National Institute of Technology Rourkela

Spring Semester 2022-23

Department of Electrical Engineering

Assignment-1

Course Tittle & Code: Communication Systems (EE3402) Instructor: Dr. S. K. Dey

1. Find the Fourier transform of (i). $g(t) = e^{-at}u(t)$, (ii) $g(t) = \prod(t/\tau)$ & (iii) $g(t) = \cos(2\pi f_0)$

2. Find the Fourier transform of a general periodic signal $g(t)$ of period T_0, and hence, determine the Fourier transform of the periodic impulse train $\delta_{T_0}(t)$ shown in Figure.

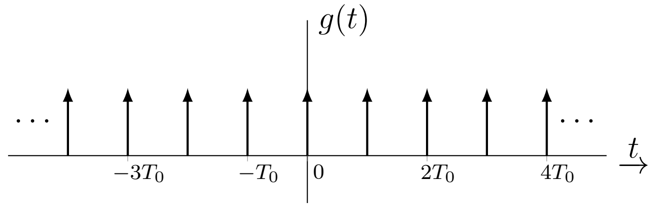
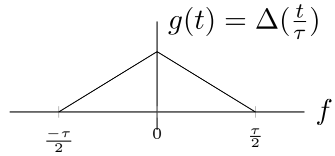
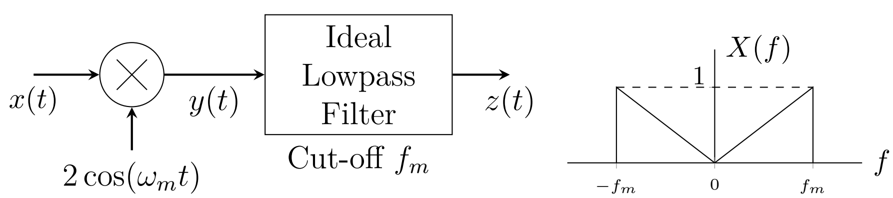


Figure 1: Impulse train

3. Use the time differentiation property to find the Fourier transform of the triangular pulse $\Delta(t/\tau)$ show in figure.



4. System shown in Fig. 2(a), $X(f)$ is shown in Fig. 2(b)



(a) System (b) Fourier transform of $x(t)$

Figure 2: System & $X(f)$

   (a) Obtain and sketch $Y(f)$ and $Z(f)$.

   (b) Compare $X(f)$ with $Z(f)$ and comment.

   (c) What is the energy of $Z(f)$?

   (d) How can $X(f)$ be recovered from $Z(f)$.

5. The system shown in Fig. 3, $x(t) = sinc(\pi t)$
   Calculate E_y, the energy in $y(t)$. What should be the value of f_c so that energy of $z(t)$, E_z, is 80% of E_y.

6. Given $x(t) = e^{-3t}u(t)$. Determine its autocorrelation function $R_x(\tau)$. What is the energy in $x(t)$? Sketch $R_x(\tau)$.

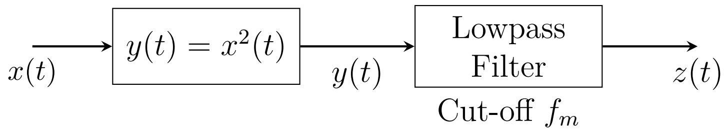


Figure 3: System

7. In a DSB system, a carrier $A_L \cos(\omega_c t + \phi)$ is added to the received signal $Am(t)\cos(\omega_c t)$. The resultant signal is passed through an envelope detector. Show that the modulating signal can be recovered at the output when $A_L >> A$.

8. A signal $x(t)$ is described as

$$x(t) = \left(\frac{3}{2}\right)\cos(190 \times 10^3 \pi t) + 5\cos(200 \times 10^3 \pi t) + \left(\frac{3}{2}\right)\cos(210 \times 10^3 \pi t)$$

   (a) Show that $x(t)$ ia an AM signal.
   (b) Determine the ratio P_s/P_c, where P_s is the power in sidebands and P_c is the power in the carrier.
   (c) What is the power efficiency (η) in the AM signal?

9. Cross-correlation of real-valued functions $g_1(t)$ and $g_2(t)$ is given by

$$R_{12}(\tau) = \int_{-\infty}^{\infty} g_1(t) g_2(t-\tau) dt$$

   (a) Show that $R_{12}(\tau) \longleftrightarrow G_1(f)G_2^*(f)$.
   (b) Using (a), show that $g(t)$ and its Hilbert transform $g_h(t)$ are orthogonal.

10. A VSB signal is modulated by $m(t) = 3\cos(6 \times 10^3 \pi t) + 5\cos(16 \times 10^3 \pi t)$. The carrier frequency is 100 kHz. The VSB filter is

$$H(f) = \begin{cases} 0.5\left[\frac{f-f_c}{f_0} + 1\right] & \text{for } (f_c - f_0) \leq |f| \leq (f_c + f_0) \\ 1 & \text{for } (f_c + f_0) \leq |f| \leq f_{max} \\ 0 & \text{otherwise} \end{cases}$$

where f_c is the carrier frequency $= 100$ kHz, $f_0 = 5$ kHz, and $f_{max} = 10$ kHz. Determine power in the VSB signal.

11. A modulated signal is described as

$$x(t) = A\cos(\omega_c t + k\frac{t^2}{2} + \theta_0), \qquad 0 \leq t \leq T$$

where θ_0 is the signal phase at $t = 0$. Interpret the above signal as an FM signal. Hence, suggest measurements to determine the constant k.

12. A carrier is frequency modulated by $m(t) = A_m \sin\, \omega_m t$ with frequency modulation sensitivity constant k_f. The resulting modulation index is β_f. The same carrier is phase modulated by $m(t)$ with phase modulation sensitivity constant k_p. The resulting modulation index is β_p. Obtain the relationship between k_f and k_p so that $\beta_f = \beta_p$.

13. (a) Estimate B_{FM} and B_{PM} for the modulating signal $m(t)$ in Fig 4 for $k_f = 2\pi \times 10^5$ and $k_p = 5\pi$. Assume the essential bandwidth of the periodic $m(t)$ as the frequency of its third harmonic.

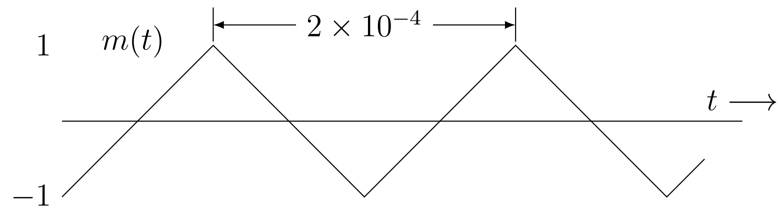


Figure 4: Message signal $m(t)$

(b) Repeat the problem if the amplitude of $m(t)$ is doubled [i.e., if $m(t)$ is multiplied by 2].

14. Discuss the nature of distortion inherent in the Armstrong indirect FM generation.

15. Design an Armstrong indirect FM modulator to generate an FM signal with carrier frequency 97.3 MHz and $\Delta f = 10.24$ kHz. An NBFM generator of $f_{c1} = 20$ kHz and $\Delta f = 5$ Hz is available. Only frequency doublers can be used as multipliers. Additionally, a local oscillator (LO) with adjustable frequency between 400 and 500 kHz is readily available for frequency mixing.

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