CS425: Computer Networks

Assignment 3

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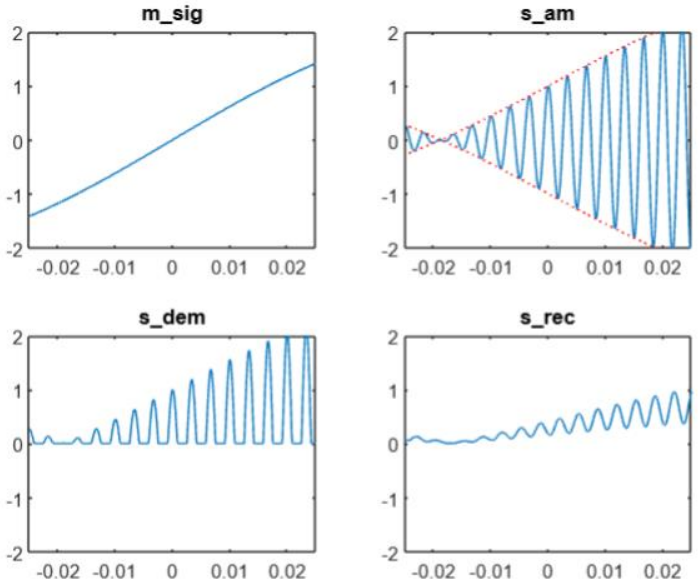
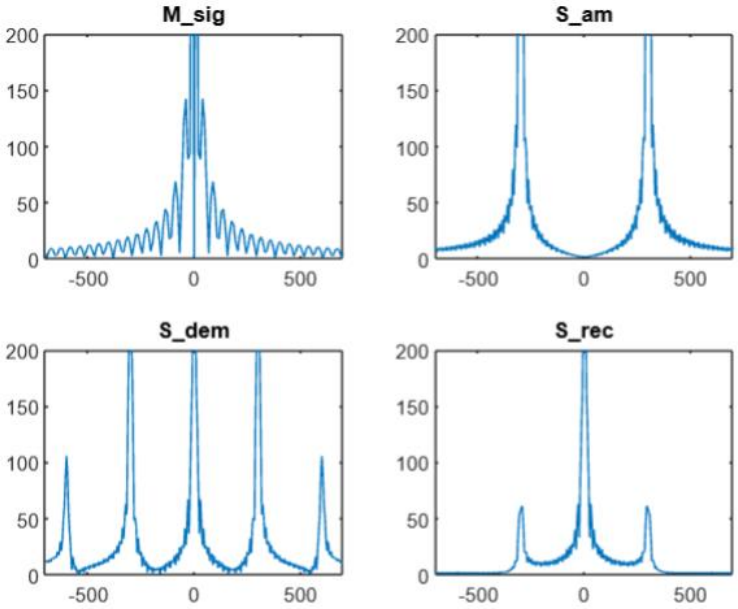
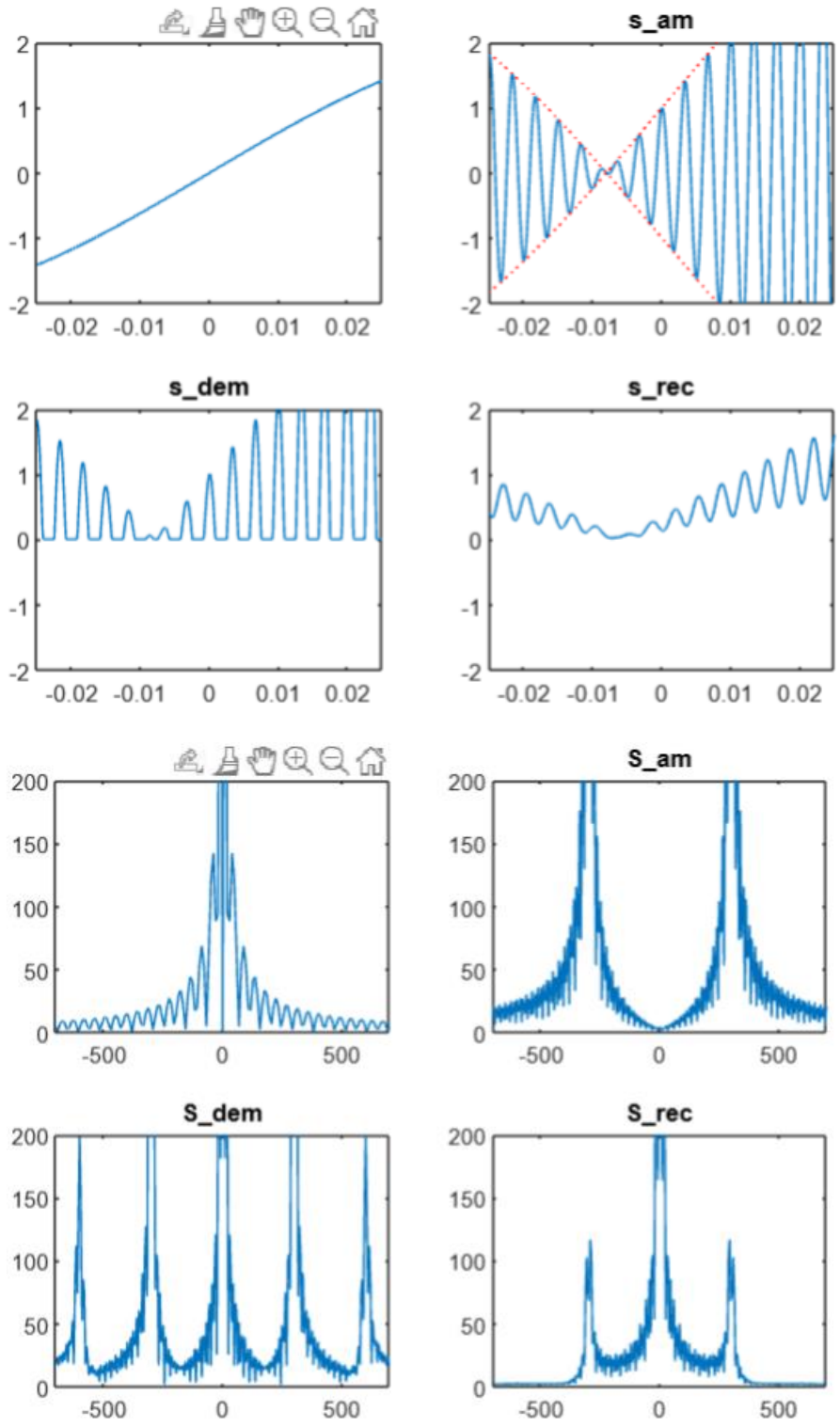
Q1 (a) modulation index (k_a = 0.9)



