HW8-Low Pass Filter

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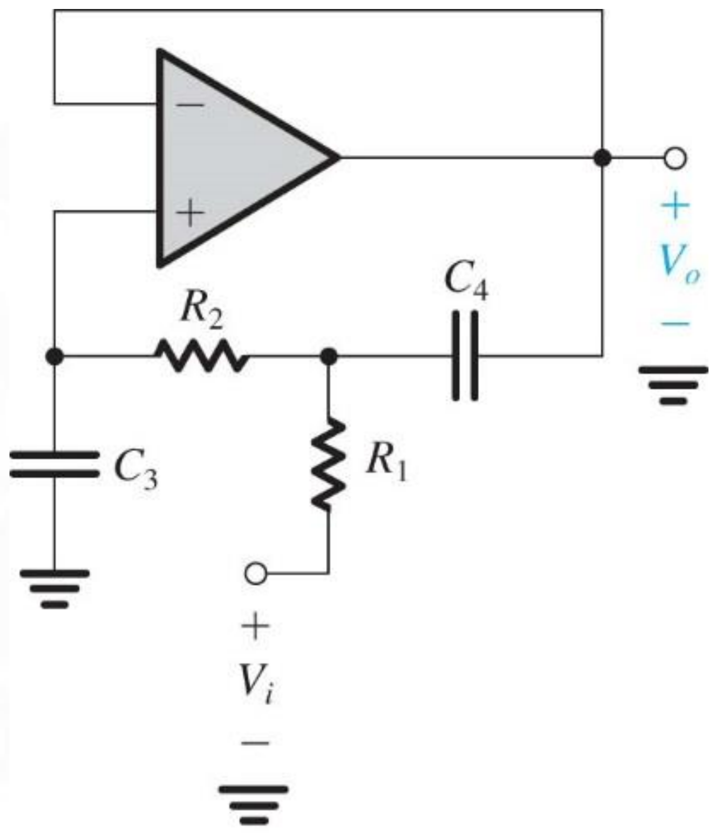
Low Pass Filter

- Vdd=1.8V



Generation of Equivalent Feedback Loops (Cont'd)

- If we apply the complementary transformation to the feedback loop in Fig. 13.34(a), we obtain the equivalent loop in Fig. 13.34(b). The new loop in Fig. 13.34(b) can be used to realize a low-pass function by injecting the input signal as shown in Fig. 13.34(c).

