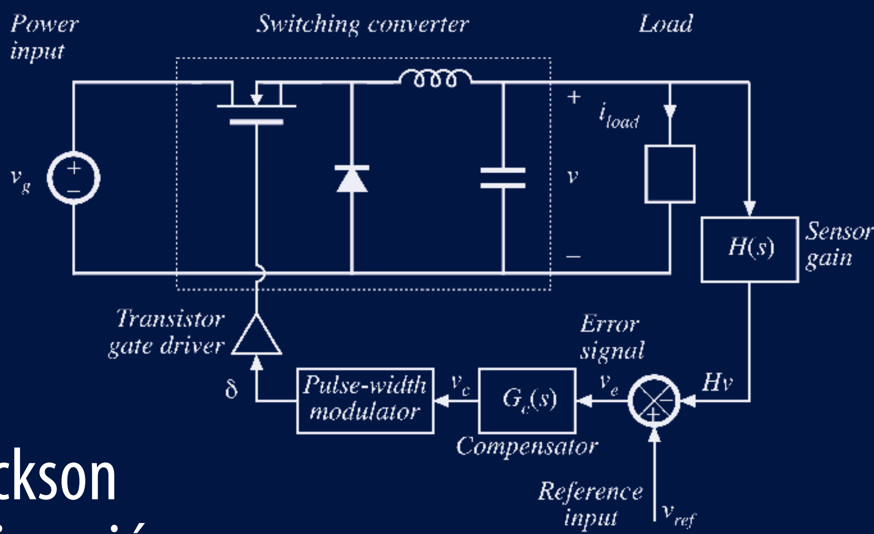

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Fundamentals of Power Electronics

Third Edition

Springer

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ISBN 978-3-030-43879-1 ISBN 978-3-030-43881-4 (eBook)
https://doi.org/10.1007/978-3-030-43881-4

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

B

Magnetics Design Tables

Geometrical data for several standard ferrite core shapes are listed here. The geometrical constant K_g is a measure of core size, useful for designing inductors and transformers that attain a given copper loss [99]. The K_g method for inductor design is described in Chap. 11. K_g is defined as

$$K_g = \frac{A_c^2 W_A}{MLT} \tag{B.1}$$

where A_c is the core cross-sectional area, W_A is the window area, and MLT is the winding mean-length-per-turn. The geometrical constant K_{gfe} is a similar measure of core size, which is useful for designing ac inductors and transformers when the total copper plus core loss is constrained. The K_{gfe} method for magnetics design is described in Chap. 12. K_{gfe} is defined as

$$K_{gfe} = \frac{W_A A_c^{2(1-1/\beta)}}{MLT\ \ell_m^{2/\beta}} u(\beta) \tag{B.2}$$

where ℓ_m is the core mean magnetic path length, and β is the core loss exponent:

$$P_{fe} = K_{fe} B_{max}^{\beta} \tag{B.3}$$

For modern ferrite materials, β typically lies in the range 2.6 to 2.8. The quantity $u(\beta)$ is defined as

$$u(\beta) = \left[\left(\frac{\beta}{2}\right)^{-\left(\frac{\beta}{\beta+2}\right)} + \left(\frac{\beta}{2}\right)^{\left(\frac{2}{\beta+2}\right)} \right]^{-\left(\frac{\beta+2}{\beta}\right)} \tag{B.4}$$

$u(\beta)$ is equal to 0.305 for $\beta = 2.7$. This quantity varies by roughly 5% over the range $2.6 \leq \beta \leq 2.8$. Values of K_{gfe} are tabulated for $\beta = 2.7$; variation of K_{gfe} over the range $2.6 \leq \beta \leq 2.8$ is typically quite small.

Thermal resistances are listed in those cases where published manufacturer's data are available. The thermal resistances listed are the approximate temperature rise from the center leg of the core to ambient, per watt of total power loss. Different temperature rises may be observed under conditions of forced air cooling, unusual power loss distributions, etc. Listed window areas are the winding areas for conventional single-section bobbins.

R. W. Erickson, D. Maksimović, *Fundamentals of Power Electronics*,
https://doi.org/10.1007/978-3-030-43881-4

An American Wire Gauge table is included at the end of this appendix.

