2024秋非线电第八章作业答案

8.1　8.2　8.6　8.7　8.10(a)　8.11　8.15　8.16

8.1

$u_{FM}(t) = U_{FM}\cos[\omega_0 t + m_f \sin\Omega_m t]$

$m_f = \frac{\Delta\omega}{\Omega_m} = \frac{k_f U_\Omega}{\Omega_m}$

由题表可知 $k_f = 2\pi\times10^3$ rad/s.

$\therefore u_{FM}(t) = 10\cos\left\{2\pi\times10^6 t + \frac{2\pi\times10^3\times2}{2\pi\times10^5}\sin(2\pi\times10^5 t) + \frac{2\pi\times10^3\times3}{2\pi\times10^3}\sin(2\pi\times10^3 t)\right\}$

$= 10\cos\left\{2\pi\times10^6 t + 0.02\sin(2\pi\times10^5 t) + 3\sin(2\pi\times10^3 t)\right\}$

所含的频谱分量为 $2\pi\times10^6 + m\cdot2\pi\times10^5 + n\cdot2\pi\times10^3$，$m, n \in \mathbb{Z}$.

8.2

(1) $BW_{AM} = 2f_m = 2\cdot10^3 = 2$kHz

由题目已知 $k_f = 3\text{kHz/V} = 2\pi\times3\text{kHz} = 6\pi\times10^3$ rad/V.

$u_{FM}(t) = U_{FM}\cos[\omega_0 t + m_f \sin\Omega_m t]$

$m_f = \frac{\Delta\omega}{\Omega_m} = \frac{k_f U_\Omega}{\Omega_m}$

$\therefore m_f = \frac{6\pi\times10^3\ \text{rad/V}\times0.1\text{V}}{2\pi\times10^3} = 0.3$

$BW_{CR} = 2(m_f+1)f_m = 2(0.3+1)\times10^3 = 2.6$kHz

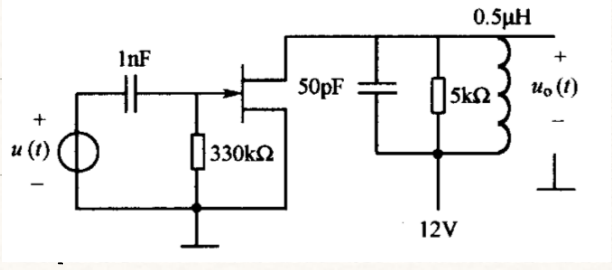
综上：$BW_{AM} = 2$kHz，$BW_{CR} = 2.6$kHz

(2) $BW_{AM} = 2f_m = 2kHz$

$M_f' = \frac{3kHz \cdot 2\pi \times 20}{2\pi \times 10^3} = 60$, $BW_{CR} = 2(M_f'+1)f_m = 122kHz$

3) 调频信号更容易实现大带宽.

8b



已知 $u_1(t) = 4\cos[10^8 t + 10\sin 10^4 t]$ V . 故 $M_f = 10$

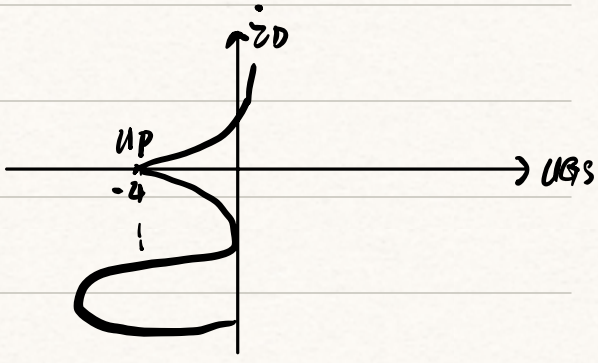
$BW_{CR} = 2(M_f+1)f_m = 2(10+1)\times 10^4 = 220kHz$.

