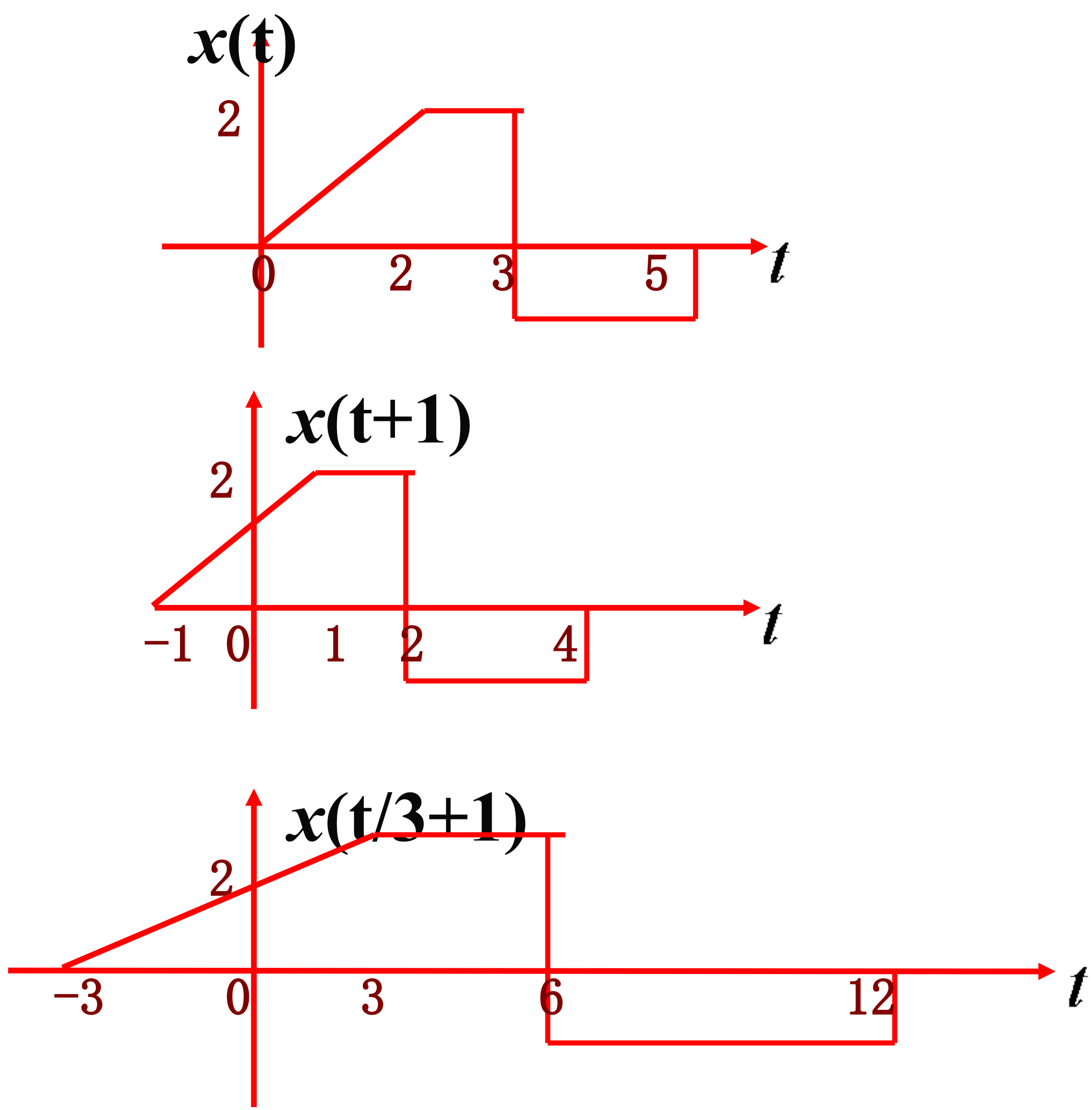
信号与系统陈后金版答案完整版

2-5: (4)



