CMOS OTA-C Yapıları

ELE415
ANALOG TÜMDEVRELER

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CMOS OTA-C Yapıları

•Sadece geçiş iletkenliği kuvvetlendiricisi ve kondansatörler kullanılarak gerçekleştirilen yapılar, yüksek frekans devrelerinde oldukça fazla yarar sağlarlar.

•Devrelerin sağladığı en büyük yarar, yapıda endüktans bulunmaması, OTA nın açık çevrimde çalışabilmesidir

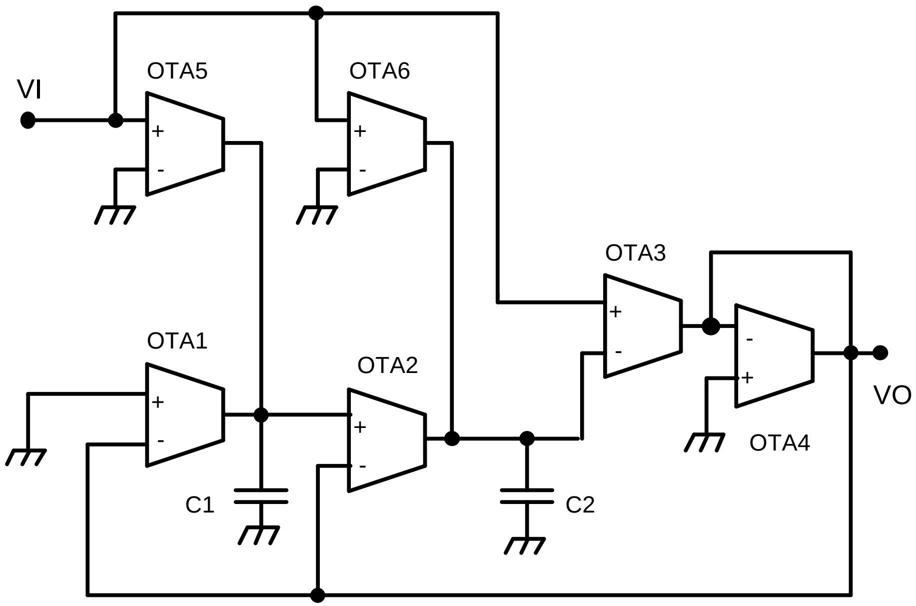
•OTA nın eğiminin bir tasarım parametresi olarak kullanılması da elde edilen diğer bir yarar olarak değerlendirilebilir.

•Bu eğim akımın bir fonksiyonu olduğundan OTA nın kuyruk akımının değiştirilmesiyle söz konusu parametre ve bununla da frekansı değiştirme olanağı bulunmaktadır.

CMOS OTA-C aktif süzgeçleri

İkinci dereceden genel transfer fonksiyonu

$$G(s) = \frac{a_2 s^2 + a_1 s + a_0}{s^2 + b_1 s + b_0}$$



$$\frac{g_{m1}}{C_1} = \frac{b_0}{b_1} \qquad \frac{g_{m2}}{C_2} = \frac{b_1}{a_2}$$

$$\frac{g_{m3}}{g_{m4}} = a_2 \qquad \frac{g_{m5}}{C_1} = \frac{a_0}{b_1}$$

$$\frac{g_{m6}}{C_2} = \frac{a_1}{a_2}$$

$$G(s)=\frac{a_2 s^2 + a_1 s + a_0}{s^2 + b_1 s + b_0} = H.\frac{s^2 + \frac{\omega_Z}{Q_Z} s + \omega_Z^{\,2}}{s^2 + \frac{\omega_P}{Q_P} s + \omega_P^{\,2}}$$

Alçak geçiren süzgeç

$$G(s)= H_1.\frac{\omega_P^{\,2}}{s^2 + \frac{\omega_P}{Q_P} s + \omega_P^{\,2}}$$

Yüksek geçiren süzgeç

$$G(s)= H_2.\frac{s^2}{s^2 + \frac{\omega_P}{Q_P} s + \omega_P^{\,2}}$$

Band geçiren süzgeç

$$G(s) = H_3 . \frac{\frac{\omega_P}{Q_P} s}{s^2 + \frac{\omega_P}{Q_P} s + \omega_P^{\,2}}$$

Çentik süzgeç

$$G(s) = H_4 . \frac{s^2 + \omega_Z^{\,2}}{s^2 + \frac{\omega_P}{Q_P} s + \omega_P^{\,2}}$$

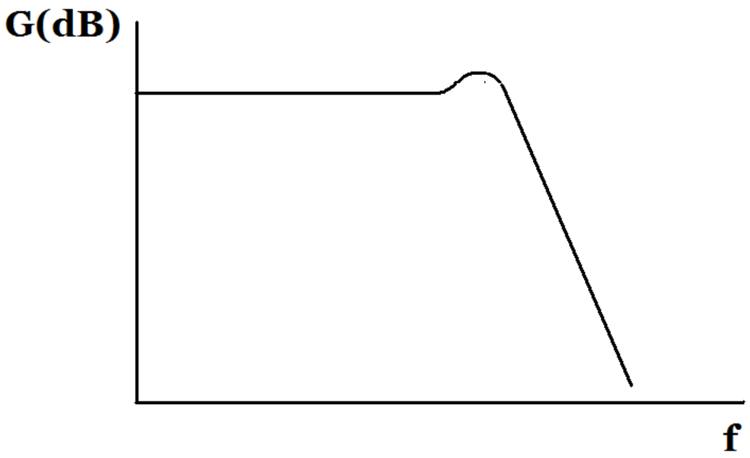
Tüm geçiren süzgeç

$$G(s) = \frac{s^2 - b_1 s + b_0}{s^2 + b_1 s + b_0} = H_5 . \frac{s^2 - \frac{\omega_P}{Q_P} s + \omega_P^{\,2}}{s^2 + \frac{\omega_P}{Q_P} s + \omega_P^{\,2}}$$

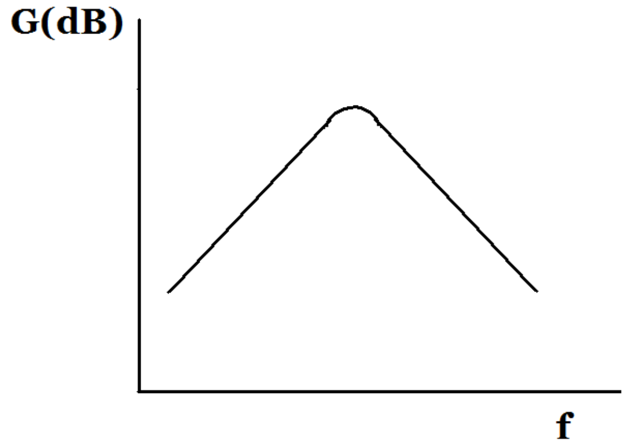
Çentik süzgeç

$$G(s) = H_4 . \frac{s^2 + \omega_Z{}^2}{s^2 + \frac{\omega_P}{Q_P} s + \omega_P{}^2}$$