Q1 (b)



Q1 (c) modulation index ($k_a = 2$)

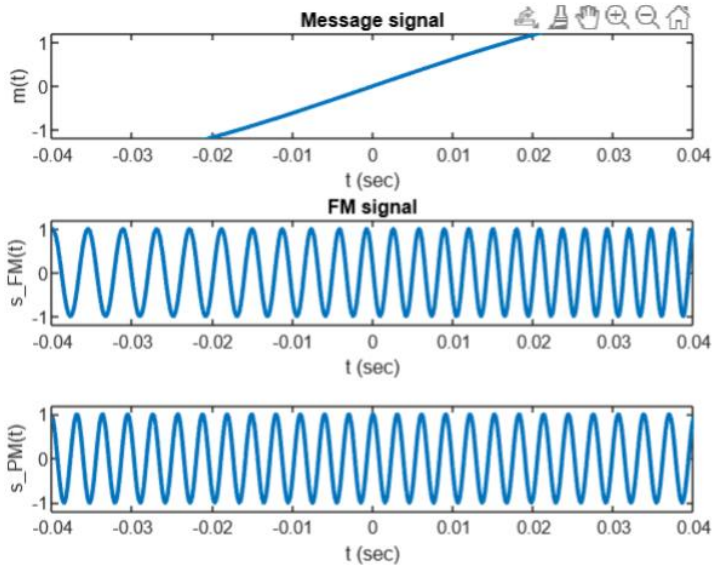


A few observations from changing the modulation index:

