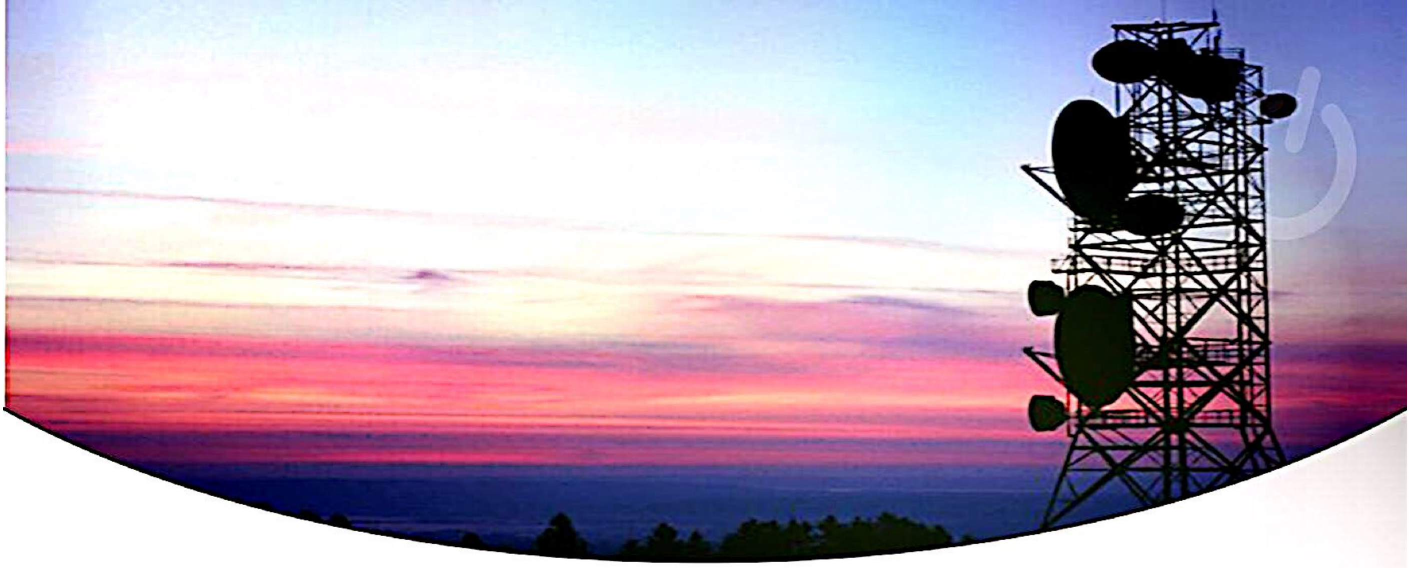


Communications1

Fall017

Dr. Mhmd Hawa

By: Mhmd Abuhashya

Zero

Handout #1

Mohammad Abu Hashya.

Summary

- **Complex exponential fourier series:** $x(t)=\sum_{n=-\infty}^{\infty}\alpha_n e^{jn\omega_0 t}$; $\omega_0=\frac{2\pi}{T}$

  α_n found by: $\alpha_n=\frac{1}{T}\int_T x(t)\,e^{-jn\omega_0 t}\,dt.$

- **Fourier Transform:** $X(\omega)=\int_{-\infty}^{\infty}x(t)\,e^{-j\omega t}\,dt$, $x(t)=\frac{1}{2\pi}\int_{-\infty}^{\infty}X(\omega)\,e^{j\omega t}\,d\omega$

$\cos\omega_0 t \xrightarrow{\text{fourier}} \pi\delta(\omega+\omega_0)+\pi\delta(\omega-\omega_0)$

$\sin\omega_0 t \longrightarrow j\pi[\delta(\omega+\omega_0)-\delta(\omega-\omega_0)]$

$e^{\pm j\omega_0 t} \longrightarrow 2\pi\,\delta(\omega\mp\omega_0)$

$rect(t/\tau) \longrightarrow \tau\,sinc\left(\frac{\omega\tau}{2\pi}\right)$

$\Delta(t/\tau) \longrightarrow \tau\,sinc^2\left(\frac{\omega\tau}{2\pi}\right)$

$sinc(t/2\pi) \longrightarrow 2\pi\,rect(\omega)$

$Saw(t/\tau) \longrightarrow \frac{-2j}{\omega}\left[sinc\left(\frac{\omega\tau}{2\pi}\right)-\cos\left(\frac{\omega\tau}{2}\right)\right]$

