## Application Note

## SVERKER 900

# Testing protection functions in Distributed Energy Resources (DER)

### Example of how to test common relay protection in DER with SVERKER 900

**Tests included: Pickup and Timing**

| Protection type to be tested | Protection setting |
|---|---|
| Vector shift | 6 Degree |
| ROCOF | 0,2Hz/s |
| Under voltage | 95% & 90% of 63,5V |
| Over voltage | 105% & 110% of 63,5V |
| Under frequency | 48Hz & 46Hz |
| Over frequency | 52Hz & 54Hz |

**Preparations:** Make one test in “Ramp Instrument” with settings for pickup tests, save test in one test file called pickup tests. Changes in “Stop value” and “Ramp speed” are made depending on test.

Settings for timing tests are made in “Sequence Instrument” and explained below.

(Each test must be saved separately and then opened in same instrument.)
(BI must be set for each instrument used.)

**Tests made in ramp instrument, manually changes are needed.**

| | **Pickup test files** | | |
|---|---|---|---|
| | **Ramp speed** | **Stop value** | |
| | Phase L1/L2/L3 | Phase L1/L2/L3 | |
| **Vector shift** | 0,2∆°/s | 10°/250°/130° | Leading angle |
| | -0,2∆°/s | 350°/230°/110° | Lagging angle |
| **ROCOF** | 0,21∆Hz/s | 51Hz/49Hz | Incr./Decr. |
| **ROCOF (timing)** | 0,25∆Hz/s | 51Hz/49Hz | Incr./Decr. |
| **Voltage** | 0,20∆V/s | 55V/75V | Under/Over. |
| **Frequency** | 0,20∆Hz/s | 45Hz/55Hz | Under |

**Tests made in sequence instrument.**

| | **Timing & Stability test files** | | |
|---|---|---|---|
| | **Pre fault value** | **Fault value** | |
| | Phase L1/L2/L3 | Phase L1/L2/L3 | |
| **Vector shift** | 0°/240°/120° | 10°/250°/130° | Leading angle |
| | 0°/240°/120° | 350°/240°/120° | Lagging angle |
| **Voltage** | 63,5V | 58V/55V | Under voltage |
| | 63,5V | 68V/72V | Over voltage |
| **Frequency** | 50Hz | 47Hz/45Hz | Under |

# Testing protection functions

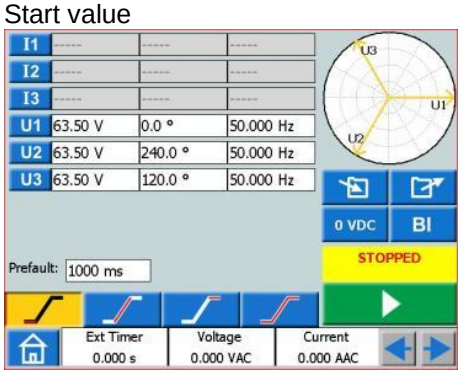
## Pickup tests

### Vector shift leading angle (3phase)

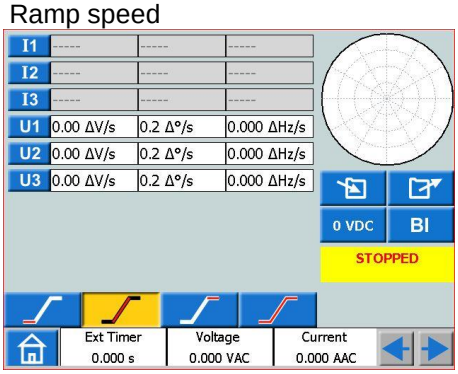
Same start value is used for all tests in “Ramping” instrument

Make one pickup test for leading angle in the ramp instrument.