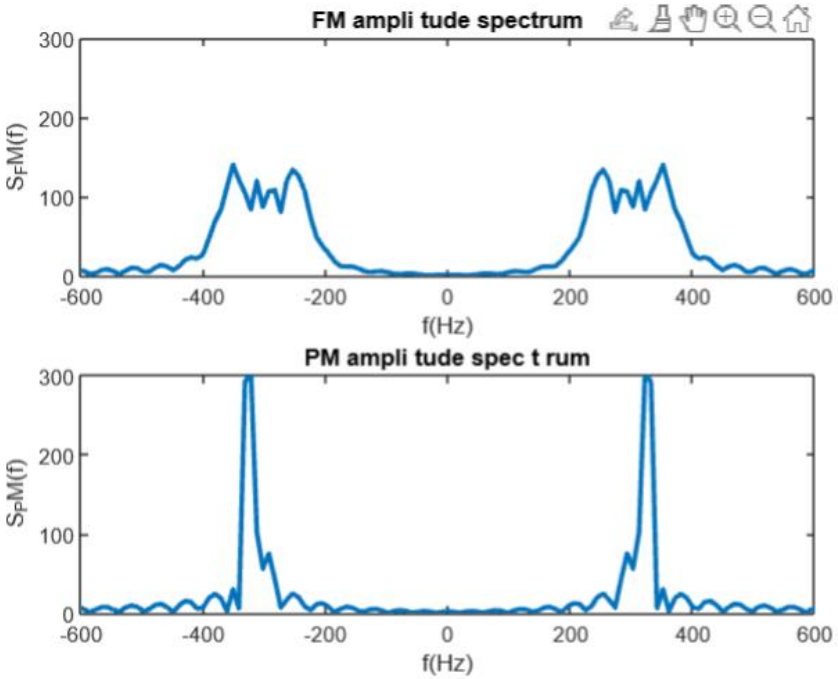
When the modulation index is increased up to 1, the component of the message signal in the modulated signal grows in time domain representation. Because the message signal's component in the modulated signal is minimal when ka << 1, retrieving the message signal in this scenario may be error-prone. Also, if ka > 1, $A_{carrier} + m(t) = 0$ at some point in time, the modulated signal becomes distorted and overlapped. When the modulation index is increased, the strength of the two peaks at

fc + fm and fc - fm increases in the frequency domain. The two side peaks are hardly visible at very low ka, but they are comparable to the central peak at fc at ka = 2.