$\delta(t) \longrightarrow 1$

$1 \longrightarrow 2\pi\,\delta(\omega)$

$rep[P(t)] \longrightarrow \sum 2\pi\alpha_n\,\delta(\omega-n\omega_0)$

$u(t) \longrightarrow \pi\delta(\omega)+1/j\omega$

$sgn(t) \longrightarrow 2/j\omega$

$e^{-t^2/2} \longrightarrow \sqrt{2\pi}\,e^{-\omega^2/2}$

$\Rightarrow$ **Properties:**

$x^*(t) \longrightarrow X^*(-\omega)$

$x(t)$ even / odd $\longrightarrow X(\omega)$ even, real / odd, ima.

$X(t) \longrightarrow 2\pi x(-\omega)$

$x(t\pm t_0) \longrightarrow X(\omega)\,e^{\pm j\omega t_0}$

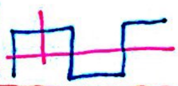
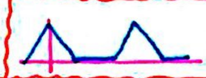
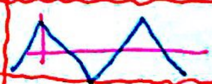
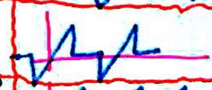
$x(t)\,e^{\pm j\omega_0 t} \longrightarrow X(\omega\mp\omega_0)$

$\frac{dx(t)}{dt} \longrightarrow j\omega\,X(\omega)$

$\int_{-\infty}^{t}x(\tau)\,d\tau \longrightarrow \frac{X(\omega)}{j\omega}+\pi X(0)\,\delta(\omega)$

- **PSD:** $PSD\equiv S(\omega)=\lim_{T\to\infty}\frac{1}{T}|X_T(\omega)|^2 \Rightarrow P=\frac{1}{2\pi}\int_{-\infty}^{\infty}S_x(\omega)\,d\omega$

- **Pavg:** $P_{avg}=\frac{1}{T}\int_T |x(t)|^2\,dt$ • **Avg.:** $x_{avg.}=\frac{1}{T}\int_T x(t)\,dt$ • **RMS:** $x_{rms}^2=\frac{1}{T}\int_T x^2(t)\,dt$

x(t) rept.	DC	$B_{x(t)}$	α_n	$\angle\alpha_n$	figure
$A\,rect(t/\tau)$	$A\tau/T$	$1/\tau$	$\frac{A\tau}{T}sinc\left(\frac{n\omega_0\tau}{2\pi}\right)$	Zero.	
$2A\,rect\left(\frac{t}{T/2}\right)-A$	0	$2/T$	$A\,sinc\left(\frac{n}{2}\right)$	Zero.	
$A\,\Delta(t/\tau)$	$\frac{A\tau}{T}$	$1/\tau$	$\frac{A\tau}{T}sinc^2\left(\frac{n\omega_0\tau}{2\pi}\right)$	Zero	
$2A\,\Delta\left(\frac{t}{T/2}\right)-A$	0	$2/T$	$A\,sinc^2\left(\frac{n}{2}\right)$	Zero	
$A\,saw(t/\tau)$	0	$3/\tau$	$\frac{-j2A}{n\omega_0 T}\left[sinc\left(\frac{n\omega_0\tau}{2\pi}\right)-\cos\left(\frac{n\omega_0\tau}{2}\right)\right]$	$\pm90°$	
$A\,saw(t/T)$	0	$3/T$	$jA\frac{\cos(n\pi)}{n\pi}$	$\pm90°$	

Best of Luck.

*** ***

Handout #2

Mohammad Abu Hashya.

Summary

* 4-Types of comm sys. :

Analog Baseband $\xrightarrow{\text{Modulation}}$ Analog Carrier

Digital Baseband $\xleftarrow{\text{De-modulation}}$ Digital Carrier

Analog Baseband $\downarrow$ Digitization.

* Advantages of Digital over Analog:

1) Immunity to NOISE Because
   - ① threshold detection @ Rx.
   - ② Availability of Regenerative Repeaters.
2) Allow Multiplexing
   - @ Baseband level: TDM.
   - @ Carrier level: FDM, CDMA, OFDMA.
3) Use spread spectrum tech. help to overcome Jamming & Interference & impairments such as Fading which increase transmission Rate.
4) Source Coding tech. ⇒ reduce amount of transmitted bits ⇒ increase Bandwidth.
5) Channel Coding tech. ⇒ reduce bit errors ⇒ improves SNR.
6) Exchanging SNR for Bandwidth.
7) Digital Hardware is flexible, allows μprocessor to perform DSP.
8) Digital signal storage is easy & inexpensive.