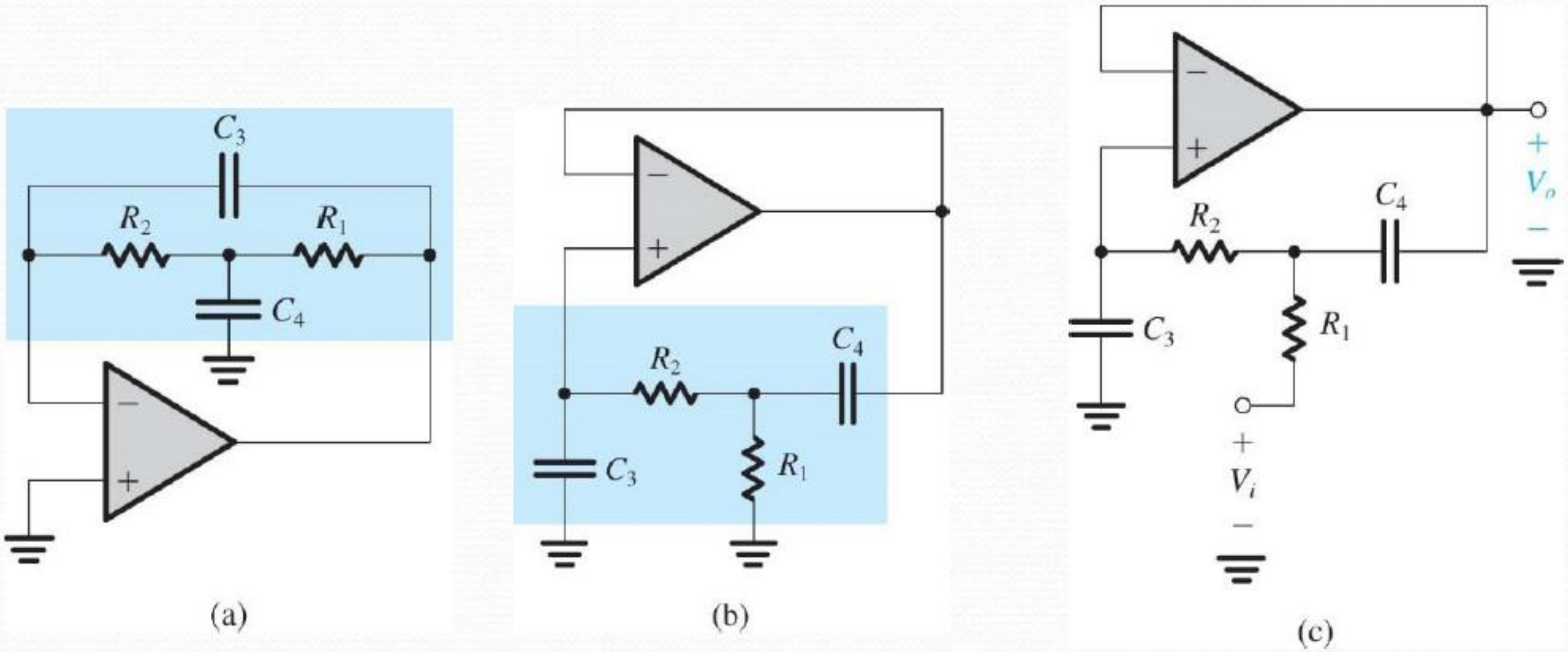
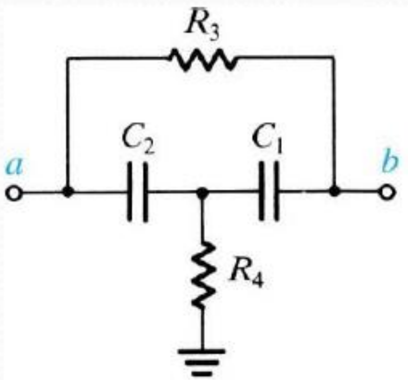


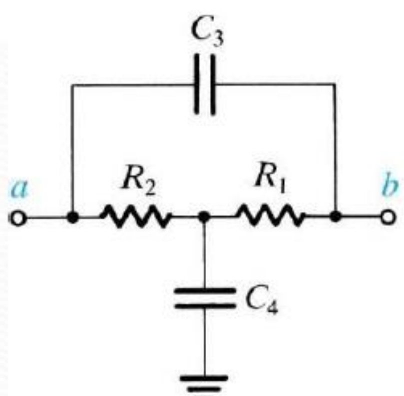
Figure 13.34 **(a)** Feedback loop obtained by placing the bridged-T network of Fig. 13.28(b) in the negative-feedback path of an op amp. **(b)** Equivalent feedback loop generated by applying the complementary transformation to the loop in **(a)**. **(c)** A low-pass filter obtained by injecting V_i through R_1 into the loop in **(b)**.

Synthesis of the Feedback Loop (Cont'd)

- Aims to have complex-conjugate transmission zeros.
- The simplest such networks are the bridged-T networks shown in Fig. 13.28 together with their transfer functions $t(s)$ from b to a, with a open-circuited.



