SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECB202 – LINEAR INTEGERATED CIRCUITS

II YEAR/ III SEMESTER

UNIT 1 – **OP AMP CHARACTERISTICS**

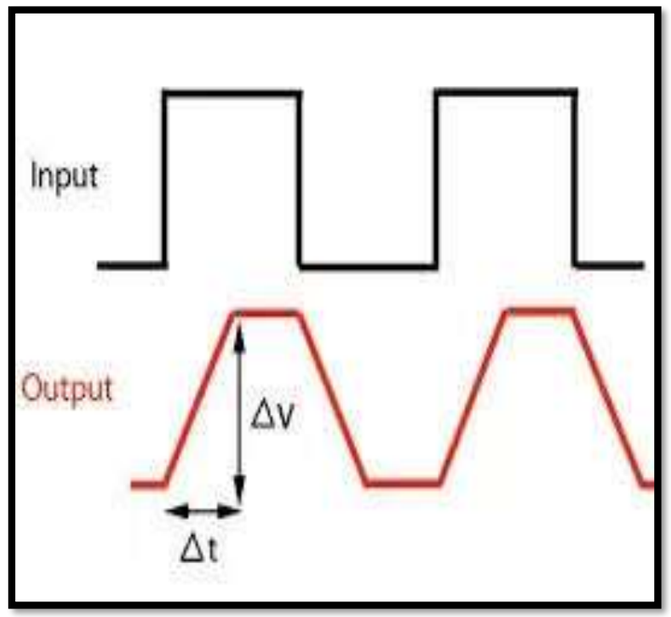
TOPIC 1- 8- Slew Rate & Frequency Compensation of Op Amp

Slew rate

- The slew rate is defined as the maximum rate of change of output voltage caused by a step input voltage.,

  Specified in V/μs

  eg : 1V/micro sec. slew rate denotes the output rises or falls by 1 volts in 1 micro seconds



- The rate at which the voltage across the capacitor dVc/dt is given by

  dVc/dt = I/C , Slew rate SR dVc/dt|max= Imax/ C

- For IC741, Imax= 15 micro amps, C= 30 Pico farad

  Slew rate = 0.5V/ micro sec

Frequency Compensation of Op Amp

- The major challenge is to improve the stability of an op-amp in a wide bandwidth of applications

- The solution is to compensate the amplifier in terms of frequency response, by using a frequency compensation circuit across the operational amplifier

- The stability of an amplifier is highly dependent on different parameters

Frequency Compensation of Op Amp

Types of Op-Amp Frequency Compensation

- External Frequency Compensation in Op Amp
  1. Dominant pole Compensation
  2. Miller compensation

- Internal Frequency Compensation in Op Amp

External Frequency Compensation in Op Amp

- External compensation techniques vary depending on the application, type of amplifier used and many other things
- The easiest way is to use out-of loop compensation technique or in-loop compensation technique
- Out of the loop compensation technique uses a simple resistor to isolate the capacitive load with the op-amp, lowering the capacitive loading of the op-amp
- The resistor typically varies from 10-50 Ohms but the increase in isolated resistor effects the op-amp bandwidth
- The bandwidth of the op-amp drastically reduced to a very low value. One of the popular ways of out of the loop frequency compensation techniques is to use Dominant pole compensation technique

