Transformer Design

Magnetics offers two methods to select a ferrite core for a power application.

CORE SELECTION BY POWER HANDLING CAPACITY

The Power Chart characterizes the power handling capacity of each ferrite core based upon the frequency of operation, the circuit topology, the flux level selected, and the amount of power required by the circuit. If these four specifics are known, the core can be selected from the Power Chart on page 64.

CORE SELECTION BY WaAc PRODUCT

The power handling capacity of a transformer core can also be determined by its WaAc product, where Wa is the available core window area, and Ac is the effective core cross-sectional area. Using the equation shown below, calculate the WaAc product and then use the Area Product Distribution (WaAc) Chart to select the appropriate core.

$$WaAc = \frac{P_o D_{cma}}{K_t B_{max} f}$$

WaAc = Product of window area and core area (cm^4)

P_o = Power Out (watts)

D_{cma} = Current Density (cir. mils/amp) Current density can be selected depending upon the amount of heat rise allowed. 750 cir. mils/amp is conservative; 500 cir. mils is aggressive.

B_{max} = Flux Density (gauss) selected based upon frequency of operation. Above 20 kHz, core losses increase. To operate ferrite cores at higher frequencies, it is necessary to operate the core flux levels lower than ± 2 kg. The Flux Density vs. Frequency chart shows the reduction in flux levels required to maintain 100 mW/cm^3 core losses at various frequencies, with a maximum temperature rise of 25°C. for a typical power material, MAGNETICS P.

A_c = Core area in cm^2

f = frequency (hertz)

K_t = Topology constant (for a space factor of 0.4)

V = Voltage

I_p = Primary current

I_s = Secondary current

N_p = Number of turns on the primary

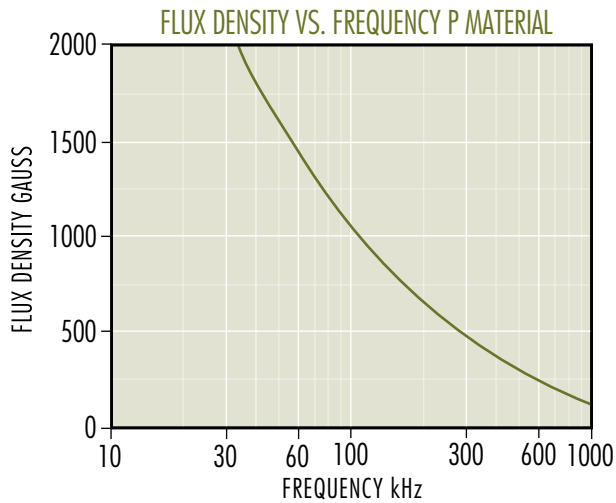
N_S = Number of turns on the secondary

TOPOLOGY CONSTANTS K_t

Forward converter = 0.0005
Half-bridge = 0.0014
Flyback = 0.00033 (single winding)
Push-Pull = 0.001
Full-bridge = 0.0014
Flyback = 0.00025 (multiple winding)

For individual cores, WaAc is listed in this catalog under "Magnetic Data."

The WaAc formula was obtained from derivations in Chapter 7 of A. I. Pressman's book, "Switching Power Supply Design. Choice of B_{max} at various frequencies, D_{cma} and alternative transformer temperature rise calculations are also discussed in Chapter 7 of the Pressman book.



Once a core is chosen, the calculation of primary and secondary turns and wire size is readily accomplished.

$$N_p = \frac{V_p \times 10^8}{4BA_c f} \qquad N_s = \frac{V_s}{V_p} N_p$$

$$I_p = \frac{P_{in}}{V_{in}} \qquad I_s = \frac{P_{out}}{V_{out}}$$

$KWa = N_p A_{wp} + N_s A_{ws}$

Where

A_{wp} = primary wire area $\qquad A_{ws}$ = secondary wire area

Assume K = .4 for toroids; .6 for pot cores and E-U-I cores

Assume $N_p A_{wp} = 1.1\ N_s A_{ws}$ to allow for losses and feedback winding

$$\text{efficiency } e = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{P_{out} + \text{wire losses} + \text{core losses}}$$

$$\text{Voltage Regulation (\%)} = \frac{|V_{no\ load}| - |V_{full\ load}|}{|V_{full\ load}|} \times 100$$