USE OF T 3000 & T 2000 FOR TRANSFORMER TESTS

FOREWORD

T 3000 and T 2000 allow a big number of tests to be performed on Current, Voltage and Power transformers. Among them, we are dealing here with three interesting topics, where our test sets display their value:

- **Verifying the CT saturation curve**
- **Load tap changer dynamic resistance test**
- **Very high current tests with BU 2000 or BU 4000 options**

1. VERIFYING THE CT SATURATION CURVE

Iron core Current Transformers meter the nominal current with high accuracy. Unfortunately, when they are used in connection with protective relays, they saturate when the current exceeds the rated limit. As a consequence, the relay can mistake just when its intervention should be immediate.

According to the standards, the Current Transformers front plate shows the amount of overload that should not cause saturation: this is reported in a form such as 5P20, where 5% is the maximum measurement error, and 20 is the multiplying coefficient for the nominal current. If you have a CT rated IN = 5 A, 5P20 means that it will not saturate for a current value of 20*5 = 100 A on the secondary side.

A large figure for the coefficient ensures that the measurement will not be distorted even under high short circuit conditions; however, the drawback is that increasing the coefficient increases the power *by the square* of the coefficient, and therefore the CT will grow in dimension, weight and cost.

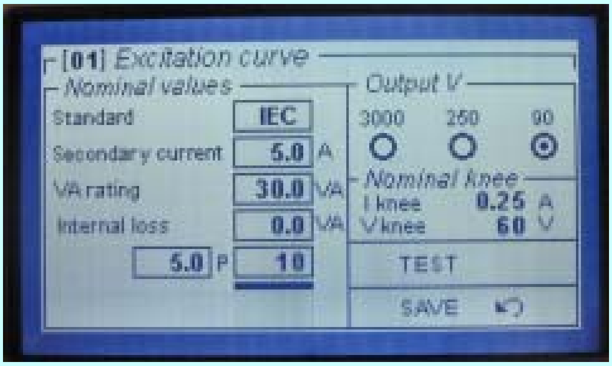
In fact, if the CT is rated, for instance, 20 VA @ IN, the maximum allowed burden will be:
Zmax = 20 / (5*5) = 0.8 Ohm.
If the transformer has a coefficient of 10, the power that it will have to deliver at 5*10 = 50 A will be:
Power = 0.8 * 50 * 50 = 2000 VA.
If the coefficient is 20, the power at 5 * 20 = 100 A will become:
Power = 0.8 * 100 * 100 = 8000 VA!

Once you have spent your money for a big coefficient, you want to make sure that it *actually meets its label*. This is when T 3000 & T 2000 come into play.

A first idea could be to take the CT at the saturation limit with the burden computed as above, and then to verify that the current measurement is correct. However, this would imply an huge amount of power, and a very high primary current. The much simpler idea is **to apply a *voltage* to the CT *secondary side***: the value of voltage that causes the saturation is the one that you are looking for.

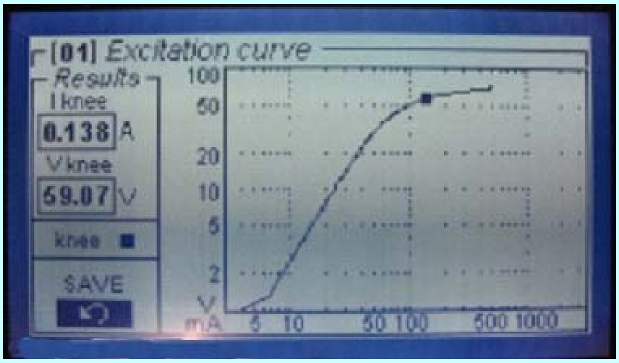
In fact, from the example above, with a 5P20 rated CT having 20 VA @ IN, the voltage at saturation would be:
Vsat = 5 * 20 * 0.8 = 80 V.
This is what T 3000 & T 2000 can do with a voltage range spanning from few Volts up to 3000 V. The highest voltage is requested for the test of big coefficient, 1 A rated CT's. The test set-up is very simple:

. Input the CT data.
. Start the test.
.When the saturation is reached, the test set computes the knee point, displays it on the diagram and prints the values on the screen.
.You can compare the test result to the nominal value, and verify that the CT is right.



Excitation curve

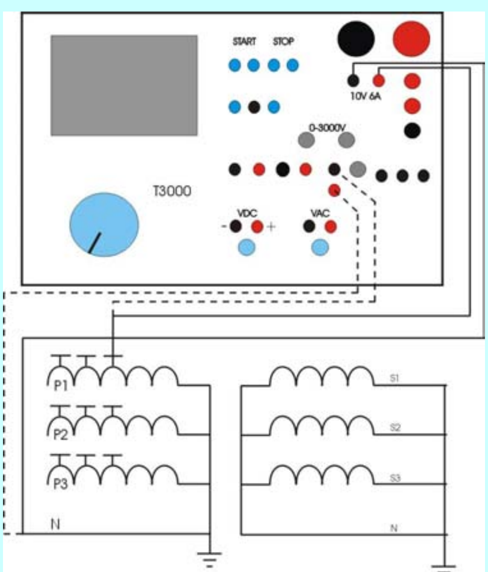
. Connect, press START, slowly increase the voltage until the diagram shows that the saturation has been reached.
. Now slowly reduce the voltage, reach the zero, press STOP: the screen becomes as follows.



