Worksheet 8.2 Planar crossed-field diode

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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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Equations of motion for electrons in a planar crossed-field diode. See Section 8.3

$$y(\theta) := \sin(\theta) - \theta$$

Equation 8.36

$$\frac{y}{h} = \frac{e}{\varepsilon_0 m_0 \omega_c^3 h} J_y \left(\sin\left(\omega_c t\right) - \omega_c t\right)$$

$$\mathrm{ydot}(\theta) := \frac{\cos(\theta) - 1}{\sin(\theta) - \theta}$$

Equation 8.40

$$\frac{\dot{y}}{\omega_c h} = \frac{\cos\left(\omega_c t\right) - 1}{\sin\left(\omega_c t\right) - \omega_c t}$$

$$\mathrm{Va}(\theta) := \left(\frac{1 - \cos(\theta)}{\theta - \sin(\theta)}\right)^2 + 1$$

Equation 8.41

$$\frac{2e}{m_0} \cdot \frac{V_a}{\omega_c^2 h^2} = \left(\frac{1 - \cos\left(\omega_c t_a\right)}{\omega_c t_a - \sin\left(\omega_c t_a\right)}\right)^2 + 1$$

$$J_y(\theta) := \frac{1}{\sin(\theta) - \theta}$$

Equation 8.42

$$\frac{e}{\varepsilon_0 m_0 \omega_c^3 h} J_y = \frac{1}{\sin\left(\omega_c t\right) - \omega_c t}$$

$V_a(\theta) := 1 + \mathrm{ydot}(\theta)^2$

Equation 8.44

$$\frac{2eV_a}{m_0\omega_c^2h^2} = \frac{V_a}{V_H} = \left(1 + \frac{\dot{y}^2}{\omega_c^2h^2}\right)$$

$B\_BH(\theta) := \dfrac{1}{\sqrt{V_a(\theta)}}$

Equation 8.43

$$\frac{B_H^2}{B^2} = \frac{2eV_a}{m_0\omega_c^2h^2}$$

$J_{CL}(\theta) := \dfrac{-2}{9}\cdot\left(V_a(\theta)\right)^{\frac{3}{2}}$

Equation 8.39

$$\frac{eJ_{cL}}{\varepsilon_0 m_0\omega_c^3h} = -\frac{2}{9}\left(\frac{2eV_a}{m_0\omega_c^2h^2}\right)^{\frac{3}{2}}$$

$J\_JCL(\theta) := \dfrac{J_y(\theta)}{J_{CL}(\theta)}$

$x(\theta) := \cos(\theta) - 1 + \dfrac{1}{2}\cdot\theta^2$

Equation 8.46

$$x = \frac{eJ_a}{\varepsilon_0 m_0\omega_c^3}\left(\cos\left(\omega_c t\right) + \frac{1}{2}\omega_c^2t^2\right)$$

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$\theta := 0, 0.1\cdot\pi .. 2\cdot\pi$