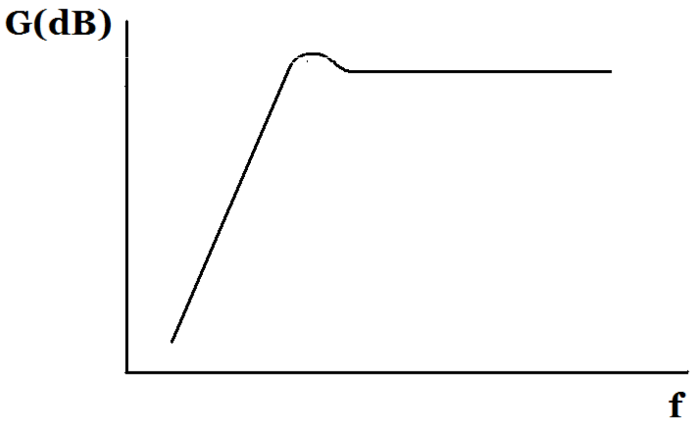
- Alçak geçiren çentik süzgeç $\omega_Z > \omega_P$
- Yüksek geçiren çentik süzgeç $\omega_P > \omega_Z$
- Bant söndüren süzgeç $\omega_P = \omega_Z$



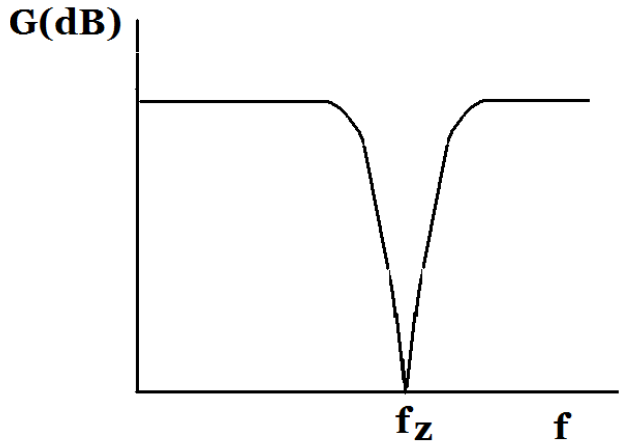
Alçak geçiren süzgeç



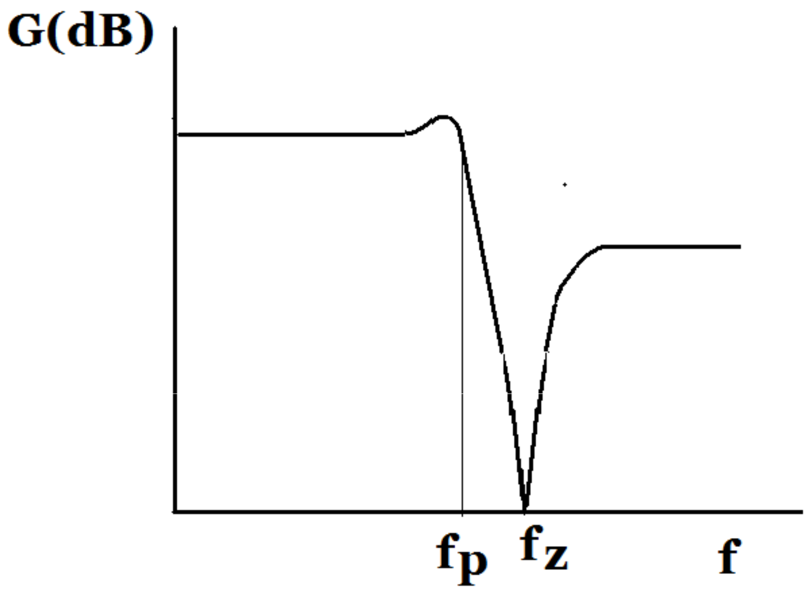
Band geçiren süzgeç



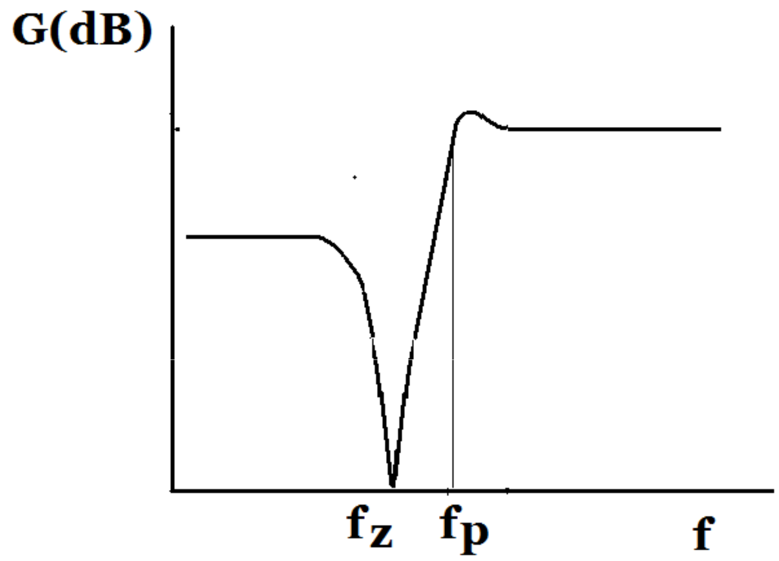
Yüksek geçiren süzgeç



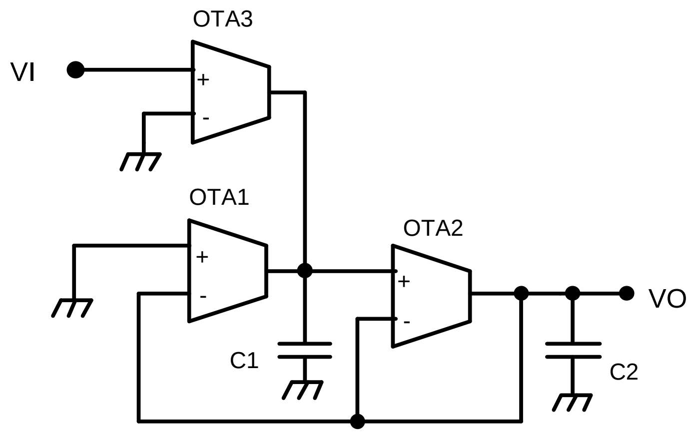
Bant söndüren süzgeç



Alçak geçiren çentik süzgeç $f_Z > f_P$



- Yüksek geçiren çentik süzgeç $f_P > f_Z$



alçak geçiren süzgeç: $a_0 \neq b_0$

$$\frac{a_0}{s^2 + b_1 s + b_0}$$

$$\frac{g_{m1}}{C_1} = \frac{b_0}{b_1}$$

$$\frac{g_{m3}}{C_1} = \frac{a_0}{b_1}$$

$$\frac{g_{m2}}{C_2} = b_1$$

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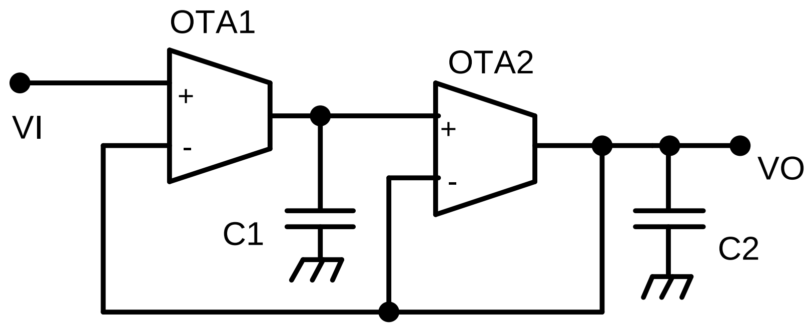
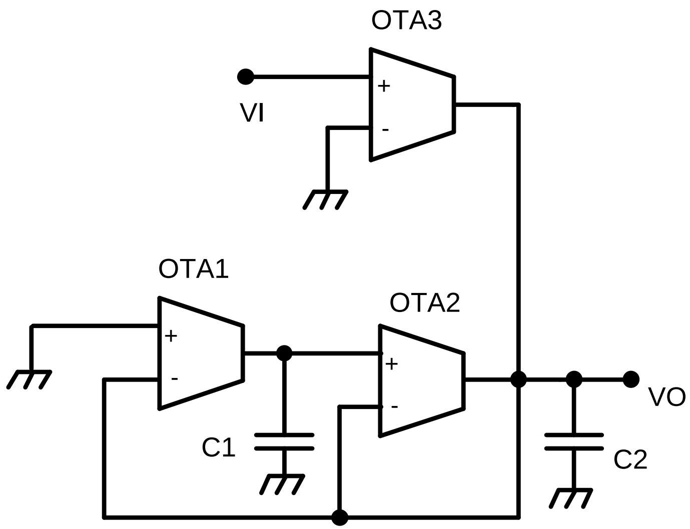


