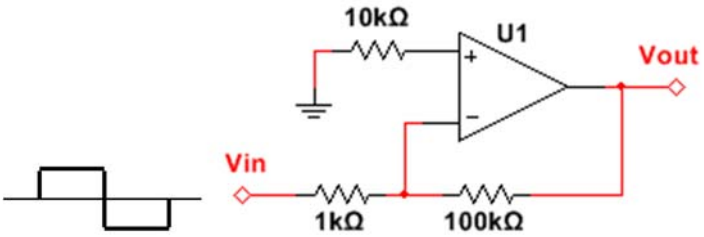
ECE 363 QUIZ 3 (F19) NAME:_____

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.

(extra sheet for work)

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings(1)(2)

		LM148	LM248	LM348
Supply Voltage		±22V	±18V	±18V
Differential Input Voltage		±44V	±36V	±36V
Output Short Circuit Duration(3)		Continuous	Continuous	Continuous
Power Dissipation (P_d at 25°C) and Thermal Resistance (θ_{jA})(4)				
PDIP (NFF) P_d		—	—	750 mW
θ_{JA}		—	—	100°C/W
CDIP (J) P_d		1100 mW	800 mW	700 mW
θ_{JA}		110°C/W	110°C/W	110°C/W
Maximum Junction Temperature (T_{jMAX})		150°C	110°C	100°C
Operating Temperature Range		$-55°C \le T_A \le +125°C$	$-25°C \le T_A \le +85°C$	$0°C \le T_A \le +70°C$
Storage Temperature Range		−65°C to +150°C	−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.) Ceramic		300°C	300°C	300°C
Lead Temperature (Soldering, 10 sec.) Plastic				260°C
Soldering Information				
Dual-In-Line Package	Soldering (10 seconds)	260°C	260°C	260°C
Small Outline Package	Vapor Phase (60 seconds)	215°C	215°C	215°C
	Infrared (15 seconds)	220°C	220°C	220°C
ESD tolerance(5)		500V	500V	500V

(1) Refer to RETS 148X for LM148 military specifications.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(3) Any of the amplifier outputs can be shorted to ground indefinitely; however, more than one should not be simultaneously shorted as the maximum junction temperature will be exceeded.
(4) The maximum power dissipation for these devices must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and the ambient temperature, T_A. The maximum available power dissipation at any temperature is $P_d = (T_{JMAX} - T_A)/\theta_{JA}$ or the 25°C P_{DMAX}, whichever is less.
(5) Human body model, 1.5 kΩ in series with 100 pF.

Electrical Characteristics

These specifications apply for $V_S = \pm15V$ and over the absolute maximum operating temperature range ($T_L \le T_A \le T_H$) unless otherwise noted.

Parameter	Conditions	LM148			LM248			LM348			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25°C$, $R_S \le 10$ kΩ		1.0	5.0		1.0	6.0		1.0	6.0	mV
Input Offset Current	$T_A = 25°C$		4	25		4	50		4	50	nA
Input Bias Current	$T_A = 25°C$		30	100		30	200		30	200	nA
Input Resistance	$T_A = 25°C$	0.8	2.5		0.8	2.5		0.8	2.5		MΩ
Supply Current All Amplifiers	$T_A = 25°C$, $V_S = \pm15V$		2.4	3.6		2.4	4.5		2.4	4.5	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm15V$ $V_{OUT} = \pm10V$, $R_L \ge 2$ kΩ	50	160		25	160		25	160		V/mV
Amplifier to Amplifier Coupling	$T_A = 25°C$, f = 1 Hz to 20 kHz (Input Referred) See Crosstalk Test Circuit		−120			−120			−120		dB
Small Signal Bandwidth	$T_A = 25°C$, LM148 Series		1.0			1.0			1.0		MHz
Phase Margin	$T_A = 25°C$, LM148 Series ($A_V = 1$)		60			60			60		degrees

Electrical Characteristics (continued)

These specifications apply for V_S = ±15V and over the absolute maximum operating temperature range ($T_L \le T_A \le T_H$) unless otherwise noted.

Parameter	Conditions	LM148			LM248			LM348			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Slew Rate	T_A = 25°C, LM148 Series (A_V = 1)		0.5			0.5			0.5		V/µs
Output Short Circuit Current	T_A = 25°C		25			25			25		mA
Input Offset Voltage	$R_S \le 10$ kΩ			6.0			7.5			7.5	mV
Input Offset Current				75			125			100	nA
Input Bias Current				325			500			400	nA
Large Signal Voltage Gain	V_S = ±15V, V_{OUT} = ±10V, $R_L > 2$ kΩ	25			15			15			V/mV
Output Voltage Swing	V_S = ±15V, R_L = 10 kΩ	±12	±13		±12	±13		±12	±13		V
	R_L = 2 kΩ	±10	±12		±10	±12		±10	±12		V
Input Voltage Range	V_S = ±15V	±12			±12			±12			V
Common-Mode Rejection Ratio	$R_S \le 10$ kΩ	70	90		70	90		70	90		dB
Supply Voltage Rejection	$R_S \le 10$ kΩ, ±5V ≤ V_S ≤ ±15V	77	96		77	96		77	96		dB

CROSS TALK TEST CIRCUIT

V_S = ±15V