VOLTECH NOTES

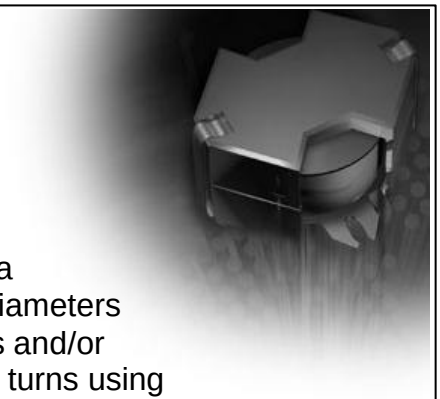
AT Series Testers

Technical Note

Shorted Turns Detection

VPN: 104-029/1

VOLTECH NOTES



1. Introduction:

Inductors are made up of a length of wire usually wound around a core. The core is usually some type of magnetic material such as iron or ferrite however air cores are also used. The wire hereafter called the winding comprises of a number of turns and in many transformers different wire diameters can exist between one winding and the another. Inductors and/or transformers that are wound containing a large amount of turns using very fine wire require a method of not only to detect shorted turns but also the ability to stress the winding in order to detect imperfections in the winding insulation. Winding imperfections can be attributed to damaged enamel and/or dropped windings etc. These imperfections could result in shorted turns during normal operation if undetected at manufacture. Partial shorted turns cannot exist for long because of high temperatures a partial short will eventually cause copper melting and create a low resistance spot weld. This low resistance short will completely short out one turn.

2. Detecting shorted turns.

Shorted turns can be detected with two methods: -

- High voltage surge or impulse testing
- High voltage stress watts testing.

High voltage surge or impulse testing.

As there is no defined method for this type of test a perfect transformer is required for comparison testing. The perfect transformer will define the required voltage level, number of pulses injected and the measured result as a comparison value. The voltage level and the number of pulses required is dependent on the total amount of stress needed on the transformers winding. As an example a mains-driven transformer can experience spikes of up to 2KV from the raw-mains therefore three pulses at a voltage level of 3KV should adequately test and stress the windings for inter-turn insulation imperfections.

Each injected high voltage pulse will produce a defined decay time or transient voltage. Poor
insulation and/or shorted turns will dissipate some of the energy producing shorter decay times.

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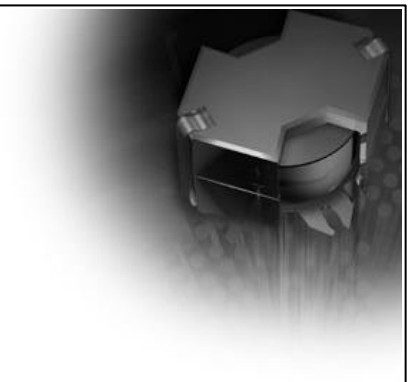
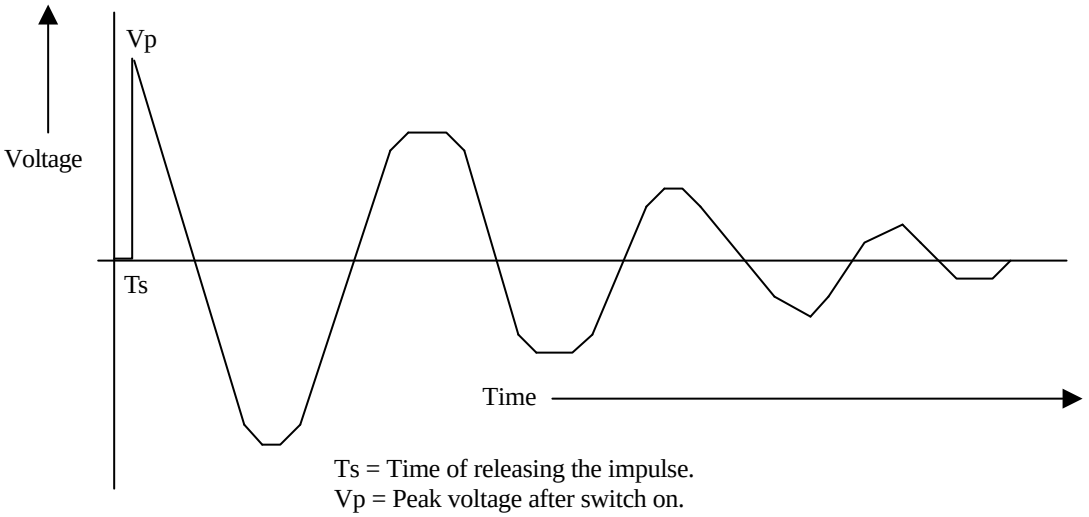


Each injected high voltage pulse will produce a defined decay time or transient voltage. Poor insulation and/or shorted turns will dissipate some of the energy producing shorter decay times.

