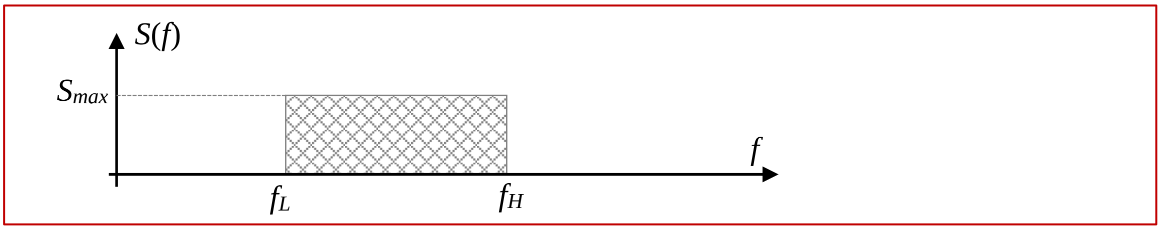
No : Answers **Name :** Solutions

Eskişehir Osmangazi University, Faculty of Engineering and Architecture

Department of Electrical Engineering & Electronics, "*Communications*" Final 16.06.2022

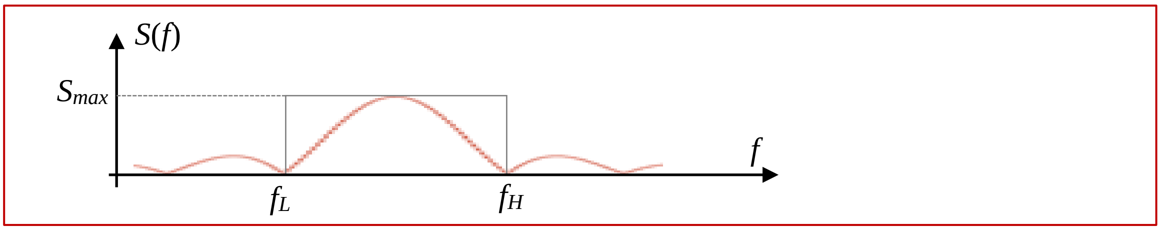
No books/notes/computers. Calculators ok. 90 minutes. No exit in 45 minutes. Good luck.

1. For a communication system that your are going to design entirely, you are allowed to use a limited bandwidth from f_L to f_H and maximum power of S_{max} at all frequencies as illustrated in the following figure.

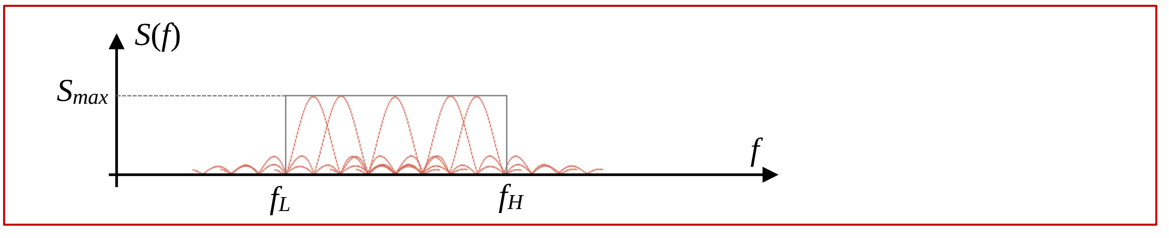


Your choices are:

a) A single BPSK carrier centered at $(f_H + f_L)/2$ (band center) at symbol rate of $(f_H - f_L)/2$ bits/s.



b) An OFDM system with 5 BPSK carriers and 3 null carriers. One of the null carriers is outside the band, the others are next to center. Carriers are placed $(f_H - f_L)/8$ apart as illustrated. Symbol rate is obviously $(f_H - f_L)/8$ and each symbol is 5 bits. No CP.

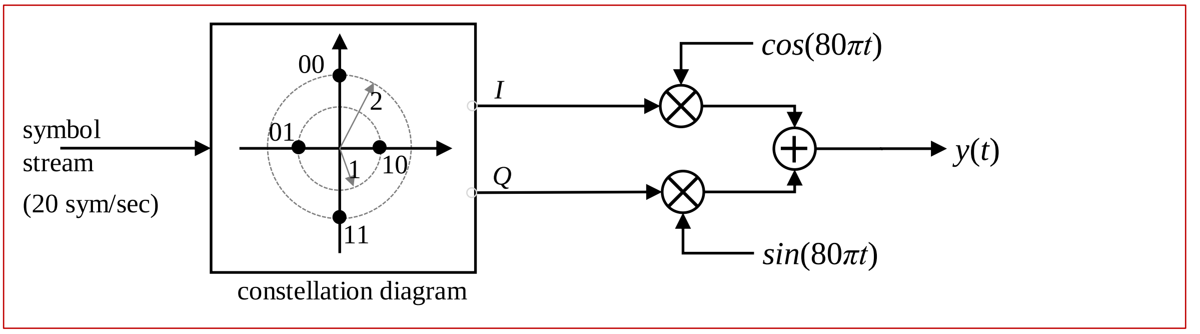


Both system can be preferred based on the qualities requested. Fill in the following table so that the systems can be compared.

