

Relay testing with LPIT101 and SVERKER 900 – Over-current and residual over-voltage in an ABB REF615

1. Introduction and purpose

This application note provides guidance on how to use the SVERKER 900 relay test set and the LPIT101 accessory to test protection relays connected to Low Power Instrument Transformers (LPITs).



Test case and functions

The example device under test is an ABB REF615 relay. Specifically, an overcurrent protection function is tested using a simulated Rogowski coil, and a residual overvoltage function is tested using a simulated capacitive voltage divider.

Why LPITs need different approach

LPITs differ from conventional current transformers (CTs) and voltage transformers (VTs) by using alternative technologies that do not rely on iron cores. Instead, they utilise capacitive or resistive voltage dividers for voltage measurement, and either proportional or derivative LPCTs (Low Power Current Transformers) for current measurement. This note and the LPIT101, focuses on LPVTs and derivative LPCTs, specifically Rogowski coils.

Key characteristics of Rogowski coils outputs

Rogowski coils generate a secondary voltage proportional to the derivative of the primary current, which introduces a 90° phase shift and frequency dependence. This imposes strict accuracy requirements on any device simulating Rogowski outputs.

What LPIT101 and SVERKER900 provide

How the LPIT101 is designed to accurately replicate these signals. Together with the SVERKER 900, it enables efficient and precise relay testing by performing all required calculations and conversions internally.

Relay testing with LPIT101

2. Reading the relay LPIT data

Begin by reading the relay settings to determine the type of LPIT sensors to simulate. In this case:

- The relay expects Rogowski coils for current measurement, with a nominal primary current of 80 A and a rated secondary voltage of 3 mV/Hz

Group / Parameter Name	IED Value	PC Value	Unit
✓ Current (3I,CT)(Current (3I,CT)): 1			
✓ Current (3I,CT)			
✓ Primary current	80,0	80,0	A
✓ Amplitude corr. A	1,000	1,000	
✓ Amplitude corr. B	1,000	1,000	
✓ Amplitude corr. C	1,000	1,000	
✓ Nominal Current	80	80	A
✓ Rated Secondary Value	3,000	3,000	mV/Hz
✓ Reverse polarity	False	False	

- For voltage measurement, the relay uses a capacitive voltage divider (CVD) with a division ratio of 10 000:1 and a nominal primary voltage of 20 000 V

Group / Parameter Name	IED Value	PC Value	Unit
✓ Voltage (3U,VT)(Voltage (3U,VT)): 1			
✓ Voltage (3U,VT)			
✓ Primary voltage	20,000	20,000	kV
✓ Secondary voltage	100	100	V
✓ VT connection	Wye	Wye	
✓ Amplitude corr. A	1,000	1,000	
✓ Amplitude corr. B	1,000	1,000	
✓ Amplitude corr. C	1,000	1,000	
✓ Division ratio	10000	10000	
✓ Voltage input type	CVD sensor	CVD sensor	

Relay testing with LPIT101

3. Connections

Mount the LPIT101 on the front panel of the SVERKER 900. It fits in only one orientation. Connect the ground lead to the ground terminal on the SVERKER.

Select the correct Ethernet cables for connection:

- Use the red leads if the relay's RJ45 ports are outlined in red
- Use the black leads if there is no red marking
- For relays with Twin-BNC terminals, use the optional Twin-BNC cables