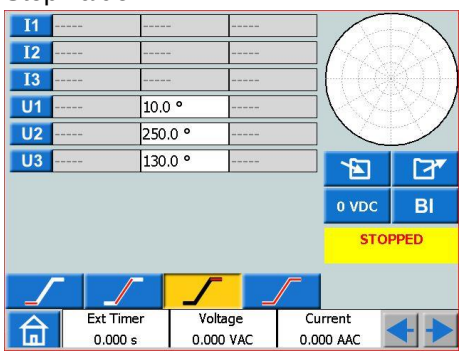
Start value



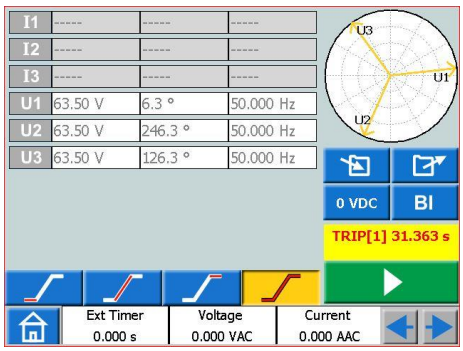

Ramp speed




Stop value



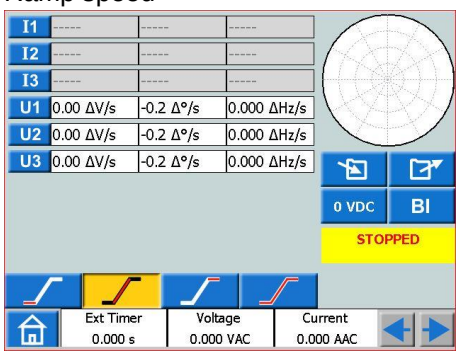

Result



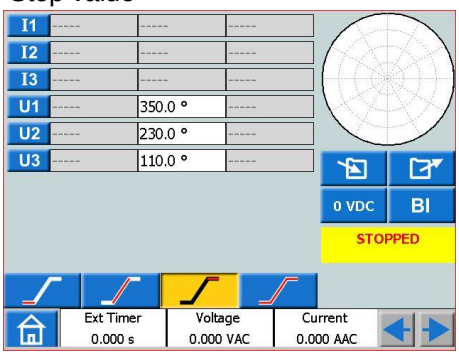

### Vector shift lagging angle

Use same test as for leading angle but change ramp speed and stop value.

Ramp speed

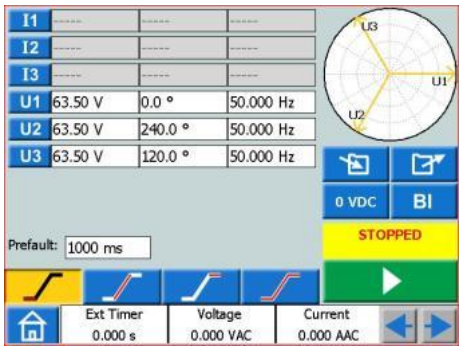



Stop value

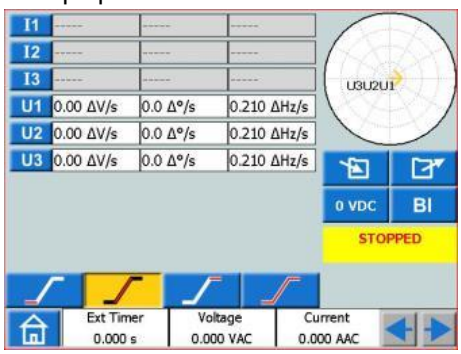


**ROCOF increasing Hz (3-phase)**
Block under voltage protection when testing ROCOF.
Make one pickup test for increasing frequency in the ramp instrument.

