A LOW PROFILE HIGH POWER INDUCTOR FOR HIGH RELIABILITY SPACE APPLICATIONS

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MIL-STD-981 OVERVIEW

Design, Manufacturing and Quality Standards for Custom Electromagnetic Devices for Space Applications

Materials and Construction:
- Outgassing per ASTM-E-595
- Dielectric Strength - tapes, films, and Insulating materials
- Magnet Wire – MW-1000 standard, minimum wire size spec
- Internal solder melt temp > 260 °C
- Solder and Flux per J-STD-005 – No pure Tin
- Wire winding & placement
- Terminals – anti-rotation features, twist
- Impregnation and potting – degassing required
POWER INDUCTORS

- Current rating > 1A
- Typically used for energy storage in DC-DC converters and high power filtering applications.
- Core materials and wire selected to achieve desired DCR, AC Loss, frequency response, and inductance value among other specifications.
- Wound on various core and bobbin types, i.e., Toroid, pot cores, E-cores,…
DESIGN CONSIDERATIONS FOR A SPACE GRADE POWER INDUCTOR

- Low Loss
- High saturation current – for transient response
- Low aging – stable electrical characteristics over time
- Wide operating temperature range – -55 to >150°C
- Mechanical Stability – high vibration/shock environments
- Low Outgassing – per NASA/ASTM-E-595
- Low Profile – for limited board space
- SMD packaging – high density routing
COMPONENTS OF THE IHLP INDUCTOR

- 200°C Polyester/Polyamide Insulation
- Copper Wire
- High Reliability Ultrasonic Weld
- Copper Lead-Frame
- Low Loss Iron Powder
DC RESISTANCE (DCR)

Copper losses ($I^2R$ loss) due to the DC resistance of the winding and terminals.

- Frequency independent
- A function of temperature coefficient of the copper wire - increases with temperature

COPPER WIRE:
- Oxygen free Cu
- Polyamide Coating
  - 5KV Breakdown
  - High Temp Operation 200°C

CONTINUOUS LEAD FRAME:
- Oxygen free Cu
- Sn/Pb Plating over Nickel Base Layer
THE CORE MATERIAL

- Base material is a proprietary atomized iron alloy

- Insulating coating is applied to iron particles
  - Insulation provides a distributed gap core
  - Reduces eddy currents and core loss
  - Provides good saturation characteristics
  - A distributed gap reduces EMI

- High temperature epoxy resin is added
  - Strength
  - Durability for thermal & Mechanical stability

Iron Particle

Fe3PO4 Insulation
MANUFACTURING PROCESS

Wind → Lead Frame → Weld

Press → Iron Powder/Resin

Cure → Trim → Form

Test → Tape/Reel
Core Loss vs. Time

Core Losses – Hysteresis and Eddy Current losses related to the magnetic flux density in core.
Saturation Comparison

DC Amps

IHLP

Drum Inductor
Saturation vs Temperature - Ferrites

- Temperature vs Inductance and DC Current
- ISAT @ 25°C, ISAT @ 85°C, ISAT @ 125°C
- Temperature Rise

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CAPACITORS • DIODES • INDUCTORS • MOSFETS • OPTOELECTRONICS • RESISTORS
Saturation VS. Temperature - IHLP

DC Bias (Amps) vs. Inductance (uH)

- 25°C
- 85°C
- 125°C
SUMMARY

- High Current, Low Profile Inductor
- Ultrasonic welding – No solder joints/internal reflow issues
- Solid Lead Frame – Minimal connection points and DCR
- Shock Resistant – Tested to 50G
- SMD
- Mechanical Stability » Electrical Stability
THANK YOU!