PHYS 4211

#250. MANY SOLUTIONS POSSIBLE?

HERE'S ONE:

BASIC IDEA: PRODUCE V_{OUT} FOR VARIOUS V_{IN}'S. THE V_{OUT} SHOULD PRODUCE 1mA INTO METER.

I NEED 4 RANGES THAT SPAN INPUTS FROM 10mV → 10V. HENCE, TRY:

\[
\begin{align*}
10 \text{ mV} & \\
100 \text{ mV} & \\
1 \text{ V} & \\
10 \text{ V} &
\end{align*}
\]

EACH SUCH V_{IN} SHOULD ULTIMATELY PRODUCE 1mA FROM OP-AMP.

∴ USE OP-AMP W/ GAIN SET BY SWITCH.
NOTE THAT \( G = 1 + \frac{R_F}{R_i} \) \( i = 1, 2, 3 \)

\( R_F = 100 \, k\Omega \)

\( R_1 = 11 \, k\Omega \) (FOR READING VOLTS BETWEEN 100 mV TO 1V)

\( R_2 = 1 \, k\Omega \) (10 mV \( \leq V_{in} \leq 100 \, mV \))

\( R_3 = 100 \, \Omega \) (0 \( \leq V_{in} \leq 10 \, mV \))

\( G = 1, \text{SWITCH} = NC \) \( (1 \leq V_{in} \leq 10 \, mV) \)

\( R_{in} = 1 \, M\Omega \)

\( R_L = 10 \, k\Omega \)

SO \( V_{out} = 10 \, V \)

\( i = 10V/10k\Omega = 1 \, mA \)

CORRESPONDING TO FULL SCALE METER DEFLECTION.

DIODES IN FRONT END CONSTRAIN INPUT TO SATISFY:

\( -V_{EE} = 0.7 \, V \leq V_{in} \leq V_{cc} + 0.7 \, V \).
OP-AMP Saturates at 13V
or so, so MAX current through meter \( = 1.3 \) mA, satisfying specification.

(a) For \( I_B = 25 \) pA (LF 411)
\[ V_{os} = I_B \times 2 \times 10^{-12} = 0.25 \text{ mV} \]
This \( V_{os} \) is small compared to 100 mV and even smaller compared to 1 mV, 1 V & 10 V.

(b) For \( I_B = 80 \text{ nA} \) (op. 741), \( V_{os} = 80 \text{ mV} \). This swamps 10 mV & takes 6.5 mV F.T. 100 mV.

\[ \text{741 NOT A GOOD DESIGN} \]

\[ \text{CH0ICE FOR "SENSITIVE" VOLTAGE OF THIS DESIGN} \]

411 is OK?
NON-INVERTING CONFIGURATION.

\[ V_{IN} \quad R_{IN} \quad C_{IN} \quad R_{1} \quad C_{2} \quad R_{2} \quad V_{OUT} \]

\[ R_{IN} \approx 10k \Omega \]

\[ V_{IN} \approx R_{IN} \text{ make HIGH PASS FILTER} \]

\[ f_{3dB} = \frac{1}{2\pi R_{IN} C_{IN}} \approx 20Hz \]

\[ C = \frac{0.8m\text{F}}{C_{IN}} \]

\[ \text{gain} = 20 \text{dB} \Rightarrow 1 + \frac{R_{2}}{R_{1}} = 10 \]

\[ \Rightarrow \left( \frac{R_{2}}{R_{1}} \right) = 9 \]

SET \[ \frac{R_{2}}{R_{1}} = 9.1 \text{ k}\Omega \]

\[ R_{1} = 1.0 \text{ k}\Omega \]
\[ f_{3dB} = \frac{20 \log \frac{C_2}{C_0}}{2 \pi f_{3dB}} \]

\[ C_2 = \frac{1}{f_{3dB}} \]

\[ C_2 = \text{MF} \]

Note that \( C_2 \) forces \( G = 1 \) \( \theta \) \( f = 0 \).

\#5, p250

\[ V_{in} \xrightarrow{3} \frac{3}{3} \xrightarrow{-} V_{out} \]

741 is almost always saturated \( (V_{out} = \pm 12 V) \) since \( A \gg 1 \).

When saturated, it takes on-and-a finite amount of time to move from \( V_{ic} \rightarrow -V_{off} \) or \( V_{ic} \rightarrow 0 \), set by slew rate.

To reach 0 V from \( \pm 12 V \), takes \( \Delta t = \frac{13}{S} = 2.6 \text{ ms} \) \( S = 0.5 \text{ V/\mu s} \).
During this time, input will move. How much?

\[ V_{in} = 1 \sin(2\pi f t) \; ; \; f = 1648 \]

\[ V_0 = \sin(2\pi f \cdot 0) = 160 \text{ mV}. \]

\[ \therefore \; V_{in} \text{ changes by about } 160 \text{ mV} \] by the time \( V_0 \) changes from \( \pm 13 \text{ V} \) to 0.