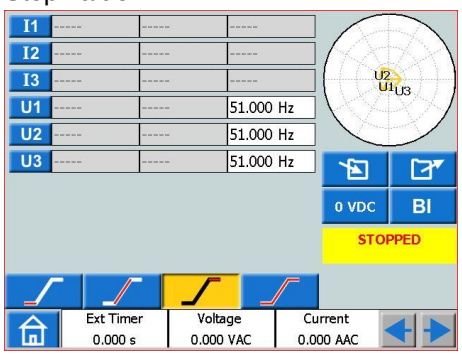
Start value



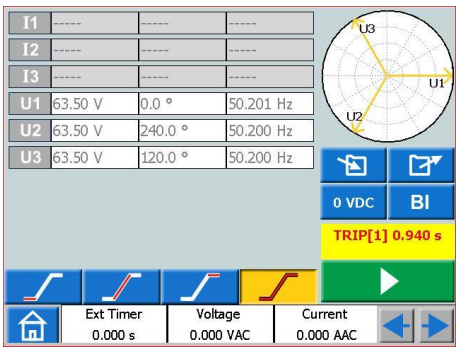

Ramp speed




Stop value

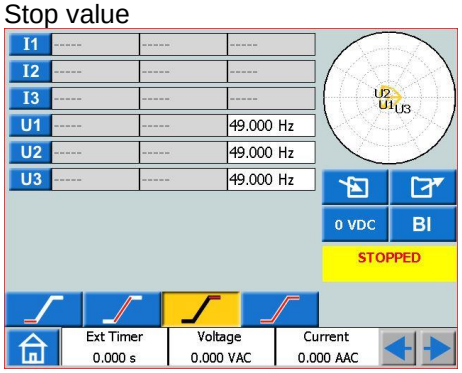



Result

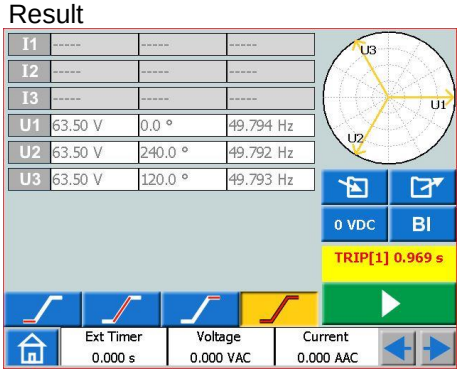



**ROCOF decreasing Hz**
Use same test for decreasing frequency but change stop value.

Stop value

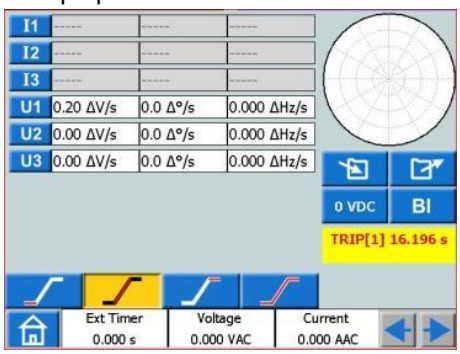



Result

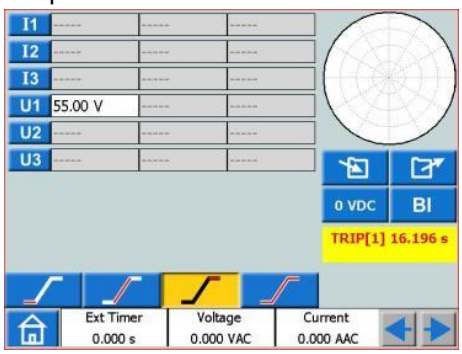


**Under voltage**
Make one pickup test for phase U1 and use same test for U2 and U3 with the same ramp speed and stop value.

