0830 4 Oct Communication System Dawson

Concepts:

Information: Signal must change

τ = time rate of change

amplitude must change above some minimum

$f \propto \frac{1}{\tau}$ C = channel capacity (BW)

n = number of amp. levels

$C = \frac{1}{\tau} \log_2(n)$

This derivation based on binary bit

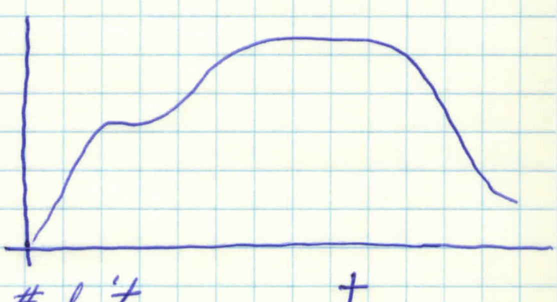
Data Processing:

Most info. is in analog.

Analog signal may be digitized

Pulse code modulation is binary.

Levels may be determined 2^n n = # bits



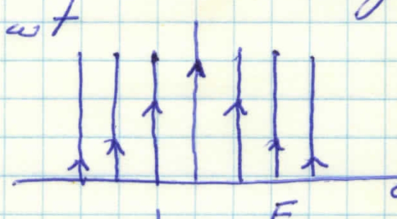
Periodic Signals

Aperiodic

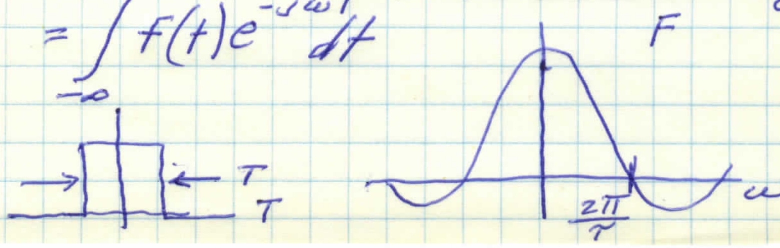
Random — most common in communication sys.

Fourier $f(t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega t}$

Periodic signal



Aperiodic $f \quad = \int_{-\infty}^{\infty} f(t) e^{-j\omega t}\, dt$



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Concepts Signal theory contd.

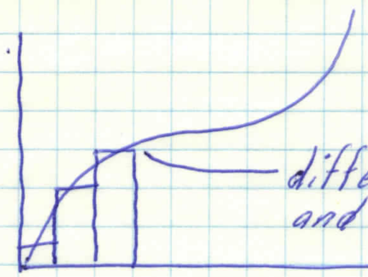
Random Signal -

Fourier transform of auto correlation $S(\omega) = \int_{-\infty}^{\infty} R(\tau) e^{-j\omega\tau} d\tau$

S = power spectral density

Noise: anything other than desired signal

Quanitization noise



Thermal noise

$\underset{\sim}{n}(t)$

$\underset{\sim}{n}$ = function t, normal distribution average zero + flat distribution

Modulation:

carrier $= A\cos[\omega_c + \phi]$

Modulation may be accomplished by changing any of these parameters

A = amplitude
ϕ = phase angle
$\omega = 2\pi f$

Appollo is ϕ mod -

Amplitude modulation: used EVA $\rightarrow$ LEM

$e(t) = (1 + m f_m(t)) \cos \omega_c t$

f_m = mod sig -
m = max. amp. of mod. signal = modulation index

Carrier suppression

$e_1(t) = m f_m(t) \cos \omega_c t$

Single sideband, suppressed carrier cannot transmit pulses -

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NASA SP-69 Space technology V-5

