Ultra-Low Resistance Tester (micro Ohm Meter)

An instrument for testing power transformer windings and circuit breaker contact resistance.

Requirements

In the electrical power generation and distribution field, maintenance of large transformers and circuit breakers is required on a regular schedule. These essential devices cost a huge amount of money and their health is very carefully monitored. Furthermore, when these devices do not operate at peak efficiency, the power wasted in heat could be substantial.

One instrument used in testing transformer windings and circuit breaker contacts is a micro Ohm meter. The windings and contacts may increase in resistance over time and start dissipating power. This added expense for the company in power lost and the possibility of catastrophic failure of the device make it worthwhile to repair a device before huge expenses are incurred. A history for each device is meticulously kept so that any deviation from the original reading can be dealt with in a timely manner.

As you may expect, the windings and contacts present a very low resistance (40 to 500 micro Ohms) and precise measurement is important. These devices are usually 3-phase, but measurements are made on one phase at a time and the leads are moved from phase to phase until all readings have been performed. The readings are made using a 4-terminal measurement (true 4-terminal Kelvin measurement method) by passing a DC current through the unknown resistance and measuring the voltage drop across it. The resistance is then calculated using Ohm's Law.

The tested devices are typically located in energized substations up to 750kV. Although the device under test is de-energized at the time of the test, it may have induced voltages of several hundred volts with respect to ground or across the open contacts. (This is a relatively low energy induced source).

When the instrument is connected to a device under test, such as a circuit breaker, the contacts of the breaker will be closed. Therefore, there is no AC induction between the negative and positive terminals of the instrument. However, there can be a voltage of several hundred volts (sometime thousands of volts) between all the terminals and ground. The instrument should work correctly and accurately in this condition.

When connected as described above, it is possible that the breaker contacts will be opened. If this happens, there can be several hundred volts across the open contacts. The instrument may be in the middle of a test, or be turned on but not testing, or turned off. In any of these conditions, the instrument shall not be damaged if this happens.

When making winding resistance tests, many readings are made on a transformer. Therefore, the time required to enter the information we refer to as Unit information is of little consequence. When testing contact resistance, there are three measurements to make and there is no stabilization time. Also, there are typically ten times as many circuit breakers in a substation as there are transformers. When all this is

considered, the customer will expect the contact resistance testing to proceed easily and rapidly. The instrument must attempt to make all functions and settings that the customer accesses during a test to be immediately accessible. Preferably on the main screen or one button press away.

The output current may be pre-selected in steps of 10 amperes up to 100 amperes. The instrument will ramp up to the test current in about 2 seconds then hold the test current, then ramp back down to zero in about 2 seconds. This is referred to as a test cycle. The time of a test cycle will be adjustable from 10 to 60 seconds. The last reading will be saved as final result. Current and time are set up prior to a test and saved as defaults until changed.

In Single polarity testing, the instrument will complete one test cycle in the positive direction. In Dual polarity testing, the instrument will make two cycles - one positive and one negative. The direction of current will be changed internally. In this mode the measured absolute value of resistance in the last readings (one for positive and one for negative polarity) will be averaged to eliminate any error caused by galvanic action at the connection of the test leads. The positive and negative test cycles will be completed within the chosen test time. Continuous testing mode is available for trouble shooting. In this mode there is no automatic test cycle and current is limited to 20 amperes. The resistance reading is simply displayed on the screen in the top (first) window.

Economic Justification

When expensive equipment is being protected from premature failure, one might expect the test equipment to be worth several thousand dollars. In calculating what the price of the product should be a number of costs have to be considered. The engineering manpower for the project is the largest one-time cost. However, this cost is divided by the number of instruments sold. It is the cost of components that dominate the final selling price.

There are a number of companies already in the game (see URLs below) which may represent significant competition.

Some Competitors

http://www.megabras.com/en/products/micro-ohmmeter/micro-ohmmeter-MPK203x.php

http://www.vanguard-instruments.com/categories/transformer-winding-resistance-meters

http://www.haefely.com/10-products/70-resistance-measurement.php

http://new.massmeasure.com/index.php?route=product/product&sort=p.price&order=DESC&page=5&manufacturer_id=52&product_id=7546&tracking=526e6df9da249

http://www.amazon.com/gp/product/B005T9E1DY/ref=as_li_qf_sp_asin_il_tl?ie=UTF8&camp=1789&creative=9325&creativeASIN=B005T9E1DY&linkCode=as2&tag=etesters-20

http://www.aemc.com/products/html/moreinfo.asp?id=903&dbname=products

http://www.ndbtech.com/lines/winding-resistance/wrt-10-winding-resistance-tester

YouTube Videos

http://www.youtube.com/watch?v=GijrrUbfIXQ

http://www.youtube.com/watch?v=4L0ch0-Paq8

http://www.youtube.com/watch?v=PKXPeTvmVQg

And many more such videos are available for viewing.

Project

About 10 years ago, I worked up a paper design for a low resistance tester that didn't go anywhere. I decided to update the schematics and parts lists and present it as a teaching tool. Keep in mind that this is a theoretical design on paper and no prototypes have been built to test the concept. However, the ideas expressed here may be useful in other similar products.