

DESCRIPTION

159159

'LIVE AND LOADED' TESTING METHOD
FOR CURRENT TRANSFORMER

Technical Field

The present invention relates to a method for testing the integrity of a
5 transformer for use in a protection system for an electrical installation. In
particular, the present invention relates to such a method, which may be
conducted during live operation of the transformer.

Background to the Invention

It is well known to provide electrical installations with protection systems
10 designed to protect the installation against abnormal conditions such as
overloading of supply lines or short circuit faulting between 'live' wiring and
earth.

Known protection systems for electrical installations normally comprise one or
more electrical current transformers, which act as sensors of circuit condition;
15 a protection relay, which acts to analyse data received from the current
transformers; and a trip circuit including trip coil and trip supply, which acts as
an actuator for controlling the main switch in the circuit.

Of the above components, the most susceptible to failure (e.g. as a result of
damage) are the current transformers because these are typically installed in
20 the primary or high voltage circuit and are continuously subject to high voltage
spikes (e.g. due to lightning or other disturbances in the supply system) and
abnormal electrical current surges (e.g. due to fault in the downstream
installation).

The current transformer (CT) typically contains no moving parts, and primarily
25 comprises an iron core built in a loop format to allow magnetic fluxes to flow in

unimpeded fashion round the loop. It is known that when such magnetic fluxes oscillate through the iron core an induced voltage is established on any winding that coils around the core, thus producing a flow of electricity or current. On the other hand, when current flows through a winding that coils
 5 around the iron core, magnetic fluxes are induced in the iron core. This reciprocating or mutually induced phenomenon between the magnetic fluxes and electric current forms the known theory of transformation of current between sets of windings (e.g. two sets of windings) that coil round the same iron core.

10 As a result of the size and material of iron core used for a particular current transformer, there is an inherent property of the core that is characterized by the maximum amount of magnetic fluxes that can be contained in the iron core. Such containment of the maximum magnetic fluxes in an iron core is known as saturation. When an iron core is saturated, the effect of magnetic
 15 fluxes produced by further additional current in the winding will no longer take place, and so the mutual induction phenomenon will not exist between the two windings as described above.

The saturation of an iron core of a current transformer is readily identifiable by applying voltage across and measuring the resulting current flow in the
 20 winding. If a graph is plotted between the voltage applied against the current injected, the plot is called Magnetization Curve, as shown in Figure 1. In the graph, the point "K" which is used to signify the starting point of saturation, is called the knee-point, which is defined as the point at which a 10% increase in voltage will cause a 50% increase in current.

25 The Magnetization Curve provides a prime indicator for characterizing a particular CT. The positioning of the knee-point "K" provides a very important source of information because it reveals the structural integrity of the CT. Any changes or decreasing of the knee-point voltage are indicative of an imminent deterioration in the core material or defect in the winding.

Within an electrical protection system, the CT serves to feed important data to the protection relay for analysis therefore. It will therefore be appreciated that a defective CT would supply distorted data to the relay, thus adversely affecting the functionality of the protection system, and possibly causing
5 inadvertent and nuisance tripping of the electrical installation. Magnetization Curve testing of CTs is therefore an essential part of the tests performed when commissioning a CT and in ongoing predictive maintenance of the protection system.

To derive a Magnetization Curve a testing voltage is applied across a selected
10 winding of the transformer. This testing voltage drives a proportional amount of current into the winding. This current acts to magnetize the iron core of the CT. As the applied voltage is increased the resulting current in the winding increases proportionally. The Magnetization Curve follows a linear path until saturation occurs, at which point the induced current increases very much
15 faster than the increase in voltage. After the knee-point "K" at which the current increases by 50% with a 10% increase in voltage, the plot of the Magnetization Curve is almost flat indicating that the iron core has totally lost its magnetic character.

Magnetization Curve tests can be conducted on either the primary winding or
20 secondary winding of a CT. Normally the secondary winding is chosen for the test because the voltage and current required for the test is well within the capacity of normal testing apparatus.

