

# LINEAR INTEGRATED CIRCUITS

# TYPES TL091M, TL091I, TL091C, TL092M, TL092I, TL092C, ~~TL094M, TL094I, TL094C~~ JFET-INPUT OPERATIONAL AMPLIFIERS

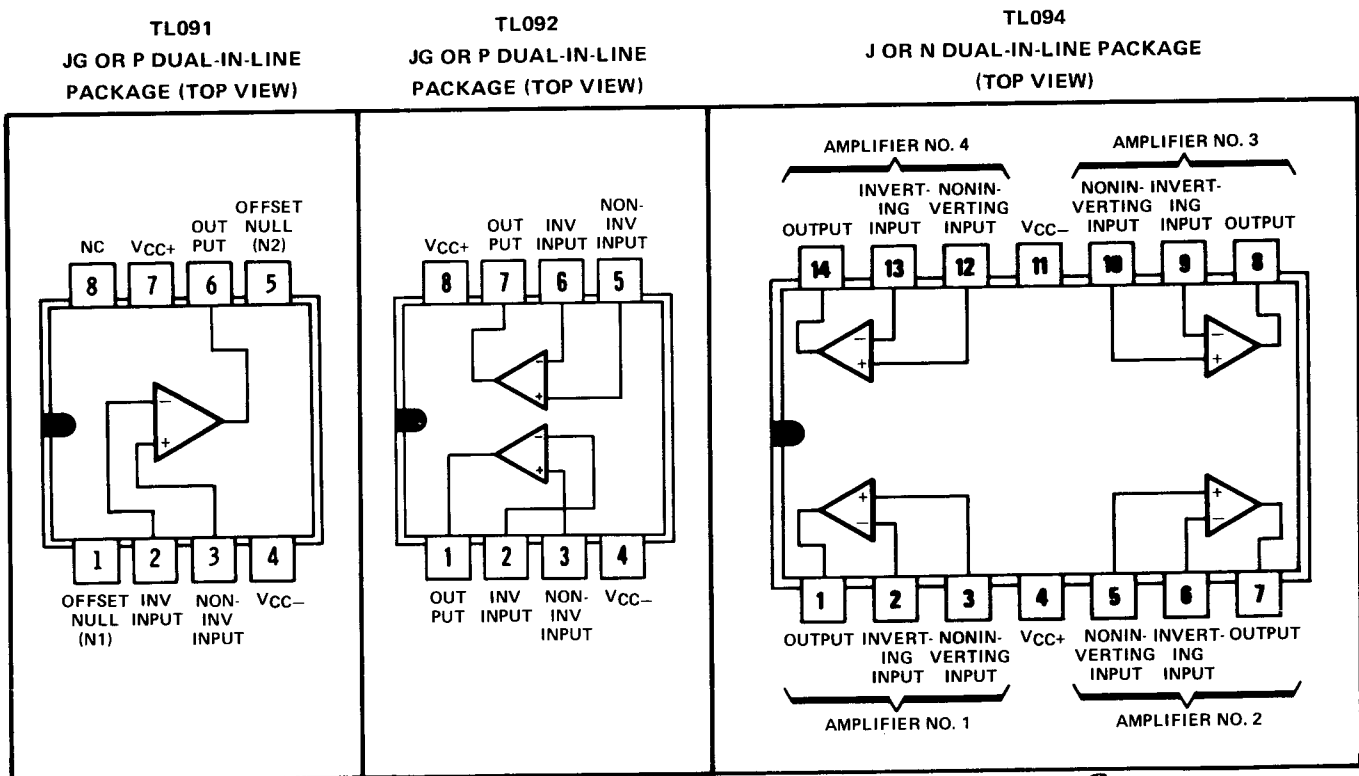
D2585, OCTOBER 1981—REVISED MAY 1982

- Wide Range of Supply Voltages  
Single Supply . . . 3 V to 36 V  
or Dual Supplies
- Class AB Output Stage
- High-Impedance N-Channel-JFET  
Input Stage . . .  $10^{12} \Omega$  typical
- Internal Frequency Compensation
- Short-Circuit Protection
- Input Common-Mode Range Includes  $V_{CC-}$
- Low Input Offset Current . . . 50 pA typical
- Low Input Bias Current . . . 200 pA typical

## description

The TL091 JFET input operational amplifier family is similar in performance to the MC3403 family but with much higher input impedance derived from a FET input stage. The N-channel-JFET input stage provides a typical input impedance of  $10^{12}$  ohms, a typical input offset current of 50 picoamperes, a typical input bias current of 200 picoamperes, and allows a common-mode input voltage range that includes the negative supply voltage. The TL091 family is designed to operate from a single supply over a range of 3 to 36 volts. Operation from split supplies is also possible provided the difference between the two supplies is 3 to 36 volts. Output voltage range is typically from  $V_{CC-}$  to 1.7 volts less than  $V_{CC+}$  with a 10-kilohm load resistor to  $V_{CC-}$ .

