After the Midterm Exam.

Nov 8 (Monday)

Topics today: Modulation, Demodulation

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

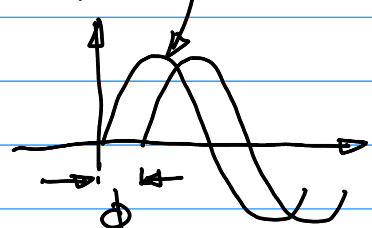
- MOD/DEMOD Technique.
- Hardson PPT. (5 Blocks)

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"

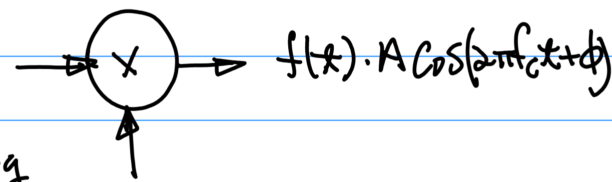
We can change phase value to make to carry information, e.g. "0" or "1".

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"



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

"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

Property 2: If $g(t) \leftrightarrow G(f)$ and $h(t) \leftrightarrow H(f)$
then $g(t)h(t) \leftrightarrow G(f) * H(f)$ ...(2)

Property 3: If $g(t) \leftrightarrow G(f)$, and $h(t) \leftrightarrow H(f)$
then
$g(t) * h(t) \leftrightarrow G(f)H(f)$ ...(3)

Property 4: Sampling Property (Based ON Eqn (2))

Ref: github, 2018F-118 ~

PSK Modulation & Demodulation

HL

First, ASK, PSK, FSK modulation and Demodulation Formulation

Table 1

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

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

Theoretical Background. Review

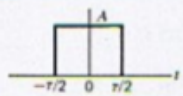
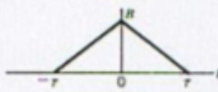
$$X(f) = \int_{-\infty}^{\infty} x(t) \exp(-j2\pi f t)\, dt$$

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

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

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	$x(t - t_0)$	$X(f)\exp(-j2\pi f t_0)$
(3) Scale change	$x(at)$	$\lvert a\rvert^{-1}X(f/a)$
(4) Frequency translation	$x(t)\exp(j2\pi f_0 t)$	$X(f - f_0)$
(5) Modulation	$x(t)\cos 2\pi f_0 t$	$\frac{1}{2}X(f - f_0) + \frac{1}{2}X(f + f_0)$
(6) Differentiation	$\frac{d^n x(t)}{dt^n}$	$(j2\pi f)^n X(f)$
(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	$x_1(t)x_2(t)$	$\int_{-\infty}^{\infty} X_1(f - f')X_2(f')\, df' = \int_{-\infty}^{\infty} X_1(f')X_2(f - f')\, df'$

	Signal	Fourier transform
(1)		$A\tau \frac{\sin \pi f\tau}{\pi f\tau} \triangleq A\tau\ \mathrm{sinc}\, f\tau$
(2)		$B\tau \frac{\sin^2 \pi f\tau}{(\pi f\tau)^2} \triangleq B\tau\ \mathrm{sinc}^2 f\tau$
(3)	$e^{-at}u(t)$	$\frac{1}{a + j2\pi f}$
(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)	$\frac{\sin 2\pi W t}{2\pi W t} \triangleq \mathrm{sinc}\, 2Wt$	
(7)	$\exp[j(2\pi f_c t + \phi)]$	$\exp(j\phi)\delta(f - f_c)$
(8)	$\cos(2\pi f_c t + \phi)$	$\frac{1}{2}\delta(f - f_c)\exp(j\phi) + \frac{1}{2}\delta(f + f_c)\exp(-j\phi)$
(9)	$\delta(t - t_0)$	$\exp(-j2\pi f t_0)$
(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)	$\mathrm{sgn}\, t = \begin{cases} +1, & t > 0 \\ -1, & t < 0 \end{cases}$	$-\frac{j}{\pi f}$
(12)	$u(t) = \begin{cases} 1, & t > 0 \\ [illegible] \end{cases}$	$\frac{1}{2}\delta(f) + \frac{1}{[illegible]}$

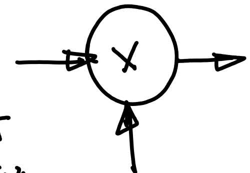
Example: From the class github, 2018F-111 ~ From Fig1. pp44

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

(1) (2) (3)