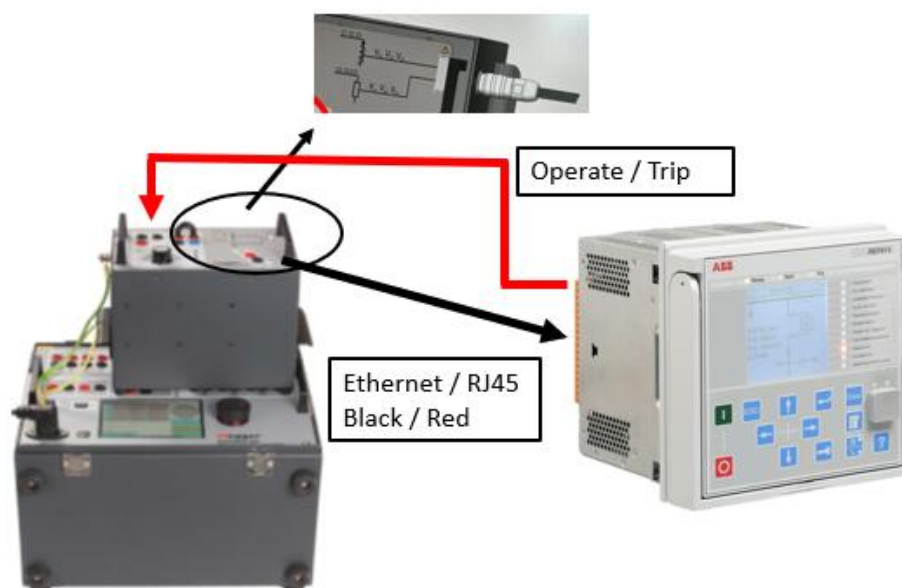
Securely fasten the multi-contact connector to the LPIT101. The leads are phase-labelled as I1/U1, I2/U2, and I3/U3. On this relay, the phase ports are X131 (phase 1), X132 (phase 2), and X133 (phase 3).

Connect the auxiliary power:

- LPIT101 AUX red (+) to X100-1
- LPIT101 AUX black (-) to X100-2


Connect the relay's trip output to SVERKER input BI1:

- X100-15 and X100-16 to BI1



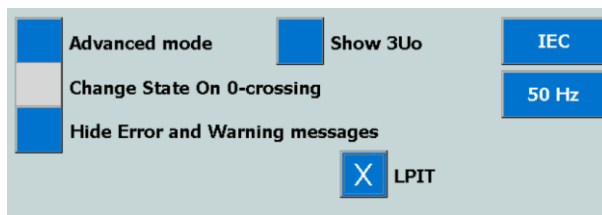
Relay testing with LPIT101

4. LPIT mode in SVERKER 900

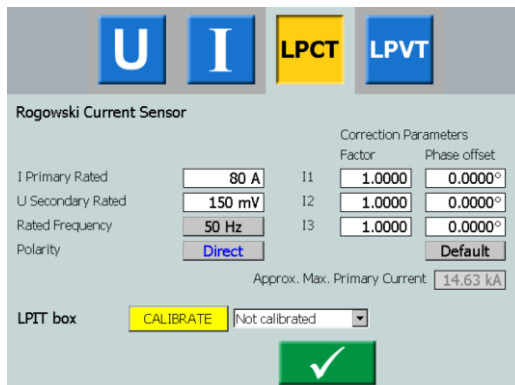
In the “System Configuration” menu,  enable LPIT mode by selecting the appropriate checkbox.

Open the “Generator Configuration” menu: 

- Press “LPCT” and enter the Rogowski coil parameters:



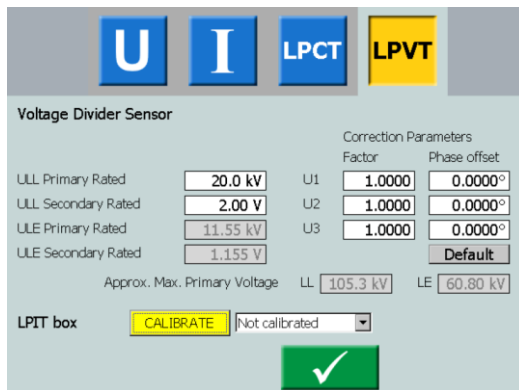
- Nominal primary current: 80 A
- Sensitivity: 3 mV/Hz
- At 50 Hz: 150 mV secondary at 80 A primary



Press “LPVT” and enter:

- Primary voltage: 20 kV
- Secondary voltage: 2 V (corresponding to the 10 000:1 ratio)


Relay testing with LPIT101



Press "CALIBRATE" and follow the on-screen instructions to calibrate the connected LPIT101 unit. The process takes a few minutes. When complete, the button label changes to "CALIBRATED"

These calibration data are specific to the connected LPIT101 unit. They are stored in the SVERKER 900 and can be reloaded for later tests when using the same LPIT101.