Device types with an "M" suffix are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ , those with an "I" suffix are characterized for operation from  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ , and those with a "C" suffix are characterized for operation from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ .

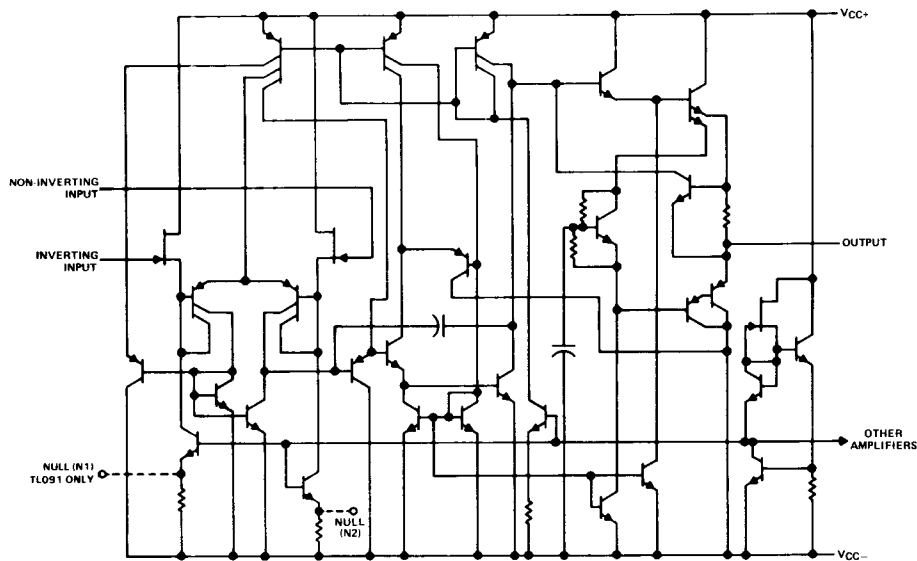


96 Res 0A2G  
004290  
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# TYPES TL091M, TL091I, TL091C, TL092M, TL092I, TL092C, TL094M, TL094I, TL094C JFET-INPUT OPERATIONAL AMPLIFIERS

schematic (each amplifier)



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

		TL091M TL092M TL094M	TL091I TL092I TL094I	TL091C TL092C TL094C	UNIT
Supply voltage $V_{CC+}$ (see Note 1)		18	18	18	V
Supply voltage $V_{CC-}$ (see Note 1)		-18	-18	-18	V
Supply voltage $V_{CC+}$ with respect to $V_{CC-}$		36	36	36	V
Differential input voltage (see Note 2)		$\pm 36$	$\pm 36$	$\pm 36$	V
Input voltage (see Notes 1 and 3)		$\pm 18$	$\pm 18$	$\pm 18$	V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 4)	J Package	1375	1025	1025	mW
	JG Package	1050	825	825	
	N Package		1150	1150	
	P Package		1000	1000	
Operating free-air temperature range		-55 to 125	-40 to 85	0 to 70	°C
Storage temperature range		-65 to 150	-65 to 150	-65 to 150	°C
Lead temperature 1/16 inch (1,6 mm) from case for 60 seconds	J or JG Package	300	300	300	°C
Lead temperature 1/16 inch (.6 mm) from case for 10 seconds	N or P Package		260	260	°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  $V_{CC-}$  minus 0.3 V.  
 4. For operation above 25°C free-air temperature, refer to Dissipation Derating Table. In the J and JG packages, TL09\_M chips are alloy-mounted; TL09\_I and TL09\_C chips are glass-mounted.

