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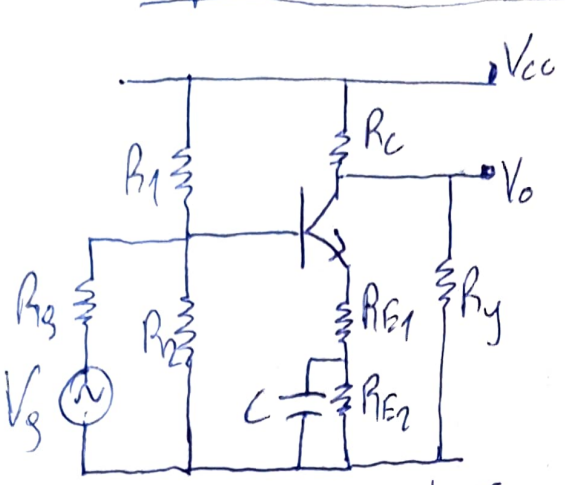
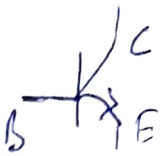
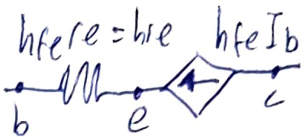
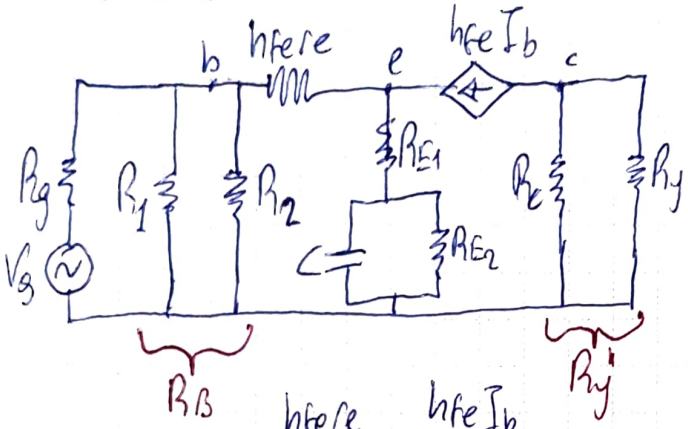
Kopruleme Kondansorunun Etkisi

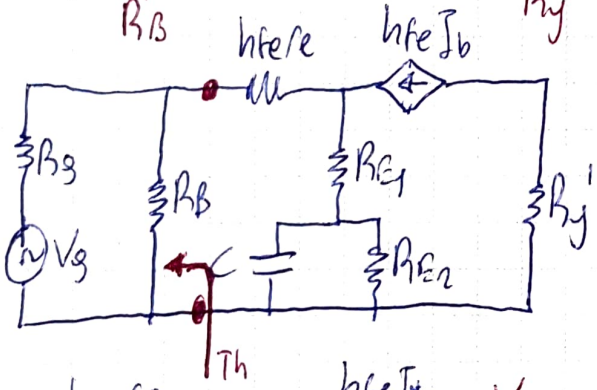


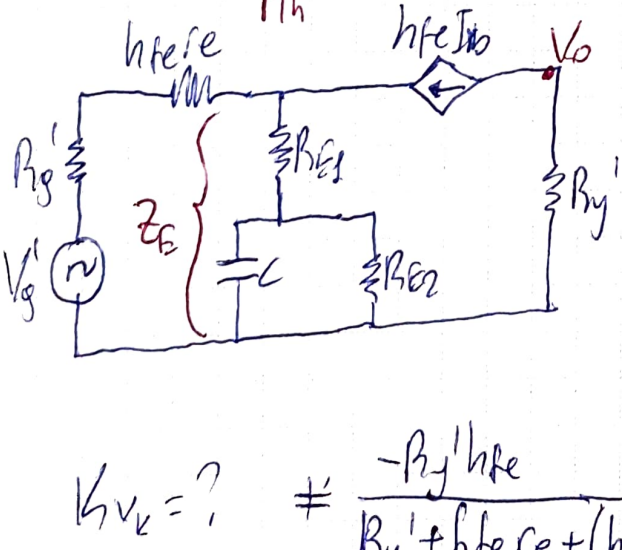


$h_{re} = h_{oe} = 0$









$$R_{Th} = R_g' = R_B \,//\, R_g'$$

$$V_{Th} = V_g' = V_g \frac{R_B}{R_B + R_g}$$

$$K_{V_L} = \frac{V_o}{V_g}$$

$$V_o = -R_y' h_{fe} I_b$$

$$V_g' = R_g' I_b + h_{fe} r_e I_b + Z_E (h_{fe}+1) I_b$$

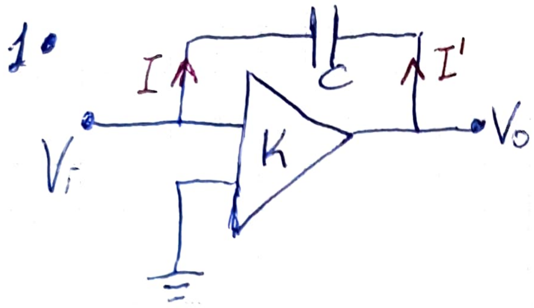
$$V_g' = \left[R_g' + h_{fe} r_e + (h_{fe}+1) Z_E \right] I_b$$

$$K_{V_L} = ? = \frac{-R_y' h_{fe}}{R_y' + h_{fe} r_e + (h_{fe}+1) Z_E} \cdot \frac{R_B + R_g}{R_B}$$

Z_E empedansini 5 donnemden bul

Miller Dönüşümü

1.

