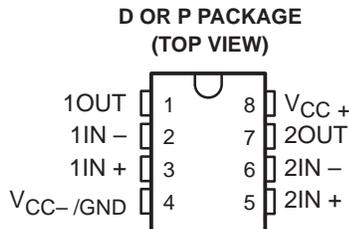


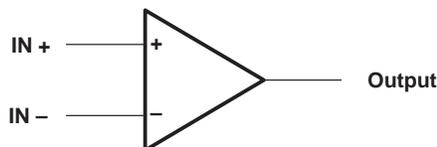
# TL322C, TL322I DUAL LOW-POWER OPERATIONAL AMPLIFIERS

SLOS086 – D2567, OCTOBER 1979 – REVISED OCTOBER 1990

- **Wide Range of Supply Voltages**  
Single Supply . . . 5 V to 30 V  
Dual Supplies . . .  $\pm 2.5$  V to  $\pm 15$  V
- **Class AB Output Stage**
- **True Differential Input Stage**
- **Low Input Bias Current**
- **Internal Frequency Compensation**
- **Short-Circuit Protection**



symbol (each amplifier)



## description

The TL322C and the TL322I are dual operational amplifiers similar in performance to the  $\mu$ A741 but with several distinct advantages. They are designed to operate from a single supply over a range of voltages from 5 V to 30 V. Operation from split supplies is also possible provided the difference between the two supplies is 5 V to 30 V. The common-mode input range includes the negative supply. Output range is from the negative supply to  $V_{CC} - 1.5$  V. Quiescent supply currents per amplifier are typically less than one-half those of the  $\mu$ A741.

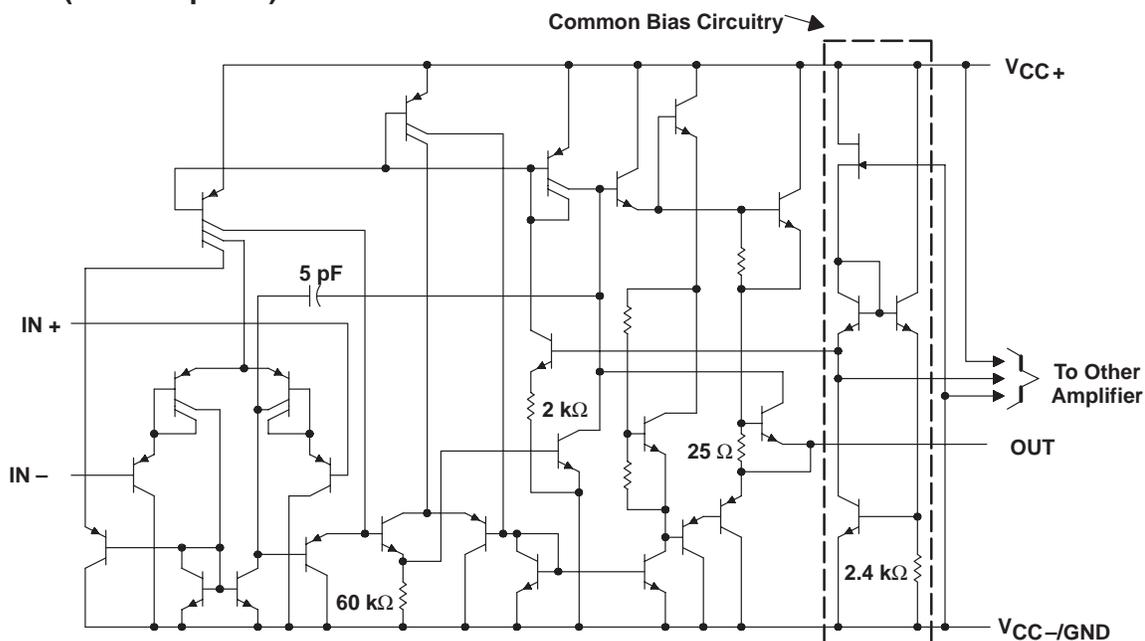
The TL322C is characterized for operation from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The TL322I is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## AVAILABLE OPTIONS

TA	V <sub>IO</sub> MAX AT 25°C	PACKAGE	
		SMALL OUTLINE (D)	PLASTIC DIP (P)
0°C to 70°C	10 mV	TL322CD	TL322CP
0°C to 70°C	8 mV	TL322ID	TL322IP

D packages are available taped and reeled. Add R suffix to device type, (e.g., TL322CDR).

