TESTING DIRECTIONAL RELAYS WITH THE PTE-100-C Plus

1. Introduction

Testing Directional or even Distance single phase Relays is easy and straightforward using the PTE-100-C Plus, which is perfectly fitted to perform this kind of tests. It only requires following closely some different procedures and good understanding of the Phase Angle values interpretation.

The following paper describe the procedures and calculations to perform this type of tests, and the proper interpretation of the measured Phase Angle values, both by the PTE-100-C Plus and the Relay under test.

Along this paper, although some particular descriptions of test connections and/arrangements will be described in detail, it is supposed that the reader have a good command of the PTE-100-C Plus operation.

2. Setting up the PTE-100-C Plus for this test.

With the PTE-100-C Plus unit properly connected to the main supply, it is necessary to connect as well the PTE-FCL (Auxiliary AC voltage supply) installed in the cover lid of the unit.

To do so, and using the cable that is supplied along with it, connect the PTE-FCL to the OUT4 of the main unit. The PTE-FCL must power up immediately in the following condition:

LED lit solid on **Line**
LED lit solid on **Fine**
LED lit solid on **Level**

You may have the cover lid with the PTE-FCL still attached to the main unit or you may have detached it from the main unit. In both cases it is important that you link the GROUND tap of the PTE-FCL to the box of the main unit using the ground cable supplied. It is even more important in the former case.

Once it is done, proceed as follows:

- Connect the PTE-FCL output taps (black and red taps) to the main unit Voltage Monitor input taps (black and red taps) making colour with colour.

- Jumper the Current Output taps using a test lead between 0 tap and the 50 A tap.

- In the main unit and using the pushbutton marked “Tap” select to light the green LED that corresponds to the 50 A tap.

- In the main unit and using the pushbutton marked as double horizontal arrows select to light the LED marked Func. Also the LED marked as “V mon” will lit solid.

- In the PTE-FCL click on the pushbutton marked as “Coarse/fine” once. It will deactivate the LED marked as Fine, and allow you to regulate the output voltage of the unit in steps of 10 V.

- In the PTE-FCL click on the pushbutton marked as “ON/OFF” once. The Voltage Output of the PTE-FCL is now activated with a value of zero.

- In the PTE-FCL turn the rotary knob to the right, for example, 4 “clicks”. It will produce a voltage of 40 V.

- Wait some of 2 or 3 seconds and check that the Display in the main unit measures the output value.

- In the main unit push several times the pushbutton marked “Function” until you reach the Phase Angle Measurement Function, which LED indicator should be lit solid.

- In the main unit, keep pushing steadily the pushbutton “Function” until it starts to flick. The Phase Angle Measuring function between the Current produced by the main unit and an external Voltage signal connected into the Voltage Monitor Taps is already activated.

- In the main unit, make sure that the Variac is on its 0 position and turn ON the current output.

- Regulate until you reach a current value of about 5 A.

Now, check the reading of the Display.

It may be around 0 degrees or 360 degrees which is the same (be aware that it may be oscillating between 356 and 4 degrees, which is the allowed error). It will indicate that the current and voltage are in phase and are you are ready to proceed further.

Also, it is possible as well that you get a reading of 180 degrees (be aware of the +/- 4 degrees error) . It indicates simply that your voltage is twisted 180 degrees. To correct this situation **unplugs the PTE-FCL connection cable from the power input, twist the connector and plug it in again.** The PTE-FCL will be activated in the initial condition, and now, as you inverted the polarity of the supply (reference for the Phase Shifter) your voltage and current are in phase, and you are ready to proceed further.

If you prefer, you are now able to identify and mark in the PTE-FCL connection cable in BOTH ENDS, which is the position on which these connector must be connected in the future, avoiding the process of checking that the Voltage and Current are in phase.

However, this procedure is extremely fast and easy to perform, apart that most of it is necessary for the further Relay testing, so it is recommended to perform it every time that you are going to perform this type of test.

3. Connecting to the Relay and checking the connection.

Now, we should be connecting to the relay. Testing Directional Relays is extremely sensitive to the right connection to the relay of the voltage and current signals related with its polarity, or, in other words, the “input” and “output” of the signal.

To make this connection easier, the user must think of the voltage and current outputs of the test set as if they were the secondary windings of the VT and CT that are being used, hence following the schematic of the connection to the relay exactly as it is in the installation prints.

Once it is connected, and in case the relay have installed a phase angle meter, would be very convenient to inject the nominal voltage and the nominal current to the relay and check if the reading is 0, as it should be in the PTE-100-C main unit Phase Angle Meter. If it is, the wiring to the relay is correct. If the relay signals 180º it means that the wiring from the test set to the relay is wrong and need to be checked.

In case the relay have not a phase angle meter installed, this test cannot be performed. However, unless the setting of the relay is extremely unusual, if you apply a fault current while you are with the voltage and current in phase (0º) the relay should trip. If it does not, then the most probable reason is that the connection is wrong and need to be checked.

4. Finding the angle limits of the operation zone

To find the limits of the operation zone it is usually easier from inside-out, it is, going from relay operated (trip) to relay not operated (reset). Along this test, if your relay has a Phase Angle Measurement Display, DO NOT PAY ANY ATTENTION TO IT, just to the test set Phase Angle Meter. Proceed as follows:

- Inject into the relay under test the desired values of voltage and current enough (usually 2 x Setting) to activate the relay trip contact. If you followed the above described procedure you are now in a situation of voltage and current in phase (0º), and your relay must trip. Be aware that depending on the current amount that you are injecting, it may take a good amount of seconds to actually trip.

