

## Low power JFET quad operational amplifier

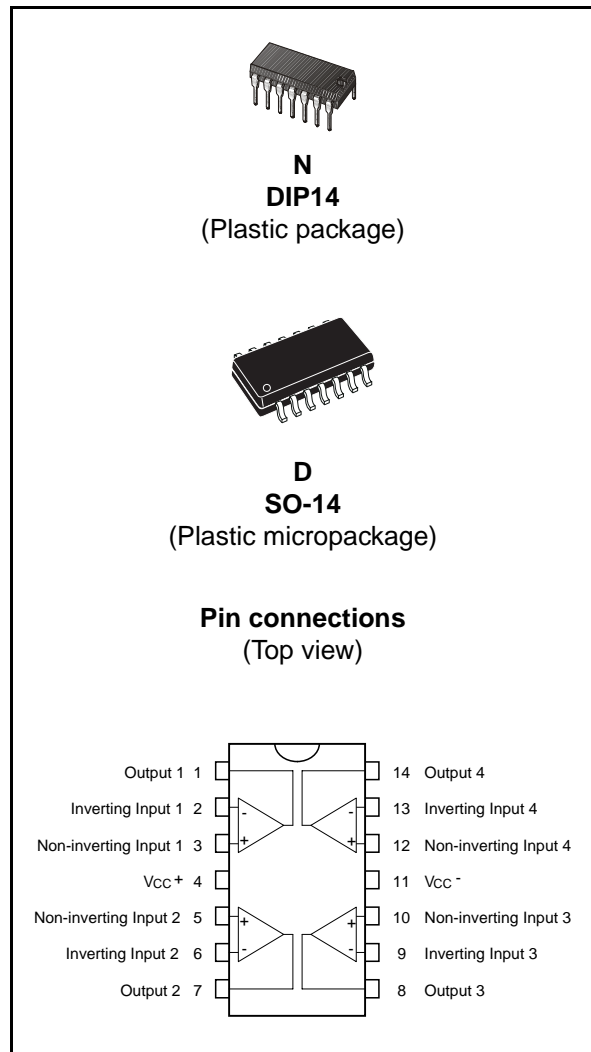
### Features

- Very low power consumption: 200  $\mu$ A
- Wide common-mode (up to  $V_{CC}^+$ ) and differential voltage ranges
- Low input bias and offset currents
- Output short-circuit protection
- High input impedance JFET input stage
- Internal frequency compensation
- Latch up free operation
- High slew rate: 3.5 V/ $\mu$ s

### Description

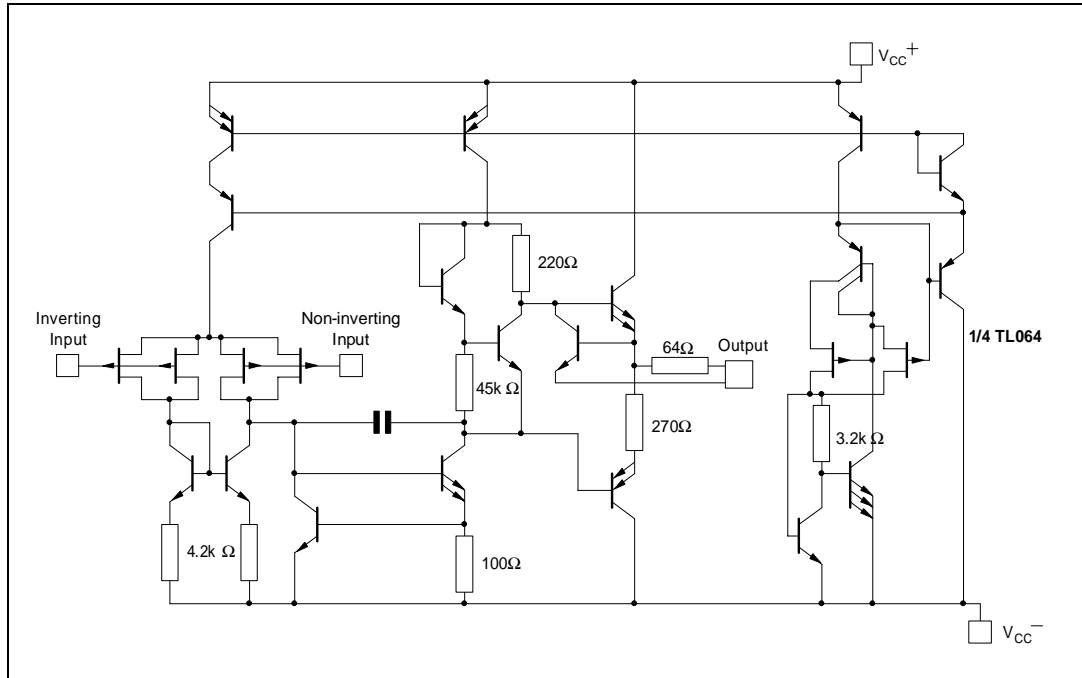
The TL064, TL064A and TL064B are high-speed JFET input single operational amplifiers. Each of these JFET input operational amplifiers incorporates well matched, high-voltage JFET and bipolar transistors in a monolithic integrated circuit.

