

Switched Mode Power Conversion

Semester II Academic Year 2025-26

Lecture 34

17th April 2026

Unapped Core

$$R = \frac{l_m}{\mu_r \mu_0 A_c}$$

$$\lambda = \frac{\mu_0 \mu_r A_c}{l_m}$$

$$L = N^2 \lambda$$

$$B = \mu_0 \mu_r H$$

$$H l_m = N i$$

$$A_c A_w = \frac{2 F_{Lpk}}{K_c K_w B_{pk}}$$

Unapped Core

$$R = \frac{l_m}{\mu_r \mu_0 A_c} \quad \Lambda = \frac{\mu_r \mu_0 A_c}{l_m} \quad L = N^2 \Lambda \quad B = \mu_r \mu_0 H$$

$$H l_m = N i \quad A_c A_w = \frac{2 F_{Lpk}}{K_c K_w B_{pk}}$$

$$L = 0.216 \text{ mH} \quad I_{avg} = 20 \text{ A} \quad \Delta i_L = 20\% \text{ of } I_{avg} = 0.2 \times 20 = 4 \text{ A}$$

$$I_{Lpk} = I_{avg} + 0.5 \Delta i_L = 22 \text{ A} \quad I_{Lrms} = \sqrt{I_{avg}^2 + \frac{\Delta i_L^2}{12}} = 20.03 \text{ A}$$

$$K_c = \frac{I_{Lpk}}{I_{Lrms}} = \frac{22}{20.03} = 1.1 \quad E_{Lpk} = \frac{1}{2} \times 0.216 \times 22^2 \times 10^{-3} \\ = 0.0522 \text{ J}$$

Unapped Core

$$L = 0.216 \text{ mH} \quad I_{\text{avg}} = 20 \text{ A}$$

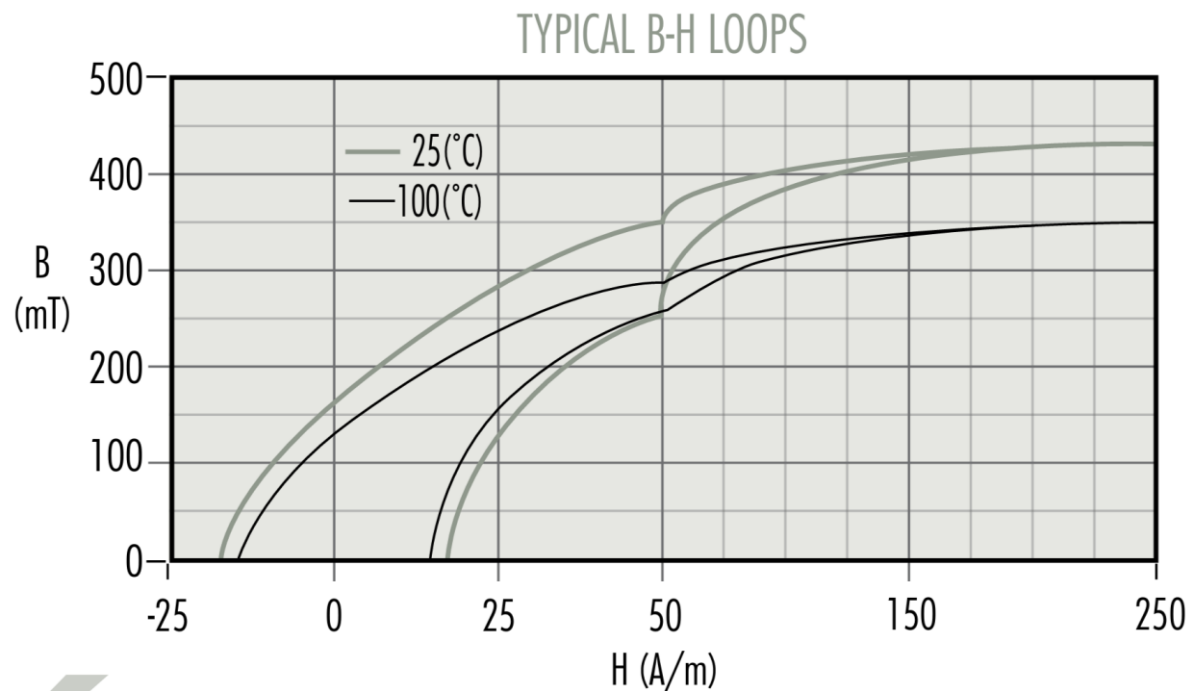
$$\Delta i_L = 20\% \text{ of } I_{\text{avg}} = 0.2 \times 20 = 4 \text{ A}$$