DISSIPATION DERATING TABLE

PACKAGE	POWER RATING	DERATING FACTOR	ABOVE $T_A$
J (Alloy-Mounted Chip)	1375 mW	11.0 mW/°C	25°C
J (Glass-Mounted Chip)	1025 mW	8.2 mW/°C	25°C
JG (Alloy-Mounted Chip)	1050 mW	8.4 mW/°C	25°C
JG (Glass-Mounted Chip)	825 mW	6.6 mW/°C	25°C
N	1150 mW	9.2 mW/°C	25°C
P	1000 mW	8.0 mW/°C	25°C

# TYPES TL091M, TL091I, TL091C, TL092M, TL092I, TL092C, TL094M, TL094I, TL094C JFET-INPUT OPERATIONAL AMPLIFIERS

electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V

PARAMETER	TEST CONDITIONS†	TL091M TL092M TL094M			TL091I TL092I TL094I			TL091C TL092C TL094C			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$T_A = 25^\circ\text{C}$ $R_S \leq 50 \Omega$		5	9		5	9		5	15	mV
	$T_A = \text{full range}$ $R_S \leq 50 \Omega$			15			15			20	
$\alpha V_{IO}$ Temperature coefficient of input offset voltage	$T_A = 25^\circ\text{C}$		10			10			10		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$ Input offset current‡	$T_A = 25^\circ\text{C}$		50	200		50	200		50	200	pA
	$T_A = \text{full range}$			20			10			5	nA
$I_{IB}$ Input bias current‡	$T_A = 25^\circ\text{C}$		200	400		200	400		200	400	pA
	$T_A = \text{full range}$			50			20			10	nA
$V_{ICR}$ Common-mode input voltage range‡	$T_A = 25^\circ\text{C}$	$V_{CC-}$ to 12	$V_{CC-}$ to 13		$V_{CC-}$ to 12	$V_{CC-}$ to 13		$V_{CC-}$ to 12	$V_{CC-}$ to 13		V
$V_{OM}$ Peak output voltage swing	$R_L = 10 \text{ k}\Omega$ , $T_A = 25^\circ\text{C}$	$\pm 12$	$\pm 13.5$		$\pm 12$	$\pm 13.5$		$\pm 12$	$\pm 13.5$		V
	$R_L = 2 \text{ k}\Omega$ , $T_A = 25^\circ\text{C}$	$\pm 10$	$\pm 13$		$\pm 10$	$\pm 13$		$\pm 10$	$\pm 13$		
	$R_L = 2 \text{ k}\Omega$ , $T_A = \text{full range}$	$\pm 10$			$\pm 10$			$\pm 10$			
$A_{VD}$ Large-signal differential voltage amplification	$R_L = 2 \text{ k}\Omega$ , $V_O = \pm 10 \text{ V}$		50	200		20	200		20	200	V/mV
	$T_A = 25^\circ\text{C}$										
	$T_A = \text{full range}$		25			15			15		
$B_{OM}$ Maximum-output-swing bandwidth	$V_{OPP} = 20 \text{ V}$ , $R_L = 2 \text{ k}\Omega$ , $A_{VD} = 1$ , $T_A = 25^\circ\text{C}$ , $\text{THD} \leq 5\%$		9			9			9		kHz
$B_1$ Unity-gain bandwidth	$R_L = 10 \text{ k}\Omega$ , $V_O = 50 \text{ mV}$ , $T_A = 25^\circ\text{C}$		1			1			1		MHz
$\phi_m$ Phase margin	$C_L = 200 \text{ pF}$ , $R_L = 2 \text{ k}\Omega$ , $T_A = 25^\circ\text{C}$		$60^\circ$			$60^\circ$			$60^\circ$		
$r_i$ Input resistance	$f = 20 \text{ Hz}$ , $T_A = 25^\circ\text{C}$		$10^{12}$			$10^{12}$			$10^{12}$		$\Omega$
$r_o$ Output resistance	$f = 20 \text{ Hz}$ , $T_A = 25^\circ\text{C}$		75			75			75		$\Omega$
CMRR Common-mode rejection ratio	$R_S = 50 \Omega$ , $T_A = 25^\circ\text{C}$ , $V_{IC} = V_{ICR}$		70	90		70	90		70	90	dB
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{CC}/\Delta V_{IO}$ )	$R_S = 50 \Omega$ , $T_A = 25^\circ\text{C}$ , $V_{CC} = \pm 2.5 \text{ V to } \pm 15 \text{ V}$		75	90		75	90		75	90	dB
$I_{OS}$ Short-circuit output current	$T_A = 25^\circ\text{C}$	$V_O = V_{CC+}$		65		65			65		mA
		$V_O = V_{CC-}$		-30		-30			-30		
$I_{CC}$ Total supply current per amplifier	No load, $V_O = 0 \text{ V}$ , $T_A = 25^\circ\text{C}$		1.5	2.5		1.5	2.5		1.5	2.5	mA

† All characteristics are specified under open-loop conditions unless otherwise noted. Full range for  $T_A$  is  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for TL094M;  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  for TL094I, and  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for TL094C.

