Communication Engineering KEC401(Ist sessional Examintion 2019-20)

Section -A

Ans1(a) In amplitude modulation, the amplitude of the carrier wave is varied in accordance with the instantaneous amplitude of the message signal .

Ans 1(b) Fourier transform of a signal can be expressed as : $X(\omega) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt$

Ans 1(c) Modulation Index μ = |min{m(t)}|/ A = 20/50=0.4

Ans1(d) $x_c(t)$ = cos200πt. cos(5sin2πt) + sin200 πt sin (5sin2πt)

$x_c(t)$ = Cos (200πt - 5sin2πt)

θ(t)= 200πt + 5sin2πt

$$\frac{d\theta}{dt} = \omega_i = 200\pi - 10\pi\cos 2\pi t$$

For maximaum value of cos2πt is +1,

$\omega_i = 200\pi - 10\pi$

Then ,f_i = 95 Hz and minimum value of cos2πt is -1,

$\omega_i = 200\pi + 10\pi$

f_i = 105 Hz .

Ans 1(e) ; Frequency shifting property: $x(t)e^{j\omega_o t} \leftrightarrow X(\omega - \omega_o)$

Section –B

Ans2a Expand the function $f(t) = \{At; 0 \le t \le 1$ by Fourier series.

Q2(a)

Example 1.1.1 Expand a function $f(t)$ shown in Fig. 1.1.1 by trigonometric Fourier series over the interval (0, 1).

Solution It is obvious from Fig. 1.1.1 that $f(t) = At$, $(0 \le t \le 1)$

Take t_0 at zero, then

$$\omega_0 = \frac{2\pi}{T} = 2\pi \qquad (\text{as } T = 1)$$

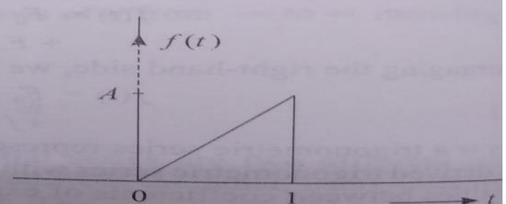


Fig. 2(a) *A Sawtooth Pulse*

The Fourier series is given by

$$f(t) = a_0 + \sum_{n=1}^{\infty}(a_n \cos 2\pi nt + b_n \sin 2\pi nt)$$

$$= a_0 + a_1 \cos 2\pi t + a_2 \cos 4\pi t + a_3 \cos 6\pi t + \ldots$$
$$+ b_1 \sin 2\pi t + b_2 \sin 4\pi t + b_3 \sin 6\pi t + \ldots$$

where the coefficients are evaluated as follows:

$$a_0 = \frac{1}{T}\int_0^T f(t)\,dt = 1\int_0^1 At\,dt = \frac{A}{2}$$

$$a_n = \frac{2}{T}\int_0^1 At\cos 2\pi nt\,dt$$

$$= \frac{A}{2\pi^2 n^2}[\cos 2\pi nt + 2\pi nt \sin 2\pi nt]_0^1 = 0$$

$$b_n = \frac{2}{T}\int_0^1 At \sin 2\pi nt\,dt$$

$$= \frac{A}{2\pi^2 n^2}[\sin 2\pi nt - 2\pi nt \cos 2\pi nt]_0^1 = -\frac{A}{\pi n}$$

Therefore, the trigonometric series will be as follows:

$$f(t) = \frac{A}{2} - \frac{A}{\pi}\sin 2\pi t - \frac{A}{2\pi}\sin 4\pi t - \frac{A}{3\pi}\sin 6\pi t \ldots$$

$$= \frac{A}{2} - \frac{A}{\pi}\sum_{n=1}^{\infty}\frac{\sin 2\pi nt}{n} \quad (0 < t < 1) \qquad (1$$

Ans.2b

Referring to Fig. the output of the multiplier is

$$d(t) = x_{DSB}(t)\cos\omega_c t = [m(t)\cos\omega_c t]\cos\omega_c t$$
$$= m(t)\cos^2\omega_c t$$
$$= \tfrac{1}{2}m(t) + \tfrac{1}{2}m(t)\cos 2\omega_c t$$

After low-pass filtering of $d(t)$, we obtain

$$y(t) = \tfrac{1}{2}m(t)$$

ıal $m(t)$.

