

WS 19.1 Magnetic fields of coils

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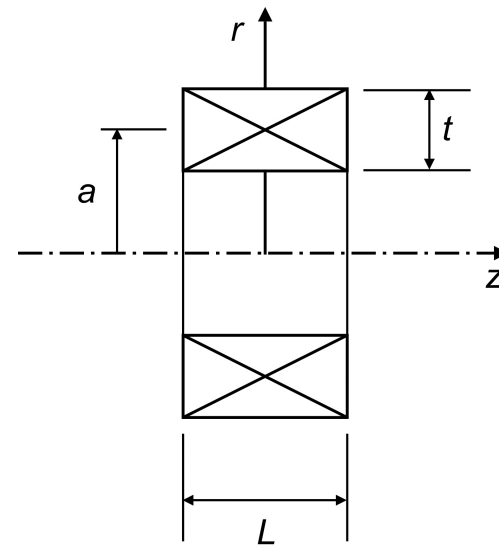
This Mathcad 14 worksheet is designed to accompany the author's book "Microwave and RF Vacuum Electronic Power Sources", Cambridge University Press (2018). The section, equation, and figure numbers refer to the corresponding sections, equations, and figures in the book. Data input fields are highlighted in yellow and output fields are highlighted in green.

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This worksheet calculates the flux density on the axis of simple circular coils.
See Section 19.5.

The variables are normalised to unit radius, unit current and to the flux density at the origin of a thin circular loop.



Thin circular loop

$$B_0(z) := \left(1 + z^2\right)^{-\frac{3}{2}}$$

Equation 19.28

$$z := -10, -9.9..10$$

Finite coil

$$B_z(z, L, t) := \frac{1}{L \cdot t} \cdot \int_{-\frac{L}{2}}^{\frac{L}{2}} \left[\int_{1-\frac{t}{2}}^{1+\frac{t}{2}} \left[1 + \frac{(z-x)^2}{r^2} \right]^{\frac{-3}{2}} dr \right] dx$$