The devices feature high slew rates, low input bias and offset currents, and low offset voltage temperature coefficient.



# 1 Schematic diagram

Figure 1. Circuit schematics



## 2 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value			Unit
		TL064M, AM, BM	TL064I, AI, BI	TL064C, AC, BC	
$V_{CC}$	Supply voltage <sup>(1)</sup>	±18			V
$V_i$	Input voltage <sup>(2)</sup>	±15			V
$V_{id}$	Differential input voltage <sup>(3)</sup>	±30			V
$P_{tot}$	Power dissipation	680			mW
$R_{thja}$	Thermal resistance junction to ambient <sup>(4) (5)</sup>				°C/W
	SO-14 DIP14	105 80			
$R_{thjc}$	Thermal resistance junction to case <sup>(4) (5)</sup>				°C/W
	SO-14 DIP14	31 33			
	Output short-circuit duration <sup>(6)</sup>	Infinite			
$T_{oper}$	Operating free-air temperature range	-55 to +125	-40 to +105	0 to +70	°C
$T_{stg}$	Storage temperature range	-65 to +150			°C
ESD	HBM: human body model <sup>(7)</sup>	900			V
	MM: machine model <sup>(8)</sup>	200			
	CDM: charged device model <sup>(9)</sup>	1500			

- All voltage values, except differential voltage, are with respect to the zero reference level (ground) of the supply voltages where the zero reference level is the midpoint between  $V_{CC}^+$  and  $V_{CC}^-$ .
- The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 volts, whichever is less.
- Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
- Short-circuits can cause excessive heating and destructive dissipation.
- $R_{th}$  are typical values.
- The output may be shorted to ground or to either supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.
- Human body model: 100pF discharged through a 1.5kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
- Machine model: a 200pF cap is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5Ω), done for all couples of pin combinations with other pins floating.
- Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.

**Table 2. Operating conditions**

Symbol	Parameter	TL064M, AM, BM	TL064I, AI, BI	TL064C, AC, BC	Unit
$V_{CC}$	Supply voltage range	6 to 36			V
$T_{oper}$	Operating free-air temperature range	-55 to +125	-40 to +105	0 to +70	°C

### 3 Electrical characteristics

Table 3.  $V_{CC} = \pm 15V$ ,  $T_{amb} = +25^{\circ}C$  (unless otherwise specified)