alçak geçiren süzgeç: $a_0 = b_0$

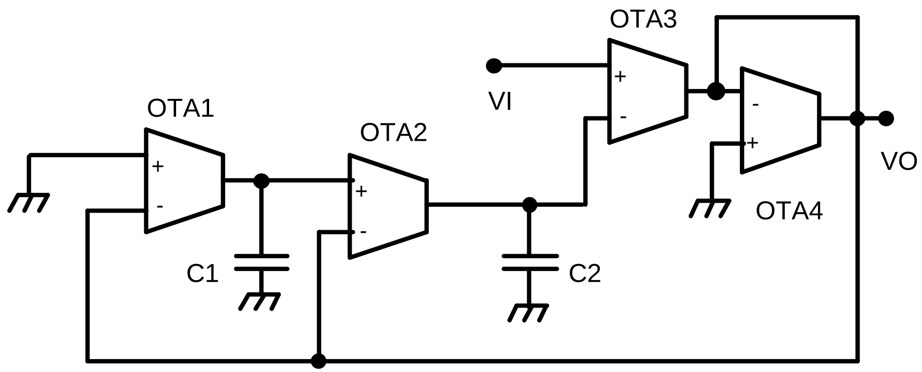
$$\frac{a_0}{s^2 + b_1 s + b_0} \qquad a_0 = b_0 \qquad \frac{g_{m1}}{C_1} = \frac{b_0}{b_1}$$

$$\frac{g_{m2}}{C_2} = b_1$$



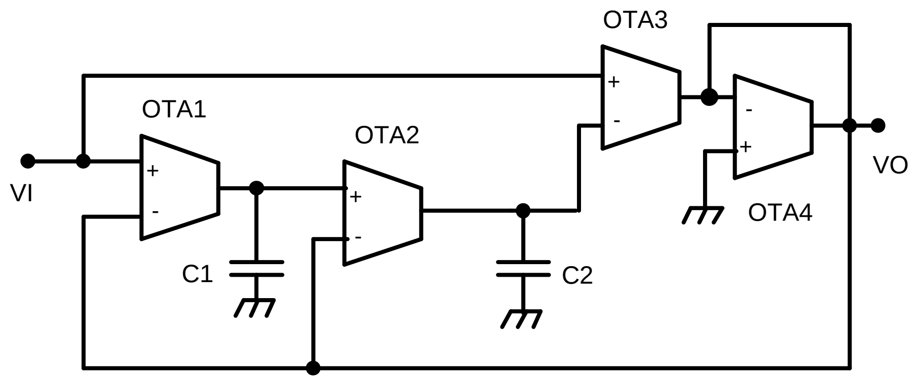
bant geçiren süzgeç

$$\frac{a_1 s}{s^2 + b_1 s + b_0} \qquad \frac{g_{m1}}{C_1} = \frac{b_0}{b_1} \qquad \frac{g_{m3}}{C_2} = a_1 \qquad \frac{g_{m2}}{C_2} = b_1$$



yüksek geçiren süzgeç

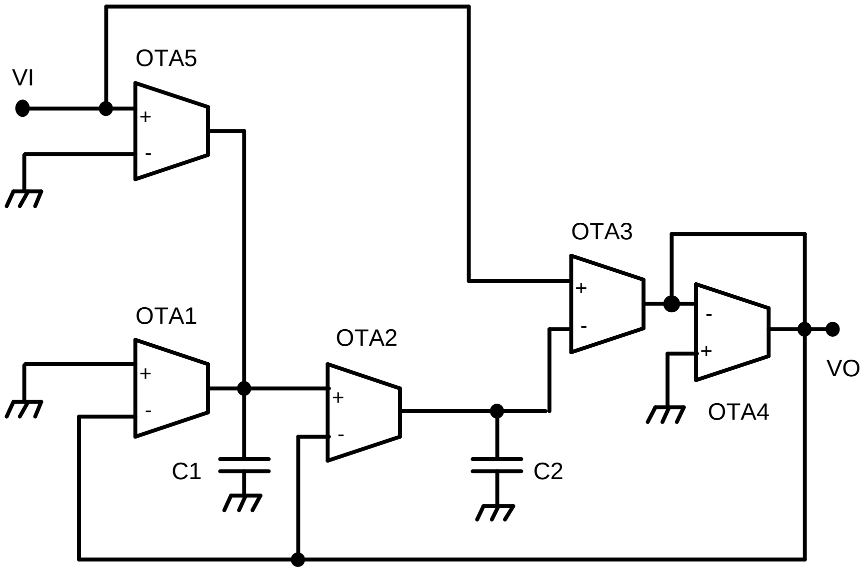
$$\frac{a_2 s^2}{s^2 + b_1 s + b_0} \qquad \frac{g_{m1}}{C_1} = \frac{b_0}{b_1} \qquad \frac{g_{m2}}{C_2} = \frac{b_1}{a_2} \qquad \frac{g_{m3}}{g_{m4}} = a_2$$



band söndüren süzgeç $a_0 = b_0$

$$\frac{a_2 s^2 + a_0}{s^2 + b_1 s + b_0} \quad \frac{g_{m1}}{C_1} = \frac{b_0}{b_1} \quad \frac{g_{m3}}{g_{m4}} = a_2 \quad \frac{g_{m2}}{C_2} = \frac{b_1}{a_2}$$