Ans2c

Consider an angle-modulated signal

$$x_c(t) = 10\cos[(10^8)\pi t + 5\sin 2\pi(10^3)t]$$

Find the maximum phase deviation and the maximum frequency deviation.

Comparing the given $x_c(t)$ with Eq. (4.1), we have

$$\theta(t) = \omega_c t + \phi(t) = (10^8)\pi t + 5\sin 2\pi(10^3)t$$

and $$\phi(t) = 5\sin 2\pi(10^3)t$$

Now $$\phi'(t) = 5(2\pi)(10^3)\cos 2\pi(10^3)t$$

Thus, the maximum phase deviation is

$$|\phi(t)|_{max} = 5\text{ rad}$$

and the maximum frequency deviation is

$$\Delta\omega = |\phi'(t)|_{max} = 5(2\pi)(10^3)\text{ rad/s}$$

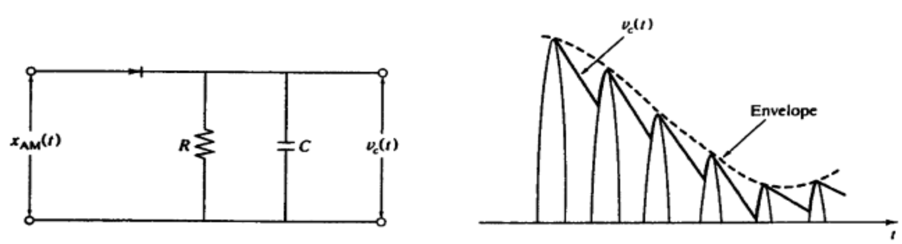
or $$\Delta f = 5\text{ kHz}$$

Ans2d.

Envelope Detector:

Figure (*a*) shows the simplest form of an envelope detector consisting of a diode and a resistor-capacitor combination. The operation of the envelope detector is as follows. During the positive half-cycle of the input signal, the diode is forward-biased and the capacitor C charges up rapidly to the peak value of the input signal. As the input signal falls below its maximum, the diode turns off. This is followed by a slow discharge of the capacitor through resistor R until the next positive half-cycle, when the input signal becomes greater than the capacitor voltage and the diode turns on again. The capacitor charges to the new peak value, and the process is repeated.

For proper operation of the envelope detector, the discharge time constant RC must be chosen properly . In practice, satisfactory operation requires that $1/f_c \ll 1/f_M$, where f_M is the message signal bandwidth.



(*a*) (*b*)

SECTION-C

Ans3a.

Ans. 3(a)

Solution A function is constant if it has a fixed value over an entire interval $(-\infty, \infty)$ as shown in Fig. 1.5.8. This function is not absolutely integrable, but its Fourier transform can be determined using the concept of delta function.

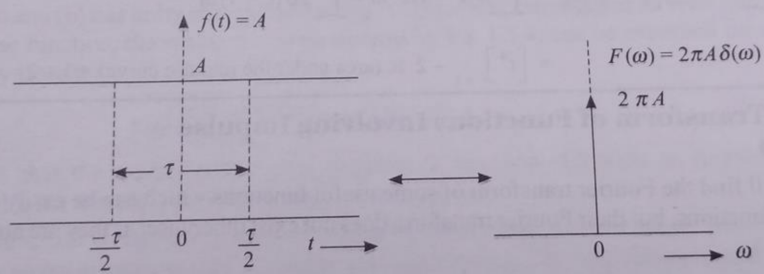


Fig. 1.5.8 *A Constant Function and Its Spectrum*

The constant function can be taken as a Gate function of height A; and width τ, in the limit τ approaching infinity. The Fourier transform of the Gate function is given as

$$G_\tau(t) \leftrightarrow A\tau Sa\left(\frac{\omega\tau}{2}\right)$$

Therefore, the Fourier transform of a constant function is,

$$F[A] = \lim_{\tau\to\infty} F\{G_\tau(t)\} = \lim_{\tau\to\infty} A\tau\, Sa\left(\frac{\omega\tau}{2}\right) = 2\pi A \lim_{\tau\to\infty} \frac{\tau}{2\pi} Sa\left(\frac{\omega\tau}{2}\right)$$

As in the limit $\tau \to \infty$, sampling function approaches a del

$$F[A] = 2\pi A\delta(\omega)$$

Ans3b.

