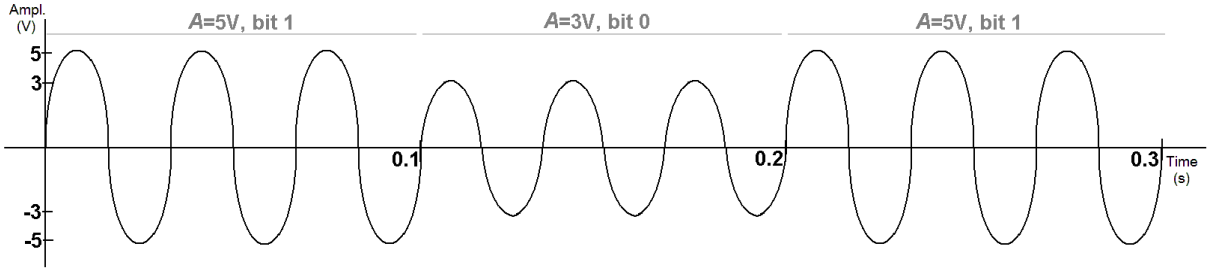
# CSE Department, North South University
# ETE131: Introduction to Telecommunications & Computer Engineering (SyR)
## Problem Sheet 5: Digital Modulation and PCM (Solutions)

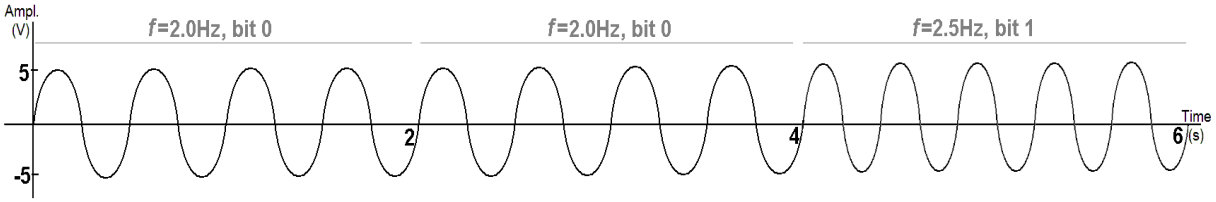
**Question 1:** You are required to transmit the bit pattern 101 via ASK with a carrier frequency of 30Hz and a baud rate of 10units/second. The peak amplitude for bits 1 and 0 are 5V and 3V respectively. Show the waveform transmitted for 101 using ASK.

$N_{baud}$ = 10 and $f$ = 30, therefore each bit interval is 0.1s and each bit is represented by 3 cycles

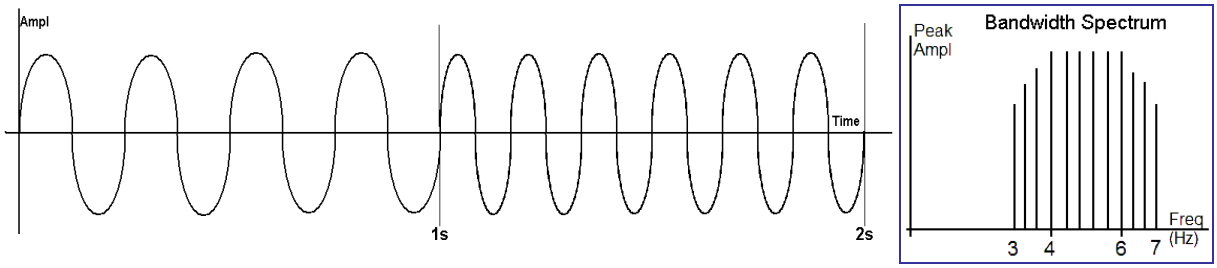



**Question 2:** You are required to transmit the bit pattern 001 via FSK with amplitude of 5V and bit interval of 2s. The carrier frequencies for bits 0 and 1 are 2.0Hz and 2.5Hz respectively. Show the waveform transmitted for 001 using FSK.

$f_0$ = 2.0, $f_1$ = 2.5, bit interval = 2s, therefore bit 0 is 4 cycles at 2Hz and bit 1 is 5 cycles at 2.5Hz




**Question 3**: The given transmission uses FSK with a high frequency for bit 1 and a low frequency for bit 0. Compute the carrier frequencies for bits 1 and 0. Given that each bit duration is 0.5s, compute the bit stream being transmitted. Draw the spectrum for the bandwidth requirements for this transmission system.

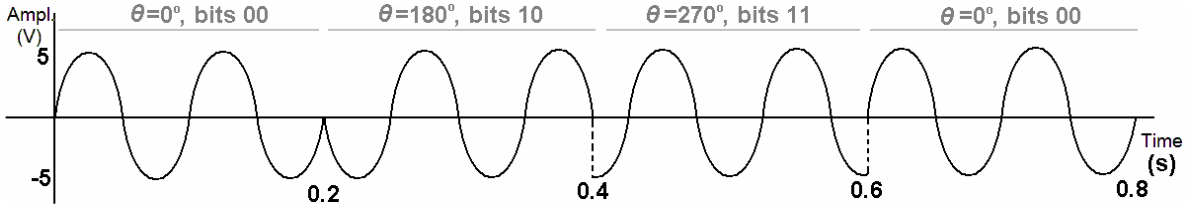



$f_0$ = 4Hz, $f_1$ = 6Hz and bit interval = 0.5s, therefore there are four bits in the signal.