## schematic (each amplifier)



All component values shown are nominal.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS  
INSTRUMENTS**

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# TL322C, TL322I

## DUAL LOW-POWER OPERATIONAL AMPLIFIERS

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### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

	TL322C	TL322I	UNIT
Supply voltage $V_{CC+}$ (see Note 1)	18	18	V
Supply voltage $V_{CC-}$ (see Note 1)	-18	-18	V
Supply voltage $V_{CC+}$ (with respect to $V_{CC-}$ )	36	36	V
Differential input voltage (see Note 2)	$\pm 36$	$\pm 36$	V
Input voltage (see Notes 1 and 3)	$\pm 18$	$\pm 18$	V
Continuous total power dissipation	See Dissipation Rating Table		
Operating free-air temperature range	0 to 70	-40 to 85	$^{\circ}\text{C}$
Storage temperature range	-65 to 150	-65 to 150	$^{\circ}\text{C}$
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260	260	$^{\circ}\text{C}$

- NOTES: 1. These voltage values are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .  
 2. Differential voltages are at the noninverting input terminal with respect to the inverting input terminal.  
 3. Neither input must ever be more positive than  $V_{CC+}$  or more negative than  $V_{CC-}$ .

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^{\circ}\text{C}$ POWER RATING	DERATING FACTOR	DERATE ABOVE $T_A$	$T_A = 70^{\circ}\text{C}$ POWER RATING	$T_A = 85^{\circ}\text{C}$ POWER RATING
D	680 mW	5.8 mW/ $^{\circ}\text{C}$	33 $^{\circ}\text{C}$	464 mW	377 mW
P	680 mW	8.0 mW/ $^{\circ}\text{C}$	65 $^{\circ}\text{C}$	640 mW	520 mW

### recommended operating conditions

	MIN	NOM	MAX	UNIT
Single supply voltage, $V_{CC}$	5		30	V
Dual supply voltage, $V_{CC+}$	2.5		15	V
Dual supply voltage, $V_{CC-}$	-2.5		-15	V

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**electrical characteristics at specified free-air temperature,  $V_{CC\pm} = 15\text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONST	TL322C			TL322I			UNIT	
		MIN	TYP	MAX	MIN	TYP	MAX		
$V_{IO}$ Input offset voltage	$V_O = 0,$ $R_S = 50\ \Omega$	25°C	2	10	2	8	mV		
		Full range		12		10			
$\alpha_{VIO}$ Temperature coefficient of input offset voltage	$V_O = 0,$ $R_S = 50\ \Omega$	25°C	10		10		$\mu\text{V}/^\circ\text{C}$		
$I_{IO}$ Input offset current	$V_O = 0$	25°C	30	50	30	75	nA		
		Full range		200		250			
$\alpha_{IIO}$ Temperature coefficient of input offset current	$V_O = 0$	25°C	50		50		$\text{pA}/^\circ\text{C}$		
$I_{IB}$ Input bias current	$V_O = 0$	25°C	-0.2	-0.5	-0.2	-0.5	$\mu\text{A}$		
		Full range		-0.8		-1			
$V_{ICR}$ Common-mode input voltage range <sup>‡</sup>		25°C	$V_{CC-}$ to 13	$V_{CC-}$ to 13.5	$V_{CC-}$ to 13	$V_{CC-}$ to 13.5	V		
$V_{OM}$ Peak output voltage swing	$R_L = 10\ \text{k}\Omega$	25°C	$\pm 12$	$\pm 13.5$	$\pm 12$	$\pm 12.5$	V		
		25°C	$\pm 10$	$\pm 13$	$\pm 10$	$\pm 12$			
		Full range	$\pm 10$		$\pm 10$				
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V},$ $R_L = 2\ \text{k}\Omega$	25°C	20	200	20	200	V/mV		
		Full range	15		15				
$B_{OM}$ Maximum-output-swing bandwidth	$V_O(\text{PP}) = 20\ \text{V},$ $A_{VD} = 1,$ $\text{THD} \leq 5\%,$ $R_L = 2\ \text{k}\Omega$	25°C	9		9		kHz		
$B_1$ Unity-gain bandwidth	$V_O = 50\ \text{mV},$ $R_L = 10\ \text{k}\Omega$	25°C	1		1		MHz		
$\phi_m$ Phase margin	$R_L = 2\ \text{k}\Omega,$ $C_L = 200\ \text{pF}$	25°C	60°		60°				
$r_i$ Input resistance	$f = 20\ \text{Hz}$	25°C	0.3	1	0.3	1	$\text{M}\Omega$		
$r_o$ Output resistance	$f = 20\ \text{Hz}$	25°C	75		75		$\Omega$		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR}\ \text{min},$ $R_S = 50\ \Omega$	25°C	70	90	70	90	dB		
$k_{SVS}$ Supply voltage sensitivity ( $\Delta V_{IO}/\Delta V_{CC}$ )	$V_{CC} = \pm 2.5\ \text{V to}$ $\pm 15\ \text{V},$ $R_S = 50\ \Omega$	25°C	30	150	30	150	$\mu\text{V}/\text{V}$		
$I_{OS}$ Short-circuit output current <sup>§</sup>	$V_O = 0$	25°C	$\pm 10$	$\pm 30$	$\pm 45$	$\pm 10$	$\pm 30$	$\pm 45$	mA
$I_{CC}$ Total supply current	$V_O = 0,$ No load	25°C	1.4	4	1.4	4	mA		

