After the Midterm Exam.

Nov 8 (Monday)

Topics today: Modulation, Demodulation

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

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

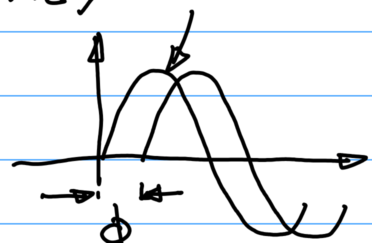
Industrial Grade IOT solution

PSK — phase shift Keying

=

CCK (Defined as IEEE 802.11b Standard)

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



phase "shift"

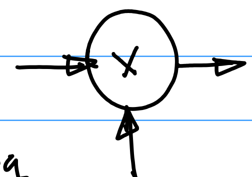
We can change phase value to make to carry information, e.g. "0" or "1".

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"



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

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

"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

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

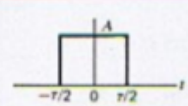
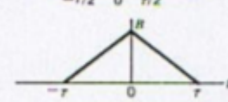
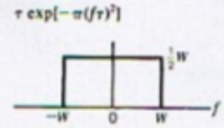
$$X(f) = \int_{-\infty}^{\infty} x(t)\exp(-j2\pi ft)\,dt$$

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

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

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	$x(at)$	$\|a\|^{-1}X(f/a)$
(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)		$A\tau \frac{\sin \pi f\tau}{\pi f\tau} \triangleq A\tau \operatorname{sinc} f\tau$
(2)		$B\tau \frac{\sin^2 \pi f\tau}{(\pi f\tau)^2} \triangleq B\tau \operatorname{sinc}^2 f\tau$
(3)	$e^{-at}u(t)$	$\frac{1}{a + j2\pi f}$
* (4)	$\exp(-\|t\|/\tau)$	$\frac{2\tau}{1 + (2\pi f\tau)^2}$
* (5)	$\exp[-\pi(t/\tau)^2]$	$\tau\exp[-\pi(f\tau)^2]$
* (6)	$\frac{\sin 2\pi Wt}{2\pi Wt} \triangleq \operatorname{sinc} 2Wt$	
(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)	$\delta(t - t_0)$	$\exp(-j2\pi ft_0)$
* (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)	$\operatorname{sgn} t = \begin{cases} +1, & t > 0 \\ -1, & t < 0 \end{cases}$	$-\frac{j}{\pi f}$
(12)	$u(t) = \begin{cases} 1, & t > 0 \\ 0, & t < 0 \end{cases}$	$\frac{1}{2}\delta(f) + \frac{1}{j2\pi f}$

Example: From the class github, 2018F-111 ~ From Fig 1. 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

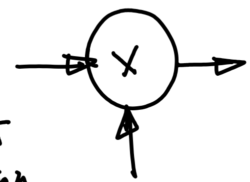
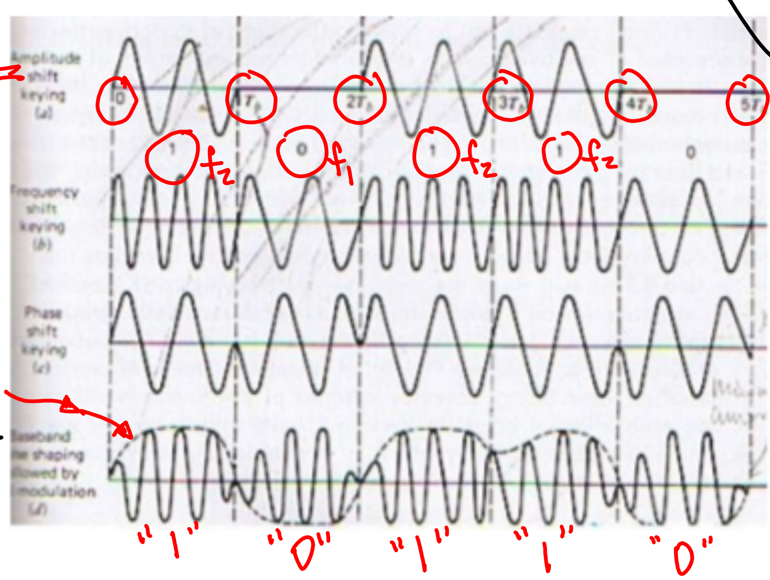


Fig.2

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



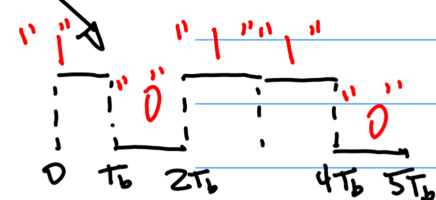
Envelop has phase change

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

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

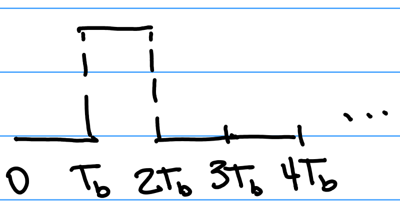
0100

$f_1 f_2 f_1 f_1$

0x4A

0100 1 1 ....

→ Waveform.



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).