B.1 Pot Core Data

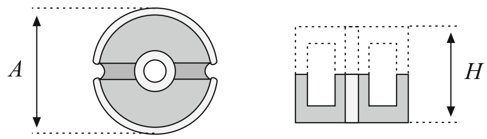

Fig. B.1 Pot core

Core type (*AH*) (mm)	Geometrical constant K_g cm^5	Geometrical constant K_{gfe} cm^x	Cross-sectional area A_c (cm^2)	Bobbin winding area W_A (cm^2)	Mean length per turn *MLT* (cm)	Magnetic path length ℓ_m (cm)	Thermal resistance R_{th} (°C/W)	Core weight (g)
704	$0.738 \cdot 10^{-6}$	$1.61 \cdot 10^{-6}$	0.070	$0.22 \cdot 10^{-3}$	1.46	1.0		0.5
905	$0.183 \cdot 10^{-3}$	$256 \cdot 10^{-6}$	0.101	0.034	1.90	1.26		1.0
1107	$0.667 \cdot 10^{-3}$	$554 \cdot 10^{-6}$	0.167	0.055	2.30	1.55		1.8
1408	$2.107 \cdot 10^{-3}$	$1.1 \cdot 10^{-3}$	0.251	0.097	2.90	2.00	100	3.2
1811	$9.45 \cdot 10^{-3}$	$2.6 \cdot 10^{-3}$	0.433	0.187	3.71	2.60	60	7.3
2213	$27.1 \cdot 10^{-3}$	$4.9 \cdot 10^{-3}$	0.635	0.297	4.42	3.15	38	13
2616	$69.1 \cdot 10^{-3}$	$8.2 \cdot 10^{-3}$	0.948	0.406	5.28	3.75	30	20
3019	0.180	$14.2 \cdot 10^{-3}$	1.38	0.587	6.20	4.50	23	34
3622	0.411	$21.7 \cdot 10^{-3}$	2.02	0.748	7.42	5.30	19	57
4229	1.15	$41.1 \cdot 10^{-3}$	2.66	1.40	8.60	6.81	13.5	104

B.2 EE Core Data

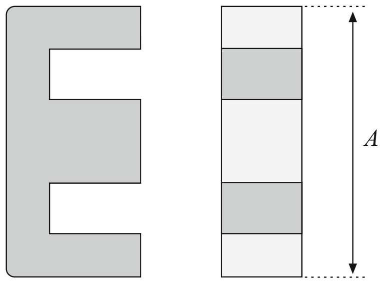

Fig. B.2 EE core

Core type (A) (mm)	Geometrical constant K_g (cm^5)	Geometrical constant K_{gfe} (cm^x)	Cross-sectional area A_c (cm^2)	Bobbin winding area W_A (cm^2)	Mean length per turn MLT (cm)	Magnetic path length ℓ_m (cm)	Core weight (g)
EE12	$0.731 \cdot 10^{-3}$	$0.458 \cdot 10^{-3}$	0.14	0.085	2.28	2.7	2.34
EE16	$2.02 \cdot 10^{-3}$	$0.842 \cdot 10^{-3}$	0.19	0.190	3.40	3.45	3.29
EE19	$4.07 \cdot 10^{-3}$	$1.3 \cdot 10^{-3}$	0.23	0.284	3.69	3.94	4.83
EE22	$8.26 \cdot 10^{-3}$	$1.8 \cdot 10^{-3}$	0.41	0.196	3.99	3.96	8.81
EE30	$85.7 \cdot 10^{-3}$	$6.7 \cdot 10^{-3}$	1.09	0.476	6.60	5.77	32.4
EE40	0.209	$11.8 \cdot 10^{-3}$	1.27	1.10	8.50	7.70	50.3
EE50	0.909	$28.4 \cdot 10^{-3}$	2.26	1.78	10.0	9.58	116
EE60	1.38	$36.4 \cdot 10^{-3}$	2.47	2.89	12.8	11.0	135
EE70/68/19	5.06	$75.9 \cdot 10^{-3}$	3.24	6.75	14.0	18.0	280

B.3 EC Core Data

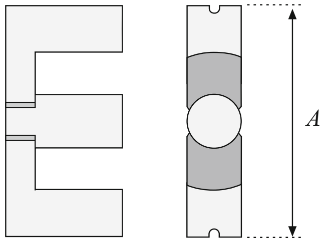

Fig. B.3 EC core

Core type (A) (mm)	Geometrical constant K_g (cm^5)	Geometrical constant K_{gfe} (cm^x)	Cross-sectional area A_c (cm^2)	Bobbin winding area W_A (cm^2)	Mean length per turn MLT (cm)	Magnetic path length ℓ_m (cm)	Thermal resistance R_{th} (°C/W)	Core weight (g)
EC35	0.131	$9.9 \cdot 10^{-3}$	0.843	0.975	5.30	7.74	18.5	35.5
EC41	0.374	$19.5 \cdot 10^{-3}$	1.21	1.35	5.30	8.93	16.5	57.0
EC52	0.914	$31.7 \cdot 10^{-3}$	1.80	2.12	7.50	10.5	11.0	111
EC70	2.84	$56.2 \cdot 10^{-3}$	2.79	4.71	12.9	14.4	7.5	256

