Problem 1 (10)

Determine the instantaneous frequency in Hz, the corresponding bandwidth (also in Hz), maximum frequency deviation of the signal,

\[ f(t) = \cos 200 \pi t \cos (5\sin 2 \pi t) + 2\sin 100 \pi t \sin(5\sin 2 \pi t) \cos 100 \pi t \]

Problem 2 (25)

An angle modulated signal with carrier frequency \( f_c = 100 \) KHz is described by the equation

\[ S(t) = 10 \cos(\omega_c t + 5 \sin 3000t + 10 \sin 2000 \pi t) \]

Find:

a) The power of the modulated signal
b) The frequency deviation \( \Delta f \)
c) The deviation ratio \( \beta \)
d) The Phase deviation \( \Delta \phi \)
e) Estimate the bandwidth of \( S(t) \)

Problem 3 (25)

A message signal \( m(t) = \cos(40 \pi t) \) is fed into an FM modulator with a carrier signal \( c(t) = 5\cos(2 \pi f_c t) \) and frequency modulation constant \( k_f = 100 \pi \).

(a) Find the expression for the modulated FM signal.
(b) Determine the modulation index.
(c) Determine the bandwidth \( W_B \) of this FM signal.
(d) Determine the average power at the output of the FM modulator.
(e) Express the FM signal in terms of its frequency components (spectra).

Problem 4 (20)

Design (only a block diagram) an Armstrong indirect FM modulator to generate an FM carrier with a carrier frequency of 98.1 MHz and \( \Delta f = 75 \) KHz. A narrow-band FM generator is available at a carrier frequency of 100 KHz and a frequency deviation \( \Delta f = 10 \) KHz. The available oscillators with adjustable frequency are in the range of 10 to 11 MHz. Frequency doublers, triplers and quintuplers are also available.

Problem 5 (20)

A communication system operates in the presence of white noise with two-sided power spectral density \( S_n(\omega) = 0.25 \times 10^{-14} \) W/Hz and with total path loss (including antennas) of 100dB. The input bandwidth is 10KHz. Calculate the minimum required carrier power of the transmitter for a 10-KHz sinusoid input and a 40-dB output S/N ratio if the modulation is

a) AM (DSB-LC), with \( m = 0.707 \)
b) FM, with \( \Delta f = 10 \)KHz.

GOOD LUCK