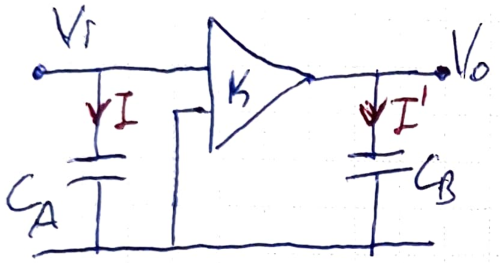


$$I = \frac{V}{Z} \qquad Z = \frac{1}{j\omega C}$$

$$I = j\omega C(V_{in} - V_{out})$$

$$I' = j\omega C(V_o - V_{in})$$

2.



$$I = j\omega C_A V_i$$

$$I' = j\omega C_B V_o$$

- 1'den

$$V_o = K V_i$$

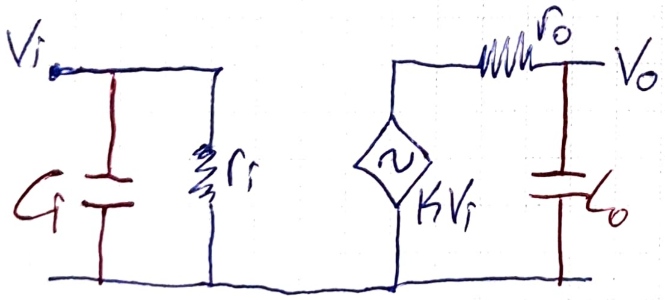
$$I = j\omega C (1-K) V_i$$

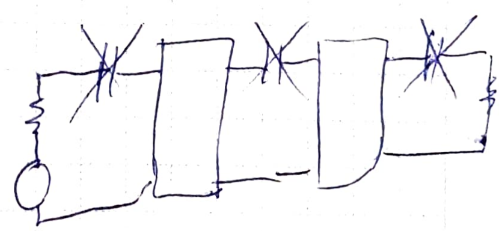
$$I' = j\omega C \left(1 - \frac{1}{K}\right) V_o$$

$$C_A = C(1-K)$$

$$C_B = C\left(1 - \frac{1}{K}\right)$$

Yüksek Frekans Cevabı





$$10\mu F \rightarrow 10kHz \quad Z = \frac{1}{2\pi 10^4 10^5} = 1{,}5\Omega$$

kısa devre

$$\rightarrow 100kHz \quad Z = \frac{1}{2\pi 10^{5} 10^{5}} = 0{,}15\Omega$$

GİMTAŞ

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Dolar

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$$f_k = \frac{1}{2\pi RC}$$

$$f_k = \frac{\omega_k}{2\pi} \quad \text{(kesim frekansı)}$$

$$S_k = -\frac{1}{RC}$$

$$\omega_k = -S_k = 1/RC$$

$$k_v(s) = k_{v_0} \frac{\omega_k}{s+\omega_k}$$

$$\left[\frac{1}{R} = \frac{f_0+f_y}{f_0 f_y} \right] \quad \left[f_0 // f_y = R \right]$$

