

Impulse Measurement Technique of Winding Component

I. Definition of impulse measurement of winding component

1. Principle of impulse winding measurement

Charge energy-stored capacitance $C1$ in advance with the maximum charging voltage of the instrument. Switch on $SW1$ in ultra-short time, and place component on $SW1$. Because $C1 \gg C2$, $C1$ quickly charges $C2$, and $SW1$ opens after a while.

At the same time, this stimulant impulse is energized on the winding under test Lx , and $C2$, Rp and Lx have a free attenuation vibration, and the vibration's index trends to decrease and is modulate to be sine signal. Pursuant to attenuation vibration of it and resonance capacitance $C2$, winding's inner status is known to judge the coil component's quality, including winding's insulation, coil's inductance, and parallel capacitance.

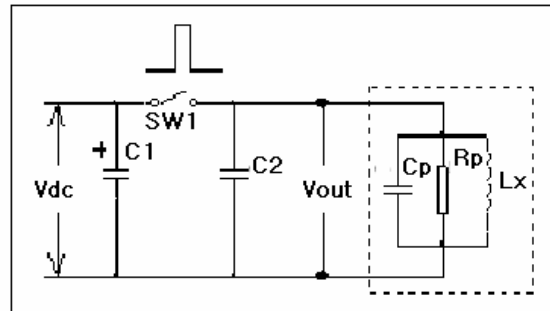


Figure 1 Impulse measurement

In Figure 1,

$C1$: energy-stored capacitance

$C2$: syntonistic capacitance

Cp : equivalent parallel capacitance at two terminals of winding

R : energy-wasted equivalent parallel resistance

Lx : winding equivalent inductance

Because of the effect of circling materials, magnetic materials, framework, process techniques and so on, decrease of insulation performance between turns and pins happens to products of winding series, such as transformer, motor, etc.

Winding's impulse measurement can test its electric performance without damaging the device under test, and the method can judge winding's

characteristics in short moment. At the

time of measurement, the same impulse with that of standard winding's measurement is put on the winding under test through capacitor's discharge. Because of winding's inductance, stray capacitance and Q value, a voltage attenuation waveform which is corresponding to this

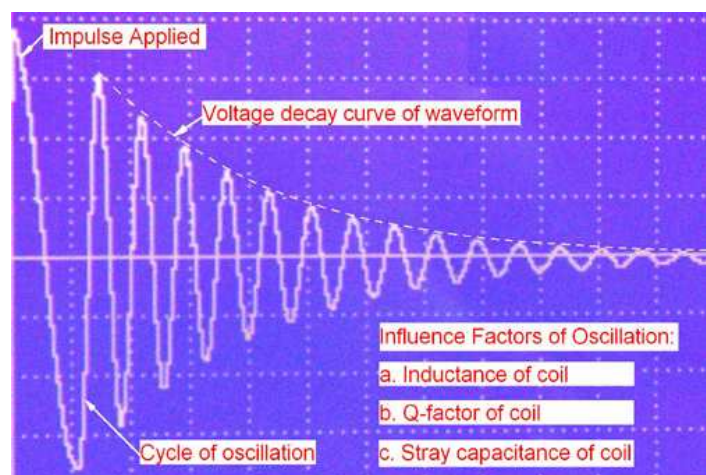


Figure 2 Winding's attenuation curve

discharge impulse is responded, and short circuit between winding's turns and layers, turns and difference of magnetic materials can be tested by comparing some characteristics of the attenuation waveform. If a high-voltage impulse is put on, insulation is judged according to appearing corona or inter-layer discharge.

2. Brief introduction of Impulse measurement program

In general, winding impulse measurement has two programs: analog and digital.

Tonghui Company provides analog TH2881 inter-turn insulation tester and digital TH2882 series impulse winding tester.

Analog winding impulse tester: TH2881A inter-turn insulation tester

This instrument's impulse measurement is a traditional measurement method. The instrument provides two high-voltage impulse output terminals H1 and H2, and synchronously tests the winding under test and standard one. Difference of attenuation resonance waveforms between the winding under test and standard winding will be observed on CRT to judge the quality of the winding under test.



Figure 3. TH2881A Inter-turn Insulation Tester

Take the example of TH2881A's testing winding:

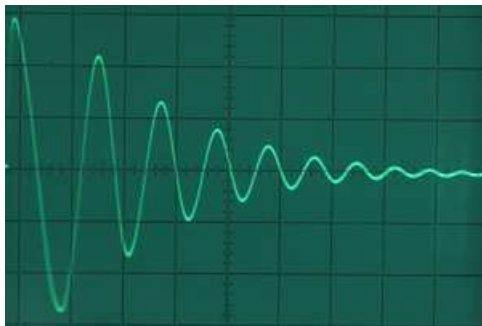


Figure 4. normal waveform

The attenuation waveforms of the standard device and the device under test are of almost superposition without obvious difference., which means there is no defect between turns of the device under test.



Figure 5. bad insulation between turns

The device under test has different waveform with standard, which means there is defect between turns of the device under test. When the waveform is displayed, discharge sound is heard, or discharge light seen and ozone smelled.



