Worksheet 10.1 Collector 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 includes the basic equations that are needed for collector design.

The beam spreading curve for a rotating beam is obtained from

$$\beta pz(R, m) := \int_0^{\sqrt{\ln(R)}} \frac{2\cdot x\cdot \exp\left(x^2\right)}{\sqrt{x^2 + 0.25\cdot\left(m^2 - 1\right)\cdot\left(1 - \exp\left(-2\cdot x^2\right)\right)}}\,dx$$

Equation 7.82

$R := 1, 1.01 .. 4$

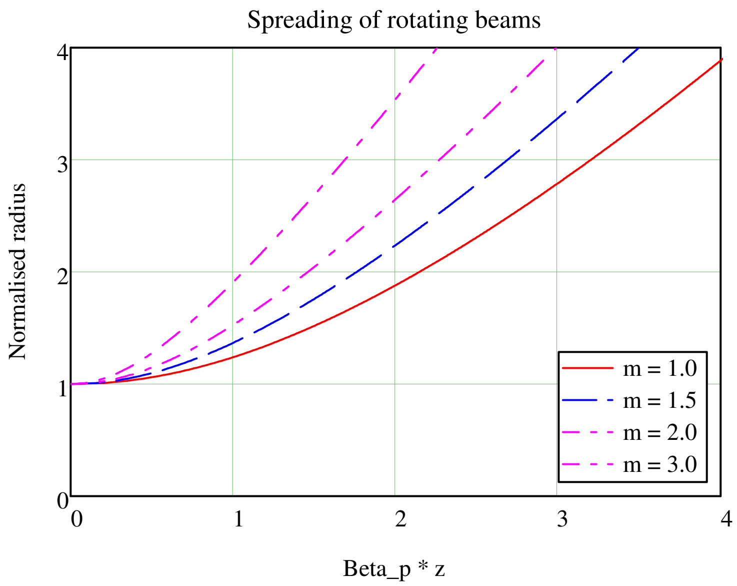
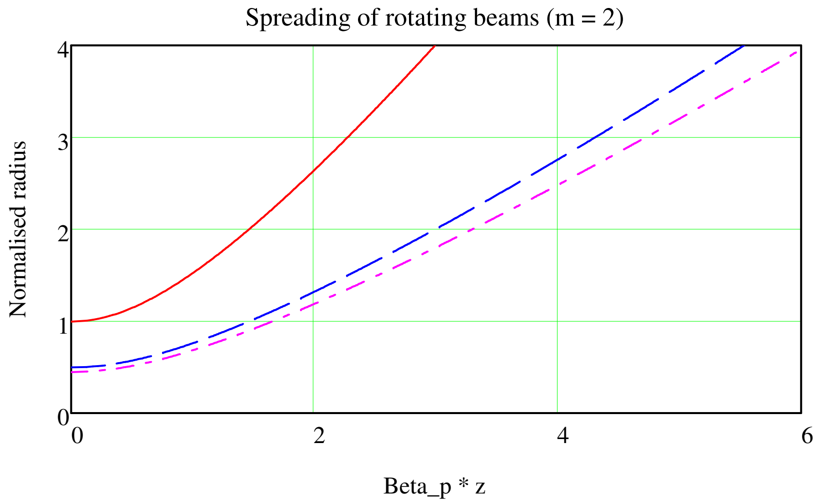


Figure 7.8

Plot the spreading curves for electrons within the beam

$R := 1, 1.01 .. 12$



Compare Figure 10.3

Calculate the normalised axial distance at which a trajectory whose initial radius is r_0 strikes the wall of a collector of radius c as a function of the magnetic field parameter m

$$Sz(c, r_0, m) := \int_0^{\sqrt{\ln\left(\frac{c}{r_0}\right)}} \frac{2 \cdot x \cdot \exp\left(x^2\right)}{\sqrt{x^2 + 0.25 \cdot \left(m^2 - 1\right) \cdot \left(1 - \exp\left(-2 \cdot x^2\right)\right)}} \, dx$$

