S.72-1140 Transmission Methods in Telecommunication Systems

Closed-book Exam on Monday 12.1.2009

1. Consider the AM signal

$$s(t) = A_c[1 + \mu\cos(2\pi f_m t)]\cos(2\pi f_c t)$$

produced by a sinusoidal modulating signal of frequency f_m. Assume that the modulation index is $\mu = 2$ (over modulation), and the carrier frequency f_c is much greater that f_m. The AM signal $s(t)$ is applied to an ideal envelope detector producing the output $v(t)$

(a) Sketch $v(t)$

(b) Determine the Fourier series representation of $v(t)$

(b) What is the ration of second-harmonic amplitude to the fundamental amplitude in $v(t)$?

2. Figure 1 shows the circuit diagram of a balanced modulator. The modulating input applied to the device is $x(t)$. The two modulators have the same amplitude sensitivity. Show that the output $s(t)$ of the balanced modulator consists of a double sideband (DSB) modulated signal.

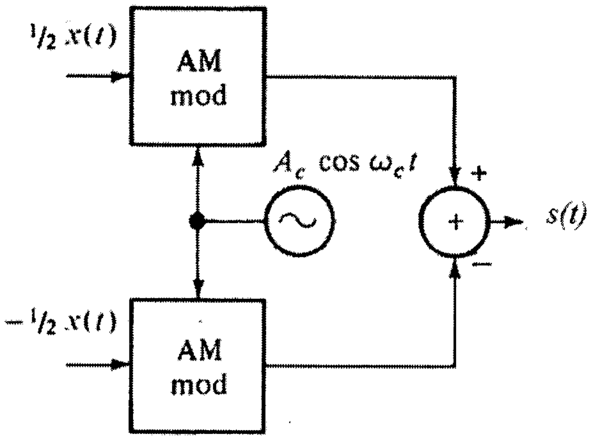

Figure 1

3. An FM signal with modulation index $\beta = 1$ is transmitted through an ideal band-pass filter with midband frequency f_c and bandwidth $5 f_m$ where f_c is the carrier frequency and f_m is the frequency of the sinusoidal modulating wave. (a) Determine and sketch the magnitude spectrum of the filter output.

4. If the lowpass components for a bandpass signal are of the form $x_I = 12\cos(6\pi t) + 3\cos(10\pi t)$ and $x_Q(t) = 2\sin(6\pi t) + 3\sin(10\pi t)$

(a) Calculate the Fourier series of the lowpass components $x_I(t)$ and $x_Q(t)$

(b) Calculate the Fourier series of the complex valued signal (complex envelope) $x_Z(t)$

(c) Assuming $f_c = 40\,\text{Hz}$, calculate the Fourier series of $x_c(t)$ where f_c is the carrier frequency and $x_c(t)$ is the composite bandpass signal

(d) Calculate amplitude $x_A(t)$ and phase $x_p(t)$ of the signal