2-9:

$$x(t)=e^{-t}[u(t-1)-u(t-2)]+t\delta(t-3),\text{求}x^{(-1)}(t),x'(t)$$

$$\text{Q}\ x(t)=e^{-t}[u(t-1)-u(t-2)]+3\delta(t-3)$$

$$\therefore x^{(-1)}(t)=\int_{-\infty}^{t}\{e^{-\tau}[u(\tau-1)-u(\tau-2)]+3\delta(\tau-3)\}d\tau$$

$$x^{(-1)}(t)=\int_{-\infty}^{t} e^{-\tau}[u(\tau-1)-u(\tau-2)]d\tau+3u(t-3)$$

$$\int_{-\infty}^{t} e^{-\tau}[u(\tau-1)-u(\tau-2)]d\tau=\begin{cases}0,t<1\\ \int_{1}^{t} e^{-\tau}d\tau,1<t<2\\ \int_{1}^{2} e^{-\tau}d\tau,t>2\end{cases}$$

$$\int_{-\infty}^{t} e^{-\tau}[u(\tau-1)-u(\tau-2)]d\tau=\begin{cases}0,t<1\\ e^{-1}-e^{-t},1<t<2\\ e^{-1}-e^{-2},t>2\end{cases}$$

$$\therefore x^{(-1)}(t)=(e^{-1}-e^{-t})[u(t-1)-u(t-2)]+(e^{-1}-e^{-2})u(t-2)+3u(t-3)$$

2-9:

$$x(t)=e^{-t}[u(t-1)-u(t-2)]+t\delta(t-3),\text{求}x^{(-1)}(t),x'(t)$$

$$\therefore x'(t)=e^{-t}[\delta(t-1)-\delta(t-2)]-e^{-t}[u(t-1)-u(t-2)]+3\delta(t-3)$$

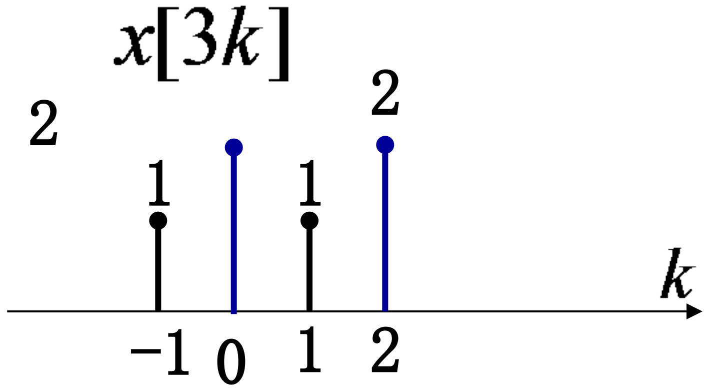
$$x'(t)=e^{-1}\delta(t-1)-e^{-2}\delta(t-2)-e^{-t}[u(t-1)-u(t-2)]+3\delta'(t-3)$$

$$=-e^{-t}[u(t-1)-u(t-2)]+e^{-1}\delta(t-1)-e^{-2}\delta(t-2)+3\delta'(t-3)$$

2-11:(3)

$$x[k]=0.9^{k}\{u[k]-u[k-5]\}=0.9^{k},0\le k\le 4$$

2-13:(3)



2-13:(4)

3-2

$$g(t)=r(t)-2r(t-1)+r(t-2)$$

$$\mathrm{Q}\ x^{(-1)}(t)=r(t)-r(t-1)$$

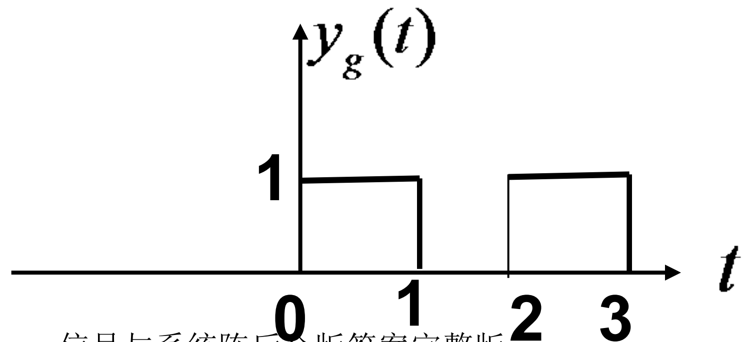
$$\therefore g(t)=x^{(-1)}(t)-x^{(-1)}(t-1)$$

