Admittance Testing Verifies CT Installation Integrity

Application Note 1109A

An admittance tester confirms the installed condition of the current transformer's internal burden and external connected burden by monitoring its admittance.

Introduction

Instrument transformers, more commonly known as Current and Potential Transformers are remotely located from the electricity meter and wired into the primary circuits of the service. During installation and subsequent evaluation of the service, the accuracy and performance of instrument transformers are often overlooked. Traditionally CT Burden testers have been the only device available for in-service accuracy certification of instrument transformers. Unfortunately, due to the limited "No Light Load" burden capabilities, testing of the instrument transformers have been neglected or performed incorrectly. The expense of removing them from the primary service and the inconvenience of service interruptions to the customer has also prevented testing. Today, the high cost of energy is driving utilities to review all aspects of revenue loss. These losses, which can be in the millions of dollars, are driving focus on the CT installation. There is an overwhelming goal to gain efficiencies and reduce losses related to power theft, billing mistakes and installation errors. Utilities have experienced single site CT installation mistakes that have cost the utility over $300,000 in favor of the customer.

505 ADMITTANCE TESTING CONNECTION DIAGRAM

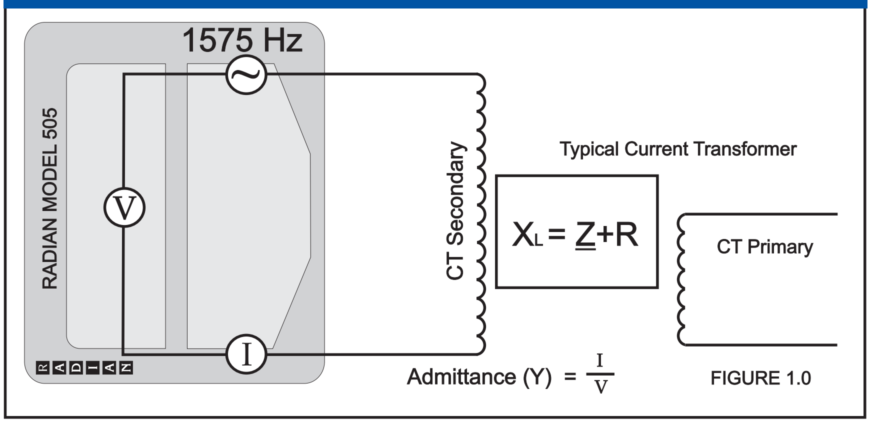

FIGURE 1.0

RADIAN

Admittance Testing 101

Admittance testing checks for abnormal admittance by injecting an audio frequency into the secondary of an in service transformer, and detecting the circuit admittance. Admittance (Y) is the inverse of impedance (Z) and is typically shown as mS (miliSiemens). The Radian 505 CT/PT Analyzer uses an audio frequency of 1575 Hz. When injected onto a 50/60Hz line, avoids interaction with harmonics that may be present, and possibly cause a false signal in the audio frequency detecting circuitry.

Why Test Admittance?

Relaying or metering current transformers have very low error when operated within the specified current and burden ratings. Therefore, it is known that the circuit admittance of any particular current transformer installation is nearly constant throughout the normal operating range, unless a fault condition develops. If the admittance measurement shows a deviation from normal while in service, it is likely that the current transformer will have: (1) an internal short (usually a shorted turn, where as the Z in FIGURE 1.0 will change); (2) an abnormal internal or external resistance (such as a high-resistance connection - loose or corroded, where as the R in FIGURE 1.0 will increase); or (3) the current transformer is operating under abnormal conditions (such as dc in the primary). Serious faults are immediately obvious due to an abnormally high admittance reading, normally at least 1.5 times the normal reading. Transformers with a wrong ratio, exampled as a connection to the wrong tap, will have readings substantially different than normal readings.

The best way to establish the "normal" reading is to record measurements during installation and at subsequent test intervals. Admittance values depend on the transformer's X_L as seen in FIGURE 1.0. The X_L value will encompass the transformer core design, burden rating, ratio, etc., but additions due to non-fault conditions (such as temperature, primary load, etc.) are small in comparison to the change caused by fault conditions. In-service current transformers are usually tested in groups, a high admittance reading obtained on one current transformer in the group strongly implies that a fault condition does exist. Admittance testing provides a quick, non-invasive way to evaluate the CT installation integrity, with or without load, at the customer site.

TYPICAL BURDEN CHALLENGE

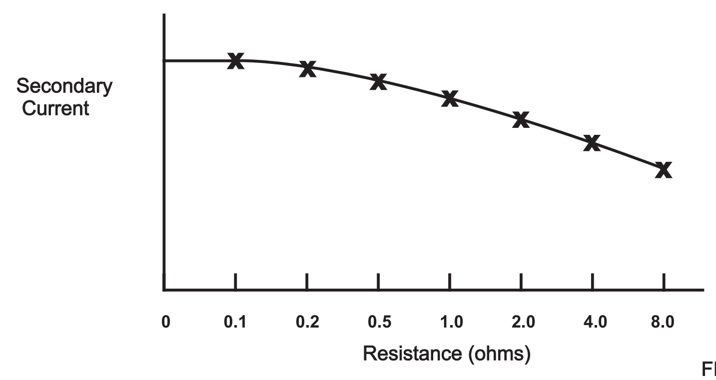

FIGURE 2.0

"Burden Only" Testing is not Sufficient

Current transformers are designed to supply a known current, dictated by the turns ratio, into a known burden and maintain a stated accuracy. The principle of a current transformer burden tester is to challenge the capability of the current transformer in service to deliver a current into the existing known burden.