The *efficiency* η of ordinary AM is defined as the percentage of the total power carried by th sidebands, that is,

$$\eta = \frac{P_s}{P_t} \times 100\%$$

where P_s is the power carried by the sidebands and P_t is the total power of the AM signal.

(i) Find η for $\mu = 0.5$ (50 percent modulation).

(ii) Show that for a single-tone AM, η_{max} is 33.3 percent at $\mu = 1$.

From Eqs. (3.5) and (3.9), a single-tone AM signal can be expressed as

$$x_{AM}(t) = A\cos\omega_c t + \mu A\cos\omega_m t\cos\omega_c t$$
$$= A\cos\omega_c t + \tfrac{1}{2}\mu A\cos(\omega_c - \omega_m)t + \tfrac{1}{2}\mu A\cos(\omega_c + \omega_m)t$$
$$P_c = \text{carrier power} = \tfrac{1}{2}A^2$$
$$P_s = \text{sideband power} = \tfrac{1}{2}\left[(\tfrac{1}{2}\mu A)^2 + (\tfrac{1}{2}\mu A)^2\right] = \tfrac{1}{4}\mu^2 A^2$$

The total power P_t is

$$P_t = P_c + P_s = \tfrac{1}{2}A^2 + \tfrac{1}{4}\mu^2 A^2 = \tfrac{1}{2}(1 + \tfrac{1}{2}\mu^2)A^2$$

Thus

$$\eta = \frac{P_s}{P_t} \times 100\% = \frac{\tfrac{1}{4}\mu^2 A^2}{(\tfrac{1}{2} + \tfrac{1}{4}\mu^2)A^2} \times 100\% = \frac{\mu^2}{2 + \mu^2} \times 100\%$$

with the condition that $\mu \leqslant 1$.

(i) For $\mu = 0.5$, $\eta = \frac{(0.5)^2}{2 + (0.5)^2} \times 100\% = 11.1\%$

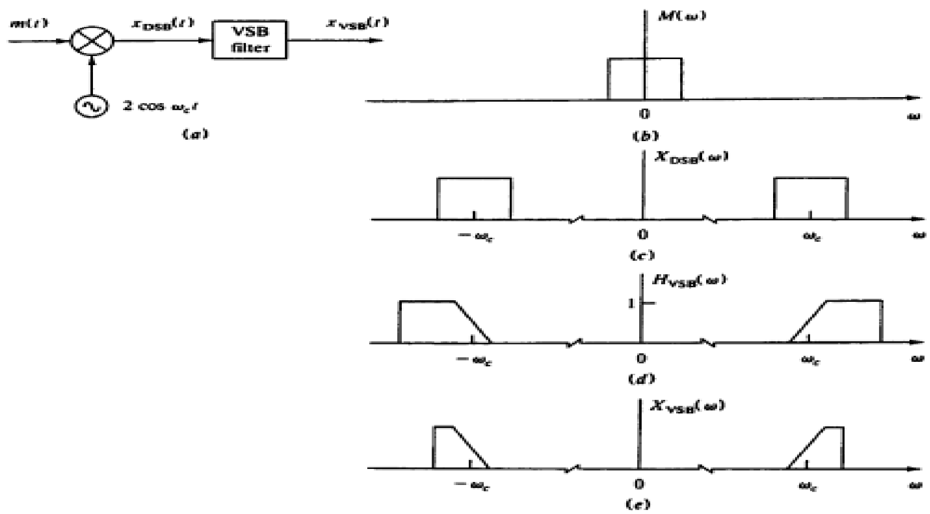
(ii) Since $\mu \leqslant 1$, it can be seen that η_{max} occurs at $\mu = 1$ and is given by

$$\eta = \tfrac{1}{3} \times 100\% = 33.3\%$$

Ans4a.

