FERRITE WATT LOSS TESTING: COMMON MANUFACTURING PROCESSES

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Agenda

• Magnetics Background

• Typical Watt Loss Measurements

• Test Procedure and Equipment

• Limits and Performance Curves

• Customer Correlation
Magnetics Background

- Manufacturer of Magnetic Cores
  - Mn-Zn Ferrites (Power Ferrites)
  - Distributed Air-Gap Powder Cores – MPP, Kool Mu, XFlux
  - Strip Wound Cores – SiFe, 50% NiFe, 80% NiFe

- R&D Focused
  - New material and core geometry development.
  - Existing material improvement.
  - Testing standardization.
  - Customer specification correlation and design.
Typical Loss Measurements

- **Power Ferrites – Core Loss**
  - Low losses at high frequencies and drive levels.
  - Minimum loss is temperature dependent.
    - R (2300 μ @ 100°C)
    - P (2500 μ @ 80°C)
    - F (3000 μ @ 25°C)
  - Measurement taken on ungapped shapes or toroids.
Typical Loss Measurements

- High Perm Ferrites – Loss Factor
  - Indication of the impedance frequency response.
  - Cores are commonly used in common mode chokes.
  - Typically measured at 25°C.
  - Measurement is taken on ungapped shapes or toroids.
Typical Loss Measurements

• Nickel Zinc
  • Commonly found in toroid, tube, multi-hole and cable shield form.
  • Used in EMI Suppression.
  • Low permeability ($80\mu$ to $1700\mu$).
  • Loss Factor and impedance at specific frequencies are common specifications.
Test Procedure and Equipment

- Function Generator – Agilent 33120A
  - Used to create test waveform (Sine wave at desired frequency).
- Amplifier – Amplifier Research
  - Used to amplify test waveform.
- Oscilloscope
  - To monitor current and voltage phase angles for power loss measurement.
- Computer and Custom Program
  - Core information stored in database.
  - Controls testing once cores are loaded in cabinet.
  - Processes information from oscilloscope to calculate watt loss.
  - Can also be operated in manual mode for non-standard cores.
Test Procedure and Equipment

- Function Generator
- Amplifier
- Tuner
- Oscilloscope
- Temperature Cabinet
Test Procedure and Equipment (cont.)

• Temperature Cabinet
  • 32 Cores at a time
  • -60°C to 200°C
Test Procedure and Equipment (cont.)

- **Watt Loss**
  - Cores are wound with two strands bifilar wire.
  - Drive winding and pick up winding.
  - Use Faraday’s Law to calculate # of turns
    - Drive voltage greater than 1 Volt but less than 60 V.
    - Wire size acceptable for signal current.
  - 6 Cores per lot are tested

- **Loss Factor**
  - Cores wound with 10 turns.
  - \( R_s \) and \( L_s \) as well as \( \mu_i \) are measured on an LCR bridge.
Limits and Performance Curves

- Typical performance curves are provided in the catalog.
  - Based on empirical data from toroid tests.
  - Mistake is to use these as limits in design.
    - Spec sheets have the limits.
  - Curve fit equations also available for use in modeling software.
    - Good estimation tool, but curves are most accurate.

P Material Curve (at 100°C)
Limits and Performance Curves

- Limits are defined for each part number.
- Provided on each individual spec sheet.

### ZP-42915-TC

<table>
<thead>
<tr>
<th>CORE LOSSES</th>
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<tbody>
<tr>
<td>$P_L$ max</td>
<td>Production lot limit Max avg</td>
</tr>
<tr>
<td>674 mW</td>
<td>614 mW</td>
</tr>
<tr>
<td>(123 mW/cm³)</td>
<td>(112 mW/cm³)</td>
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### ZW-42915-TC

<table>
<thead>
<tr>
<th>ELECTRICAL LOSSES</th>
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<tbody>
<tr>
<td>$\tan \delta / \mu_i$</td>
<td>Production lot limit Average</td>
</tr>
<tr>
<td>$\leq 3.5 \cdot 10^{-6}$</td>
<td>$\leq 3 \cdot 10^{-6}$</td>
</tr>
<tr>
<td>$\leq 55 \cdot 10^{-6}$</td>
<td>$\leq 45 \cdot 10^{-6}$</td>
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Customer Test Correlation

- Customers typically do not test for watt loss
  - Equipment is not available to them, wouldn’t be useful anyway.
  - Q Factor is a common measurement for power materials.
    - Relates to efficiency of the wound unit.
    - Problem: Measures core and winding properties, not dependent on watt loss alone.
      - Q is not guaranteed by a core supplier, only losses that they are measuring are guaranteed.
- Temperature Rise
  - Source of heat is from losses.
  - Both material and winding losses contribute.
  - In ferrites, wire losses would most likely be the culprit.
- Correlation is the only logical action.
Questions?