$$I_{\text{Lpk}} = I_{\text{avg}} + 0.5 \Delta i_L = 22 \text{ A}$$

$$I_{\text{Lrms}} = \sqrt{I_{\text{Lavg}}^2 + \frac{\Delta i_L^2}{12}} = 20.03 \text{ A}$$

$$K_c = \frac{I_{\text{Lpk}}}{I_{\text{Lrms}}} = \frac{22}{20.03} = 1.1$$

$$E_{\text{Lpk}} = \frac{1}{2} \times 0.216 \times 22^2 \times 10^{-3} \\ = 0.0522 \text{ J}$$



$$B_{\text{pk}} = 0.3 \text{ T} \quad B_{\text{sat}} = 0.47 \text{ T}$$

$$\mu_i = 2500 \quad [\text{Zero DC bias relative permeability}]$$

Unapped Core

$$B_{pk} = 0.3 T$$

$$B_{sat} = 0.47 T$$

$$J = 5 A/mm^2$$

$$\mu_i = 2500 \quad [\text{Zero DC bias relative permeability}]$$

$$K_w = 0.3$$

$$\text{Area product} = \frac{2 E_{lph}}{K_c K_w J B_{pk}} = 21.2 \text{ cm}^4$$

$$\text{Area of conductor} = \frac{I_{rms}}{J} = \frac{20.03}{5} = 4 \text{ mm}^2$$

$$\underline{SWG = 13} \quad \underline{A_{con} = 4.3 \text{ mm}^2}$$

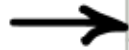
Ungapped Core (Toroidal)



		MAGNETIC DATA						HARDWARE
SIZE (mm)	ORDERING CODE	I_e (mm)	A_e (mm ²)	V_e (mm ³)	Window Area (cm ²)	W_{Ac} (cm ⁴)	Weight (grams/pc)	Headers & Mounts
49.1 x 33.8 x 15.9	O_44916TC	127	120	15,298	8.99	10.6	75.3	TVH49164A
49.1 x 31.8 x 15.9	O_44920TC	123.2	135.4	16,676	7.94	9.45	83	TVH49164A
49.1 x 31.8 x 19.05	O_44925TC	123	162	20,000	7.94	12.8	98	TVH49164A
49.1 x 33.8 x 31.3	O_44932TC	127	237	30,100	8.99	21.2	150.6	TVH49164A
60.96 x 41.78 x 12.7	O_46013TC	157.6	120.4	18,968	13.68	16.48	94	
60.96 x 41.78 x 19.05	O_46019TC	157.6	180.5	28,453	13.68	24.7	141	
61 x 35.6 x 12.7	O_46113TC	144.6	157.4	22,774	9.93	15.5	113	TVH49164A
63 x 38 x 24.5	O_46325TC	152	300	45,598	11.1	33.2	225	TVH49164A
63 x 38 x 24.5	O_46326TC	152	300	45,600	11.3	33.9	225	TVH49164A
73.7 x 38.9 x 12.5	O_47313TC	165	210	34,771	11.9	25	172	
73.7 x 38.9 x 25.2	O_47325TC	165	423	70,099	11.9	50.3	347	
73.7 x 38.9 x 25.4	O_47326TC	165	427	70,595	11.9	50.8	350	
85.7 x 55.5 x 12.7	O_48613TC	214.9	188.8	40,582	24.2	45.7	201	
85.7 x 55.5 x 19.05	O_48619TC	215	283	60,874	24.2	68.4	302	
85.7 x 55.5 x 25.4	O_48625TC	215	375	80,700	24.2	90.8	399	
85.7 x 55.5 x 25.4	O_48626TC	215	377	81,165	24.2	91.2	402	
102 x 65.8 x 15	O_49715TC	255.3	267.2	68,821	34	90.8	341	
107 x 65 x 18	O_49718TC	259.31	370.27	96,013	28.6	106	475	
107 x 65 x 25	O_49725TC	259.31	514.3	133,351	33.2	171	660	
140 x 106 x 25	O_49740TC	381.5	422.3	161,086	88.2	372	797	

$$\Lambda = 5.86 \mu\text{H/turn}^2$$

Ungapped Core (Toroidal)