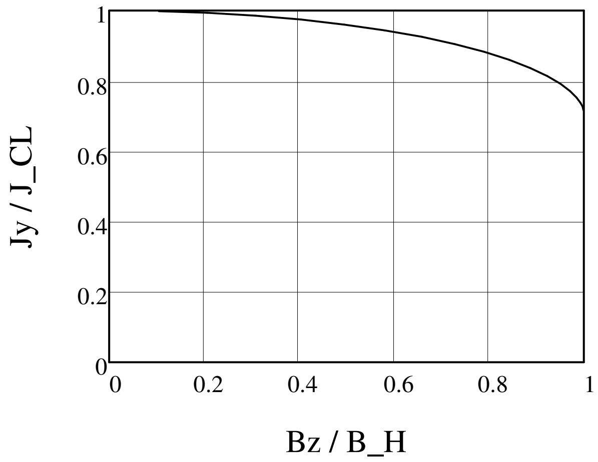

Figure 8.5

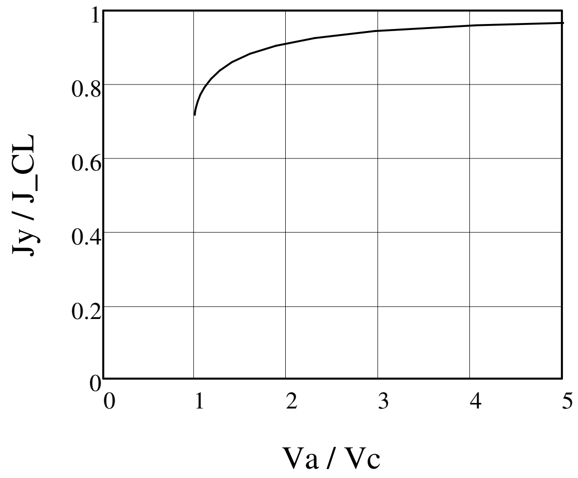

Figure 8.6

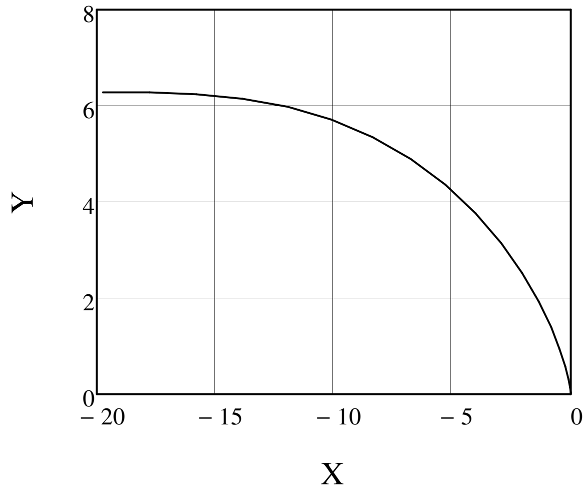

Figure 8.7

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Data digitised from fig. 6, Va = 100 V, in
Bradshaw, J. A. (1961). Cutoff characteristics of the static magnetron diode.
Crossed-Field Microwave Devices. E. Okress. New York, Academic Press. **1**.

$$xx := (-59.41\ \ -55.44\ \ -51.47\ \ -49.62\ \ -46.97\ \ -44.59\ \ -43.01\ \ -40.89\ \ -36.39\ \ -32.16\ \ -27.66\ \ -17.87\ \ 11.5\ \ 30.55\ \ 53.57\ \ 118.13)^T$$

$$VVa := \frac{2^{\frac{xx}{36.31}}}{0.435} \qquad VVa^T = (0.74\ \ 0.798\ \ 0.861\ \ 0.892\ \ 0.938\ \ 0.981\ \ 1.011\ \ 1.053\ \ 1.148\ \ 1.244\ \ 1.356\ \ 1.634\ \ 2.863\ \ 4.119\ \ 6.392\ \ 21.922)$$

$$Ia := \frac{1}{132.87}\cdot(5.35\ \ 5.87\ \ 8.79\ \ 15.14\ \ 28.1\ \ 51.91\ \ 66.99\ \ 89.75\ \ 104.04\ \ 113.82\ \ 116.21\ \ 120.7\ \ 126.52\ \ 128.38\ \ 130.49\ \ 130.5)^T$$