- In the PTE-FCL, use the pushbutton marked “Parameter” to select the LED marked “Angle” to lit solid. It means that now the rotary knob will regulate Phase Angle instead of V Level.
- If you followed the procedure you should be in Coarse regulation right now. Start to turn slowly and step by step to the right the rotary knob until the relay reset (it will mean that you are changing in increments of 10º per step of the rotary knob). If you desire better resolution, step back 10º with the rotary knob (one click) and wait until the relay trip again. Then use the pushbutton marked “Coarse/Fine” and select until the LED marked “Fine” lit solid.
- Start to turn the rotary knob again to the right until the relay reset. It is going to need much more turning because now your regulation resolution is “Fine” which means steps of 0.1º.
- Read in the Display of the main unit the Phase Angle Value indicated and write it.
- Change the regulation to “coarse”, regulate with the rotary knob the phase angle to 0º again and wait until the relay trip.
- Repeat the process but regulating to the left now. Write the Phase angle value indicated in the Display as well.

The test is finished. Turn off at least the current output to the relay, to avoid unnecessary heating and stress to the relay under test.

At this moment, the user should have two Phase Angle values, which corresponds each one to one limit of the directional characteristic.

5. Representing and calculating the found Angle Limits

The user may now notice that the obtained values are not the ones that he was expecting according to the relay setting of MTA. It is due to the different ways that the phase angle values are measured by the PTE-100-C Plus and the Relay Under Test.

It is very important to say here that BOTH angle values define EXACTLY THE SAME CURRENT VECTOR.

The following explain the above mentioned statement:

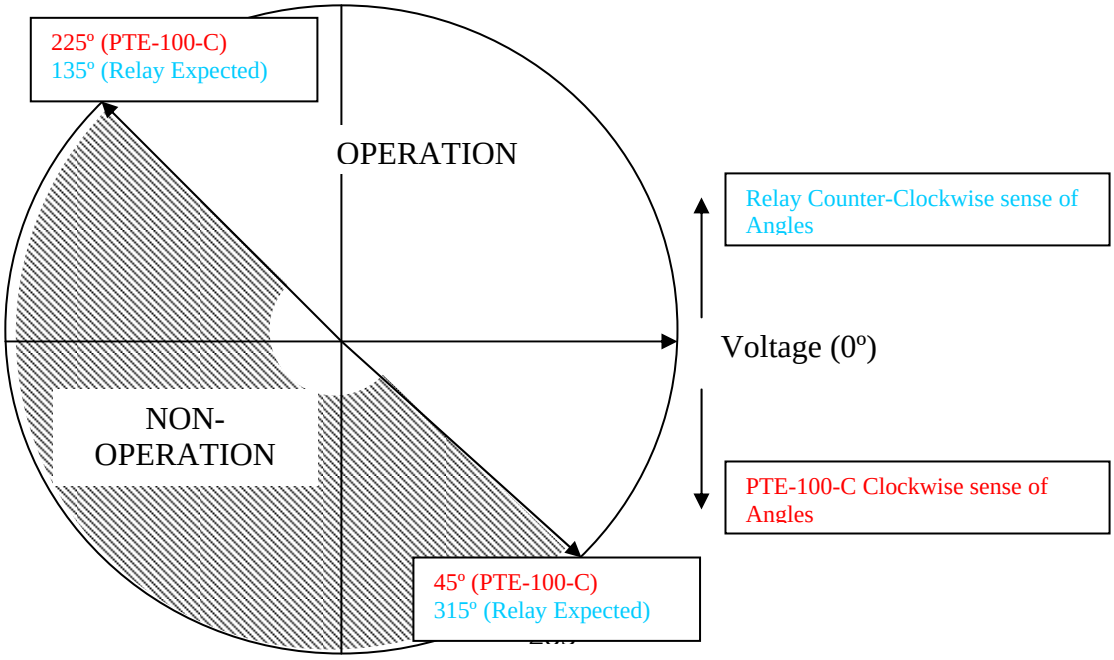
- The PTE-100-C Plus Phase Angle Meter show the angle value as the Angle between the Voltage connected to its Monitor taps and the Current being produced by the test set on its current output in CLOCKWISE sense.
- The relay and/or the relay setting information may be indicating the very same Angle between the Voltage and the Current that it receives, as the Angle between the Voltage and the Current in COUNTERCLOKWISE sense.

It means that the same vector position in a V/C graphic can be defined by two different angle values, the Clockwise value and the Counter-clockwise value.

Let’s explain it better with an example:

- Say that we get as Operation Limits the angle values 45º and 225º from the PTE-100-C Plus.
- However, we have as expected results in our Relay Setting information or the test procedure acceptance range the values 315º and 135º.

Evidently, the relay information is describing angles measured in Counter-Clockwise sense. Nevertheless, they are defining exactly the same position than the Clockwise values obtained in the PTE-100-C Plus:



As a matter of fact, as it is evident in the figure, we are always able to apply when the Relay expected values (REV) and the Found Values by the PTE-100-C (FVPTE) the following formula to determine numerically the Operation Limits.

REV= 360 – FVPTE

When assessing if the results of the tests are correct or not, be always aware that the PTE-100-C Plus Phase Angle Meter have a typical error of +/- 3 Degrees using current levels over 2 A. Lower current values increase the error even up to +/- 6 degrees. **This is valid for the 100 A and 50 A Current Output Taps.**

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