Symbol	Parameter	TL064M			TL064I			TL064C			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
$V_{io}$	Input offset voltage ( $R_S = 50\Omega$ ) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		3	6 15		3	6 9		3	15 20	mV
$DV_{io}$	Temperature coefficient of input offset voltage ( $R_S = 50\Omega$ )		10			10			10		$\mu V/^{\circ}C$
$I_{io}$	Input offset current <sup>(1)</sup> $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		5	100 20		5	100 10		5	200 5	pA nA
$I_{ib}$	Input bias current <sup>(1)</sup> $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		30	200 50		30	200 20		30	400 10	pA nA
$V_{icm}$	Input common mode voltage range	$\pm 11.5$	+15 -12		$\pm 11.5$	+15 -12		$\pm 11$	+15 -12		V
$V_{opp}$	Output voltage swing, $R_L = 10k\Omega$ $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$	20 20	27		20 20	27		20 20	27		V
$A_{vd}$	Large signal voltage gain $R_L = 10k\Omega$ , $V_o = \pm 10V$ , $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$	4 4	6		4 4	6		3 3	6		V/mV
GBP	Gain bandwidth product $T_{amb} = +25^{\circ}C$ , $R_L = 10k\Omega$ , $C_L = 100pF$		1			1			1		MHz
$R_i$	Input resistance		$10^{12}$			$10^{12}$			$10^{12}$		$\Omega$
CMR	Common mode rejection ratio $R_S = 50\Omega$	80	86		80	86		70	76		dB
SVR	Supply voltage rejection ratio $R_S = 50\Omega$	80	95		80	95		70	95		dB
$I_{CC}$	Supply current, no load $T_{amb} = +25^{\circ}C$ , no load, no signal		200	250		200	250		200	250	$\mu A$
$P_D$	Total power consumption $T_{amb} = +25^{\circ}C$ , no load, no signal		120			120			120		dB
SR	Slew rate $V_i = 10V$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $A_v = 1$		6	7.5		6	7.5		6	7.5	mW
$t_r$	Rise time $V_i = 20mV$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $A_v = 1$		0.2			0.2			0.2		$\mu s$

**Table 3.  $V_{CC} = \pm 15V, T_{amb} = +25^{\circ}C$  (unless otherwise specified) (continued)**

Symbol	Parameter	TL064M			TL064I			TL064C			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
$K_{ov}$	Overshoot factor (see <i>Figure 17</i> ) $V_i = 20mV, R_L = 10k\Omega,$ $C_L = 100pF, A_v = 1$		10			10			10		%
$e_n$	Equivalent input noise voltage $R_S = 100\Omega, f = 1KHz$		42			42			42		$\frac{nV}{\sqrt{Hz}}$

1. The 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 possible.

**Table 4.  $V_{CC} = \pm 15V, T_{amb} = +25^{\circ}C$  (unless otherwise specified)**

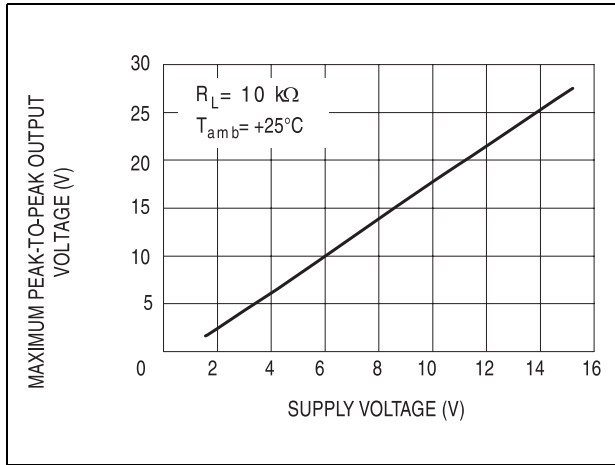
Symbol	Parameter	TL064AC, AI, AM			TL064BC, BI, BM			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
$V_{io}$	Input offset voltage ( $R_S = 50\Omega$ ) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		3	6 7.5		2	3 5	mV
$DV_{io}$	Temperature coefficient of input offset voltage ( $R_S = 50\Omega$ )		10			10		$\mu V/^{\circ}C$
$I_{io}$	Input offset current <sup>(1)</sup> $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		5	100 3		5	100 3	pA nA
$I_{ib}$	Input bias current <sup>(1)</sup> $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$		30	200 7		30	200 7	pA nA
$V_{icm}$	Input common mode voltage range	$\pm 11.5$	+15 -12		$\pm 11.5$	+15 -12		V
$V_{opp}$	Output voltage swing ( $R_L = 10k\Omega$ ) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$	20 20	27		20 20	27		V
$A_{vd}$	Large signal voltage gain, $R_L = 10k\Omega, V_o = \pm 10V$ $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$	4 4	6		4 4	6		V/mV
GBP	Gain bandwidth product $T_{amb} = +25^{\circ}C, R_L = 10k\Omega, C_L = 100pF$		1			1		MHz
$R_i$	Input resistance		$10^{12}$			$10^{12}$		$\Omega$
CMR	Common mode rejection ratio $R_S = 50\Omega$	80	86		80	86		dB
SVR	Supply voltage rejection ratio $R_S = 50\Omega$	80	95		80	95		dB
$I_{CC}$	Supply current, no load $T_{amb} = +25^{\circ}C, \text{no load, no signal}$		200	250		200	250	$\mu A$