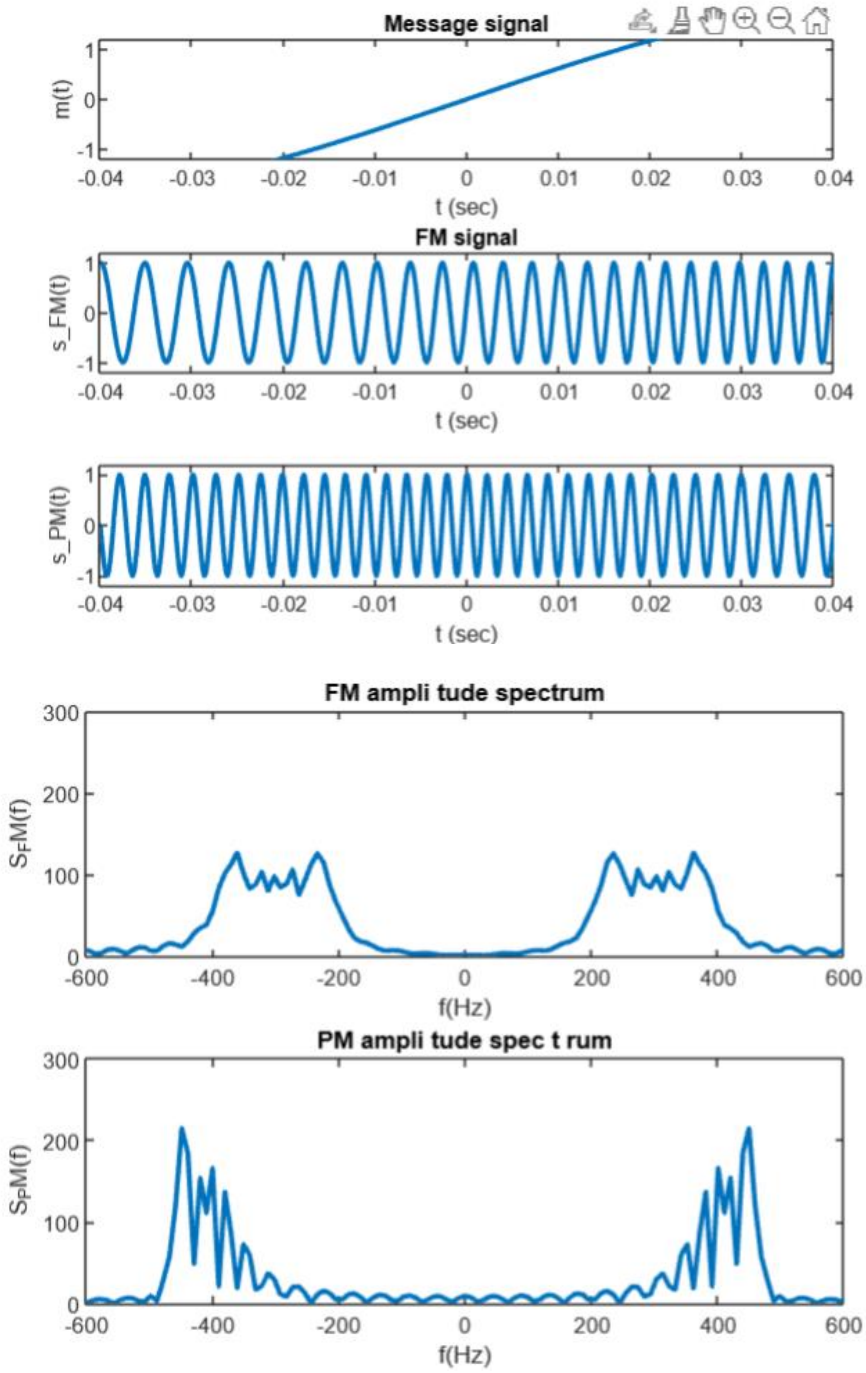
Q2 (a)



Q2 (b)