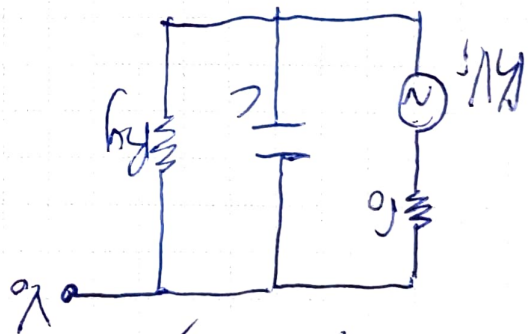
$$S_k = -\frac{f_0+f_y}{C f_0 f_y}$$

$$k_{v_0} = k \frac{f_y}{f_0+f_y}$$

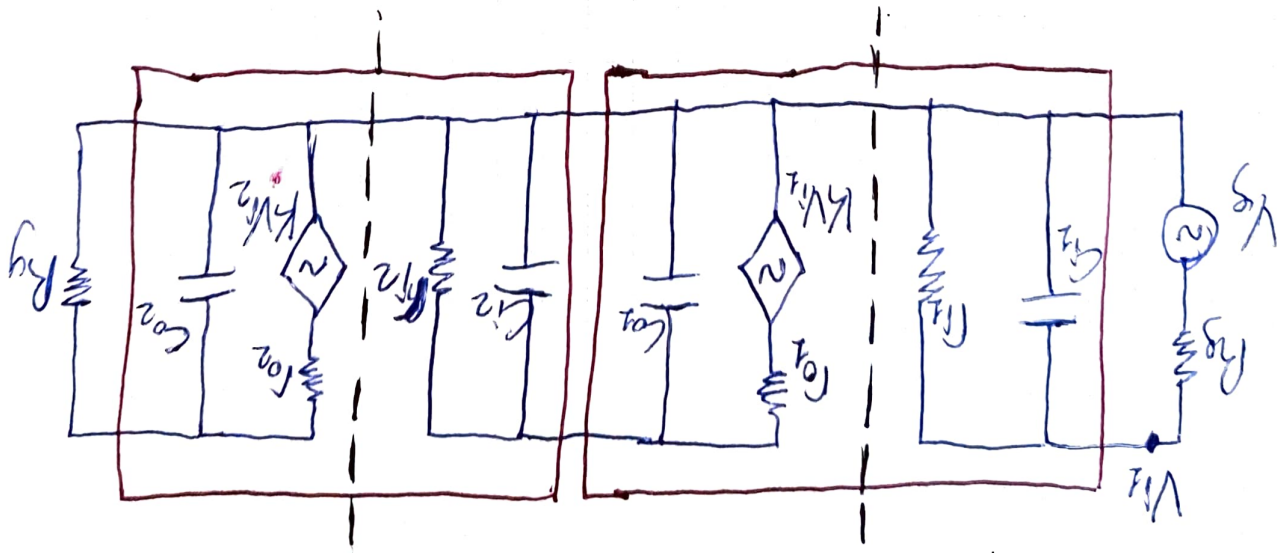
$$k_v(s) = k_{v_0} \frac{-S_k}{s-S_k}$$

$$k(s) = \frac{V_0}{V_i} = k \cdot \frac{f_y}{f_0+f_y} \cdot \frac{s + \frac{f_0+f_y}{C f_0 f_y}}{s + \frac{f_0+f_y}{C f_0 f_y}}$$

$$V_0 = k \cdot V_i \cdot \frac{f_y}{f_0+f_y+sC f_0 f_y}$$



Temel devre



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$$f_k = \frac{1}{2\pi RC}$$

- İşaret dörtgen sinusoidal ise;
  $S = j\omega$ olur.

$$K_v(j\omega) = K_{v_0} \frac{\omega_k}{j\omega + \omega_k}$$

- Modülü ve fazını bulursak;

$$K_v(j\omega) = \left| K_v(j\omega) \right| = \frac{K_{v_0}\,\omega_k}{\sqrt{\omega^2 + \omega_k^2}}$$

Orta frekansı referans olarak sıfıra eşitlenirse $\frac{|K|}{K_{\infty}}$ bulunur

- Normalize kazanç:

$$\frac{K_v(\omega)}{K_{v_0}} = \frac{\omega_k}{\sqrt{\omega_k^2 + \omega^2}}$$

$$f_k = \frac{\omega_k}{2\pi} \qquad f = \frac{\omega}{2\pi}$$

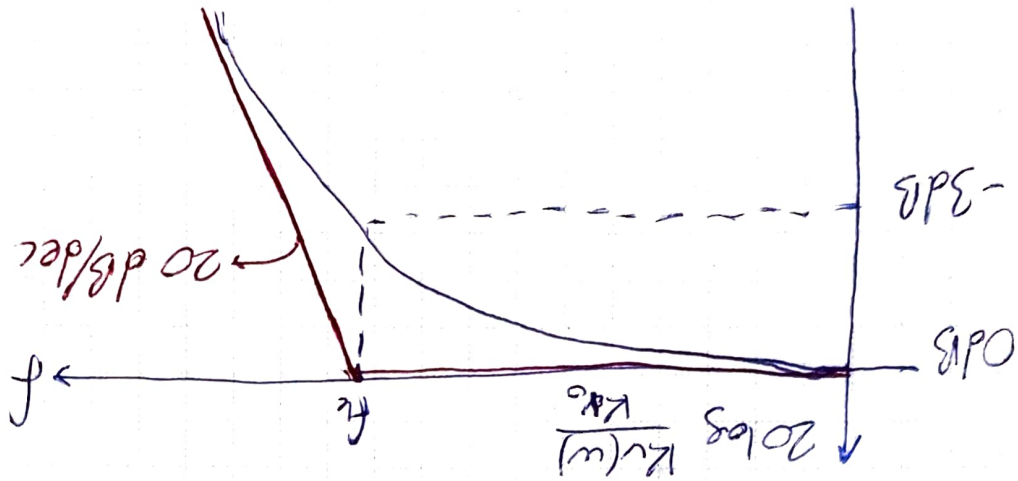
$$= \frac{f_k}{\sqrt{f_k^2 + f^2}}$$

$$\varphi(\omega) = \varphi_0 - \operatorname{Arc\,tan} \frac{\omega}{\omega_k}$$

normalize kazanç dB cinsinden olursa ne olur?

$$20 \log \frac{K_v(\omega)}{K_{v_0}} = 20 \log (f_k) - 20 \log (f_k^2 + f^2)^{1/2}$$

