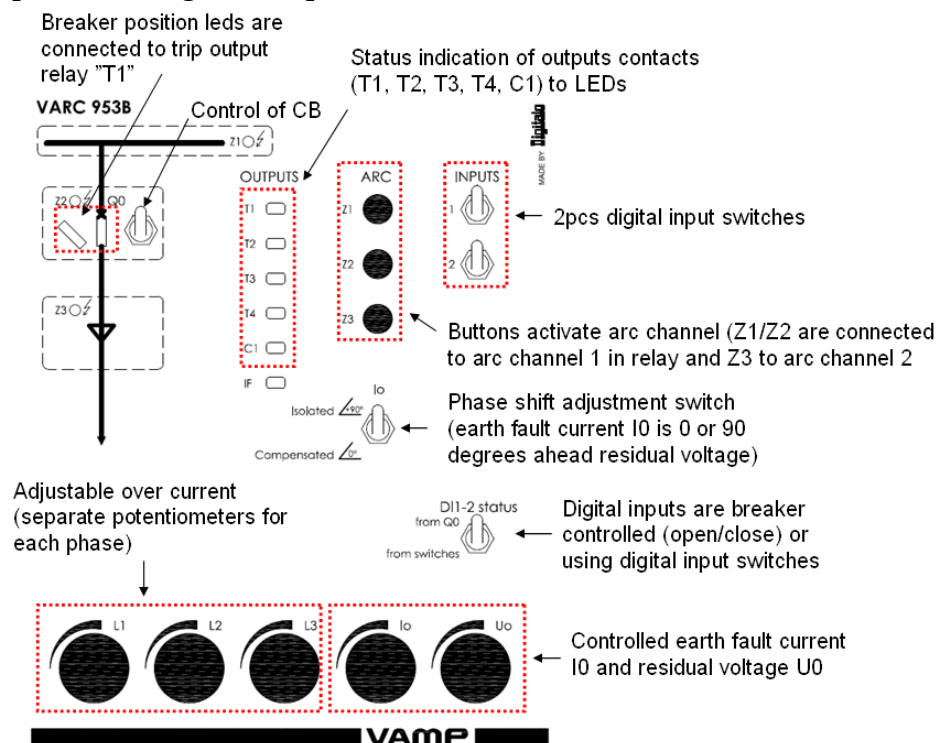


Figure 1.2-1 The view of VARC 953B simulator

2. The Relay Connection to Computer (VAMPSET) Using USB-port

The VAMPSET program can use USB connection between relay and computer communication. A standard USB-B cable can be used for this connection. Also TCP/IP LAN connection can be used, but then optional hardware is required. In this guide is shown only the usb connection creating.

The computer create a virtual comport when the relay is connected to a PC with usb-cable. The right serial port number must check from “Control panel” of computer and then it is selected from VAMPSET menu.

The USB serial port number of computer is found as follows:
Control panel → System → Hardware → Device Manager,
(Figure 2-1) → Ports (Com & LPT). The right usb serial port number of the computer is COM3 in this example (figure 2-1).

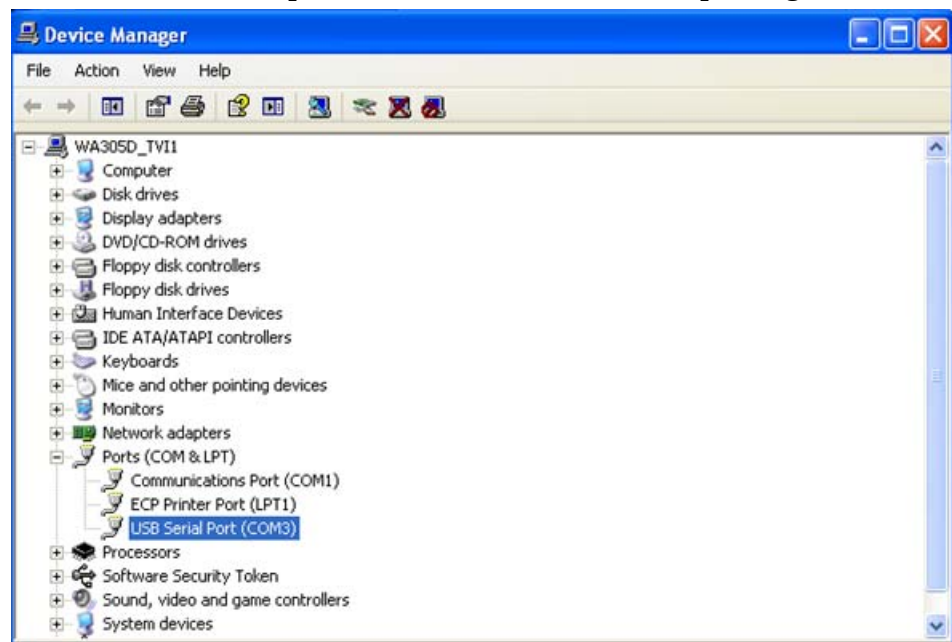


Figure 2-1 The USB serial port number of the computer

The same port number than in computer must be chosen also from Vampset communication settings. In this example the port “COM3” is chosen and communication speed can be set up to 187500 bps when usb cable is used.

The communication settings of Vampset are found as follows:
Settings → Communication settings (figure 2-2 and 2-3).

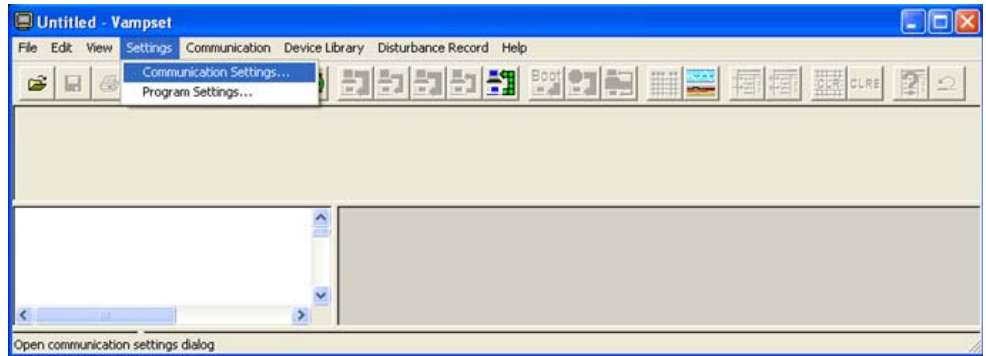


Figure 2-2 The Vampset communication settings

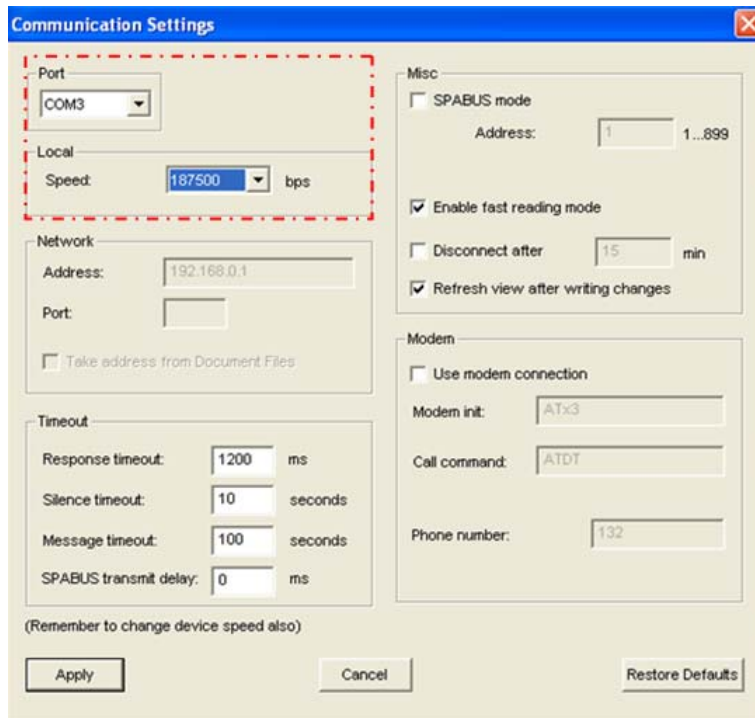


Figure 2-3 Choosing the right port and speed from communication settings of the Vampset

After these settings are done, the connection can be done pushing the “Connect” button (figure 2-4). The default password of configurator is 2.

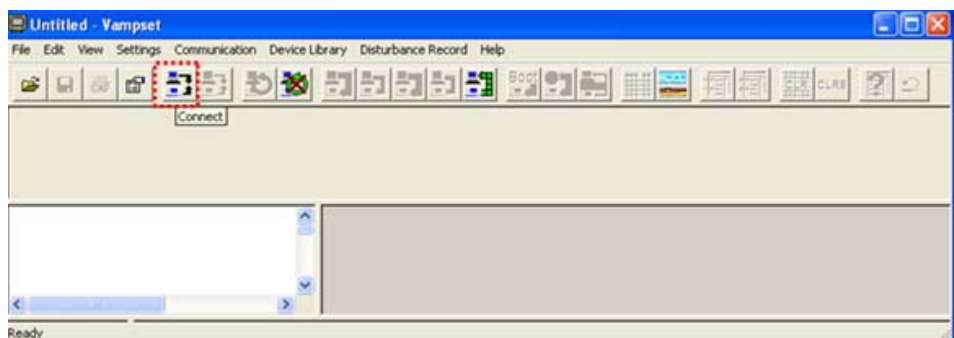


Figure 2-4 The connection to the relay

After communication is created the relay settings can be read to Vampset (figure 2-5). When connection is created the continuous updating can be pressed on (figure 2-6). Then all relay events and measurements are updated automatically to vampset. The relay settings can be saved to vampset after these steps. The settings are saved as VARC953B name in this case (figure 2-6)