Set the SVERKER generators to "individual" mode in the same menu.

During a test, press the "Measurement Mode" button  to toggle between viewing primary current/voltage and secondary voltage values.

5. Timing test on overcurrent protection

The overcurrent protection is configured in two stages.

IDMT stage (overload protection):

- Start value: $1.1 \times I_n = 88 \text{ A}$
- Time multiplier: 0.2
- IEC characteristic: Normal Inverse
- Secondary start voltage: 165 mV at 88 A

Definite time short-circuit stage:

- Start value: $5 \times I_n = 400 \text{ A}$
- Operate time delay: 400 ms
- Secondary start voltage: 750 mV at 400 A

Relay testing with LPIT101

Group / Parameter Name	IED Value	PC Value	Unit
✓ PHIPTOC1(50P/51P[1]): 1			
✓ 3l>>(1)			
✓ Operation	on	on	
✓ Num of start phases	1 out of 3	1 out of 3	
✓ Reset delay time	20	20	ms
✓ Setting Group 1			☑
✓ Start value	5,00	5,00	xIn
✓ Start value Mult	1,0	1,0	
✓ Operate delay time	400	400	ms

Because the overload stage follows an inverse time characteristic, it is useful to plot the measured points together with a reference IEC Normal Inverse curve of the same parameters.

Open the Prefault-Fault instrument Set BI to contact sensing, normally open.



Configure a prefault state:

- Current: 80 A
- Voltage generators: off
- Prefault: 1000 ms

I1	80.0 A	0.0 °	50.000 Hz
I2	80.0 A	240.0 °	50.000 Hz
I3	80.0 A	120.0 °	50.000 Hz
U1	-----	-----	-----
U2	-----	-----	-----
U3	-----	-----	-----

110 VDC BI

STOPPED

Prefault: 1000 ms

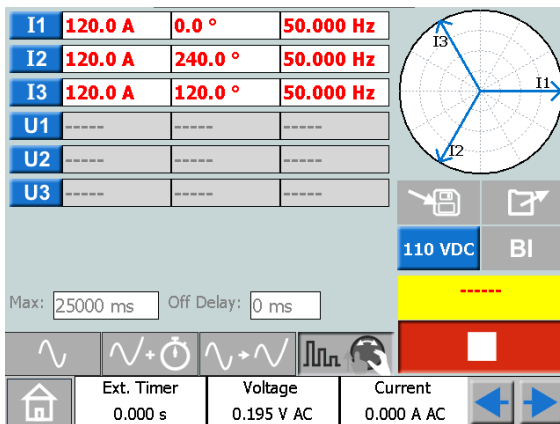
Ext. Timer 0.000 s Voltage 0.194 V AC Current 0.000 A AC

Configure the fault state:

- Three-phase fault
- Fault current: 100 A (approximately 14% above the start value; IEC recommends $\leq 20\%$ above the start value)
- Maximum fault duration: 25 000 ms

Press “MTT” , then “PLAY”. The instrument enters standby mode.

Relay testing with LPIT101



Start the test by pressing the control knob. Perform multiple tests at increasing current levels to obtain several points on the IDMT curve.

The short-circuit stage operates at 400 A. Ensure that IDMT points are tested slightly below this value, and constant-time points slightly above it, including additional points at higher currents.

When the required number of shots has been recorded, press “STOP” to exit standby mode and display the results.