$$a_0 = b_0$$



Çentik (band söndüren) süzgeç $a_0 \neq b_0$

$$\frac{a_2 s^2 + a_0}{s^2 + b_1 s + b_0} \qquad \frac{g_{m1}}{C_1} = \frac{b_0}{b_1} \qquad \frac{g_{m2}}{C_2} = \frac{b_1}{a_2} \qquad \frac{g_{m5}}{C_1} = \frac{a_0}{b_1}$$

$$\frac{g_{m3}}{g_{m4}} = a_2$$

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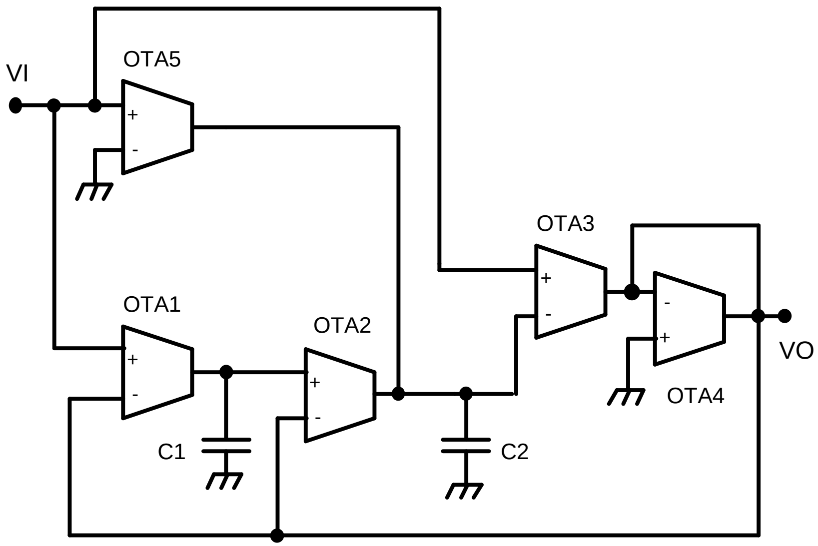

tümgeçiren süzgeç

$$\frac{s^2 - b_1 s + b_0}{s^2 + b_1 s + b_0} \qquad \frac{g_{m1}}{C_1} = \frac{b_0}{b_1} \qquad \frac{g_{m2}}{C_2} = \frac{b_1}{a_2}$$

$$\frac{g_{m5}}{C_2} = b_1 \qquad \frac{g_{m3}}{g_{m4}} = 1$$

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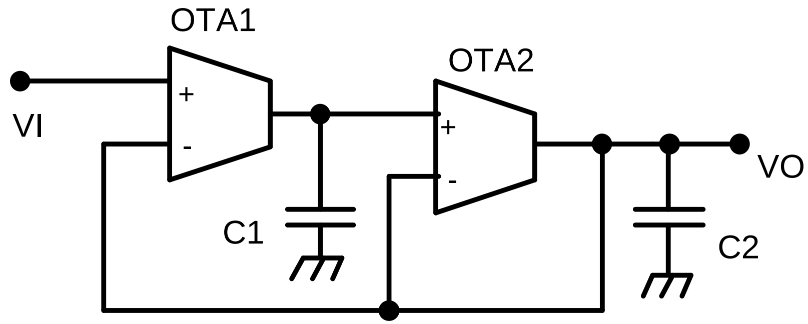
Örnek: 3MHz Butterworth alçak geçiren süzgeç, $a_0 = b_0$



$$b_0 = \omega_P{}^2$$

$$G(s) = \frac{b_0}{s^2 + b_1 s + b_0} = \frac{\omega_P{}^2}{s^2 + \frac{\omega_P}{Q_P} s + \omega_P{}^2}$$

$$b_1 = \frac{\omega_P}{Q_P}$$

$$a_0 = b_0 \qquad \frac{g_{m1}}{C_1} = \frac{b_0}{b_1} \qquad \frac{g_{m2}}{C_2} = b_1$$

Butterworth süzgeci için

$$Q_P = \frac{1}{\sqrt{2}} = 0.707$$

$$\omega_P = 2..\pi.f_P = 2 \;\, x \;\, \pi \;\, x \;\, 3 \;\, x \;\, 10^6$$

$$= 18.84x10^6 \, rad/sn$$

$$b_0 = \omega_P{}^2 \qquad\qquad b_1 = \frac{\omega_P}{Q_P} = \frac{g_{m2}}{C_2}$$

$$b_0 = \omega_P{}^2 = \frac{g_{m1}}{C_1}.b_1 = \frac{g_{m1}}{C_1}.\frac{g_{m2}}{C_2}$$