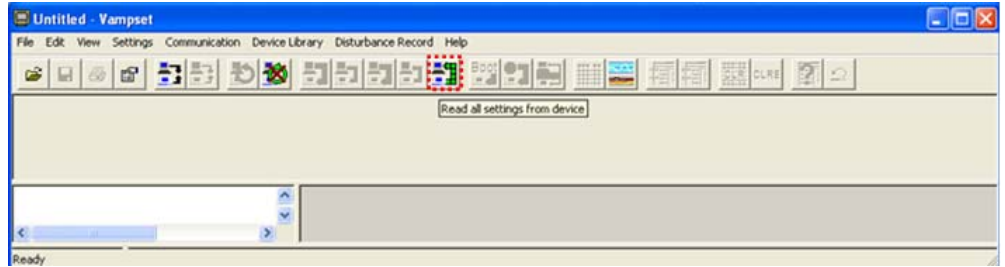


Figure 2-5 The settings from relay to Vampset

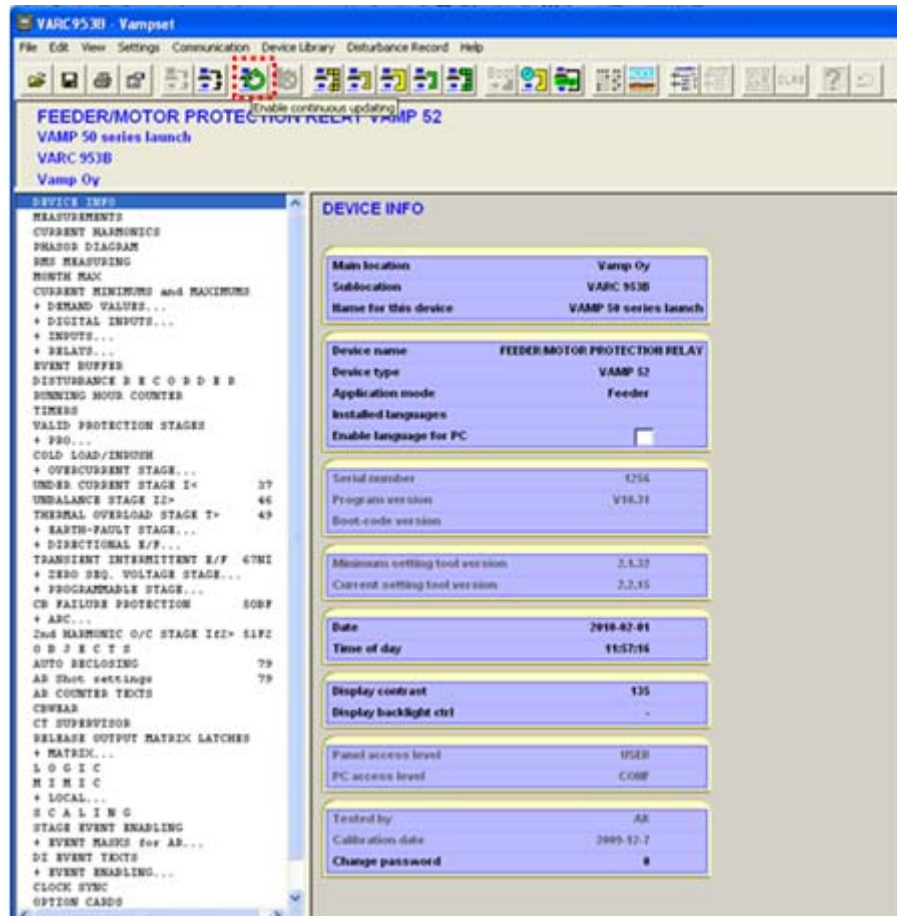


Figure 2-6 Continious updating

3. The General Vampset Settings before the Simulation And Some Features

Some relay settings are good to check before simulation. Common settings and features are shown in this chapter. The date and time of the day can be checked from “Device info” of Vampset. The “feeder” mode is used as in application mode when this distribution process simulator is used.

| DEVICE INFO | |
|------------------------------|-------------------------------|
| Main location | Vamp Oy |
| Sublocation | VARC 953B |
| Name for this device | VAMP 50 series launch |
| Device name | FEEDER.MOTOR PROTECTION RELAY |
| Device type | VAMP 52 |
| Application mode | Feeder |
| Installed languages | |
| Enable language for PC | <input type="checkbox"/> |
| Serial number | 1256 |
| Program version | V10.31 |
| Boot-code version | |
| Minimum setting tool version | 2.1.32 |
| Current setting tool version | 2.2.15 |
| Date | 2010-02-10 |
| Time of day | 12:23:52 |
| Display contrast | 135 |
| Display backlight ctrl | - |
| Panel access level | USER |
| PC access level | CONF |
| Tested by | AK |
| Calibration date | 2009-12-7 |
| Change password | 0 |

Figure 3-1 Device info

The scaling of the current transformer is set to 500/5 A and the ratio of residual current transformer is 50/5 on all examples in this guide. The used voltage measurement mode is “U0” in relay. This measurement mode makes possible the directional earth fault protection. The Figure 3-2 shows the used scaling settings and modes on examples in this guide.

| SCALING | |
|---------------------------|-----------|
| CT primary | 500 A |
| CT secondary | 5 A |
| Nominal input | 5 A |
| | |
| Rated voltage | 11000 V |
| | |
| Io1 CT primary | 50 A |
| Io1 CT secondary | 5.0 A |
| Nominal Io1 input | 1.0 A |
| | |
| VTo secondary | 100.000 V |
| Voltage meas. mode | Uo |
| Frequency adaptation mode | Auto |

Figure 3-2 The scaling settings

Disturbance recorder setting example is shown in figure 3-3. In the other things the recordable channels, sample rate and recording length can be chosen from here.

| DISTURBANCE RECORDER | |
|----------------------|-------------------------------------|
| Dist. rec. version | 1.2 |
| | |
| RECORDER CHANNELS | |
| Ch | IL1,IL2,IL3,Io1,Uo,DI,DO |
| Add recorder channel | - |
| Remove all channels | - |
| | |
| Recording mode | Overflow |
| Sample rate | 1/10ms |
| Recording length | 10.00 s |
| Pre trig time | 50 % |
| Event enabling | <input checked="" type="checkbox"/> |
| Maximum time setting | 55.64 s |

Figure 3-3 Disturbance recorder settings

Protection stages can be connected on or off by using “Valid protection stage” menu (left figure below). The common change of the setting group can be done there. Detailed settings of the protection stages are defined using its own protection stage menu. The status of all protection stages are seen from “Protection stage status” menu (right figure below). From there is seen the used setting group of the protection stage.

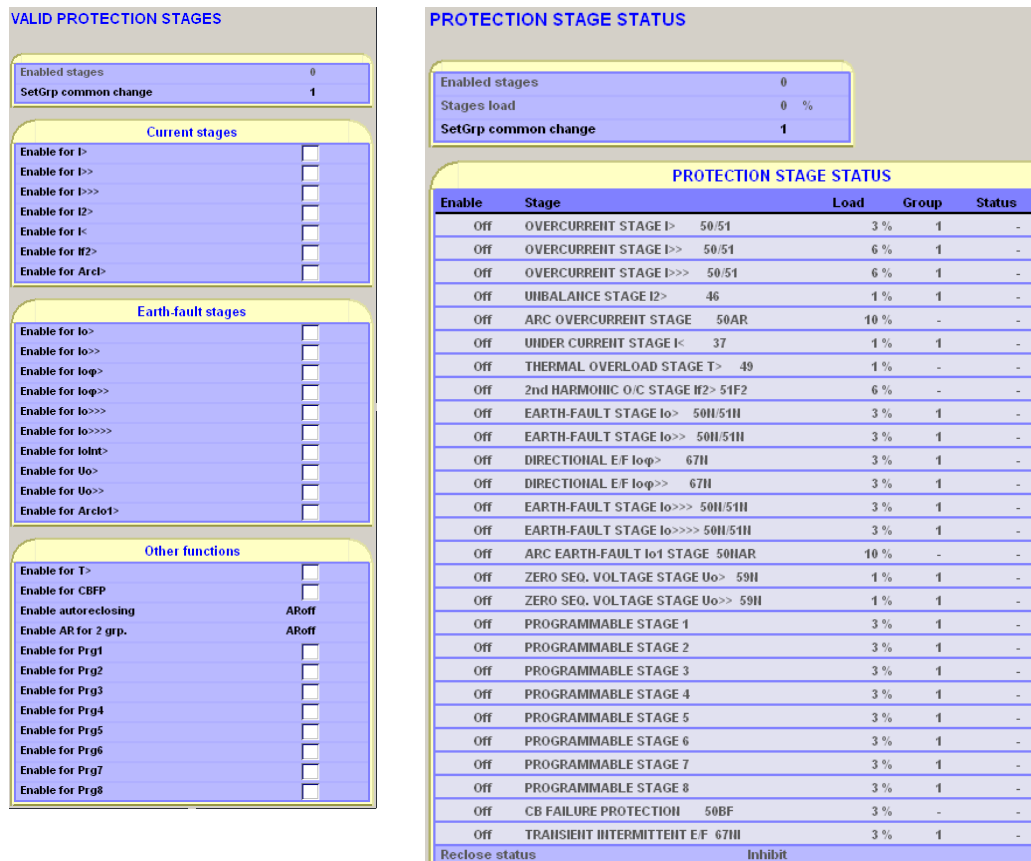


Figure 3-4 The valid protection stages and protection stage status

The wanted operations can be connected to start or to trip of the some functions via “output matrix” menu (figure 3-5). The breaker status leads on simulator display are connected to the trip output relay “T1” of Vamp 52. Then the trip output relay “T1” must be connected to the trip signal of the used protection stages that on simulator display is seen when some protection stage trips (breaker is opened = red led is on).

Figure 3-5 shows the output matrix connection example. The trip of output relay has connected to trip of I> -stage. Then the led on simulator panel which indicates the breaker status ignites when I> -stage trips. Led “LA” is connected to ignite when I> -stage starts and led “LB” is connected to ignite when I> -stage trips. Also the disturbance decoder starts when I> -stage trips.

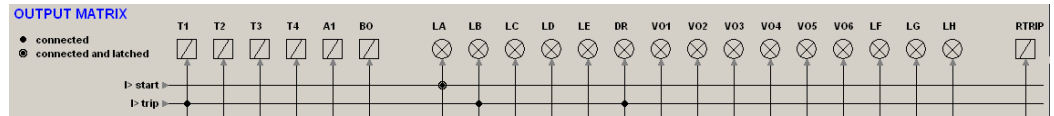


Figure 3-5 Output matrix

Digital inputs "DI1" and "DI2" can be used for many different purposes. For example digital inputs can be used releasing latches (figure 3-6 digital inputs "DI2" is used). Then for example the latched leds on relay display or trip output relays can be released by switching digital input 2 on from the pane of the simulator. The DI status switch on simulator panel must be then "from switches" position (figure 3-7).