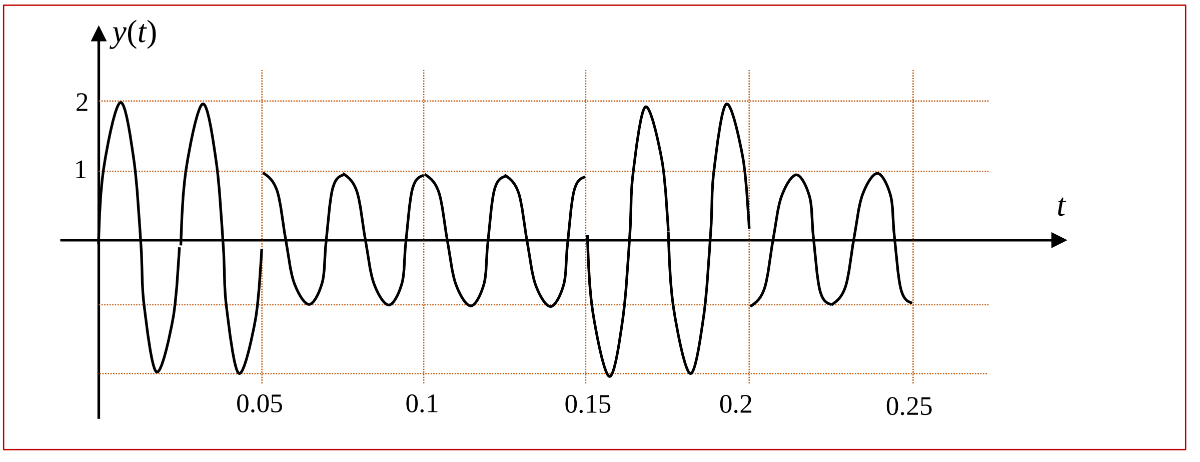
Quality	BPSK (a)	OFDM (b)	
Bit rate	BW/2	5BW/8	? value
BW efficiency	lower	higher	? lower/higher
out-band activity	worse	better	? better/worse
complexity	lower	higher	? lower/higher
carrier sync.	square law	square law	? how

BW efficiency : how efficient the available BW and power are utilized
out-band activity : excess power wasted outside the band (also causes interference)
complexity : how difficult to design the system

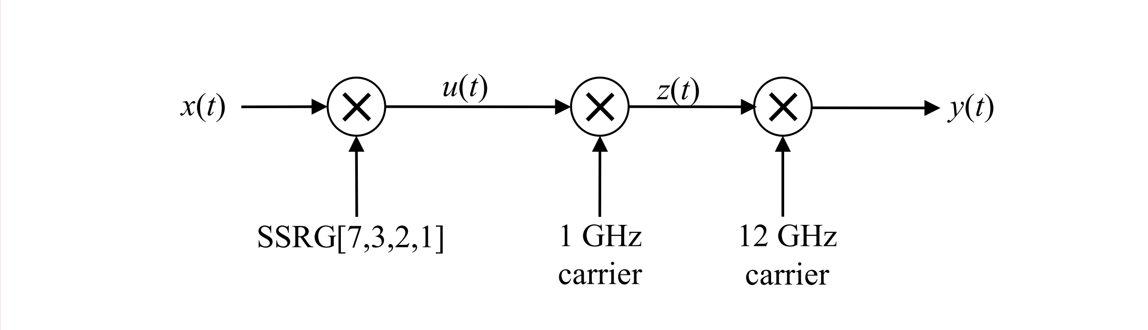
2. The following quadrature modulator is given.



