Appendix D

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 [1]. The K_g method for inductor design is described in Chapter 14. K_g is defined as

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

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 Chapter 15. K_{gfe} is defined as

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

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

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

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

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

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

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

D.1 POT CORE DATA

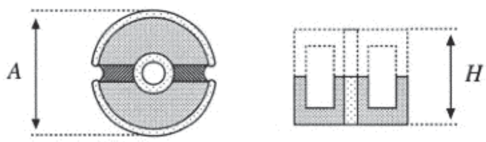

Fig. D.1

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	$0.738\cdot10^{-6}$	$1.61\cdot10^{-6}$	0.070	$0.22\cdot10^{-3}$	1.46	1.0		0.5
905	$0.183\cdot10^{-3}$	$256\cdot10^{-6}$	0.101	0.034	1.90	1.26		1.0
1107	$0.667\cdot10^{-3}$	$554\cdot10^{-6}$	0.167	0.055	2.30	1.55		1.8
1408	$2.107\cdot10^{-3}$	$1.1\cdot10^{-3}$	0.251	0.097	2.90	2.00	100	3.2
1811	$9.45\cdot10^{-3}$	$2.6\cdot10^{-3}$	0.433	0.187	3.71	2.60	60	7.3
2213	$27.1\cdot10^{-3}$	$4.9\cdot10^{-3}$	0.635	0.297	4.42	3.15	38	13
2616	$69.1\cdot10^{-3}$	$8.2\cdot10^{-3}$	0.948	0.406	5.28	3.75	30	20
3019	0.180	$14.2\cdot10^{-3}$	1.38	0.587	6.20	4.50	23	34
3622	0.411	$21.7\cdot10^{-3}$	2.02	0.748	7.42	5.30	19	57
4229	1.15	$41.1\cdot10^{-3}$	2.66	1.40	8.60	6.81	13.5	104

D.2 EE CORE DATA

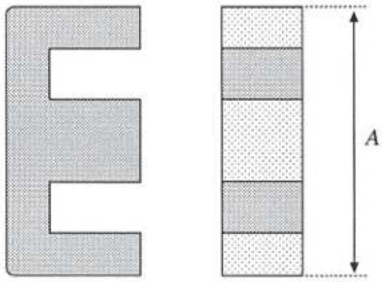

Fig. D.2

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

D.3 EC CORE DATA

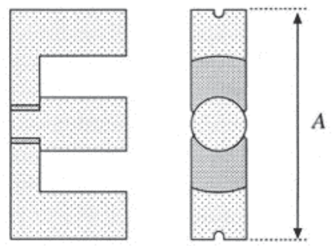

Fig. D.3

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

D.4 ETD CORE DATA

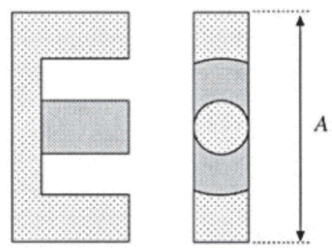

Fig. D.4

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

D.5 PQ CORE DATA

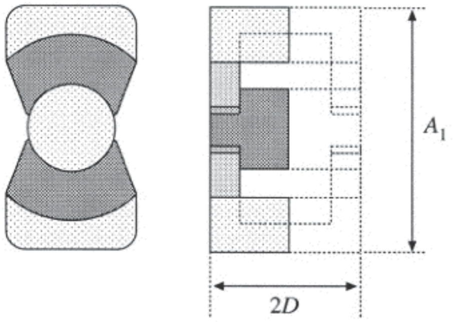

Fig. D.5

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)
PQ 20/16	$22.4\cdot10^{-3}$	$3.7\cdot10^{-3}$	0.62	0.256	4.4	3.74	13
PQ 20/20	$33.6\cdot10^{-3}$	$4.8\cdot10^{-3}$	0.62	0.384	4.4	4.54	15
PQ 26/20	$83.9\cdot10^{-3}$	$7.2\cdot10^{-3}$	1.19	0.333	5.62	4.63	31
PQ 26/25	0.125	$9.4\cdot10^{-3}$	1.18	0.503	5.62	5.55	36
PQ 32/20	0.203	$11.7\cdot10^{-3}$	1.70	0.471	6.71	5.55	42
PQ 32/30	0.384	$18.6\cdot10^{-3}$	1.61	0.995	6.71	7.46	55
PQ 35/35	0.820	$30.4\cdot10^{-3}$	1.96	1.61	7.52	8.79	73
PQ 40/40	1.20	$39.1\cdot10^{-3}$	2.01	2.50	8.39	10.2	95

D.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

References

[1] C. W. T. McLyman, *Transformer and Inductor Design Handbook,* Second edition, New York: Marcel Dekker, 1988.

[2] *Ferrite Materials and Components Catalog,* Philips Components.