Thermal Effects of PoE Phantom Current on Magnetics

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Topics of discussion

- Test setup
- Test results
  - Transformer
  - 4 wire choke
  - Encapsulation materials
- “THERMAL” spreadsheet
- Summary

What causes an increase in temperature

- Exclusively I^2R losses in windings that have phantom current flowing in PoE LAN magnetics.
  - Transformer's secondary winding in a 2 core design (see Figure 1).
  - Shunt choke in a 3 core design (see Figure 2).
  - A shared choke if present (see Figure 3).
  - EMI choke in phantom current circuit (see Figure 4).

Sources of I^2R Losses

Transformer Secondary

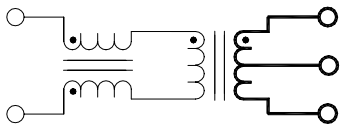


Figure 1.

Shunt Choke

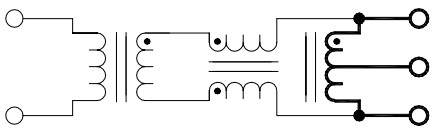


Figure 2.

Shared Choke

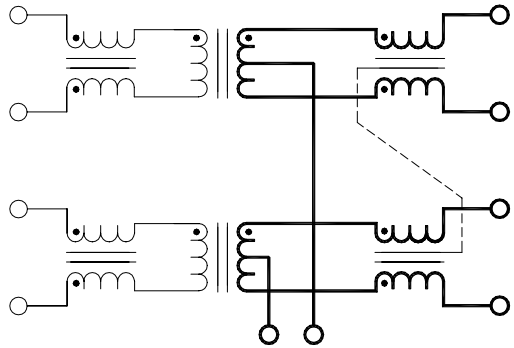


Figure 3.

4 Wire Choke

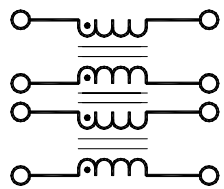


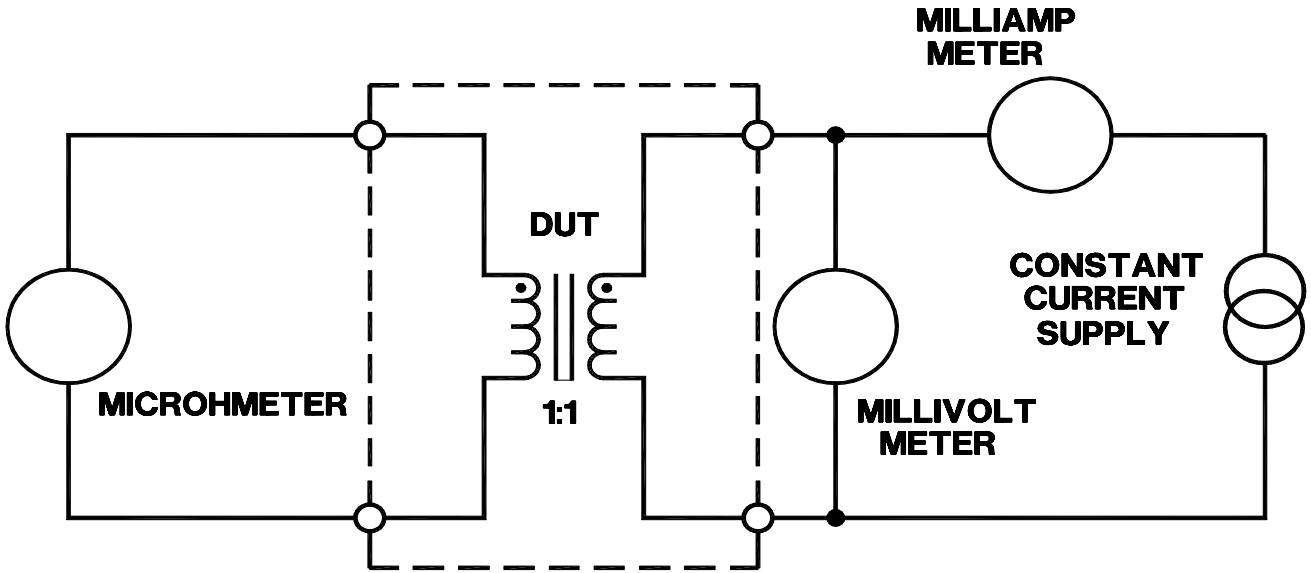
Figure 4.

