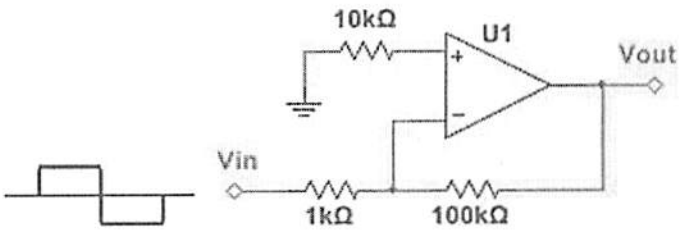
ECE 363 QUIZ 3 (F19) **NAME:** Solutions

1 problem for 20 pts

Op Amp Speed and Output Error

Consider an inverting amplifier built with an LM248 op amp. The closed loop gain is |G| = +40 dB. The input V_{IN} is a 20 mV_{PP} square wave at 3 kHz.



(a) Compute the amplifier's small-signal bandwidth and rise time T_R.

(b) Compute the slew rate-limited rise time T_{SR} for V_{OUT}.

(c) Sketch both the input V_{IN} and output V_{OUT} over a 1 ms interval. Label important features!

(d) Compute the worst-case output error voltage.

(a) $BW = \frac{GBW}{Gain}$ ← 1.0MHz (datasheet)

40 dB = $20\log_{10}|Gain|$

$|Gain| = 10^{40/20} = 100$

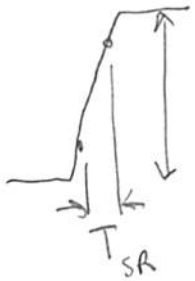
$BW = \frac{1MHz}{100} = .01MHz$

$= \boxed{10KHz}$

+5

$T_R = \frac{0.35}{BW} = \frac{0.35}{10KHz} = .035\ KHz^{-1} = .035\ ms = \boxed{35\mu s}$

(b) $SR = 0.5\frac{V}{\mu s}$



$V_{out,pp} = 100 \times .02V_{pp} = 2V_{pp}$

$SR = \frac{0.8\,V_{out,pp}}{T_{SR}}$

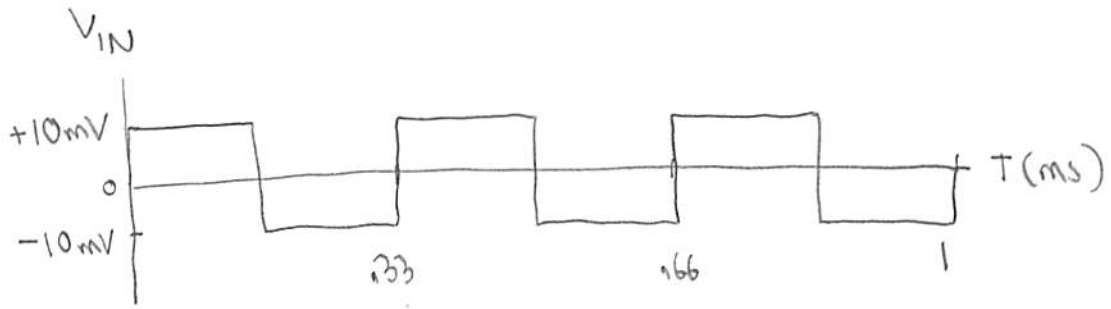
$\rightarrow T_{SR} = \frac{0.8 \times 2V}{0.5\ V/\mu s} = \boxed{3.2\mu s}$

+5

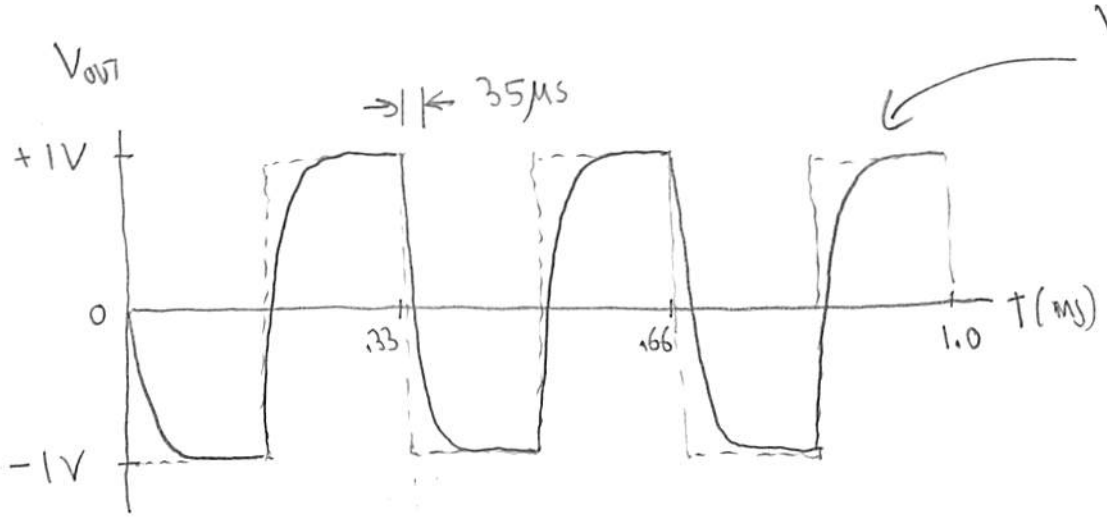
(c) 3KHz : 1 cycle = $\frac{1}{3KHz} = 0.33\ ms = 333\mu s$

*Since $T_R > T_{SR}$, limited by small signal BW.

(extra sheet for work)



(+5)



(d)

Max Values

$I_{IN(BIAS)} = 200\ nA$

$I_{IN(OS)} = 50\ nA$

$V_{IN(OS)} = 6\ mV$

$R_{TH(+)} = 10K$

$R_{TH(-)} = 1K \,//\, 100K = 0.99K$

$I_{IN(BIAS)}$: $\Delta V_{OUT} = 100 \times (200 \times 10^{-9})(10^4 - .99 \times 10^3) = 180.2\ mV$

$I_{IN(OS)}$: $\Delta V_{OUT} = 100 \times (50 \times 10^{-9})\left(\frac{10^4 + .99 \times 10^3}{2}\right) = 27.5\ mV$

$V_{IN(OS)}$: $\Delta V_{OUT} = 100 \times 6\ mV = 600\ mV$

(+5)

$\Rightarrow$ Worst case output error $= 180.2\ mV + 27.5\ mV + 600\ mV = \boxed{807.7\ mV}$