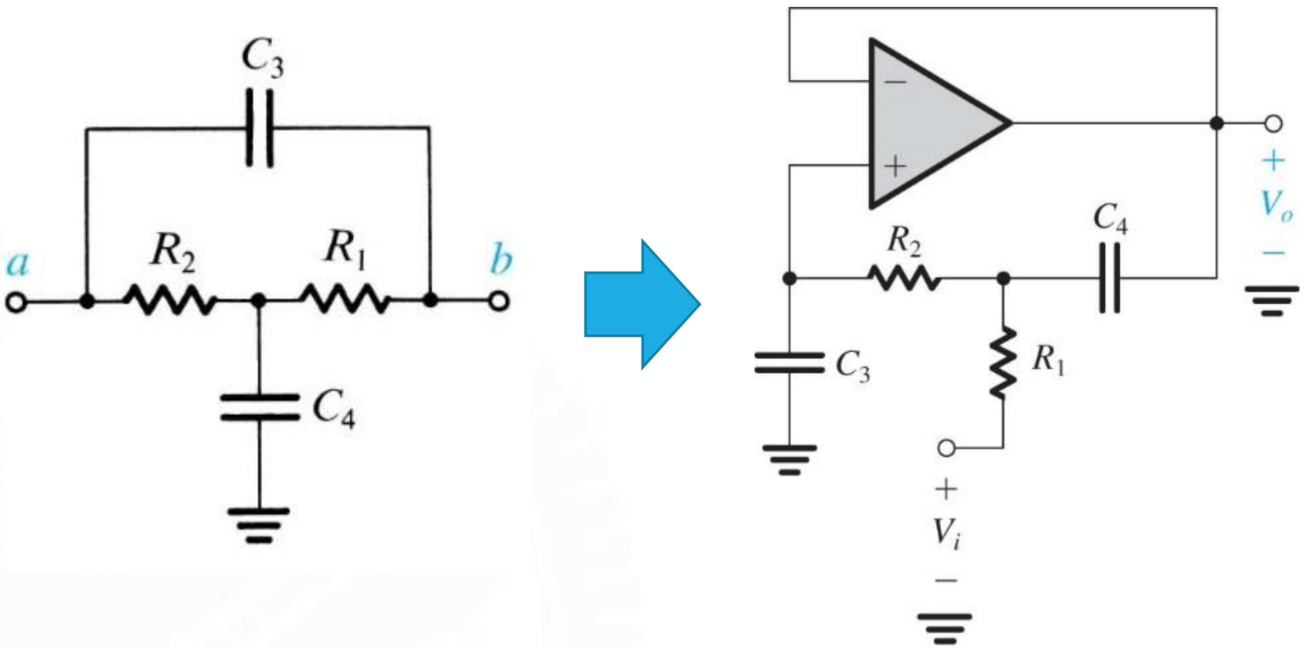
$$t(s) = \frac{s^2 + s\left(\frac{1}{C_1} + \frac{1}{C_2}\right)\frac{1}{R_3} + \frac{1}{C_1 C_2 R_3 R_4}}{s^2 + s\left(\frac{1}{C_1 R_3} + \frac{1}{C_2 R_3} + \frac{1}{C_1 R_4}\right) + \frac{1}{C_1 C_2 R_3 R_4}}$$



$$t(s) = \frac{s^2 + s\left(\frac{1}{R_1} + \frac{1}{R_2}\right)\frac{1}{C_4} + \frac{1}{C_3 C_4 R_1 R_2}}{s^2 + s\left(\frac{1}{C_4 R_1} + \frac{1}{C_4 R_2} + \frac{1}{C_3 R_2}\right) + \frac{1}{C_3 C_4 R_1 R_2}}$$

(b)