ASK, FSK, PSK

Amplitude, Frequency Shift Keying, Phase shift Keying

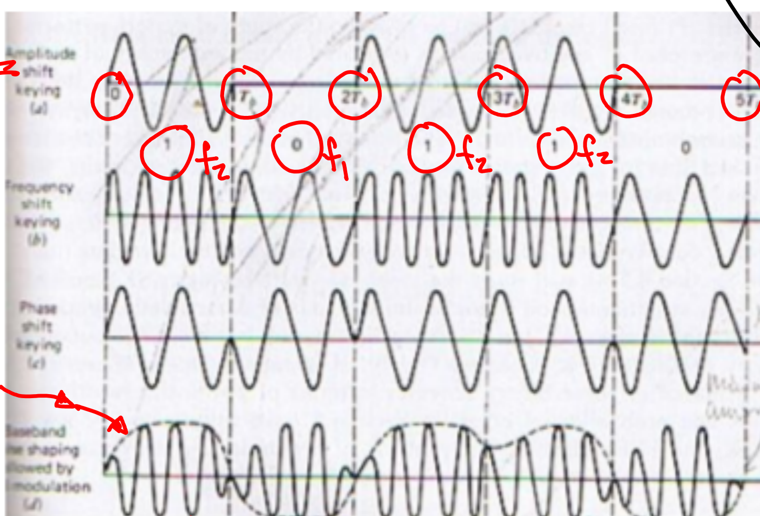


$f(t) \cdot A\cos(2\pi f_c t + \phi)$

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

"Carrier Signal" $f_c = 2.4\,GHz$ "Wifi"

Fig.2



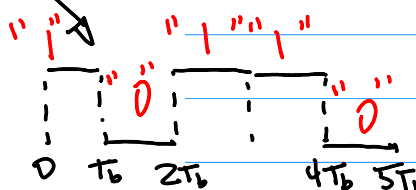
Envelop has phase change

Fig.3

ASK

FSK

PSK



Base Band Shaping + Analog Modulation (DSB)

Suppose we have to transmit "SJSU CMPE245"

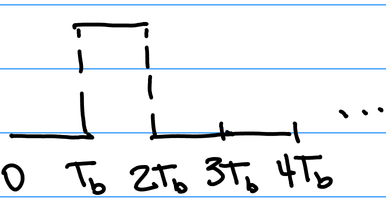
↓ By ASCII code

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

0x4A

0100 1 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

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

$i = 1, 2. \quad \ldots (1)$

P_1 = Phase 1 = 0 Degree

P_2 = phase 2 = 180 Degree

from Eqn (1).

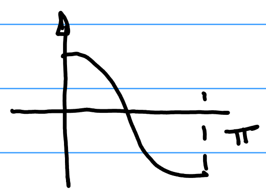
for phase 1: $A\cos(2\pi f_c t + \phi_1)$

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

$= A\cos 2\pi f_c t$

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

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



Nov.10 (Wed)

Note: 1° References on PSK modulation Demodulation on github ~ cmpe245; (2021F-111~)

2° Project By End of the Semester. LoRA R.F. to establish C.R. (Cognitive Radio), Team Based Project.

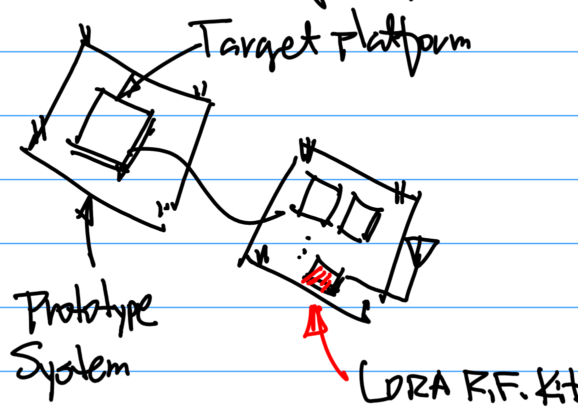
(1) LoRA R.F. Kit to Implement SPI Based I/F to your target platform;
One kit per team;

(2) Formal Presentation With Demo, Requires Both R.F. Kit. Any Suggestions?

(3) Project Counts 20 pts. requires integration to your target platform.
Sample code for LPC1769 platform is provided "as it is", Individual responsibility to make it as an integral part of your final project.

Homework (Due A week from today) Nov. 17.

1. Build Hardware Interface to R.F module (Lora).



S.P.I. I/F. "3+1" pins

S.P.I. | MOSI. (Master Out Slave In)
MISO
SCK (Serial clock)

"plus 1 pin" : Enable/or Select pin.

Submission:

1° photo of the Setup should R.F. module integrated with your embedded wireless System.