RLC 谐调回路 $f = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{50pF \times 0.5\mu H}} = 2\times 10^8 Hz$ > 信号带宽 220kHz

自生负偏压电路 $U_Q = -U_1$

$\therefore u_{GS}(t) = -4 + 4\cos[10^8 t + 10\sin 10^4 t]$ V (U_Q↓ U_1↓)

导通角 $\varphi = \cos^{-1}\left(\frac{-4-(-4)}{4}\right) = \frac{\pi}{2}$



$I_p = \frac{I_{DSS}}{U_P^2} U_1^2 (1-\cos\varphi) = \frac{4mA}{16} \times 16 \times 1 = 4mA$

因为 $f_{RLC} = 2\times 10^8 Hz$, $f_0 = 10^8 Hz$, 故 RLC 电路谐振在中心频率的 2 倍频上.

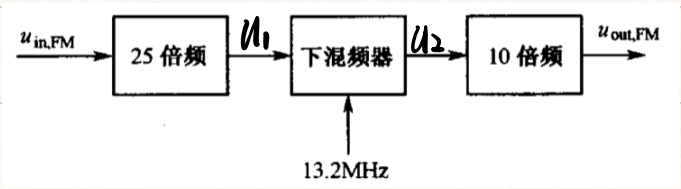
(成为 2 倍频电路)

FM 通过倍频 { ω_m 不变. $\omega_0 \to n\omega_0$ $\Delta\omega \to n\Delta\omega$

故 $\alpha_2(\varphi) = 0.5$ 则 $I_{D2} = I_p \alpha_2(\varphi) = 1mA$

则 $u_0(t) = 12 - I_{D2} R_L \cos[2\times 10^8 t + 20\sin 10^4 t] = 12 - 5\cos[2\times 10^8 t + 20\sin 10^4 t]$ (V)

87



$u_{FM}(t)=U_{Fm}\cos[\omega_0 t+\Delta\omega\int_0^t s(t)dt]$，$m_f=\frac{\Delta\omega}{\omega_m}$，$f_0=100kHz$，$\Delta f=180Hz$，$f_m=2kHz$

FM调幅倍频网络 $\begin{cases}\omega_m\text{不变}\\ \omega_0\to n\omega_0\\ \Delta\omega\to n\Delta\omega\end{cases}$　　FM调幅混频网络 $\begin{cases}\omega_0\to\omega_1=\omega_2\pm\omega_0\\ \Delta\omega\to\text{不变}\\ \omega_m\to\text{不变}\end{cases}$

u_1：$\begin{cases}f_m\text{不变}\\ f_0\to 75f_0\\ \Delta f\to 75\Delta f\end{cases}$　　u_2 $\begin{cases}f_m\text{不变}\\ f_0\to 13.2MHz-75f_0\\ \Delta f\to 75\Delta f\end{cases}$

$u_{out,FM}$ $\begin{cases}f_m\text{不变}\\ f_0\to 10(13.2MHz-75f_0)\\ \Delta f\to 10\times 75\Delta f\end{cases}$

