**12.1-1** $\frac{S_o}{N_o} = \gamma = \frac{S_i}{\mathcal{N}B}$, $\mathcal{N} = 2 \times S_n(\omega) = 2 \times 10^{-8}$, $B = \frac{\alpha}{2\pi} = 4000$ Hz.

$$\gamma = 1000 = \frac{S_i}{2 \times 10^{-8} \times 4000} \Rightarrow S_i = 0.08$$

Also, $H_c(\omega) = 10^{-3}$. Hence, $S_T = \frac{S_i}{|H_c(\omega)|^2} = 8 \times 10^4$

$$S_T = \frac{1}{2\pi}\beta[2 \times 8000\pi] = 8 \times 10^4 \Rightarrow \beta = 10$$

**12.2-1** (a) $30 \text{ dB} = 1000 = \frac{S_o}{N_o} = \gamma = \frac{S_i}{\mathcal{N}B} = \frac{S_i}{10^{-10} \times 4000} \Rightarrow S_i = 4 \times 10^{-4}$

(b) From Eq. (12.7), $N_o = \mathcal{N}B = 10^{-10}(4000) = 4 \times 10^{-7}$

(c) $S_i = |H_c(\omega)|^2 S_T$ and $10^{-8} S_T = 4 \times 10^{-4} \Rightarrow S_T = 4 \times 10^4$



**12.3-1** $\frac{S_o}{N_o} = 28\text{dB} = 631$. Hence,

$$\frac{S_o}{N_o} = 631 = 3\beta^2\gamma\frac{\overline{m^2(t)}}{m_p^2}$$

$$= 3(2)^2\gamma\frac{\sigma_m^2}{(3\sigma_m)^2}$$

Therefore, $\gamma = \frac{631 \times 9}{12} = 473.25$

(a) Also, $\gamma = \frac{S_i}{\mathcal{N}B} \Rightarrow S_i = \gamma\mathcal{N}B = 473.25 \times 2 \times 10^{-10} \times 15000 = 1.4197 \times 10^{-3}$

(b) $\beta = \frac{\Delta\omega}{2\pi B} = \frac{k_f m_p}{2\pi B} \Rightarrow 2 = \frac{k_f(3\sigma_m)}{30{,}000\pi} \Rightarrow k_f\sigma_m = 20{,}000\pi$,

$$S_o = \alpha^2 k_f^2 \overline{m^2(t)} = \alpha^2 k_f^2 \sigma_m^2 = \left(10^{-4}\right)^2 (20{,}000\pi)^2 = 4\pi^2$$

(c) $N_o = \frac{S_o}{631} = 0.0199$

**12.3-3** $m(t) = \cos^3 \omega_o t$ and $m_p = 1$

$\dot{m}(t) = -3\omega_o \cos^2 \omega_o t \sin \omega_o t$ and $\ddot{m}(t) = -3\omega_o\left[\omega_o \cos^2 \omega_o t \cos \omega_o t - 2\omega_o \cos \omega_o t \sin^2 \omega_o t\right]$

For a maximum

$\ddot{m}(t) = 0$. This yields $\cos^2 \omega_o t = 2\sin^2 \omega_0 t$

or $1 - \sin^2 \omega_o t = 2\sin^2 \omega_o t \Rightarrow \sin \omega_o t = \frac{1}{\sqrt{3}}$, $\cos \omega_o t = \sqrt{\frac{2}{3}}$

and

$$m_p' = \left|-3\omega_o \cos^2 \omega_o t \sin \omega_o t\right| = 3\omega_o\left(\frac{2}{3}\right)\left(\frac{1}{\sqrt{3}}\right) = \frac{2}{\sqrt{3}}\omega_o$$

$$\frac{(S_o/N_o)_{PM}}{(S_o/N_o)_{FM}} = \frac{(3\omega_o)^2 m_p^2}{3m_p'^2} = \frac{9\omega_o^2}{3\left(\frac{4}{3}\omega_o^2\right)} = 2.25$$