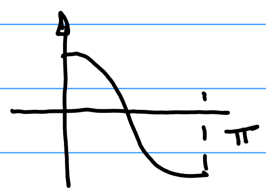
for Phase 1: $A\cos(2\pi f_c t+\phi_1)$

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

$= A\cos 2\pi f_c t$

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

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



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.

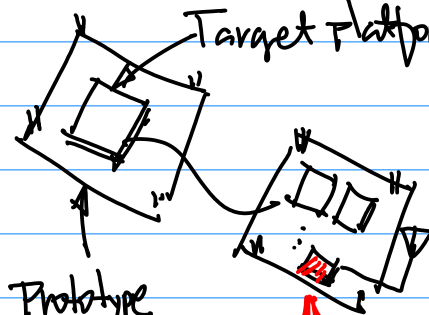
(1) LoRA R.F. kit to Implement SPI Based I/F to your target platform;
One kit per team;

(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 show 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

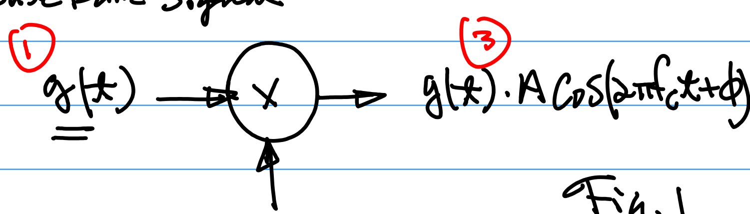


Fig. 1

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

"Carrier Signal" $f_c = 2.4$ 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.

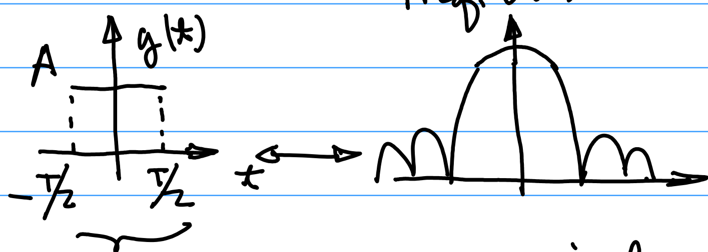
$$g(t) \leftrightarrow F.T.[g(t)] = G(f) \quad \ldots (1)$$

CMPE245

Nov 15 (Monday)

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

Time Domain   Freq. Domain



One period : T.
tied to the Bit Rate

$$G(f) = A\tau \frac{\sin \pi f \tau}{\pi f \tau}$$

Fig. 2.

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

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

(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) $\delta(t - t_0)$	$\exp(-j2\pi f t_0)$

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

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

"Carrier Signal", f_c: Carrier frequency.

In Wifi Communication, $f_c = 2.4$ GHz

from this table,

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

$$= \cos(2\pi f_c t)$$

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

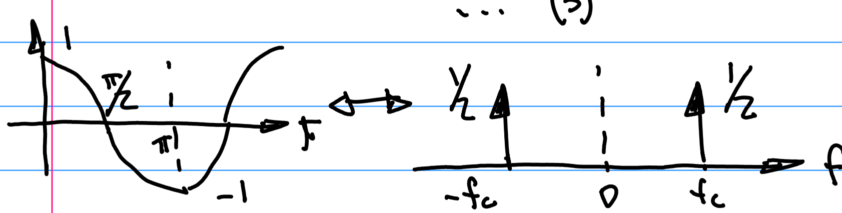


Fig. 3

Note: 1° midterm key is ready, to Be Posted on CANVAS.

2° Resume Semester Long Project.

Homework: Nov. 22nd (Monday)

Team Implementation of Hardware Interface to LORA module.

What to Submit to CANVAS:

1° photo of Hardware Implementation

a. Embedded Target platform
b. R.F. Board/module
c. LORA RF module

2° Since it is a team Project, team members To identify your team, And team Coordinator's Name and Contact information.

3° Photo of Pin Connection Diagram (from the vendor's website) the information about your

4° Provide target platform. if you are using LPC1769, provide URL link of the code Sample on the class github.

CMPE245

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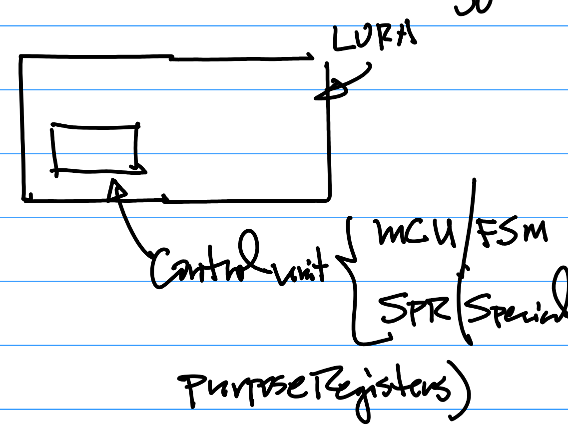
(1) Two modules.

LoRa.c — Add files via upload

LoRa.h — Add files via upload



(2) Tested module

```
/*
 * LoRa.c
 *
 *  Created on: Oct 29, 2017
 *  CTI One Corporation released for Dr

 */

/*
 * LoRa.cpp
 *
 *  Created on: Oct 29, 2017
 *  CTI One Corporation released for Dr
 */


#include <stdio.h>
#include <stddef.h>
#include "LoRa.h"
#include "ssp.h"
#include "extint.h"
// registers
#define REG_FIFO                    0x00
#define REG_OP_MODE                 0x01
#define REG_FRF_MSB                 0x06
#define REG_FRF_MID                 0x07
#define REG_FRF_LSB                 0x08
#define REG_PA_CONFIG               0x09
:
```

(3) header files needed for the testing of this code.