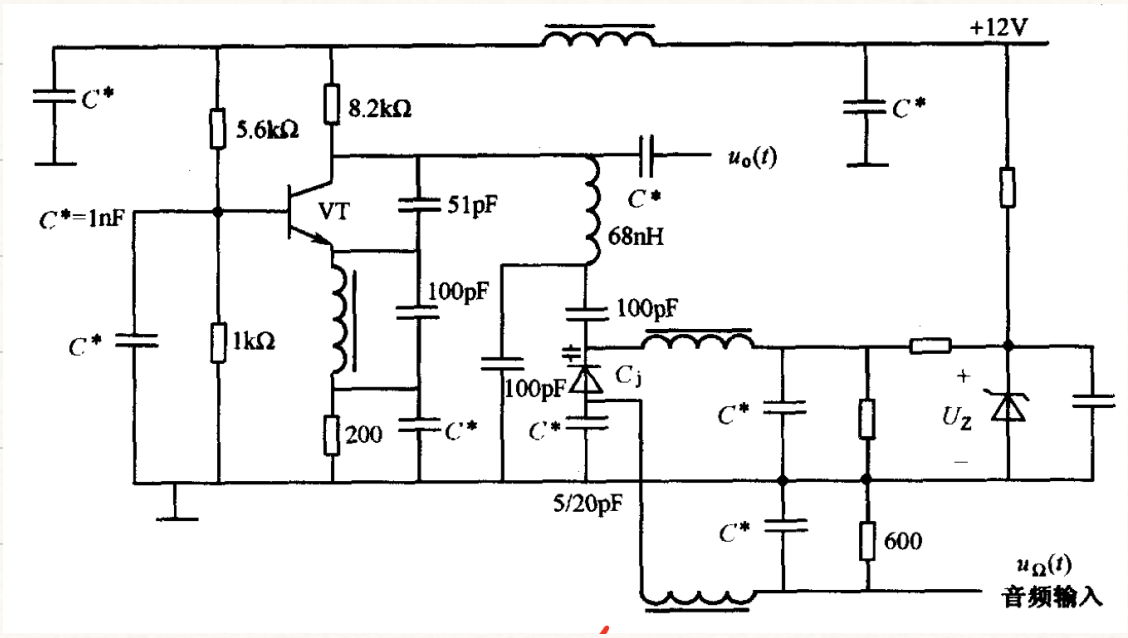
算上：$f_0=10(13.2MHz-75\times 100kHz)=10MHz$

$\Delta f_m=10\times 75\times 180Hz=45kHz$

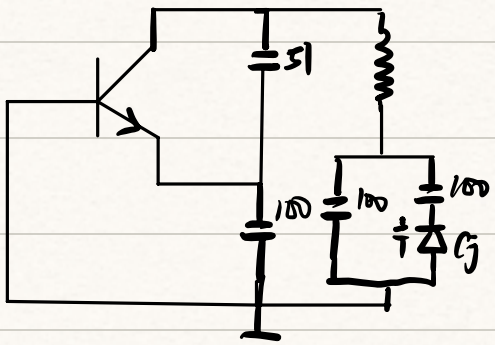
$m_f=\frac{\Delta f_m}{f_m}=\frac{45kHz}{2kHz}=22.5$

$BW_{CR}=2(m_f+1)f_m=2(22.5+1)\times 2kHz=94kHz$

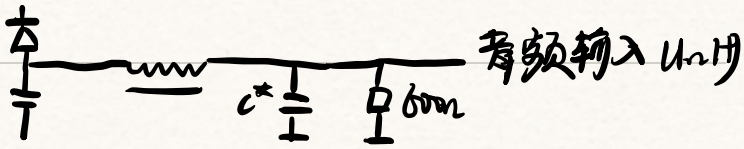
8.10(2)



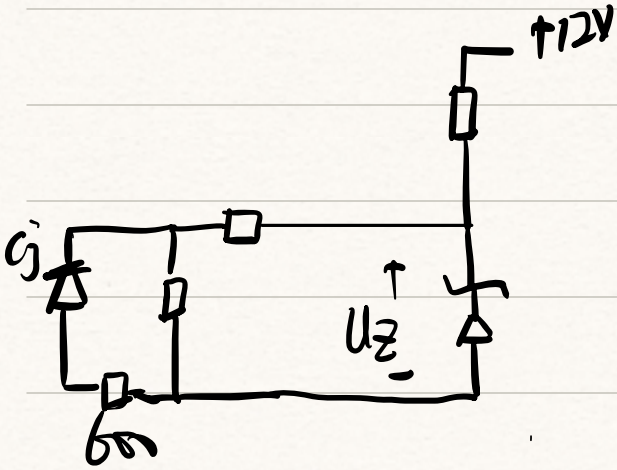
(2)



振荡电路



音频电路.