$$= 20 \log (f_k) - 10 \log (f_k^2 + f^2)$$



Bode kazanç karakteristiği 20dB/dec eğimindedir

$f \ll f_k \quad \phi(f) = \phi_0$

$f = f_k \quad \phi(f) = \phi_0 - \frac{\pi}{4}$

$f \gg f_k \quad \phi(f) = \phi_0 - \frac{\pi}{2}$

frekans bağımlı faz değişimleri

$20\log\frac{|K_v(\omega)|}{|K_{v_0}|} \cong 0$

$f \ll f_k$

$20\log\frac{|K_v(\omega)|}{|K_{v_0}|} = -3dB$

$f = f_k$

$= -20\log\left(\frac{f}{f_k}\right)$

$= 20\log(f_k) - 20\log(f)$

$20\log\frac{|K_v(\omega)|}{|K_{v_0}|} = 20\log(f_k) - 20\log(f)$

$f \gg f_k$ olursa

Alçak Frekans Cevabı

$$K_v(s) = K_{v_0} \frac{s}{s+w_k}$$

$$K_v(jw) = K_{v_0} \frac{jw}{jw+w_k}$$

$$K_v(w) = |K_v(jw)| = K_{v_0} \frac{w}{\sqrt{w^2+w_k^2}}$$

$$\phi(w) = \phi_0 + \frac{\pi}{2} - Arctg \frac{w}{w_k}$$

$$K_v(f) = K_{v_0} \frac{f}{\sqrt{f^2+f_k^2}}$$

Yüksek Frekans Cevabı

$$K_v(s) = K_{v_0} \frac{w_k}{s+w_k}$$

$$K_v(jw) = K_{v_0} \frac{w_k}{jw+w_k}$$

$$K(w) = |K_v(jw)| = K_{v_0} \frac{w_k}{\sqrt{w^2+w_k^2}}$$

$$\phi(w) = \phi_0 - Arctg \frac{w}{w_k}$$

$$K_v(f) = K_{v_0} \frac{f_k}{\sqrt{f^2+f_k^2}}$$

Kesim frekansı $\Rightarrow \frac{K_{v0}}{\sqrt{2}}$

$$f_1 = f_k = \frac{1}{2\pi(r_0+R_y)C}$$

$$f_2 = f_k = \frac{1}{2\pi RC}$$

$R \rightarrow r_0 // R_y$

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Çok Katlı Kuvvetlendiricilerde Frekans Cevabı

$K_v = K_{v_1} \cdot K_{v_2} \cdot K_{v_3} \cdots K_{v_n}$

n katlı kutup

- Alçak frekans;

$$K_v(f) = K_{v_0} \frac{f^n}{(f^2 + f_k^2)^{n/2}}$$

$K_v(f) = \frac{K_{v_0}}{\sqrt{2}}$ ise kesme gider.

$$\frac{K_{v_0}}{\sqrt{2}} = K_{v_0} \frac{f_1^n}{(f_1^2 + f_k^2)^{n/2}}$$

$$f_1^n \sqrt{2} = (f_1^2 + f_k^2)^{n/2}$$

kare al

$$f_1^{2n} \cdot 2 = (f_1^2 + f_k^2)^n$$

n dereee kök al

$$f_1^2 \sqrt[n]{2} = f_1^2 + f_k^2$$

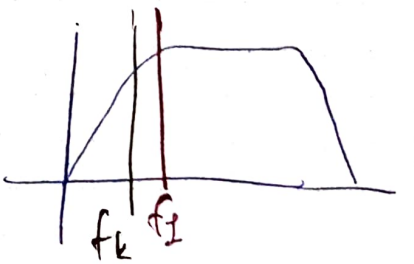
$$f_1^2 (\sqrt[n]{2} - 1) = f_k^2$$

$$f_1^2 = \frac{f_k^2}{(\sqrt[n]{2} - 1)}$$

$$f_1 = \frac{f_k}{\sqrt{2^{1/n} - 1}}$$

Dolar / Euro

$f_1 > f_k$



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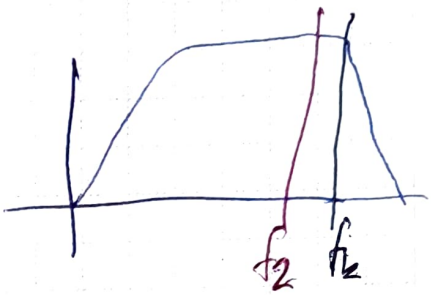
- Yüksek frekans;

$$K_v(f) = K_{vo} \frac{f_k^n}{(f^2 + f_k)^{n/2}}$$

f_2 için $\longrightarrow |K_v(f)| = \frac{K_{vo}}{\sqrt{2}}$

$$f_2 = f_k \left(2^{1/n} - 1\right)^{1/2} \qquad f_2 < f_k$$



- Birbirine yakın kutup frekansları

f_{k1} , f_{k2} , f_{k3} ...

$$f = \sqrt[n]{f_{k1} \cdot f_{k2} \cdot f_{k3} \cdot \ldots \cdot f_{kn}}$$

tüm frekanslar geometrik ortalaması alınıp çıkan frekans n katlı kutup ile aynı.

1- Alçak frekansta f_1 bu ortalamadaki frekanslardan (f_k) en büyüğünden daha büyüktür.

2- Yüksek frekansta f_2 ise bu f_k'lar arasından en küçüğünden daha küçük olmalıdır.

3- Alçak frekans değerlerinden çok büyük, yüksek frekans değerlerinden çok küçük bir f_k var ise bunu baskın frekans denir. $f_1 \cong f_{baskın}$ ve $f_2 \cong f_{baskın}$ alınır.

Tek kutup (tek kat) gibi işlem yapılır.

Dolar
Euro

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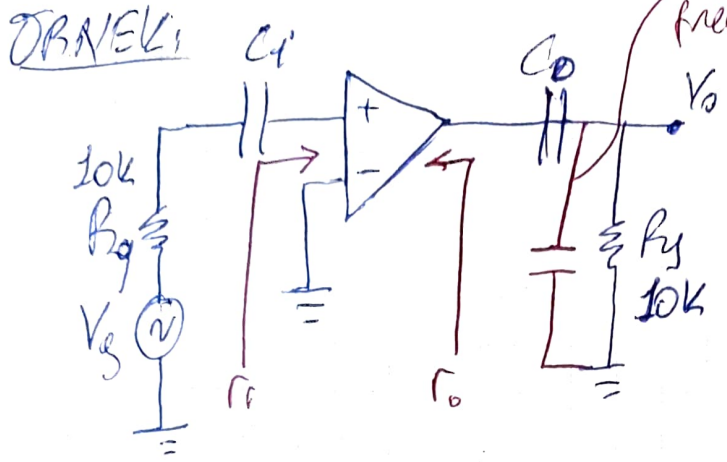
Bunda kondansatör kontrolü yüksek frekans bölgesinden başlanır frekans belirler (kritik)

ÖRNEK:



Yük bağlı değilken

$$\frac{V_o'}{V_i} = K(s) = \frac{10^8\pi}{s+10^6\pi}$$

ise;

a) Orta frekans bölgesinde $\frac{V_o}{V_g} = K_{V_k} = ?$

b) Alt kesim frekansı 20Hz olması için ve eğim 40 dB/dec olması için $C_1, C_2 = ?$

$$K(\omega) = K_{V_0} \frac{\omega_k}{s+\omega_k}$$

$$\omega_k = 10^6\pi$$

$$K_{V_0} = 100$$

$$\frac{100}{110} = \frac{V_i}{V_g} \cdot \frac{V_o'}{V_i} \cdot \frac{V_o}{V_o'} = \frac{R_y}{r_o+R_y}$$

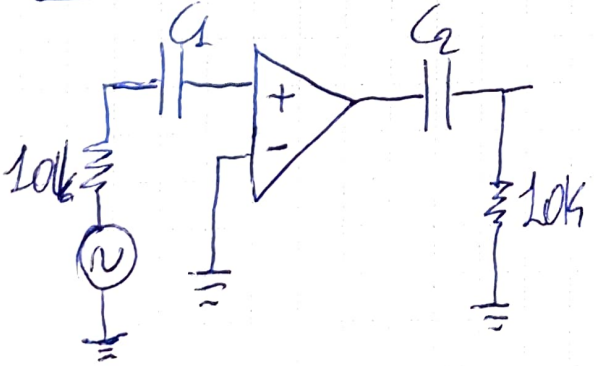
$$\frac{1}{2\pi RC} = 20Hz$$

$R \hookrightarrow r_o + R_y$

$[r_i = 100k \quad r_o = 10k \quad C_1 = 100pF \quad C_o = 10pF]$

2 kere eğim yapmış 2 kondansatör de devrede etkiliyor.

ÖRNEK:



$$\frac{V_o'}{V_i} = K(s) = \frac{10^8\pi}{s+10^6\pi}$$

$r_i = 100K \quad C_1 = 100pF$

$r_o = 10k \quad C_o = 10pF$

orta frekansta $\rightarrow \frac{V_o}{V_g} = ?$

$f_1 = 20Hz$ eğim 40dB/dec ise

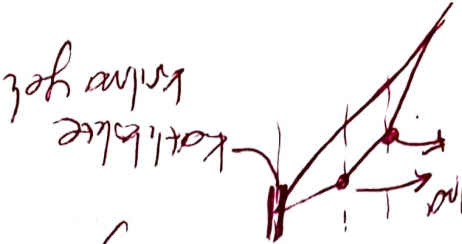
$C_1 = ? \quad C_2 = ?$

555 entegresi

Dolar

Euro

...../...../201...



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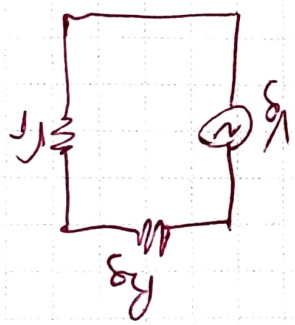
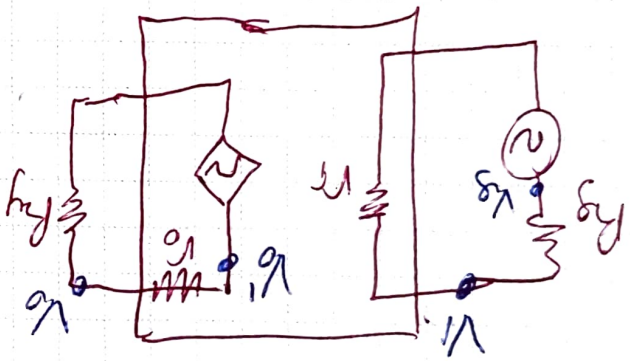
Dolar

Euro





$$\frac{V_o}{V_g} = \frac{V_i}{V_g} \cdot \frac{V_o'}{V_i} \cdot \frac{V_o}{V_o'}$$

$$A_{V_o} = 10^2 = 100 = \frac{V_o'}{V_i}$$

$$A_{V_o} \omega_t = 10^8 \pi$$

$$\omega_t = 10^6 \pi$$

$$H(s) = A_{V_o} \frac{\omega_t}{s+\omega_t} = \frac{10^8 \pi}{s+10^6 \pi}$$

$$\frac{V_o}{V_g} = 45,45$$

$$\frac{V_o}{V_g} = \frac{100}{110} \cdot 100 \cdot \frac{10}{20}$$

$$\frac{V_o}{V_g} = \frac{R_i}{R_i + R_g} \cdot 200 \cdot \frac{R_y}{r_o + R_y}$$

$$\frac{V_i}{V_g} = \frac{R}{R + R_g}$$

/ /201

Dolar

Euro

$f_1 = \frac{f_k}{\sqrt{\sqrt{2}-1}}$ (Alt kesim) $\quad f_2 = f_k\sqrt{\sqrt{2}-1}$ (üst kesim)

$f_k = f_1\sqrt{\sqrt{2}-1} = 20\sqrt{2^{1/2}-1} = 12{,}87$ Hz

$f_{k_{C_1}} = \frac{1}{2\pi R C_1}$; $12{,}87 = \frac{1}{2\pi\, 110k \cdot C_1}$