Certain difficulties can be encountered when using the conventional method of conducting Magnetization Curve testing. One difficulty arises as a result of
25 the fact that the current transformer is installed in the primary (i.e. high voltage) circuit, which inevitably requires that the supply in the primary circuit be switched off and isolated from the other 'live' part. The first reason for this requirement is that the conventional method needs to apply voltage on the winding (e.g. the secondary winding) and this is not possible if the iron core is
30 already magnetized with the load current in the primary circuit. The second

reason for this requirement is that the secondary circuit of a CT has to be open-circuited and this is not practically possible because if a CT is open-circuited an abnormally high voltage might occur across its opened terminals. This high voltage may result in the breakdown of insulation of CT and is
5 extremely dangerous to the person working on it.

It will therefore be appreciated that the conventional method of Magnetization Curve testing is inconvenient because it requires shutting down of the primary circuit of the CT for testing thereof. In practice, this often necessitates plant shutdown, which is particularly troublesome for factories where continuous
10 and non-interruption of power supply is highly desirable.

The Applicant's have now devised a new method of testing the integrity of a CT that overcomes some of the problems faced by the conventional method of Magnetization Curve testing. In particular, the new method provided herein enables testing to be performed on a CT without the need to shut down the
15 primary circuit thereof. That is to say, it enables 'live and loaded' testing of the CT without the need to interrupt operation of the CT or the need for plant shutdown in order that testing may be carried out.

It is an object of the present invention to provide a method for testing the integrity of a current transformer which does not require the CT to be isolated
20 from a 'live' electrical installation with which it is associated.

It is another object of the present invention to provide a method for testing the integrity of a current transformer which does not require measurements at the primary circuit thereof.

Summary of the Invention

25 According to a first aspect of the present invention there is provided a method for testing the integrity of a current transformer for use in a protection system for an electrical installation, said current transformer having primary windings

defining a primary circuit and secondary windings defining a secondary circuit,
said method comprising the steps of

(i) applying a voltage (v) to said secondary circuit;

(ii) applying an initial resistance load to said secondary circuit;

5 (iii) measuring the resulting load current (i_l) of the secondary circuit;

(iv) measuring total current of the primary circuit (I_P);

(v) calculating total current (i_p) of the secondary circuit by use of the formula

$$i_p = I_P * N_P / n_P \dots\dots\dots (5)$$

10 where n_P and N_P are respectively the number of turns in the secondary and
primary windings of the current transformer

(vi) making the assumption that under normal load conditions

$$i_p \cong i_l \dots\dots\dots (6)$$

(vii) calculating magnetizing current (i_m) of the secondary circuit by use of the
formula

$$15 \quad i_m = i_p - i_l \dots\dots\dots (7)$$

(viii) applying a gradually increasing resistance load to said secondary circuit
and repeating steps (iii) to (vi) to obtain the voltage (v) and magnetizing
current (i_m) of the secondary circuit for said gradually increasing resistance
load;

20 (ix) plotting a Magnetization Curve of voltage (v) versus magnetizing current
(i_m) in the secondary circuit; and

(x) calculating from said Magnetization Curve a knee-point at which an x% increase in voltage (v) results in a y% increase in magnetizing current (i_m) in the secondary circuit, wherein x is from 5 to 20 and y is from 30 to 70.

5 Preferably, the knee-point is defined such that an 10% increase in voltage (v) results in a 50% increase in magnetizing current (i_m) in the secondary circuit (i.e. x is 10 and y is 50).

The theory underlying the method provided herein may be understood by first considering the electrical characteristics of a winding of a CT. The winding is in essence, a coiled up wire. In terms of electrical characteristics, a straight
10 length of wire possesses a pure d.c. (direct current) resistance (" r "), while a coiled up wire possesses a combination of d.c. resistance (" r ") and a.c. (alternate current) inductive reactance, or inductance (" l ") which can be expressed in mathematical term as:

$$(r + j l) \dots\dots\dots(1)$$

15 where j denotes the reactive power or imaginary component in a vector configuration.