Table 4.  $V_{CC} = \pm 15V$ ,  $T_{amb} = +25^{\circ}C$  (unless otherwise specified) (continued)

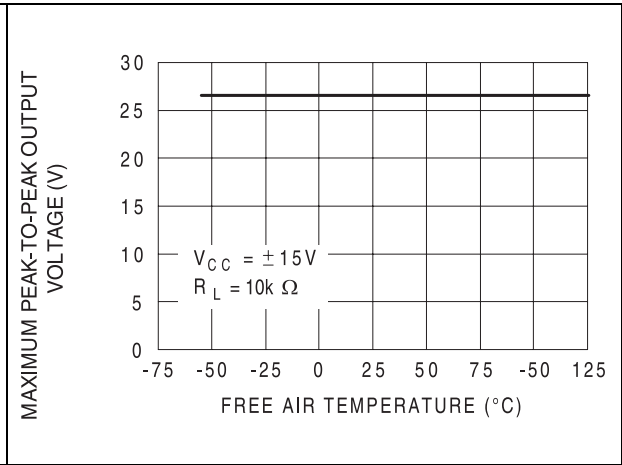
Symbol	Parameter	TL064AC, AI, AM			TL064BC, BI, BM			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
$P_D$	Total power consumption $T_{amb} = +25^{\circ}C$ , no load, no signal		120			120		dB
SR	Slew rate $V_i = 10V$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $A_v = 1$	1.5	3.5		1.5	3.5		V/ $\mu s$
$t_r$	Rise time $V_i = 20mV$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $A_v = 1$		0.2			0.2		$\mu s$
$K_{ov}$	Overshoot factor (see <a href="#">Figure 17</a> ) $V_i = 20mV$ , $R_L = 10k\Omega$ , $C_L = 100pF$ , $A_v = 1$		10			10		%
$e_n$	Equivalent input noise voltage $R_S = 100\Omega$ , $f = 1KHz$		42			42		$\frac{nV}{\sqrt{Hz}}$

1. The 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 possible.

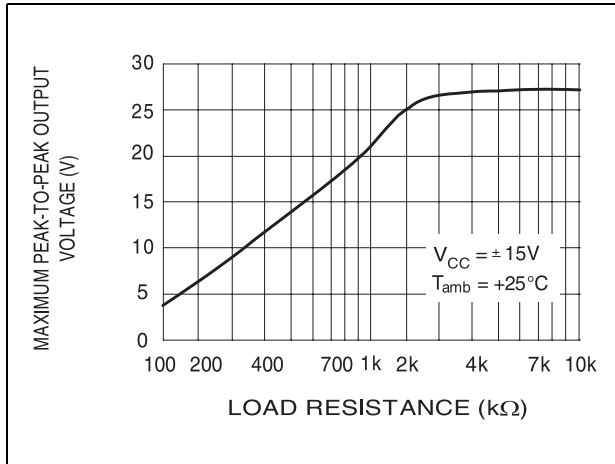
**Figure 2. Maximum peak-to-peak output voltage versus supply voltage**