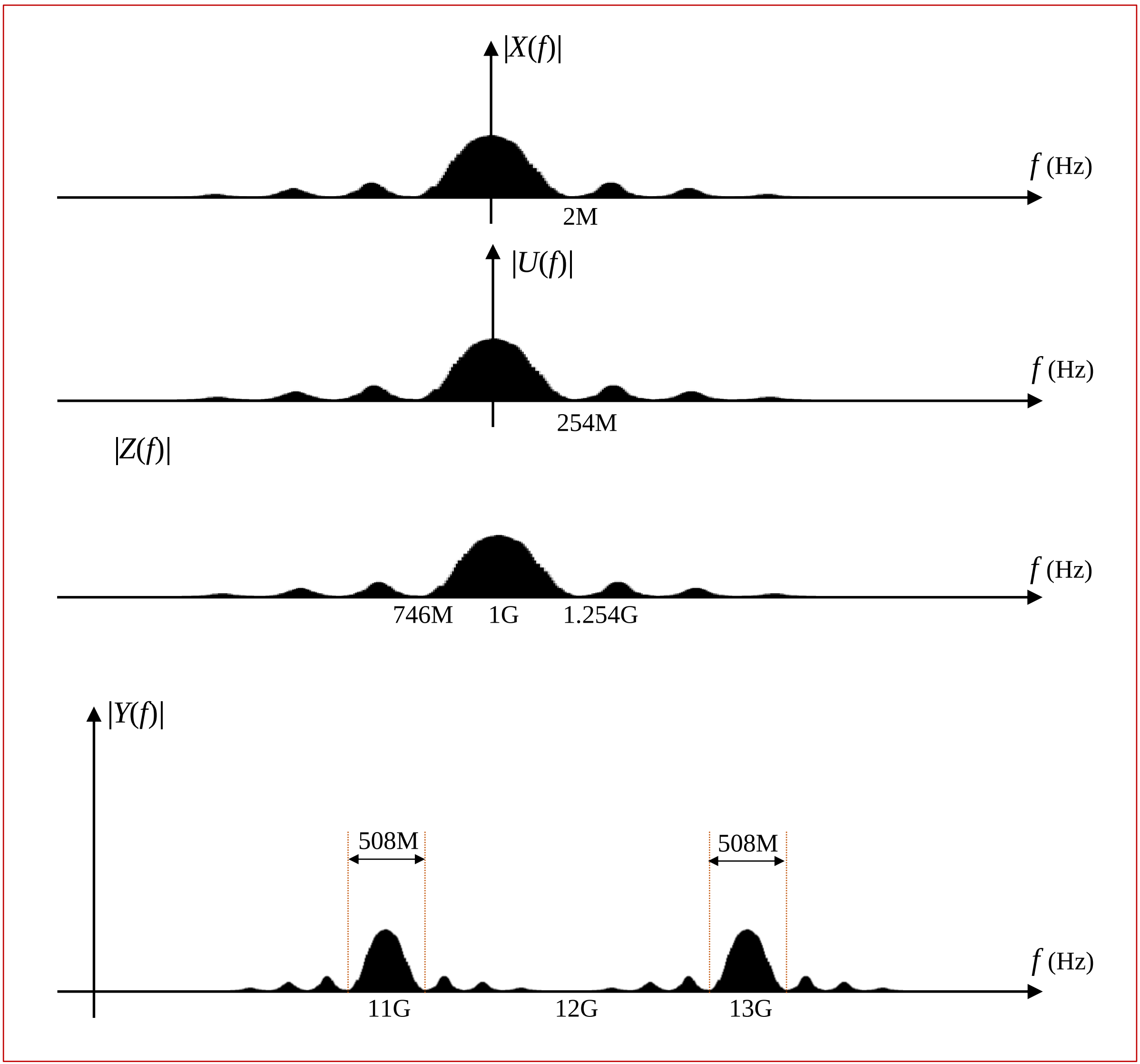
Draw $y(t)$ when the symbol stream is {00,10,10,11,01}. Put quantitative (amplitude, time etc.) numbers on the graph.



3. $x(t)$ is a 2 Mbps binary antipodal random rectangular pulse stream. The following transmitter schema with DSSS is given. Chip rate of the m-sequence generator is 127 chips/bit.



Draw the single sides spectrum of the output $y(t)$. Mark frequencies.