(4) Special Purpose Registers of LORA module

https://github.com/hualili/CMPE245-Embedded-Wireless/blob/master/LoRa.c

And Lora.h file Below.

https://github.com/hualili/CMPE245-Embedded-Wireless/blob/master/LoRa.h

```
/*
 * LoRa.h
 *
 *  Created on: Oct 29, 2017
 *  CTI One Corporation released for Dr. Harry Li
 */

#ifndef LORA_H_
#define LORA_H_

/*
 * LoRa.h
 *
 *  Created on: Oct 29, 2017
 *  CTI One Corporation released for Dr. Harry Li
 */


#include <stddef.h>
#include "ssp.h"

//#define LORA_DEFAULT_SS_PIN         10
#define LORA_DEFAULT_RESET_PIN       2
#define LORA_DEFAULT_DIO0_PIN        3
```

Origin of SSP code is from NXP.

(5) SSP code for SPI Interface.

(6) Pin mappings may be changed for different Vendors, Check your Vendor's website, get

Top level (Conceptual level) Description of LORA:

the Latest pin Connection diagram.

5° Submit SPI interface (Screen Capture of your) Program, together with the Source code to establish work in progress.

Note: Submission on CANVAS.

Example: Continuation of modulation Discussion.

Ref: github/hualili/cmpe245/~

2018F-111-lec5-BB-Signals-2018-10-1.pdf

Technique for Convolution.

	Convolution (Time Domain)	Fourier Transform (Freq.)
(8) Convolution	$\int_{-\infty}^{\infty} x_1(t-t')x_2(t')\,dt' = \int_{-\infty}^{\infty} x_1(t')x_2(t-t')\,dt'$	$X_1(f)X_2(f)$

Notation for convolution of 2 Signals

$x_1(t)$, $x_2(t)$, or $g(t)$, $h(t)$

1° Notation: $g(t) * h(t)$ Convolution.

"$*$" Symbol for the operator of convolution;

2° Definition:

$$g(t) * h(t) = \int_{-\infty}^{+\infty} g(\tau) h(\tau-\tau)\, d\tau \quad \ldots (1)$$

If discrete signal:

$g(t) \to g(k)$, $h(t) \to h(k)$

$$\sum_{k=0}^{N-1} g(k) h(n-k) \quad \ldots (2)$$

Property (of convolution):

if $g(t) \longleftrightarrow FT[g(t)] = G(f)$

$h(t) \longleftrightarrow FT[h(t)] = H(f)$

then

$$g(t) * h(t) \longleftrightarrow G(f)H(f) \quad \ldots (3)$$

Pf:

$$g(t) * h(t) = \int_{-\infty}^{+\infty} g(\tau) h(t-\tau)\, d\tau$$

then,

$$FT[g(t) * h(t)] = \int_{-\infty}^{+\infty} g(t) * h(t)\, e^{-j2\pi f t}\, dt$$

$$= \int_{-\infty}^{+\infty} \left[\int_{-\infty}^{+\infty} g(\tau) h(t-\tau)\, d\tau \right] e^{-j2\pi f t}\, dt$$

$$= \int_{-\infty}^{+\infty} g(\tau) e^{-j2\pi f \tau} e^{j2\pi f \tau}\, d\tau \int_{-\infty}^{+\infty} h(t-\tau) e^{-j2\pi f t}\, dt$$

$$= \underbrace{\int_{-\infty}^{+\infty} g(\tau) e^{-j2\pi f \tau}\, d\tau}_{G(f)} \underbrace{\int_{-\infty}^{+\infty} h(t-\tau) e^{-j2\pi f (t-\tau)}\, d(t-\tau)}_{H(f)}$$

$$= G(f)H(f)$$

Symmetric Property to Eqn (3):

Property 2.

If $g(t) \leftrightarrow FT[g(t)] = G(f)$

$h(t) \leftrightarrow FT[h(t)] = H(f)$

then,

$$g(t)h(t) \leftrightarrow G(f) * H(f) \quad \ldots (4)$$

Example: Convolution and Signal Sampling.

1° Sampling with Impulse function $\delta(t)$

First, Definition of $\delta(t)$

$$\delta(t) = \begin{cases} +\infty & t = 0 \\ 0 & t \neq 0 \end{cases} \quad \text{and} \quad \ldots (5a)$$

$$\int_{-\infty}^{+\infty} \delta(t)\,dt = 1 \quad \ldots (5b)$$

Nov. 17 (Wed)

Note: Homework on Lora-RF module Hardware Integration is Due Today on CANVAS 11:59 pm.

Example: Impulse Function & its Sampling Application.