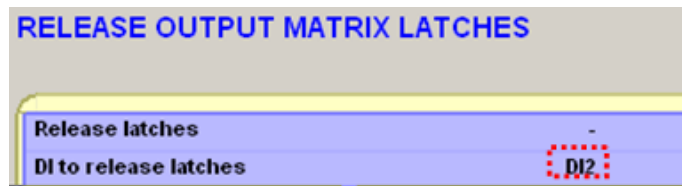


Figure 3-6 Release output matrix latches

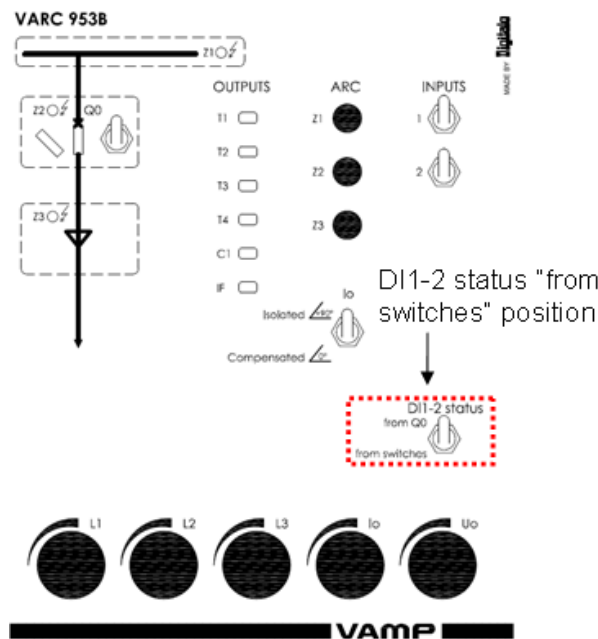


Figure 3-7 DI1-2 status position

The fault logs and counters can be cleared from "Protection stage status 2" menu, see figure 3-8. When "clear" is chosen this changes must to write to relay by bushing "Write changes to device" -button on Vampset that the changes take effect.

| PROTECTION STAGE STATUS 2 | |
|---------------------------|-------|
| Total # of starts | 0 |
| Total # of trips | 0 |
| Clear all S&T cntrs | Clear |
| Clear fault logs | Clear |

Figure 3-8 Fault logs and counters clearing

The relay measurements can be seen from “Measurements” menu of the Vampset (Figure 3-9).

| MEASUREMENTS | |
|-----------------------|-----------|
| Phase current IL1 | 1035 A |
| Phase current IL2 | 1023 A |
| Phase current IL3 | 1013 A |
| Io1 residual current | 0.01 A |
| Calculated Io | 53.18 A |
| Zero sequence voltage | 0.0 % |
| Frequency | 49.992 Hz |
| Adapted frequency | 50.0 Hz |

Figure 3-9 Relay measurements on vampset

Figure 3-10 shows the phasor diagram display on vampset. The phase currents are unequal in left picture and equal in right picture. From figure is seen that the phase shift is about 120 degrees between phases. The phase shift stays in the same when phase currents are adjusted.

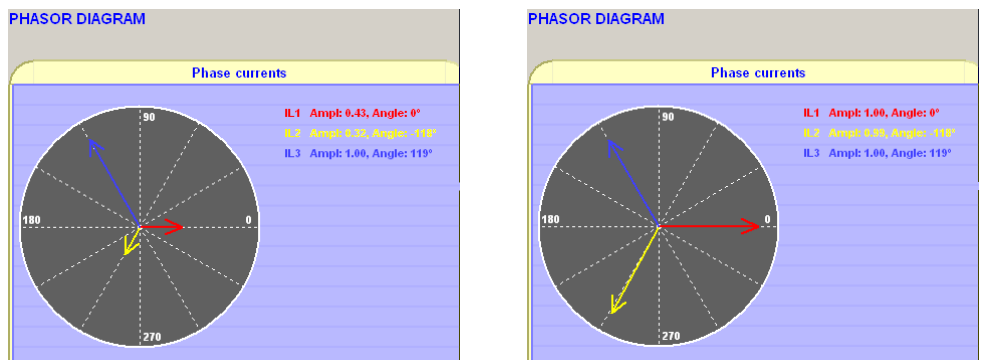


Figure 3-10 Phasor diagram

The condensed general vampset settings before the simulation:

- Relay time checking and application mode to feeder
- Transformer scaling settings
- Protection stage chosen and settings
- Matrix connections
- Disturbance recorder activation
- Settings saving to Vampset

4. The Simulation Exercises/Examples

Some simulation exercises/examples are shown in this chapter. The transformer scaling has set to 500/5 A in all examples.

4.1. Overcurrent Protection I>>> Simulations (Exercise 1)

In this chapter overcurrent protection stage I>>> is simulated. Overcurrent protection is used against short circuit faults and heavy overloads. The inverse operation time has not in this stage (I>>>). If inverse operation time is used the I>-stage must be chosen. At first I>>> overcurrent protection is chosen from “Valid protection stages” of the Vampset. This can be chosen also from its own I>>> function.

The screenshot shows two configuration panels. The top panel, titled 'VALID PROTECTION STAGES', contains a table with two rows: 'Enabled stages' with a value of 2, and 'SetGrp common change' with a value of 1. The bottom panel, titled 'Current stages', contains a table with seven rows, each with a checkbox. The 'Enable for I>>>' row has a green checkmark in its checkbox, while all other checkboxes are empty.

| VALID PROTECTION STAGES | |
|-------------------------|---|
| Enabled stages | 2 |
| SetGrp common change | 1 |

| Current stages | |
|------------------|-------------------------------------|
| Enable for I> | <input type="checkbox"/> |
| Enable for I>> | <input type="checkbox"/> |
| Enable for I>>> | <input checked="" type="checkbox"/> |
| Enable for I2> | <input type="checkbox"/> |
| Enable for I< | <input type="checkbox"/> |
| Enable for If2> | <input type="checkbox"/> |
| Enable for Arcl> | <input type="checkbox"/> |

Figure 4.1-1 Current protection stage I>>> enabling

For example following settings of the overcurrent stage I>>> can be used as in figure 4-2. Pick-up setting is set to 2,2 X In in this example and then current limit is 1100 A (transformer scaling has set to 500/5 A). Operation delay can be set to 0,1 second.

OVERCURRENT STAGE I>>> 50/51

| | |
|---|----------|
| Enable for I>>> <input checked="" type="checkbox"/> | |
| Max. of IL1 IL2 IL3 | 1006 A |
| Status | - |
| Start counter | 0 |
| Trip counter | 0 |
| Set group DI control - | |
| Group | 1 |
| Group 1 | |
| Pick-up setting | 1100 A |
| Pick-up setting | 2.20 xIn |
| Operation delay | 0.10 s |

Figure 4.1-2 The settings of the overcurrent stage I>>> on exercise 1

The output matrix settings in exercise 1 are shown in figure 4-1-3. Trip output relay “T1” and led “LB” are goes on when I>>> stage trips. The trip output relay “T3” and led “LA” goes on when I>>> stage starts (these two connections are latched). Disturbance record is programmed to start after I>>> stage starts.

OUTPUT MATRIX

| | T1 | T2 | T3 | T4 | A1 | B0 | LA | LB | LC | LD | LE | DR | V01 | V02 | V03 | V04 | V05 | V06 | LF | LG | LH | RTRIP |
|-------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------|-------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------|
| ● connected | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| ⊗ connected and latched | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| I> start | | | | | | | | | | | | | | | | | | | | | | |
| I> trip | | | | | | | | | | | | | | | | | | | | | | |
| I>> start | | | | | | | | | | | | | | | | | | | | | | |
| I>> trip | | | | | | | | | | | | | | | | | | | | | | |
| I>>> start | | | | | | | | | | | | | | | | | | | | | | |
| I>>> trip | | | | | | | | | | | | | | | | | | | | | | |

Figure 4.1-3 The output matrix settings on exercise 1

After these settings L1 phase current (for example) is increased until relay trips. DI1-2 status switch must be in “from Q0” position that the breaker position can be recorded to disturbance decoding.

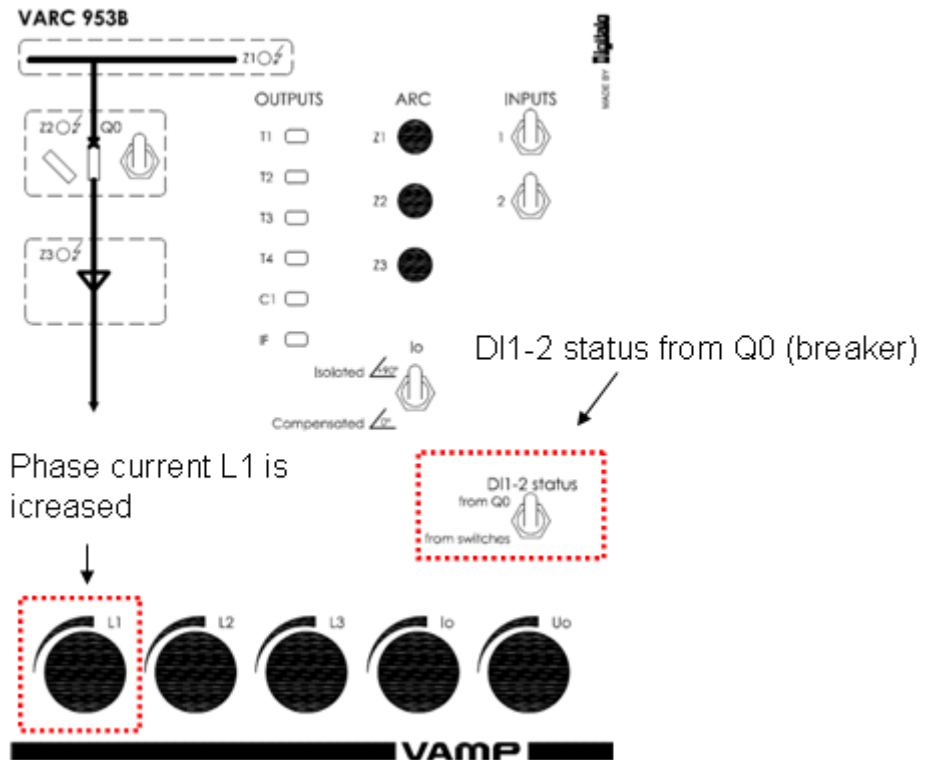


Figure 4.1-4 Current increasing on exercise 1

Figure 4.1-5 shows the overcurrent protection ($I >>>$) fault log on exercise 1. In the other things the date, fault type and fault currents is seen from fault log. Two faults are recorded to fault log in figure. Phase current L1 is increased to over set limit on fault log 1 and phase currents L1 and L2 are increased to over set limit on fault log 2.

| FAULT LOG | | | | | | | |
|-----------|------------|--------------|-------|------------|---------------|---------------|-------------------|
| | Date | hh:mm:ss.ms | Group | Fault type | Fault current | Elapsed delay | Pre-fault current |
| [1] | 2010-02-18 | 08:02:45.587 | 1 | 1-11 | 2.40 xIn | 100 % | 1.61 xIn |
| [2] | 2010-02-18 | 08:01:45.077 | 1 | 1-2 | 10.52 xIn | 100 % | 1.98 xIn |

Figure 4.1-5 Overcurrent protection ($I >>>$) fault log on exercise 1

Figure 4.1-6 shows the disturbance recording on exercise 1. From figure is seen that relay trip when the current of the phase L1 goes over the set limit 1100 A. The maximum current of phase L1 is 1174,4 A. The digital inputs DI1 and 2 are shown the breaker position. When the value of the DI1 is 1 breaker is closed and when the value of the DI2 is 1 breaker is open. It is seen from disturbance record that trip output relay “T3” and led “LA” changes to 1 values when relay starts. The trip output relay “T1” and led “LB” changes to 1 values when relay trip. It is seen also that the disturbance record has started when $I >>>$ stage starts.