† All characteristics are under open-loop conditions unless otherwise noted. Full range for  $T_A$  is 0°C to 70°C for TL322C and -40°C to 85°C for TL322I.

‡ The  $V_{ICR}$  limits are directly linked volt-for-volt to supply voltage; the positive limit is 2 V less than  $V_{CC+}$ .

§ Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.

# TL322C, TL322I DUAL LOW-POWER OPERATIONAL AMPLIFIERS

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electrical characteristics,  $V_{CC+} = 5\text{ V}$ ,  $V_{CC-} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITION <sup>†</sup>	TL322C			TL322I			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$	Input offset voltage	$V_O = 2.5\text{ V}$ , $R_S = 50\ \Omega$			8			mV
$I_{IO}$	Input offset current	$V_O = 2.5\text{ V}$			75			nA
$I_{IB}$	Input bias current				-0.5			pA
$V_{OM}$	Peak output voltage swing <sup>‡</sup>	$R_L = 10\text{ k}\Omega$			3.3 3.5			V
		$R_L = 10\text{ k}\Omega$ , $V_{CC+} = 5\text{ V to } 30\text{ V}$			$V_{CC+} - 1.7$			
$A_{VD}$	Large-signal differential voltage amplification	$V_O = 1.7\text{ V to } 3.3\text{ V}$ , $R_L = 2\text{ k}\Omega$			20 200			V/mV
$k_{SVS}$	Supply voltage sensitivity ( $\Delta V_{IO} / \Delta V_{CC+}$ )	$V_{CC} = \pm 2.5\text{ V to } \pm 15\text{ V}$			150			$\mu\text{V/V}$
$I_{CC}$	Supply current	$V_O = 2.5\text{ V}$ , No load			1.2 4			mA
$V_{O1} / V_{O2}$	Crosstalk attenuation	$A_{VD} = 100$ , $f = 1\text{ kHz to } 20\text{ kHz}$			120			dB

<sup>†</sup> All characteristics are specified under open-loop conditions.

<sup>‡</sup> Output will swing essentially to ground.

switching characteristics,  $V_{CC+} = 15\text{ V}$ ,  $V_{CC-} = -15\text{ V}$ ,  $A_{VD} = 1$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
SR	Slew rate at unity gain	$V_I = \pm 10\text{ V}$ , $C_L = 100\text{ pF}$ , See Figure 1			0.6	V/ $\mu\text{s}$
$t_r$	Rise time	$\Delta V_O = 50\text{ mV}$ , $C_L = 100\text{ pF}$ , $R_L = 10\text{ k}\Omega$ , See Figure 1			0.35	$\mu\text{s}$
$t_f$	Fall time				0.35	$\mu\text{s}$
	Overshoot factor				20%	
	Crossover distortion	$V_{I(PP)} = 30\text{ mV}$ , $V_{O(PP)} = 2\text{ V}$ , $f = 10\text{ kHz}$			1%	