#	I1: A	I2: A	I3: A	Time: ms
1	120.000	120.000	120.000	4214
2	160.000	160.000	160.000	2256
3	240.000	240.000	240.000	1353
4	320.000	320.000	320.000	1050
5	380.000	380.000	380.000	925
6	420.000	420.000	420.000	407
7	480.000	480.000	480.000	407
8	560.000	560.000	560.000	404

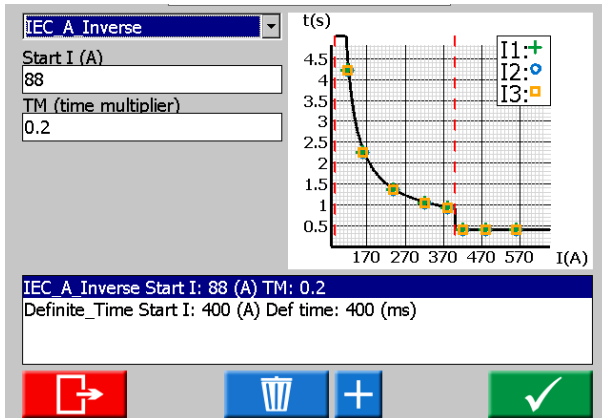
Condensed

Ext. Timer: 0.000 s Voltage: 0.000 V AC Current: 0.000 A AC

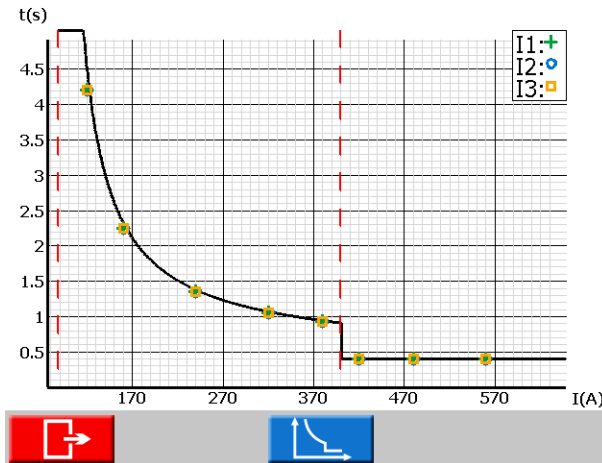
Press “PLOT” then “CURVE” to define the reference curve:

- Select IEC_A_Inverse
- Enter the start value and time multiplier
- Add a constant-time stage:
 - Start: 400 A
 - Delay: 400 ms

Relay testing with LPIT101



Press “OK” to view the plotted results and reference curve.



Save the test:

Press “SAVE”

Complete the metadata and press “OK”

The results are now saved, indicated by the now yellow text on red background in the field above the “PLAY” button.



Relay testing with LPIT101

6. Testing the residual over-voltage function

This function is configured with:

- Time delay: 100 ms
- Start value: $0.1 \times U_n = 2 \text{ kV}$ (primary)

Group / Parameter Name	IED Value	PC Value	Unit
ROVPTOV1(59G(1)): 1			
Uo(1)			
Operation	on	on	
Reset delay time	20	20	ms
Uo signal Sel	Calculated Uo	Calculated Uo	
Setting Group 1			
Start value	0.100	0.100	xUn
Operate delay time	100	100	ms

To test using unbalanced voltages:

- Set two generators to 11.547 kV and one to 4.9 kV (line-to-ground).
This produces a residual voltage of approximately 2.2 kV.

Alternatively, method

- Set one generator to 6.6 kV to produce approximately 2.2 kV residual voltage.

The residual voltage is defined as:

$$\bar{U}_0 = \frac{1}{3} (\bar{U}_a + \bar{U}_b + \bar{U}_c)$$

Alternatively, use a single-phase injection:

$$\bar{U}_0 = \frac{1}{3} (0 + 6.6 \text{ kV} + 0)$$

Enable “Show 3U0” in “System Configuration” to view the calculated residual voltage.