As you see, the dot tells where the knee point is located. The measured saturation voltage, shown to the left, is 59.07 V, in good agreement with the nominal one.

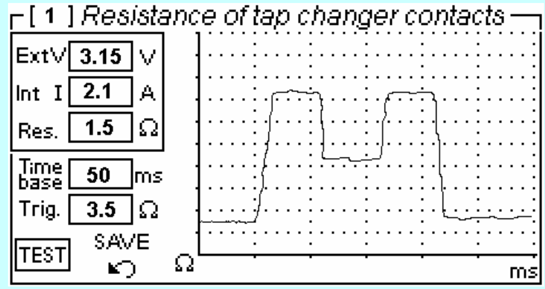
2. LOAD TAP CHANGER DYNAMIC RESISTANCE TEST

Load tap changers are heavy and bulky devices: performing a preventive maintenance requires a lot of time and it can also be a waste if the LTC is good. ***T 3000 & T 2000 are the sole devices that allow performing a fast test that tells if the LTC is good or not, without the need of opening it.*** Purpose of the test is to verify that, during the tap change, there is no transient open circuit condition. The connection diagram is the following.

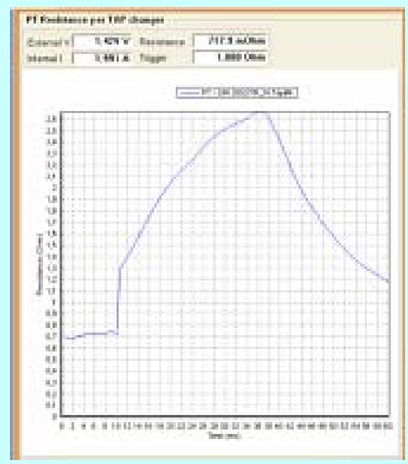


The PT primary is disconnected, and the DC current output is connected to the winding. ***PT secondary are short-circuited to ground: this nulls the effect of the primary inductance. Also the other two primaries should be short-circuited.*** During the test, T 3000 or T 2000 act as an oscilloscope, with the Y axis in Ohm. The operator sets a trigger resistance threshold above the value of the primary resistance, that he can previously measure; then, issues a tap change command.

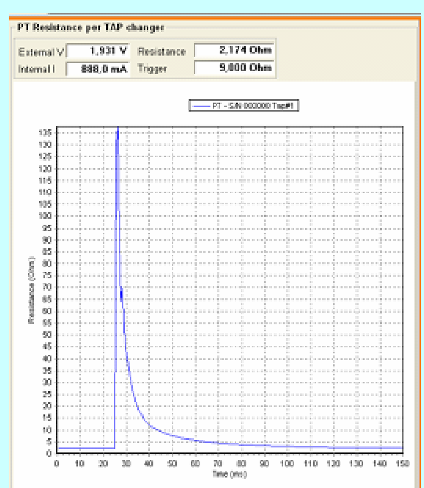
During the test the resistance changes; as soon as the threshold is passed, the display shows the resistance change versus time. In theory, the display should look like the following one:



However, the stray inductance slows down the current increase, so that the resistance diagram is very much integrated. The following picture shows the real case of an 100 MVA transformer.



The point is that if one of the contacts or resistors that intervene during the switchover is open, the time constant disappears: on the same transformer, the following picture shows a fault (note the different resistance scale).



In conclusion, the test tells you how long does the tap change take, and if there is an open circuit during the switchover, and ***this is what you want to know to decide if the intervention is necessary***.

3. VERY HIGH CURRENT TESTS WITH BU 2000 OR BU 4000 OPTIONS

Generating high currents for a primary injection test is a problem because, as the test current grows, the corresponding power grows with the square of the current.
The additional aggravation is that, as CT's are located high from the ground (between 5 and 10 m), there is the problem of carrying the current up there. This is performed with cables
of suitable cross section and length, but there are two frustrating consequences:

. Almost all of the test power is wasted into the connection cable rather than on the CT target;
.Connection cables are *very much reactive*: increasing the copper cross section does not help reducing the power demand. The only solution is to make special connection cables, made of many twisted pairs; the consequence is even heavier connection cables.

BU 2000 high current booster

The basic idea of BU 2000 is to move the power transformer close to the target, in order to minimize losses caused by the connection cables. Of course, these transformers have to be powered, but the supply voltage is about 100 times the output voltage, the current is 100 times less, the power loss is 10,000 times less than with the high current connection cables.

T 3000 & T 2000 have enough power to feed a transformer up to 2,000 A; for higher currents, we need an additional module, that allows getting up to 4,000 A: the additional power is taken directly from the mains.

How to set-up up to 2,000 A

The two wound cables are 10 m long and carry the supply to the transformer and the current measurement from the transformer to the test set. The two big current clamps support the weight of the transformer. Considering that the transformer + cable + clamps weigh 20 kg, this is less than the weight of the connection cables!

Of course, for 4,000 A the set includes 4 transformers, and the weight becomes 50 kg, but this is no wonder for those who want to test at 4,000 A!

Once the connection is performed, the test is conducted as with a normal generator, and T 3000 and T 2000 display the generated current, the secondary current and the current ratio.

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