سیستم های مخابراتی - تمرین سری چهار - علی یداللهی - ۴۰۰۱۰۲۲۲۳

سؤال 1)

1. سری فوریه $s(t)$ را می نویسیم:

$$s(t) = \sum_{n=-\infty}^{\infty} C_n e^{j2\pi n f_c t}$$

$$C_n = \frac{1}{T_p} \int_{-\frac{T_p}{2}}^{\frac{T_p}{2}} s(t)\, e^{-j2\pi n f_c t}\, dt$$

$$= \frac{1}{T_p} \left[\int_{-\frac{T_p}{2}}^{0} (-A)\, e^{-j2\pi n f_c t}\, dt + \int_{0}^{\frac{T_p}{2}} A e^{-j2\pi n f_c t}\, dt \right]$$

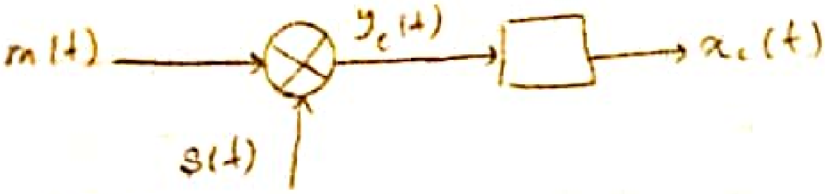
$$= \frac{1}{T_p} \left[\frac{A}{jn2\pi f_c} e^{-j2\pi n f_c t} \Big|_{-\frac{T_p}{2}}^{0} - \frac{A e^{-j2\pi n f_c t}}{jn2\pi f_c} \Big|_{0}^{\frac{T_p}{2}} \right]$$

$$= \frac{A}{j2\pi n} \left[1 - e^{j2\pi n f_c \frac{T_p}{2}} \right] - \frac{A}{j2\pi n} \left[e^{-j2\pi n f_c T_p/2} - 1 \right]$$

$$= \frac{A}{j2\pi n} \left(1 - e^{jn\pi}\right) - \frac{A}{j2\pi n} \left(e^{-jn\pi} - 1\right)$$

$$= \frac{A}{2jn\pi} \left(2 - \left(e^{jn\pi} + e^{-jn\pi}\right) \right)$$

$$= \frac{A}{jn\pi} \left(1 - \cos(n\pi) \right) = \frac{A}{jn\pi} \left(1 - (-1)^n \right)$$



$$y_c(t) = m(t)s(t) = m(t)\left[\sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} \frac{A}{jn\pi}(1-(-1)^n)e^{j2\pi n f_c t} + C_0\right]$$

$$\rightarrow Y_c(f) = \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} \frac{A}{jn\pi}(1-(-1)^n)M(f-nf_c) + C_0 M(f)$$

پس از عبور از فیلتر داریم :

$$X_c(f) = \frac{A}{j(-1)\pi}(1-(-1)^{(-1)})M(f+f_c) + \frac{A}{j(1)\pi}(1-(-1)^{(1)})M(f-f_c)$$

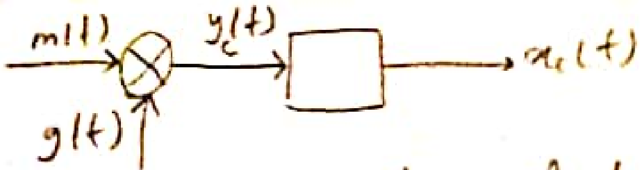
$$\rightarrow X_c(f) = \frac{2A}{j\pi}\left[M(f-f_c) - M(f+f_c)\right]$$

$$\rightarrow x_c(t) = \frac{2A}{j\pi}m(t)\left[e^{j2\pi f_c t} - e^{-j2\pi f_c t}\right]$$

$$\rightarrow x_c(t) = \frac{4A}{\pi}m(t)\left(\frac{e^{j2\pi f_c t} - e^{-j2\pi f_c t}}{2j}\right)$$

$$= \underbrace{\frac{4A}{\pi}}_{A_c} m(t)\sin(2\pi f_c t)$$

2.



