Problem 3.28

The energy of the carrier over a bit duration is defined by

$$E = \int_0^{T_b} c^2(t)dt$$

$$= A_c^2 \int_0^{T_b} \cos^2(2\pi f t)dt \qquad (1)$$

Using the identity

$$\cos^2\theta = \frac{1}{2}(1 + \cos 2\theta)$$

we rewrite Eq. (1) as

$$E = \frac{1}{2}A_c^2 \int_0^{T_b} [1 + \cos(4\pi f_c t)]dt$$

$$= \frac{1}{2}A_c^2 \int_0^{T_b} dt + \frac{1}{2}A_c^2 \int_0^{T_b} \cos(4\pi f_c t)dt \qquad (2)$$

Typically, the carrier frequency f_c is high compared to the bit rate $1/T_b$; we may therefore set the integral term in Eq. (2) approximately equal to zero, in which case we write

$$E \approx \frac{1}{2}A_c^2 \int_0^{T_b} dt$$

$$= \frac{1}{2}A_c^2 T_b \qquad (3)$$

For the energy E to equal unity, we may solve Eq. (3) for the carrier amplitude A_c, obtaining

$$A_c = \sqrt{\frac{2}{T_b}}$$

which is the desired result. On this basis, we express the carrier as

$$c(t) = \sqrt{\frac{2}{T_b}} \cos(2\pi f_c t)$$