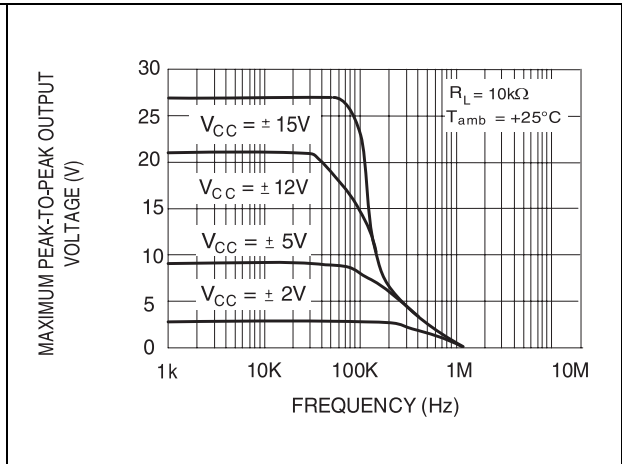
**Figure 3. Maximum peak-to-peak output voltage versus free air temp**



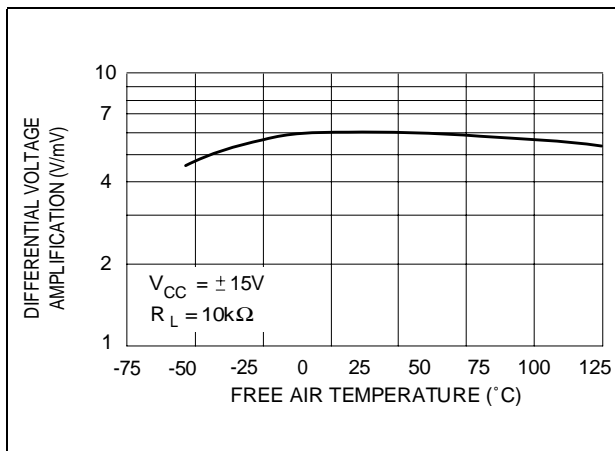
**Figure 4. Maximum peak-to-peak output voltage versus load resistance**



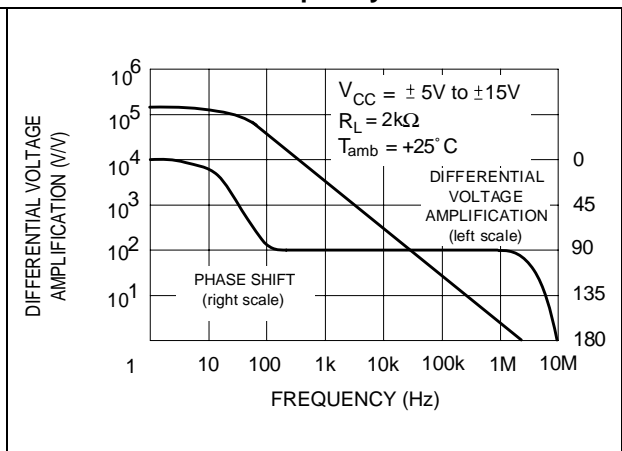
**Figure 5. Maximum peak-to-peak output voltage versus frequency**



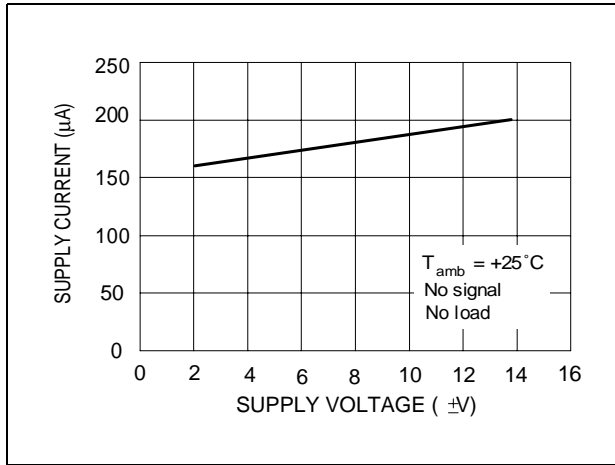
**Figure 6. Differential voltage amplification versus free air temperature**