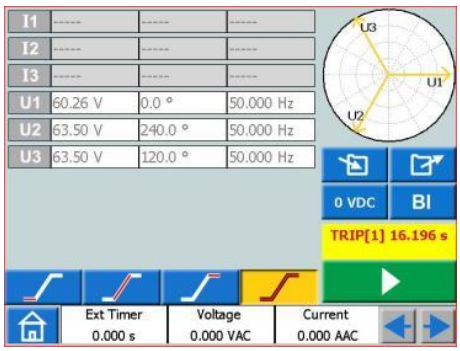
Ramp speed



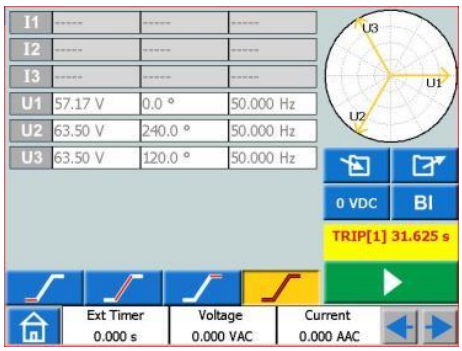

Stop value




Level 1 result



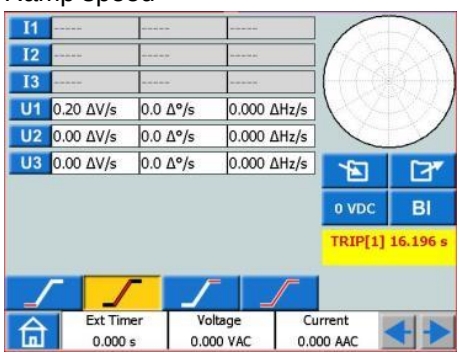

Level 2 result



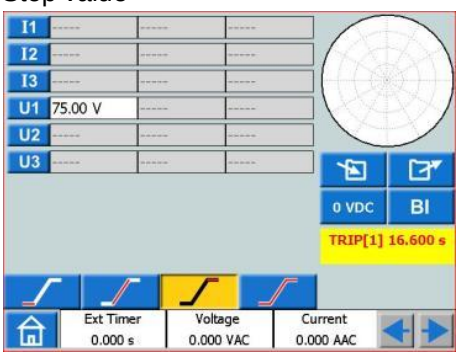

(Block level 1 in protection when checking level 2)

**Over voltage**
Use the same test as for under voltage and change stop value for phase U1, U2 and U3.

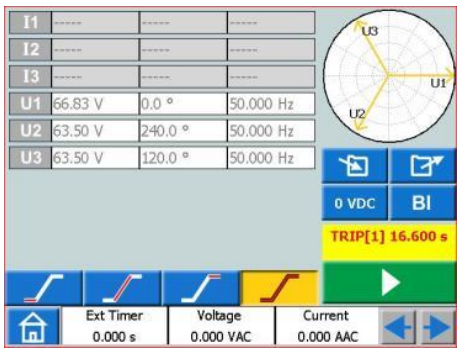
Ramp speed



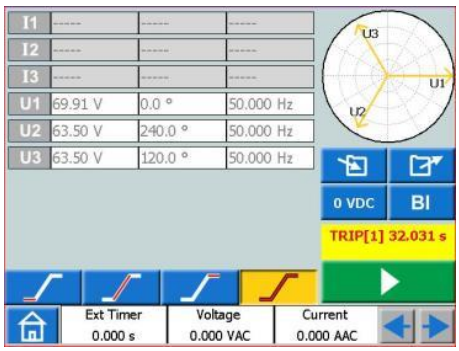

Stop value



Level 1 Result



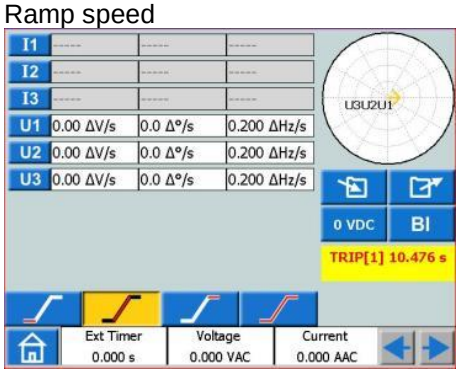

Level 2 Result



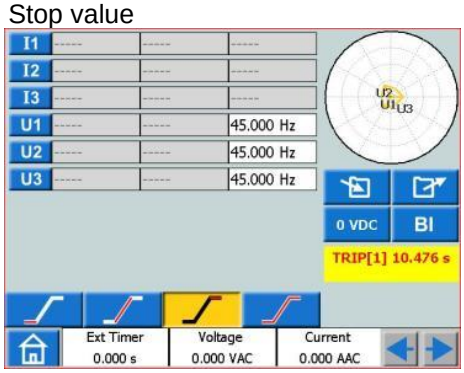

(Block level 1 in protection when checking level 2)

