Lecture # 21/22, 11/19/21

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- Today

  →

— Summarize 4 constraints

$$\boxed{\begin{aligned} n I_{max} &\approx B_{max} \frac{l_g}{\mu_0} \\ L &\approx \frac{\mu_0 A_c n^2}{l_g} \\ K_u W_A &\geq n A_w \\ R &= \rho \frac{n (MLT)}{A_w} \end{aligned}}$$

A_c, W_A, MLT : core geometry

I_{max}, B_{max}, μ_0, K_u, R, ρ : knowns / specs

$\underbrace{n,\ l_g,\ A_w}$: unknowns

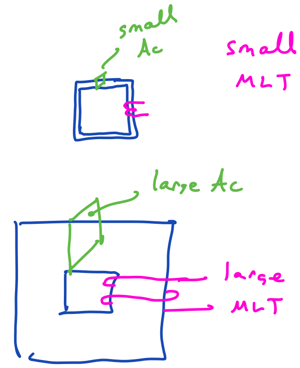
→ Strategy to solve:
Eliminate 3 unknowns to get
1 eqn w/ other quantities

— Core Geometrical Constant "K_g"

Eliminate n, l_g, A_w to get ... skip algebra

$$\underbrace{\frac{A_c^2 W_A}{(MLT)}}_{\text{fcn of geometry}} \geq \underbrace{\frac{\rho L^2 I_{max}^2}{B_{max}^2 R K_u}}_{\text{known specs}}$$

$$\overbrace{\text{"}K_g\text{"}} = \frac{A_c^2 W_A}{MLT}$$



K_g is a FOM which is $\propto$ to core physical size

smaller core ... how?

- use material w/ higher B_{sat}
- allow for larger $R \Rightarrow$ more copper loss

- Step by Step Procedure:

units for formulas

ρ [ ]

I_{max} [ ]

L [ ]

R [ ]

K_u [ ]

B_{max} [ ]

A_c [cm^2]

W_A [cm^2]

(MLT) [cm]

Step #1) Pick core big enough

$$K_g \geq \frac{\rho L^2 I_{max}^2}{B_{max}^2 R K_u} 10^8 \quad \text{in } [cm^5]$$

Step #2) Pick air gap

$$l_g = \frac{\mu_0 L I_{max}^2}{B_{max}^2 A_c} 10^4 \quad \text{in } [m]$$

Step #3) Pick turns

$$n = \text{round}\left(\frac{L I_{max}}{B_{max} A_c} 10^4\right)$$

Step #4) Check wire size

$$A_w \leq \frac{K_u W_A}{n} \quad \text{in } [cm^2]$$

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$R =$

— Thoughts

- Procedure above accounts for saturation, fill factor limits, etc.

- Sanity checks

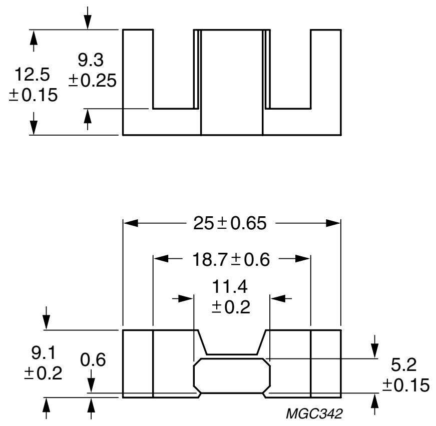
1)

2)

CORES

Effective core parameters

SYMBOL	PARAMETER	VALUE	UNIT
$\Sigma(I/A)$	core factor (C1)	1.00	mm^{-1}
V_e	effective volume	3300	mm^3
l_e	effective length	57.0	mm
A_e	effective area	58.0	mm^2
A_{min}	minimum area	55.0	mm^2
m	mass of core half	≈ 8	g



Dimensions in mm.

Fig.1 EFD25/13/9 core half.

Core halves and sets

A_L measured as a set or in combination with a non-gapped core half, clamping force for A_L measurements, 40 ±20 N.