根据系统积分特性:输入信号积分,输出也积分,有:

$$y_g(t)=y^{(-1)}(t)-y^{(-1)}(t-1)$$

$$=[u(t+1)+u(t+2)]-[u(t-1)+u(t-3)]$$

$$=[u(t+1)-[u(t-1)]+[u(t-2)-u(t-3)]$$



3-4 已知离散时间LTI系统,输入 $x_1[k]=\delta[k-1]$ 时,输出;

$y_1[k]=(\frac{1}{2})^{k-1}u[k-1]$,求当输入$x_2[k]=2\delta[k]+u[k]$时系统响应$y_2[k]$。

$$x_2[k]=2x_1[k+1]+\sum_{n=-\infty}^{k}\delta[n]$$

$$x_2[k]=2x_1[k+1]+\sum_{n=-\infty}^{k}x_1[n+1]$$

$$\therefore\ y_2[k]=2y_1[k+1]+\sum_{n=-\infty}^{k}y_1[n+1]$$

$$\therefore\ y_2[k]=2(\frac{1}{2})^{k}u[k]+\sum_{n=-\infty}^{k}(\frac{1}{2})^{n}u[n]$$

$$\therefore\ y_2[k]=2(\frac{1}{2})^{k}u[k]+\sum_{n=0}^{k}(\frac{1}{2})^{n}=[2+(\frac{1}{2})^{k}]u[k]$$

3-14(1)

$$[\delta(t+1)+2\delta(t-1)]*[\delta(t-1)-\delta(t-3)]$$

$$=\delta(t)+2\delta(t-2)-\delta(t-2)-2\delta(t-4)$$

3-14(2)

$$[u(t)-u(t-1)]*[u(t-2)-u(t-3)]$$

$$=r(t-2)-r(t-3)-r(t-3)+r(t-4)$$

$$=r(t-2)-2r(t-3)+r(t-4)$$

3-20: $y''(t)+7y'(t)+10y(t)=2x'(t)+3x(t);\ x(t)=e^{-t}u(t);$

$$y(0^-)=1,\ y'(0^-)=1$$

解: **1 :求冲激响应h(t):** 输入$x(t)=\delta(t)$，有:

$$h''(t)+7h'(t)+10h(t)=2\delta'(t)+3\delta(t),t\geq 0$$

特征根为$s_1=-2, s_2=-5$，又因为$n>m$，所以:

则 $h(t)=K_1e^{-2t}u(t)+K_2e^{-5t}u(t)$

$$h'(t)=-2K_1e^{-2t}u(t)+K_1\delta(t)-5K_2e^{-5t}u(t)+K_2\delta(t)$$

$$=-2K_1e^{-2t}u(t)-5K_2e^{-5t}u(t)+(K_1+K_2)\delta(t)$$

$$h''(t)=4K_1e^{-2t}u(t)-2K_1\delta(t)+25K_2e^{-5t}u(t)-5K_2\delta(t)$$

$$+(K_1+K_2)\delta'(t)$$

代入方程有:

$2K_2\delta(t)+5K$ $\therefore K_2=7/3;\ K_1=-1/3;$ $2\delta'(t)+3\delta(t)$

2 :求零输入响应:

特征根为$s_1=-2, s_2=-5$;所以:

则 $y_{zi}(t)=K_1e^{-2t}+K_2e^{-5t}, t\geq 0^-$

利用初始条件,有:

$$y(0^-)=K_1+K_2=1$$

$$y'(0^-)=-2K_1-5K_2=1 \Rightarrow K_1=2, K_2=-1$$

$$\therefore \quad y_{zi}(t)=2e^{-2t}-e^{-5t}, t\geq 0^-$$

3:求零状态响应：

$$y_{zs}(t)=x(t)*h(t)=\int_{-\infty}^{\infty}x(\tau)h(t-\tau)d\tau$$

$$=\int_{-\infty}^{\infty}[-\frac{1}{3}e^{-2\tau}u(\tau)+\frac{7}{3}e^{-5\tau}u(\tau)]e^{-(t-\tau)}u(t-\tau)$$

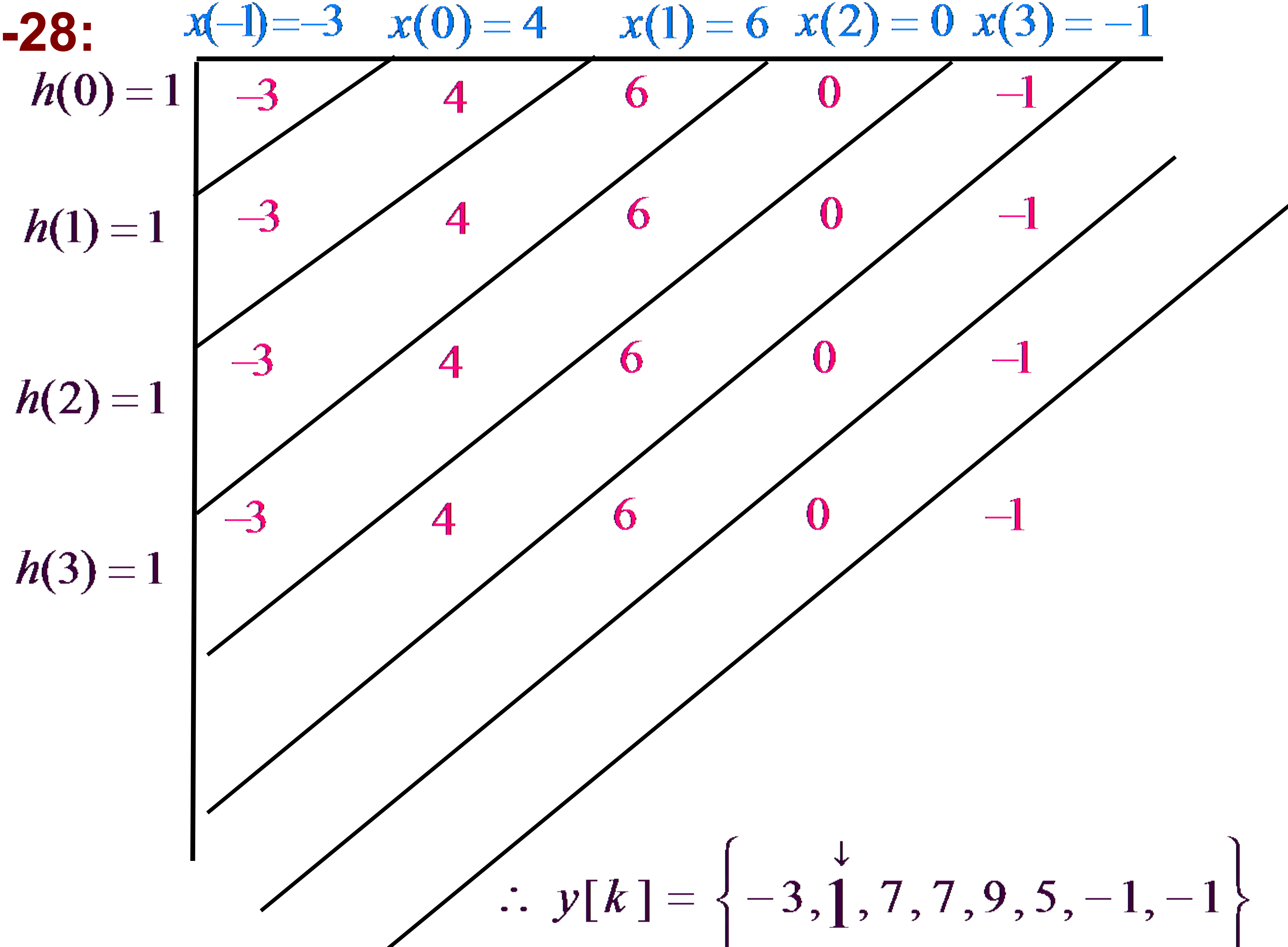
$$=\int_{0}^{\infty}[-\frac{1}{3}e^{-2\tau}+\frac{7}{3}e^{-5\tau}]e^{-(t-\tau)}d\tau$$