Low Pass Filter

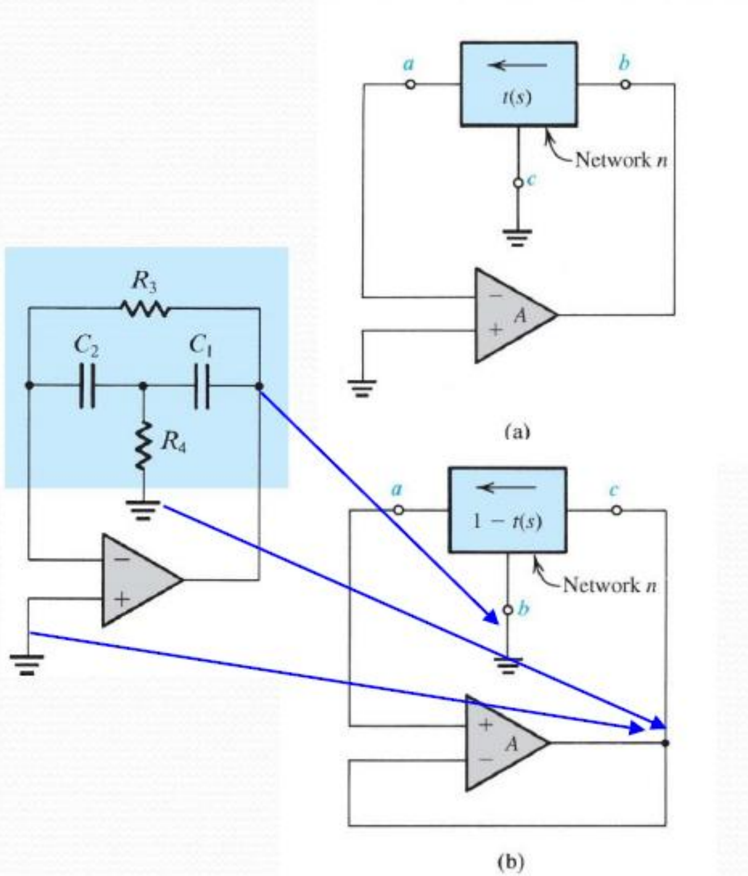


- Transfer function：

$$t(s)=\frac{s^2+s\left(\frac{1}{R_1}+\frac{1}{R_2}\right)\frac{1}{C_4}+\frac{1}{C_3C_4R_1R_2}}{s^2+s\left(\frac{1}{C_4R_1}+\frac{1}{C_4R_2}+\frac{1}{C_3R_2}\right)+\frac{1}{C_3C_4R_1R_2}}$$

Generation of Equivalent Feedback Loops(Cont'd)

- Application of the complementary transformation
- The design of the circuit in Fig. 13.33(b) is based on Eqs. (13.73) through (13.76): namely, $R_3 = R$, $R_4 = R/4Q^2$, $C_1 = C_2 = C$, $CR = 2Q/\omega_0$ and the value of C is arbitrarily chosen to be practically convenient --- a high-pass function.