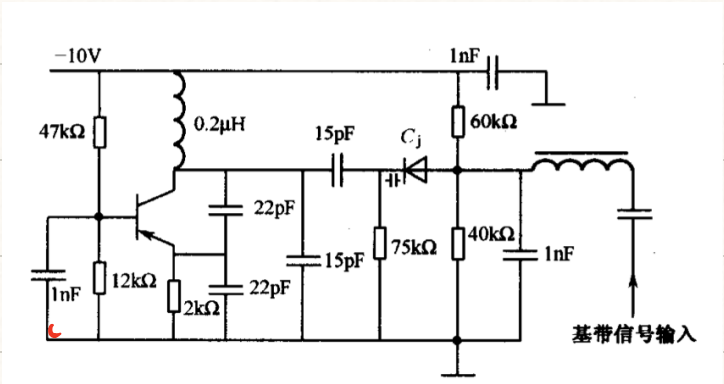


变容管直流偏置电路.

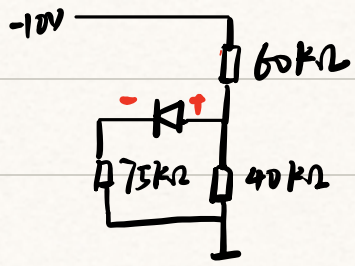
8.11 ppt 变容管直接调频

$C_j = C_{j0}\left(1+\frac{u_C}{u_\varphi}\right)^{-\gamma}$ $\Rightarrow \gamma = 1.5$, $u_\varphi = 0.5$

$= 540\left(1+\frac{u}{0.5}\right)^{-1.5}$



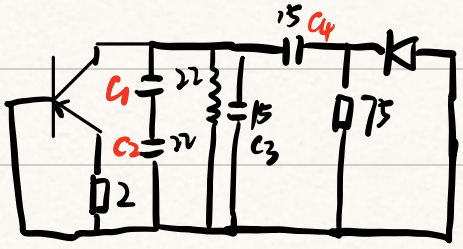
① C_j 的偏置电路



$U_Q = 10V \cdot \frac{40}{40+60} = 4V$

$C_{jQ} = 540(1+2\times 4V)^{-1.5} = 20pF$

② 画出交流电路



$\begin{cases} C_1 \text{并联} C_2 = C_1 + C_2 \\ C_1 \text{串联} C_2 = \frac{C_1 C_2}{C_1 + C_2} \end{cases}$

$C_{12} = C_1 // C_2 = 11pF$

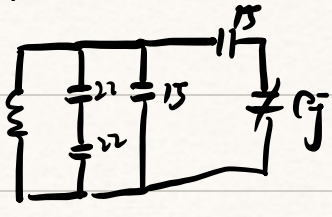
$C_{jQ} // C_4 = \frac{15\times 20}{15+20} = \frac{60}{7} pF$

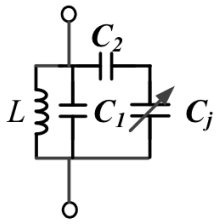
$\Rightarrow C_\Sigma = 11pF // 15pF // \frac{60}{7} pF = 34.57 pF$

中心频率

$\because f_0 = \frac{1}{2\pi\sqrt{LC_\Sigma}} = \frac{1}{2\pi\sqrt{0.2\times 10^{-6}\times 34.57\times 10^{-12}}} = 60.53 MHz$