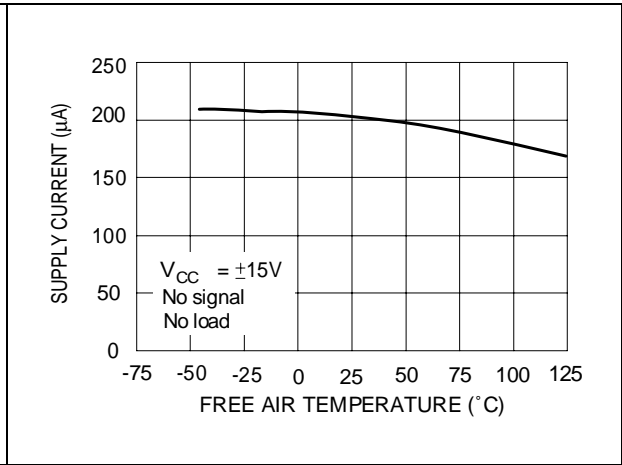
**Figure 7. Large signal differential voltage amplification and phase shift versus frequency**



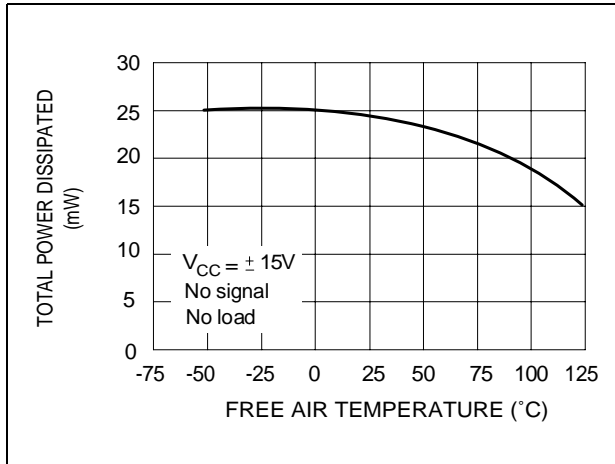
**Figure 8. Supply current per amplifier versus supply voltage**



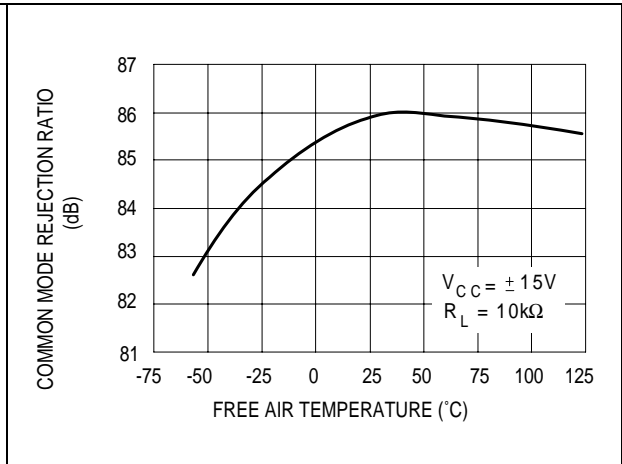
**Figure 9. Supply current per amplifier versus free air temperature**



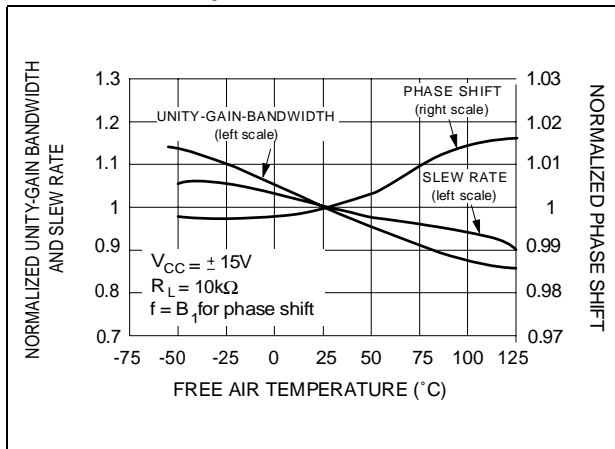
**Figure 10. Total power dissipated versus free air temperature**