## PARAMETER MEASUREMENT INFORMATION

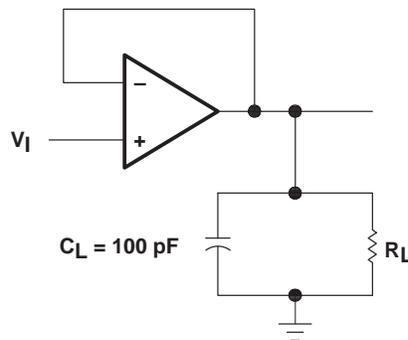
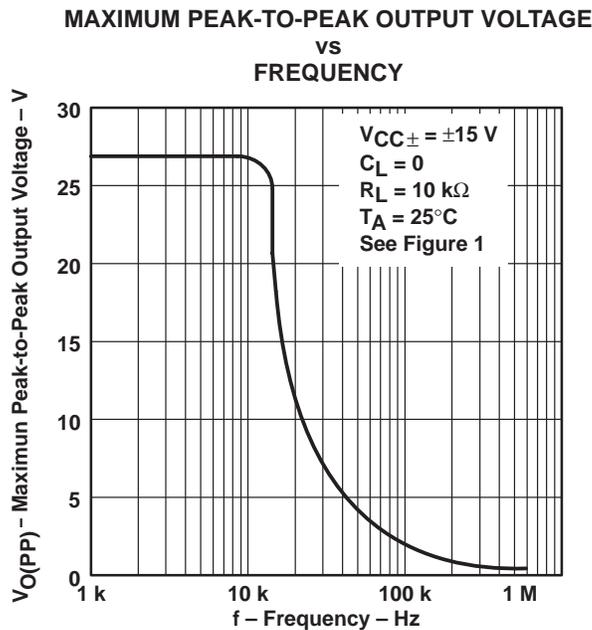
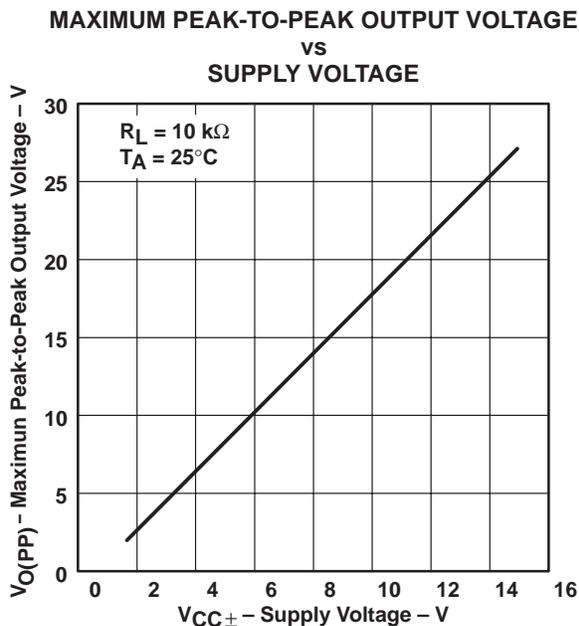
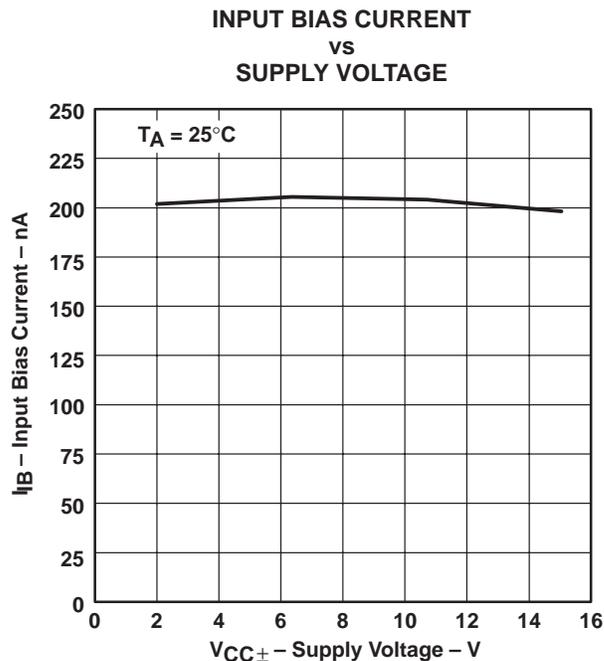
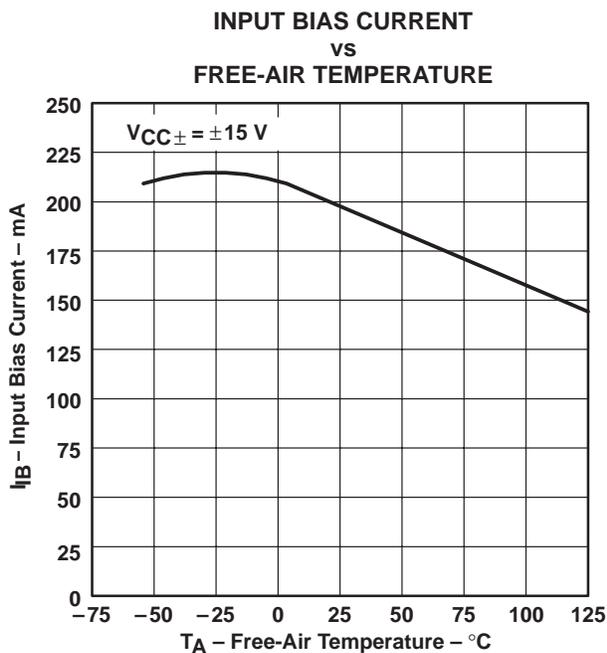