R → $(R_g + r_i)$

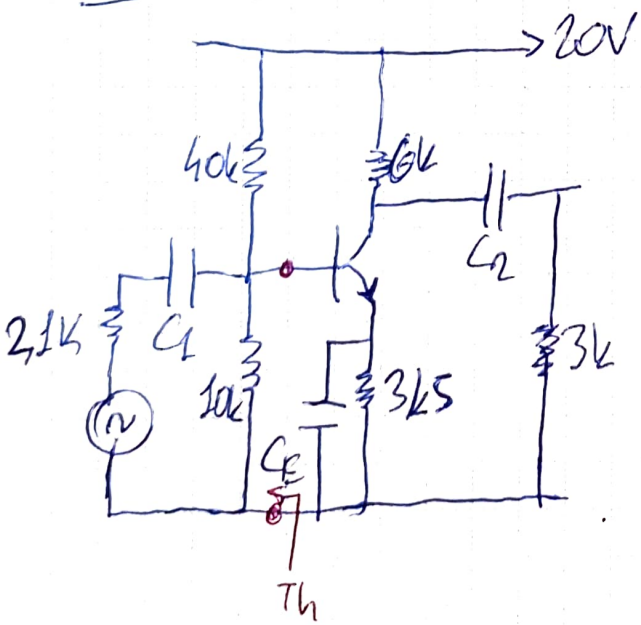
$\boxed{C_1 = 112{,}4\,nF}$

$f_{k_{C_2}} = \frac{1}{2\pi R C_2}$; $12{,}87 = \frac{1}{2\pi\, 20k\, C_2}$

R → $(r_o + R_y)$

$\boxed{C_2 = 618{,}3\,nF}$

ÖRNEK:



$h_{FE} = 100$ $\quad V_{BE} = 0{,}6V$

$V_T = 25mV$

$C_1 = 10\mu F$

$C_2 = 1\mu F$

$C_E = 20\mu F$

Orta frekans kazanç = ? (K_V = ?)

K_{V_k} = ?

Alt kesim frekansı = ?

Bode diyagramını çiziniz?

Dolar

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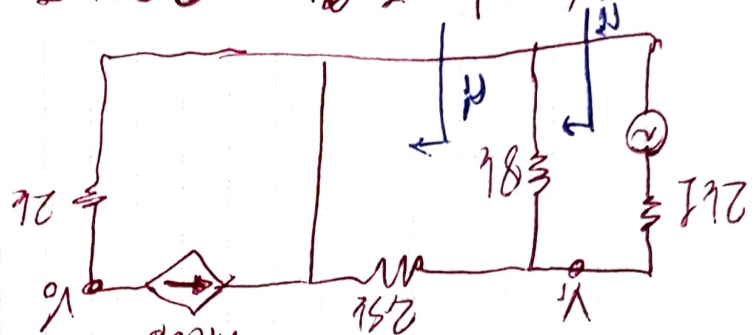
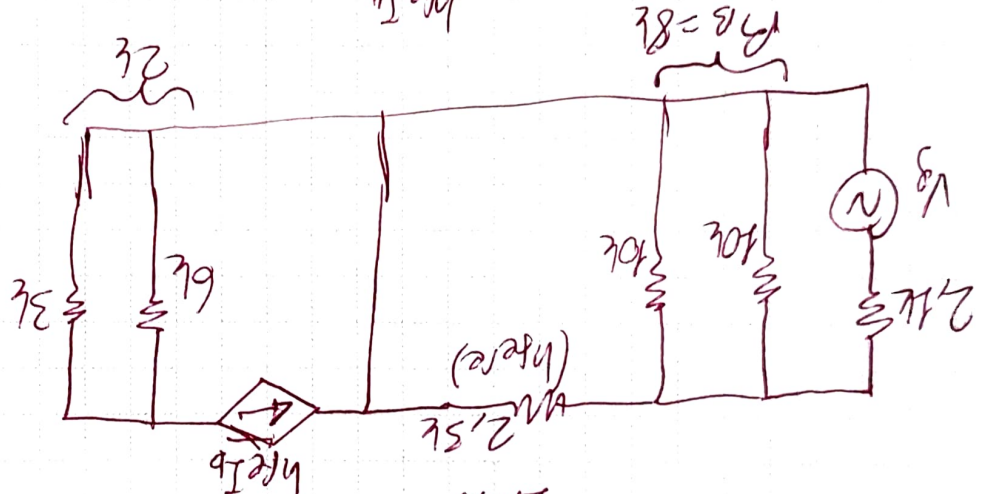
$A_v = \frac{V_o}{V_i} = \frac{-200 I_b}{2,5 k I_b} = -80$

$V_i = 2,5 k I_b$

$V_o = -h_{fe} I_b 2k = -200 k I_b$





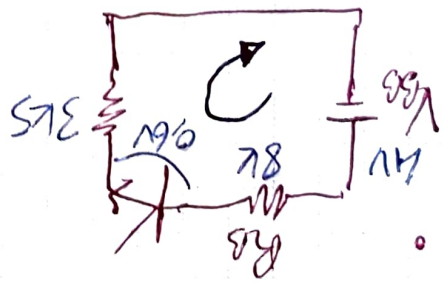
$r_e = \frac{V_T}{I_E} = \frac{25mV}{1mA} = 25\Omega$

$I_E = \pm 1mA$

$I_B = 9,96\mu A$

$3,4 = 3k1,5k I_B$

$4 = 8k I_B + 0,6 + 3,5k * 101 I_B$



$R_B = 40 // 40 = 8k$

$V_{BB} = 20 \frac{40}{40+40} = 5V$

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- $V_{Vk} = \frac{V_o}{V_g} = \frac{V_o}{V_i} \cdot \frac{V_i}{V_g} = -80 \frac{r_i}{r_i + R_g}$

$$r_i' = \frac{V_i}{I_b} = 2{,}5k$$

$$r_i = 2{,}5k // 8k = 1{,}9k$$

$$V_{Vk} = -80 \frac{1{,}9}{1{,}9 + 2{,}1} = -38$$

- $f_{1C_1} = \frac{1}{2\pi R_i C_1} = \frac{1}{2\pi (1{,}9 + 2{,}1)k \, 10.10^{-6}} = 3{,}98\,Hz$

