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Introduction to Communication Systems (ECEG-3174): Worksheet I – Chapter II

Frequency Domain Analysis of Signal and Systems

Q#1

Calculate the Fourier series approximation to the periodic signal that has period T = 2L and can be expressed on its fundamental domain as

$$x(\mathrm{t}) = \begin{cases} 1 & -\mathrm{L} < \mathrm{t} \leq 0 \\ 1 - \frac{\mathrm{t}}{\mathrm{L}} & 0 < \mathrm{t} \leq \mathrm{L} \end{cases}$$

Q#2

Given the periodic signal with period T = 2 and can be expressed on its fundamental domain as below;

$$x(\mathrm{t}) = 1 - |\mathrm{t}|, -1 < \mathrm{t} < 1$$

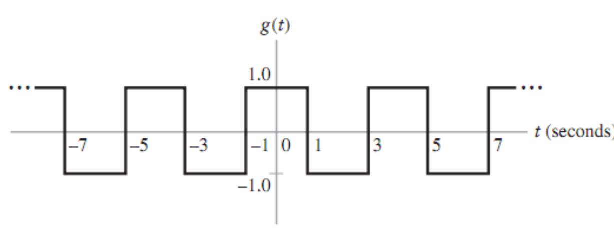
a. Calculate the Fourier series approximation
b. There are no sine terms. Why not?
c. Plot the amplitude and phase spectrum
d. Calculate the power spectral Density, the total power and 3- db bandwidth of the signal
e. Calculate the autocorrelation of $f(t)$

Q#3 – Matlab

a. Use Matlab to perform Fourier series calculation of the above two periodic function. Plot both the amplitude and phase of the harmonics.
b. Discuss the convergence rate the series at the discontinuities, if there are any, and the Gibbs phenomenon
c. Plot the power spectral density and autocorrelation

Q#4

Consider the square wave $g(t)$. Find the Fourier series expansion, power spectral density, average power, and autocorrelation function of this square wave. Does the wave have dc power? Explain your answer.



Q#5

Given time delayed rectangular signal, with the width τ =1,

$$x(t) = \Pi(t - 3)$$

a. Calculate the Fourier transform
b. Plot the amplitude and phase spectrum
c. Calculate the power spectral Density, the total power , 3- dB and 95% energy bandwidth of the signal

Q#6

Evaluate the inverse Fourier transform of the one-sided frequency function.

$$G(f) = \begin{cases} \exp(-f) & f > 0 \\ \frac{1}{2} & f = 0 \\ 0 & f < 0 \end{cases}$$

Hence, show that is complex, and that its real and imaginary parts constitute a Hilbert transform pair.

Q#7

Let $X(t) = X_R(t) + X_I(t)$; where $X_R(t)$ is the real part and $X_I(t)$ is the imaginary part of $X(t)$. Show that

$$X_R(t) + \leftrightarrow \frac{1}{2}\,[X(f) + X^*(-f)]\,; \qquad X_I(t) \leftrightarrow \frac{1}{2j}\,[X(f) - X^*(-f)]$$

Q#8

Evaluate the Hilbert transform of Unit step function and sinusoidal signal $s(t) = cos\, 2\pi f t + \theta_0$.

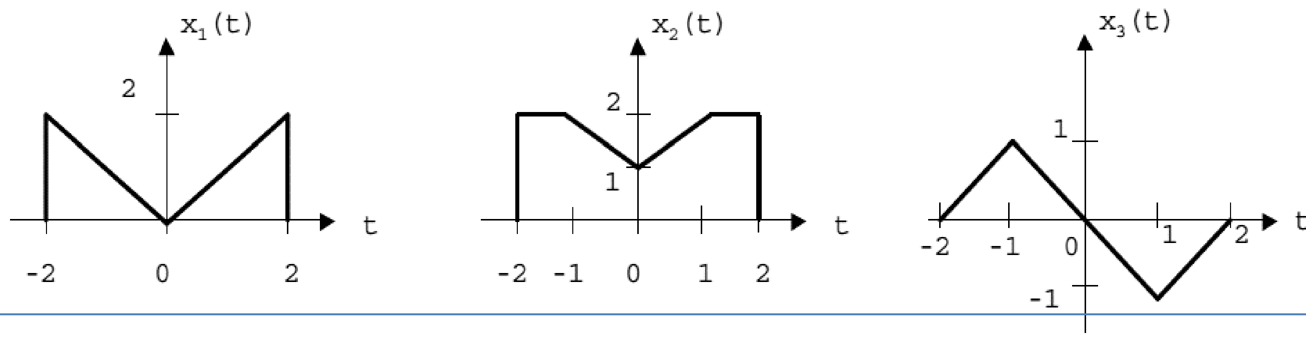
Q#9

Find and sketch the Fourier transforms for the following signals:

