# Appendix 2

# 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 which attain a given copper loss [1]. The $K_g$ method for inductor design is described in Chapter 13. $K_g$ is defined as

$$K_g = \frac{A_c^2 W_A}{MLT} \tag{A2.1}$$

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 14. $K_{gfe}$ is defined as

$$K_{gfe} = \frac{W_A \; A_c^{2(1-1/\beta)}}{MLT \; l_e^{2/\beta}} \; u(\beta) \tag{A2.2}$$

where $l_e$ is the core mean magnetic path length, and $\beta$ is the core loss exponent:

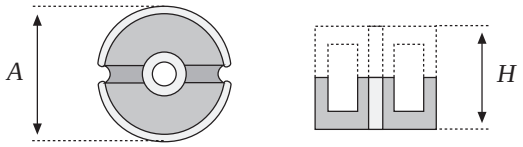
$$P_{fe} = K_{fe} B_{\max}^{\beta} \tag{A2.3}$$

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

$$u(\beta) = \left[ \left( \frac{\beta}{2} \right)^{-\left( \frac{\beta}{\beta+2} \right)} + \left( \frac{\beta}{2} \right)^{\left( \frac{2}{\beta+2} \right)} \right]^{-\left( \frac{\beta+2}{\beta} \right)} \tag{A2.4}$$

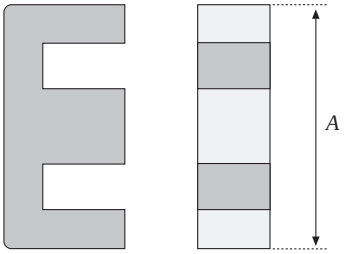
$u(\beta)$ is equal to 0.305 for $\beta = 2.7$. This quantity varies by roughly 5% over the range $2.6 \leq \beta \leq 2.8$. Values of $K_{gfe}$ are tabulated for $\beta = 2.7$; variation of $K_{gfe}$ over the range $2.6 \leq \beta \leq 2.8$ is typically quite small.

## A2.1 Pot core data



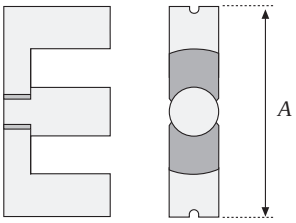

| Core type (*AH*) (mm) | Geometrical constant $K_g$ $cm^5$ | Geometrical constant $K_{gfe}$ $cm^x$ | Cross-sectional area $A_c$ ($cm^2$) | Bobbin winding area $W_A$ ($cm^2$) | Mean length per turn *MLT* (cm) | Magnetic path length $l_m$ (cm) | Thermal resistance $R_{th}$ (°C/W) | Core weight (g) |
|---|---|---|---|---|---|---|---|---|
| 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 |

## A2.2 EE core data



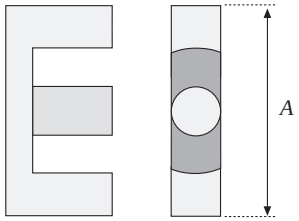

| Core type (*A*) (mm) | Geometrical constant $K_g$ $cm^5$ | Geometrical constant $K_{gfe}$ $cm^x$ | Cross-sectional area $A_c$ ($cm^2$) | Bobbin winding area $W_A$ ($cm^2$) | Mean length per turn $MLT$ (cm) | Magnetic path length $l_m$ (cm) | Core weight (g) |
|---|---|---|---|---|---|---|---|
| EE12 | $0.731 \cdot 10^{-3}$ | $0.458 \cdot 10^{-3}$ | 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 | $127 \cdot 10^{-3}$ | 3.24 | 6.75 | 14.0 | 9.0 | 280 |

## A2.3 EC core data



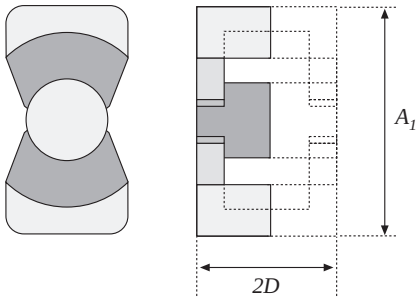

| Core type (*A*) (mm) | Geometrical constant $K_g$ $cm^5$ | Geometrical constant $K_{gfe}$ $cm^x$ | Cross-sectional area $A_c$ ($cm^2$) | Bobbin winding area $W_A$ ($cm^2$) | Mean length per turn $MLT$ (cm) | Magnetic path length $l_m$ (cm) | Thermal resistance $R_{th}$ (°C/W) | Core weight (g) |
|---|---|---|---|---|---|---|---|---|
| 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 |

## A2.4 ETD core data




| 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 |

## A2.5 PQ core data




| Core type ($A_1$/2*D*) (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 | $22.4 \cdot 10^{-3}$ | $3.7 \cdot 10^{-3}$ | 0.62 | 0.256 | 4.4 | 3.74 | 13 |
| PQ 20/20 | $33.6 \cdot 10^{-3}$ | $4.8 \cdot 10^{-3}$ | 0.62 | 0.384 | 4.4 | 4.54 | 15 |
| PQ 26/20 | $83.9 \cdot 10^{-3}$ | $7.2 \cdot 10^{-3}$ | 1.19 | 0.333 | 5.62 | 4.63 | 31 |
| PQ 26/25 | 0.125 | $9.4 \cdot 10^{-3}$ | 1.18 | 0.503 | 5.62 | 5.55 | 36 |
| PQ 32/20 | 0.203 | $11.7 \cdot 10^{-3}$ | 1.70 | 0.471 | 6.71 | 5.55 | 42 |
| PQ 32/30 | 0.384 | $18.6 \cdot 10^{-3}$ | 1.61 | 0.995 | 6.71 | 7.46 | 55 |
| PQ 35/35 | 0.820 | $30.4 \cdot 10^{-3}$ | 1.96 | 1.61 | 7.52 | 8.79 | 73 |
| PQ 40/40 | 1.20 | $39.1 \cdot 10^{-3}$ | 2.01 | 2.50 | 8.39 | 10.2 | 95 |

## A2.6 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 |
| 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 |