FM and Digital Representation of Signals (Lectures 7 and 8)

1. **An FM modulated signal is given by**

$$x(t) = 10\cos(15000\pi t)$$

for $0 \le t \le 1$. Find the message if $k_f = 2000$ and $f_c = 5KHz$.

2. **Given the baseband signal-to-noise ratio $SNR_{Baseband}$, consider an FM detector for singletone modulation, that is, the modulating wave is a sinusoidal wave.**

$$m(t) = A_m \cos(2\pi f_m t).$$

(a) Compute the output SNR in terms of the modulation index β, where $\beta \triangleq \Delta f/W$.

(b) Comparing with the figure of merit for a full AM system (i.e. $\mu = 1$), at what value of β will FM start to offer improved noise performance?

3. **Suppose the modulating signal for FM is modelled as a zero-mean Gaussian random process $m(t)$ with standard deviation σ_m. One can make the approximation $m_p = 4\sigma_m$ as the overload probability $|m(t)| > 4\sigma_m$ is very small. Determine the output SNR for the FM receiver in the presence of additive white Gaussian noise, in terms of the deviation ratio β and the baseband SNR.**

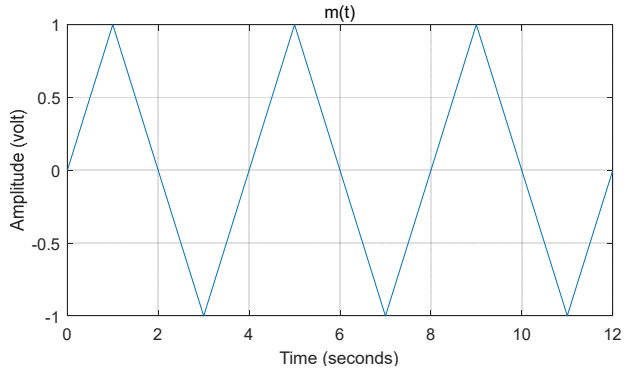
4. **Assume that the bandwidth of a speech signal is between 50 Hz up to 10 KHz. We want to sample this signal at the Nyquist rate, and then quantize using 16 bits per sample. How many megabytes of storage do you need to store one hour of this speech signal?**

5. **A PCM output is produced by a uniform quantizer that has 2^n levels. Assume that the input signal is a zero-mean Gaussian process with standard deviation σ.**

(a) If the quantizer range is required to be $\pm 4\sigma$, show that the quantization signal-to-noise is $6n - 7.3$ dB.

(b) Write down an expression for the probability that the input signal will overload the quantizer (i.e., when the input signal falls outside of the quantizer range).

6. **The input to a uniform n-bit quantizer is the periodic triangular waveform shown below, which has a period of $T = 4$ seconds, and an amplitude that varies between $+1$ and -1 Volt.**



Derive an expression for the signal-to-noise ratio (in decibels) at the output of the quantizer. Assume that the dynamic range of the quantizer matches that of the input signal.