$$g(t) = C_0 + \sum_{n=-\infty}^{\infty} C_n e^{j2\pi n f_c t}$$

Subject:
Date

تمرین سیستم سوال یک ادامه:

$$y_c(t) = m(t)\left[C_0 + \sum_{n=-\infty}^{\infty} C_n e^{j2\pi n f_c t}\right]$$

$$Y_c(f) = C_0 M(f) = \sum_{n=-\infty}^{\infty} C_n M(f - n f_c)$$

$$\rightarrow X_c(f) = C_1 M(f - f_c) + C_{-1} M(f + f_c)$$

$$\xrightarrow[]{C_1 = -C_{-1}\ :\ \overset{\text{فرد}}{g(t)}} C_1\left(M(f - f_c) - M(f + f_c)\right)$$

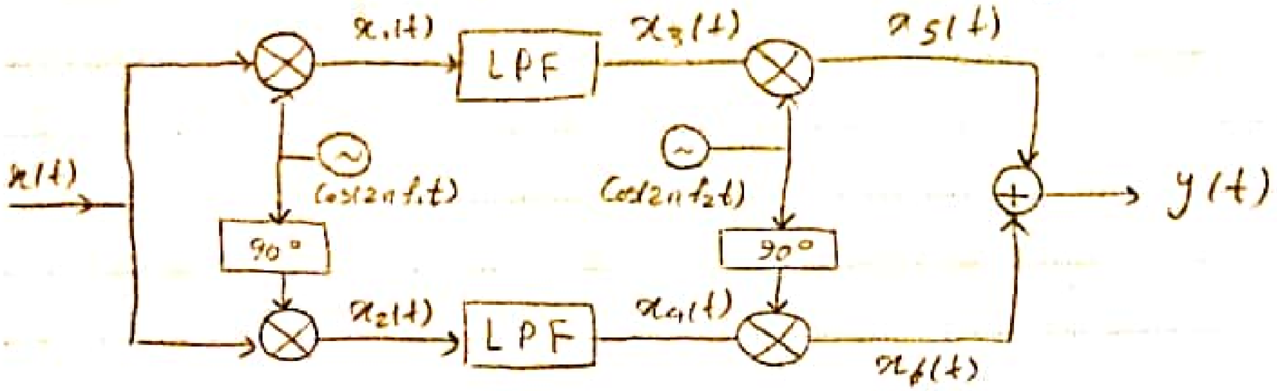
$$\rightarrow x_c(t) = C_1 m(t)\left[e^{j2\pi f_c t} - e^{-j2\pi f_c t}\right]$$

$$\rightarrow x_c(t) = 2C_1 j\, m(t)\sin(2\pi f_c t)$$

Subject.
Date

تمرین سیستم سری ۹

سوال 2)



$$x_1(t) = \cos(2\pi f_m t)\cos(2\pi f_1 t) = \frac{1}{2}\cos(2\pi(f_m+f_1)t) + \frac{1}{2}\cos(2\pi(f_m-f_1)t)$$

$$x_2(t) = \cos(2\pi f_m t)\sin(2\pi f_1 t) = \frac{1}{2}\sin(2\pi(f_m+f_1)t) + \frac{1}{2}\sin(2\pi(f_1-f_m)t)$$

* اگر $|f_1-f_m|<W$ و $f_1+f_m>W$ باشد (مثلاً می‌توان $f_1=W$ در نظر گرفت)

$$\rightarrow x_3(t) = \frac{1}{2}\cos(2\pi(f_m-f_1)t), \quad x_4(t) = \frac{1}{2}\sin(2\pi(f_1-f_m)t)$$

$$x_5(t) = \frac{1}{2}\underbrace{\cos(2\pi(f_m-f_1)t)}_{\cos(2\pi(f_1-f_m)t)}\cos(2\pi f_2 t)$$

$$x_6(t) = \frac{1}{2}\sin(2\pi(f_1-f_m)t)\sin(2\pi f_2 t)$$

$$\rightarrow y(t) = x_5(t)+x_6(t) = \frac{1}{2}\left[\cos(2\pi(f_1-f_m)t)\cos(2\pi f_2 t) + \sin(2\pi(f_1-f_m)t)\sin(2\pi f_2 t)\right]$$

$$\rightarrow y(t) = \frac{1}{2}\cos(2\pi(f_1-f_m-f_2)t) = \frac{1}{2}\cos(2\pi(f_m-f_1+f_2)t)$$