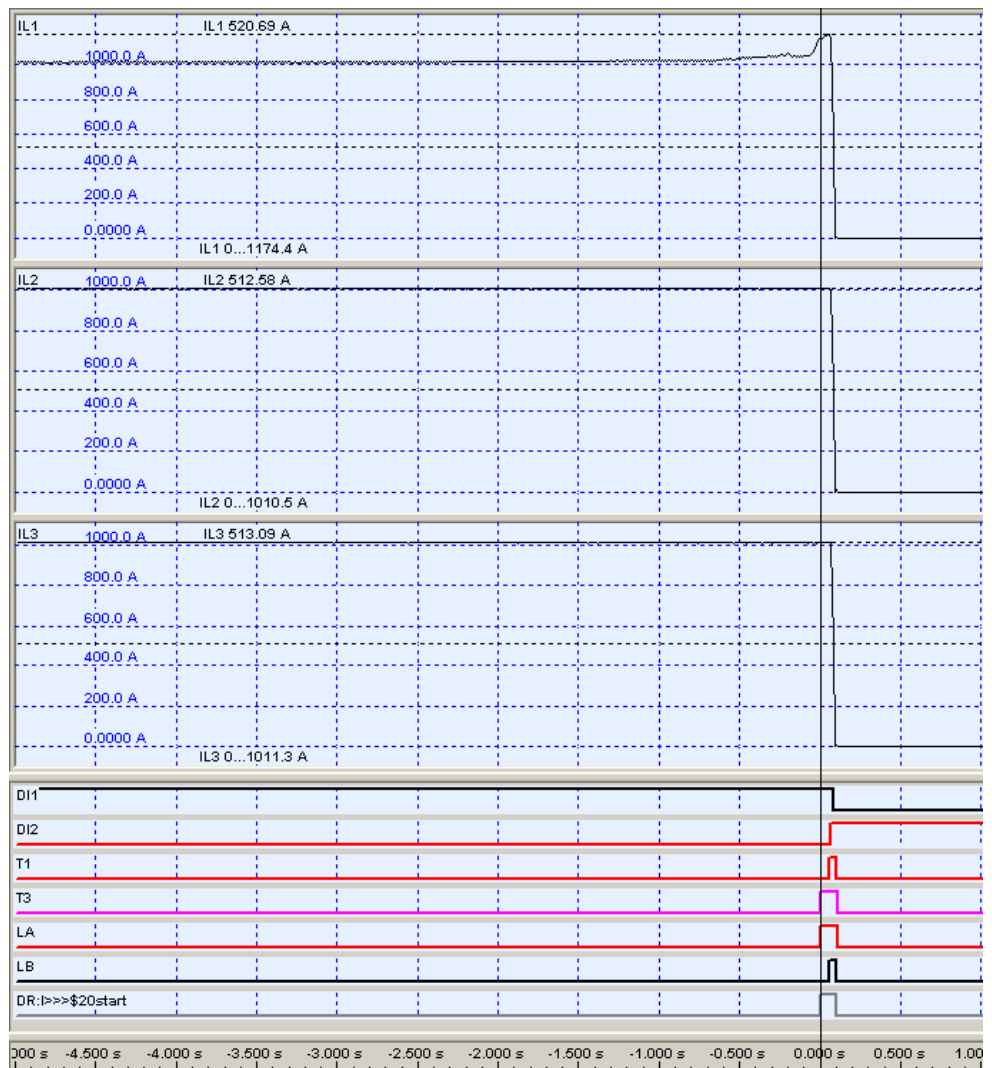


Figure 4.1-6 Disturbance recording on exercise 1

4.2. ARC Overcurrent (ArcI>) Stage Simulations (Exercise 2)

ARC overcurrent stage is simulated in this case. This function trips if both arc and overcurrent in some phases is detected at the same time (overcurrent at least as much the pick up setting). The arc sensors in zone Z1 and Z2 are connected to arc input S1 of the relay and arc sensor in zone Z3 is connected to arc input S2 of the relay. Then both arc activate buttons “Z1” and “Z2” are activated the same arc input S1 of the relay.

At first ArcI> stage is enabled and all the others stages are disabled. The settings arc overcurrent stage is shown in figure 4.2-1. The red circles are shown the settings which are changed. Pick-up setting is set to 0,5 pu in this example and it means that the phase current must be at least 250 A that arc makes relay to trip (scaling on Vampset $500/5 \rightarrow 500 \times 0,5 =$

250 A) In practise the current limit depends on the properties of the measure transformers and then current limit is not exactly the calculated value. The S2 is chosen to arc input in this example, S2 or both S1/S2 could be chosen also. In simulation model the arc sensor S2 is connected to Z3 area.

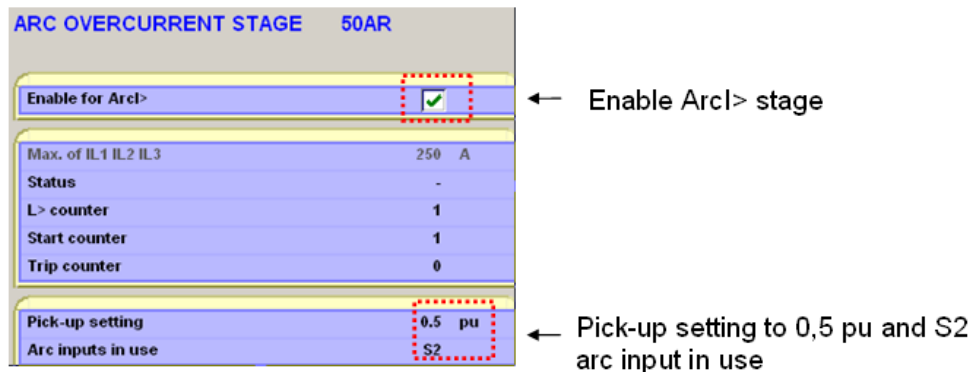


Figure 4.2-1 ARC overcurrent stage settings (Exercise 2)

Following output matrix settings were used in exercise 2. The start of the ArcI> function is connected the trip relay “T3” and led “LA” (both signal are latched in matrix). The trip of the ArcI> function is connected trip relay “T1” and led “LB”. Also the disturbance decoder is activated when ArcI> function starts.

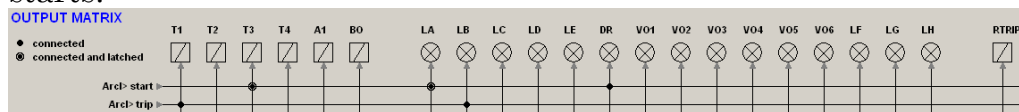


Figure 4.2-2 Output matrix settings at exercise 2

Figure 4.2-3 shows the operations on display of the simulator at case 2. At first all or one phase current is increased more than pick-up setting. The phase current must increased at least to 250 A in this example. Then ARC putton “Z3” is pressed (this buttom activates the arc input channel). Simultaneous arc and over current makes the relay trips.

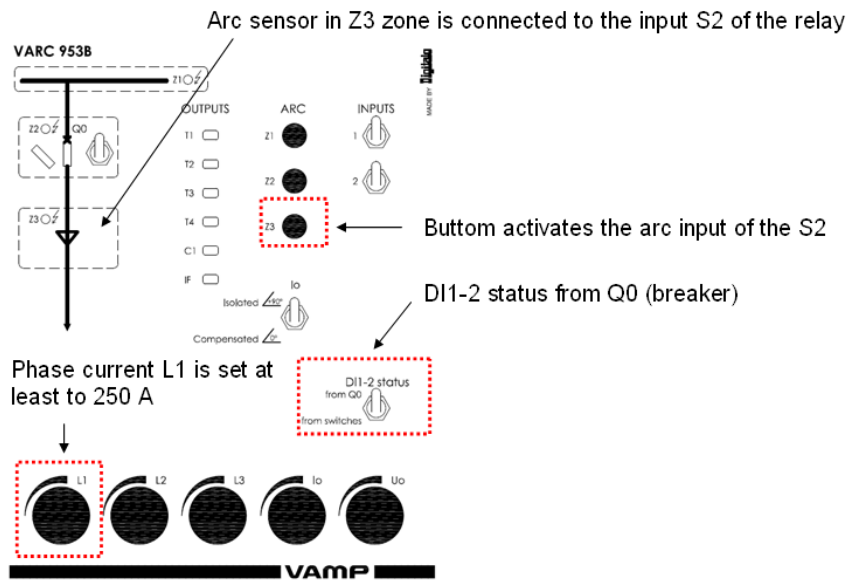


Figure 4.2-3 Simulator operations on exercise 2

Figure 4.2-4 shows the disturbance recording on exercise 2. From figure is seen that the arc overcurrent stage makes the relay trip when the current in some phase is over the set limit and arc input starts in the same time. The digital inputs DI1 and 2 are shown the breaker position. When the value of the DI1 is 1 breaker is closed and when the value of the DI2 is 1 breaker is open. It is seen from disturbance decord that trip output relay “T3” and led “LA” signals are changed to 1 values when ArcI> -function starts. The trip output relay “T1” and led “LB” signals are changed to 1 values when ArcI> -function trips.