Q2 (c) k_f = 100*pi, k_p = 5



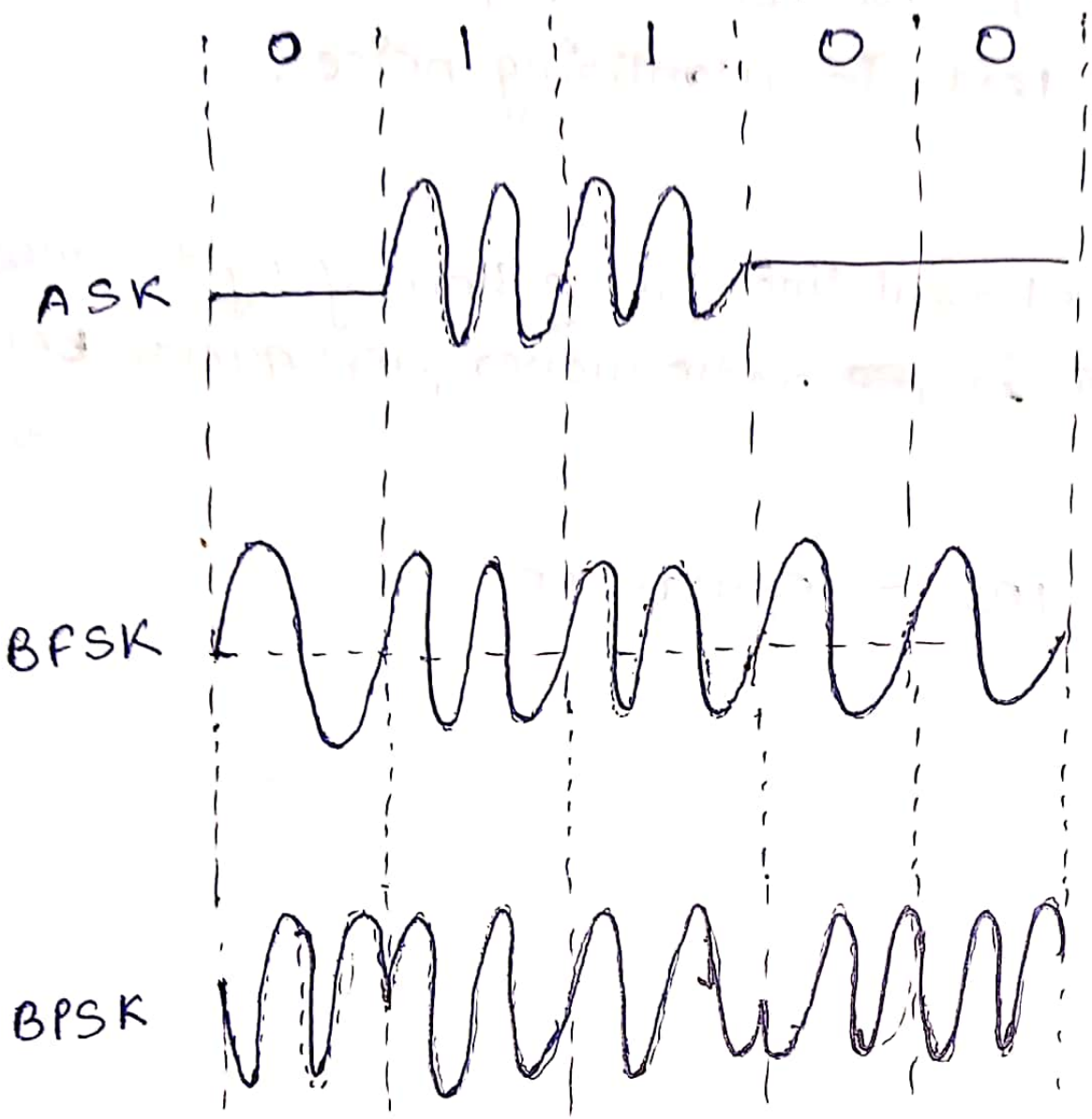
A few observations:

1. As the modulation index increases, the number of frequency bands goes up as well.

2. There is no change in overall power.

3. The amplitude increases as the band widens.

Q3



Q4 Bandwidth efficiency (given) = 1 = $\frac{R}{B}$

where R = rate of data

B = bandwidth

⇒ $\frac{E_b}{N_0}$ = ratio of signal energy per bit to noise power density

~~$\frac{E_b}{N_0} = SNR \times \frac{B}{R}$~~ $SNR = \frac{E_b}{N_0} \times \frac{R}{B}$

$SNR = \frac{E_b}{N_0}$ ($R/B = 1$)

$(SNR)_{dB} = \left(\frac{E_b}{N_0}\right)_{dB}$ (since $10\log\frac{R}{B} = 0$)

⇒ For FSK : In figure $\frac{E_b}{N_0} = 13.5$

$(SNR)_{dB} = 13.5\ dB$

⇒ For ASK : From figure $\frac{E_b}{N_0} = 13.5$

$(SNR)_{dB} = 13.5\ dB$

⇒ For PSK : From figure $\frac{E_b}{N_0} = 10.5$

$(SNR)_{dB} = 10.5\ dB$

⇒ For QPSK : Effective Bandwidth is halved, so $\frac{R}{B} = 2$

$\left(\frac{R}{B}\right)_{dB} = 10\log 2 = 3.01\ dB$

$(SNR)_{dB} = 10.5 + 3.01$

⇒ $13.51\ dB$

5. **(10 points)** The analog waveform shown in below is to be delta modulated. The sampling period and the step size are indicated by the grid on the figure. The first DM output and the staircase function for this period are also shown. Show the rest of the staircase function and give the DM output. Indicate regions where slope overload distortion exists.