Subject:
Date

تمرین سیستم ادامه سؤال 2

* اگر $x(t) = \cos(2\pi f_m t)$, $A_c = 1$

$$x_{USSB}(t) = \frac{1}{2}\cos(2\pi f_m t)\cos(2\pi f_c t) - \frac{1}{2}\sin(2\pi f_m t)\sin(2\pi f_c t)$$

$$= \frac{1}{2}\cos(2\pi(f_m + f_c)t)$$

$$\rightarrow f_m - f_1 + f_2 = f_m + f_c \rightarrow f_2 = f_c + f_1 \quad \text{USSB}$$

$$* \; x_{LSSB} = \frac{1}{2}\cos(2\pi f_m t)\cos(2\pi f_c t) + \frac{1}{2}\sin(2\pi f_m t)\sin(2\pi f_c t)$$

$$= \frac{1}{2}\cos(2\pi(f_c - f_m)t) \quad \text{LSSB}$$

$$\rightarrow f_c - f_m = f_m - f_1 + f_2 \rightarrow f_2 = f_c + f_1 - 2f_m$$

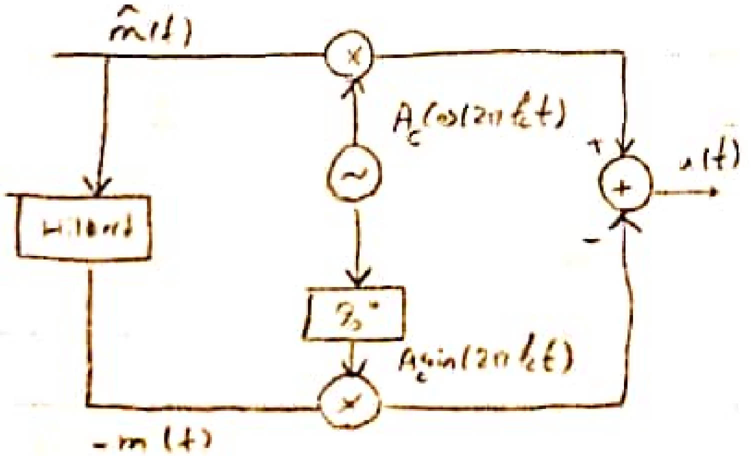
USSB: $f_1 = W$, $f_2 = f_c + W$

LSSB: $f_1 = W$, $f_2 = f_c + W - 2f_m$

سؤال 3)

Phase shift method

1.



$$\hat{\hat{m}}(t) = -m(t)$$

تمرین سیستم

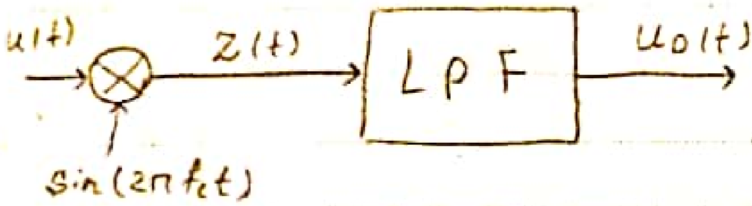
سوال 5 - ادامه)

$$u(t)=\frac{A_c}{2}\hat{m}(t)\cos(2\pi f_c t)-\frac{A_c}{2}(-m(t))\sin(2\pi f_c t)$$

$$=\frac{A_c}{2}\hat{m}(t)\cos(2\pi f_c t)+\frac{A_c}{2}m(t)\sin(2\pi f_c t)$$

2.