Phase angle modulation: Apollo & future telecomm-applications -

$$e(t) = A \cos(\omega_c t + \phi(t))$$

$$= A \cos(\theta(t))$$

$$\theta(t) = \omega_c t + M f_m(t) + \theta_t$$

θ_t = reference funct. which is here 0

$$\omega t = \frac{d\theta(t)}{dt}$$

$$= \omega_c + m \dot{f}_m(t)$$

$$\omega(t) = \omega_c + \Delta f_\omega \cdot f_m(t)$$

$$\theta(t) = \omega_c t + \Delta f_\omega \int f_m(t)\,dt$$

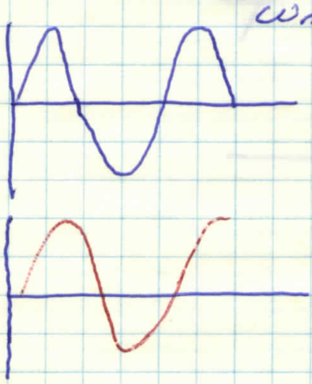
Δf = peak devia.

$$+ \Delta f_\omega \int \cos \omega t\,dt$$

$$= \omega_c t + \frac{\Delta f}{\omega_m} \sin \omega_m t$$

$$\frac{\Delta \omega}{\omega_m} = \frac{\Delta f}{f_m} = \beta$$

$f_m = \cos \omega_m t$



$$e(t) = A \cos[\omega_c T + \beta \sin \omega_m t]$$

Fourier coefficients are Bessel functs.

$$\cos[\beta \sin \omega_m t] = J(\beta) + 2\sum_{n=2}$$

$$\sin[\beta \sin \omega_m t] = 2\sum_{n=1}$$

At this point degenerated into mass of math understandable to neither me

In terms of modulation as $\beta \uparrow$ total BW $\uparrow$

See fig. 1 + 2.

β for phase mod. is constant.

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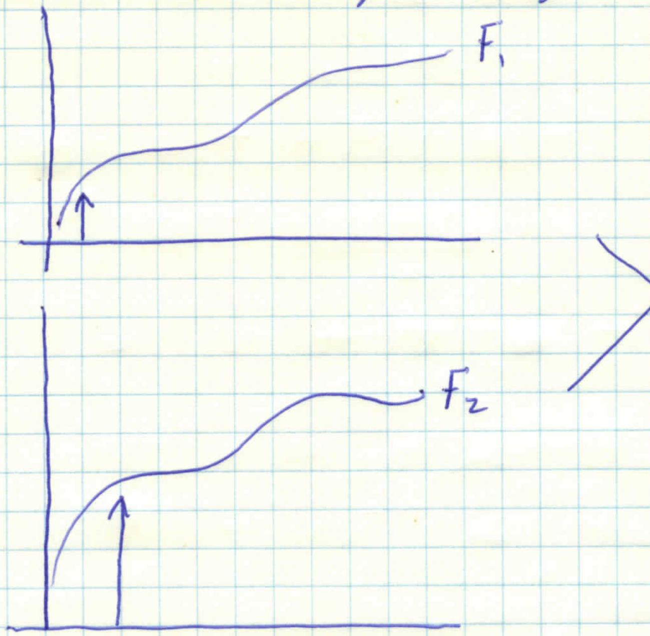
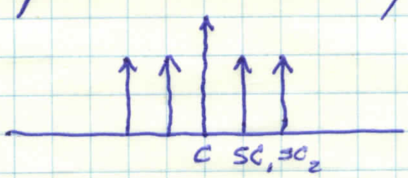
Freq. division multiplex system –

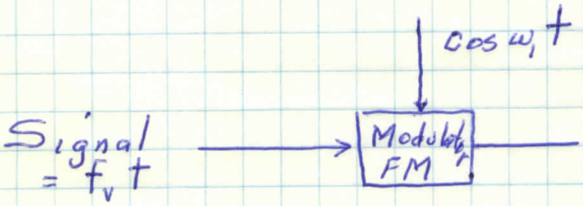


Time sharing multiplex

Freq. division multiplex –



SC = sub carrier
C = carrier



amplitude

$$\beta \cos\left[\omega_1 t + \Delta f \int f_v(t)\, d\tau\right]$$

$\theta_r = k$
$at = \pm 1$

This signal uses PM

$$e(t) = \cos[\omega_c t + M_1 \sin \omega_1 t + M_2 \sin \omega_2 t + \theta_r\, a(t))$$

Carrier Power $= P_C = P_R\, J_0^2(M_{\upsilon D})\, J_0^2(M_v) \cos^2(\theta_R)$

