Power inductors improve reliability in high temperature designs

Eaton’s high current FP3 power inductors are designed for high density, medium current applications using a high temperature iron powder core material. These inductors do not exhibit the thermal aging issue frequently associated with iron powder core inductors. In fact the FP3 core is rated for +200 °C without thermal degradation. The FP3 family is rated for +155 °C operation. The calculations below will allow users to take advantage of this high temperature capability.

In the Figure 1 example, a buck regulator will be used to convert a 12 V input to a 5 V output with a load current of 4.5 A. The operating frequency was chosen to be 600 kHz to reduce the size of the filter components, while still maintaining good efficiency. The converter is designed to have 20% ripple current, so a relatively low ESR output filter capacitor will be used, as is typical in switching power supplies.

![Figure 1. Buck regulator](image)

First calculate the needed inductance value:
\[
V = L \cdot \frac{dI}{dt}
\]
where:
- \( V = Vin - Vout \) (voltage across the inductor)
- \( \frac{dT}{dt} = On\ time\ of\ drive = Vout/Vin/frequency \)
- \( \Delta I = Chosen\ above\ to\ be\ 20\% \)

Second calculate the required inductance:
\[
L = \frac{V \cdot \frac{dT}{dt}}{\Delta I} = \frac{(12-5) \cdot (12/5)/600k}{0.2 \cdot 4.5}
\]

\( L = 4.8 \mu H \)

Choose 4.7 \( \mu H \), the nearest standard value

Recalculate ripple current at 23% using 4.7 \( \mu H \)

Third determine peak to peak flux density,
\[
B_{p-p} = K \cdot L \cdot \Delta I
\]
where:
- \( K: K\text{-factor from Table 1} \)
- \( L: Inductance \mu H \)
- \( \Delta I: Peak\ to\ peak\ ripple\ current\ (Amps) \)

\( B_{p-p} = 105 \cdot 4.7 \cdot 0.23 \cdot 4.5 = 510 \text{ Gauss} \)
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### Technical Note

Effective December 2017

#### Part Number K-factor

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<td>FP3-150-R</td>
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**Table 1. K-factor**

Fourth determine the total losses in the inductor:

**Total losses = DC loss + AC loss**

DC loss = $I^2 \times DCR = 4.5^2 \times 0.040 = 0.81$ W (DCR from FP3 datasheet)

AC loss from table at Bp-p of 510 = 0.15 W

Total Loss = DC loss + AC loss = 0.96 W

Finally determine the temperature rise.

Total loss = 0.96 W, using the table,

Temperature rise is 80 °C

Assuming an ambient temperature of +70 °C, The temperature of the inductor is $T = 70 + 80 = 150$ °C

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Note the data assumes no cooling airflow. Cooling will reduce the temperature of the inductor.

The FP3 is rated for +155 °C operation.

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