During the magnetization of a CT, current is injected into the primary circuit thereof and a proportional amount of current is caused to flow in the secondary circuit. The ratio of the primary to secondary current is fixed for a
20 particular CT and defines the 'transformation ratio' of that CT (see equation (5) below).

To induce current flow in the secondary circuit of the CT, the primary circuit has to magnetize the iron core so that the linkage of magnetic fluxes is established round the core inclusive of the secondary winding. To effect this
25 magnetization, requires a small amount of primary current known as 'magnetizing current' (" I_M ").

It will therefore be appreciated that the current of the primary circuit of the CT ("I_P") actually comprises two components, viz. the magnetizing current (I_M) which is used for magnetizing the iron core; and the load current ("I_L") which is used for driving the secondary current. In mathematical terms this is expressed in vector equation form as:

$$I_P = I_M + I_L \dots\dots\dots(2)$$

where I_P, I_M, and I_L are vector quantities measured in the primary circuit of the CT.

The Applicant has realized that the voltage V that drives the magnetizing current, I_M, and load current, I_L, is the same since it appears across the same terminals of the primary circuit of the CT. Hence a relationship exists between the magnetizing current I_M and load current I_L such that a change of amplitude in one will affect the amplitude of the other. Thus, if the primary current I_P is kept constant, then I_M will react inversely to I_L in order to maintain the vectoral equilibrium of equation (2). This realization is a crucial part of the theory underlying the method of the claimed invention.

The Applicant has also realized that it is difficult, and possibly unsafe, to measure values for V, I_P and I_L at the primary circuit because the operating voltage in the primary circuit is usually too high. To overcome this difficulty, the method of the claimed invention relies on the theory of 'mirror' voltage ("v") and current ("i_p and i_l") in the secondary circuit, which as described above are proportional to those in the primary circuit by a factor of transformation ratio. The measurement of the lower voltage v, and current i_p and i_l in the secondary circuit is relatively straightforward and safe, thereby enabling ready application of the method herein.

Extending the theory of 'mirror' voltage and current in the secondary circuit, another equation for the current in the secondary circuit may be expressed vectorally as:

$$i_p = i_m + i_l \dots\dots\dots(3)$$

where i_p , i_m , and i_l are vector quantities measured in the secondary circuit which are proportional to those in the primary circuit by the transformation ratio.

- 5 Rearranging equation (3), provides:

$$i_m = i_p - i_l \dots\dots\dots(4)$$

and i_m can then be computed because i_p is the mirror current of I_P .

In more detail:

$$i_p = I_P * N_P/n_P \dots\dots\dots(5)$$

- 10 where n_P and N_P are respectively the number of turns in the secondary and primary windings of CT (i.e. the transformation ratio).

In addition, i_l can be measured from the secondary circuit thereby enabling ready calculation of i_m by application of Formula (4). From the known values of v and i_m , the magnetization curve of CT can then be plotted.

- 15 As mentioned above, under normal load conditions, the magnetizing current in the secondary circuit i_m is insignificantly small compared to i_p . Hence it can reasonably be assumed that:

$$i_p \cong i_l \dots\dots\dots(6)$$

where i_p is the normal mirror load current,

- 20 Hence equation (4) can be rewritten as:

$$i_m = i_p - i_l \dots\dots\dots(7)$$

From equation (7) above it follows that i_l (i.e. the load current in the 'live' secondary circuit) must be changed in order to vary i_m . This variation of current i_l can be achieved by incorporating an adjustable 'artificial load resistance' to replace the existing load in the secondary circuit. As i_m is increased, this in turn increases the voltage v across the primary circuit which is needed to inject the current i_m .

In accord with the method of the claimed invention, the Magnetization Curve of the CT is therefore derived by plotting change in voltage v versus current i_m obtained as a result of variation of current i_l in the secondary circuit.

It will be appreciated that i_m is a characteristic of the primary circuit. However, as provided herein, the mirror representation of current in the secondary circuit thereof (i.e. v for V ; i_p for I_p ; i_l for I_L and I_M for i_m) and the application of equation (6) negates the need to obtain this value directly from the primary circuit.