$$=(\frac{1}{4}e^{-t}+\frac{1}{3}e^{-2t}-\frac{7}{12}e^{-5t})u(t)$$

4:求全响应：

$$y(t)=y_{zi}(t)+y_{zs}(t)$$

3-28:



$$\therefore\ y[k]=\{-3,\overset{\downarrow}{1},7,7,9,5,-1,-1\}$$

3-31: $y[k]-\frac{5}{6}y[k-1]+\frac{1}{6}y[k-2]=x[k], y(-1)=0, y(-2)=1,$

$x[k]=u[k]$

解: (1) 根据单位脉冲响应的定义,应满足方程:

$$h[k]-\frac{5}{6}h[k-1]+\frac{1}{6}h[k-2]=\delta[k]$$

第一步:求等效初始条件：

$$Q\,h[-1]=0, h[-2]=0$$

$$h[k]=[C_1(\frac{1}{2})^k+C_2(\frac{1}{3})^k]u[k]$$

代入等效初始条件：

第二步 $h[0]=C_1+C_2$

特征方 $h[1]=$ $h[k]=[3(\frac{1}{2})^k-2(\frac{1}{3})^k]u[k]$ $=3, C_2=-2$

(2) :(a)计算零输入响应:

特征方程为: $r^2 - 5r/6 + 1/6 = 0$

$$\therefore r_1 = 1/2, r_2 = 1/3$$

则 $y_{zi}[k] = C_1(\frac{1}{2})^k + C_2(\frac{1}{3})^k, \quad k \ge 0$

代入初始条件,有:

$$y[-1] = 2C_1 + 3C_2 = 0$$

$$y[-2] = 4C_1 + 9C_2 = 1 \Rightarrow C_1 = -1/2, C_2 = 1/3$$

则 $y_{zi}[k] = -\frac{1}{2}(\frac{1}{2})^k + \frac{1}{3}(\frac{1}{3})^k, \quad k \ge 0$

$$= -(\frac{1}{2})^{k+1} + (\frac{1}{3})^{k+1}, \quad k \ge 0$$

(2) (b)计算零状态响应:

$$y_{zs}[k]=\sum_{n=-\infty}^{\infty}x[n]h[k-n]=u[k]*\left(3(\frac{1}{2})^{k}-2(\frac{1}{3})^{k}\right)u[k]$$

$$=\sum_{n=-\infty}^{\infty}u[n]\cdot\left(3(\frac{1}{2})^{k-n}-2(\frac{1}{3})^{k-n}\right)u[k-n]$$

$$=\sum_{n=0}^{k}\left(3(\frac{1}{2})^{k-n}-2(\frac{1}{3})^{k-n}\right)$$

$$=\sum_{n=0}^{k}3(\frac{1}{2})^{k-n}-\sum_{n=0}^{k}2(\frac{1}{3})^{k-n}$$

$$=[\ 3-3(\frac{1}{2})^{k}+(\frac{1}{3})^{k}\ ]u[k]$$

完全响应:

$$y[k]=y_{zi}[k]+y_{zs}[k]$$

$$=[\ \frac{1}{2}-\frac{7}{2}(\frac{1}{2})^{k}+\frac{4}{3}(\frac{1}{3})^{k}\ ]u[k]$$

(3) 计算固有响应与强迫响应:

完全响应:
$$y[k]=[\ \frac{1}{2}-\frac{7}{2}(\frac{1}{2})^k+\frac{4}{3}(\frac{1}{3})^k\ ]u[k]$$

固有响应:
$$y_h[k]=[-\frac{7}{2}(\frac{1}{2})^k+\frac{4}{3}(\frac{1}{3})^k\ ]u[k]$$

强迫响应:
$$y_p[k]=\frac{1}{2}u[k]$$

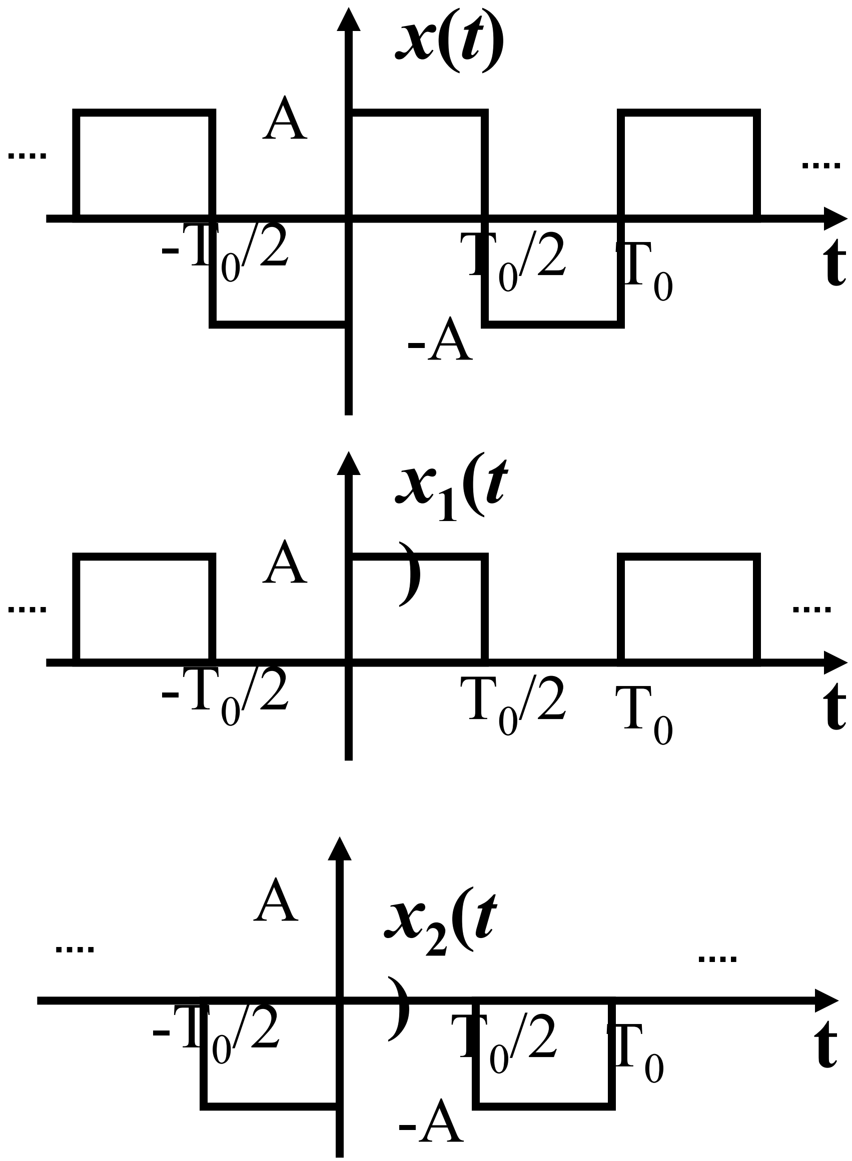
(4) 计算瞬态响应与稳态响应:

瞬态响应:
$$y_t[k]=[-\frac{7}{2}(\frac{1}{2})^k+\frac{4}{3}(\frac{1}{3})^k\ ]u[k]$$

稳态响应:
$$y_s[k]=\frac{1}{2}u[k]$$

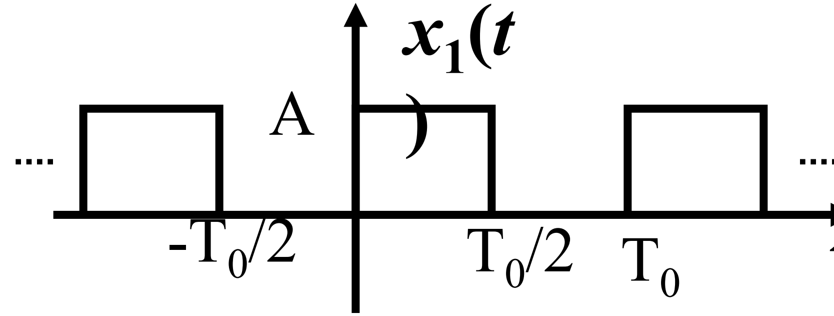
第四章

4-5(d)波形如图:



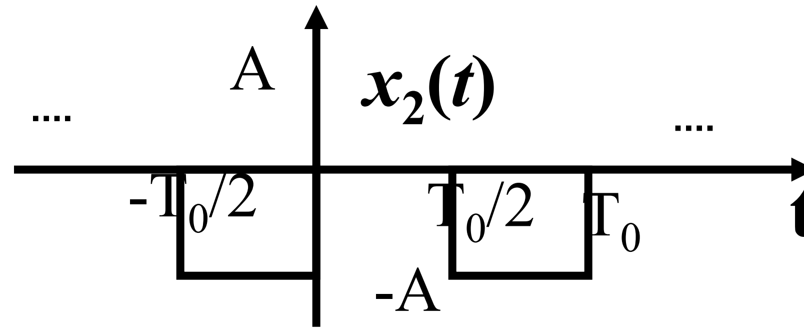
$$x(t)=x_1(t)+x_2(t)$$

$x_1(t)$的傅里叶级数系数为：



$$a_n = \frac{AT_0}{2T_0} Sa\left(\frac{n\omega_0 T_0}{4}\right) e^{-j\frac{n\omega_0 T_0}{4}}$$

$x_2(t)$的傅里叶级数系数为：



$$b_n = -\frac{AT_0}{2T_0} Sa\left(\frac{n\omega_0 T_0}{4}\right) e^{j\frac{n\omega_0 T_0}{4}}$$

$x(t)$的傅里叶级数系数为：

$$C_n = a_n + b_n = \frac{AT_0}{2T_0} Sa\left(\frac{n\omega_0 T_0}{4}\right)\left[e^{-j\frac{n\omega_0 T_0}{4}} - e^{j\frac{n\omega_0 T_0}{4}}\right]$$

$$= \frac{AT_0}{2T_0} Sa\left(\frac{n\omega_0 T_0}{4}\right)\left[-2j\sin\left(\frac{n\omega_0 T_0}{4}\right)\right]$$

$$= \frac{A}{2} Sa\left(\frac{n\pi}{2}\right)\left[-2j\sin\left(\frac{n\pi}{2}\right)\right]$$

4-8 $\tilde{x}(t) = 2\cos(2\pi t - 3) + \sin(6\pi t)$

$\tilde{x}(t)$角频率$\omega_0 = 2\pi$

利用欧拉公式: $\tilde{x}(t) = 2 \times \frac{1}{2}(e^{j(2\pi t-3)} + e^{-j(2\pi t-3)}) + \frac{1}{2j}(e^{j6\pi t} - e^{-j6\pi t})$

$$= (e^{j(\omega_0 t-3)} + e^{-j(\omega_0 t-3)}) + \frac{1}{2j}(e^{j3\omega_0 t} - e^{-j3\omega_0 t})$$

$$= e^{-3j}e^{j\omega_0 t} + e^{3j}e^{-j\omega_0 t} + \frac{1}{2j}(e^{j3\omega_0 t} - e^{-j3\omega_0 t})$$

$$\therefore C_1 = e^{-3j};\ C_{-1} = e^{3j}$$

$$C_3 = \frac{1}{2j};\ C_{-3} = \frac{-1}{2j}$$

平均功率P为:

$$\therefore P = \sum_{n=-\infty}^{\infty} |C_n|^2 = 1 + 1 + \frac{1}{4} + \frac{1}{4} = 2.5$$