最大频偏 $\Delta\omega = D_1\omega_0$, $D_1 = \frac{1}{2}M\gamma(A-B)$





$$A=\frac{C_{jQ}}{C_{jQ}+\frac{C_1C_2}{C_1+C_2}}$$

$$B=\frac{C_{jQ}}{C_{jQ}+C_2}$$

$C_{open}=15$串$[15//(22串22)]$

$=15串[15+11]=9.512pF$

$C_{close}=15$

$A=\frac{C_{jQ}}{C_{jQ}+C_{open}}=\frac{20}{20+9.512}=0.677$

$B=\frac{C_{jQ}}{C_{jQ}+C_{close}}=\frac{20}{20+15}=0.5714$

$M=\frac{U_n}{U_Q+U_\phi}=\frac{135mV}{4V+0.5V}=0.03$

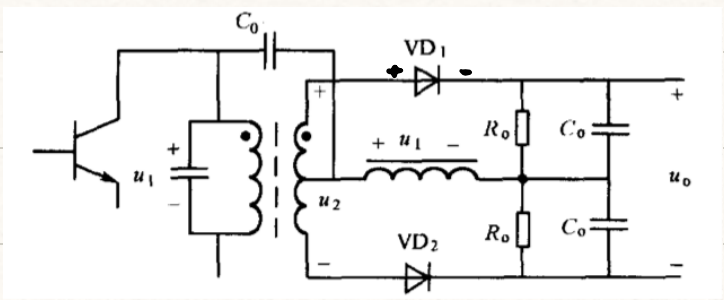
3) $D_1=\frac{1}{2}M\gamma(A-B)=\frac{1}{2}\times0.03\times1.5(0.677-0.5714)=2.38\times10^{-3}$

$\Delta f=D_1\times f_0=2.38\times10^{-3}\times60.3MHz=144.06kHz$

$m_f=\frac{\Delta f}{f_m}=\frac{144.06kHz}{10^4/2\pi}=90.51kHz$

$BW_{CR}=2(m_f+1)f_m=2(90.51+1)10^4/2\pi=291.2kHz$

8.15

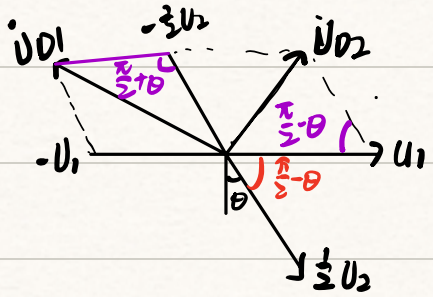


$H(j\omega)=\frac{\dot{U}_2}{\dot{U}_1}=2\exp\left\{j\left[-\frac{\pi}{2}+\frac{\Delta\omega}{\alpha}s(t)\right]\right\}$。

设$s(t)>0$

叠加型相位鉴频器

(1) 不能，若VD_1反接，则 $\begin{cases}\dot{U}_{D1}=-\dot{U}_1-\frac{1}{2}\dot{U}_2\\ \dot{U}_{D2}=\dot{U}_1-\frac{1}{2}\dot{U}_2\end{cases}$



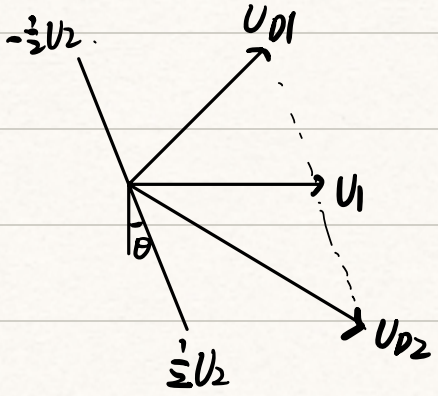
$$|U_{D1}| = \sqrt{\left(\frac{1}{2}U_2\right)^2 + U_1^2 - 2U_1\cdot\frac{1}{2}U_2\cos\left(\frac{\pi}{2}+\theta\right)} = \frac{\sqrt{5}}{2}U_1\sqrt{1+\sin\theta} = \frac{\sqrt{5}}{2}U_1\left(\cos\frac{\theta}{2}+\sin\frac{\theta}{2}\right)$$

$$|U_{D2}| = \sqrt{U_1^2+\left(\frac{1}{2}U_2\right)^2 - 2U_1\cdot\frac{1}{2}U_2\cos\left(\frac{\pi}{2}-\theta\right)} = \frac{\sqrt{5}}{2}U_1\sqrt{1-\sin\theta} = \frac{\sqrt{5}}{2}U_1\left(\cos\frac{\theta}{2}-\sin\frac{\theta}{2}\right)$$

$$U_O = -|U_{D1}| - |U_{D2}| = -\sqrt{5}U_1\cos\frac{\theta}{2} \xrightarrow{\frac{\Delta W}{\alpha}\ll 1} -\sqrt{5}U_1 \text{ 与 SIN 无关，故不能鉴频。}$$