‡ The  $V_{ICR}$  limits are directly linked volt-for-volt to supply voltage, i.e., the positive limit is 3 volts less than  $V_{CC+}$ .

§ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as is possible.

# TYPES TL091M, TL091I, TL091C, TL092M, TL092I, TL092C, TL094M, TL094I, TL094C JFET-INPUT OPERATIONAL AMPLIFIERS

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

PARAMETER	TEST CONDITIONS†	TL091M, TL092M, TL094M			TL091I, TL092I, TL094I			TL091C, TL092C, TL094C			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 2.5\text{ V}$ , $R_S \leq 50\ \Omega$		5	9		5	9		5	15	mV
$I_{IO}$ Input offset current §	$V_O = 2.5\text{ V}$		50	200		50	200		50	200	pA
$I_{IB}$ Input bias current §	$V_O = 2.5\text{ V}$		200	400		200	400		200	400	pA
$V_{OM}$ Peak output voltage swing ¶	$R_L = 10\text{ k}\Omega$ to gnd	3.3	3.5		3.3	3.5		3.3	3.5		V
	$R_L = 10\text{ k}\Omega$ to gnd, $V_{CC} = 5\text{ V to } 30\text{ V}$	$V_{CC+} - 1.7$			$V_{CC+} - 1.7$			$V_{CC+} - 1.7$			
$A_{VD}$ Large-signal differential voltage amplification	$\Delta V_O = 1.6\text{ V}$ , $R_L = 2\text{ k}\Omega$	20	200		20	200		20	200		V/mV
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{CC}/\Delta V_{IO}$ )	$R_S = 50\ \Omega$ , $V_{CC} = \pm 3\text{ V to } \pm 15\text{ V}$	75			75			75			dB
$I_{CC}$ Supply current (per amplifier)	$V_O = 2.5\text{ V}$ , No load		1.5	2.5		1.5	2.5		1.5	2.5	mA
$V_{O1}/V_{O2}$ Channel separation	$f = 1\text{ kHz to } 20\text{ kHz}$		120			120			120		dB

† All characteristics are specified under open-loop conditions.

§ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as is possible.

¶ The output will swing essentially to ground provided that the load resistor,  $R_L$ , is connected from the output to ground.

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

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR Slew rate at unity gain	$V_I = \pm 10\text{ V}$ , See Figure 1		0.6		V/ $\mu\text{s}$
$t_r$ Rise time	$\Delta V_O = 50\text{ mV}$ , See Figure 1		0.2		$\mu\text{s}$
$t_f$ Fall time			0.2		$\mu\text{s}$
Overshoot factor				20%	
Crossover distortion	$V_{Ipp} = 30\text{ mV}$ , $V_{Opp} = 2\text{ V}$ , $f = 10\text{ kHz}$		1%		
$V_n$ Equivalent input noise voltage	$R_S = 100\ \Omega$ , $f = 1\text{ kHz}$		34		nV/ $\sqrt{\text{Hz}}$

## PARAMETER MEASUREMENT INFORMATION

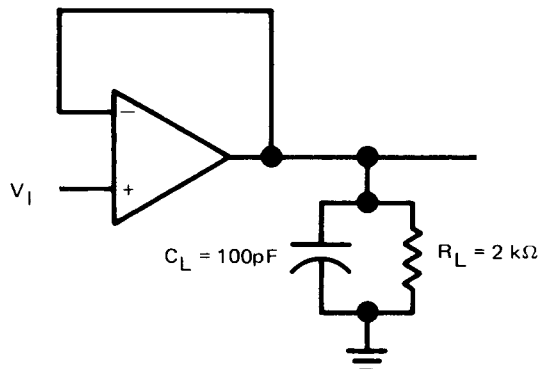


FIGURE 1—UNITY-GAIN AMPLIFIER

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