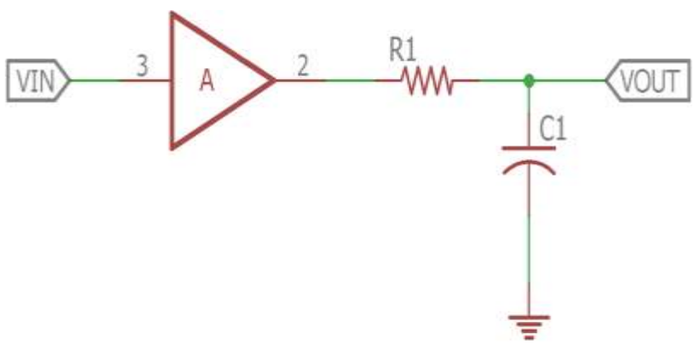
Dominant pole Compensation

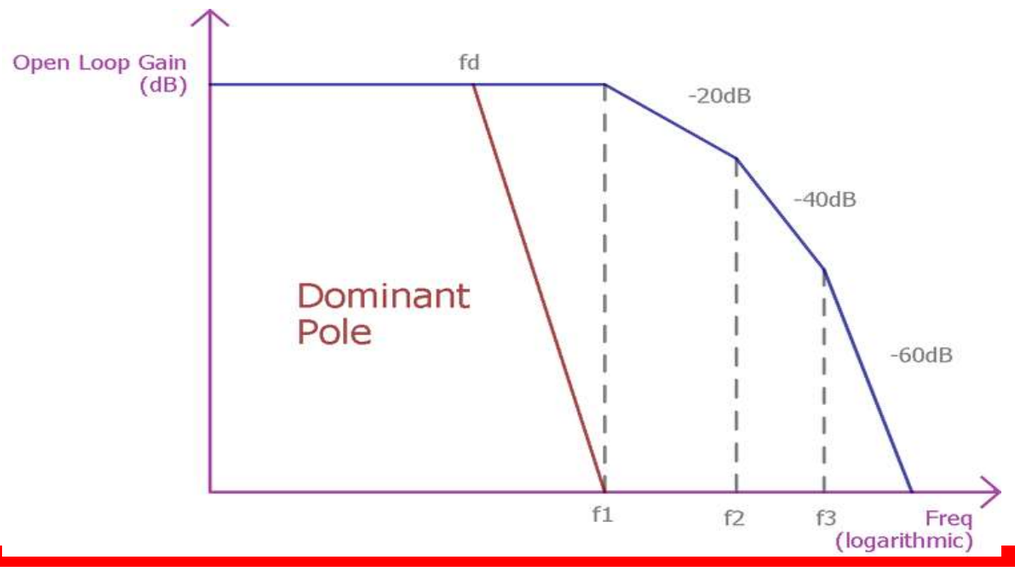
- This technique uses a simple **RC network** connected across the output of the operational amplifier circuit
- This works great to overcome the instability issue
- The RC network creates a pole at unity or 0dB gain that dominates or cancels out other high-frequency poles effect
- The transfer function of the dominant pole configuration

$$A(s) = \frac{A \times \omega1 \times \omega2 \times \omega3}{(s+\omega1) \times (s+\omega2) \times (s+\omega3)}$$

Where,

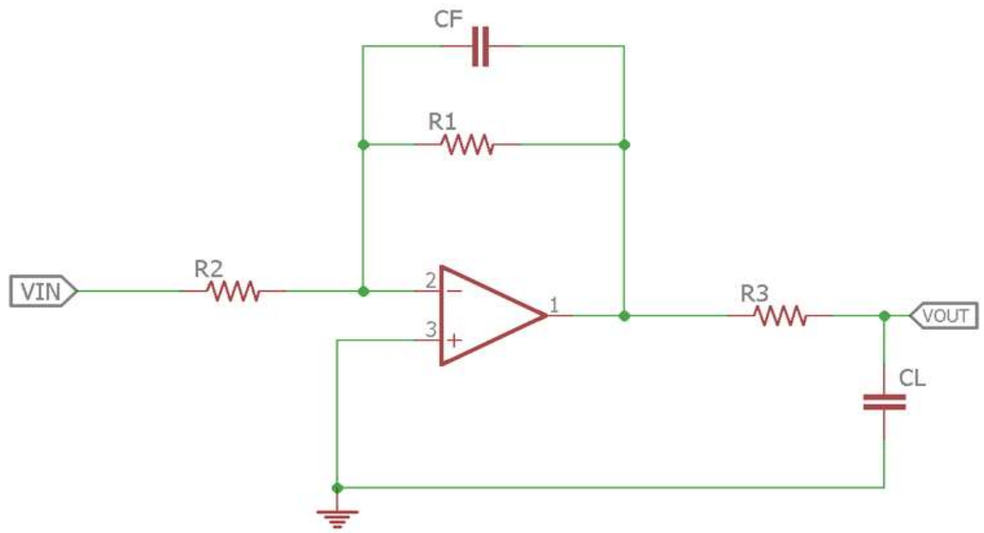
- A(s)is the uncompensated transfer function
- A is the open-loop gain
- ώ1,ώ2, and ώ3 are the frequencies where the gain roll-off at -20dB, -40dB, -60dB respectively
- The **Bode plot** below shows what happens if the dominant pole compensation technique is added across the op-amp output
- where fd is the **dominant pole frequency**.