The value displayed for 3U0 is calculated as:

$$3 * \bar{U}_0 = (\bar{U}_a + \bar{U}_b + \bar{U}_c)$$

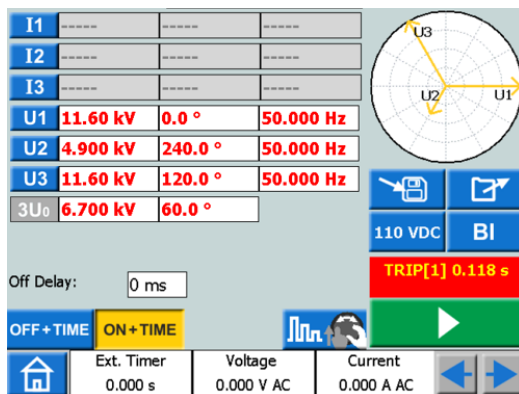
Relay testing with LPIT101

Timing test

Since this function has a definite-time characteristic, the main instrument is used for timing measurements regardless of which method is selected.

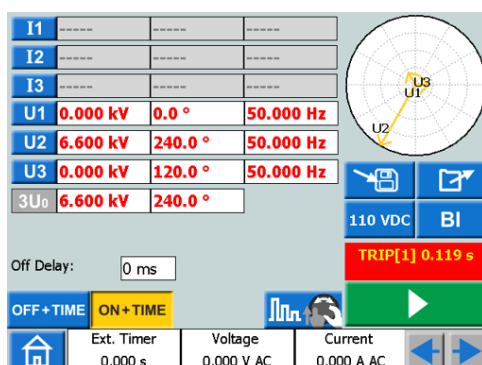
Using the first method (three unbalanced voltages):

- Turn off the current generators
- Turn on all three voltage generators
- Verify that BI1 is still set to "contact sensing, normally open"
- Set the generator voltages as shown in the figure below
- Press "ON+TIME" to start the test
- Allow the relay to operate and store the result




Using the second method (single-phase injection):

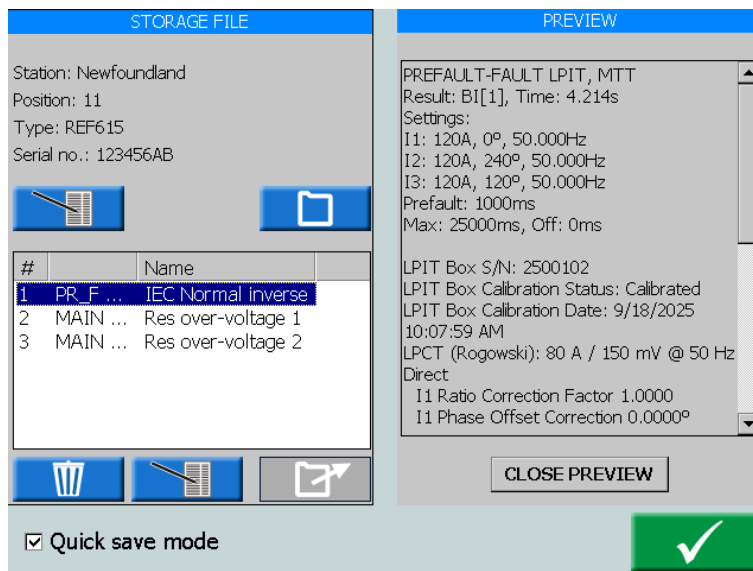
- Set the SVERKER voltages as shown in the figure below
- Verify that BI1 is still set to "contact sensing, normally open"
- Press "ON+TIME" to start the test
- Allow the relay to operate and store the result



Relay testing with LPIT101

7. Concluding remarks

To view stored test results, press "LOAD"  a preview of each result is available.



Testing relays using LPITs introduces a primary-value-based workflow. The LPIT101, used in conjunction with the SVERKER 900, enables precise and straightforward testing, even for complex sensor types like Rogowski coils.