Sol Given a function $g(t)$ to Sample this function, we have

$$\int_{-\infty}^{+\infty} g(t)\,\delta(t)\,dt =$$

$$\int_{-\infty}^{-\varepsilon} g(t)\,\delta(t)\,dt + \int_{-\varepsilon}^{+\varepsilon} g(t)\,\delta(t)\,dt + \int_{+\varepsilon}^{+\infty} g(t)\,\delta(t)\,dt \quad \ldots (6)$$

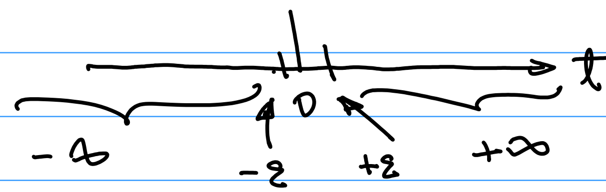


Fig 1.

$$\int_{-\infty}^{-\varepsilon} g(t)\,\delta(t)\,dt = 0$$

$$\int_{+\varepsilon}^{+\infty} g(t)\,\delta(t)\,dt = 0$$

hence,

Eqn (6) Becomes $\int_{-\varepsilon}^{+\varepsilon} g(t)\,\delta(t)\,dt$

$$\lim_{\varepsilon \to 0} \int_{-\varepsilon}^{+\varepsilon} g(t)\,\delta(t)\,dt = g(0) \quad \ldots (7)$$

$g(t)$ is Sampled at $t = 0$ By $\delta(t)$.

Consider the following Applications.

Sample $g(t)$ at any given time instance t_0

$$\int_{-\infty}^{+\infty} g(t)\,\delta(t - t_0)\,dt = \int_{-\infty}^{t_0 - \varepsilon} \cancel{g(t)\,\delta(t - t_0)\,dt}^{\,0}$$

$$+ \int_{t_0 - \varepsilon}^{t_0 + \varepsilon} g(t)\,\delta(t - t_0)\,dt + \int_{t + \varepsilon}^{+\infty} \cancel{g(t)\,\delta(t - t_0)\,dt}^{\,0}$$

$$= \int_{t_0-\varepsilon}^{t_0+\varepsilon} g(t)\,\delta(t-t_0)\,dt$$

$$= g(t_0)$$

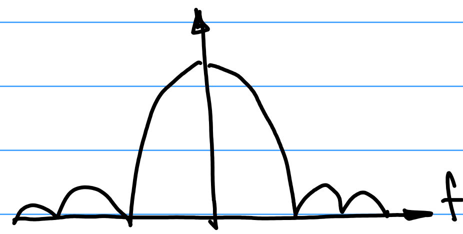


Fig. 2a

Example: Given $G(f) = A\tau \dfrac{\sin \pi f \tau}{\pi f \tau}$

(Spectrum of Base Band Signal)

Carrier Signal $h(t) = \cos 2\pi f_c t$

whose F.T.

$$\boxed{H(f) = \frac{1}{2}\left[\delta(f-f_c) + \delta(f+f_c)\right]} \quad \ldots (6b)$$

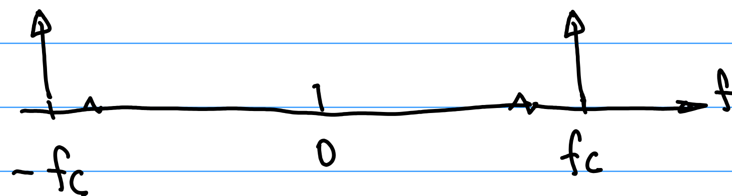


Fig. 2b

Find: $G(f) * H(f) = ?$ And illustrate the result.

$$G(f) * H(f) = \int_{-\infty}^{+\infty} G(f-u)\,H(u)\,du$$

$$= \int_{-\infty}^{+\infty} A\tau \frac{\sin \pi (f-u)\tau}{\pi (f-u)\tau} \cdot \frac{1}{2}\left[\delta(u-f_c) + \delta(u+f_c)\right] du$$

$$= \boxed{\frac{A}{2}\tau \frac{\sin \pi (f+f_c)\tau}{\pi (f+f_c)\tau} + \frac{A\tau}{2} \frac{\sin \pi (f-f_c)\tau}{\pi (f-f_c)\tau}} \quad \ldots (7)$$

Note: please make sure How Eqn (7) is achived.

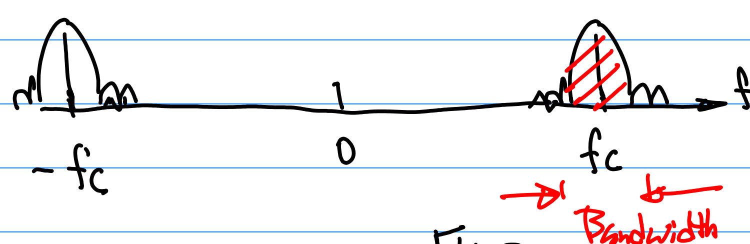
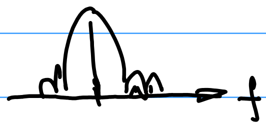
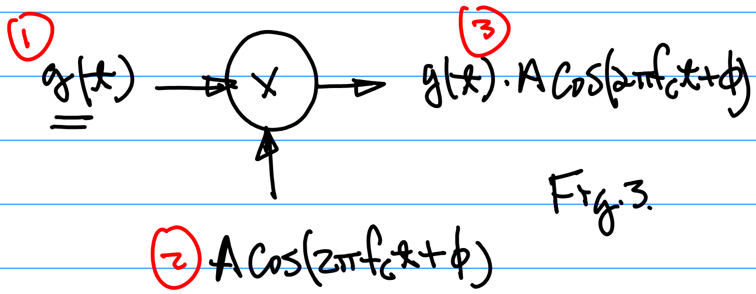


