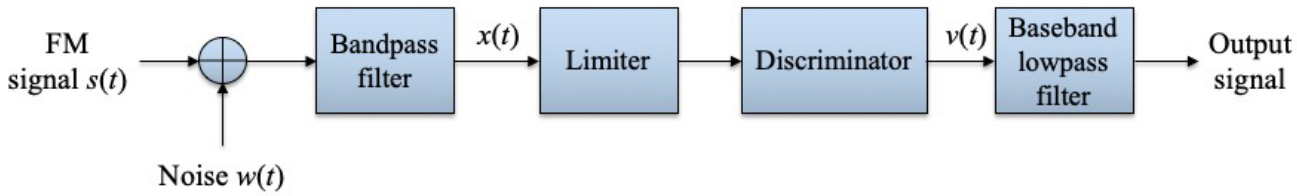
Problems for the 7th Quiz (May 3)

Name:_____ Student ID:_____ Score:_____

1. An FM receiver can be structured as follows.



(a) (50%) The effective PSD of $n_d(t)$ at the discriminator output is given by

$$\mathrm{PSD}_{n_d}(f) = \left|\frac{f}{A_c}\right|^2 \mathrm{PSD}_{n_Q}(f) = \frac{f^2}{A_c^2} N_0 \quad \text{for } |f| < \frac{B_T}{2}.$$

Explain what the noise quieting effect of an FM system is.

(b) (50%) When $n_I(t) = \lambda A_c \cos(\psi(t))$ and $n_Q(t) = \lambda A_c \sin(\psi(t))$, we obtain

$$2\pi n_d(t) = \lambda \psi'(t) \frac{\cos(\psi(t)) + \lambda}{1 + 2\lambda \cos(\psi(t)) + \lambda^2}.$$

Give a scenario (of λ and $\psi(t)$), in which a noise spike occurs at the receiver.

Solution.

(a) For fixed noise power level N_0 and fixed message bandwidth W, increasing carrier power A_c^2 will decrease the effective noise power at the demodulator output (by a factor of $1/A_c^2$). This is called the noise quieting effect.

(b) When $\psi(t) = \pi$,

$$2\pi n_d(t) = \lambda \psi'(t) \frac{\cos(\psi(t)) + \lambda}{1 + 2\lambda \cos(\psi(t)) + \lambda^2} = \lambda \psi'(t) \frac{-1 + \lambda}{1 - 2\lambda + \lambda^2} = \frac{\lambda}{\lambda - 1} \psi'(t).$$

Since

$$\lim_{\lambda \downarrow 1} = \frac{\lambda}{\lambda - 1} = \infty \quad \text{and} \quad \lim_{\lambda \uparrow 1} = \frac{\lambda}{\lambda - 1} = -\infty,$$

a discontinuity appears at λ close to 1.