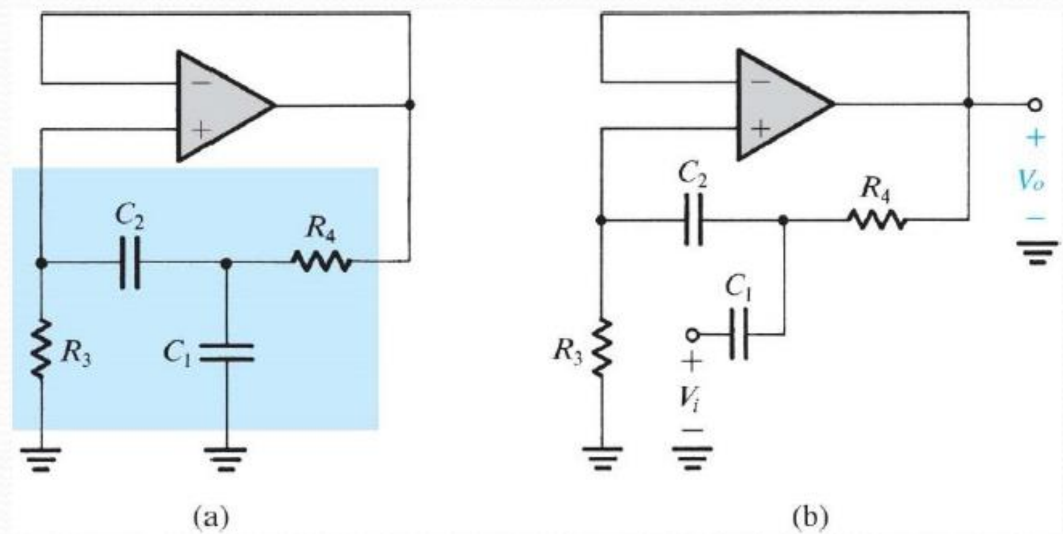


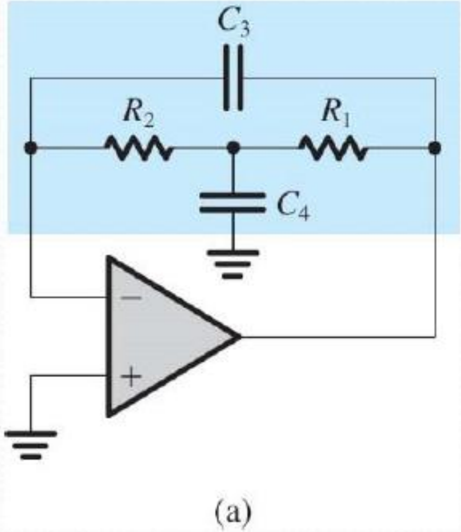
Figure 13.33 **(a)** Feedback loop obtained by applying the complementary transformation to the loop in Fig. 13.29. **(b)** Injecting the input signal through C_1 realizes the high-pass function. This is one of the **Sallenand-Key** family of circuits.

Generation of Equivalent Feedback Loops (Cont'd)

As another example, Fig. 13.34(a) shows the feedback loop generated by placing the two-port RC network of Fig. 13.28(b) in the negative-feedback path of an op amp. Using the expression for $t(s)$ given in Fig. 13.28(b), we can write for the active-filter poles

- $\omega_0 = 1/\sqrt{C_3C_4R_1R_2}$ (13.77)
- $Q = \left[\frac{\sqrt{C_3C_4R_1R_2}}{C_4}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)\right]^{-1}$ (13.78)

(the only different result from the previous in page 75)

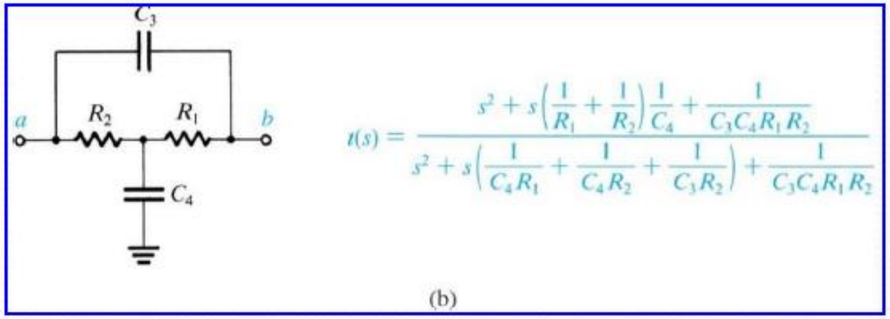


(a)

- Normally the design of this circuit is based on selecting $R_1 = R_2 = R$, $C_4 = C$, and $C_3 = C/m$. When substituted in Eqs. (13.77) and (13.78), these yield

  - $m = 4Q^2$ (13.79)
  - $CR = 2Q/\omega_0$ (13.80)