Butterworth süzgeci için

$$Q_P = \frac{1}{\sqrt{2}} = 0.707$$

$$\omega_P = 2..\pi.f_P = 2 \; x \; \pi \; x \; 3 \; x \; 10^6$$

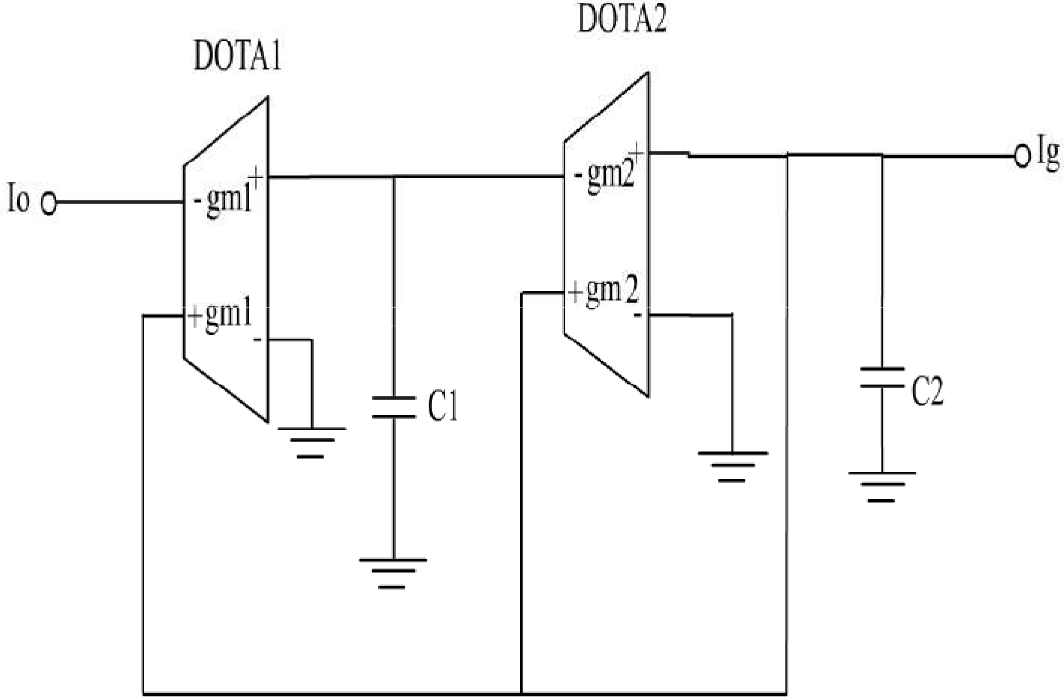
$$= 18.84 x 10^6 \, rad / sn$$

$g_{m1} = g_{m2} = 1,33$ mA/V

$C_1 = 100$ pF, $C_2 = 50$ pF

Akım Modlu DOTA-C aktif süzgeçleri

Akım Modlu Alçak Geçiren Süzgeç



$$H(s) = \frac{a_0}{s^2 + b_1 s + b_0}$$

$$\frac{g_{m1}}{C_1} = \frac{b_0}{b_1}, \qquad \frac{g_{m2}}{C_2} = b_1,$$

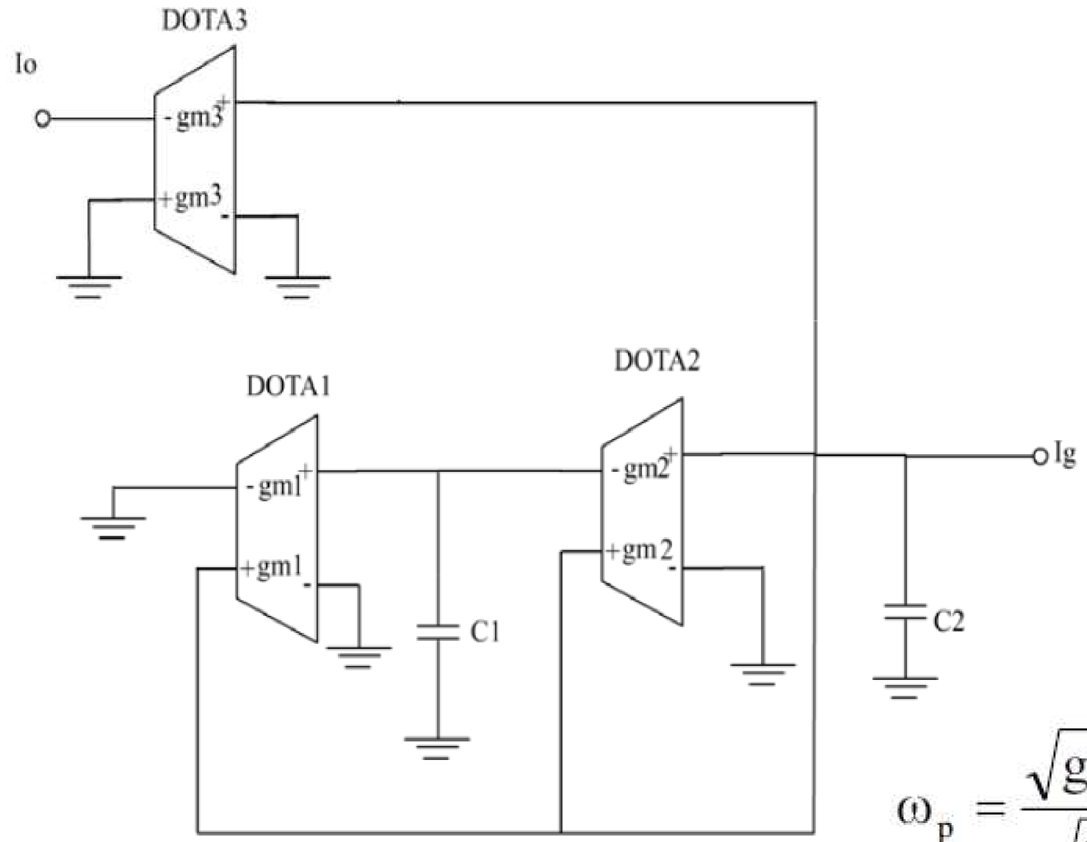
$$a_0 = b_0$$

$$b_1 = \frac{\omega_p}{Q_p} \qquad b_0 = \omega_p{}^2$$

$$\omega_p = \frac{\sqrt{g_{m1}} \cdot \sqrt{g_{m2}}}{\sqrt{C_1} \cdot \sqrt{C_2}} \qquad Q_p = \frac{\sqrt{g_{m1}} \cdot \sqrt{C_2}}{\sqrt{g_{m2}}\,\sqrt{C_1}}$$

Akım Modlu DOTA-C aktif süzgeçleri

Akım Modlu Band Geçiren Süzgeç:



$$H(s) = \frac{a_1 s}{s^2 + b_1 s + b_0}$$

$$\frac{g_{m1}}{C_1} = \frac{b_0}{b_1}, \qquad \frac{g_{m2}}{C_2} = b_1,$$

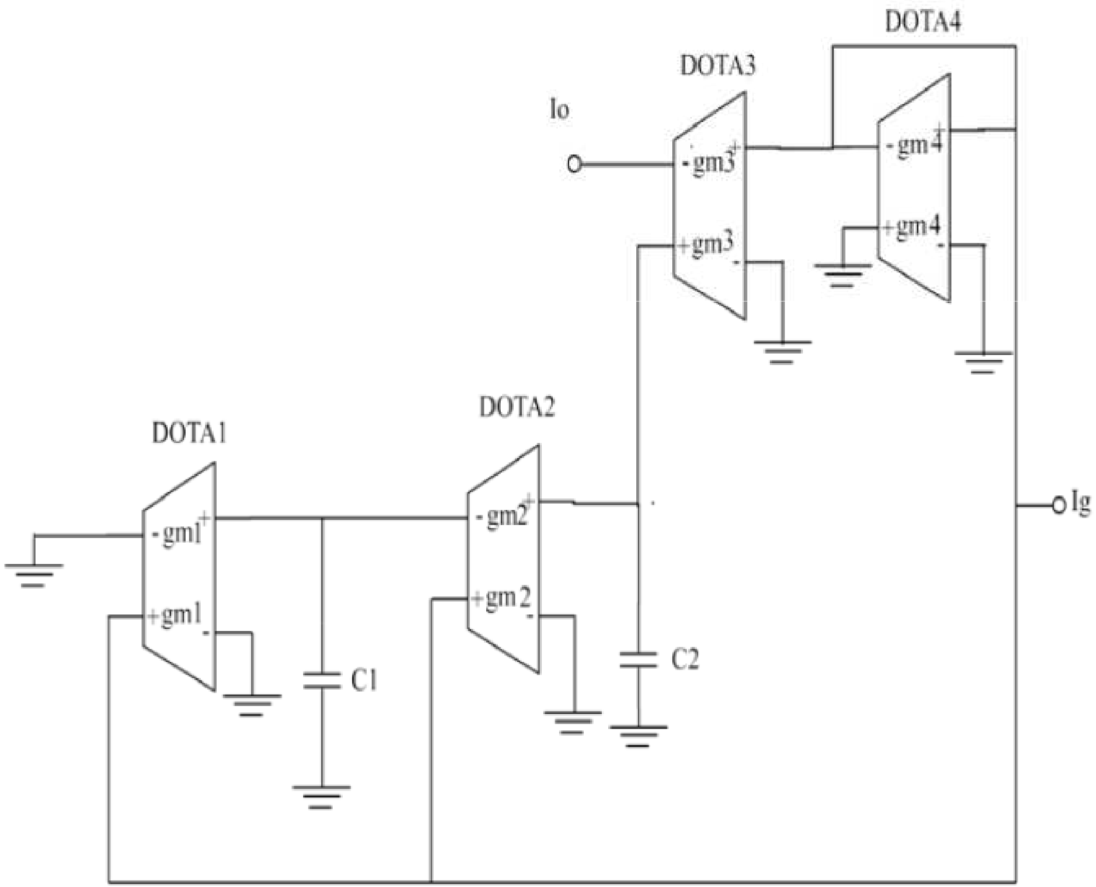
$$\frac{g_{m3}}{C_2} = a_1$$

$$b_1 = \frac{\omega_p}{Q_p} \qquad b_0 = \omega_p^{\ 2}$$

$$\omega_p = \frac{\sqrt{g_{m1}} \cdot \sqrt{g_{m2}}}{\sqrt{C_1} \cdot \sqrt{C_2}} \qquad Q_p = \frac{\sqrt{g_{m1}} \cdot \sqrt{C_2}}{\sqrt{g_{m2}}\sqrt{C_1}}$$

Akım Modlu DOTA-C aktif süzgeçleri

Akım Modlu Yüksek geçiren Süzgeç



$$H(s) = \frac{a_2 s^2}{s^2 + b_1 s + b_0}$$

$$\frac{g_{m1}}{C_1} = \frac{b_0}{b_1}, \qquad \frac{g_{m3}}{g_{m4}} = a_2,$$

$$\frac{g_{m2}}{C_2} = \frac{b_2}{a_2}$$

$$b_1 = \frac{\omega_p}{Q_p} \qquad b_0 = \omega_p{}^2$$

$$\omega_p = \frac{\sqrt{g_{m1}} \cdot \sqrt{g_{m2}}\sqrt{g_{m3}}}{\sqrt{C_1} \cdot \sqrt{C_2}\sqrt{g_{m4}}}$$

$$Q_p = \frac{\sqrt{g_{m1}}\sqrt{g_{m4}} \cdot \sqrt{C_2}}{\sqrt{g_{m2}}\sqrt{g_{m3}}\sqrt{C_1}}$$

OTA-C Osilatörleri

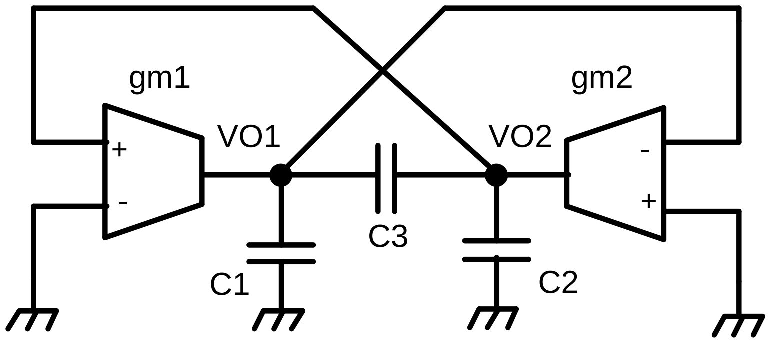
Devrelerin çalışması ikinci dereceden bir osilatör devresinin karakteristik denkleminin elde edilmesine dayanır. Bu karakteristik denklem

$$s^2 - b.s + \Omega_O^2 = 0$$

b=0 osilasyon koşulu, Ω_0 osilasyon açısal frekansı

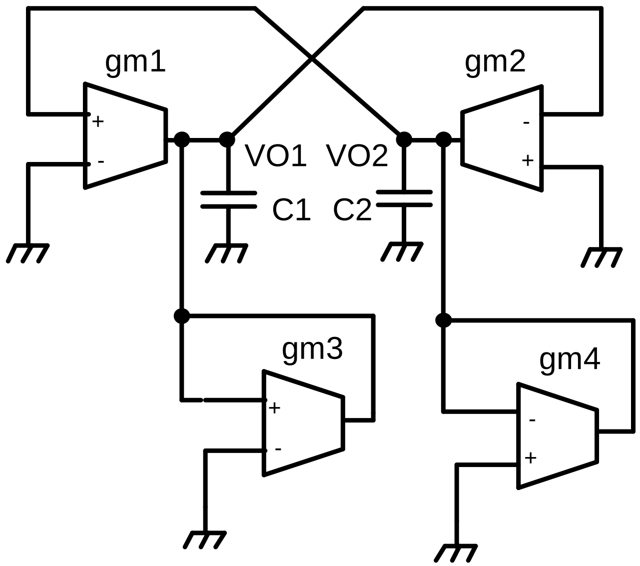
b ve Ω_0 büyüklükleri OTA ların geçiş iletkenliklerinin ve kapasitelerin fonksiyonu

OTA-C Osilatörleri



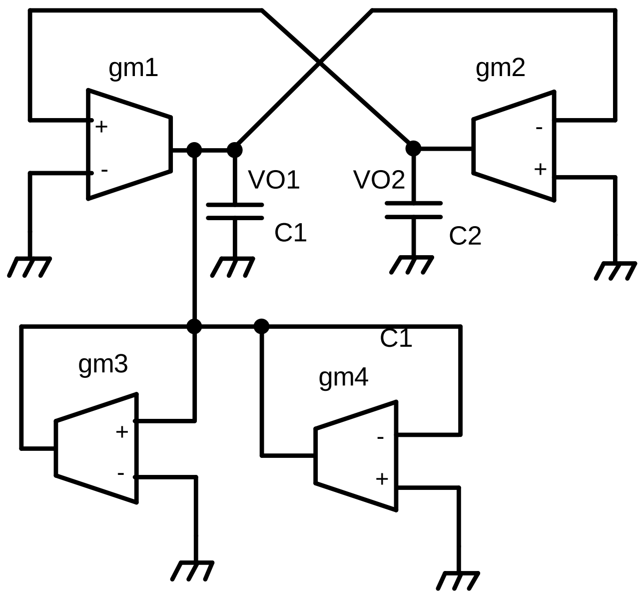
Devre	b	Ω_0^2
2OTA3C osilatörü	$\dfrac{(g_{m1}-g_{m2}).C_3}{(C_1+C_3)(C_2+C_3)-C_3^2}$	$\dfrac{g_{m1}.g_{m2}}{(C_1+C_3)(C_2+C_3)-C_3^2}$