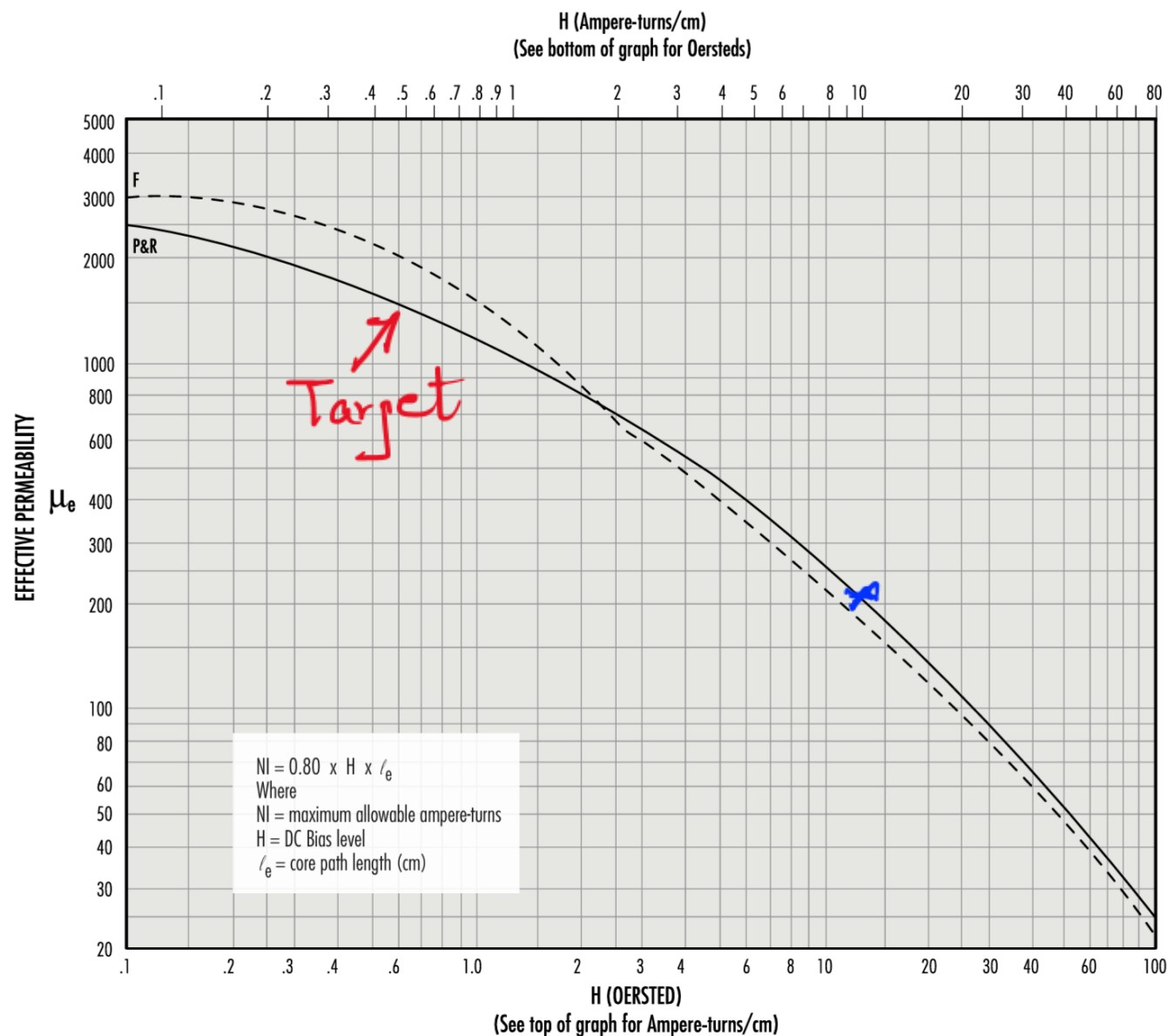


SIZE (mm)	ORDERING CODE	Y	Z	NOMINAL A_L (mH/1000T)					
				R $\pm$ 25%	P $\pm$ 25%	F $\pm$ 20%	T $\pm$ 25%	J $\pm$ 20%	W $\pm$ 30%
49.1 x 33.8 x 15.9	0_44916TC		✓	2,710	2,950	3,540		5,900	11,800
49.1 x 31.8 x 15.9	0_44920TC		✓	2,790	3,032	3,640		6,065	12,130
49.1 x 31.8 x 19.05	0_44925TC		✓	3,420	3,718	4,460		7,435	14,870
49.1 x 33.8 x 31.3	0_44932TC		✓	5,430	5,900	7,080		11,800	23,600
60.96 x 41.78 x 12.7	0_46013TC		✓		1,960			4,800	9,483
60.96 x 41.78 x 19.05	0_46019TC		✓					7,100	
61 x 35.6 x 12.7	0_46113TC		✓	3,140	3,491	4,107		6,845	13,690
63 x 38 x 24.5	0_46325TC		✓						21,056
63 x 38 x 24.5	0_46326TC		✓	5,770	6,270	7,530		12,500	
73.7 x 38.9 x 12.5	0_47313TC		✓	3,700	4,024	4,880	5,790	8,140	16,280
73.7 x 38.9 x 25.2	0_47325TC		✓	7,400	8,050	9,760		16,280	
73.7 x 38.9 x 25.4	0_47326TC		✓						27,610
85.7 x 55.5 x 12.7	0_48613TC		✓	2,510	2,726	3,310		5,520	11,040
85.7 x 55.5 x 19.05	0_48619TC		✓						14,900
85.7 x 55.5 x 25.4	0_48625TC		✓	5,040	5,480	6,570		10,960	
85.7 x 55.5 x 25.4	0_48626TC		✓						18,760
102 x 65.8 x 15	0_49715TC		✓	3,025	3,464	3,945		6,575	11,178
107 x 65 x 18	0_49718TC		✓	4,127	4,486	5,383		8,972	15,252
107 x 65 x 25	0_49725TC		✓	5,732	6,230	7,477		12,461	21,184
140 x 106 x 25	0_49740TC		✓	3,200	3,477	4,173		6,955	11,823

$$L = 5.9 \mu\text{H}/\text{turn}^2$$

$$N = \sqrt{\frac{L}{\lambda}} = 6$$

Un-gapped Core (Toroidal)