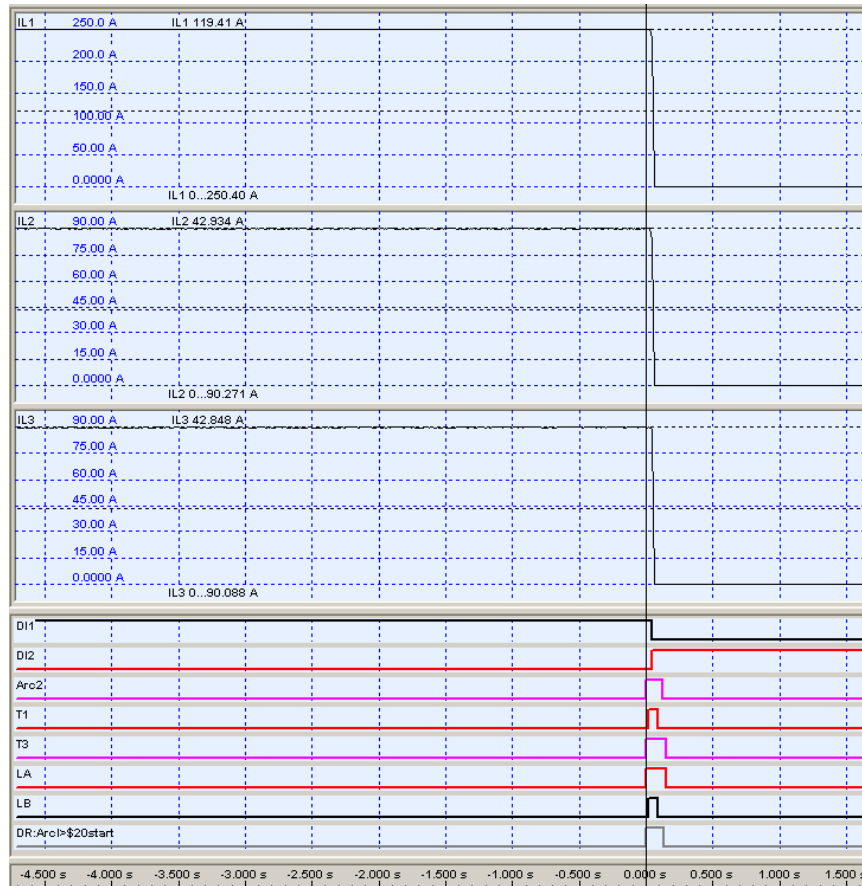


Figure 4.2-4 Disturbance recording on exercise 2

4.3. Unbalance Stage I2> Simulations (Exercise 3)

The unbalance stage (I2>) protection is simulated in this case. The purpose is to detect unbalanced load conditions, for example a broken conductor of a heavy loaded overhead line in case there is no earth fault.

In figure below is shown the used settings in this example. Pick-up setting K2 is set to 10 % and operation delay is set to minimum 1 second. The details of the “K2” are explained on Technical description of VAMP 50 manual.

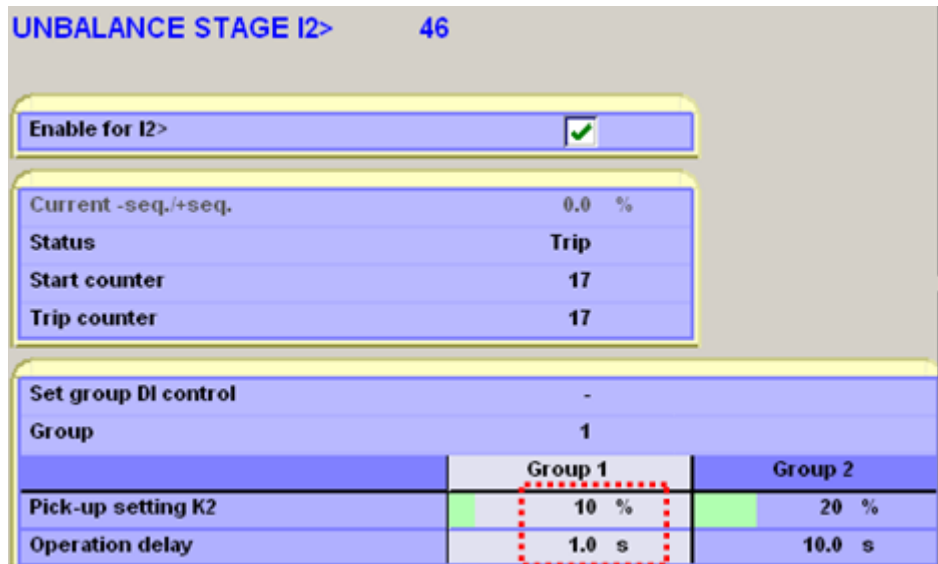


Figure 4.3-1 ARC overcurrent stage settings on Exercise 3

Figure 4.3-2 shows the output matrix settings on exercise 3. The output relay “T1” and led “LB” are activated when I2> -stage trips and the output relay ”T3” and led “LA” are activated when I2> -stage starts. Disturbance decoder activates when I2> starts.

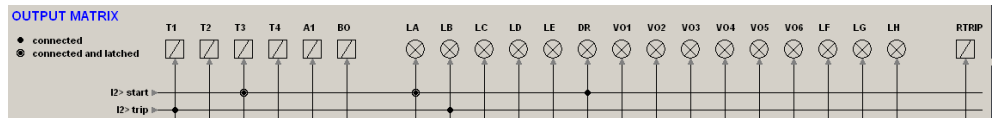


Figure 4.3-2 Output matrix settings on Exercise 3

Figure 4.3-3 shows the operations on display of the simulator on exercise 3. Unbalance stage detects unbalanced load conditions. The relay trips when unbalance between phase currents has more than settings.

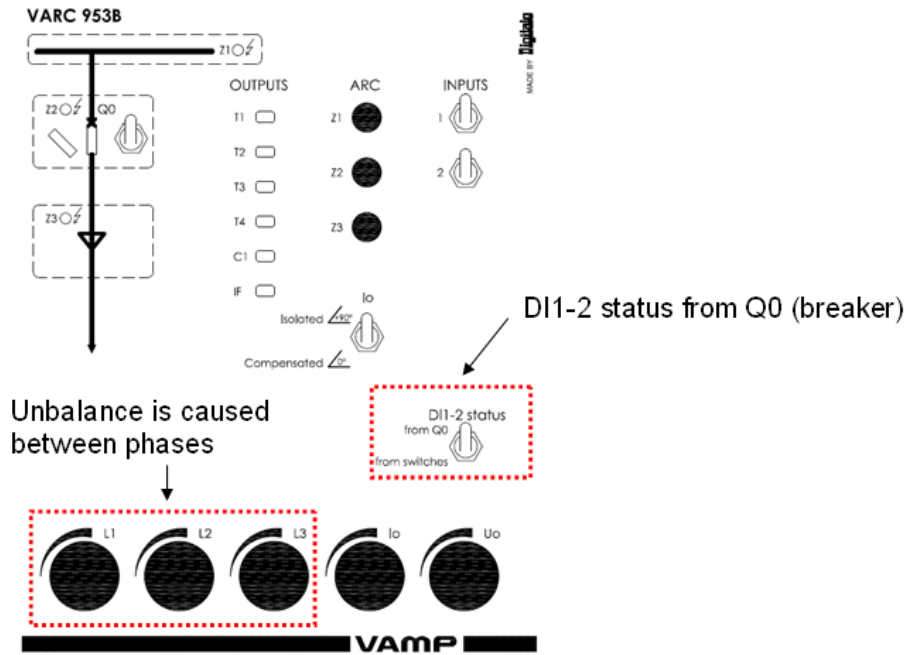


Figure 4.3-3 Simulator operations on exercise 3

Figure below shows the unbalance stage (I2>) fault log on exercise 3. In this example the phase current L1 was decreased until unbalance was more than the set limit 10 %. From figure is seen that unbalance was 11 % before trip.

| FAULT LOG | | | | | |
|-----------|------------|--------------|-------|---------------|---------------|
| | Date | hh:mm:ss.ms | Group | Fault current | Elapsed delay |
| [1] | 2010-02-18 | 12:09:48.358 | 1 | 11 % | 100 % |

Figure 4.3-4 Unbalance stage (I2>) fault log on exercise 3

Figure 4.3-5 shows the disturbance record in exercise 3. The phase current (L1) is decreased until unbalance function trips. From figure is seen that the breaker is opened (DI2 goes to 1) after 0,8 seconds when I2> function starts (led A). The operation delay was set to one second.

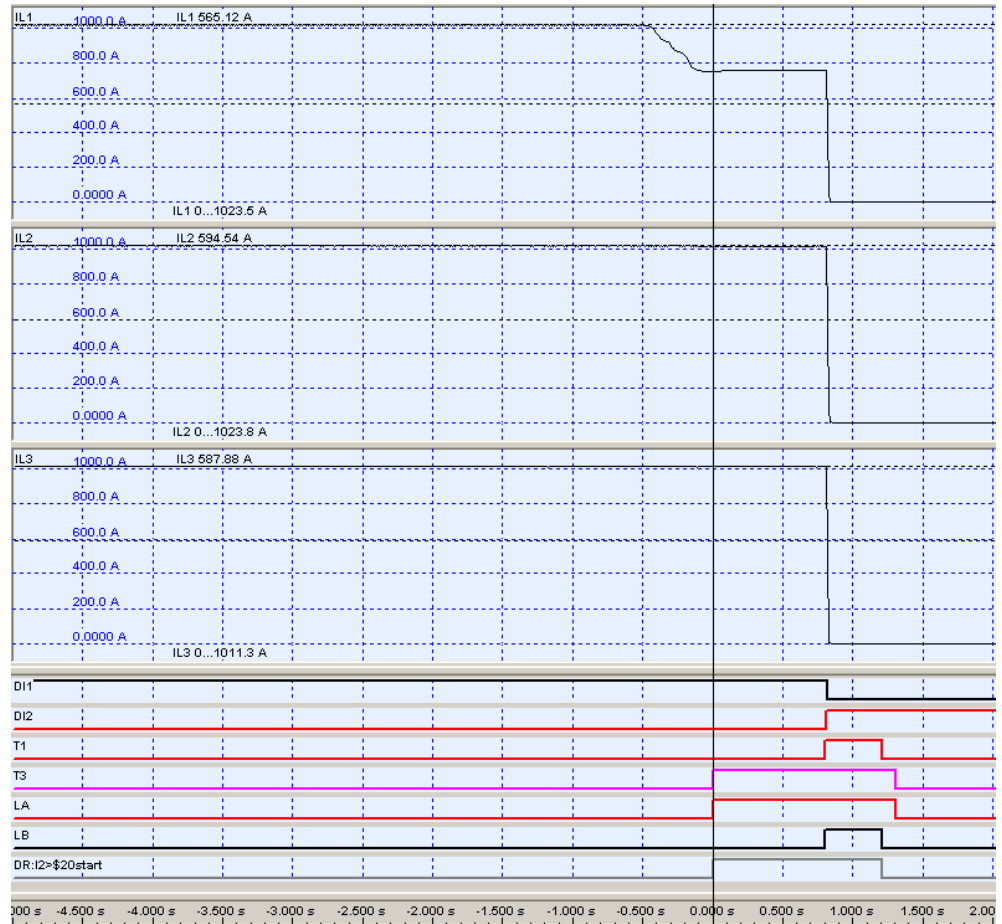


Figure 4.3-5 Disturbance recording on exercise 3

4.4. Directional Earth Fault Protection I0Φ> -Stage Simulations (Exercise 4)

It is possible to use two different network models in the simulator. The compensated or neutral isolated network can be used. Both network models are used in this exercise when earth fault protection is simulated. At first the compensated network situation has simulated and after that the network has changed to neutral isolated. Earth fault situation can be simulated by adjusting the zero sequence voltage and the residual current.

