After the Midterm Exam.
Nov 8 (Monday)

Topics today: Modulation, Demodulation

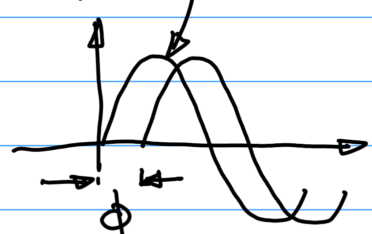
Example: Road Map for the 2nd half of the Semester.

MOD/DEMOD Technique. → PPT. (5 Blocks)

Hardson Industrial Grade IOT solution

PSK — Phase shift Keying
=
CCK (Defined as IEEE 802.11b Standard)

Note: 1. Phase, $A\sin(\omega_c t+\phi)$ ...(1)



phase "shift"

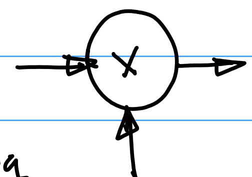
We can change phase value to make to carry information, e.g. "0" or "1".

2. Background on Modulation.

What is modulation? A technique By multiplying a modulating function to a exist function to move the modulating function to a higher frequency range.

Block Diagram to illustrate Modulation Technique

$f(t)$ "Modulating Signal"



$f(t)\cdot A\cos(2\pi f_c t+\phi)$

$A\cos(2\pi f_c t+\phi)$
"Carrier Signal"

Fig. 1

Why? (The objective) The objective of modulation is to move the Base Band Signal (e.g. modulating Signal) to higher Frequency Range.

- Better/more Efficient Transmission
- Better Random Noise Resistance, Robustness
- To gain fast Transmission Bit Rate.

Ref on Theoretical Background, Fourier Transform. 2018F-117. on github

Properties in Fourier Transform provides foundation for good understanding of the Technique

<u>Property 2</u>: If $g(t) \leftrightarrow G(f)$ and $h(t) \leftrightarrow H(f)$
then $g(t)h(t) \leftrightarrow \underline{G(f) * H(f)}$ ...(2)

<u>Property 3</u>: If $g(t) \leftrightarrow G(f)$, and $h(t) \leftrightarrow H(f)$
then $g(t) * h(t) \leftrightarrow \underline{G(f)H(f)}$ ...(3)

<u>Property 4</u>: Sampling Property (Based ON Eqn (2))

Ref: github, 2018F-118 ~

PSK Modulation & Demodulation

HL

First, ASK, PSK, FSK modulation and Demodulation Formulation

Table 1

	$S_1(t) = 0$
ASK	$S_2(t) = A\cos 2\pi f_c t,\ t \in [0, T_b]$ ...(1)

Ref: from the class github. 2018F-111 ~

Theoretical Background. Review

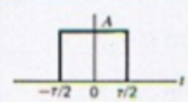
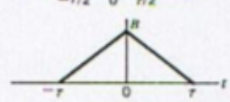
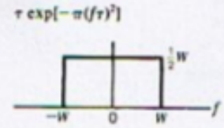
$$X(f) = \int_{-\infty}^{\infty} x(t)\exp(-j2\pi ft)\,dt$$

$$x(t) = \int_{-\infty}^{\infty} X(f)\exp(j2\pi ft)\,df$$

$$\int_{-\infty}^{\infty} |x(t)|^2\,dt = \int_{-\infty}^{\infty} |X(f)|^2\,df$$

Table C.1. Transform theorems.

Name of theorem	Signal	Fourier transform
(1) Superposition	$a_1x_1(t) + a_2x_2(t)$	$a_1X_1(f) + a_2X_2(f)$
(2) Time delay	$x(t - t_0)$	$X(f)\exp(-j2\pi ft_0)$
(3) Scale change	$x(at)$	$\lvert a\rvert^{-1}X(f/a)$
(4) Frequency translation	$x(t)\exp(j2\pi f_0t)$	$X(f - f_0)$
(5) Modulation	$x(t)\cos 2\pi f_0t$	$\frac{1}{2}X(f - f_0) + \frac{1}{2}X(f + f_0)$
(6) Differentiation	$\frac{d^nx(t)}{dt^n}$	$(j2\pi f)^nX(f)$
(7) Integration	$\int_{-\infty}^{t} x(t')\,dt'$	$(j2\pi f)^{-1}X(f) + \frac{1}{2}X(0)\delta(f)$
(8) Convolution	$\int_{-\infty}^{\infty} x_1(t - t')x_2(t')\,dt' = \int_{-\infty}^{\infty} x_1(t')x_2(t - t')\,dt'$	$X_1(f)X_2(f)$
(9) Multiplication	$x_1(t)x_2(t)$	$\int_{-\infty}^{\infty} X_1(f - f')X_2(f')\,df' = \int_{-\infty}^{\infty} X_1(f')X_2(f - f')\,df'$