$$H = \frac{NI}{l_m(\text{cm})} = 10.4 \text{ Aturns/cm}$$

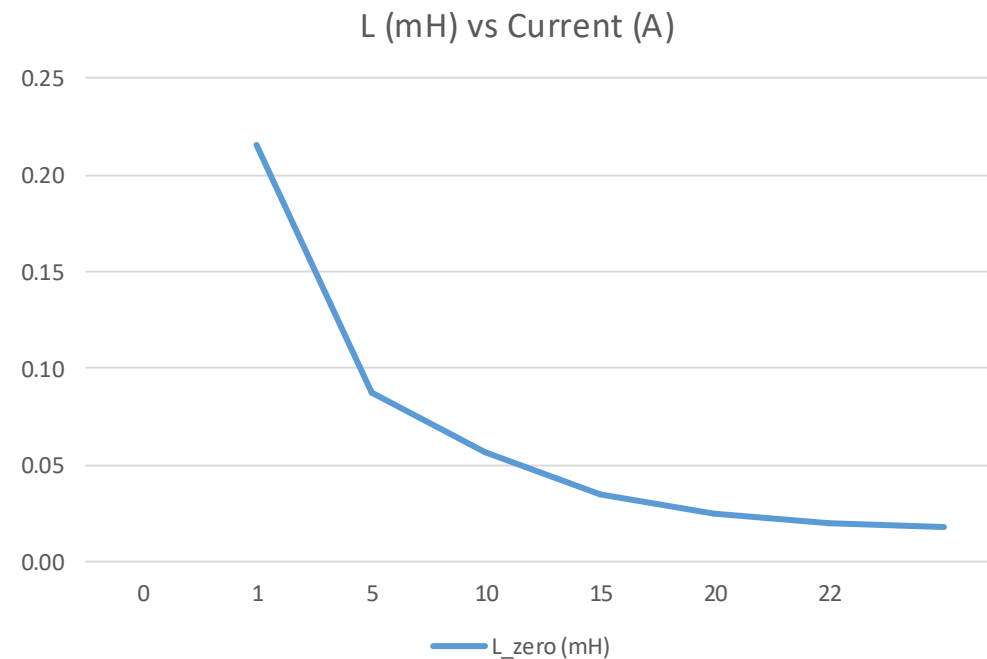
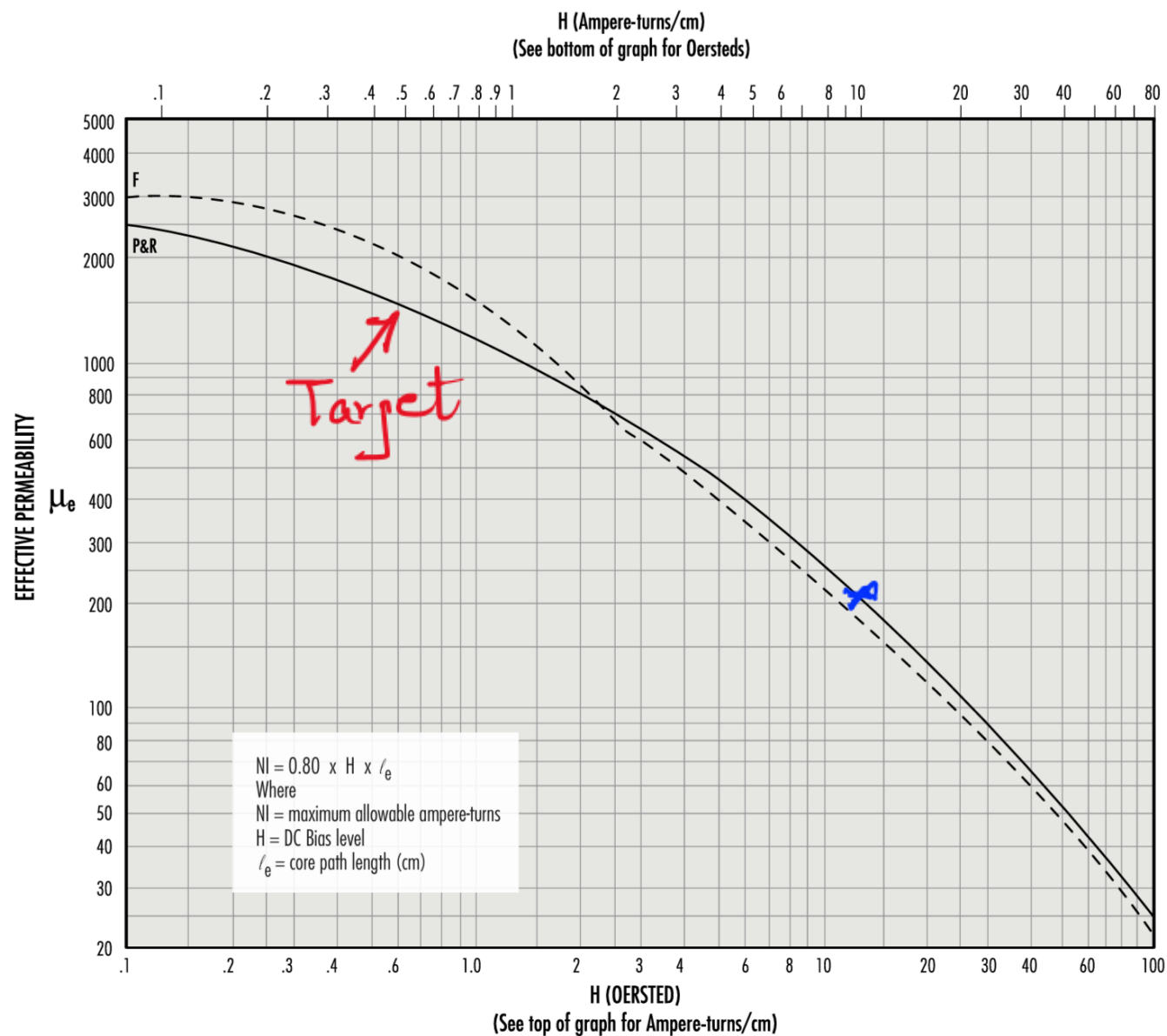
$$\mu_r \approx 205$$

