Problem 7.10
Justify Eqs. (7.47) and (7.49).

Solution
Starting with Eq. (7.47), we write

$$\mathbf{s}_1 = \frac{2}{T_b}\sqrt{E_b}\int_0^{T_b}\cos^2(2\pi f_c t)\,dt$$

$$= \frac{1}{T_b}\sqrt{E_b}\int_0^{T_b}[\cos^2(4\pi f_c t) + 1]\,dt \qquad (1)$$

For $f_c = n/T_b$ for some integer n, Eq. (1) takes the form

$$\mathbf{s}_1 = \frac{\sqrt{E_b}}{T_b}\int_0^{T_b}\left[\cos\left(\frac{4\pi n}{T_b}t\right) + 1\right]dt$$

$$= \frac{\sqrt{E_b}}{T_b}\left[\frac{T_b}{4\pi n}\sin\left(\frac{4\pi n}{T_b}t\right) + t\right]_0^{T_b}$$

$$= \frac{\sqrt{E_b}}{T_b}\left[\frac{T_b}{4\pi n}\sin(4\pi n) + T_b\right], \quad n \text{ integer}$$

$$= \sqrt{E_b}$$

Similarly, for symbol 0, we have

$$\mathbf{s}_2 = -\sqrt{E_b}$$