(a) Unit step function
(b) $v(t) = sinc(2t)sinc(4t)$.
(c) $s(t) = v(t)\, cos\, 200\pi t$.
(d) Classify each of the signals in (a)-(c) as baseband or band pass and Evaluate the Complex Envelope Representation for the band pass signals.

Q#10

Determine the Fourier transform of the signals shown below.



Q#11

A system with input $x(t)$ has output given by $y(t) = \int_{-\infty}^{t} e^{\tau - t} x(\tau)\, d\tau$

(a) Show that the system is LTI and find its impulse response.

(b) Find the transfer function H(f) and plot |H(f)|.

(c) If the input x(t) = 2sinc(2t), find the energy of the output.

Q#12

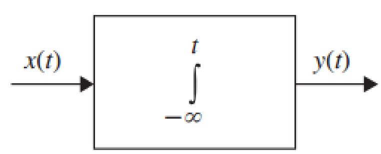
Given and integrator system $h(t)$,

a. Check the causality, linearity, stability and time invariance of the system

b. Calculate and plot (Matlab) the impulse response, the amplitude and phase response of response of system

c. For single tone signal $(cos(2\pi f_0 t))$ as an input; Calculate the time & frequency response of the output.

d. Calculate the signal power and the 3dB bandwidth of the output signal



Integrator.

Fundamentals of Analog Transmission

Q#1

Consider the signal

$$x(t) = 2W\, sinc(2W\, t)\, cos(2\pi f_0 t)$$

a. Is the signal narrowband or wideband? Justify your answer.

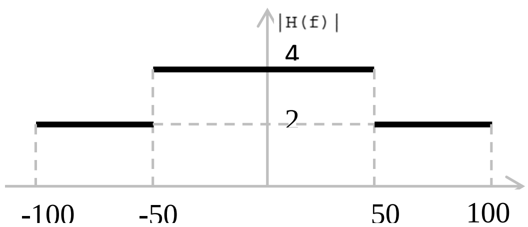
b. Obtain and sketch the spectrum of the analytical signal $xp(t) = x(t) + j\hat{x}(t)$

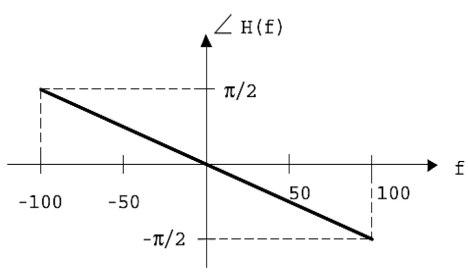
c. Obtain and sketch the spectrum of the complex envelope (or complex baseband representation) $\tilde{x}(t)$

d. Find the complex envelope $\tilde{x}(t)$

Q#2 - *Distortionless Transmission*

A given communication channel has amplitude and phase responses as shown in the figure below:





Find the output to each of the inputs given below. For which cases is the transmission distortion-less? For the other cases, With Plot of amplitude and phase spectrum of the output indicates what type of distortion in imposed.

a. $cos(48\pi t) + 5\,cos(126\pi t)$

b. $cos(126\pi t) + 0.5\,cos(170\pi t)$

c. $\cos(126\pi t) + 3\cos(144\pi t)$

d. $\cos(10\pi t) + 4\cos(50\pi t)$

Q#3 (*) - *Transmission of Bandpass Signals Through Bandpass Systems*

The bandpass signal $x(t) = sinc(t)\,cos(2\pi f_0 t)$ is passed through a bandpass filter with impulse response $h(t) = sinc^2\,(t)\,sin(2\pi f_0 t)$, Using the lowpass equivalents of both input and impulse response, find the lowpass equivalent of the output and from it find the output $y(t)$.