$$L_{\text{actual}} = 0.02 \text{ mH}$$

$$H = \frac{NI}{l_m} = 1039 \text{ A/m}$$

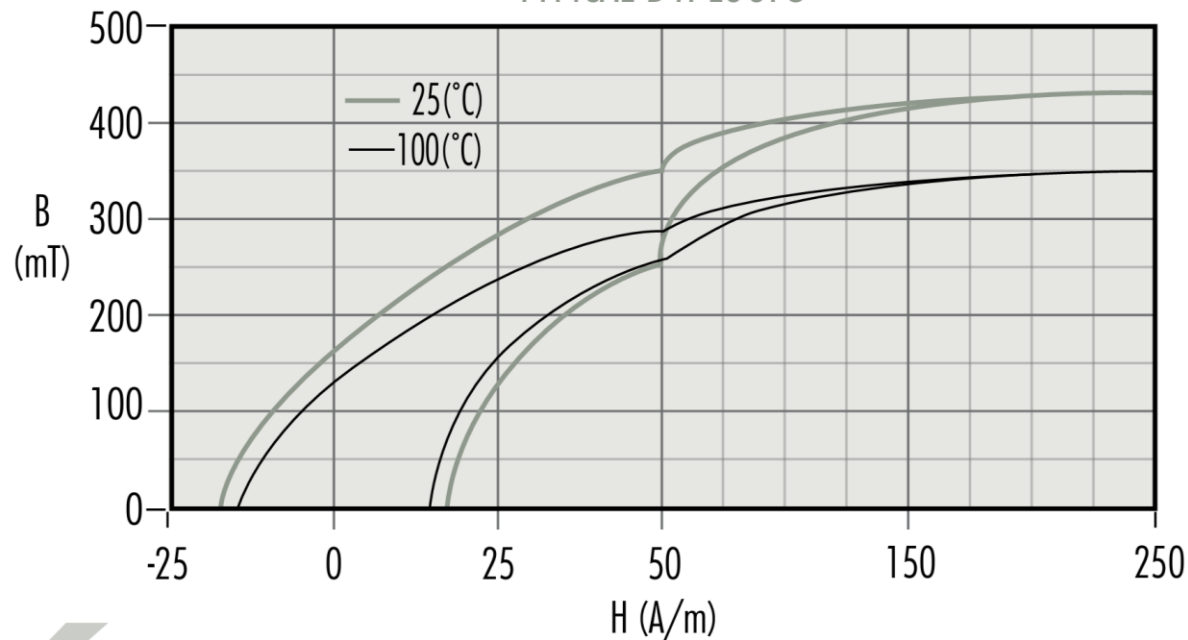
Core will saturate

Unapped Core (Toroidal)



Ungapped Core (Toroidal)