NOTE: BOLD LINES INDICATE PHANTOM (PoE) CURRENT PATH.

Factors affecting temperature rise

- Current.
- Winding resistance.
  - Core geometry.
  - Wire gauge.
  - Number of turns in winding.
- Encapsulation Material.
- Dimensions of cavity in which the magnetics reside.

Test Setup



1. TEMPERATURE COEFFICIENT OF RESISTANCE IN COPPER WIRE

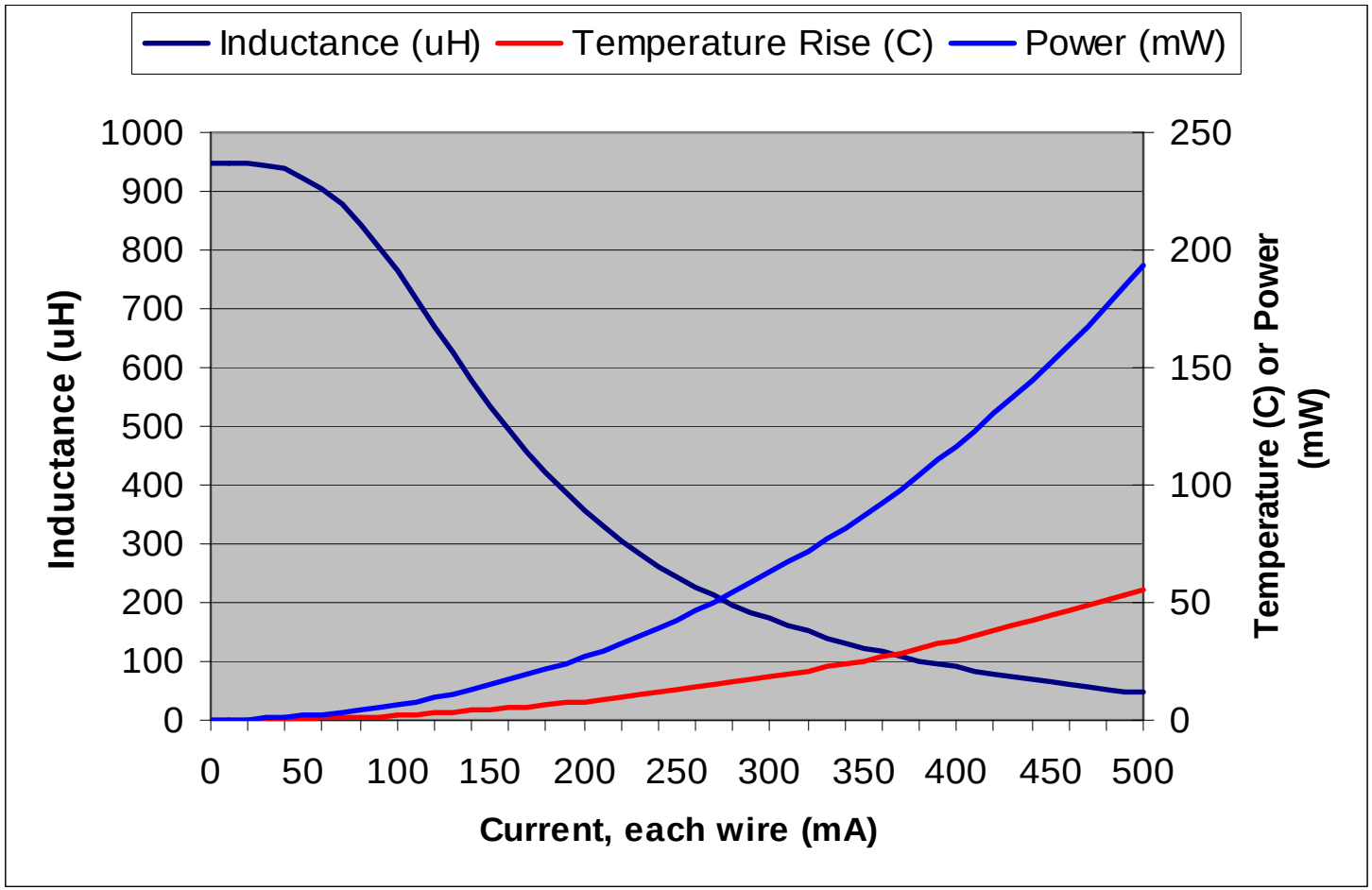
   RESISTANCE (R) = R_{20} ● (1.00393) ● (T – 20))