Demodulation:



$$z(t)=\frac{A_c}{2}\cos(2\pi f_c t)\sin(2\pi f_c t)\hat{m}(t)+\frac{A_c}{2}\sin^2(2\pi f_c t)m(t)$$

$$=\frac{A_c}{4}\sin(4\pi f_c t)\hat{m}(t)+\frac{A_c}{4}\left(1-\cos(4\pi f_c t)\right)m(t)$$

$$\longrightarrow u_0(t)=\frac{A_c}{4}m(t)$$

سوال ۴)

$$y(t)=y_I(t)\cos(2\pi f_c t)-y_Q(t)\sin(2\pi f_c t)$$

$$y(t)=\frac{\alpha}{2}\left[\cos(2\pi(f_c+f_m)t)-\cos(2\pi(f_c-f_m)t)\right]$$

$$+\frac{1}{2}\cos(2\pi(f_c-f_m)t)+\cos(2\pi f_c t)$$

$$=-\alpha\sin(2\pi f_m t)\sin(2\pi f_c t)+\frac{1}{2}\left[\cos(2\pi f_c t)\cos(2\pi f_m t)\right.$$

$$\left.+\sin(2\pi f_c t)\sin(2\pi f_m t)\right]$$

$$+\cos(2\pi f_c t)$$

Subject:
Date:

سؤال 4)

$$= \left(\frac{1}{2}\cos(2\pi f_m t)+1\right)\cos(2\pi f_c t)$$

$$-\left[\alpha\sin(2\pi f_m t)-\frac{1}{2}\sin(2\pi f_m t\right]\sin(2\pi f_c t)$$

$$y_I(t) = 1+\frac{1}{2}\cos(2\pi f_m t)$$

$$y_Q(t) = (\alpha-\frac{1}{2})\sin(2\pi f_m t)$$

$$e(t) = \sqrt{y_I^2(t)+y_Q^2(t)} = \sqrt{\left[1+\frac{1}{2}\cos(2\pi f_m t)\right]^2+\left[(\frac{1}{2}-\alpha)\sin(2\pi f_m t)\right]^2}$$

$$= \left[1+\frac{1}{2}\cos(2\pi f_m t)\right]\sqrt{1+\left(\frac{(\frac{1}{2}-\alpha)\sin(2\pi f_m t)}{1+\frac{1}{2}\cos(2\pi f_m t)}\right)^2}$$

$$= \left[1+\frac{1}{2}\cos(2\pi f_m t)\right]\sqrt{1+\left(\frac{(1-2\alpha)\sin(2\pi f_m t)}{2+\cos(2\pi f_m t)}\right)^2}$$

2.

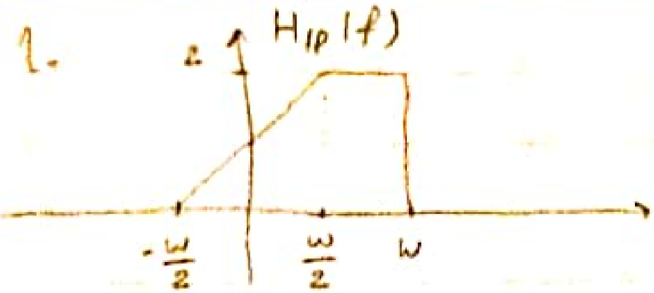
$0\leq\alpha<1 \rightarrow (1-2\alpha)^2\leq 1 \longrightarrow$ در $\alpha=0$ مقدار $d(t)$ ماکزیمم می شود

Subject:
Date

تمرین سیستم

سوال 5)

1.



$$h_{lp}(t) = F^{-1}\{H_{lp}(f)\}$$

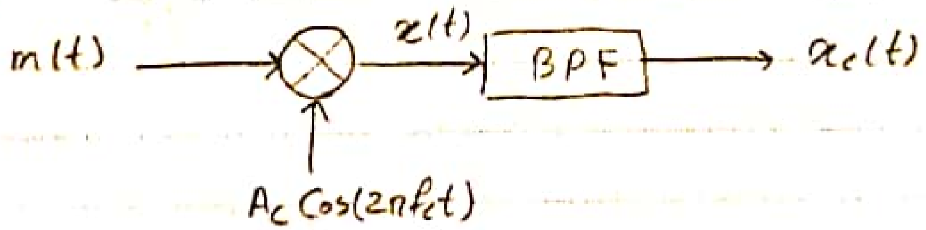
$$= \int_{-\frac{W}{2}}^{W} H_{lp}(f)\, e^{j2\pi f t}\, df = \int_{-\frac{W}{2}}^{\frac{W}{2}} \left(\frac{2f}{W}+1\right) e^{j2\pi f t} + \int_{\frac{W}{2}}^{W} 2 e^{j2\pi f t}\, df$$