4.4.1. Earth Fault and Compensated Network (Exercise 4.1)

In this exercise is simulated earth fault protection when the network is compensated. Then “Res” mode must be selected. The figure 4.4..1-1 shows the used settings in this case. All the others protections stages are not in use. Zero sequence voltage

limit is set to 5 % and the residual current limit to 0,2 pu (10 A) and the operation delay is one second.

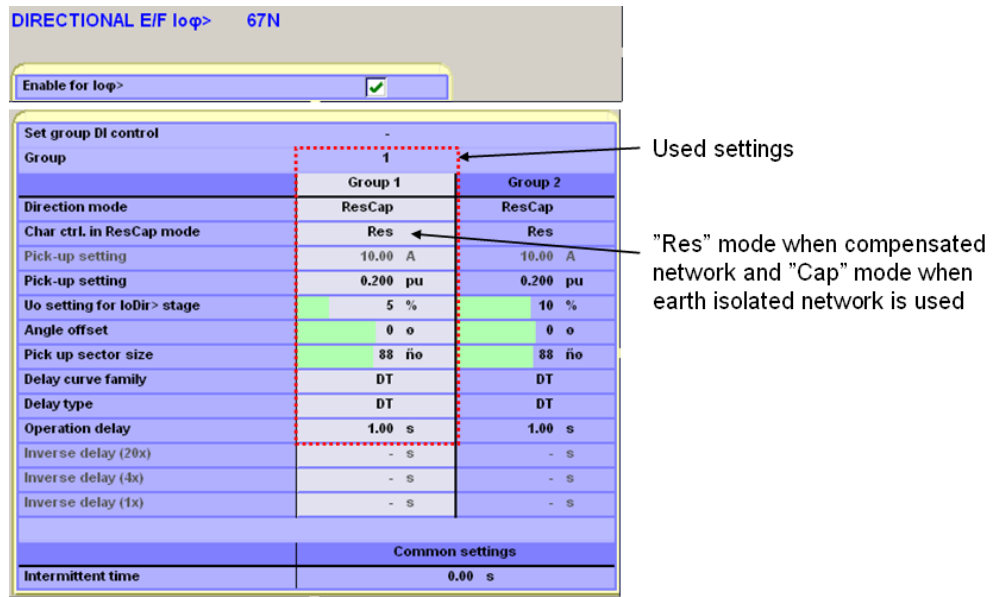


Figure 4.4.1-1 . Directional earth fault protection I0Φ> -stage settings when compensated network

Figure 4.4.1-2 shows the output matrix settings on exercise 4. The output relay “T1” and led “LB” are activated when I0Φ> -stage trips and the out put relay ”T3” and led “LA” are activated when I0Φ> -stage starts (latched). Disturbance decoder activates when I0Φ> -stage starts.

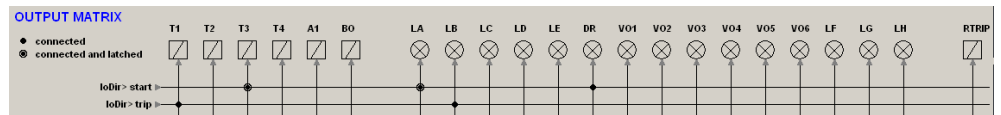


Figure 4.4.1-2 The output matrix settings on exercise 4.1 when network is compensated

Figure 4.4.1-3 shows the operations of the simulator on exercise 4.1. Zero sequence voltage and the residual current are increased to over set limits.

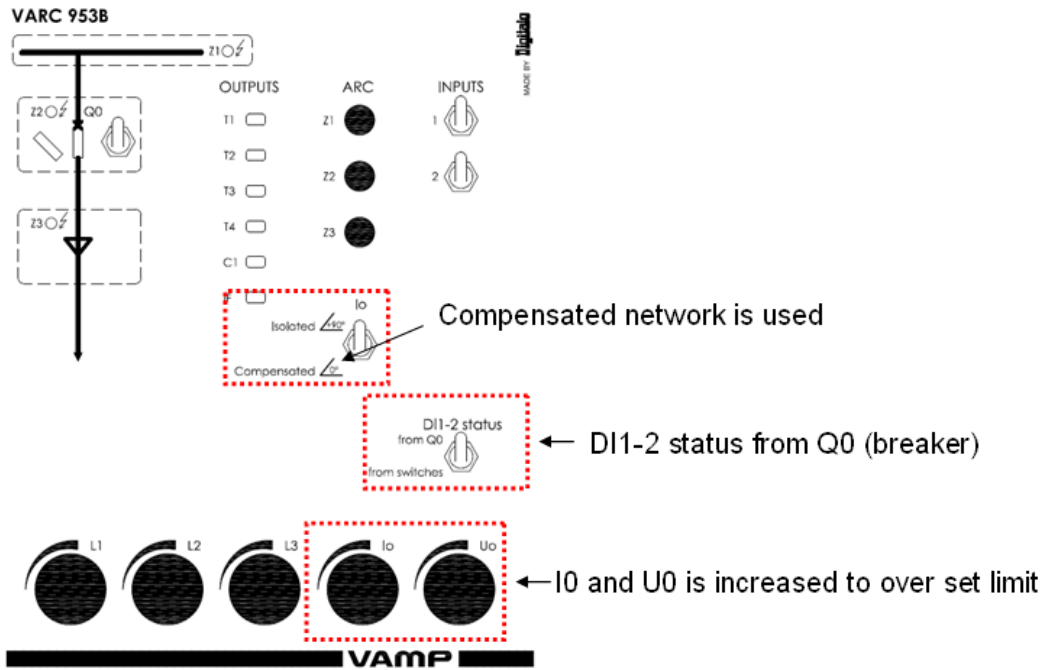


Figure 4.4.1-3 Simulator operations on exercise 4.1 when network is compensated

Figure below shows fault log on exercise 4.1. From fault log is seen that both residual current and zero sequence voltage are gone over set limit.

| FAULT LOG | | | | | | | |
|-----------|-------------|--------------|---------------|-------------|---------------|---------------|-------|
| Date | hh:mm:ss.ms | Group | Fault current | Fault angle | Fault voltage | Elapsed delay | |
| [1] | 2010-02-18 | 13:49:34.818 | 1 | 0.35 pu | -4 ° | 6.7 % | 100 % |

Figure 4.4.1-4 Directional earth fault protection ($I0\Phi>$) fault log on exercise 4.1

Figure 4.4.1-5 shows the disturbance record in exercise 4.1. The both $I0$ and $U0$ are increased to over setting limits on simulator. It is seen from figure that both values $I0$ and $U0$ must exceed the setting limits before the directional overcurrent stage trips. The zero sequence voltage is over set limit in all time but function trips only when residual current increase over set limit also. From figure is seen that the fuction starts when residual current increases over set limit and the trip comes after the set delay (1 second).

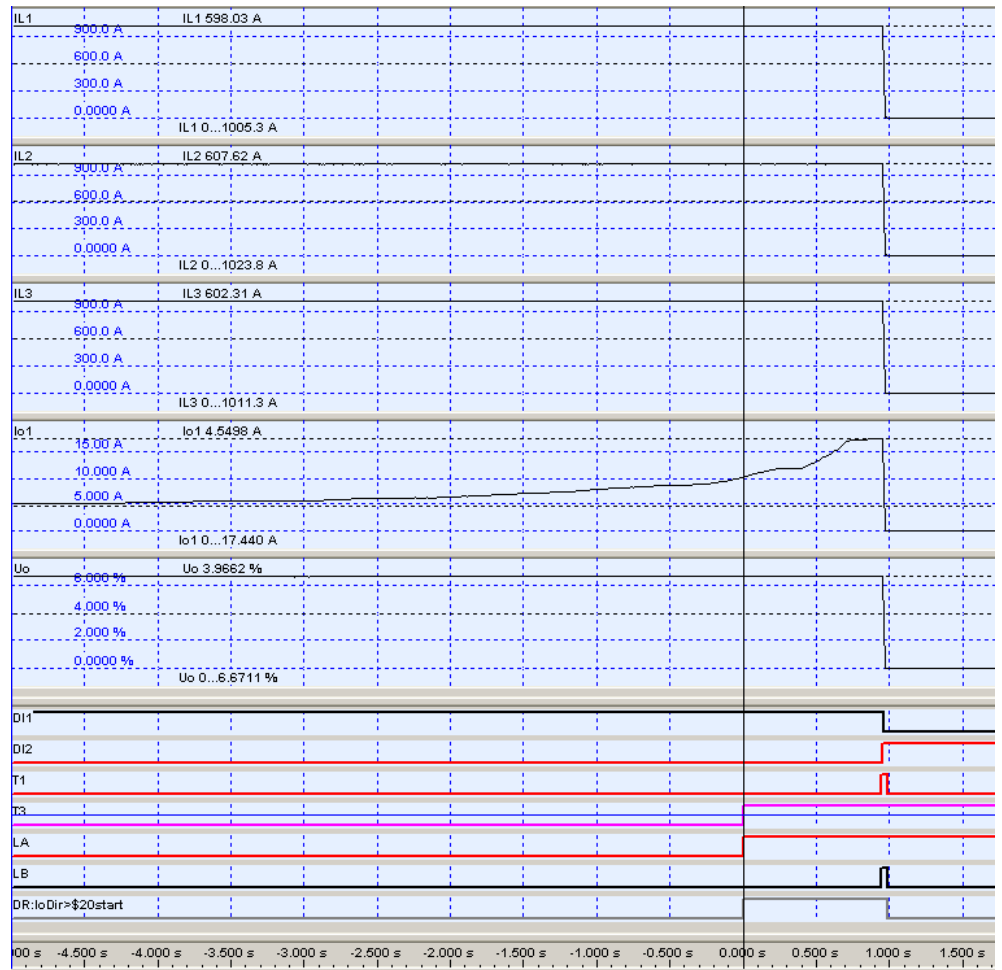


Figure 4.4.1-5 Disturbance recording on exercise 4.1 when network is compensated

4.4.2. Neutral Isolated network and earth fault (Exercise 4.2)

The network is changed to neutral isolated in simulator. Then “Cap” mode must be selected on I0Φ> -stage of the Vampset. The other settings are same than in previous exercise 4.1. The Matrix settings of the relay can be kept the same than in the previous exercise.

