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SECOND COLLEGE ON THEORETICAL AND EXPERIMENTAL RADIOPROPAGATION PHYSICS

(7 January - 1 February 1991)

Co-sponsered by ICTP, URSI, ICSU and with the participation of ICS

SOME PROBLEMS ON COMMUNICATION THEORY

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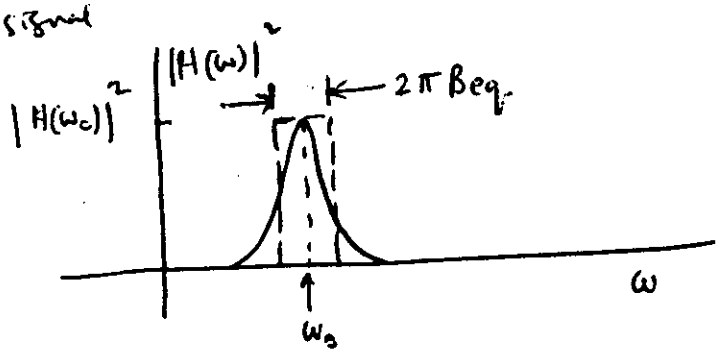
Signals and systems

1. The PSD of a signal can be determined by using practical filters. A signal $g(t)$ is passed through a narrowband filter of variable centre frequency ω_c. If the TF of the filter is $H(\omega)$, show that the input signal power is equal to the output signal power of an ideal filter of bandwidth B_{eq} (known as equivalent bandwidth) where

$$2\pi B_{eq} = \frac{1}{|H(\omega_c)|^2} \int_0^\infty |H(\omega)|^2 d\omega$$

Show how this result can be used to determine the PSD of a signal

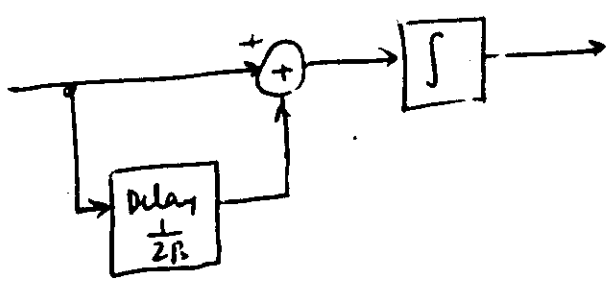


2. The circuit shown below is a zero-order hold used to reconstruct a signal $g(t)$ from its samples

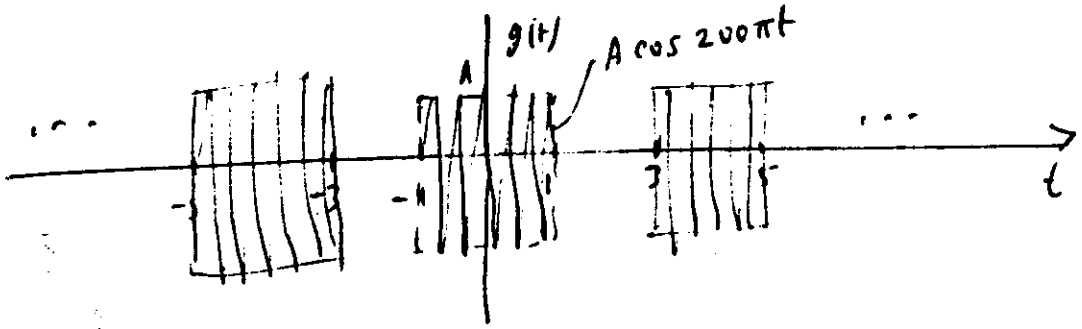
(a) Find the unit impulse response of the circuit

(b) Find the TF $H(\omega)$ and sketch $|H(\omega)|$ and $\theta_H(\omega)$

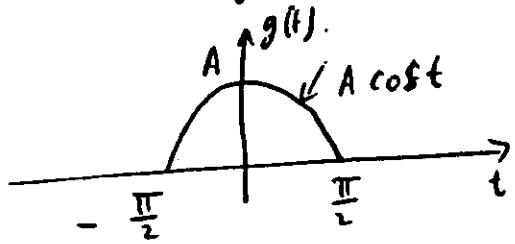
(c) Show that when a sampled signal $g_s(t)$ is applied at the input of this circuit, the output is a staircase approximation of $g(t)$



trigonometric Fourier series and sketch the magnitude and phase spectra.