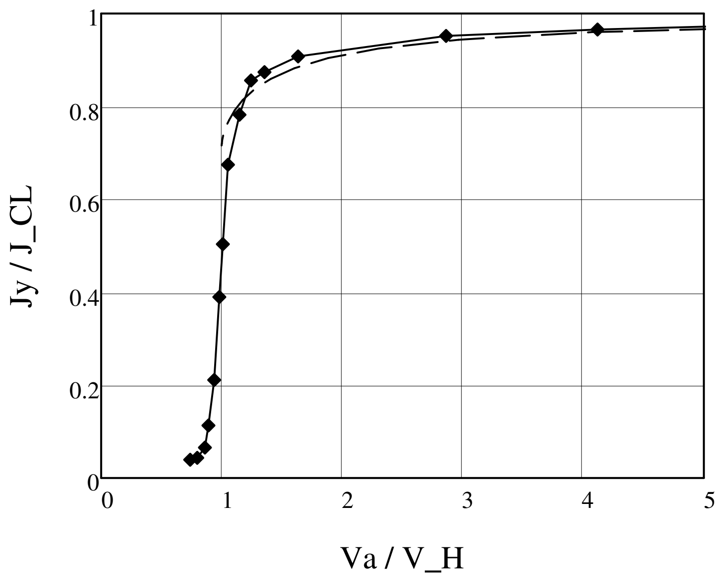

Figure 8.14

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Slater orbits

$\theta := 0, 0.1\cdot\pi .. 8\cdot\pi$

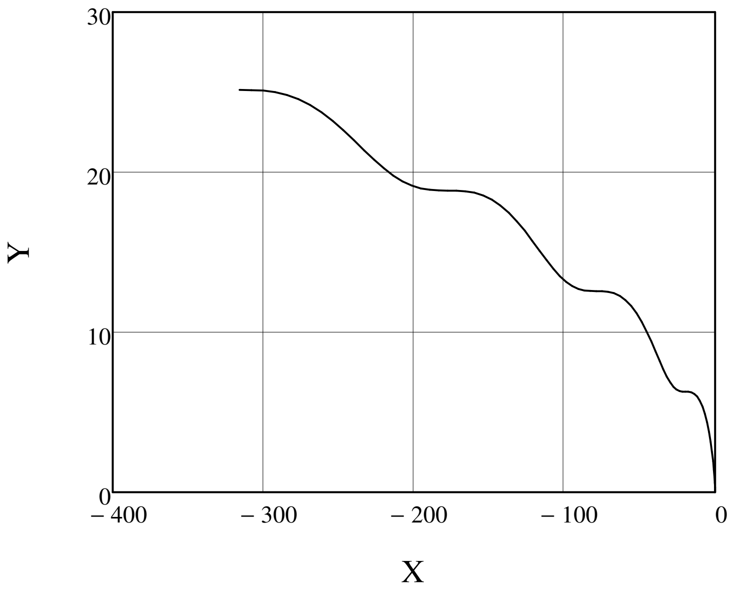

Figure 8.8

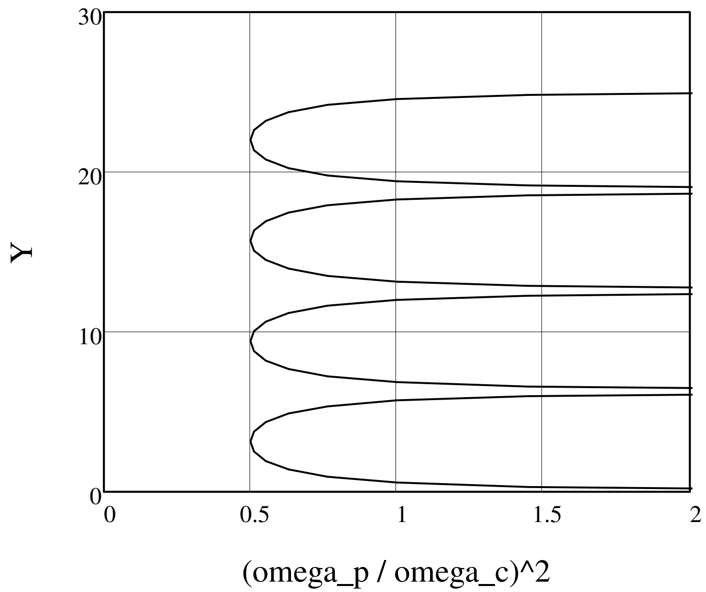

Figure 8.9

$$\frac{\omega_p^{\,2}}{\omega_c^{\,2}} = \frac{1}{1 - \cos(\theta)}$$

Equation 8.52

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