Whilst manual implementation is possible, it will be appreciated that the method of the claimed invention is readily amenable to implementation by computer-assisted means using suitable software. In one particular aspect, the method herein is implemented by way of computer software is written in Visual C Language on the Windows/CVI development platform produced by National Instruments of USA.

Suitable software is arranged to perform the initial task of acquisition of suitable voltage and current data from the CT secondary circuit, and conversion of that analog data into digital form. The software is also arranged to analyse the digital form data to produce a Magnetization Curve for the CT.

In more detail, the software suitably executes the following mathematical computation and analysis on the digital signals:

- (i) computation of the root means square (rms) values of initial load current i_l for one cycle of digital data. From equation (6), the initial i_l is taken as i_p , hence $i_p = i_l$ because i_m is negligibly small;
- (ii) computation of the root means square (rms) values of voltage v for every
5 1 cycle of digital data;
- (iii) computation of the root means square (rms) values of load current i_l for every 1 cycle of digital data;
- (iv) computation of the rms values of magnetization current i_m from equation (7), that is to say $i_m = i_p - i_l$.
- 10 (v) computationally checking the knee-point condition. That is to say, checking for the point at which an increase in v of 10% results in an increase of i_m increase by 50%. In mathematical terms, the check is for when $(v_2 - v_1)/v_1 \leq 10\%$; $(i_{m2} - i_{m1})/i_{m1} = 50\%$, where v_1 ; v_2 ; i_{m1} and i_{m2} are rms values of voltages and current computed for data taken at two adjacent points 1 and
15 2 respectively. At the point where the knee-point condition is satisfied, the knee-point voltage and current are stored for display.
- (vi) displaying on a display of a suitable computer:
 - (a) the plot of v (vertical axis) versus i_m (horizontal axis) as Magnetization Curve; and
 - 20 (b) the knee-point on the curve.

The computer-assisted means comprises any suitable computer device such as a personal computer or hand-held computing device, and is optionally provided with suitable hard-wired or telecommunications capability to enable communication with a network system. Suitably, the device additionally
25 comprises a data input system for user input of data thereto. More preferably,

the data input system comprises a man machine interface (MMI) preferably selected from a keypad, voice recognition interface or graphical user interface (GUI).

5 Suitably, the device additionally comprises a display for display of data, and in particular the Magnetization Curve and knee-point value, to the user. The display may for example, comprise a screen such as an LED or LCD screen.

According to another aspect of the present invention there is provided a method for testing the integrity of a current transformer for use in a protection system for an electrical installation, said current transformer having primary
10 windings defining a primary circuit and secondary windings defining a secondary circuit, said method comprising the steps of

(i) applying a voltage (v) to said secondary circuit;

(ii) applying an initial resistance load to said secondary circuit;

(iii) obtaining a magnetizing current (i_m) of the secondary circuit by use of the
15 formula

$$i_m = i_p - i_l \dots\dots\dots(7)$$

(iv) applying a gradually increasing resistance load to said secondary circuit and obtaining the voltage (v) and magnetizing current (i_m) of the secondary circuit as said resistance load gradually increases;

20 (v) plotting a graph of voltage (v) versus magnetizing current (i_m) in the secondary circuit; and

(vi) identifying from said graph a knee-point at which an $x\%$ increase in voltage (v) results in a $y\%$ increase in magnetizing current (i_m) in the secondary circuit, wherein x is from 5 to 20 and y is from 30 to 70.

Suitably, the current transformer connects to the live circuit of an electrical installation.

According to a further aspect of the present invention there is provided a method of obtaining the magnetizing current (i_m) in the secondary circuit of a current transformer suitable for use in the testing method described above,
 5 the method comprising the steps of

(i) obtaining total current (i_p) of the secondary circuit by use of the formula

$$i_p = I_P * N_P / n_P \dots\dots\dots (5)$$

wherein I_P is total current of the primary circuit; and n_P and N_P are respectively
 10 the number of turns in the secondary and primary windings of the current transformer;

(ii) calculating magnetizing current (i_m) of the secondary circuit by use of the formula

$$i_m = i_p - i_l \dots\dots\dots (7)$$

15 assuming that

$$i_p \cong i_l \dots\dots\dots (6)$$

wherein i_p is the initial total current load.