Fig. 2c





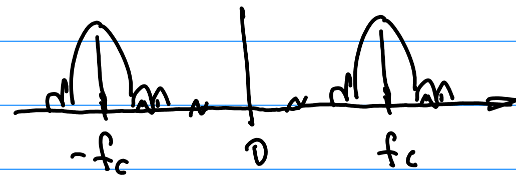
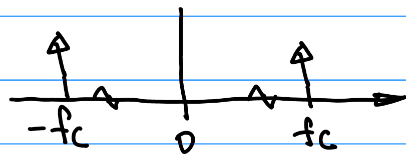


Fig.3.



Ref: see class github/hualili/cmpe245...

- 2018F-117-Mod.pdf
- 2018F-118-DeMOD.jpg

Example

For One Bit (Period)

Table 1

ASK	$S_1(t)=0$ $S_2(t)=A\cos 2\pi f_c t,\ t\in[0,T_b]$ ... (1)
PSK	$S_1(t)=A\cos(2\pi f_c t+\phi_1)$ $S_2(t)=A\cos(2\pi f_c t+\phi_2)$ ... (2) $t\in[0,T_b]$, $\phi_1=0$, $\phi_2=\pi$
FSK	$S_1(t)=A\cos[2\pi(f_c-f_d)t]$ $S_2(t)=A\cos[2\pi(f_c+f_d)t]$ ... (3)

Note 1. Eqn(1) ~ (3), $g(t)$ Base Band Signal is implied

if Amplitude in (1) is "0", then modulation produces the modulated Signal $S_1(t)=0$

if Amplitude is equal to "1" (or A) then the output is

$$S_2(t)=A\cos 2\pi f_c t$$

ASK Technology is employed for the R.F. Kit in this class.

Note 2: PSK (Phase Shift Keying)

Base Band Signal $g(t)$ is utilized to change phase value, ϕ_1, ϕ_2 for Example,

"1" $\rightarrow$ ϕ_1

"0" $\rightarrow$ ϕ_2

In addition, it is Binary Phase Shift Keying. (ϕ_1, ϕ_2)

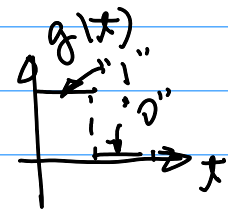
Note 3. FSK: Frequency Shift Keying

"1" freq change, f_c+f_d
"0" " " , f_c-f_d

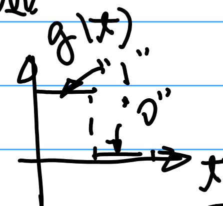
Draw waveforms in Time Domain.

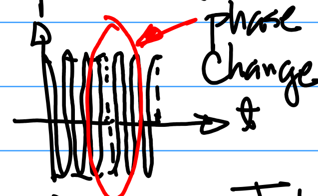
Base Band 1 0
ASK

Amplitude g(t)
ASK

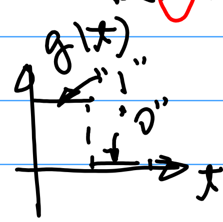


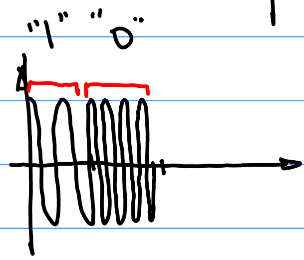
PSK
phase change Induced By g(t)
PSK waveform





FSK
freq changed induced By g(t)
FSK





Nov. 22nd (monday)

Note: 1° Homework has to be individual, e.g., photos, code, implementation have to be accomplished by Each individual;
2° Project (Semester Project on LoRA RF) formal presentation is scheduled

on Dec 6 (monday)

The presentation Requirements

(1) Implementation of LoRA RF on your chosen platform.
Demo: "Hello, First_Last_Name of the team coordinator (a), then First Last Name of Each team member (b), & the work accomplished by each team member." example:

		Task
John Doe	Coordinator	Hardware + Driver
Mr. A	member 1	"
Ms. B	member 2	Init & Config. R.F.
⋮		

(2) Short PPT. (3~5 slides)
(3) Report : IEEE Paper Template (github)
Sections —— Contributor's Name
(First paragraph for Each Section indicates person(s) who contributed (Lead the creation of the Section)

Submission :
1° Report; 2° PPT; 3° photos 4° 5~10 Seconds Video clips.

Example: PSK → BPSK (Binary PSK)

Bandwidth Aspects.

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

ϕ_i, $i=1$, or 2

ϕ_1, ϕ_2 ... (1a)

↓

QPSK (Quadratic PSK)

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

ϕ_i, $i=1,2,3,4$.

$\phi_1, \phi_2, \phi_3, \phi_4$ ... (1b)

From Eqn (7), pp53.

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

$$\boxed{H(f)=\frac{1}{2}[\delta(f-f_c)+\delta(f+f_c)]} \quad \ldots (6b)$$

from pp 53.