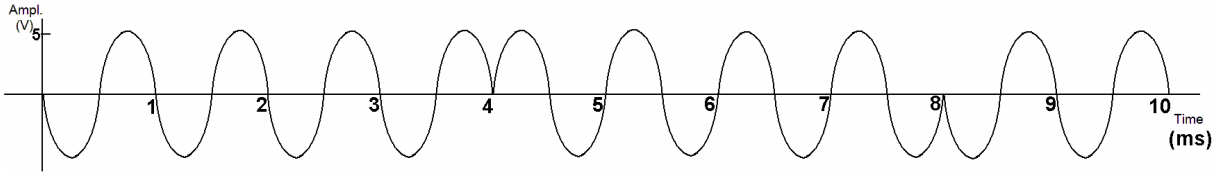
First 0.5s, $f$=4Hz, i.e. bit 0 Second 0.5s, $f$=4Hz, i.e. bit 0 Third 0.5s, $f$=6Hz, = bit 1
Fourth 0.5s, $f$=6Hz, = bit 1 Therefore the transmission was 0011

**Question 4:** You are required to transmit the bit pattern 00101100 via QPSK with an amplitude of 5V, a frequency of 10Hz, and a baud rate of 5 units/second. Show the waveform transmitted for this signal. What is the bit rate of this transmission?

Transmitting 8 bits with QPSK, therefore 4 signal units are needed. Since $N_{baud}$=5, each unit is 0.2s

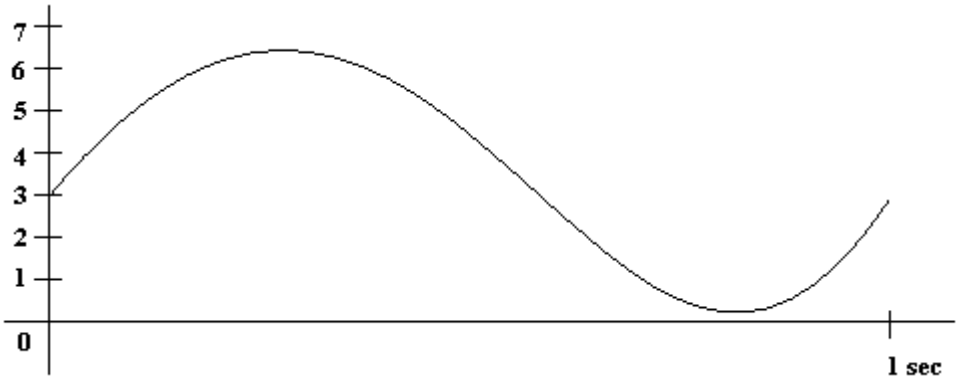


**Question 5:** The given BPSK signal is being transmitted with a bit-rate 500bps. Compute the carrier frequency of the signal. What is the bit stream being transmitted?

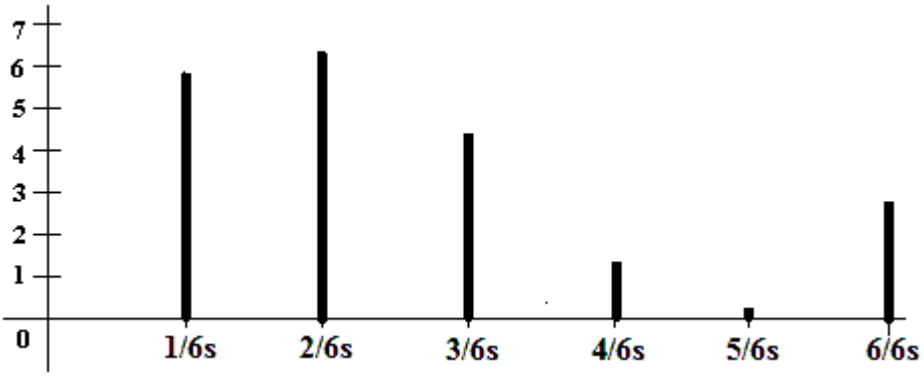



Period $T$ = 1ms, therefore $f_c$ = 1/1ms = 1/0.001 = 1000Hz
Bit-rate = 500bps, therefore each bit = 0.002s = 2ms.
First 2ms, $\theta$=180°, i.e. bit 1 Second 2ms, $\theta$=180° i.e. bit 1 Third 2ms, $\theta$=0°, i.e. bit 0
Fourth 2ms, $\theta$=0°, i.e. bit 0 Fifth 2ms, $\theta$=180°, i.e. bit 1 Bit-Stream - 11001

**Question 6:** You are given the following analog wave pattern. Assume you can sample at 8 voltage levels (0, 1, 2, 3, 4, 5, 6 and 7). You are told that the sampling rate is 6 samples per second and time 0 is not being accounted for as a sample.




a) Show the waveform after Pulse Amplitude Modulation is applied to it.




b) How many bits are needed to represent each sample?
Since there are eight levels (0-7), only three bits are needed per sample

c) Convert each of the sampled values into a string of bits via quantization and encoding.
Sample-1 at 1/6s = 5.9 ≈ 6 = 110 Sample-2 at 2/6s = 6.2 ≈ 6 = 110
Sample-3 at 3/6s = 4.4 ≈ 4 = 100 Sample-4 at 4/6s = 1.3 ≈ 1 = 001
Sample-5 at 5/6s = 0.2 ≈ 0 = 000 Sample-6 at 6/6s = 2.9 ≈ 3 = 011

After Encoding: 110110100001000011