Equation 19.31

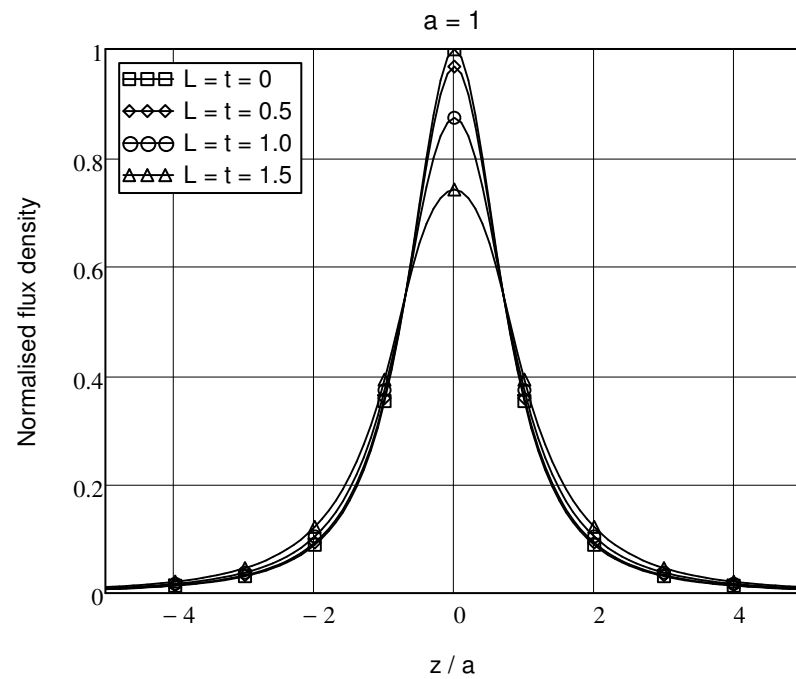


Figure 19.13

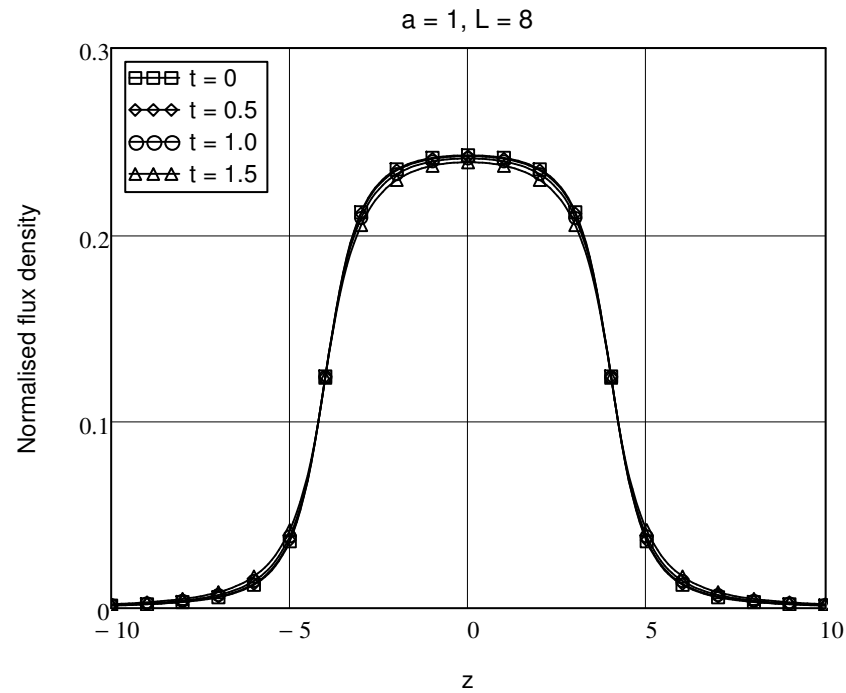


Figure 19.14

Maximally flat and equal ripple fields of arrays of circular current loops

$$B_2(z, d) := (B_0(z + d) + B_0(z - d)) \cdot \frac{1}{2}$$

$$B_3(z, d, I_1) := (I_1 \cdot B_0(z + d) + B_0(z) + I_1 \cdot B_0(z - d)) \cdot \frac{1}{1 + 2 \cdot I_1}$$

Equation 19.33

$$B_4(z, d_1, d_2, I_1) := (I_1 \cdot B_0(z + d_2) + B_0(z + d_1) + B_0(z - d_1) + I_1 \cdot B_0(z - d_2)) \cdot \frac{1}{2 + 2 \cdot I_1}$$

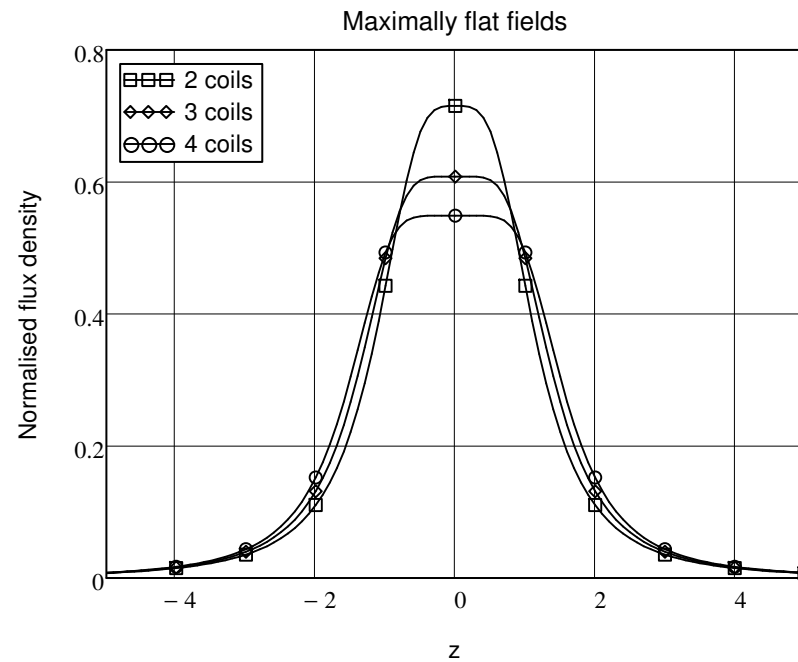
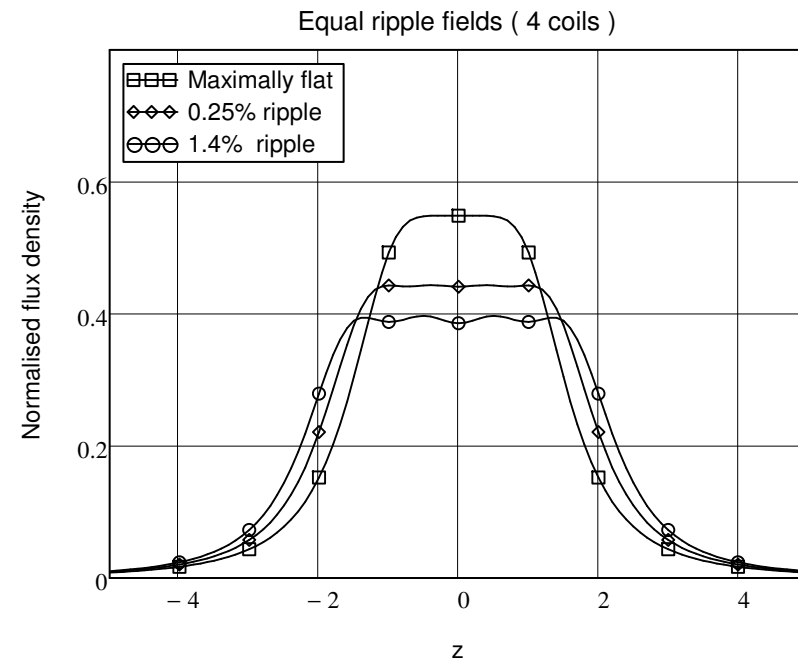


Figure 19.15

2 coils: $d = \pm 0.5$; $I = 1.0$

3 coils: $d = 0, \pm 0.76$; $I = 1.0, I_1 = 1.8816$

4 coils: $d = \pm 0.2432, \pm 0.9407$; $I = 1.0, I_1 = 2.2604$



4 coils 0% ripple: $d = \pm 0.2432, \pm 0.9407$; $I = 1.0, I_1 = 2.2604$

4 coils 0.25% ripple: $d = \pm 0.3986, \pm 1.3211$; $I = 1.0, I_1 = 1.6208$

4 coils 1.4% ripple: $d = \pm 0.5046, \pm 1.5774$; $I = 1.0, I_1 = 1.3942$