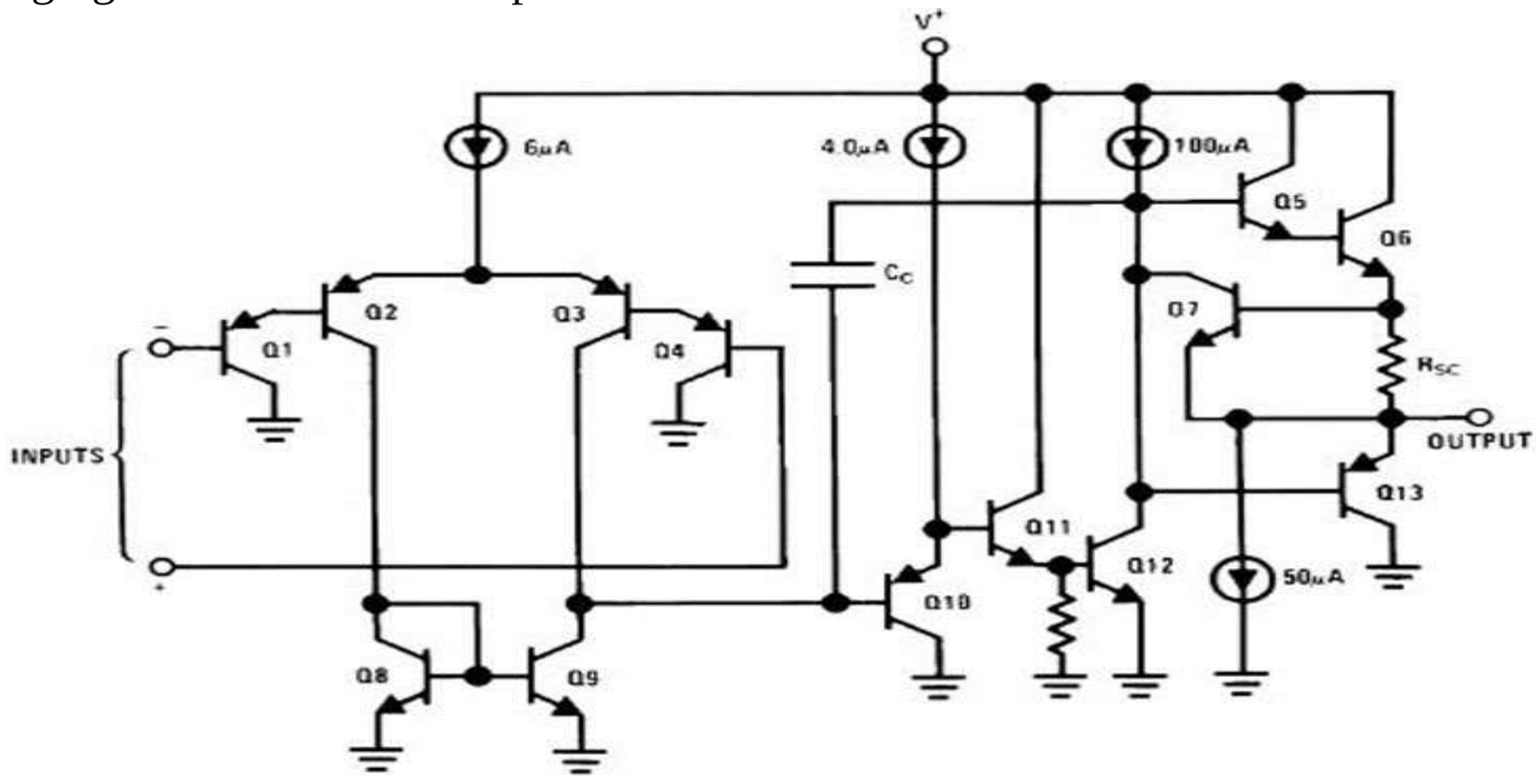
Miller compensation

- Another effective compensation technique is the miller compensation technique and it is an in-loop compensation technique where a simple capacitor is used with or without load isolation resistor (Nulling resistor)
- a capacitor is connected in the feedback loop to compensate the op-amp frequency response
- also , a capacitor is connected to the feedback with a resistor across the output
- The circuit is a simple negative feedback amplifier with inverting gain dependent on R1 and R2
- The R3 is the null resistor and the CL is the capacitive load across the op-amp output
- CF is the feedback capacitor which is used for the compensation purposes
- The Capacitor and the resistor value depend on the type of amplifier stages, pole compensation, and the capacitive load



Internal Frequency Compensation Techniques

- Modern operational amplifiers have internal compensation technique
- In the internal compensation technique, a small feedback capacitor is connected inside of the op-amp IC between the second stages Common emitter transistor
- For example, the below image is the internal diagram of popular op-amp LM358
- The Cc capacitor is connected across the Q5 and Q10. It is the compensation Capacitor (Cc)
- This compensation capacitor improves the stability of the amplifier and as well as prevent the oscillation and ringing effect across the output



THANK YOU