B.4 ETD Core Data

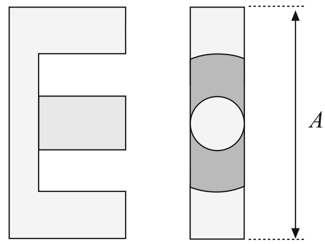

Fig. B.4 ETD core

Core type (A) (mm)	Geometrical constant K_g (cm^5)	Geometrical constant K_{gfe} (cm^x)	Cross-sectional area A_c (cm^2)	Bobbin winding area W_A (cm^2)	Mean length per turn MLT (cm)	Magnetic path length ℓ_m (cm)	Thermal resistance R_{th} (°C/W)	Core weight (g)
ETD29	0.0978	$8.5 \cdot 10^{-3}$	0.76	0.903	5.33	7.20		30
ETD34	0.193	$13.1 \cdot 10^{-3}$	0.97	1.23	6.00	7.86	19	40
ETD39	0.397	$19.8 \cdot 10^{-3}$	1.25	1.74	6.86	9.21	15	60
ETD44	0.846	$30.4 \cdot 10^{-3}$	1.74	2.13	7.62	10.3	12	94
ETD49	1.42	$41.0 \cdot 10^{-3}$	2.11	2.71	8.51	11.4	11	124

B.5 PQ Core Data

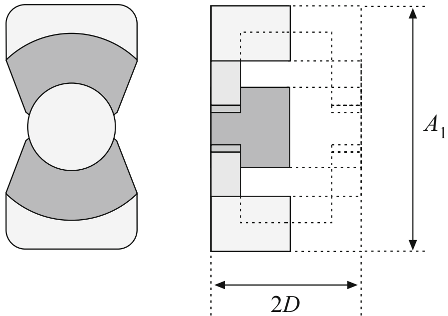

Fig. B.5 PQ core

Core type $(A_1/2D)$ (mm)	Geometrical constant K_g (cm^5)	Geometrical constant K_{gfe} (cm^x)	Cross-sectional area A_c (cm^2)	Bobbin winding area W_A (cm^2)	Mean length per turn MLT (cm)	Magnetic path length ℓ_m (cm)	Core weight (g)
PQ20/16	$22.4 \cdot 10^{-3}$	$3.7 \cdot 10^{-3}$	0.62	0.256	4.4	3.74	13
PQ20/20	$33.6 \cdot 10^{-3}$	$4.8 \cdot 10^{-3}$	0.62	0.384	4.4	4.54	15
PQ26/20	$83.9 \cdot 10^{-3}$	$7.2 \cdot 10^{-3}$	1.19	0.333	5.62	4.63	31
PQ26/25	0.125	$9.4 \cdot 10^{-3}$	1.18	0.503	5.62	5.55	36
PQ32/20	0.203	$11.7 \cdot 10^{-3}$	1.70	0.471	6.71	5.55	42
PQ32/30	0.384	$18.6 \cdot 10^{-3}$	1.61	0.995	6.71	7.46	55
PQ35/35	0.820	$30.4 \cdot 10^{-3}$	1.96	1.61	7.52	8.79	73
PQ40/40	1.20	$39.1 \cdot 10^{-3}$	2.01	2.50	8.39	10.2	95

B.6 American Wire Gauge Data

AWG #	Bare area, 10^{-3} cm^2	Resistance, 10^{-6} Ω/cm	Diameter, cm
0000	1072.3	1.608	1.168
000	850.3	2.027	1.040
00	674.2	2.557	0.927
0	534.8	3.224	0.825
1	424.1	4.065	0.735
2	336.3	5.128	0.654
3	266.7	6.463	0.583
4	211.5	8.153	0.519
5	167.7	10.28	0.462
6	133.0	13.0	0.411
7	105.5	16.3	0.366
8	83.67	20.6	0.326
9	66.32	26.0	0.291
10	52.41	32.9	0.267
11	41.60	41.37	0.238
12	33.08	52.09	0.213
13	26.26	69.64	0.190
14	20.02	82.80	0.171
15	16.51	104.3	0.153
16	13.07	131.8	0.137
17	10.39	165.8	0.122
18	8.228	209.5	0.109
19	6.531	263.9	0.0948
20	5.188	332.3	0.0874
21	4.116	418.9	0.0785
22	3.243	531.4	0.0701
23	2.508	666.0	0.0632
24	2.047	842.1	0.0566
25	1.623	1062.0	0.0505
26	1.280	1345.0	0.0452
27	1.021	1687.6	0.0409
28	0.8046	2142.7	0.0366
29	0.6470	2664.3	0.0330