Figure 6. open-circuit waveform

The winding of device under test is of open-circuit, the waveform is displayed as an arc line, and discharge happens at breakpoint.

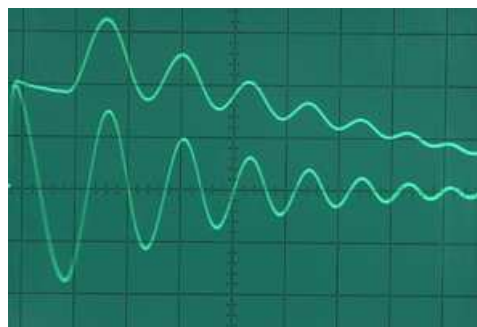


Figure 7. short-circuit waveform

If the device under test is completely short-circuit, the waveform is displayed as a horizontal line.

Analog tester has the following advantages and disadvantages:

Advantages:

- a. waveform directly observed;
- b. easy operation.

Disadvantages:

- a. Because of being affected a lot by factitious factors, the product can't be judged by data;
- b. Standard device needs to be clipped on test terminals for long time, and standard device will endure high voltage for long time
- c. The device under test with small inductance is difficult to test, and it's usually applicable to test winding product more than 1mH, such as motors;
- d. The test terminal outputs high-voltage impulse for long time, which affects instrument's life. At the time of measurement, the impulse is output once every 20mS, in order to make CRT get steady and visible waveform;
- e. When the inductance with small quantity is measured, because of very short display time, the display brightness reduces a lot so that observation is affected.

Digital memorying winding impulse tester:
 TH2882-3/TH2882-5/TH2882S-3/TH2882S-5

Adopting method of high-speed digital sampling, products of this series stores waveforms of standard winding in the instrument, and compares the measured waveform and standard waveform to judge the winding under test according to set



Figure 8 TH2882 series impulse winding tester

criteria, including area, area difference, overzeroing, corona, etc. This measurement method has the following advantages:

- a. High-speed digital sampling makes judgment automatically complete, which can eliminate effect of factitious factors;
- b. It's not necessary to synchronously test standard device at the time of measurement. All the tests use uniform data, and waveform of standard device can be stored, loaded, transferred to be stored, and shared;
- c. Wide range of inductance can be tested;
- d. High voltage is output instantly, and, in theory, one measurement only needs to output high-voltage impulse once, which can prolong instrument's life a lot.
- e. There is not the problem of display brightness, and waveform can be displayed in the optimal status;
- f. Because of adoption of digital and intelligent technology, many additional analysis functions can be performed, such as time and period measurement, voltage measurement, average for multi times, continuous measurement, automatic level control (ALC) of output voltage, and sound mode selection of PASS/FAIL, etc.;
- g. Many forms of criteria can be taken to tell small changes of the winding under test, such as area, area difference, overzeroing, corona, etc.;
- h. Interface is used for different aims, such as USB interface for transfer and storage of data and standard waveform, and different interfaces are used for different purposes, such as USB interface for data and standard waveform's transfer and storage; IEE488 interface and RS232 interface for communication between people and instrument or building automatic measurement system; HANDLER/SCANNER interface for auto machinery processor and impulse transformer winding automatic measurement system.

II. Why to perform impulse measurement?

Generally, winding component composed of one or several turns, such as inductor, transformer, motor, needs to be evaluated in the following ways:

1. turn's winding resistance (copper resistance), winding inductance L , turns N , turns ratio N_p/N_s , capacitance between turns C_p , and core status (Q, ACR, LK), etc., belong to low-voltage parameter measurement. They can be tested through automatic transformer measurement system, LCR meter, turns tester, and DC low-ohm meter, etc.
2. Compression resistance and insulation between different turns or turn to core and crust, tested through hi-pot tester and insulation resistance meter.
3. Insulation of turns, tested through impulse winding tester (inter-turn insulation tester)

Generally eligible component after inspection is used in electronic products, and even in short term it works well, after being used for a long term, its life and stability will be affected because

of potential bad factors caused by winding's bad insulation.

Bad performance of product caused by insulation problem:

- a. Bad hardness, short life;
- b. Not good anti-noise capability;
- b. Not good stability under high temperature.

Common reasons causing winding's bad insulation:

- a. Bad insulation of enamel-coated wire, insulation adhesive tape or framework;
- b. Originally designed outlet mode or bad process technique;
- b. Safe distance not left between pins or existence of pollutant after soldering.

After circling procedure, impulse measurement is performed before magnetic material is added, and the following phenomena happen:

- a. Winding's bad insulation (attenuation and discharge of forepart of waveform);
- b. Obviously wrong turns or connection (Lx, resonance cycle of forepart changes);
- c. Wrong circling means (parallel capacitance Cx, resonance cycle of post part changes).

III. How to perform impulse measurement

1. Used in which departments?

Nice design, correct use of material and sound process can ensure component's long-term stability under normal operation.

(1) R&D or project department: to inspect project design or bad modification;

(2) Incoming inspection: to check incoming materials' quality, and to prevent material with bad quality mixing;

(3) Production line: to monitor product's quality on production line at any moment.