Generation of VSB Signals:

A VSB signal can be generated by passing a DSB signal through a sideband-shaping filter (or vestigial filter), as shown in Fig. (*a*). Figure (*b*) to (*e*) illustrates the spectrum of a VSB signal [$x_{VSB}(t)$] in relation to that of the message signal $m(t)$, assuming that the lower sideband is transformed to vestigial sideband.



Ans4b.

Referring to Fig. which is the redrawing of Fig. with a single-tone modulating signal, we have

$$m(t) = \cos \omega_m t$$

$$\cos\left(\omega_c t - \frac{\pi}{2}\right) = \sin \omega_c t$$

$$\hat{m}(t) = \cos\left(\omega_m t - \frac{\pi}{2}\right) = \sin \omega_m t$$

Hence,

$$y(t) = \cos \omega_m t \cos \omega_c t \mp \sin \omega_m t \sin \omega_c t$$
$$= \cos(\omega_c \pm \omega_m)t$$

Thus, with subtraction we have

$$y(t) = x_{USB}(t) = \cos(\omega_c + \omega_m)t$$

and with addition we have

$$y(t) = x_{LSB}(t) = \cos(\omega_c - \omega_m)t$$

Ans5a. The following expression is expanded

$$x_c(t) = \cos(\omega_c t + \beta \sin\omega_m t)\text{----}1$$

Equation1 Can also be written as $x_c(t) = A\sum_{n=-\infty}^{n=\infty} J_n(\beta)\,(cos(\omega_c + n\omega_m)t)$

$$x_c(t) = AJ_0(0.2)(cos(\omega_c + 0\omega_m)t) + J_1(0.2)cos(\omega_c + 1\omega_m)t + J_{-1}(0.2)cos(\omega_c - 1\omega_m)t + J_2(0.2)cos(\omega_c + 2\omega_m)t + J_{-2}(0.2)cos(\omega_c - 2\omega_m)t$$

$$x_c(t) = 0.990A(cos(\omega_c)t) + 0.100Acos(\omega_c + 1\omega_m)t - 0.100Acos(\omega_c - 1\omega_m)t + 0.005Acos(\omega_c + 2\omega_m)t + 0.005Acos(\omega_c - 2\omega_m)t$$

For β=0.2, the components will exist ony at n=0,1,2, where at n=2, the frequency modulated component has a very negligible amplitude(0.005), thus, it has only three components at $\omega_c\ for\ n = 0; \omega_c \pm \omega_m\ \ for\ n = 1$

Ans. 5(b)

1. Indirect Method:

In this method, an NB angle-modulated signal is produced first and then converted to a WB angle-modulated signal by using frequency multipliers The frequency multiplier multiplies the argument of the input sinusoid by n. Thus, if the input of a frequency multiplier is

$$x(t) = A\cos[\omega_c t + \phi(t)]$$

then the output of the frequency multiplier is

$$y(t) = A\cos[n\omega_c t + n\phi(t)]$$

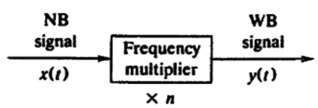
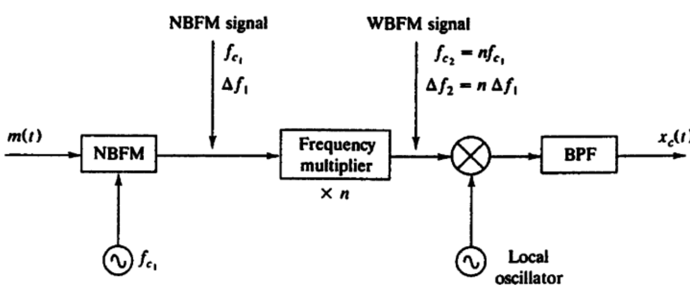


Fig. 4-4 Frequency multiplier



NB-to-WB conversion