According to a further aspect of the present invention there is provided a computer program product for use with a digital computer comprising software
 20 code portions for performing, or requesting user input enabling the performing, of the software implementable steps of the methods described above, when said program is run on said digital computer.

According to a further aspect of the present invention there is provided a digital computer system for implementing the steps of the methods described herein comprising

a digital computer system; and

- 5 executable on said digital computer system, a computer program product as described above.

Suitably, the digital computer system additionally comprises a display for displaying output to a user.

Brief Description of the Drawings

- 10 The invention will now be described further with reference to the accompanying drawings, in which:-

Figure 1 shows a representative Magnetization Curve herein;

- 15 Figure 2 shows suitable apparatus for carrying out the method of the present invention on a three coil current transformer connecting to a three wire, high voltage electrical installation; and

Figure 3 shows suitable apparatus for carrying out the method of the present invention on a four coil current transformer connecting to a four wire, low voltage electrical installation; and

- 20 Figure 1 illustrates a representative Magnetization Curve herein, in which voltage applied to the CT is plotted against current flow produced at the winding. In the conventional prior art approach, the voltage is applied across the primary circuit of a CT which has been disconnected from the electrical installation. In the method of the claimed invention however, the voltage is applied across the secondary circuit of a CT that still has its primary circuit

'live' (i.e. connected to the electrical installation). In more detail, the Magnetization Curve of the method according to the claimed invention is a graph of voltage v versus magnetizing current in the secondary circuit I_m . In the graph, the point "K" signifies the starting point of saturation and is called
5 the knee-point, which is defined as the point at which a 10% increase in voltage will cause a 50% increase in current.

As shown in Figure 1, the knee-point, K corresponds to a voltage of about 24.0 volts.

It will be appreciated that in variations, the definition of knee-point can be
10 varied to define a point at which a $y\%$ increase in voltage will cause an $x\%$ increase in current, wherein y and x are variable.

Referring now to the drawings, Figure 2 illustrates a suitable system for conducting the method of the claimed invention on a current transformer 110.

The current transformer 110 may be seen to comprise three primary circuit
15 wires 120a-c connecting to a three wire 130a-c high voltage electrical installation. Circuit breakers 132a-c are provided to enable isolation of the CT from the electrical installation, as necessary. The current transformer may also be seen to comprise three coil windings 122a-c forming the secondary circuit thereof.

20 In accord with the present invention, the windings 122a-c of the secondary circuit connect to suitable testing apparatus herein for measurement of voltage and current therein. In more detail, the secondary circuit 122a-c connects to a computer-assisted analyser (CAA) 142 through an interface box 140. The CAA 142 is programmed with suitable data acquisition and analysis
25 software, as described hereinbefore. The voltage points connect directly to the interface box 140 while the current is connected via a current clamp 144, which is a small and easily detachable CT clamp used to measure the current in the CT 110 without having to break the secondary circuit 122a-c of the CT

110. In addition, a burden box 150 also connects to the secondary circuit thereby enabling replacement of the existing load in the secondary circuit. The burden box 150 consists of a variable resistor having a range of from 0 to 1000 Ohms variable resistance. A jumper 124 is used to provide temporary shorting because the CT should not be open-circuited.

In a measurement operation, the resistance of the burden box 150 is set at an initial minimum value at or about the 0 Ohm position. The 'scan-start' function of the CAA 142 is then initiated and the resistance of the burden box 150 is raised slowly at a rate of about 10 Ohm per second. While the resistance on the burden box 150 is increased, the 'scan' programme of the CAA 142 acts to continuously capture, compute and save the rms values of voltage v and current i_m and to check the knee-point (K) condition at every cycle interval.

As soon as the knee-point condition (i.e. 10% increase in voltage v versus 50% increase in current i_m) is detected by the CAA 142 a prompt is provided to alert the operator who then stops the test operation. The plot of Magnetization Curve (i.e. voltage v versus current i_m) as well as the knee-point (K) voltage is then displayed on the display 146 of the CAA 142. For later reference, captured and analysed data is typically stored on the CAA 142.