OTA-C Osilatörleri



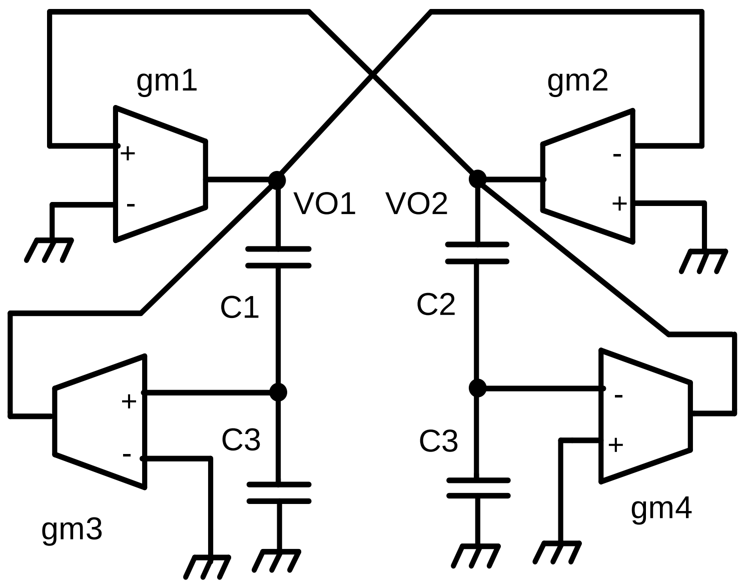
Devre	b	Ω_0^2
4OTA2CI osilatörü	$\dfrac{g_{m3}.C_2 - g_{m4}.C_1}{C_1.C_2}$	$\dfrac{g_{m1}.g_{m2} - g_{m3}.g_{m4}}{C_1.C_2}$

OTA-C Osilatörleri



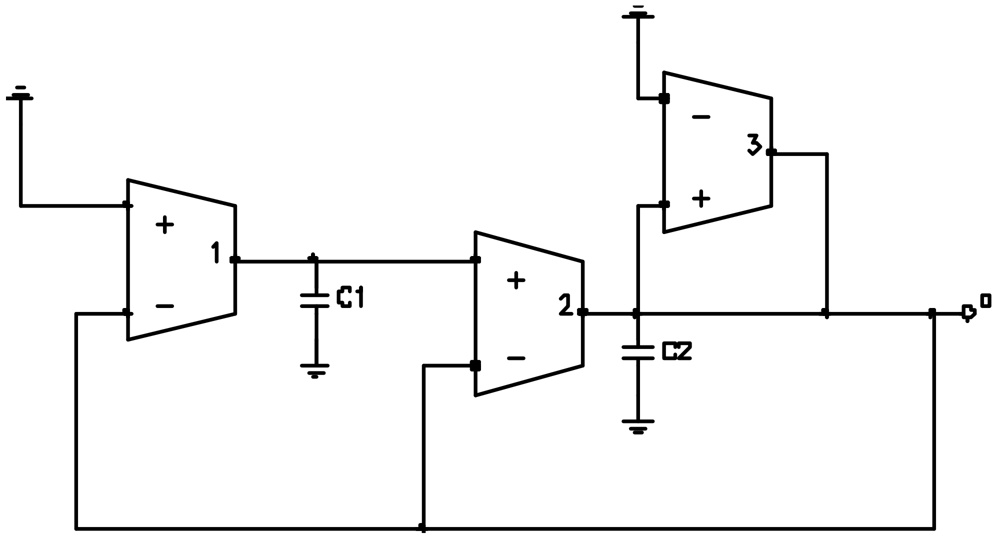
Devre	b	$\Omega_0{}^2$
4OTA2CII osilatörü	$\dfrac{(g_{m3} - g_{m4}).C_2}{C_1.C_2}$	$\dfrac{g_{m1} \cdot g_{m2}}{C_1.C_2}$

OTA-C Osilatörleri



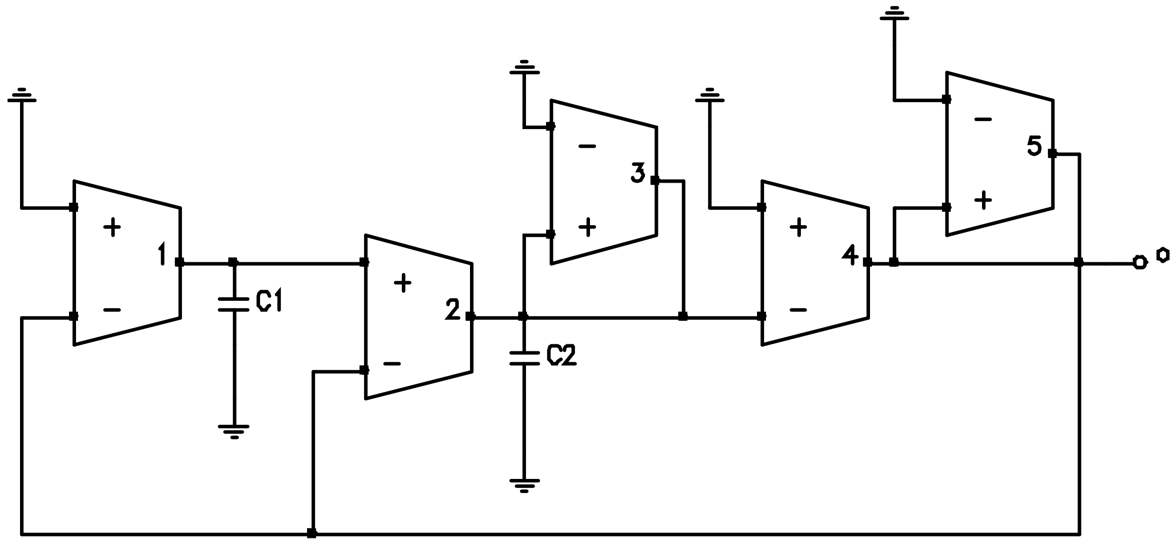
Devre	b	$\Omega_0{}^2$
4OTA4C osilatörü	$\dfrac{\left(g_{m3}-g_{m4}\right).\dfrac{C_1C_2C_3}{\left(C_1+C_3\right)\left(C_2+C_3\right)}}{C_1.C_2}$	$\dfrac{g_{m1}.g_{m2}\left(1+\dfrac{C_1}{C_3}\right).\left(1+\dfrac{C_2}{C_3}\right)-g_{m3}.g_{m4}\dfrac{C_1C_2}{C_3{}^2}}{C_1.C_2}$

