Prob. Tutorial problems

① Determine the output voltage in each of the following cases for the open-loop D.A shown in Fig.

(a) $V_{in_1} = 5\mu V$ dc $V_{in_2} = -7\mu V$ dc

(b) $V_{in_1} = 10mV$ rms $V_{in_2} = 20mV$ rms.

The op-amp is a 741 with the following specifications $A = 200000$ $R_i = 2M\Omega$. $R_o = 75\Omega$ $+V_{cc} = +15V$ $-V_{EE} = -15V$ and output voltage swing $= \pm 14V$.

(a) $V_o = 200000\left[5\times10^{-6} + 7\times10^{-6}\right] = 2.4$ V dc.

Assume that output offset voltage is zero.

(b) $V_o = 200000\left[10\times10^{-3} - 20\times10^{-3}\right]$

$= -2000$ V rms.

The theoritical value of out voltage is $V_o = -2000$ V rms. The op-amp saturates at ± 14 V. The actual o/p is clipped as shown in Fig. This non sinusoidal waveform is unacceptable in amplifier applications.

② For the µA 741 op-amp PSRR = 70dB min what is the numerical value of PSRR.

$$PSRR = 20\log\frac{\Delta V_{io}}{\Delta V_e} = 70$$

$$\frac{\Delta V_{io}}{\Delta V} = ? \quad \text{Antilog}(3.5).$$

③ The output voltage of a certain op-amp ckt changes by 20V in 4 μsec. What is its slew rate.

$$SR = \frac{20}{4} V/\mu sec = 5V/\mu sec$$

④ For the 741C op-amp, the supply voltage rejection ratio is 150 μV/V. Cal the change in this op-amp's o/p offset voltage V_{io} if the supply voltages varies from ±10V to ±12V.

$$150 = \frac{\Delta V_{io}}{2}$$

$$\Delta V_{io} = 300 \mu V.$$

⑤ The 714C op-amp is used in a particular application. The change in the op-amps input offset voltage V_{io} caused by variations in the supply voltages is 60 μV. Determine the change in the supply voltages. Assume that SVRR for 714C is 104 dB.

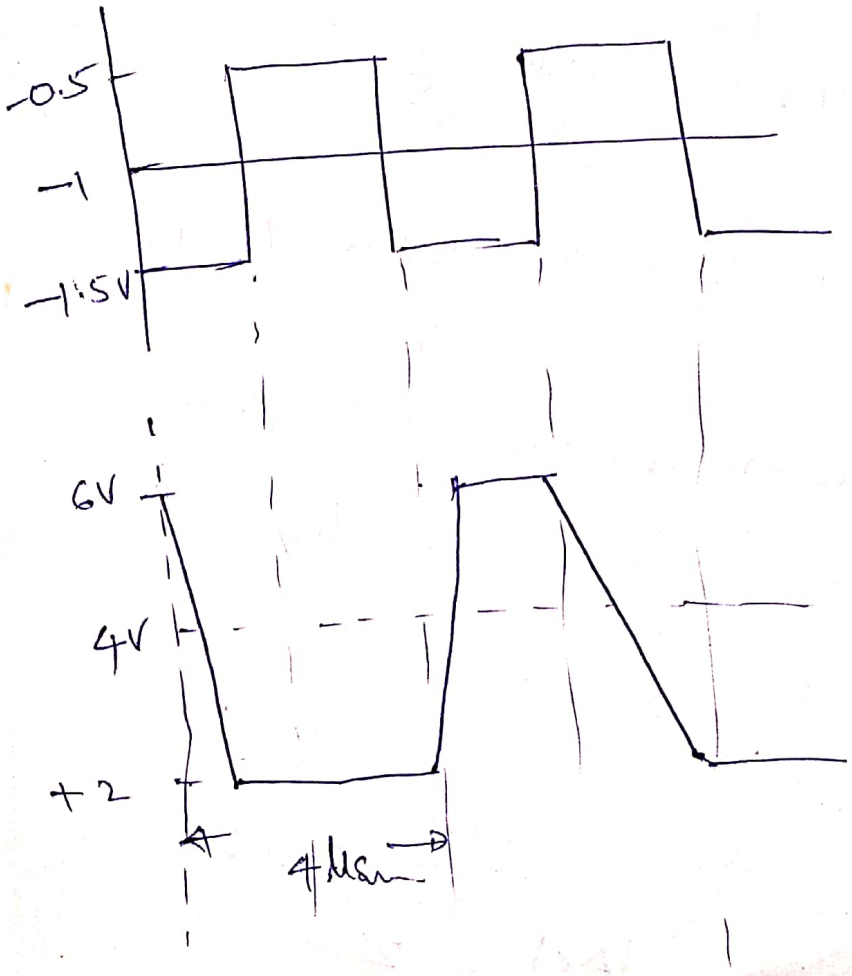
Tutorial problems

⑥ An op-amp with a slew rate of 10V/μsec is used as an inverting amplifier with a gain −4. It has a 250 kHz square wave as the i/p with an amplitude of 0.5 V_p and −1 V dc average voltage.