$$= \frac{2}{W}\left[\frac{1}{j2\pi t} f e^{j2\pi f t} + \frac{1}{4\pi^2 t^2} e^{j2\pi f t}\right]_{-\frac{W}{2}}^{\frac{W}{2}} + \frac{e^{j2\pi f t}}{j2\pi t}\Big|_{-\frac{W}{2}}^{\frac{W}{2}}$$

$$+ \frac{2}{j2\pi t} e^{j2\pi f t}\Big|_{\frac{W}{2}}^{W} = \frac{1}{j\pi t} e^{j2\pi W t} + \frac{j}{\pi^2 t^2 W} \sin(\pi W t)$$

$$= \frac{j}{\pi t}\left[\mathrm{sinc}(Wt) - e^{j2\pi W t}\right]$$

2.



$$x(t) = A_c m(t) \cos(2\pi f_c t) = x_I(t)\cos(2\pi f_c t) - x_Q(t) \sin(2\pi f_c t)$$

$$x_I(t) = A_c m(t) \quad x_Q(t) = 0 \quad , x_{lp} = x_I(t) + j x_Q(t) = A_c m(t)$$

$$x_{c,lp}(t) = \frac{1}{2} V_{lp}(t) * h_{lp}(t) = \frac{1}{2} A_c m(t) + \frac{j}{\pi t}\left[\mathrm{sinc}(Wt) - e^{j2\pi W t}\right]$$

Subject:
Date:

سؤال ۵ ادامه

$$= \frac{1}{2} A_c \left[m(t) * \frac{j\,\mathrm{sinc}(Wt)}{\pi t} + m(t) * \frac{e^{j2\pi W t}}{j\pi t} \right]$$

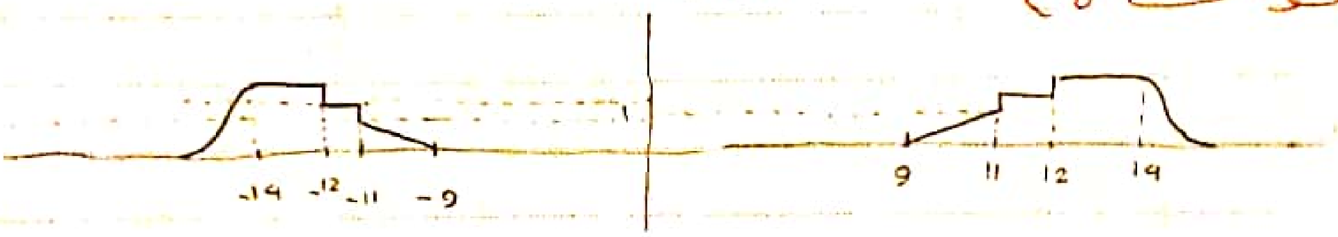
$$F\left\{ m(t) * \frac{e^{j2\pi W t}}{j\pi t} \right\} = -M(f)\,\mathrm{sgn}(f-W) = M(f)$$

$$x_{c,lp}(t) = \frac{1}{2} A_c \left[m(t) * \frac{j\,\mathrm{sinc}(Wt)}{\pi t} + m(t) \right]$$

$$\longrightarrow x_c(t) = \mathrm{Re}\left\{ x_{c,lp}(t)\, e^{j2\pi f_c t} \right\}$$

$$= \frac{1}{2} A_c m(t) \cos(2\pi f_c t) - \frac{1}{2} A_c \left[m(t) * \frac{\mathrm{sinc}(Wt)}{\pi t} \right] \sin(2\pi f_c t)$$