It will be appreciated that the procedure described above relies on creating 'artificial' magnetization current i_m under normal load conditions. In more detail, under normal load conditions, the magnetizing current i_m is insignificantly small because the load current i_l usually dominates the current flow of the secondary circuit of CT. The procedure described above creates an 'artificial' magnetizing current i_m , which is applied via an external burden load to replace the existing load. The function of the external burden box 130 is thus two fold: (i) to reduce the load current i_l and hence creating the 'artificial' magnetization current i_m ; and (ii) to vary the magnetization current i_m and the corresponding voltage v .

Figure 3 illustrates a suitable system for conducting the method of the claimed invention on another current transformer 210, which has four windings 220a-d and connects to a three phase, four wire 230a-d low voltage electrical installation.

5 In more detail, the current transformer 210 may be seen to comprise four primary circuit wires 220a-d connecting to a four wire 230a-d low voltage electrical installation. Wire 220d is a neutral. Circuit breakers 232a-c are provided to enable isolation of the CT from the electrical installation, as necessary. Neutral wire 220d which, in normal practice, does not need
10 isolation through circuit breaker, is connected to the busbar 230d by means of a link 234. The current transformer may also be seen to comprise three coil windings 222a-d forming the secondary circuit thereof.

In accord with the present invention, the windings 122a-d of the secondary circuit connect to suitable testing apparatus herein for measurement of
15 voltage and current therein. In more detail, the secondary circuit 122a-d connects to a computer-assisted analyser (CAA) 242 through an interface box 240. The CAA 242 is programmed with suitable data acquisition and analysis software, as described hereinbefore. The voltage points connect directly to the interface box 240 while the current is connected via a current clamp 244,
20 which is a small and easily detachable CT clamp used to measure the current in the CT 210 without having to break the secondary circuit 222a-c of the CT 210. In addition, a burden box 250 also connects to the secondary circuit thereby enabling replacement of the existing load in the secondary circuit. The burden box 250 consists of a variable resistor having a range of from 0 to
25 1000 Ohms variable resistance. A jumper 224 is used to provide temporary shorting because the CT should not be open-circuited.

In a measurement operation, the resistance of the burden box 250 is set at an initial minimum value at or about the 0 Ohm position. The 'scan-start' function of the CAA 242 is then initiated and the resistance of the burden box 250 is
30 raised slowly at a rate of about 10 Ohm per second. While the resistance on

the burden box 250 is increased, the 'scan' programme of the CAA 242 acts to continuously capture, compute and save the rms values of voltage v and current i_m and to check the knee-point (K) condition at every cycle interval.

5 As soon as the knee-point condition (i.e. 10% increase in voltage v versus 50% increase in current i_m) is detected by the CAA 242 a prompt is provided to alert the operator who then stops the test operation. The plot of Magnetization Curve (i.e. voltage v versus current i_m) as well as the knee-point (K) voltage is then displayed on the display 246 of the CAA 242. For later reference, captured and analysed data is typically stored on the CAA 242.

10 It will be understood that the present disclosure is for the purpose of illustration only and the invention extends to modifications, variations and improvements thereto.

The application of which this description and claims form part may be used as a basis for priority in respect of any subsequent application. The claims of
15 such subsequent application may be directed to any feature or combination of features described therein. They may take the form of product, method or use claims and may include, by way of example and without limitation, one or more of the following claims.

Claims

1. A method for testing the integrity of a current transformer for use in a protection system for an electrical installation, said current transformer having primary windings defining a primary circuit and secondary windings defining a secondary circuit, said method comprising the steps of:

(i) applying a voltage (v) to said secondary circuit;

(ii) applying an initial resistance load to said secondary circuit;

(iii) measuring the resulting load current (i_l) of the secondary circuit;

(iv) measuring total current of the primary circuit (I_P);

(v) calculating total current (i_p) of the secondary circuit by use of the formula

$$i_p = I_P * N_P / n_P \dots\dots\dots (5)$$

where n_P and N_P are respectively the number of turns in the secondary and primary windings of the current transformer;