Telem. Channel Data $P_{\upsilon D} = R_R\, J_0^{0}(M_v)\; 2 J_1^2(M_{\upsilon D}) \cos^2(\theta_R)$

$$P_v = P_R\, J_0^2(M_{\upsilon D})\; 2 J_1^2(m_v) \cos^2(\theta_R)$$

M = Mod. index

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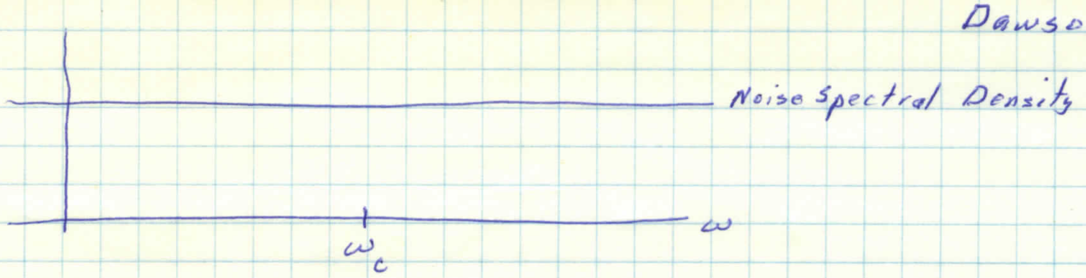
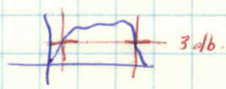
Noise -



Signal Noise Ratio: $\dfrac{E_{sig}\ RMS}{E_{noise}\ "\ RMS}$



$E = \sqrt{\dfrac{KTB}{R}}$

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F.M. Threshold Improvement - Later

Circuit Margin -

$$Db - = 10 \log_{10} \frac{S}{N} = \frac{E\{s^2(t)\}}{E\{n^2(t)\}}$$

DbW is ref. to 1 watt.

$$\text{Margin} = \frac{(S/N)\ \text{actual}}{(S/N)\ \text{required}}$$

Word intelligibility enters this -

Sample circuit margin calculation was explained see Fig 2+3

Ranging: Radar - skin track
transponder (used on Apollo)

Pulse radar - envelope detection
correlation " - mixer c̄ main bang -

4 Oct. Communication

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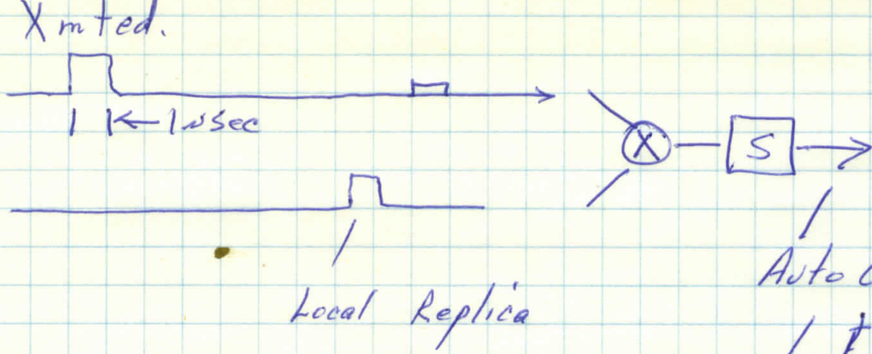
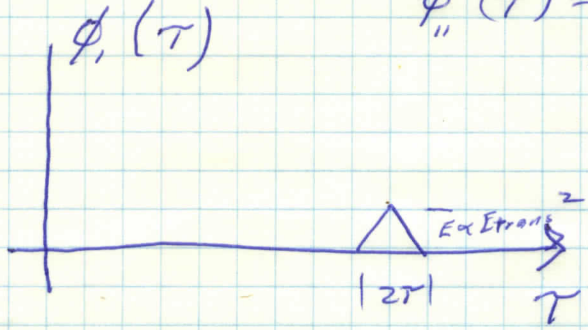


$$\phi_{11}(\tau) = \int f_1(t) f_1(t+\tau)\,dt$$



Pseudo Random Noise Signals -

Actually periodic signals which possess certain random criteria -

1. balance
2. run
3. correlation