FIGURE 1 (decay versus time of one pulse from a surge test).



Ts = Time of releasing the impulse.
Vp = Peak voltage after switch on.

The AT3600 provides a high voltage surge test from 100VAC to 5KVAC and a choice of 1 to 99 impulses, results on the AT3600 are presented as a volt-second measurement, if the transformer is faulty the result will be a smaller value than that of the perfect transformer.

High voltage stress watts testing.

A transformer will still draw current and consume power when testing a transformer at no load with the secondary open circuit. This power consumption or copper loss is measured in watts and is the power absorbed by a coil subjected to an alternating current. Typically the current draw due to copper loss is only a few percent of the normal load hence is usually negligible. Therefore the measured power is due to eddy currents and hysteresis known as core loss.

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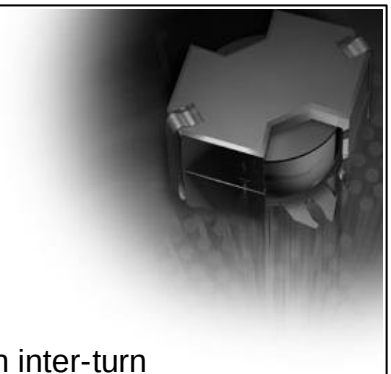


Watts testing is usually operated at the transformers full line voltage and operating frequency. Faraday's law shows below that providing the voltage and frequency is increased proportionally core loss should remain the same. Therefore a stress watts test can be performed at twice the voltage rating and twice the frequency rating of the transformer.

A dramatic increase in measured power would indicate that an inter-turn insulation winding fault. A dramatic increase in measured power would indicate that an inter-turn insulation winding fault or shorted turn was present as a larger amount of current would be consumed through the copper loss.

FIGURE 2 (Watts test Line frequency power transformer operating parameters are 220V primary 44V secondary turns ratio 5:1).

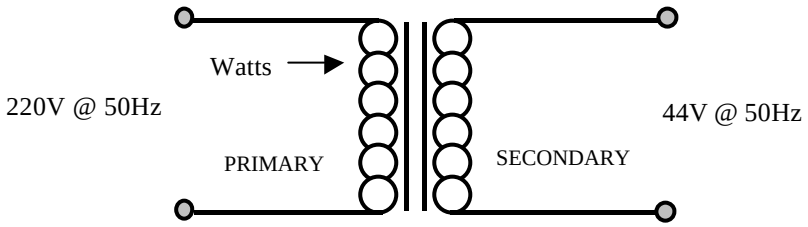
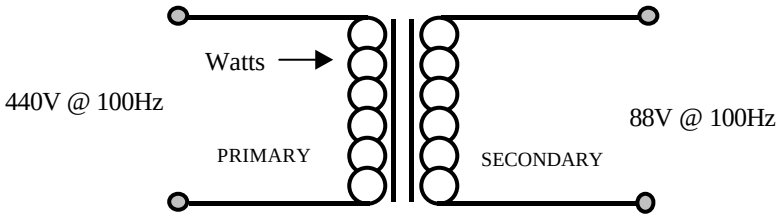


FIGURE 3 (Stress Watts Test Line frequency power transformer operating parameters 220V primary 44V secondary turns ratio 5:1).



HYSTERESIS

is the energy used up by changing the magnetic state of the core during each cycle.

EDDY CURRENTS

are currents induced in the core by time varying fluxes.

COPPER LOSS

The power in watts absorbed by a coil subjected to an alternating current.

As we have proportionally increased the voltage and frequency from figure 2 to figure 3 the core loss will remain the same allowing the windings to be stressed at a greater voltage than used in normal operation. The flux density (B) in the core will remain the same: -

$$B \mu V / (f * A * N)$$

N = The number of turns
A = The cross sectional area of the core.
V = Voltage applied.
f = Frequency applied.

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The AT3600 provides a stress watts test from 1V to 270V @ 20Hz to 1.5KHz to indicate faults in the inter-turn insulation of a winding, results are presented in Watts. This test can be used on windings with very fine wire. Where voltage and current levels require extending up to 650V RMS and 10A RMS for MAGX, WATX, STRX and VOCX use Voltech's ACI (AC Interface fixture).

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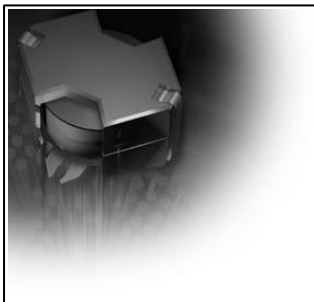

AT Series Testers

VOLTECHNOTES

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