* A/D Conversion: Sampling → Quantization → Mapping → Encoding & pulse-shaping.

Sampling:

* convert m(t) from Continuous to discrete separated by T_s: sampling time.
* Nyquist-Shannon sampling theorem: $\boxed{f_s \geq 2B}$ ⇒ No aliasing $f_s = \frac{1}{T_s}$ sampling freq.
* if $f_s < 2B$ aliasing will occure.

Ex. Voice ($B = 4KHz$ ⇒ sampled @ 8KHz) & CD(Audio) ($B = 20KHz$ ⇒ sampled @ 44.1KHz)

* practically its hard to have impulse, so we use pulses.
* Types of Sampling: ideal/practical/Natural.

※ Quantization :

* Samples approximated to a small set of discrete quantitation levels.
* Quantization Error : $\Delta V = \frac{2m_p}{L}$ → m_p: peak of m(t), L: # of levels.
  - ↳ it is decreased by 2-methods: L↑ OR rounded off method.

#of bits = $\log_2 L$
- → Voice: (8-bits) ⇒ $\boxed{L=256}$ levels.
- → CD: (16-bits) ⇒ $\boxed{L=65536}$ Levels.

※ Mapping :

* Gives 1's & 0's for the Descretized signal.
* Bit Time: $T_o = \frac{T_s}{\log_2 L}$ ⇒ $f_o = f_s \log_2 L$ ⇒ $f_s = 2B_m$
* PCM ≡ Pulse Code Modulation. (includ sampling + Quan. + Mapping).
* a% above Nyquist Rate ⇒ $(a\% + 1) * f_s$; $f_s = 2B_m$.

※ Encoding :

- **Source Coding**: Compression Data.
  - ⇒ Examples: ① Shannon code. ② Huffman Code. ③ Lempel-Ziv coding. ④ RLE (Run length Encoding). ⑤ LPC (Linear Prediction Coding) ⑥ CELP (Code Excited Linear prediction). ⑦ Arithmatic Coding. ⑧ MPEG-4 vedio Coding.
- **Channel Coding**: Error Correcting. $C = B_{ch} * \log_2(1+SNR)$
  - ⇒ Examples: ① Hamming Codes. ② Turbo Codes. ③ Convelution Codes ④ Reed-Solomn Codes.
- **Line Coding**:
  * represent the final bit (1 & 0) in form of voltage or current.

* The need of Line Coding:

1. self clocking @ Rx.
2. Control the DC component (its BAD to have DC value) ⇒ Noise.
   * Codes which eliminate DC: Zero-DC , DC equalized.
3. To transmitte @ high data Rate (which require small B).
4. Increase P_{signal} ⇒ increase SNR.
5. To Reduce amount of power @ Low f. (important in telephony).

Line Coding	Procedure	Bandwidth	Applications
Unipolar	NRZ: $1 \rightarrow +P(t)$, $0 \rightarrow$ Zero RZ: same NRZ But it goes to 0 @ the middle of the bit time.	f_0 $2f_0$	TTL Logic.
Polar	NRZ: $1 \rightarrow +P(t)$, $0 \rightarrow -P(t)$ RZ: same but goes to Zero @ the middle.	f_0 $2f_0$	computer motherboard & Ethernet (1000 Base-SX & LX)
NRZI	$1 \rightarrow +P(t), -P(t), +P(t), \dots$ $0 \rightarrow$ No Transition.	f_0	CD, USB-port & Ethernet (100-Base FX)
Bipolar (AMI)	$1 \rightarrow +P(t), -P(t), +P(t), \dots$ $0 \rightarrow$ Zero.	f_0	B8ZS, HDB3 & E_1-system.
Duobinary	$1 \rightarrow +P(t)$ if # of 0's even. $1 \rightarrow -P(t)$ if # of 0's odd. $0 \rightarrow$ Zero.	$0.5f_0$	40 Gbit/s & 20G bit/s fiper Tx system.
MLT-3	$1 \rightarrow +P(t), 0, -P(t), +P(t), \dots$ $0 \rightarrow$ NO Transition.	$0.9f_0$	Ethernet (100 Base Tx)
Manchester	$1 \rightarrow$ High to Low. $0 \rightarrow$ Low to High.	$2f_0$	IEEE 802.3 & 802.4 Ethernet (10 Base-T)
M-ary	it make a table with number M-bits & gives them values (see Ex.).	$f_{symbol} = \frac{f_0}{\log_2 M}$	—

- Main disadvantage for Unipolar $\Rightarrow$ has a DC value.
- Main advantage for all other types $\Rightarrow$ has 0-DC value.