The burden challenge is presented to the in service current transformer secondary in the form of a known ohmic resistance value that is added in series with the current transformer secondary loop. The total burden of the current transformer secondary loop is made up of the watthour meter or relay current coils, the mounting device, test switch, connection resistances, and the length and size of the loop wiring. Therefore, each current transformer has a unique secondary burden when installed in a relaying or metering circuit. Assuming that the technician or engineer has properly sized the current transformer to withstand the secondary burden, the current transformer will provide currents according to its accuracy class rating. Should the burden tester's additional burden exceed the designed burden capability of the current transformer, the transformer will not be able to supply the same level of current to the increased burden and the net result is a drop in the transformers secondary current. A typical burden challenge is shown in FIGURE 2.0.

Detection Capabilities Admittance Vs. Burden Testing

Detection Ability	Burden Test	Admittance Test
Open Secondary	●	●
CT Shorting Clip	●	●
High Secondary Burden	◒	●
CT Name Plate Error	◒	●
CT Magnetization	◒	●
Shorted Windings		●
Bad Meter CT		●
Power Theft		●

The amount of this current drop is dependent on a number of factors and is not absolutely definable. The operating current level of the current transformer is a major factor. Current transformers operating at very low currents can support several times the burden rating because at low currents the flux density of the core is reduced leaving a considerable margin for additional flux before saturation. Therefore, performing burden test at low secondary current levels is not very accurate or conclusive. The most accurate and revealing burden tests are performed at the full rated secondary current. At the upper end of the current range, additional burden quickly pushes the current transformer out of its operating range and causes significant drops in output current.

Another factor affecting the current transformer burden capability is the current transformer rating factor. Current transformers with high rating factors can support additional burden than that given on the CT nameplate for the nominal 5 ampere rating. Therefore, the same interpretative consideration as with low secondary currents must be exercised in these cases.

Additional CT Tests

CT Ratio Test

A CT ratio test is performed by placing clamp-on amp meters on both the primary and the secondary circuit wires. Then record the measurement of current flowing in both at as near to simultaneous as possible. The simultaneous readings are required for loads that are variable. The ratio is calculated by dividing the current reading of the secondary into the primary current reading. Example (350 primary amps / 3.5 secondary amps = 100:1 ratio). The resultant is the ratio. The nameplate rating for a 5 amp current transformer would be five times that or 500:5.

Phase Angle Test

Some test equipment provides a phase angle indication. The phase angle measurement can be used to verify polarity of the current transformer under test. Depending upon the test instrument, this can be a meter reading, a light indicating correct or reverse polarity, or as a text message on a display.

CT Demagnetization

In cases where the CT becomes magnetized from events as leaving the CT shorting clip open or a near lightning strike, the CT's performance is greatly reduced. It is important to recognize an error condition is present before testing continues. If CT errors are present and it is suspected that the CT is magnetized, then the CT should be demagnetized before performing any tests that require accurate current measurements.

CT demagnetization is performed by varying the secondary resistance gradually from low to high then back to low at a consistent rate. The amount of variable secondary resistance will be determined by what resistance is required to drive the current transformer into saturation (Bm) as seen in FIGURE 3.0. FIGURE 3.0 shows the transformer flux (B) along with the excitation current (H) and its considered to have hysteresis due to reversing magnetics caused by the AC current. A resistance that will cause a 65% to 75% reduction in secondary loop current will typically drive the CT into saturation.

CT SATURATION - HYSTERESIS LOOP

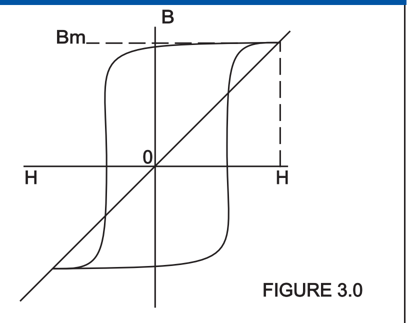

FIGURE 3.0

As an example, provided the current transformer under test produces at least 50% of secondary current, a series secondary resistance is varied gradually from 0.1 to 8 ohms and back to 0.1 ohms at a consistent rate. This operation effectively overburdens the current transformer and demagnetizes the core.

Extreme care should be exercised when demagnetizing a current transformer core as the voltage developed across its terminals will approach and may reach the secondary terminal voltage limit. Perform with appropriate equipment and training.

Radian Research Model 505 CT/PT Transfer Analyzer

The Model 505 is lightweight, portable and ideal for field testing. It was designed for testing CTs and PTs without interruption of the customer's service, testing functions include: RMS voltage, RMS current, V-I_s phase, CT admittance, CT ratio, I_p-I_s phase and CT/PT burden. Its unique powering by service or battery, in addition to its data storage capabilities provides ultimate flexibility. The 505 CT/PT Transformer Analyzer provides all the necessary test to allow a technician or engineer to evaluate the performance and integrity of any CT installation. For more information on the 505, please visit www.radianresearch.com or contact your local agent.

Bibliography
IEEE PC57.13.1/D8
Draft Guide for Field Testing of Relaying Current Transformers

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