**Under frequency (3-phase)**
Make one pickup test.

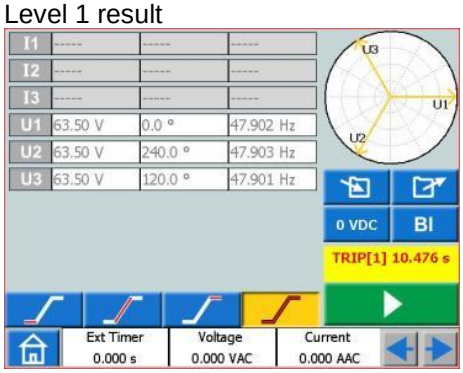
Ramp speed



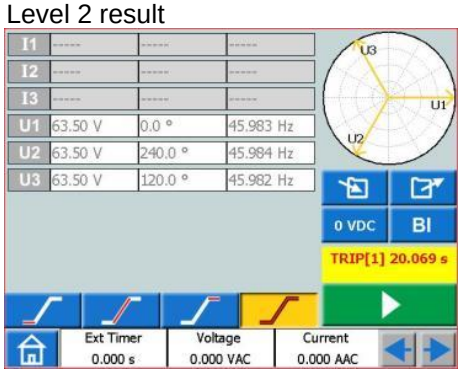

Stop value




Level 1 result



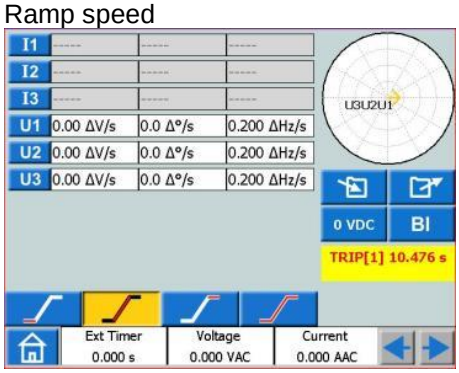

Level 2 result



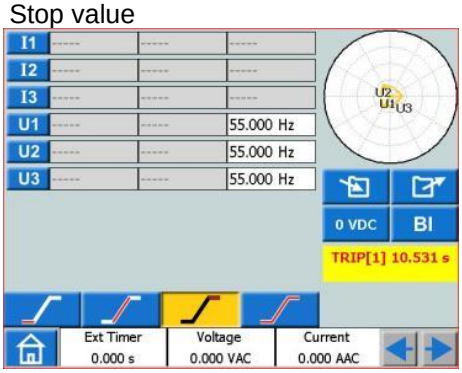

(Block level 1 in protection when checking level 2)

**Over frequency**
Use same test as for under freq. but change stop value. The ramp speed is the same.

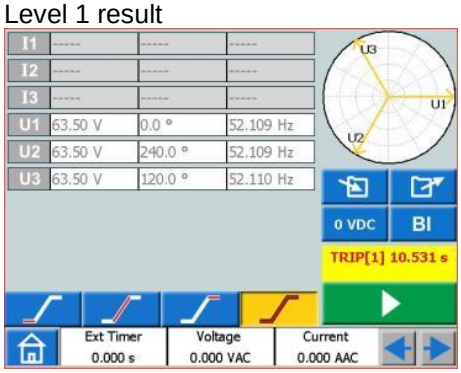
Ramp speed



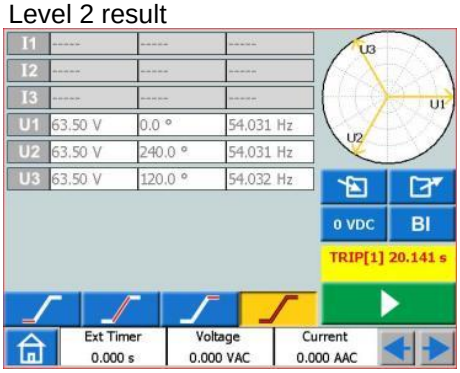

Stop value




Level 1 result




Level 2 result

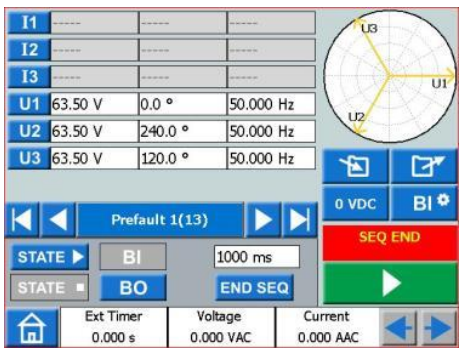



(Block level 1 in protection when checking level 2)

