通信原理
习题课

Assignment No. 8

1. An FM signal has an amplitude of 5 volts, carrier frequency of 120 MHz and peak frequency deviation of 75 KHz. The modulating message signal is a single tone of 4 KHz with amplitude of 2 volts. The FM signal is transmitted through a transmission line using a bandwidth based on Carson's rule. The gain of the transmission line is 1 in the pass-band. At the output of the transmission line, the FM signal is demodulated using a demodulator including a limiter, differentiator, envelop detector, D.C. blocking and an ideal low-pass filter which has a bandwidth of 4 KHz and unity gain in the pass-band. The signal amplitude at the output of the limiter is assumed to be 2 volt. The white noise at the input of the transmission line has a double-sided PSD of $\eta/2 = 10^{-6}$ W/Hz.

a. Determine the SNR at the input and the output of the demodulator, respectively.

b. Determine if the system is under the threshold.

Solution

$A_c = 5V, f_c = 120M$ Hz, $A_m = 2$V, $f_m = 4k$ Hz, $\beta = \dfrac{k_f A_m}{f_m}$

Input

By Carson's Rule,

$$BW = 2(\beta + 1)f_m = 2\left(\frac{75k}{4k} + 1\right)4k = 158k \text{ Hz}$$

Input signal

$$S_i = \frac{5^2}{2} = 12.5\text{w}$$

Noise

$$N_i = \frac{\eta}{2}\, 2B = \eta B = 2 \times 10^{-6} \times 158k = 0.316\text{w}$$

So,

$$SNR_i = \frac{S_i}{N_i} = 15.97\text{dB}$$

Since SNR_i is greater than 10dB, the system is above the threshold.

Output

Demodulated message signal is

$$V_l 2\pi k_f m(t)$$

$V_l = 2$, denotes the output signal amplitude of the Limiter.

Output signal

$$S_o = V_l^2 \left(2\pi k_f\right)^2 \overline{m^2(t)}$$

Noise

$$N_o = \frac{8\pi^2 \eta f_m^3}{3A_c^2}$$

So,

$$SNR_o = \frac{S_o}{N_o} = 65.18\text{dB}$$