Extra exercises

Exercise 1

Your friend has bought two Icom IC-9100, a multiple band HF/VHF/UHF radio capable of doing FM modulation and demodulation. He is using them to transmit a modulating signal $m(t) = 2\cos(2\pi\, 1000t)$. The power of the FM signal is 50 W, and it has a carrier frequency of $f_c = 100$ MHz and a peak frequency deviation $\Delta f = 10$ kHz.

a) Write the waveform expression for the FM waveform without any integral
b) Determine the approximated bandwidth of the FM waveform. Is the modulated signal a Narrow-Band or a Wide-Band Signal? (explain)

Your friend is very curious about the possibilities of the Icom IC-9100, and he is now considering the option of digitalizing the information and using BFSK as modulation scheme, with a space frequency of $f_{space} = 99.95$ MHz and a mark frequency of $f_{mark} = 100.05$ MHz.

c) If the digital signal is transmitted at a rate of $R_b = 3$ kbps, how much bandwidth is needed for the BFSK transmission?

Exercise 2

Consider the baseband signal $m(t) = 2\cos(2\pi 100\, t) - \cos(2\pi 500\, t)$. The signal is AM-modulated by a carrier wave $c(t)$.

a) Determine the resulting (traditional) AM-signal $v_{AM}(t)$ and plot the amplitude spectrum $V_{AM}(f)$ when $f_c = 1500$ kHz, the carrier amplitude is $A_c = 10$ and the amplitude sensitivity is k_a =0.2.
b) Determine the result of a double-sideband–suppressed-carrier modulation (DSB-SC) of $m(t)$ – with the carrier amplitude decreased by a factor of five compared to the amplitude modulated (AM) signal: calculate the signal $v_{dsb-SC}(t)$ and plot the amplitude spectrum $V_{dsb-SC}(f)$.
c) In view of the results, explain briefly the advantages and disadvantages of DSB-SC versus standard AM.

Exercise 3

Consider the following baseband signal $v(t) = 3\sin(2\pi 200\, t) - 2\sin(2\pi 800\, t)$

The signal is modulated by the carrier wave $c(t)$ in an AM-transmitter:
$c(t) = A_c\cos(2\pi\, f_c\, t)$. The power of the carrier signal is 8 W.

1. Determine the maximum usable amplitude sensitivity k_a for an ordinary AM-modulation
2. Determine the resulting AM-signal $v_{AM}(t)$ and plot the amplitude spectrum $V_{AM}(t)$ for $f_c = 1500$ kHz.

Exercise 4

An FM signal with carrier frequency f_c =750 kHz is generated in an FM system with frequency sensitivity $k_f = 15$ kHz/V. For a sinusoidal modulating signal of the form $m(t) = A_m \cos(2\pi f_m t)$ with $f_m = 25$ kHz and $A_m = 5$ V, the FM signal is given by: $s(t) = A_c \cos\left(2\pi f_c t + \beta \sin(2\pi f_m t)\right)$

where β is the modulation index.

a. Determine the values of the frequency deviation Δf, the modulation index , and plot/sketch the amplitude spectrum

b. Via an ideal multiplicator, the FM signal $s(t)$ is now squared. Determine the values of the frequency deviation and the modulation index of the resulting signal $s^2(t)$, and plot/sketch the amplitude spectrum of this signal

Exercise 5

A communication system transmits at 100 kbps. For each of the following modulation types, determine the bandwidth of the transmission.

a) FSK, with frequency deviation 200 kHz.
b) OOK
c) QPSK
d) 16-PSK
e) 16-QAM
f) 512-QAM