(a) Find the time t it takes to reach max output voltage.

(b) Draw the o/p waveform.

(a) $t = \frac{\Delta V}{S} = \frac{4\,V_{p\text{-}p}}{10\,V/\mu sec} = 0.4\,\mu sec$



(7) The o/p voltages of an op-amp are $v_1 = 1005\ \mu V$ $v_2 = 995\ \mu V$. The op-amp parameters are CMRR = 100 dB, $A_d = A_0 = 2 \times 10^5$. Determine the

(a) The differential voltage v_d

(b) The common-mode voltage v_c

(c) $|A_c|$ and

(d) The o/p voltage.

Soln: $20 \log CMRR = 100\ dB$.

$$\log CMRR = 5.$$

$$CMRR = \frac{A_d}{A_c} = 10^5$$

(a) $v_d = v_1 - v_2 = 1005\ \mu V - 995\ \mu V$

$= 10\ \mu V$.

(b) The common mode voltage is.

$$v_c = \frac{v_1 + v_2}{2} = 1000\ \mu V.$$

(c) $$\left| \frac{A_d}{A_c} \right| = 10^5$$

$$A_c = \frac{A_d}{10^5} = \frac{2 \times 10^5}{10^5} = \pm 2$$

$$|A_c| = 2$$

(d) The output voltage

$$V_o = A_d V_d + A_c V_c$$

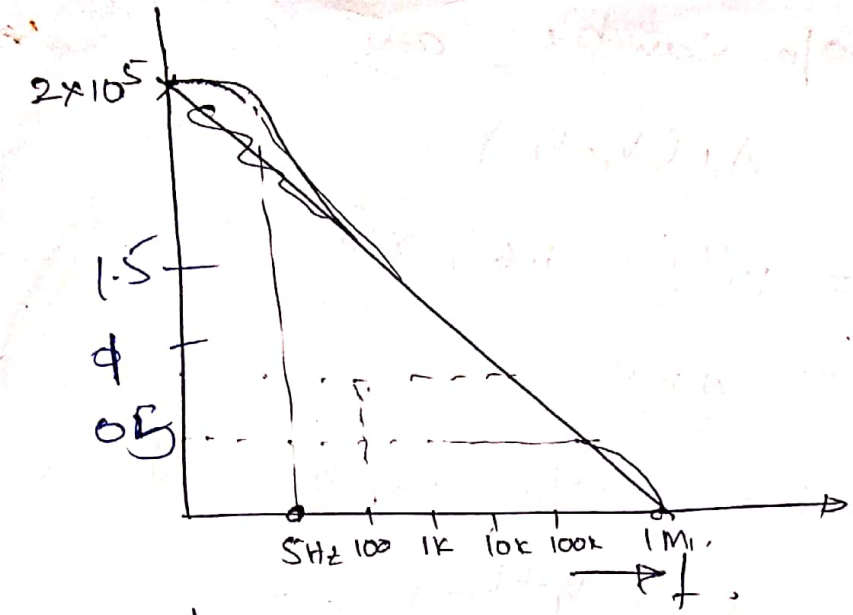
$$= 2\times10^5 \times 10\,\mu V \pm 2 \times 995\,\mu V$$

$$= 2.002\,V = 1.998\,V$$

(8) Determine the closed loop o/p resistance at the noninverting terminal of a NI amplifier with $A_{OL} = 10^5$, $R_c = 10\,k\Omega$, $R_f = 10k\Omega$

$$R_{if} = \frac{R_i(1+A_{OL})}{1+R_f/R_1} = \frac{10^4(1+10^5)}{2}$$

$$= 450\,M\Omega.$$



Probs.

(1) An op-amp has a differential gain of 80dB and CMRR of 95dB. If $V_1 = 2\mu V$ and $V_2 = 1.6\mu V$, the cal the differential and common mode output values.

$A_d = 80dB$ and $CMRR = 95dB$.

A_d in dB $= 20 \log A_d$.