($R_i \rightarrow (r_i + R_g)$)

$$f_{1C_2} = \frac{1}{2\pi (r_o + R_y) C_2} = \frac{1}{2\pi (6+3)k \, 10^{-6}} = 17{,}68\,Hz$$

($(r_o + R_y) \rightarrow R_c$)

$$f_{1CE} = \frac{1}{2\pi R_e C_E} \qquad R_e = \frac{R_g' // h_{ie}}{h_{fe}} // R_E$$

Eşdeğer devredeki emitör ile toprak arası direnç

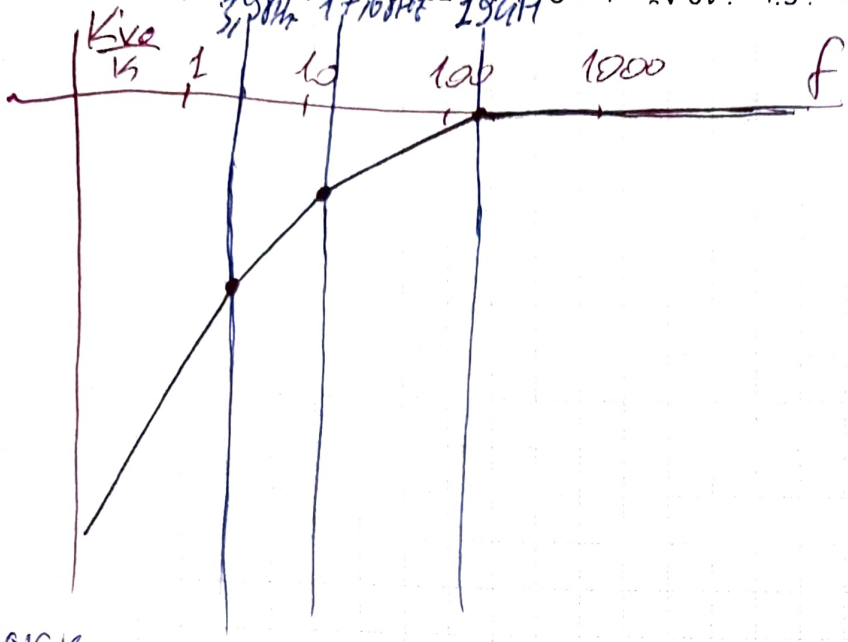
$$R_g' = R_B // R_g = 8k // 2{,}1k = 1{,}66k$$

$$R_e = \frac{1{,}66k // 2{,}5k}{100} = 41\,\Omega$$

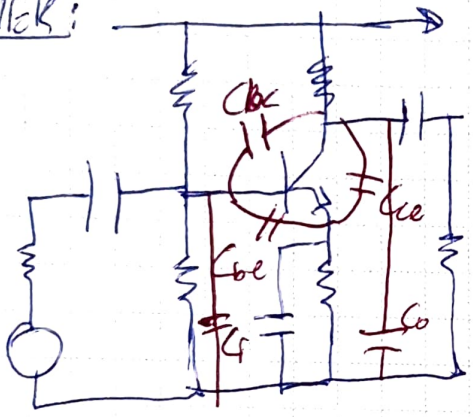
$$f_{1CE} = \frac{1}{2\pi \, 41 \times 20 \times 10^{-6}} = 194\,Hz$$

Alt kesim frekansı 194 Hz dir.

Hepsi birbirine yakın olursa geometrik ortalaması alınır.



ÖRNEK:



$h_{FE} = 100$ $V_{BE} = 0,6V$

$V_T = 25mV$

$C_i = 4pF$ $C_{be} = 48pF$

$C_o = 8pF$ $C_{bc} = 1,5pF$

$C_{ce} = 6pf$

giriş devresinin üst kesim frekansını etkisini inceleyiniz.

$$f_{H2} = \frac{1}{2\pi RC}$$

C_{bc} → kondansatörü miller dönüşümü ile girişe yansıtarak çıkışa aktarılır.

- giriş $R = R_g // r_i = 2,1 // 1,3k$

$\cong 1k$ (miller dönüşümünün giriş tarafına etkisi)