OTA-C Osilatörleri

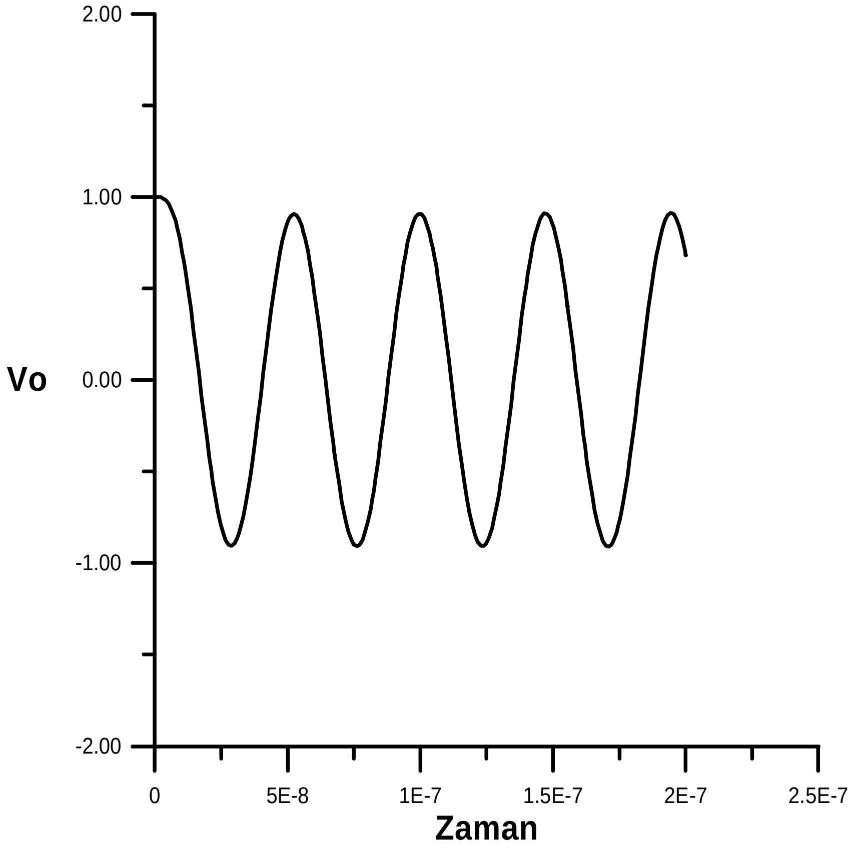


Devre	b	Ω_0^2
3OTA-2C	$\dfrac{g_{m2} - g_{m3}}{C_2}$	$\dfrac{g_{m1} \cdot g_{m2}}{C_1 . C_2}$

OTA-C Osilatörleri

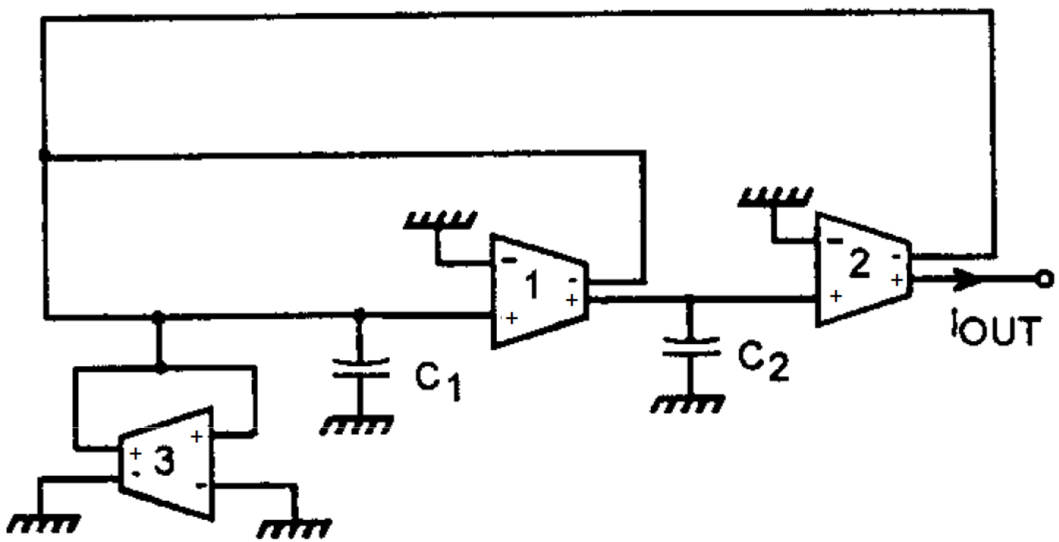


Devre	b	Ω_0^2
5OTA-2C	$\dfrac{\left(\dfrac{g_{m2}\cdot g_{m4}}{g_{m5}} - g_{m3}\right)}{C_2}$	$\dfrac{g_{m1}.g_{m2}.g_{m5}}{g_{m4}.C_1.C_2}$



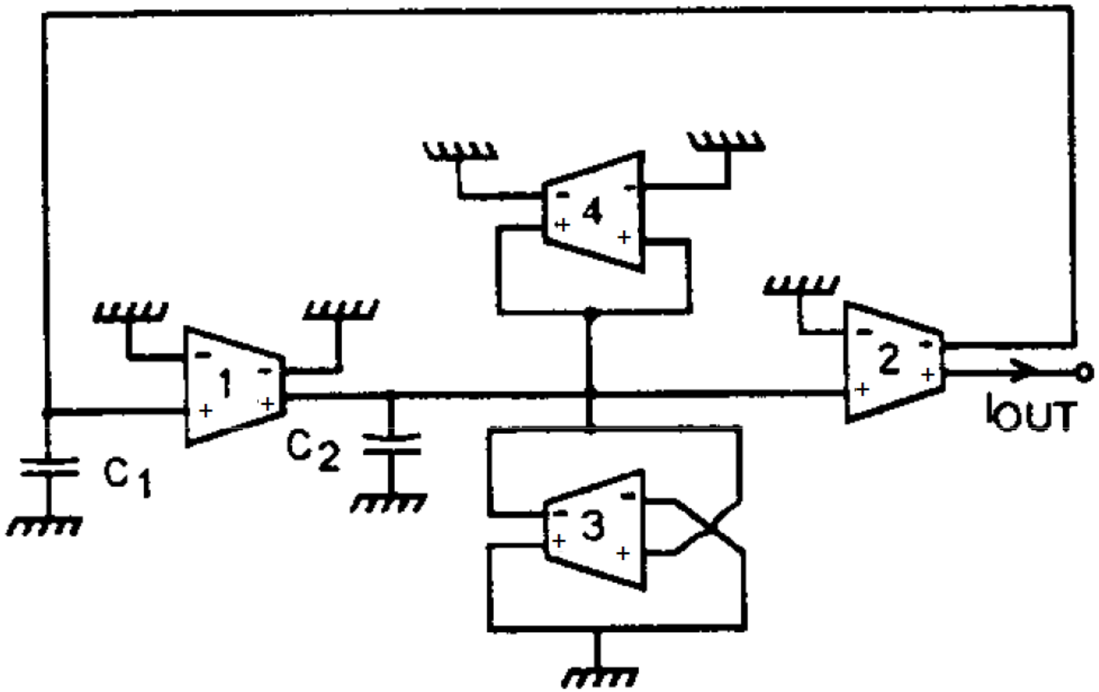
5OTA-2C devresi için elde edilen benzetim sonucu:
C_1=C_2=100pF, g_{m1}=1 mA/V, g_{m2}=1 mA/V,
g_{m3}=0.7 mA/V, g_{m4}=1 mA/V, g_{m5}=1 mA/V.

Akım Modlu DOTA-C Osilatörleri



Devre	b	Ω_0^2
3DOTA2C osilatörü	$\dfrac{g_{m1}-g_{m3}}{C_1}$	$\dfrac{g_{m1}\cdot g_{m2}}{C_1 C_2}$

Akım Modlu DOTA-C Osilatörleri



Devre	b	Ω_0^2
4DOTA2C osilatörü	$\frac{g_{m3} - g_{m4}}{C_2}$	$\frac{g_{m1} \cdot g_{m2}}{C_1 C_2}$