**Problem 4.12**

(a) From Table A3.1 in Appendix 3, we find (by interpolation) that $J_0(\beta)$ is zero for the following values of modulation index:
$\beta = 2.44$,
$\beta = 5.52$,
$\beta = 8.65$,
$\beta = 11.8$,
and so on.

(b) The modulation index is defined by

$$\beta = \frac{\Delta f}{f_m} = \frac{k_f A_m}{f_m}$$

Therefore, the frequency sensitivity factor is

$$k_f = \frac{\beta f_m}{A_m} \tag{1}$$

We are given $f_m = 1$ kHz and $A_m = 2$ volts. Hence, with $J_0(\beta) = 0$ for the first time when $\beta = 2.44$, the use of Eq. (1) yields

$$k_f = \frac{2.44 \times 10^3}{2}$$

$$= 1.22 \times 10^3 \text{ hertz/volt}$$

Next, we note that $J_0(\beta) = 0$ for the second time when $\beta = 5.52$. Hence, the corresponding value of $A_m$ for which the carrier component is reduced to zero is

$$A_m = \frac{\beta f_m}{k_f}$$

$$= \frac{5.52 \times 10^3}{1.22 \times 10^3}$$

$$= 4.52 \text{ volts}$$