12) 可以鉴频

$$\begin{cases}\dot{U}_{D1} = \dot{U}_1 - \frac{1}{2}\dot{U}_2\\ \dot{U}_{D2} = \dot{U}_1 + \frac{1}{2}\dot{U}_2\end{cases}$$



同理(1) $\Rightarrow U_O = |U_{D1}| - |U_{D2}| = -2\sqrt{5}U_1\sin\frac{\theta}{2} \approx \sqrt{5}U_1\frac{\Delta W}{\alpha}$ SIN 极性鉴频。

8.16

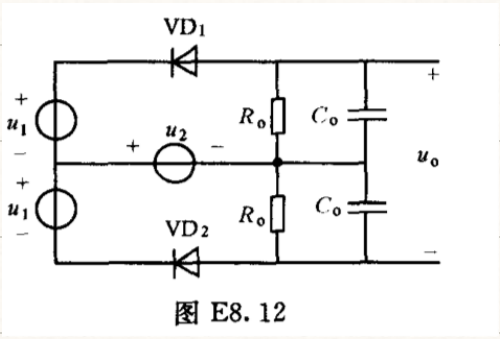


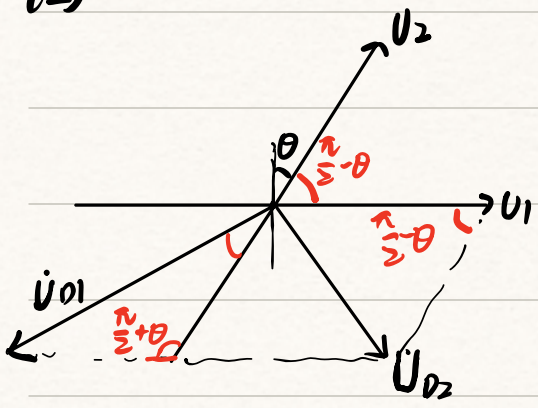
图 E8.12

$$H(j\omega) = \frac{\dot{U}_2}{\dot{U}_1} = \exp\left\{j\left[\frac{\pi}{2} - \arctan\left(\frac{\omega-\omega_0}{\alpha}\right)\right]\right\}$$

$$\theta = \arctan\left(\frac{\omega-\omega_0}{\alpha}\right)$$

(1) $\begin{cases} \dot{U}_{D1} = -\dot{U}_1 - \dot{U}_2 \\ \dot{U}_{D2} = \dot{U}_1 - \dot{U}_2 \end{cases}$ $\theta = \arctan\frac{w-w_0}{\alpha}$

(2)



$$\begin{cases} |U_{D1}| = \sqrt{U_1^2+U_2^2-2U_1U_2\cos(\frac{\pi}{2}+\theta)} = \sqrt{2}U\sqrt{1+\sin\theta} = \sqrt{2}U\left(\cos\frac{\theta}{2}+\sin\frac{\theta}{2}\right) \\ |U_{D2}| = \sqrt{U_1^2+U_2^2-2U_1U_2\cos(\frac{\pi}{2}-\theta)} = \sqrt{2}U\sqrt{1-\sin\theta} = \sqrt{2}U\left(\cos\frac{\theta}{2}-\sin\frac{\theta}{2}\right) \end{cases}$$

(3) $U_0 = |U_{D1}| + |U_{D2}| = -2\sqrt{2}U\sin\frac{\theta}{2} \approx -2\sqrt{2}U\arctan\left(\frac{\Delta w}{\alpha}s(t)\right) \approx -\sqrt{2}U\frac{\Delta w}{\alpha}s(t)$