TYPICAL B-H LOOPS

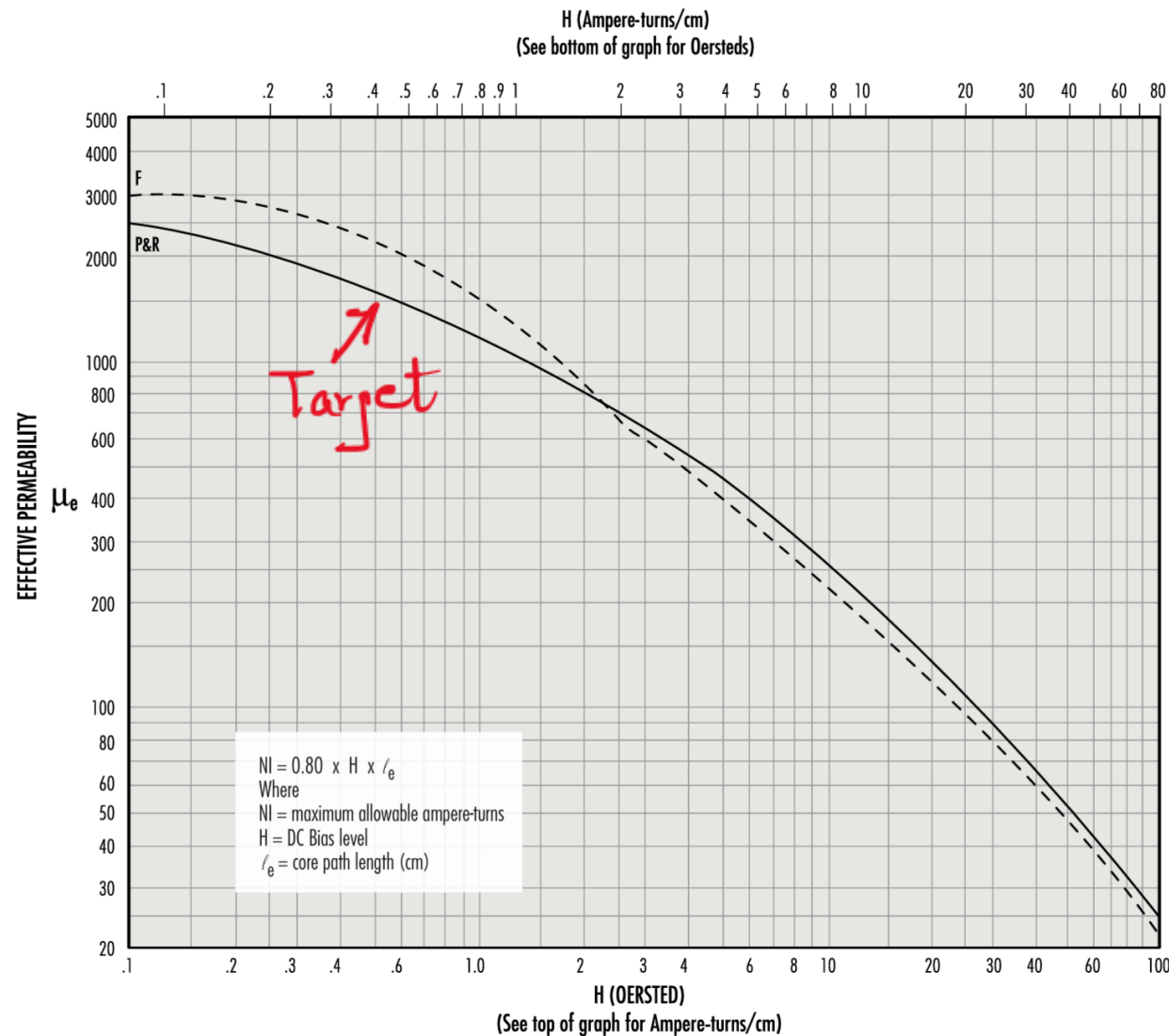


$$B_{pk} = 0.3T$$

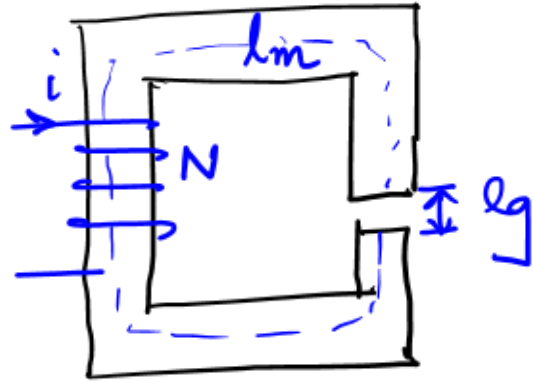
$$\mu_r = 1500$$

$$H \approx 50 \text{ A/m}$$

$$0.5 \text{ A/cm}$$



Gapped Core



$$N i = H_m l_m + H_g l_g = H l_e \quad l_e = l_m + l_g$$

$$\Rightarrow \frac{B}{\mu_0 \mu_r} l_m + \frac{B}{\mu_0} l_g = \frac{B}{\mu_0 \mu_e} l_e$$