4. Find the Fourier transform of the function sketched below

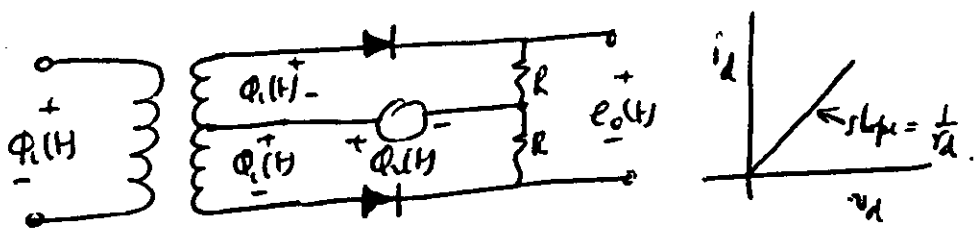


Analog Modulation

1. The two diodes used in the circuit shown below are identical, with voltage current characteristics as shown.

(a) Find $e_0(t)$ if $\phi_2(t) = A\cos\omega_c t$ and $A \gg |\phi_1(t)|\ \forall t$

(b) Show that the circuit can be used as a DSB-SC modulator or a synchronous demodulator by suitably filtering the output $e_0(t)$



2 A 10MHz carrier is frequency modulated by a sinusoidal signal 0.5 KHz so that the maximum freq. deviation is 1 MHz. Determine the bandwidth of the FM carrier. How does it change if the modulating signal amplitude is doubled? How does it change if the frequency of the modulating signal is also doubled?

Pulse Modulation

1. A signal $m_1(t)$ is bandlimited to 3 KHz, and three other signals $m_2(t)$, $m_3(t)$ and $m_4(t)$ are bandlimited to 1 KHz each. These signals are to be sampled at the Nyquist rate. Suggest a suitable multiplexing arrangement. What must be the speed of the commutator in samples/sec? If the commutator output is quantized ($L = 1024$) and being coded, what is the output bit rate?

2. A TV signal's bandwidth is 4.2 MHz. If the number of quantizing levels is to be 512, determine the number of binary pulses/second of the corresponding PCM signal and the transmission bandwidth.

Probability and Random Variable

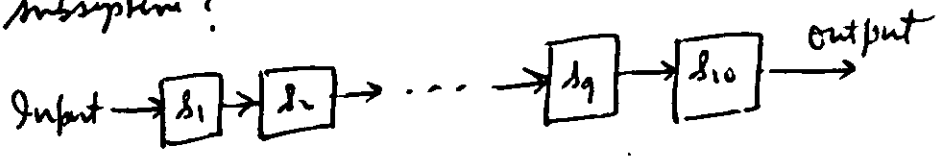
1. Three regular dice are thrown. Assign probabilities to the events characterizing the sum of the point appearing on the three dice equal to (a) 3 (b) 9

2. What is the probability that a bridge hand will obtain
   a) all 13 cards in one suit?
   b) all one value (A, K, Q, ..., 3, 2) regardless of the suit?

3.. In the system shown below, the entire system fails if any subsystem fails. The prob. of failure of one of the subsystems is 0.01.

a) What is the probability of failure of ~~any~~ the system?

b) The reliability of the system is the probability of not failing. If the system reliability is required to be 0.99, what must be the failure probability of each subsystem?



4. A binary source generates digits 1 and 0 randomly with $P(1) = 0.8$ and $P(0) = 0.2$

a) What is the probability that two 1's and 3 0's will occur in a 5 digit sequence?

b) What is the probability that at least three 1's will occur in a 5 digit sequence?

Information Theory

1- A source emits 6 messages with probabilities 1/2, 1/4, 1/8, 1/16, 1/32 and 1/32, respectively. Find the entropy of the source. Obtain a binary code (prefix type) and find the average length of code word. Determine the efficiency and redundancy of the code.

SOURCE

B. P. Lathi, "Modern Digital and Analog Communication Systems", HRW, 1983.