Bandwidth for BPSK: From Eqn (7), pp53.

$$B.W.=2\cdot\frac{1}{T} \quad \ldots (2)$$

Bandwidth for QPSK: From Eqn (7). pp53.

$$B.W._Q=2\cdot\frac{1}{T} \quad \ldots (2\text{-}b)$$

Example: Demodulation.

Theoretical Background:

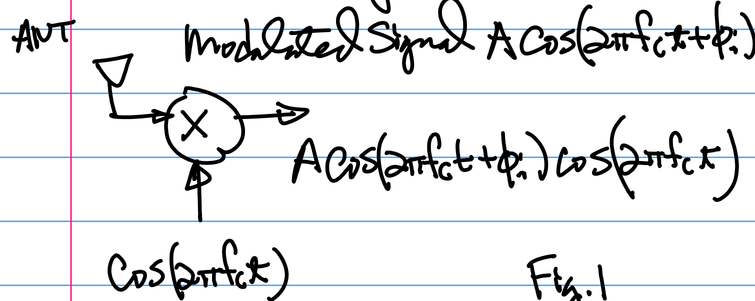


Fig. 1

From Property 2, Eqn (4), pp52

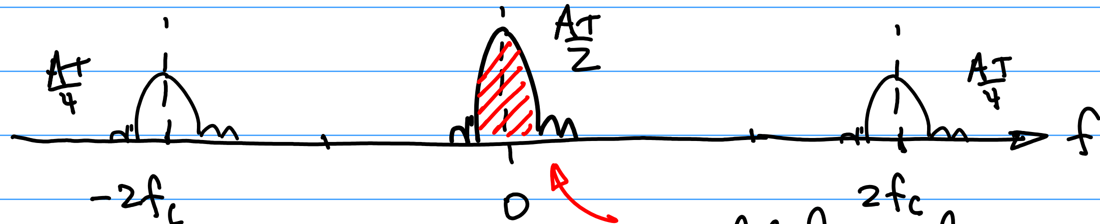
Since $A\cos(2\pi f_c t+\phi_i) \longleftrightarrow$

$$\boxed{\frac{A}{2}T\frac{\sin\pi(f+f_c)T}{\pi(f+f_c)T}+\frac{A}{2}T\frac{\sin\pi(f-f_c)T}{\pi(f-f_c)T}}$$

$$\left[\frac{A}{2}T\frac{\sin\pi(f+f_c)T}{\pi(f+f_c)T}+\frac{A}{2}T\frac{\sin\pi(f-f_c)T}{\pi(f-f_c)T}\right] * \frac{1}{2}\left[\delta(f-f_c)+\delta(f+f_c)\right]$$

$$=\underline{\underline{\frac{A}{4}T}}\frac{\sin\pi f_cT}{\pi f_cT}+\frac{AT}{4}\frac{\sin\pi(f-2f_c)T}{\pi(f-2f_c)T}+\frac{A}{4}T\frac{\sin\pi(f+2f_c)T}{\pi(f+2f_c)T}+\underline{\underline{\frac{A}{4}T}}\frac{\sin\pi f_cT}{\pi f_cT}$$

$$=\frac{A}{2}T\frac{\sin\pi f_cT}{\pi f_cT}+\frac{AT}{4}\frac{\sin\pi(f-2f_c)T}{\pi(f-2f_c)T}+\frac{A}{4}T\frac{\sin\pi(f+2f_c)T}{\pi(f+2f_c)T}$$

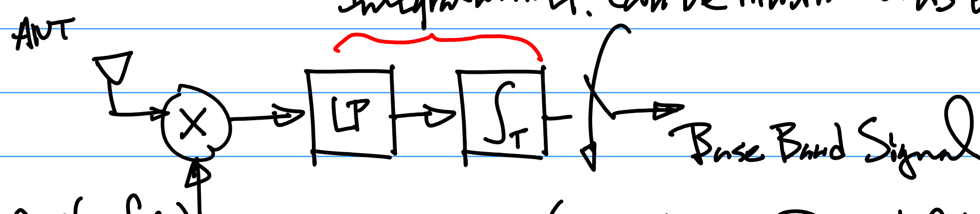


Demodulated Signal

Use Low Pass Filter to Recover the Base Band Signal

Fig.2

Integral with LP. can be illustrated as on Block " $\boxed{\int_T}$ "



$A\cos(2\pi f_ct+\phi_i)\cos(2\pi f_ct)$

Demodulation for BPSK.

Example: Demodulation.