4-9: $(1)\ x(t)=u(t)-u(t-2)$

解法一: $u(t)\overset{FT}{\Leftrightarrow}\pi\delta(\omega)+\dfrac{1}{j\omega}$

利用时移性质:

$$u(t-2)\overset{FT}{\Leftrightarrow}[\pi\delta(\omega)+\frac{1}{j\omega}]e^{-2j\omega}=\pi\delta(\omega)+\frac{1}{j\omega}e^{-2j\omega}$$

$$x(t)\overset{FT}{\Leftrightarrow}(\pi\delta(\omega)+\frac{1}{j\omega})-[\pi\delta(\omega)+\frac{1}{j\omega}e^{-2j\omega}]=\frac{1}{j\omega}(1-e^{-2j\omega})$$

解法二: $x(t)=p_2(t-1)$

Q $F\{p_2(t)\}=2Sa(\omega)$

$\therefore\ F\{x(t)\}=2Sa(\omega)e^{-j\omega}$

4-9(4): $x(t) = e^{-2t}[u(t) - u(t-2)]$

解: $x(t) = e^{-2t}u(t) - e^{-4}e^{-2(t-2)}u(t-2)$

$$\because e^{-t}u(t) \overset{FT}{\Leftrightarrow} \frac{1}{j\omega+2}$$

利用时移性质:

$$e^{-2(t-2)}u(t-2) \overset{FT}{\Leftrightarrow} \frac{1}{j\omega+2}e^{-2j\omega}$$

$$\therefore F\{x(t)\} = \frac{1}{j\omega+2} - \frac{e^{-4}}{j\omega+2}e^{-2j\omega}$$

4-8(9):

$$x(t)=\frac{d}{dt}\left[\frac{\sin(\pi t)}{\pi t}*\frac{\sin(2\pi t)}{\pi t}\right]$$

$$\because \frac{\sin(\pi t)}{\pi t}\overset{FT}{\Leftrightarrow}u(\omega+\pi)-u(\omega-\pi)=p_{2\pi}(\omega)$$

$$\frac{\sin(2\pi t)}{\pi t}\overset{FT}{\Leftrightarrow}u(\omega+2\pi)-u(\omega-2\pi)=p_{4\pi}(\omega)$$

$$\therefore x(t)=\frac{d}{dt}\left[\frac{\sin(\pi t)}{\pi t}*\frac{\sin(2\pi t)}{\pi t}\right]\overset{FT}{\Leftrightarrow}j\omega[p_{2\pi}(\omega)\times p_{4\pi}(\omega)]=j\omega p_{2\pi}(\omega)$$

4-13(3):

$$X(j\omega)=Sa^2(\omega\tau)$$

设$x_1(t)\overset{FT}{\Leftrightarrow}X_1(j\omega)=Sa(\omega\tau)$

则：$X(j\omega)=X_1(j\omega)\times X_1(j\omega)$

利用卷积性质有：

$$x(t)=x_1(t)*x_1(t)$$

由$X_1(j\omega)=Sa(\omega\tau)$，有：$x_1(t)=\frac{1}{2\tau}p_{2\tau}(t)$

$$\therefore\quad x(t)=x_1(t)*x_1(t)=\frac{1}{4\tau^2}p_{2\tau}(t)*p_{2\tau}(t)$$

$$=\frac{1}{4\tau^2}[u(t+\tau)-u(t-\tau)]*[u(t+\tau)-u(t-\tau)]$$

$$=\frac{1}{4\tau^2}[r(t+2\tau)-r(t)-r(t-2\tau)]$$