DIRECTIONAL E/F I0Φ> 67N

Enable for I0Φ>

| Set group DI control | | |
|-----------------------------|----------|----------|
| Group | 1 | |
| | Group 1 | Group 2 |
| Direction mode | ResCap | ResCap |
| Char ctrl. in ResCap mode | Cap | Res |
| Pick-up setting | 10.00 A | 10.00 A |
| Pick-up setting | 0.200 pu | 0.200 pu |
| U0 setting for I0Dir> stage | 5 % | 10 % |
| Angle offset | 0 o | 0 o |
| Pick up sector size | 88 no | 88 no |
| Delay curve family | DT | DT |
| Delay type | DT | DT |
| Operation delay | 1.00 s | 1.00 s |
| Inverse delay (20x) | - s | - s |
| Inverse delay (4x) | - s | - s |
| Inverse delay (1x) | - s | - s |
| Common settings | | |
| Intermittent time | 0.00 s | |

Mode is changed to "Cap"

Figure 4.4.2-1 Directional earth fault protection I0Φ> -stage settings when compensated network

The network is changed to neutral isolated in simulator (the changing switch is shown in the figure 4.4.2-2). Then I0 and U0 are increased until relay trips. After that the network can be changed back to compensated in simulator and now the I0Φ> -stage should not to trip if I0 and U0 are increased a little bit over the set limit because the I0Φ> -stage setting of the Vampset is in "Cap" mode.

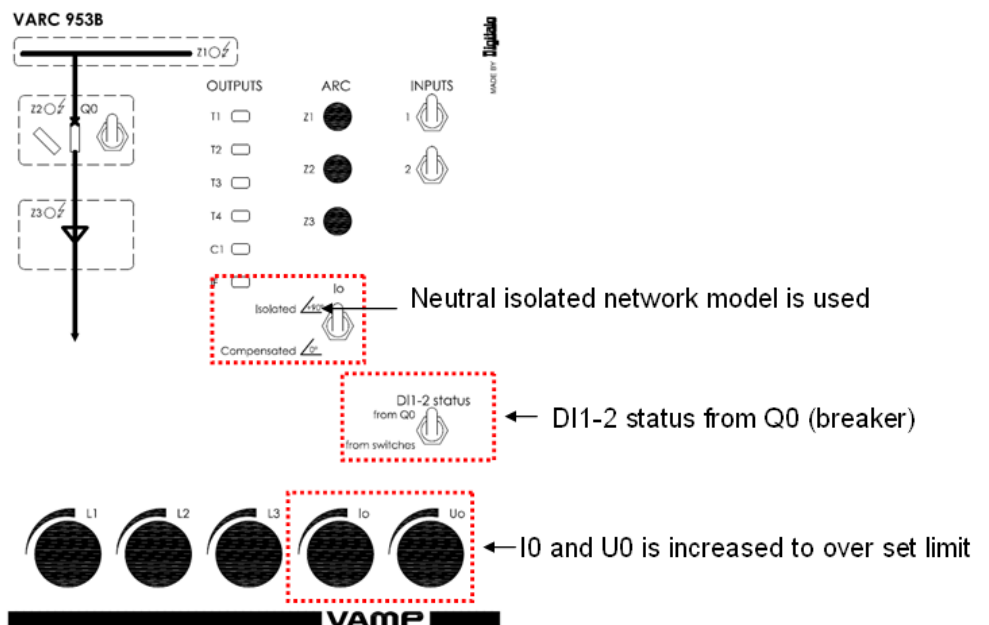


Figure 4.4.2-2 Simulator operations on exercise 4.2 when network is neutral isolated

Figure 4.4.2-3 shows the fault log of earth fault protection function. Fault current has been 0,48 pu, fault voltage 6,7 % and fault angle has been 82 degrees before trip.

| FAULT LOG | | | | | | | |
|-----------|------------|--------------|-------|---------------|-------------|---------------|---------------|
| [1] | Date | hh:mm:ss.ms | Group | Fault current | Fault angle | Fault voltage | Elapsed delay |
| [1] | 2010-02-19 | 09:22:09.458 | 1 | 0.48 pu | 82 o | 6.7 % | 100 % |

Figure 4.4.2-3 Directional earth fault protection ($I0\Phi>$) fault log on exercise 4.2

The disturbance record (figure 4.4.2-4) shows that $I0\Phi>$ - function trips when $I0$ and $U0$ are increased over the set limits (T3 and led LB changes from 0 to 1). The zero sequence voltage is increased to over set limit at first and then residual current is increased until relay trips.

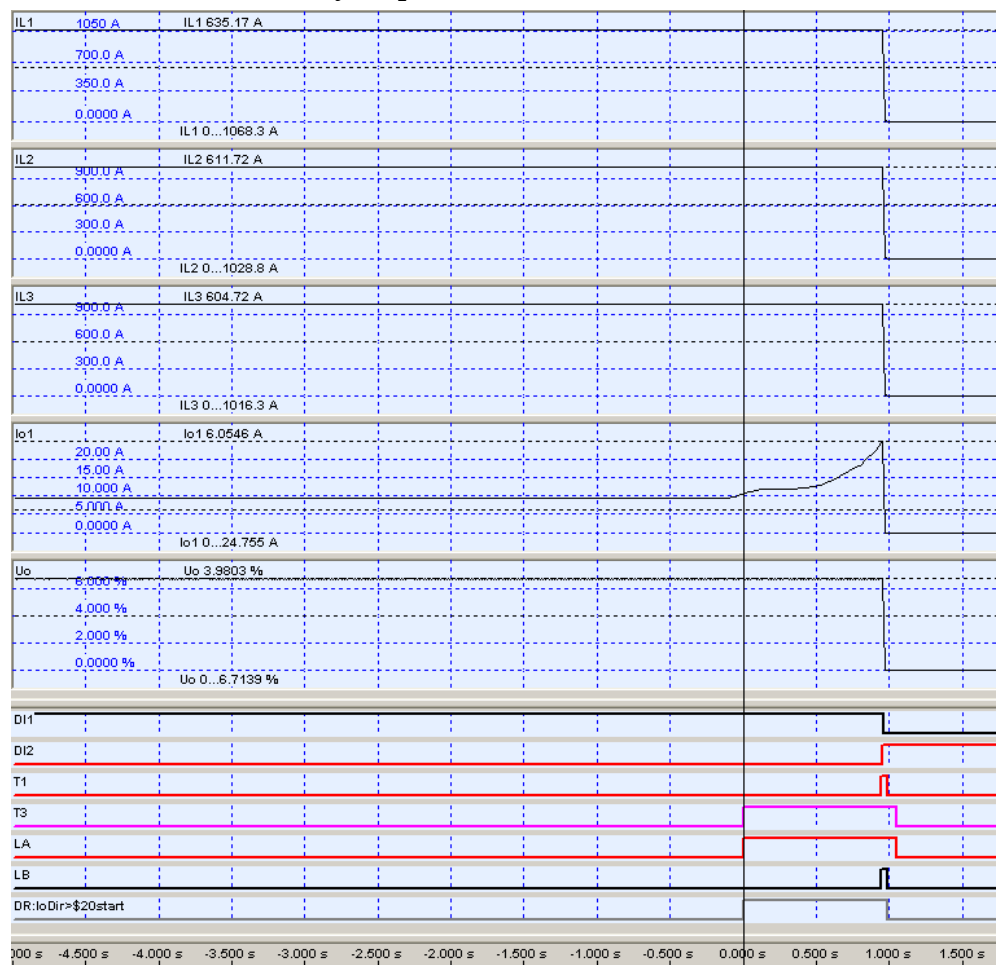


Figure 4.4.2-4 Disturbance recording on exercise 4.2 when network is earth isolated

4.5. Auto-Reclosing Simulations (Exercise 5)

Two auto-reclosing simulations are done in this exercise. At first case the auto-reclosing is activated when directional earth fault protection trips and overcurrent protection I>>> stage activates the auto-reclosing function in second case.

4.5.1. Auto-Reclosing Activates When Directional Earth Fault Protection (I0Φ>) Trips

At first the auto-reclosing must be activated from “Valid protection stages” (figure 4.5.1-1) or from it own function (Auto reclosing, figure 4.5.1-2).

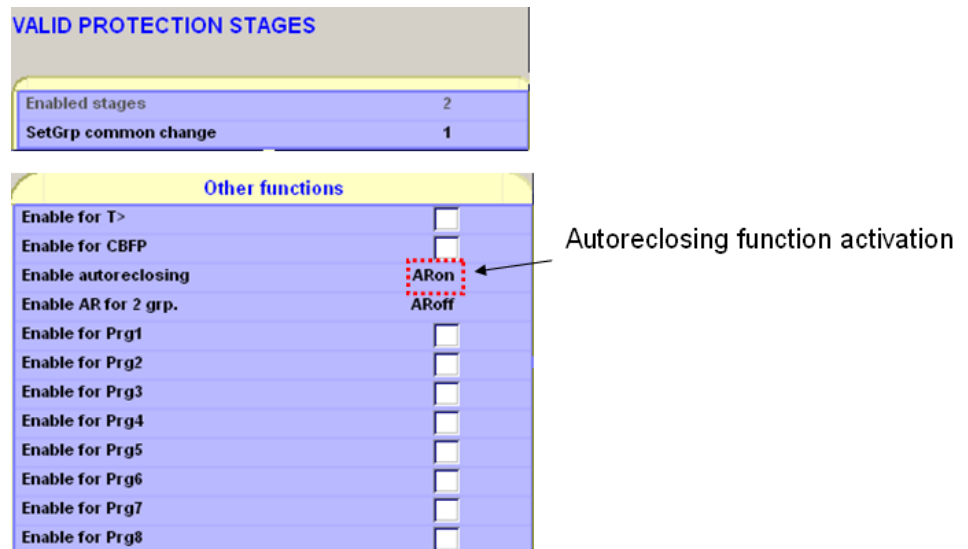


Figure 4.5.1-1 Autoreclosing activation

| AUTO RECLOSING 79 | |
|--------------------------------|-------------------------------------|
| Enable autoreclosing | ARon |
| DI for ARon/ARoff | - |
| Enable AR for 2 grp. | ARoff |
| Breaker object in use | - |
| Breaker 1 object | - |
| Breaker 2 object | - |
| Input for selecting CB2 | - |
| Reclose status | Locked |
| AR shot number | EID |
| Reclaim time | 5.00 s |
| Block by external synchrocheck | - |
| AR info for mimic display | <input checked="" type="checkbox"/> |
| Clear counters | - |

Figure 4.5.1-2 Auto reclosing function

The autoreclosing setting menu is shown in figure 4.5.1-3. The shots 1, 2 and 3 of the AR 1 are activated in this example. Then reclosing is tried three times before the final trip. The dead time is set to 0,3 seconds in shot 1 and to 60 seconds in shots 2 and 3. Reclaim time is varied. If the reclaim time is varied between the shots the cross must be under “Use shot specific reclaim time”. If the cross has not the reclaim time is same to all shots (in this example it would be then five seconds).