$80 = 20 \log A_d$

$A_d = \text{Antilog } 4$

$= 10^4$.

CMRR in dB $= 20 \log CMRR$.

$95 = 20 \log CMRR$

$CMRR = \text{Antilog } \frac{9.5}{20}$

$= \text{Antilog } 4.75$.

$= 10^{4.75}$.

$= 5.6234 \times 10^4$

Differential o/p can be cal as.

$$V_d = A_d (V_1 - V_2)$$

$$= 10^4 (2 - 1.6) \times 10^{-6}.$$

$$= 4mV.$$

And Common mode o/p can be cal as

$$V_c = A_c \left(\frac{V_1 + V_2}{2} \right),$$

$$CMRR = \frac{A_d}{A_c}.$$

$$A_c = 0.1778.$$

$$V_c = 0.1778 \left(\frac{2+1.6}{2} \right) \times 10^{-6}$$

$$= 0.32 \mu V.$$

(2) An op-amp has 7KHz sine wave o/p signal. Find the largest amplitude that the o/p of the amp can have without distortion with I_{CQ} of 8MA and C of 27pF

$$S = \frac{I}{C} = \frac{8 \times 10^{-6}}{27 \times 10^{-12}} = 0.2962 \text{ V/}\mu\text{s}.$$

$$f_m = \frac{S}{2\pi V_m} = 7KHz.$$

$$V_m = \frac{0.2962 \times 10^6}{2\pi \times 7 \times 10^3} = 6.736 \text{ V}.$$

A Square wave of peak to peak amplitude of 750 mV has to be amplified to a p-p amplitude of 3.8 V, with a rise time of 4.5 μsec or less. can IC 741 op-amp be used

The IC 741 has a slew rate of 0.5V/μs

According to definition.

$$S = \frac{\Delta V}{\Delta t}$$

Now rise time is the time required by the o/p to rise from 10% to 90% of its final value.

$$\Delta V = (0.9 - 0.1) \times 3.8 = 3.04 \text{ V}$$

This happen in 4.5 μsec i.e

$$\Delta t = 4.5 \text{ μsec}$$

$$S = \frac{3.04}{4.5} = 0.675 \text{ V/μs}$$

The slew rate of IC 741 is 0.5V/μs which is too low compared to what is required.

The o/p signal V_i to an op-amp is 0.5 sin $1.13 \times 10^5 t$ is to be amplified to the maximum extent. How much maximum gain can be had by using op-amp with slew rate of 0.4 V/μsec.

(4) The common mode o/p to a certain diff. A. having differential gain of 125 is $4 \sin 200\pi t$ Determine the common mode o/p if CMRR is 60dB.

$$60 = 20 \log \left| \frac{A_d}{A_c} \right| \Rightarrow \frac{A_d}{A_c} = 1000$$

$A_d = 125$.

$A_c = 0.125$.

The common mode o/p is

$V_{ocm} = A_c V_{cm}$

$= 0.125 \times 4 \sin 200\pi t$.

$V_{ocm} = 0.5 \sin 200\pi t$ V.

(5). For an op-amp having a slew rate of 3V/μsec what is the max closed loop voltage gain that can be used when the o/p signal varies by 0.4 V in 12 μsec.

$V_o = A V_i$.

$\frac{dV_o}{dt} = A \cdot \frac{dV_i}{dt}$.

$S = A \cdot \frac{dV_i}{dt}$.

$A = \frac{S}{\frac{dV_i}{dt}}$.

$= \frac{S}{} = \frac{3 \times 10^6}{\frac{0.4}{12 \times 10^{-6}}}$.

$= \frac{36}{0.4} = \frac{36}{4} \times 10 = \frac{360}{4}$

$A = 90$

(7) The 741 IC is used as an inverting amp with a gain of 50. The sinusoidal o/p signal has a variable freq and maximum amplitude of 20mv peak. what is the the maximum freq of the o/p at which the o/p will be undistorted. Assume that the amplitude is initially nulled

The Slewrate of 741 IC is 0.5V/μs.

$$S = 2\pi f_m V_m.$$

V_m = 20mV (o/p

gain = 50.

$$\text{Gain} = \frac{V_m(o/p)}{V_m(i/p} = ?$$

$$V_m(o/p) = 50 \times 20 \times 10^{-3} = 1V.$$

$$0.5 \times 10^6 = 2\pi f_m \times 1.$$

$$f_m = 79.577 \text{ KHz}$$

(8). How fast can the o/p of an op-amp change by 10V if its Slewrate is 1V/μs.