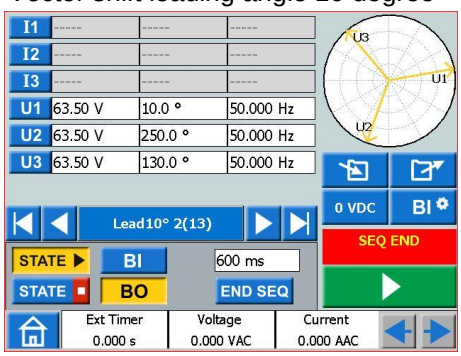
## Timing tests

Vectorshift leading angle/lagging angle (3-phase) Over/Under frequency (3-phase)
Make one time test in the sequencer instrument.

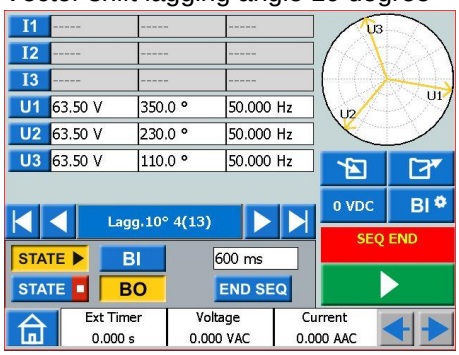
Pre-fault



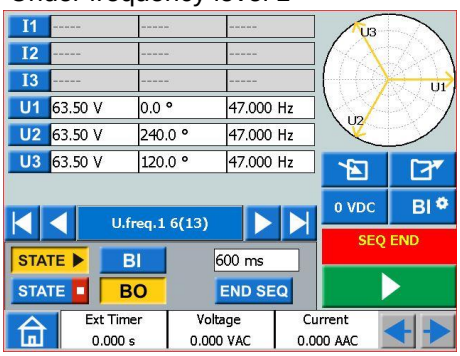

Vector shift leading angle 10 degree



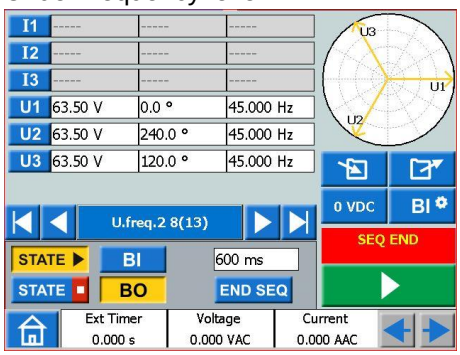
Vector shift lagging angle 10 degree



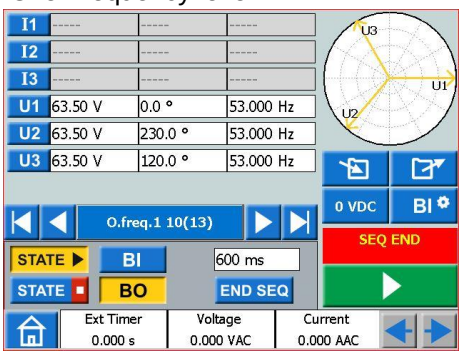

Under frequency level 1



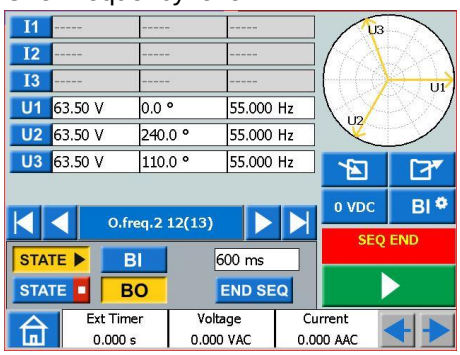

Under frequency level 2




Over frequency level 1




Over frequency level 2




Copy state 1(Pre-fault) into state 3, 5, 7, 9, 11 and 13. Set state 13 to “END SEQ”