2. In which procedure to perform impulse measurement?

Suggestion: after the winding procedure and before adding magnetic materials

Reasons: a. Impulse measurement is performed to test winding's insulation, not characteristics of magnetic materials;

b. Magnetic materials will absorb test energy so that situation of winding's bad insulation could not appear;

c. General magnetic materials allow biggish error to cause biggish change of inductance, while winding's insulation has little difference, which makes badness judgment not easy.

If the inspection doesn't aim at insulation or the procedure can't be seperated, it could be arranged to be taken at the phase of finishing product, and the effect of magnetic materials should be considered.

3. How to decide measurement impulse voltage?

Suggestion: The highest impulse voltage possibly coming forth in electric environment should be considered, and test with the impulse voltage of its 1.5 to 3 times.

Reasons: a. General tests are all taken under room temperature, and insulation capability of insulation materials decrease under the highest operating temperature of component;

b. In ultra-short test time, potential badness only appearing after long-term insulation.

1. How to make standard device of measurement?

a. to make sample 0pcs (finished product) according to the techniques with optimal standard;
b. to inspect Hi-Pot, IR and low-voltage parameters, including DCR, LCR, TR, etc. as required;
c. to remove magnetic materials, and perform winding's self insulation measurement (impulse measurement) according to the actual case. If there is no clear unconventionality or turns are short, the device can be used as standard sample;

d. to perform standard waveform memory for sample in impulse tester;

e. to ensure objectively permissible error and specific inspection aim;

f. to adjust inspection criteria according to cognized passed product and failed product;

g. Judgment criteria are recorded in operation manual;

f. to save standard waveform into USB disk, or save standard waveform in USB disk into computer, in order to load at any time;

h. to save cognized sample more than 5pcs for later standard maintenance.

IV. Correct measurement operations and safety

Note: Impulse measurement uses high voltage to perform measurement, so operators should wear insulation gloves and lay insulation gluey cushion under feet. And in order to avoid electric shock hazard, there should be reliable safety grounding for AC power source's input!

Appropriate measurement environment:

1. In order to keep operators' safety, instrument's correct operation and accurate measurement result, please connect the grounding terminals of the measurement instrument and table-board to a safety earth ground.
2. Impulse measurement tests insulation ability, and moist and grimy table-board usually cause measurement error.
3. In order to keep safety and ease of operation, foot switch is recommended to start instrument's measurement.

V. Techniques of impulse measurement

Judgment method:

1. **Area comparison:** usually used to compare attenuation speed.
2. **Area difference:** usually used to compare surging frequency.
3. **Overzeroing judgment:** when winding attenuates at different voltages, inductance changes, and resonance frequency also changes, and the change is judged pursuant to the overzeroing point.
4. **Flutter:** usually used to detect partial discharge.
5. **Eye observation of exceptional waveform:** If discharge occupies so low ratio of the whole area that it's difficult to judge, operator may observe to judge clear exception, and add judging principle in manual.

VI. Tonghui's impulse measurement solutions**TH2882-3 Impulse Winding Tester**

Single-phase, output voltage: 300V—3000V

TH2882S-3 Impulse Winding Tester

Three-phase, output voltage: 300V—3000V

TH2882-5 Impulse Winding Tester

Single-phase, output voltage: 500V—5000V

TH2882S-5 Impulse Winding Tester

Three-phase, output voltage: 500V—5000V

Characteristics of TH2882 series impulse winding tester

1. Having the fast ascending rate of output impulse, it's suitable to test winding products with small inductance and high frequency;
2. With digital sampling rate of 40MHz, it's suitable to test products with middle and small inductances and it has good measurement characteristics. And it can detect partial discharge (corona);
4. Low shock energy, short impulse time, minor damage to the device under test;
TH2882-3/TH2882S-3: Max. shock energy of 0.09 joule
TH2882-5/TH2882S-5: Max. shock energy of 0.25 joule
TH2882S is especially suitable to test three-phase motor;
5. 320×240 large graphic LCD display;
6. Measurement time, period, voltage and so on can be displayed on screen;
7. Multi detection and judgment functions: area comparison, area difference comparison, zeroing, flutter;
8. Capability of displaying multi waveforms makes it easy to judge through eyeballing and improves inspection capability;
9. High measurement speed, only 0.6s for single sampling measurement;
10. To ensure veracity of set voltage, the instrument has the capability of automatic level control (ALC), which makes actual output voltage and set voltage accordant;
11. PSAA/FAIL judge result has multi alarm abilities, and beeper volume, length, time, reading on

- screen and indication can be controlled;
12. 60 sets of Flash Memory standard waveforms saved/loaded, USB interface providing capabilities of outer storage and transferred storage to be shared;
 13. Standard IEEE488 and RS232C interfaces connected with PC;
 14. HANDLER/SCANNER interface is provided for automatic test and makes the instrument expand to be impulse transformer winding test system;
 15. 3 sets of independent memory waveforms selectable, which is suitable to scan three-phase motor or multi-turn high-voltage winding.

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