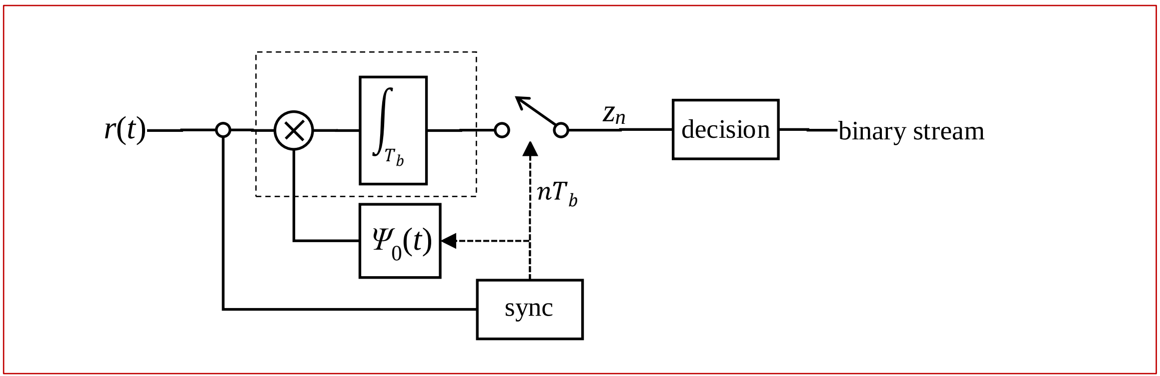


4. A binary communication system uses the following waveforms;

$$\psi_0(t) = \begin{cases} \sin\left(\frac{2\pi t}{T_b}\right), & 0 < t < T_b \\ 0, & otherwise \end{cases} \quad , \quad \psi_1(t) = \begin{cases} \cos\left(\frac{2\pi t}{T_b}\right), & 0 < t < T_b \\ 0, & otherwise \end{cases}$$

(note that the waveforms are not antipodal)

The receiver is basic correlator receiver with a single correlator.



Determine the correlator output at the decision instants when;

a) $r(t) = \psi_0(t)$

b) $r(t) = \psi_1(t)$

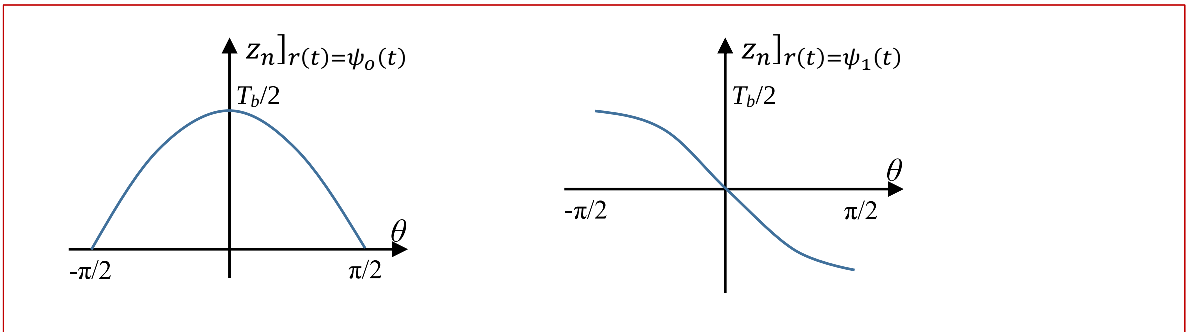
c) Draw approximate (estimated) z_n vs θ graph when the sync circuit is out of sync by θ. That is, the input is $\psi_i(t+\theta)$ (θ ranges from -90° to +90°).

a) $z_n = \int_0^{T_b} \left[\sin\left(\frac{2\pi t}{T_b}\right)\right]^2 dt = \int_0^{T_b} \left[\frac{1}{2} - \frac{1}{2}\cos\left(\frac{4\pi t}{T_b}\right)\right] dt = \left[\frac{t}{2} - \frac{T_b}{8\pi}\sin\left(\frac{4\pi t}{T_b}\right)\right]_0^{T_b} = \frac{T_b}{2}$

b) $z_n]_{r(t)=\psi_1(t)}$ =0 (orthogonal)

c) $z_n(\theta) = \int_0^{T_b} \sin\left(\frac{2\pi t}{T_b}\right) \sin\left(\frac{2\pi t}{T_b} + \theta\right) dt = \frac{1}{2} \int_0^{T_b} \left[\cos(\theta) - \cos\left(\frac{4\pi t}{T_b} + \theta\right)\right] dt$

$= \frac{\cos(\theta) T_b}{2} - \frac{1}{2} \int_0^{T_b} \cos\left(\frac{4\pi t}{T_b} + \theta\right) dt = \frac{\cos(\theta) T_b}{2} - \frac{T_b}{8\pi} \sin\left(\frac{4\pi t}{T_b} + \theta\right)\Big]_0^{T_b} = \frac{T_b}{2}\cos(\theta)$



Any estimated drawings with such monotonic characteristics are acceptable.