(continued)

AWG #	Bare area, 10^{-3} cm^2	Resistance, 10^{-6} Ω/cm	Diameter, cm
30	0.5067	3402.2	0.0294
31	0.4013	4294.6	0.0267
32	0.3242	5314.9	0.0241
33	0.2554	6748.6	0.0236
34	0.2011	8572.8	0.0191
35	0.1589	10849	0.0170
36	0.1266	13608	0.0152
37	0.1026	16801	0.0140
38	0.08107	21266	0.0124
39	0.06207	27775	0.0109
40	0.04869	35400	0.0096
41	0.03972	43405	0.00863
42	0.03166	54429	0.00762
43	0.02452	70308	0.00685
44	0.0202	85072	0.00635

PRINCIPLES OF POWER ELECTRONICS

Second Edition

(Preliminary Draft KPVS22-12-6)

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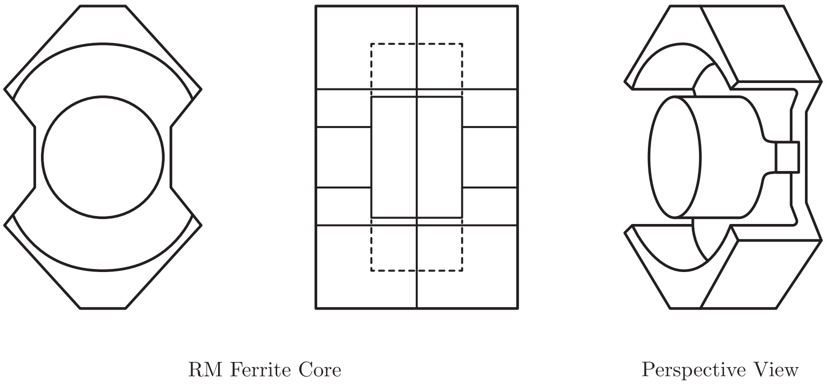

Figure 20.2 Representative core shape for the RM family of ferrite cores. The illustration shows the geometry of the RM8, RM10 and RM12 cores.

Core factor, which has units of linear dimension to the fifth power (e.g., m^5), expresses a geometrical property of a magnetic core. Given a design requirement for a filter inductor as expressed by the left side of (20.15), we know the minimum value of K_g that a core must have to implement the inductor. A designer may calculate K_g for a given core from data sheet information, or leverage pre-tabulated values of K_g, which are available for a variety of cores. For example, Table 20.1 shows a variety of data about the RM (Rectangular Modular) family of ferrite cores, including the core factor K_g. The physical structure of RM-type cores is illustrated in Fig. 20.2. The core halves are designed to clamp around a toroidal bobbin and winding such that the inductor presents an approximately square footprint. The cylindrical centerpost may be machined down on one or both core halves to provide a gap for energy storage.

Core	Effective Magnetic Path Length ℓ_c (mm)	Effective Core Area $A_{c,e}$ (mm^2)	Minimum Core Area $A_{c,\min}$ (mm^2)	Core Window Area $W_{A,c}$ (mm^2)	Bobbin Window Area $W_{A,b}$ (mm^2)	Bobbin Mean Turn Length ℓ_t (mm)
RM4	22.7	14.0	10.7	15.6	7.7	20
RM5	22.4	23.7	17.3	18.2	9.5	25
RM6	28.6	36.6	30.2	26.0	15	30
RM8	38.0	64.0	53.5	48.9	30.0	42
RM10	44.0	98.0	86.6	69.5	41.5	52
RM12	56.9	140	121	110	73.0	61
RM14	70.0	178	165	155	107	71.5

Core	Effective Core Volume $V_{c,e}$ (mm^3)	Core Set Weight (g)	Effective Surface Area $A_{s,e}$ (mm^2)	Thermal Resistance R_{th} (°C/W)	Core Area Product $A_{c,e}W_{A,b}$ (mm^4)	Core Factor K_g $A^2_{c,\min}W_{A,b}/\ell_t$ (mm^5)
RM4	318	1.7	586	86	1.1×10^{2}	4.4×10^{1}
RM5	530	3.0	787	69	2.3×10^{2}	1.1×10^{2}
RM6	1050	5.5	1130	60	5.5×10^{2}	4.6×10^{2}
RM8	2430	13	2020	38	1.92×10^{3}	2.0×10^{3}
RM10	4310	23	2960	30	4.07×10^{3}	6.0×10^{3}
RM12	7970	42	4460	23	1.02×10^{4}	1.8×10^{4}
RM14	12500	74	6820	19	1.90×10^{4}	4.07×10^{4}

Table 20.1 Core Data for the RM (Rectangular Modular) family of ferrite cores.