   WHERE: T = TEMPERATURE IN ^{O}C
   R_{20} = RESISTANCE AT 20 ^{O}C

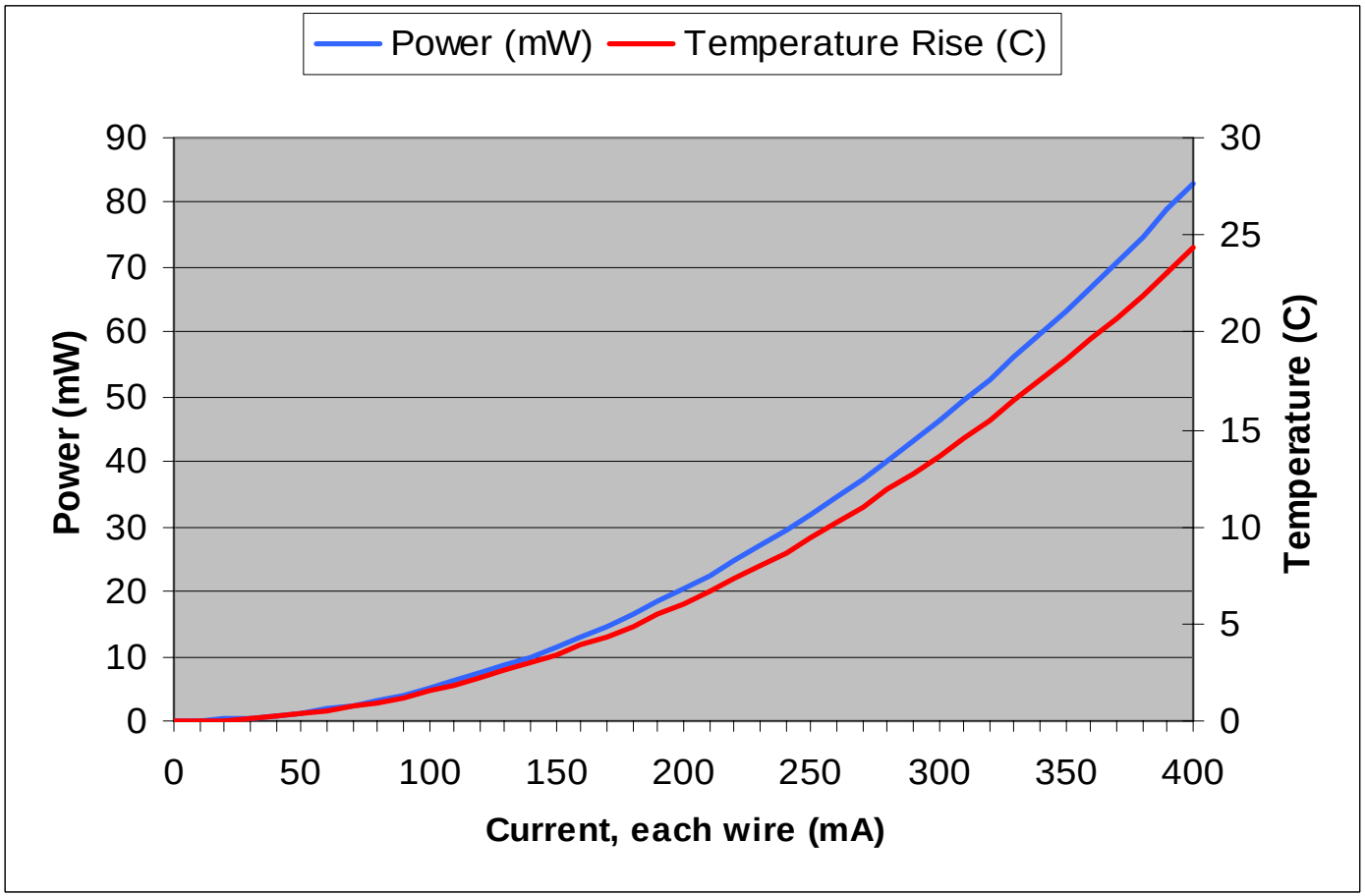
2. CAVITY DIMENSIONS = .500W x .485L x .225H