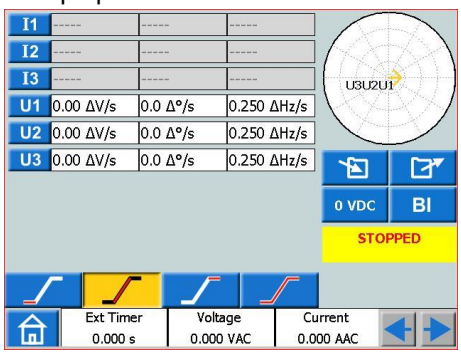
Result

| # | U1: V | ° | Hz | U2: V | ° | Hz | U3: V | ° | Hz | BI | Time... | BO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 63.50 | 0.0 | 50.0... | 63.50 | 240.0 | 50.0... | 63.50 | 120.0 | 50.0... | | 1000 | 0 |
| 2 | 63.50 | 10.0 | 50.0... | 63.50 | 250.0 | 50.0... | 63.50 | 130.0 | 50.0... | 2 | 337 | 1 |
| 3 | 63.50 | 0.0 | 50.0... | 63.50 | 240.0 | 50.0... | 63.50 | 120.0 | 50.0... | | 1000 | 0 |
| 4 | 63.50 | 350.0 | 50.0... | 63.50 | 230.0 | 50.0... | 63.50 | 110.0 | 50.0... | 2 | 329 | 1 |
| 5 | 63.50 | 0.0 | 50.0... | 63.50 | 240.0 | 50.0... | 63.50 | 120.0 | 50.0... | | 1000 | 0 |
| 6 | 63.50 | 0.0 | 47.0... | 63.50 | 240.0 | 47.0... | 63.50 | 120.0 | 47.0... | 1 | 504 | 1 |
| 7 | 63.50 | 0.0 | 50.0... | 63.50 | 240.0 | 50.0... | 63.50 | 120.0 | 50.0... | | 1000 | 0 |
| 8 | 63.50 | 0.0 | 45.0... | 63.50 | 240.0 | 45.0... | 63.50 | 120.0 | 45.0... | 1 | 110 | 1 |
| 9 | 63.50 | 0.0 | 50.0... | 63.50 | 240.0 | 50.0... | 63.50 | 120.0 | 50.0... | | 1000 | 0 |
| 10 | 63.50 | 0.0 | 53.0... | 63.50 | 230.0 | 53.0... | 63.50 | 120.0 | 53.0... | 1 | 529 | 1 |
| 11 | 63.50 | 0.0 | 50.0... | 63.50 | 240.0 | 50.0... | 63.50 | 120.0 | 50.0... | | 1000 | 0 |
| 12 | 63.50 | 0.0 | 55.0... | 63.50 | 240.0 | 55.0... | 63.50 | 110.0 | 55.0... | 1 | 124 | 1 |

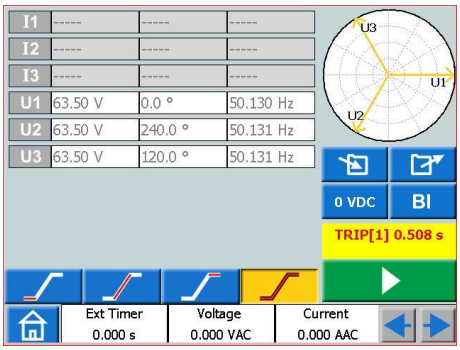
### ROCOF increasing Hz

Use same test as in pickup tests and change ramp speed.

Ramp speed



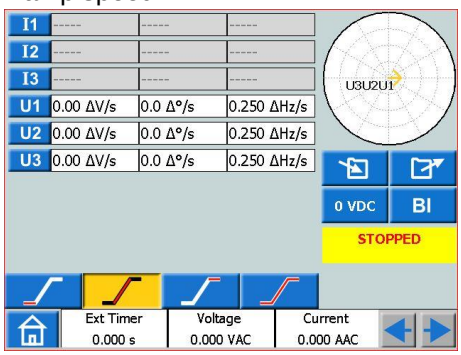

Result



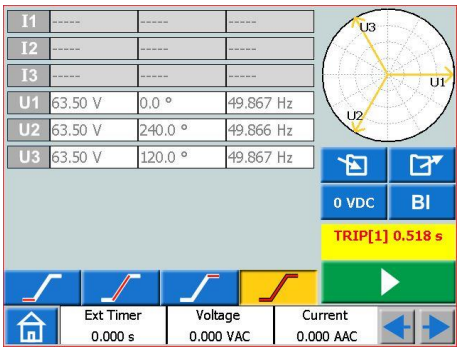

### ROCOF decreasing Hz

Use same test as for increasing and change stop value to same as pick up test.