2018F-117-Mod.pdf

2018F-118-DeMOD.jpg

from ANT

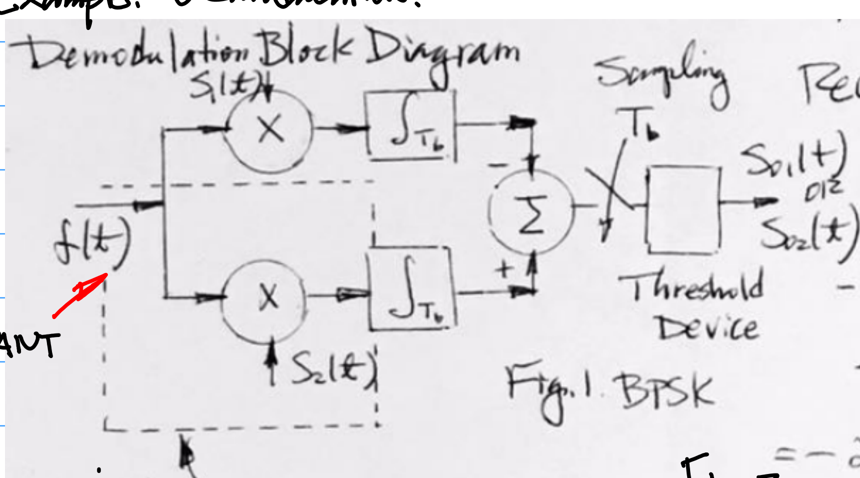


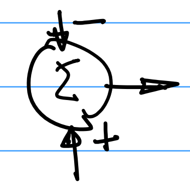
Fig.3

First, In Time Domain, modulated Signals

PSK $S_1(t) = A\cos(2\pi f_c t + \phi_1)$
$S_2(t) = A\cos(2\pi f_c t + \phi_2)$ ... (2)
$t \in [0, T_b]$, $\phi_1 = 0$, $\phi_2 = \pi$

2nd, Build Demod System with 2 Branches (multipliers) as shown in Fig. 3. PP57.

3rd, Build A Comparator,

"  "

"Threshold" unit will make Decision Based on the Compared difference.

From the handout, Fig3, PP.57

$$S_{o1}(t) = \int_{t=(k-1)T_b}^{kT_b} f(t)[S_2(t) - S_1(t)]\,dt \quad \cdots (4)$$

$$\begin{cases} -f(t)s_1(t) & : \text{Upper Branch} \\ f(t)s_2(t) & : \text{Lower Branch} \end{cases}$$

Both going through "$\int_T$" operation.

$$\int_{(k-1)T_b}^{kT_b} [f(t)S_2(t) - f(t)S_1(t)]\,dt$$

4th Step, Evaluate Eqn(4) Based on what is given for Received modulated

Signal f(t).

if Output $= -A^2T$, then $S_1(t)$, e.g. ϕ_1 is from the Base Band Signal

if Output $= A^2T$, then $S_2(t)$, ϕ_2 is from the Base Band Signal.

Nov. 29 (Monday)

1. https://www.sjsu.edu/classes/final-exam-schedule/fall-2021.php

Group I Classes

Group I classes are those classes which meet M, W, F, MTW, MWR, MTWF, MWRF, MTWRF, MW, WF, MWF, MF, TW, WR, MT.

Regular Class Start Times	Final Examination Days	Final Examination Times
7:00 through 8:25 AM	Tuesday, December 14	7:15-9:30 AM
8:30 through 9:25 AM	Thursday, December 9	7:15-9:30 AM
9:30 through 10:25 AM	Monday, December 13	7:15-9:30 AM
10:30 through 11:25 AM	Wednesday, December 8	9:45 AM-12:00 PM
11:30 AM through 12:25 PM	Friday, December 10	9:45 AM-12:00 PM
12:30 through 1:25 PM	Tuesday, December 14	12:15-2:30 PM
1:30 through 2:25 PM	Thursday, December 9	12:15-2:30 PM
2:30 through 3:25 PM	Monday, December 13	12:15-2:30 PM
3:30 through 4:25 PM*	Wednesday, December 8	2:45-5:00 PM
4:30* through 5:25 PM*	Friday, December 10	2:45-5:00 PM

Final Schedule

2. Graded Midterm Papers will Return to you

3. Last Homework (Due Next Monday) Dec. 6

a. Take photos of your prototype System.

b. Photo of the Entire System, e.g. Host Laptop Computer, target plate form, RF Board;

c. Photo of a Screen Capture when

running "LISA" Algorithm, like the implementation in Project, Be Sure to have console display with your name (FirstName, Last Name, SID) and message of LISA Program Successful execution

d. Zip them, Submit on CANVAS.

File Naming Convention:

FirstName_LastName_Prototype245.zip.

Discussion On CCK Technique

Ref. 1&2 from the class github. from cmpe245/2018F folder

2021F-110-2CCK-example.JPG

2021F-110b-1CCK-example.JPG

Ref 3.

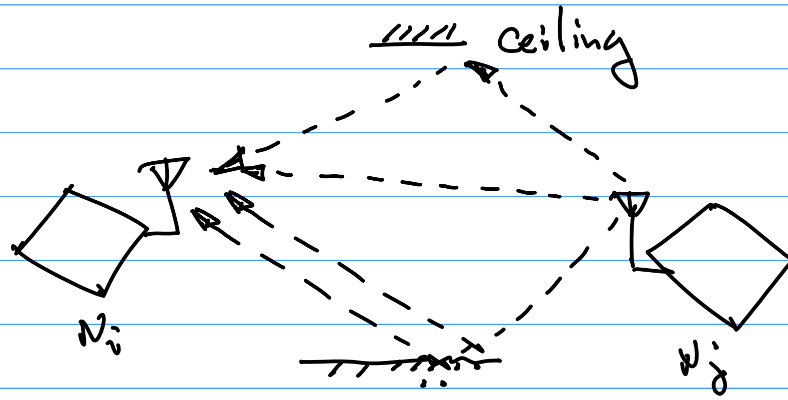
CCKIntersil_NTEK_DSP_AN.PDF

Ref 4. IEEE 802.11b Protocol where CCK is being employed.