سؤال 6)



قسمت مثبت :

$$H(f): \begin{cases} 9 < f < 11 : & \frac{1}{2} f - \frac{9}{2} \\ 11 < f < 12 : & \frac{3}{2} \\ 12 < f < 14 : & 4 \end{cases}$$

$$X_{c_1}(f): \begin{cases} M(f-10)\left(\frac{f}{2} - \frac{9}{2}\right) & 9 < f < 11 \\ \frac{3}{2} M(f-10) & 11 < f < 12 \\ 2\, M(f-10) & 12 < f < 14 \end{cases}$$

شیفت بدون در نظر گرفتن ضریب
$\longrightarrow$

$$\longrightarrow M_1'(f): \begin{cases} M(f)\left(\frac{f}{2} + \frac{1}{2}\right) & -1 < f < 1 \\ \frac{3}{2} M(f) & 1 < f < 2 \\ 2\, M(f) & 2 < f < 4 \end{cases}$$

PAPCO

تمرین سیستم

سوال 6 ـ ادامه:

قسمت منفی:

$$H_2(f):\begin{cases} -\frac{1}{2}f-\frac{9}{2} & -11<f<-9 \\ \frac{3}{2} & -12<f<-11 \\ 2 & -14<f<-12 \end{cases}$$

$$X_{c_2}(f):\begin{cases} M(f+10)\left(-\frac{f}{2}-\frac{9}{2}\right) & -11<f<-9 \\ \frac{3}{2}M(f+10) & -12<f<-11 \\ 2M(f+10) & -14<f<-12 \end{cases}$$

حول فرکانس صفر

$$m_2'(f):\begin{cases} M(f)\left(-\frac{f}{2}+\frac{1}{2}\right) & -1<f<1 \\ \frac{3}{2}M(f) & -2<f<-1 \\ 2M(f) & -4<f<-2 \end{cases}$$

$m'(f)$ (قبل از اعمال $H_1(f)$) : $m_1'(f)+m_2'(f)$

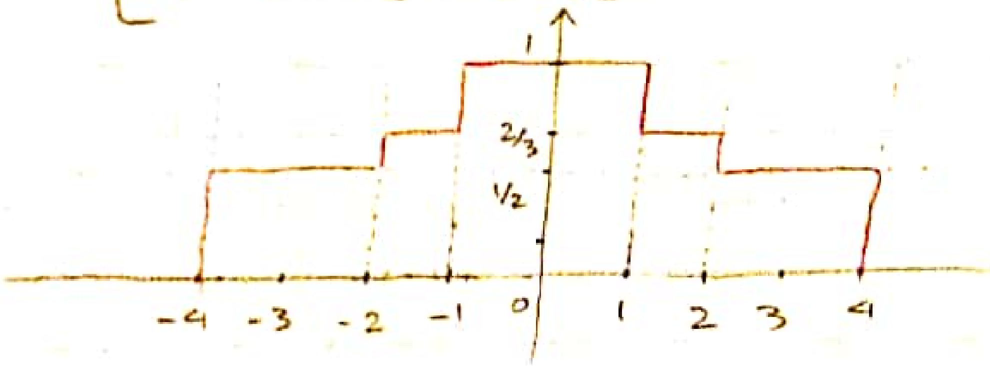
$$=\begin{cases} 2M(f) & -4<f<-2 \\ \frac{3}{2}M(f) & -2<f<-1 \\ M(f) & -1<f<1 \\ \frac{3}{2}M(f) & 1<f<2 \\ 2M(f) & 2<f<4 \end{cases}$$

Subject:
Date:

سوال 6 ـ ادامه

$$M'(f)\, H_0(f) = M(f)$$

$$H_0(f) = \begin{cases} -4 < f < -2 & : 1/2 \\ -2 < f < -1 & : 2/3 \\ -1 < f < 1 & : 1 \\ 1 < f < 2 & : 2/3 \\ 2 < f < 4 & : 1/2 \end{cases}$$



Scanned by CamScanner