$$\Rightarrow \frac{l_e}{\mu_e} = \frac{l_m}{\mu_r} + l_g$$

$$\Rightarrow \mu_e = \frac{l_e}{\frac{l_m}{\mu_r} + l_g}$$

$$L = \frac{\mu_0 \mu_e N^2}{l_e}$$

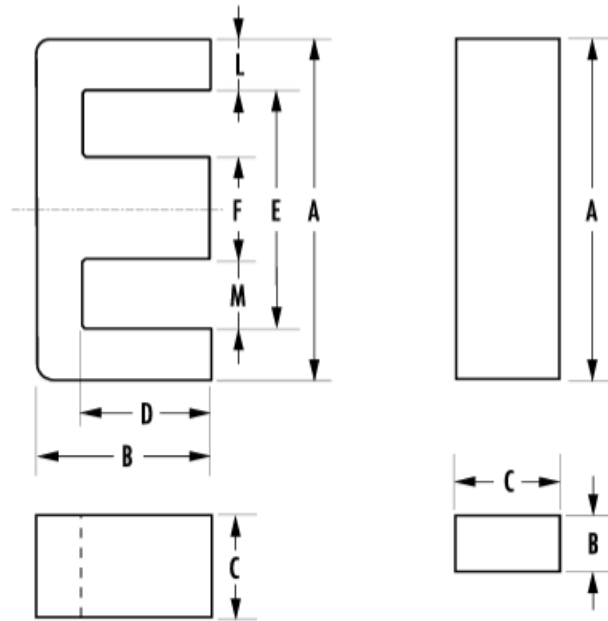
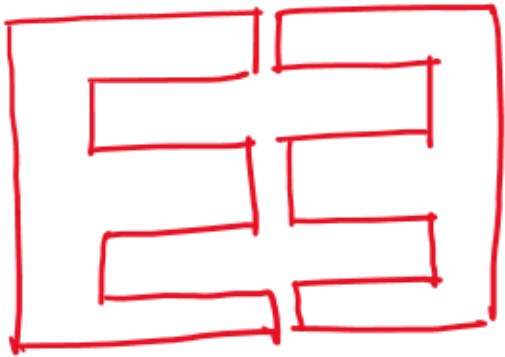
$$H_m = \frac{N i}{l_m} - \frac{H_g l_g}{l_m}$$

$$\Rightarrow H_m = \frac{N i}{l_m} - \frac{B l_g}{\mu_0 l_m}$$

Gapped Core

→ Air gap not possible in toroidal core

→ Possible in EE core



Gapped Core

TYPE/SIZE	ORDERING CODE	MAGNETIC DATA						HARDWARE
		l_e (mm)	A_e (mm ²)	A_e min (mm ²)	V_e (mm ³)	$W_a A_c$ (cm ⁴)	Weight (grams per set)	Bobbins
E 40/17/11	O_44011EC	76.7	127	114	9,780	1.26	49	
E 42/21/9	O_44016EC	98.4	107	106	10,500	1.65	52	
E 43/21/15	O_44020EC	97.0	178	175	17,300	3.55	87	PCB4020N1
I 43/6/15	O_44020IC	67.1	177	176	11,900	1.36	60	PCB4020N1
E 43/21/20	O_44022EC	97.0	233	233	22,700	4.22	114	PCB4022N1
E 42/33/20	O_44033EC	145	236	234	34,200	6.36	164	
E 41/17/12	O_44317EC	77.0	149	142	11,500	1.88	57	PCB4317M1
E 47/20/16	O_44721EC	88.9	234	226	20,800	3.3	103	PCB4721M1
E 56/28/21	O_45528EC	124	353	345	44,000	9.78	212	PCB5528WC
E 56/28/25	O_45530EC	123	420	411	52,000	12.1	255	PCB5530FA
E 56/24/19	O_45724EC	107	337	337	36,000	6.98	179	PCB5724M1
E 60/22/16	O_46016EC	110	248	240	27,200	5.74	135	
E 60/31/22	O_46022EC	139	402	401	55,900	21.0	200	
E 65/32/27	O_46527EC	147	540	530	79,000	23.5	410	00B652701
E 70/33/32	O_47133EC	149	683	676	102,000	23.3	495	
E 72/28/19	O_47228EC	137	368	363	50,300	15.0	250	00B722801
E 80/38/20	O_48020EC	184	392	392	72,300	31.6	357	00B8020B1
E 100/59/27	O_49928EC	274	738	692	202,000	90.6	980	

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Gapped Core

Max. B



Hm, Hg



Ni



μ_r, μ_e



L