Background: Why CCK?

1° Continue PSK Technology. Higher Bit Rate (Keep mini/or Same Bandwidth by Changing phase shifts)

2° To gain better "Robustness" Better Resistance to Random Noise, to deal with "multi-path" interference



Example: Definitions

$$c_j = \sum_{i=1}^{n-j} a_i a_{i+j} \quad \ldots (1a)$$

and b_i elements, where i = 1, 2, .
autocorrelative series are given b

$$C_j = \sum_{i=1}^{n-j} a_i\, a_{i+j} \qquad \text{and}$$

$$d_j = \sum_{i=1}^{n-j} b_i b_{i+j} \quad \ldots (1b)$$

Application

..., n, the respective
by:

$$d_j = \sum_{i=1}^{n-j} b_i\, b_{i+j} \qquad \text{(EQ. 1)}$$

Step 1. To transmit a message "SJSU_CMPE245"

↓ ASCII Code, Table Look Up

Letter "S", Suppose it is ASCII Code as 0xd5

0xd5

1011 ¦ 0101 Binary Code for the Letter.

A Sequence of Bits, then Group them into 2 consecutive bits

1011 ¦ 0101 (marked as pairs of 2 Bits)

$(d_7 d_6 \cdots d_2 d_1 d_0) = (10110101)$

Hence, $d_1 d_0 = 01$

$d_3 d_2 = 01$

$d_5 d_4 = 11$

$d_7 d_6 = 10$

Step 2. Assign Phase function to Each group, as follows,

$d_1 d_0 \to \phi_1$

$d_3 d_2 \to \phi_2$

$d_5 d_4 \to \phi_3$

$d_7 d_6 \to \phi_4$

Whose value $(\phi_i, i=1,2,\cdots,4)$ is defined By Look-up table Technique.

TABLE 4. DQPSK MODULATION OF PHASE PARAMETERS

DIBIT (d_{i+1}, d_i)	PHASE
00	0
01	π
10	$\pi/2$
11	$-\pi/2$

Based on the Table, we have

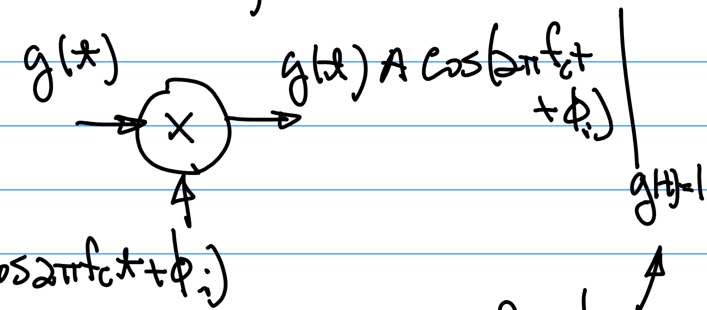
$d_1 d_0 = 01 \to \phi_1 = \pi$

$d_3 d_2 = 01 \to \phi_2 = \pi$

$d_5 d_4 = 11 \to \phi_3 = -\pi/2$

$d_7 d_6 = 10 \to \phi_4 = \pi/2$

Note: phase shift defines PSK modulation,



Reflected in ϕ_i

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

For modulation.

Step 3. Generate Code word

$$c = \left\{ e^{j(\varphi_1+\varphi_2+\varphi_3+\varphi_4)}, e^{j(\varphi_1+\varphi_3+\varphi_4)}, e^{j(\varphi_1+\varphi_2+\varphi_4)}, -e^{j(\varphi_1+\varphi_4)}, e^{j(\varphi_1+\varphi_2+\varphi_3)}, e^{j(\varphi_1+\varphi_3)}, -e^{j(\varphi_1+\varphi_2)}, e^{j\varphi_1} \right\} \quad \cdots (2)$$

"C" : Coded word, consists of 8 individually coded bit

Tp3. From Eqn (2):

$$C = (C_7, C_6, C_5, \cdots, C_2, C_1, C_0) \quad \cdots (2b)$$

To find each bit,

$C_0 = e^{j\phi_1}$, $C_1 = e^{j(\phi_1+\phi_2)}$, ...,

$C_7 = e^{j(\phi_1+\phi_2+\phi_3+\phi_4)}$

Now, Compute each bit

$$C_7 = e^{j(\phi_1+\phi_2+\phi_3+\phi_4)}$$
$$= e^{j(\pi+\pi-\pi/2+\pi/2)}$$
$$= e^{j2\pi}$$

Euler Equ: $e^{j2\pi} = \cos 2\pi + j\sin 2\pi$
$$= 1 + j\cdot 0 = 1$$

$C_7 = 1.$

Continue this process,

$$C_6 = e^{j(\phi_1+\phi_3+\phi_4)} = e^{j(\pi-\pi/2+\pi/2)}$$
$$= e^{j\pi} = \cos\pi + j\sin\pi = -1$$

etc.

Therefore, we can find the entire Code word.

See Handout Example, and white Paper.