GRADE	A_L (nH)	μ_e	AIR GAP (μm)	TYPE NUMBER
3C90	160 ±3%	≈ 125	≈ 570	EFD25/13/9-3C90-A160
	250 ±3%	≈ 196	≈ 320	EFD25/13/9-3C90-A250
	315 ±5%	≈ 246	≈ 240	EFD25/13/9-3C90-A315
	400 ±8%	≈ 313	≈ 180	EFD25/13/9-3C90-A400
	630 ±10%	≈ 493	≈ 100	EFD25/13/9-3C90-A630
	2200 ±25%	≈ 1720	≈ 0	EFD25/13/9-3C90
3C94	160 ±3%	≈ 125	≈ 570	EFD25/13/9-3C94-A160
	250 ±3%	≈ 196	≈ 320	EFD25/13/9-3C94-A250
	315 ±5%	≈ 246	≈ 240	EFD25/13/9-3C94-A315
	400 ±8%	≈ 313	≈ 180	EFD25/13/9-3C94-A400
	630 ±10%	≈ 493	≈ 100	EFD25/13/9-3C94-A630
	2200 ±25%	≈ 1720	≈ 0	EFD25/13/9-3C94
3C95 des	2660 ±25%	≈ 2085	≈ 0	EFD25/13/9-3C95
3C96 des	2000 ±25%	≈ 1560	≈ 0	EFD25/13/9-3C96

GRADE	A_L (nH)	μ_e	AIR GAP (μm)	TYPE NUMBER
3F3	160 ±3%	≈ 125	≈ 570	EFD25/13/9-3F3-A160
	250 ±3%	≈ 196	≈ 320	EFD25/13/9-3F3-A250
	315 ±5%	≈ 246	≈ 240	EFD25/13/9-3F3-A315
	400 ±8%	≈ 313	≈ 180	EFD25/13/9-3F3-A400
	630 ±10%	≈ 493	≈ 100	EFD25/13/9-3F3-A630
	2000 ±25%	≈ 1560	≈ 0	EFD25/13/9-3F3
3F35 des	1500 ±25%	≈ 1170	≈ 0	EFD25/13/9-3F35
3F4 des	160 ±3%	≈ 125	≈ 500	EFD25/13/9-3F4-A160
	250 ±3%	≈ 196	≈ 270	EFD25/13/9-3F4-A250
	315 ±5%	≈ 246	≈ 290	EFD25/13/9-3F4-A315
	400 ±8%	≈ 313	≈ 130	EFD25/13/9-3F4-A400
	630 ±10%	≈ 493	≈ 60	EFD25/13/9-3F4-A630
	1000 ±25%	≈ 780	≈ 0	EFD25/13/9-3F4
3F45 prot	1000 ±25%	≈ 780	≈ 0	EFD25/13/9-3F45

Properties of core sets under power conditions

GRADE	B (mT) at	CORE LOSS (W) at				
	H = 250 A/m; f = 25 kHz; T = 100 °C	f = 25 kHz; $\hat{B}$ = 200 mT; T = 100 °C	f = 100 kHz; $\hat{B}$ = 100 mT; T = 100 °C	f = 100 kHz; $\hat{B}$ = 200 mT; T = 25 °C	f = 100 kHz; $\hat{B}$ = 200 mT; T = 100 °C	f = 400 kHz; $\hat{B}$ = 50 mT; T = 100 °C
3C90	≥330	≤ 0.35	≤ 0.38	–	–	–
3C94	≥330	–	≤ 0.30	–	≤ 1.8	–
3C95	≥330	–	–	≤ 1.95	≤ 1.85	–
3C96	≥330	–	≤ 0.22	–	≤ 1.4	≤ 0.6
3F35	≥300	–	–	–	–	≤ 0.28
3F3	≥315	–	≤ 0.38	–	–	≤ 0.66
3F4	≥300	–	–	–	–	–

Properties of core sets under power conditions (continued)

GRADE	B (mT) at	CORE LOSS (W) at				
	H = 250 A/m; f = 25 kHz; T = 100 °C	f = 500 kHz; $\hat{B}$ = 50 mT; T = 100 °C	f = 500 kHz; $\hat{B}$ = 100 mT; T = 100 °C	f = 1 MHz; $\hat{B}$ = 30 mT; T = 100 °C	f = 1 MHz; $\hat{B}$ = 50 mT; T = 100 °C	f = 3 MHz; $\hat{B}$ = 10 mT; T = 100 °C
3C90	≥330	–	–	–	–	–
3C94	≥330	–	–	–	–	–
3C95	≥330	–	–	–	–	–
3C96	≥330	≤ 1.2	–	–	–	–
3F35	≥300	≤ 0.42	≤ 3.4	–	–	–
3F3	≥315	–	–	–	–	–
3F4	≥300	–	–	≤ 1.0	–	≤ 1.6
3F45	≥300	–	–	≤ 0.75	≤ 2.8	≤ 1.25

Our cores look like