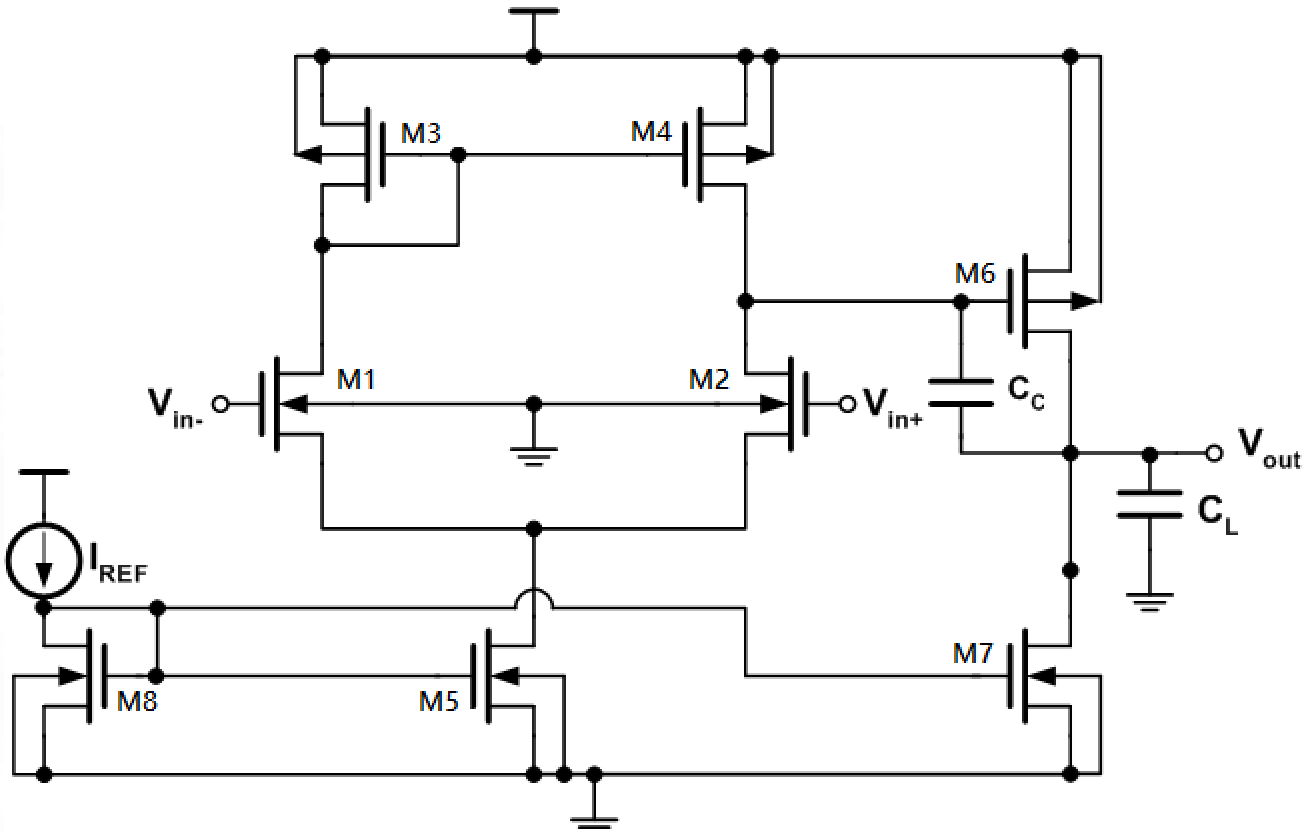
  with the remaining degree of freedom (the value of C or R) left to the designer to choose.



(b)