$$C = C_i + C_{be} + (1-k)C_{cb}$$

$\downarrow$ -80

$C = 4p + 48p + 81 \times 1,5p = 173,5pF$

$$f_{21} = \frac{1}{2\pi 10^3 173,5 \cdot 10^{-12}} = 0,92MHz = 920kHz$$

Dolar
Euro

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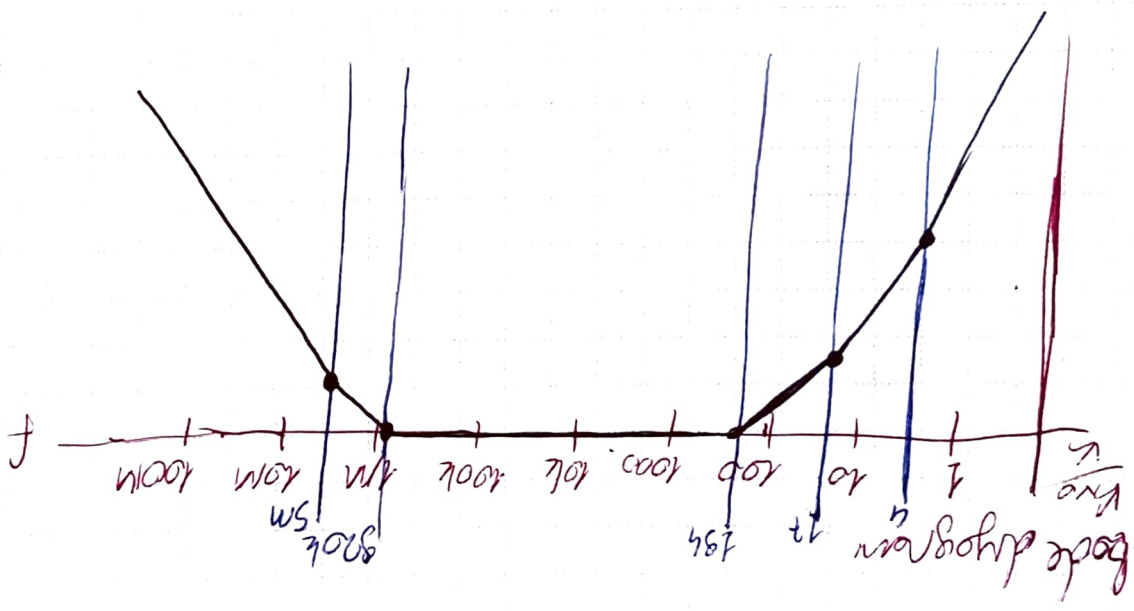


$$f_{co} = \frac{1}{2\pi \cdot 2k \times 15,52 \times 10^{-12}} = 5,1MHz$$

$$C = 8p + 6p + \left(1 + \frac{1}{80}\right)45p = 45,518pF$$

miller düzeltmesinin eklenişi etkisi

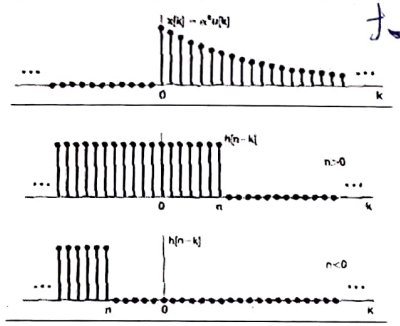
$$C = C_o + C_{ce} + \left(A - \frac{1}{k}\right)C_{cb}$$

$$R = r_o // R_y = 6k // 3k = 2k$$

• Çıkış

Ayrık-zaman LTI sistemlerin konvolüsyon toplamı gösterilimi

ÇÖZÜM: Aşağıda $x[k]$ ve $h[n-k]$ $n<0$ ve $n\geq 0$ için çizilmiştir.



Ayrık-zaman LTI sistemlerin konvolüsyon toplamı gösterilimi

- Şekillerden $n<0$ ise, $x[k]$ ile $h[n-k]$ dizilerinin kesişmeyip $x[k]\,h[n-k]$ çarpımının sıfıra eşit olduğu görülmektedir. O halde, $n<0$ ise $y[n]=0$.
- $n\geq 0$ ise, diziler $0\leq k\leq n$ aralığında kesiştiğinden $x[k]\,h[n-k]$ çarpımı şöyle olur:

$$x[k]h[n-k]=\begin{cases}\alpha^k, & 0\leq k\leq n\\ 0, & \text{aksi halde}\end{cases}$$

- $y[n]$'yi belirlemek için konvolüsyon toplamı hesaplanmalıdır.

$$y[n]=\sum_{k=-\infty}^{\infty}x[k]h[n-k]=\sum_{k=0}^{n}x[k]h[n-k]$$

$$=\sum_{k=0}^{n}\alpha^k=\frac{1-\alpha^{n+1}}{1-\alpha}$$

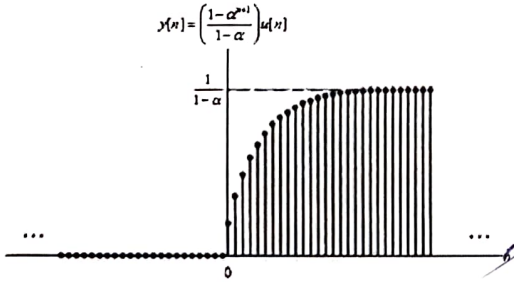
Hatırlatma: $\sum_{k=n_1}^{n_2}q^k=\frac{q^{n_1}-q^{n_2+1}}{1-q}$, $1\neq q$

Ayrık-zaman LTI sistemlerin konvolüsyon toplamı gösterilimi

Özetle,

$$y[n]=\begin{cases}\dfrac{1-\alpha^{n+1}}{1-\alpha}, & n\geq 0\\ 0, & n<0\end{cases}$$

$$y[n]=\left(\frac{1-\alpha^{n+1}}{1-\alpha}\right)u[n]$$



Ayrık-zaman LTI sistemlerin konvolüsyon toplamı gösterilimi

ÖRNEK: Bir ayrık-zaman LTI sistemin impuls yanıtı $h[n]$ ve sisteme uygulanan giriş $x[n]$ aşağıda verilmiştir. Sistemin çıkışını hesaplayınız.

$$x[n]=\begin{cases}1, & 0\leq n\leq 4\\ 0, & \text{aksi halde}\end{cases}\qquad h[n]=\begin{cases}\alpha^n, & 0\leq n\leq 6\\ 0, & \text{aksi halde}\end{cases}$$