2° photo or Jpeg, or pdf Shows the pin Connection/connectivity diagram.

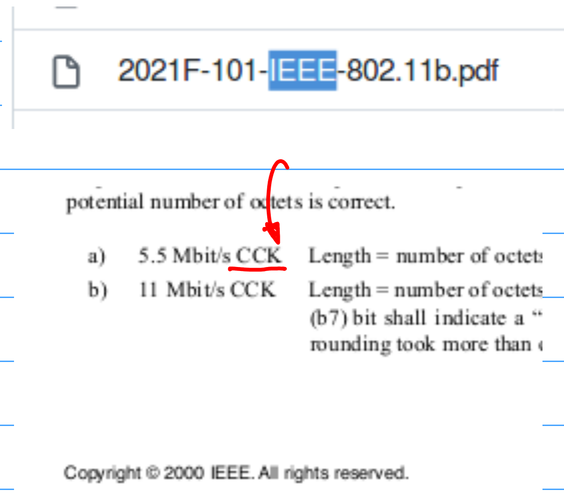
3° One paragraph Description for System Bring-up. (LORA R.F. Kit) Be sure to provide URL.

4° Elect a team Coordinator, provide Coordinator's name and all the team members Name.

4° Create One pdf file for all the homework material, then zip it. Note: please indicate the teammember who has the physical R.F. Kit. In your first photo, please provide this information.

Discussion on modulation Technique.

IEEE802.11b.



2021F-101-IEEE-802.11b.pdf

potential number of octets is correct.

a) 5.5 Mbit/s CCK Length = number of octets

b) 11 Mbit/s CCK Length = number of octets (b7) bit shall indicate a " rounding took more than

Example: from pp.46. Illustration of modulation in Time Domain.

"modulating Signal"
Base Band Signal

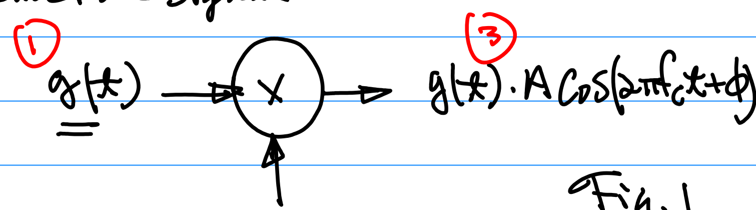


Fig. 1

"Carrier Signal" $f_c = 2.4\,\text{GHz}$ "Wifi"

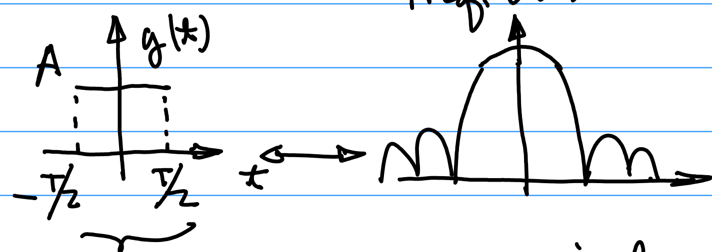
Let's take a look this modulation in the Frequency Domain.

First, Take each of the Signals, 3 of them in Fig.1. then perform Fourier Transform on each of them.

$$g(t) \leftrightarrow F.T.[g(t)] = G(f) \quad \ldots (1)$$

$$g(t) \longleftrightarrow G(f) = A_T \frac{\sin \pi f T}{\pi f T} \quad \ldots (2)$$

Time Domain   Freq. Domain



One period : T.
tied to the
Bit Rate

$$G(f) = A_T \frac{\sin \pi f T}{\pi f T}$$

Fig. 2.

2017F-108-lec-BB-Sign... A

Now, for the 2nd Signal in Fig. 1
(Modulation Block Diagram)

(8) $\cos(2\pi f_c t + \phi)$	$\frac{1}{2}\delta(f - f_c)\exp(j\phi) + \frac{1}{2}\delta(f + f_c)\exp(-j\phi)$

$\frac{1}{2}[\delta(f - f_c) + \delta(f + f_c)]$
(Assuming $\phi = 0$)

$\cos(2\pi f_c t + \phi)$
"Carrier Signal", f_c: Carrier frequency.

In Wifi Communication, $f_c = 2.4\,\text{GHz}$
from this table,
Assuming $\phi = 0$ $\cos(2\pi f_c t + \phi)$
$= \cos(2\pi f_c t)$

$$\cos(2\pi f_c t) \longleftrightarrow \frac{1}{2}[\delta(f - f_c) + \delta(f + f_c)] \quad \ldots (3)$$