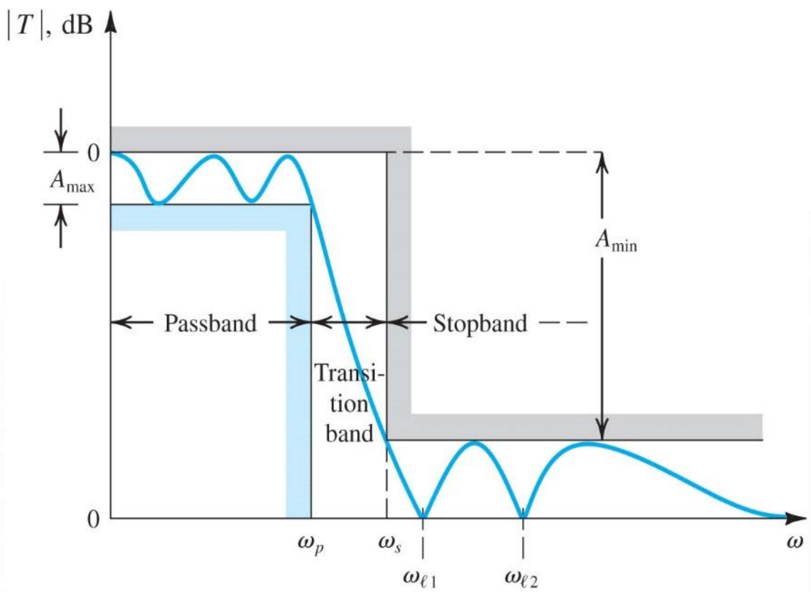
Two stage opamp

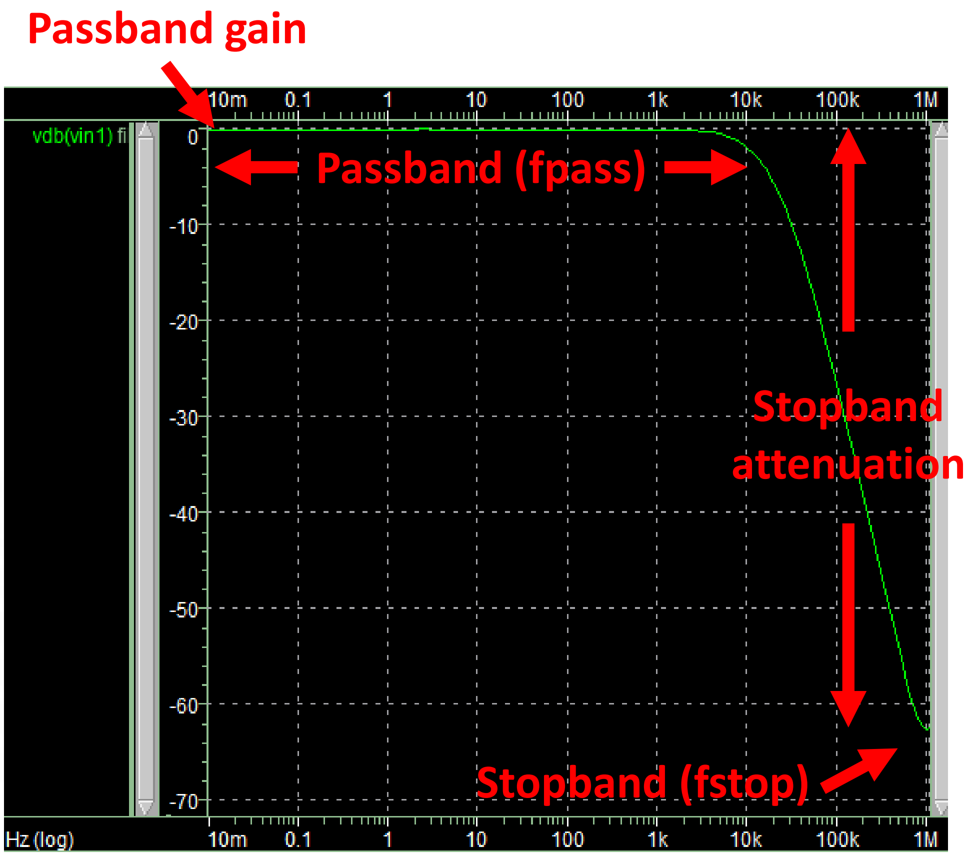
- Vdd=1.8V, Vin+=Vin-=0.9V



Simulation Result

- Frequency response



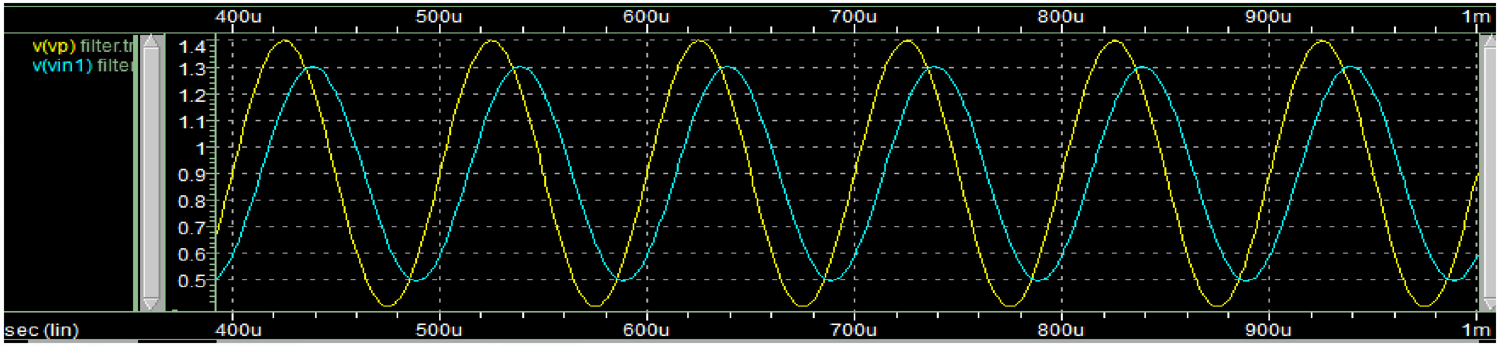


Simulation Result

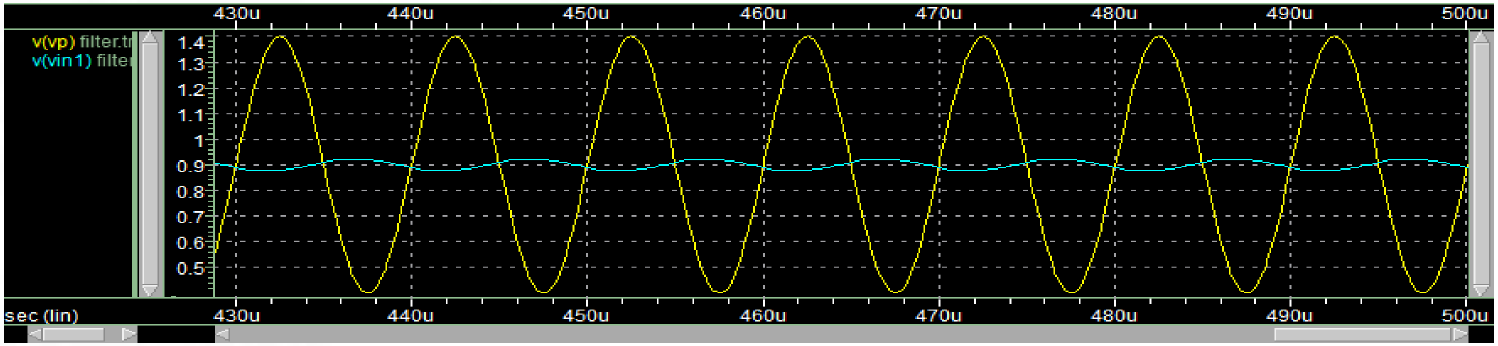
- Transient analysis

Input→1kHz

Input→10kHz



Input→100kHz



Design Specification

Parameter	Value
Power supply VDD	1.8V
Passband (fpass)	0-10kHz
Passband gain	0dB
Stopband (fstop)	100kHz
Stopband attenuation	40dB

- 作業上傳到E3, 繳交以下檔案 ,檔名: hw8 _學號
  - 報告（.pdf） (ex:hw8_0560030.pdf)
    1. 每個規格需符合,並附上模擬結果圖
       - AC analysis (output frequency response)
       - Transient analysis (with 1kHz, 10kHz, 100kHz of 1Vpp sine wave input)
    2. 解釋設計方法
  - Spice file（.sp）(ex:hw8_0560030.sp)
- Deadline:12/25
- 12/25以後繳交作業,遲交一個禮拜分數-10%,兩個禮拜-20%,以此類推分數

END