# IHLP Selection Example

## INPUT

| $L_{REQ}$ | $I_{DC}$ | ΔI | Freq. | $T_{AMB}$ | V-µs | δ |
|---|---|---|---|---|---|---|
| 0.54 µH | 20 A | 7.39 A | 300 kHz | 50 °C | 4.14 | 0.46 |

## IHLP SELECTED

**Step 1.**

| IHLP-4040DZ-01 0.56 µH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| L | DCR | $I_{HEAT}$ | $I_{SAT}$ | $R_{TH}$ | $P_{HEAT}$ | $ET_{100}$ | $K_0$ | $K_1$ |
| 0.56 µH | 0.0017 Ω | 30 A | 49 A | 26.96 °C/W | 1.48 W | 0.88 | 18.31 | 0.00340 |

## VERIFICATION

**Step 2.**

$$B_{PK_{OPER}} = \frac{4.14}{0.88} \text{ x } 100 = 470.5 \text{ G}$$

**Step 3.**

$$f_e = \frac{300\ 000}{2\pi\ (0.46 - 0.46^2)} = 192\ 216.1 \text{ Hz}$$

**Step 4.**

$$P_{CORE} = 18.31 \text{ x } 192\ 216^{0.188} \text{ x } 470.5^{2.118} \text{ x } 300\ 000 \text{ x } 10^{-14} = 0.248 \text{ W}$$

**Step 5.**

The core losses are 0.248 W which is less then $^1/_3$ of $P_{HEAT}$ (0.493 W)

**Step 6.**

$$P_{CUallowed} = 1.48 - 0.248 = 1.32 \text{ W}$$

**Step 7.**

$$R_{OPER} = 0.0017 \text{ x } \left[\frac{274.5 + 50}{259.5}\right] = 0.00213\ \Omega$$

$$P_{DC} = 20^2 \text{ x } 0.00213 = 0.852 \text{ W}$$

$$P_{AC} = 0.00340 \text{ x } 7.39^2 \text{ x } \sqrt{300\ 000} \text{ x } 0.00213 = 0.217 \text{ W}$$

**Step 8.**

$$P_{TOTAL} = 0.248 + 0.852 + 0.217 = 1.317 \text{ W}$$

**Step 9.**

$$\Delta T = 1.317 \text{ x } 26.96 = 35.51 \text{ °C}$$
$$T_{OPER} = 50 + 35.51 = 85.51 \text{ °C}$$

**Step 10.**

$$I_{PEAK} = 20 + \frac{7.39}{2} = 23.7 \text{ A}$$

$I_{SAT}$ = 49 A which is greater then the required 23.7 A

# IHLP Selection Example

## SELECTION CRITERIA

1. Limit core losses ($P_{CORE}$) to ≤ $^1/_3$ of total losses for 40 °C temperature rise ($P_{HEAT}$).
2. Total copper losses allowed will be equal to $P_{HEAT}$ - $P_{CORE}$.
3. Maximum component temperature should be kept ≤ 125 °C, 155 °C for -51 components.
4. Maximum $\Delta T$ should be ≤ 40 °C (this can be exceeded provided caution is taken to insure max. temperature ≤ 125 °C/155 °C).
5. $I_{PEAK} \le I_{SAT}$ (recommended, $I_{PEAK}$ can exceed $I_{SAT}$ with caution due to soft saturation of IHLP product).

## GOVERNING EQUATIONS

1. $$B_{PK_{OPER}} = \frac{ET_{ckt}}{ET_{100}} \times 100 \quad [G]$$
2. $$f_e = \frac{f_0}{2\pi\,(\delta - \delta^2)} \quad [Hz]$$
3. $$P_{CORE} = K_0 f_e^{K_f - 1} B_{pk}^{Kb} \times f_0 \times 10^{-14} \quad [W]$$
4. $$P_{AC} = K_1 \times \Delta I^2 \times \sqrt{f_0} \times R_{OPER} \quad [W]$$
5. $$R_{OPER} = R_{TYP.} \times \left[\frac{274.5 + T_{AMB}}{259.5}\right] \quad [A]$$
6. $$P_{DC} = I^2_{DC} \times R_{OPER} \quad [W]$$
7. $$P_{TOTAL} = P_{CORE} + P_{DC} + P_{AC} \quad [W]$$
8. $$\Delta T = P_{TOTAL} \times R_{TH} \quad [°C]$$
9. $$T_{OPER} = T_{AMB} + \Delta T \quad [°C]$$
10. $$I_{PEAK} = I_{DC} + \frac{\Delta I}{2} \quad [A]$$

**Notes**

(1) Equation #5 assumes a 40 °C temperature rise and will have the same units as $R_{TYP.}$

(2) For equations #3 f in Hz and $B_{PK}$ in G.

(3) $R_{OPER}$ is based on a 40 °C temperature rise.

(4) $K_f$ is 1.188 for -01 material, 1.173 for -11 material, and 1.044 for -51 material.

(5) $K_b$ is 2.118 for -01 material, 2.213 for -11 material, and 2.497 for -51 material.

(6) For IHLP-2525EZ-01 - $K_f$ = 1.181 and $K_b$ = 2.166.

## SELECTION PROCESS

**Note**

- This process assumes that the following is known: Required inductance, frequency, $I_{DC}$, $\Delta I$, $T_{AMB}$, and V-µs (ET) required.

**Step 1.** Select inductor value based on controller data sheet recommendation and current ($I_{DC}$) rating.

**Step 2.** Determine peak operational flux density in Gauss using equation #1.

**Step 3.** Calculate effective frequency using equation #2.

**Step 4.** Determine core loss using equation #3 (see notes #1 and #2) and compare to selection criteria #1.

**Step 5.** If core losses are > $^1/_3$ $P_{HEAT}$ select a larger inductor.

**Step 6.** Use selection criteria #2 to determine allowable copper losses.

**Step 7.** Determine actual copper losses using equations #4, #5 and #6.

**Step 8.** Use equation #7 for total losses.

**Step 9.** Determine $\Delta T$ using equation #8 and insure $T_{OPER}$ ≤ 125 °C (155 °C for -51 material) using equation #9.

**Step 10.** Verify $I_{PEAK}$ is less then $I_{SAT}$ using equation #10 for the selected part (see selection criteria #5).

## DEFINITIONS

| | |
|---|---|
| $ET_{ckt}$ | V-µs product of the circuit |
| $ET_{100}$ | V-µs product at 100 Gauss from table #1 |
| $P_{CORE}$ | Core losses in W |
| $P_{DC}$ | Losses due to the $D_{CR}$ of the inductor copper winding in W |
| $K_0$ | IHLP core constant from table #1 |
| $f_0$ | Switching frequency in Hz |
| $R_{TH}$ | Thermal gradient of IHLP from Table #1 |
| $f_e$ | Effective frequency in Hz |
| $\delta$ | Duty cycle |
| $P_{AC}$- | Losses in the coil due to AC effects |
| $K_1$- | AC loss constant from Table #1 |