Figure 1. Unity-Gain Amplifier

TYPICAL CHARACTERISTICS†

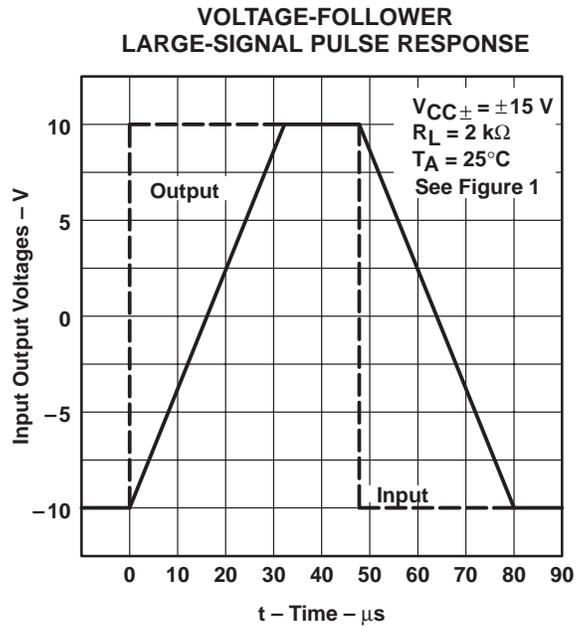
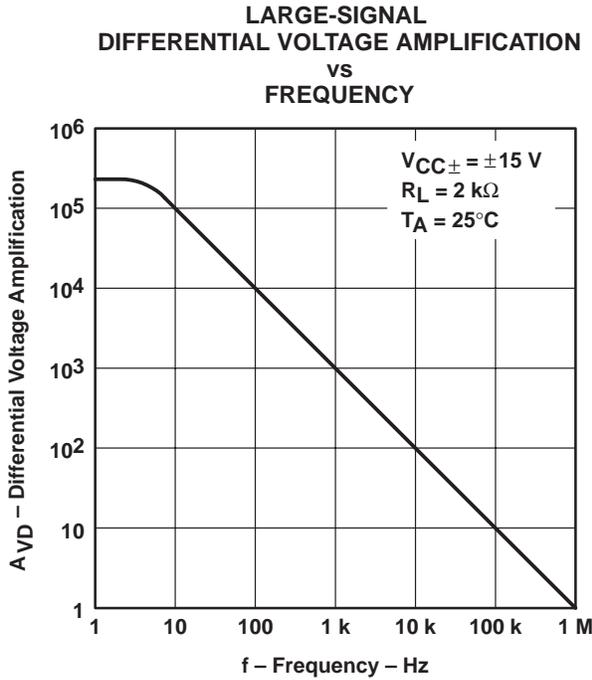


† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

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## TYPICAL CHARACTERISTICS



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