Ramp speed



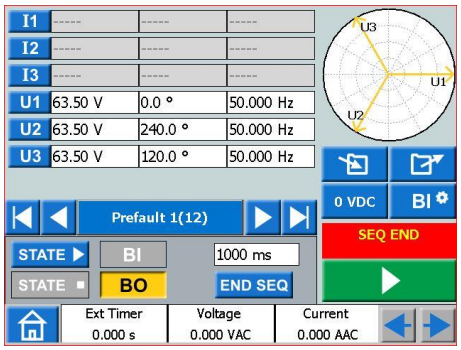

Result



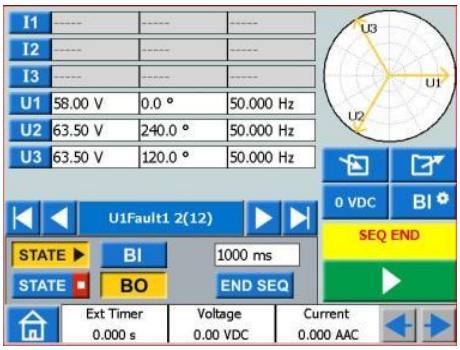

### Under voltage

Make the time test in the sequencer instrument.

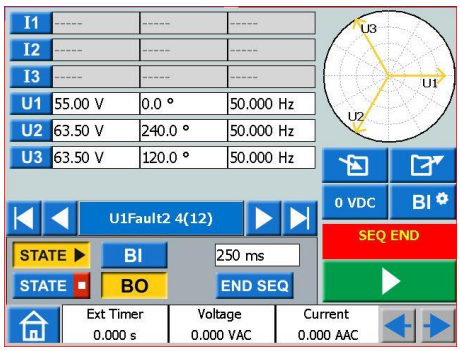
Pre-fault




Level 1



Level 2

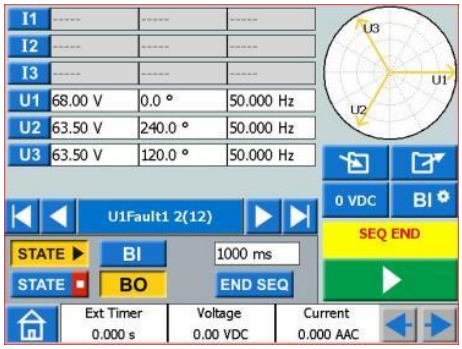



Copy state 1 into state 3, 5, 7, 9 and 11 (pre-fault)
Copy state 2 into state 6 and 10 change to phase U2
Copy state 4 into state 8 and 12 change to phase U3

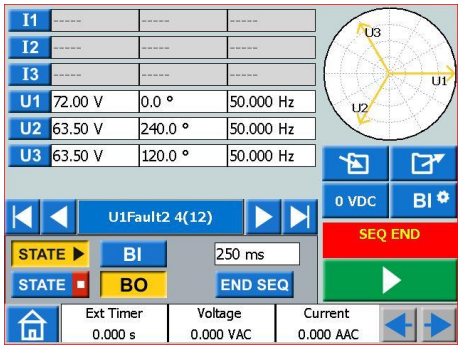
**Over voltage**

Use the same sequence as in under voltage but change voltage level.

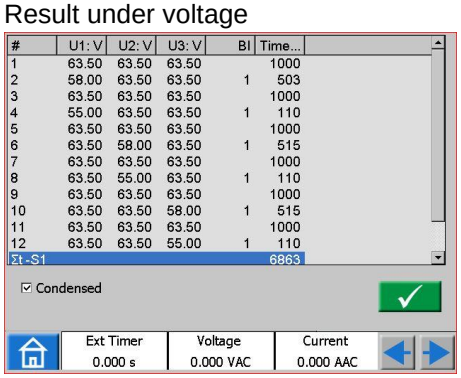
Level 1




Level 2




Result under voltage




Result over voltage