(vi) making the assumption that under normal load conditions

$$i_p \cong i_l \dots\dots\dots (6)$$

(vii) calculating magnetizing current (i_m) of the secondary circuit by use of the formula

$$i_m = i_p - i_l \dots\dots\dots (7)$$

(viii) applying a gradually increasing resistance load to said secondary circuit and repeating steps (iii) to (vi) to obtain the voltage (v) and magnetizing current (i_m) of the secondary circuit for said gradually increasing resistance load;

5 (ix) plotting a Magnetization Curve of voltage (v) versus magnetizing current (i_m) in the secondary circuit; and

(x) calculating from said Magnetization Curve a knee-point at which an x% increase in voltage (v) results in a y% increase in magnetizing current (i_m) in the secondary circuit, wherein x is from 5 to 20 and y is from 30 to 70.

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2. A method according to claim 1, wherein said initial resistance load is close to zero Ohms and $i_p = i_l$.

3. A method according to either of claims 1 or 2, wherein the resistance load is applied by a variable resistor having a resistance of from 0 to 1000 Ohms.

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4. A method according to any of claims 1 to 3, wherein said knee-point corresponds to the point at which a 10% increase in voltage (v) results in a 50% increase in magnetizing current (i_m) in the secondary circuit.

5. A method according to any of claims 1 to 4, wherein said current transformer connects to the live circuit of an electrical installation.

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6. A method for testing the integrity of a current transformer for use in a protection system for an electrical installation, said current transformer having primary windings defining a primary circuit and secondary windings defining a secondary circuit, said method comprising the steps of:

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- (i) applying a voltage (v) to said secondary circuit;
- (ii) applying an initial resistance load to said secondary circuit;
- (iii) obtaining a magnetizing current (i_m) of the secondary circuit by use of the formula

$$5 \qquad i_m = i_p - i_l \dots\dots\dots(7)$$

- (iv) applying a gradually increasing resistance load to said secondary circuit and obtaining the voltage (v) and magnetizing current (i_m) of the secondary circuit as said resistance load gradually increases;

- 10 (v) plotting a graph of voltage (v) versus magnetizing current (i_m) in the secondary circuit; and

- (vi) identifying from said graph a knee-point at which an x% increase in voltage (v) results in a y% increase in magnetizing current (i_m) in the secondary circuit, wherein x is from 5 to 20 and y is from 30 to 70.

- 15 7. A method according to claim 6, wherein said current transformer connects to the live circuit of an electrical installation.

- 8. A method of obtaining the magnetizing current (i_m) in the secondary circuit of a current transformer for use in the method according to any of claims 1 to 7, the method comprising the steps of

- 20 (i) obtaining total current (i_p) of the secondary circuit by use of the formula

$$i_p = I_p * N_p / n_p \dots\dots\dots (5)$$

wherein I_p is total current of the primary circuit; and n_p and N_p are respectively the number of turns in the secondary and primary windings of the current transformer;

- 5 (ii) calculating magnetizing current (i_m) of the secondary circuit by use of the formula

$$i_m = i_p - i_l \dots\dots\dots(7)$$

assuming that

$$i_p \cong i_l \dots\dots\dots(6)$$

wherein i_p is the initial total current load.

- 10 9. A computer program product for use with a digital computer comprising software code portions for performing, or requesting user input enabling the performing, of the steps (i) to (x) of any of claims 1 to 5, when said program is run on said digital computer.
- 15 10. A computer program product for use with a digital computer comprising software code portions for performing, or requesting user input enabling the performing, of the steps (i) to (vi) of either of claims 6 or 7, when said program is run on said digital computer.
- 20 11. A computer program product for use with a digital computer comprising software code portions for performing, or requesting user input enabling the performing, of the steps (i) to (ii) of claim 8, when said program is run on said digital computer.
12. A digital computer system comprising
- a digital computer product; and

executable on said digital computer system, a computer program product according to any of claims 9 to 11.

13. A digital computer system according to claim 12 additionally comprising a display for displaying output to a user.