(1) 	$A\tau\frac{\sin \pi f\tau}{\pi f\tau} \triangleq A\tau\,\text{sinc}\,f\tau$
(2) 	$B\tau\frac{\sin^2 \pi f\tau}{(\pi f\tau)^2} \triangleq B\tau\,\text{sinc}^2\,f\tau$
(3) $e^{-\alpha t}u(t)$	$\frac{1}{\alpha + j2\pi f}$
(4) $\exp(-\lvert t\rvert/\tau)$	$\frac{2\tau}{1 + (2\pi f\tau)^2}$
(5) $\exp[-\pi(t/\tau)^2]$	$\tau\exp[-\pi(f\tau)^2]$
(6) $\frac{\sin 2\pi Wt}{2\pi Wt} \triangleq \text{sinc}\,2Wt$	
(7) $\exp[j(2\pi f_ct + \phi)]$	$\exp(j\phi)\delta(f - f_c)$
(8) $\cos(2\pi f_ct + \phi)$	$\frac{1}{2}\delta(f - f_c)\exp(j\phi) + \frac{1}{2}\delta(f + f_c)\exp(-j\phi)$
(9) $\delta(t - t_0)$	$\exp(-j2\pi ft_0)$
(10) $\sum_{m=-\infty}^{\infty} \delta(t - mT_s)$	$\frac{1}{T_s}\sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{T_s}\right)$
(11) $\text{sgn}\,t = \begin{cases} +1, & t > 0 \\ -1, & t < 0 \end{cases}$	$-\frac{j}{\pi f}$
(12) $u(t) = \begin{cases} 1, & t > 0 \\ \ldots \end{cases}$	$\frac{1}{2}\delta(f) + \frac{1}{\ldots}$

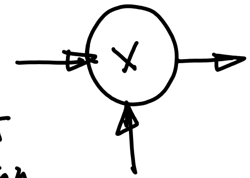
Example: From the class github, 2018F-111 ~ From Fig1. PP44

Amplitude Signal → Base Band Signal $\underline{\underline{f(t)}}$ "modulating Signal"

(1) (2) (3)

ASK, FSK, PSK

Amplitude Frequency Shift Keying Phase Shift Keying



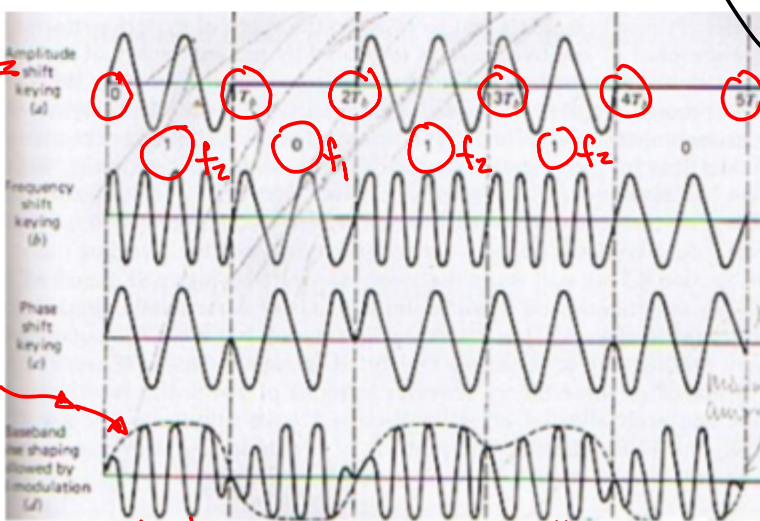
$f(t) \cdot A\cos(2\pi f_c t + \phi)$

$A\cos(2\pi f_c t+\phi)$

"Carrier Signal"

Fig.2

$f_c = 2.4\,GHz$ "Wifi"



Envelop has phase change

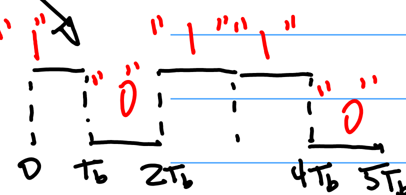
Fig.3

ASK

FSK

PSK

Base Band Shaping + Analog Modulation (DSB)



Suppose we have to transmit "SJSU CMPE245"

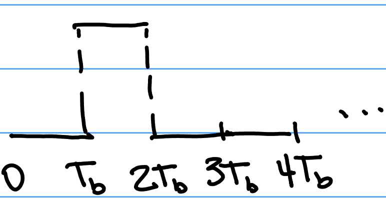
↓ J By ASCII code

Decimal	Octal	Hex	Binary	Value
074	112	4A	0100 1010	J

0x4A

0100 1 ...

→ Waveform.



Note from (2) (F.S.K.)

Base Band Signal 0x4A in Binaries "0" → f_1

"1" → f_2

$f_1 < f_2$ for example.

0x4A

↓

0x4

↓ Binary

0100

$f_1 f_2 f_1 f_1$

0x4'A

↓

0x4

↓

0 1 0 0

$P_1 P_2 P_1 P_1$

Modulated Signal

$A\cos(2\pi f_c t+\phi_i)$

$i=1,2.$ ...(1)

P_1 = Phase 1 = 0 Degree

P_2 = phase 2 = 180 Degree

from Eqn (1).

for Phase 1: $A\cos(2\pi f_c t+\phi_1)$

$=A\cos(2\pi f_c t+0)$

$=A\cos 2\pi f_c t$

for phase 2: $A\cos(2\pi f_c t+\phi_2)$

$=A\cos(2\pi f_c+\pi)=-A\cos 2\pi f_c t$