Calculate the power density at the wall of a collector of radius c, normalised to the power density in the initial beam, as a function of normalised axial position and magnetic field parameter m

$$P(c, r_0, m) := \begin{vmatrix} -\left(\frac{r_0}{c}\right)\cdot\frac{1}{\left(\frac{d}{dr_0}Sz(c, r_0, m)\right)} & \text{if } r_0 \le 1 \\ 0 & \text{otherwise} \end{vmatrix}$$

Plot the normalised power density on the wall of a collector of radius c for a beam whose initial radius is 1 and magnetic field parameter is 2

$r_0 := 0, 0.001 .. 1.01$

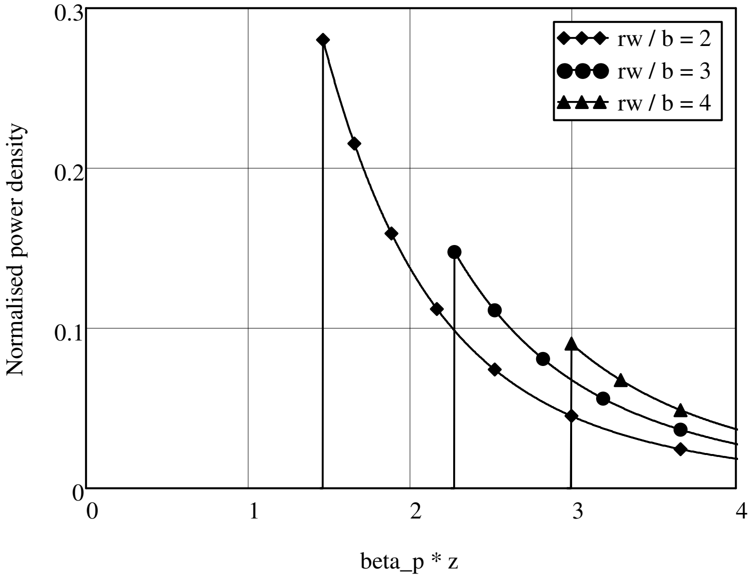


Figure 10.4

Efficiency of a tube with a depressed collector expressed in terms of the electronic efficiency η_e and the collector efficiency η_c

$$\eta_{rf}(\eta_e, \eta_c) := \frac{\eta_e}{1 - \eta_c \cdot (1 - \eta_e)}$$

Equation 10.13

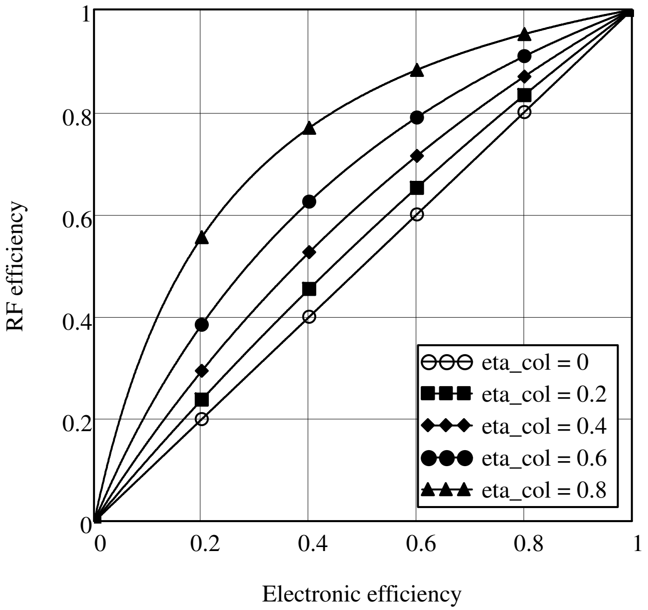


Figure 10.7

Effect of number of stages on the collector efficiency

$$\eta_c(\eta_e, n) := 1 - \frac{\eta_e}{n \cdot (1 - \eta_e)}$$

Equation 10.22

$n := 1, 2 .. 10$