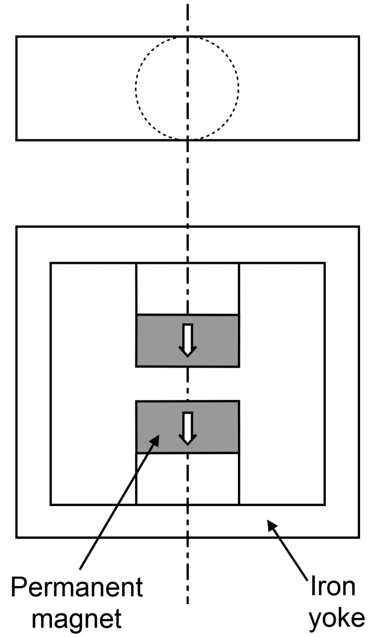
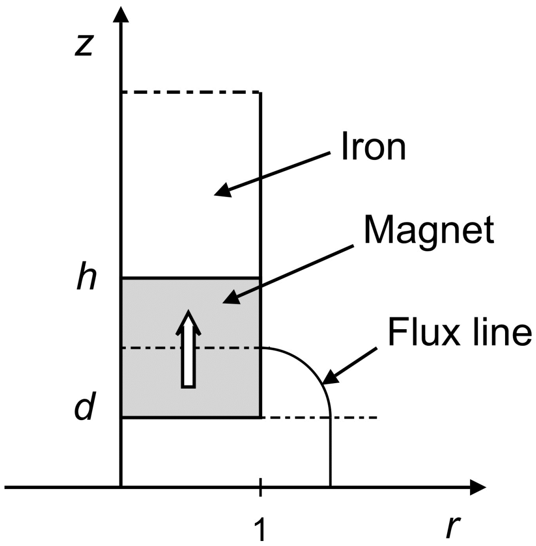
WS 19.2 Permanent magnet design

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.

This sheet illustrates the design of a permanent magnet for a magnetron or CFA. See Section 19.7.1

An initial estimate for h is used to calculate a revised value h_2. This figure is substituted for h and the process repeated until it has converged.





Magnet dimensions

Pole-piece radius $R_g := 15 \cdot mm$ Air gap $d := 5 \cdot mm$ Top of permanent magnet $h := 9.2 \cdot mm$

Normalised dimensions $d_1 := \frac{d}{R_g}$ $d_1 = 0.333$ $h_1 := \frac{h}{R_g}$ $h_1 = 0.613$

Flux density in the air gap $B_g := 0.4 \cdot T$ $H_g := \frac{B_g}{\mu_0}$

$c_1 := \frac{4}{\pi} - 1 = 0.273$

Fringing flux $\Delta\Phi(d_1, h_1) := \frac{8 \cdot d_1}{\pi} \cdot \left[\left(\frac{h_1 + c_1 \cdot d_1}{h_1 - d_1}\right) \cdot \ln\left(\frac{h_1 + c_1 \cdot d_1}{d_1 + c_1 \cdot d_1}\right) - 1\right]$ Equation 19.42 $\Delta\Phi(d_1, h_1) = 0.233$

Magnet flux density $B_m(d_1, h_1) := B_g \cdot (1 + \Delta\Phi(d_1, h_1))$ Equation 19.43 $B_m(d_1, h_1) = 0.493\,T$

Properties of a Samariuim Cobalt magnet

$B_r := 1.02 \cdot T$ $H_c := 732 \cdot 10^3 \cdot \frac{A}{m}$

$H_m(d_1, h_1) := H_c \cdot \left(1 - \frac{B_m(d_1, h_1)}{B_r}\right)$ Equation 19.44 $H_m(d_1, h_1) = 378 \cdot kA \cdot m^{-1}$

Magnet height $h2(h_1) := \left(1 + \frac{B_g}{\mu_0 \cdot H_m(d_1, h_1)}\right) \cdot d_1$ $h_2 := h2(h_1) \cdot R_g$ Equation 19.45 $h_2 = 9.2 \cdot mm$