AR Shot settings 79

Use shot specific reclaim time

Reclaim time 5.00 s

Shot 1

| Enable | AR | ExtSync | Start delay | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-------------|-----------|---------------------|--------------|
| On | 1 | - | 0.02 s | 0.30 s | 0.02 s | 5.00 s |
| Off | 2 | - | 0.02 s | 0.30 s | 0.02 s | 5.00 s |
| Off | 3 | - | 0.02 s | 0.30 s | 0.02 s | 5.00 s |
| Off | 4 | - | 0.02 s | 0.30 s | 0.02 s | 5.00 s |

Shot 2

| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-----------|---------------------|--------------|
| On | 1 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 2 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 3 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 4 | - | 60.00 s | 0.02 s | 20.00 s |

Shot 3

| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-----------|---------------------|--------------|
| On | 1 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 2 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 3 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 4 | - | 60.00 s | 0.02 s | 20.00 s |

Shot 4

| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-----------|---------------------|--------------|
| Off | 1 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 2 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 3 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 4 | - | 5.00 s | 0.02 s | 10.00 s |

Shot 5

| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-----------|---------------------|--------------|
| Off | 1 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 2 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 3 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 4 | - | 5.00 s | 0.02 s | 10.00 s |

Figure 4.5.1-3 AR shot settings on exercise 5.1

Figure 4.5.1-4 shows one connection example on auto-reclosing matrix. In the figure the auto-reclosing function is connected to activate when directional earth fault protection –stage (IODir>) trips. The relay trip or start of any stages can be used to auto-reclosing function activation.

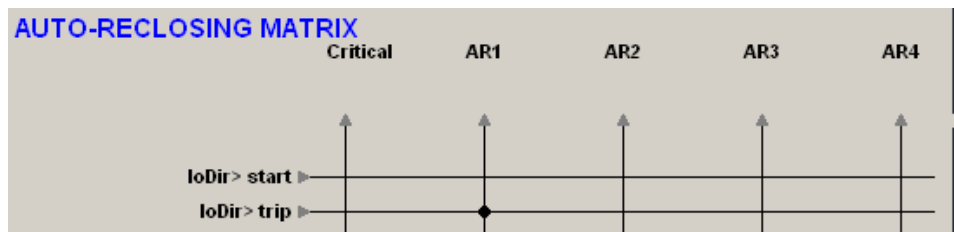


Figure 4.5.1-4 Auto-reclosing matrix connection examples on exercise 5.1

The position of the breaker must connect to the output relays in output matrix. Then the relay recognizes the breaker position and auto-reclosing function can operate.

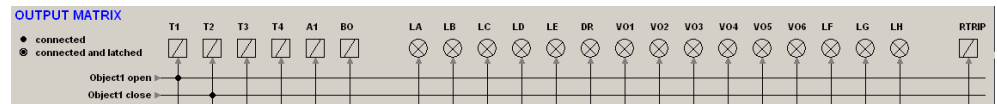


Figure 4.5.1-5 The output matrix settings on exercise 5.1

The directional earth fault protection ($I0\Phi>$) function is activated and same settings are used as in exercise 4.2. The used network is neutral isolated in simulator. Then zero sequence voltage and residual current are increase to over set limits. When directional earth fault protection trips three reclosing should be making after that should come the final trip. In figure below are shown the auto-reclosing counter display from auto-reclosing function when directional earth fault protection has tripped and it is seen that all three shots are done before final trip.

| TOTAL COUNTERS | |
|------------------|---|
| AR start counter | 3 |
| AR fail counter | 3 |

| | |
|---------------------|---|
| Shot1 start counter | 1 |
| Shot2 start counter | 1 |
| Shot3 start counter | 1 |
| Shot4 start counter | 0 |
| Shot5 start counter | 0 |

| Request from AR1 | |
|---------------------|---|
| Shot1 start counter | 1 |
| Shot2 start counter | 1 |
| Shot3 start counter | 1 |
| Shot4 start counter | 0 |
| Shot5 start counter | 0 |

Figure 4.5.1-6 Auto-reclosing counter

4.5.2. Auto-Reclosing Activates When Overcurrent Protection $I>>>$ Trips

First the overcurrent protection function $I>>>$ is activated and the others functions are not used. Auto-reclosing shot settings are changed as in figure 4.5.2-1. The shots 1 and 2 of the AR 1 are activated in this example. Then reclosing is tried two times before the final trip. The dead time is set to 0,3 seconds in shot 1 and to 60 seconds in shot 2.

AR Shot settings 79

Use shot specific reclaim time

Reclaim time 5.00 s

Shot 1

| Enable | AR | ExtSync | Start delay | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-------------|-----------|---------------------|--------------|
| On | 1 | - | 0.02 s | 0.30 s | 0.02 s | 5.00 s |
| Off | 2 | - | 0.02 s | 0.30 s | 0.02 s | 5.00 s |
| Off | 3 | - | 0.02 s | 0.30 s | 0.02 s | 5.00 s |
| Off | 4 | - | 0.02 s | 0.30 s | 0.02 s | 5.00 s |

Shot 2

| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-----------|---------------------|--------------|
| On | 1 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 2 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 3 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 4 | - | 60.00 s | 0.02 s | 20.00 s |

Shot 3

| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-----------|---------------------|--------------|
| Off | 1 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 2 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 3 | - | 60.00 s | 0.02 s | 20.00 s |
| Off | 4 | - | 60.00 s | 0.02 s | 20.00 s |

Shot 4

| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-----------|---------------------|--------------|
| Off | 1 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 2 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 3 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 4 | - | 5.00 s | 0.02 s | 10.00 s |

Shot 5

| Enable | AR | ExtSync | Dead time | Discrimination time | Reclaim time |
|--------|----|---------|-----------|---------------------|--------------|
| Off | 1 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 2 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 3 | - | 5.00 s | 0.02 s | 10.00 s |
| Off | 4 | - | 5.00 s | 0.02 s | 10.00 s |

Figure 4.5.2-1 AR shot settings on exercise 5.2

The autoreclosing matrix settings are changed so that auto-reclosing function activates when overcurrent protection (I>>>) trips (figure 4.5.2-2). The same output matrix settings are used than in exercise 5.1 (figure 4.5.2-3).

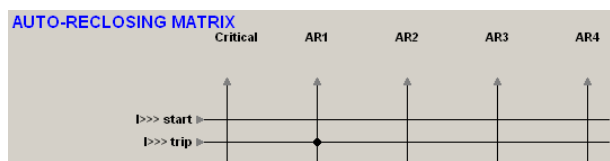


Figure 4.5.2-2 Two auto-reclosing matrix connection examples on exercise 4.5.2

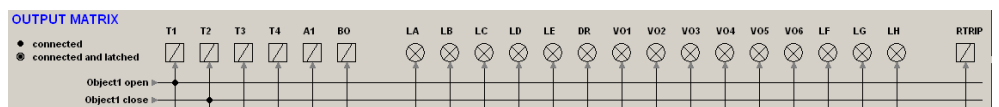


Figure 4.5.2-3 The output matrix settings on exercise 5.2

Overcurrent protection function is activated and the same settings are used than in exercise 1. After trip of the overcurrent protection the auto-reclosing should start and two reclosing should be done before the final trip.

4.6. Current Transformer Supervisor Simulating (Exercise 6)

When Current transformer supervisor function is activated the relay supervises the external wiring between the relay terminal and current transformer and in addition the function supervises the current transformer.

The current transformer supervisor function measures the phase currents. The function starts if one of the three phase currents decreases below $I_{min}<$ setting and in the same time other phase current increases over $I_{max}>$ setting. The $I_{max}>$ setting has used 300 A ($0,6 \times I_n$) and $I_{min}<$ setting has used 100 A ($0,2 \times I_n$) in this example. The operation delay is set to three seconds. The settings are shown in figure 4.6-1. It is seen from figure that ct supervisor function has started when the setting limits are exceeded.

| CT SUPERVISOR | |
|-------------------------|-------------------------------------|
| Enable for CT alarm | <input checked="" type="checkbox"/> |
| CT supervisor status | Start |
| Max. of IL1 IL2 IL3 | 343 A |
| Min. of IL1 IL2 IL3 | 85 A |
| $I_{max}>$ setting | 300 A |
| $I_{min}<$ setting | 100 A |
| $I_{max}>$ setting | 0.60 $\times I_n$ |
| $I_{min}<$ setting | 0.20 $\times I_n$ |
| Operation delay | 3.00 s |
| CT supervisor event on | <input checked="" type="checkbox"/> |
| CT supervisor event off | <input checked="" type="checkbox"/> |

Figure 4.6-1 Current transformer supervisor settings

Figure 4.6-2 shows the fault log of the ct supervisor. The start time, I_{max} and I_{min} are seen from that fault log.

| FAULT LOG | | | | |
|-----------|------------|--------------|-----------|-----------|
| | Date | hh:mm:ss.ms | I_{max} | I_{min} |
| [1] | 2010-02-10 | 12:52:34.798 | 343 A | 85 A |

Figure 4.6-2 Fault log of the current transformer supervisor

The start of the current transformer supervisor function can be set to make the relay trip by using output matrix. One example is shown in figure below. T1 trip output relay is connected to the breaker in the display of the simulator. Then the breaker goes open when ct supervisor operates.

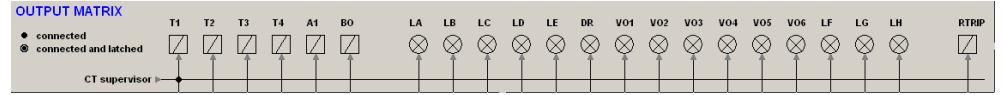


Figure 4.6-3 The output matrix settings on exercise 6