3. DUT = 1 to 4 TRANSFORMERS

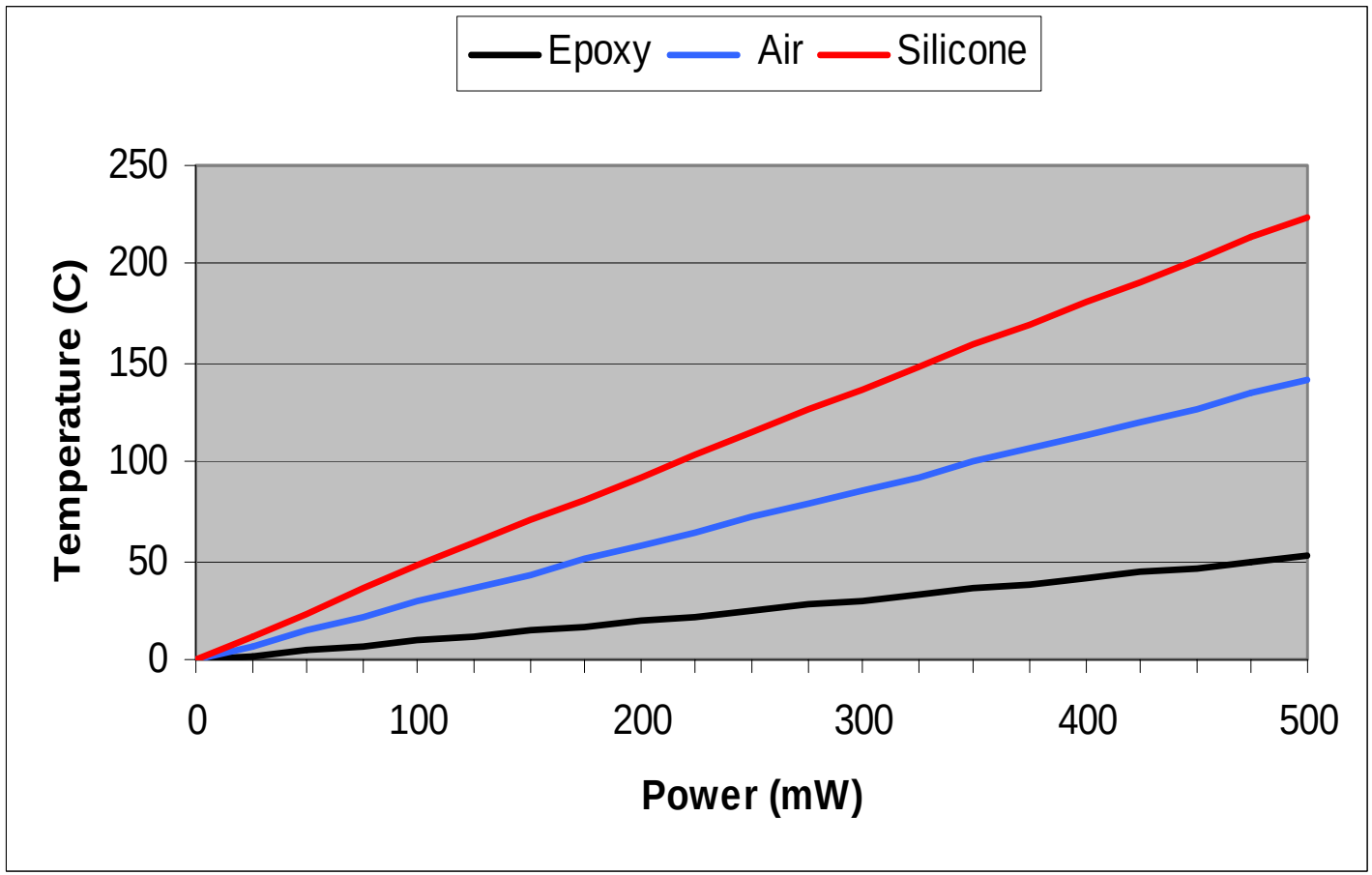
10/100 or Gigabit Transformer



4 Wire Choke


Power (mW)
Temperature Rise (C)
Power (mW)
Temperature (C)
Current, each wire (mA)
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25
30
0
50
100
150
200
250
300
350
400

Encapsulation Medium



"Thermal" spreadsheet

- Tool for predicting temperature rise and transformer inductance resulting from PoE phantom currents.
- Results based on experimental data.
- Shows effect of changing wire gauge and/or core geometries has on temperature rise and space requirements.

Summary

- 175 mA over 4 pairs should result in a 12 ºC worst case increase in internal temperature with 37 AWG wire.
- 350 mA over 2 pairs should result in a 25 ºC worst case increase in internal temperature with 37 AWG wire.
- A more serious problem is the impact increasing PoE current has on the transformer's inductance.