- **Unipolar** :
  - Advantages : compitable with TTL Logic (NRZ better than RZ).
  - Disadvantages : → No self clocking & there is DC.

- **Polar** :
  - Advantages : polar has $P_{signal} > P_{signal}$ for unipolar ⇒ Better SNR
    & polar NRZ has $P_{signal} > P_{signal}$ of polar RZ
  - Disadvantages : polar NRZ it is lack clock info.

- **Bipolar (AMI)** : → Disadvantage : when transmitte along run of 0's , it produces No transition (suffers a Drawback).

- **Doubinary** :
  - Advantages : smallest Bandwidth since $\left(\frac{f_o}{2}\right)$.
    - Detection Errors without additional bits for that.
  - Disadvantage : Low freq. Compenents.

- **MLT-3** : → Advantages :
  - Emitting less EM interference.
  - small Bandwidth $= 0.9 f_o$

- **Manchester** :
  - Advantages : self clocking & zero-DC.
  - Disadvantages : very Long Bandwidth $= 2f_o$.

- **M-ary** : → Advantage : it reduce the Bandwidth by $\log_2 M$ $\left(f_{sym} = \frac{f_o}{\log_2 M}\right)$.

* **f_{symbol} & f_o** :
  - for all types without M-ary ⇒ $f_{sym} = f_o$.
  - for M-ary ⇒ $f_{sym} = \frac{f_o}{\log_2 M}$

※ Pulse Shaping :

⇒ We use it for: ① Control PSD. ② Decrease Bandwidth
③ Reducing High freq. ④ Eliminate Distortion like ISI (Inter symbol Interference).

* **Bandwidth for Raised Cosine** : $B = \frac{f_o}{2}(1+\alpha)$ → α: Roll-off Factor.

→ f_o found After using the encoding type (polar, unipolar, manchester, ...).

* Important Abbreviations in Handout 2 :

- DSP ≡ Digital Signal Processing.
- SDH ≡ Synchronous Digital Hierarchy.
- ADSL ≡ Asymmetric Digital Subscriber Line.
- TDM ≡ Time Division Multiplexing.
- FDM ≡ Frequancy Division Multiplexing.
- CDMA ≡ Code Division Multiple Access.
- OFDMA ≡ Orthogonal Frequancy Division Multiple Access.
- SNR ≡ Signal to Noise Ratio.
- SQNR ≡ Signal to Quantization Noise Ratio.
- AMI ≡ Alternate Mark Inversion.

* Example on Digital Transmision :

[1] Digital TV. [2] SDH. [3] ADSL. [4] Ethernet.

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Best of Luck.

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Handout #3

Mohammad Abu Hashya

Summary

※ All Abbreviations in this Handout provided as follows:

- ASK ≡ Amplitude Shift Keying.
- FSK ≡ Frequancy Shift Keying.
- PSK ≡ Phase shift Keying.
- QAM ≡ Quadrature Amplitude Modulation.
- OOK ≡ On OFF Keying;
- BPSK ≡ Binary Phase Shift Keying.
- QPSK ≡ Quadrature (Quaternary) phase shift Keying.
- TCM ≡ Trellis Coded Modulation.
- AWGN ≡ Additive White Gaussian Noise.
- CCK ≡ Complementary Code Keying;
- OFDM ≡ orthogonal Frequancy Division Multiplexing.
- DVB ≡ Digital Vedio Broadcasting.
- DVB-T ≡ Digital Vedio Broadcasting for Terrestrial Television.
- DAB ≡ Digital Audio Broad casting.
- DMT ≡ Discrete Multi-Tone Modulation.
- DQPSK ≡ Differential Quadrature Phase Shift Keying;

※ Shannon's Limit: $C = B\log_2(1+SNR)$ → bps.

C ≡ Channel Capacity: it is the Maximum number of binary bits that can be transmitted per second with probability of error arbitrarily close to Zero.

- Major Modulation Techniques : ASK - FSK - PSK - QAM.

1 ASK :

- for example send $2A\cos\omega_c t \rightarrow$ logic 1 & $A\cos\omega_c t \rightarrow$ logic 0
- special case of ASK: "OOK"
  it send $A\cos\omega_c t \rightarrow 1$ & zero voltage $\rightarrow 0$
- Polar NRZ + AM = ASK.
  - * AM with $m<1 \Rightarrow$ ASK.
  - * AM with $m=1 \Rightarrow$ OOK.
- $\boxed{B_{ASK} = 2f_o}$
- ASK → (Advantages) : simplest Kind of modulation to generate & detect.
  → (Disadvantages): Big $BW = 2f_o$ & used just @ very high SNR.

2 FSK :

- Mark frequancy → logic 1 & space frequancy → logic 0.
- Polar NRZ + FM = FSK.
- $\boxed{B_{FSK} = 2\Delta f + 2f_o = 2f_o(\beta+1)}$
- FSK (Advantages) → vs. ASK the carrier has a constant amplitude, FSK has immunity to non-linearites, rapid fading, adjacent channel interference. it has ability to exchange SNR for BW. used in early slow dial-up modems.

3 PSK :

- BPSK: cosine with phase shift 0 → logic 1 & cosine with phase shift 180 → logic 0.
- Polar NRZ + PM = BPSK.
- $\boxed{B_{BPSK} = 2f_o}$
- Peak phase deviation $\equiv \Delta\theta = \frac{\pi}{2}$
  $\Rightarrow \theta_{max} - \theta_{min} = 2\Delta\theta = \pi$
- 4-ary + PM = QPSK.
- $\boxed{B_{QPSK} = f_o}$

* Constellation Diagram :

$\Rightarrow$ Axis are called I (in-phase) & Q (quadrature).

- BPSK : 2-points.
- QPSK : 4-points.

} we take them with constant freq. & constant Amplitude.

- Highest order PSK: 8-PSK. "Highest practically".
- more than 8-phases: error-rate becomes too high.
- in PSK points are positioned in a circle:
  Becuase: → gives Maximum phase separation.
  → best immunity to noise.
  → gives same carrier amplitude.
- $B_{M\text{-}PSK} = 2 \text{ Baud Rate} = \frac{2f_o}{\log_2 M}$

$\boxed{4}$ QAM: → Analog QAM.
→ Digital QAM.

- Analog QAM: used in NTSC & PAL where I & Q carry the components of chrominance information.
- $B_{QAM} = 2B$
- $B_{M\text{-}QAM} = \frac{2f_o}{\log_2 M}$
- Points must be closer to each other: for more susceptible to noise But results higher BER, so higher order-QAM deliver less reliably than lower order unless SNR is increased.
- Non-square Constellation: acheive better performance BUT harder to modulate and demodulate.
- TCM: it is the type Modulation that use an extra bit for parity not for data. [e.g send 7bits → 6 bits for data
  → 1 bit for parity].

*Performance of digital modulation techniques in presence of Noise:

- SNR $\propto$ BER
- Good Quality: $BER \leq 10^{-6}$
- The variance of the Noise $(\sigma^2) \equiv$ Average Power of the Noise.
- $X \sim (0,1)$: $f(x) = \frac{1}{\sqrt{2\pi}} e^{-x^2/2} \Rightarrow Q(x) = 1 - F(x)$
- Use the table to find $Q(x)$, if it is NOT in the table, Then Do interpolation.
- $K = \log_2 M$
- $T_{symb} = K T_o$

Modulation with AWGN	BER
ASK	$Q\left(\sqrt{\frac{E_b}{N_0}}\right)$
FSK	$Q\left(\sqrt{E_b/N_0}\right)$
BPSK	$Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$
QPSK	$Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$

※ Comparison of Digital Modulation schems:

- ON the BER curves: ← to the left "for the same E_b/N_0" Less BER, need Less SNR, better immunity to Noise.

* Bandwidth for BPSK, QPSK, M-PSK, M-QAM found by: $BW = 2 \times \text{Baud Rate} = \frac{2 f_0}{\log_2 M}$

⇒ The following Table could be observed:

Modulation	Bandwidth	Modulation	Bandwidth
ASK	$2f_0$	16-PSK	$f_0/2$
FSK	$2\Delta f + 2B = 2f_0(\beta+1)$	16-QAM	$f_0/2$
BPSK	$2f_0$	64-QAM	$f_0/3$
QPSK	f_0	256-QAM	$f_0/4$
8-PSK	$2f_0/3$		

※ Applications of Digital Modulation techniques:

1. IEEE 802.11 (Wi-Fi). "CCK"
2. IEEE 802.16 (Wi-MAX). "OFDM".
3. DVB "standard in Europe".
4. DAB "it use DQPSK".
5. ADSL "it use DMT".

Best of **** **** Luck.