**Figure 11. Common mode rejection ratio versus free air temperature**



**Figure 12. Normalized unity gain bandwidth, slew rate, and phase shift versus temperature**



**Figure 13. Input bias current versus free air temperature**

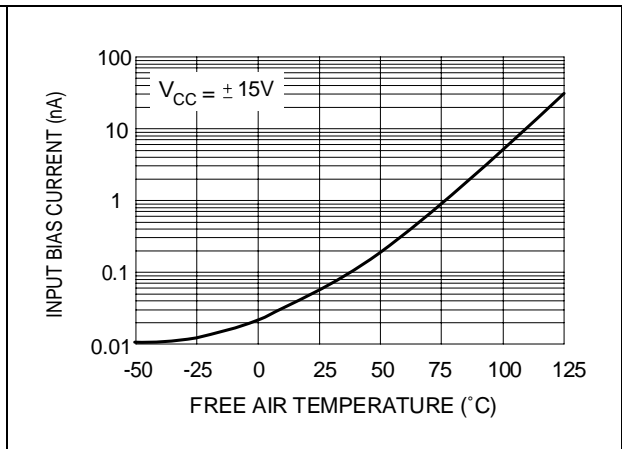




Figure 14. Voltage follower large signal pulse response

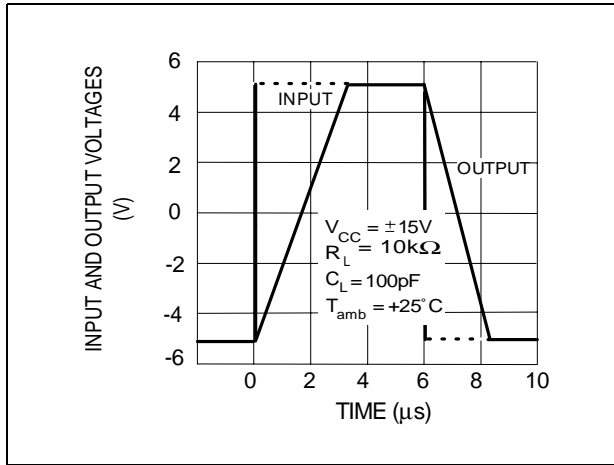


Figure 15. Output voltage versus elapsed time response

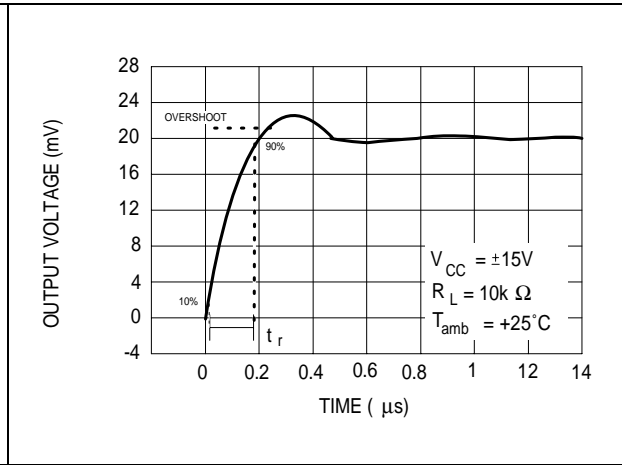
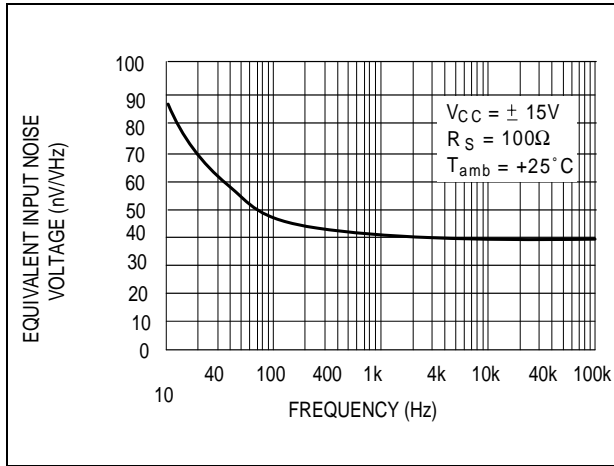


Figure 16. Equivalent input noise voltage versus frequency



### Parameter measurement information

Figure 17. Voltage follower

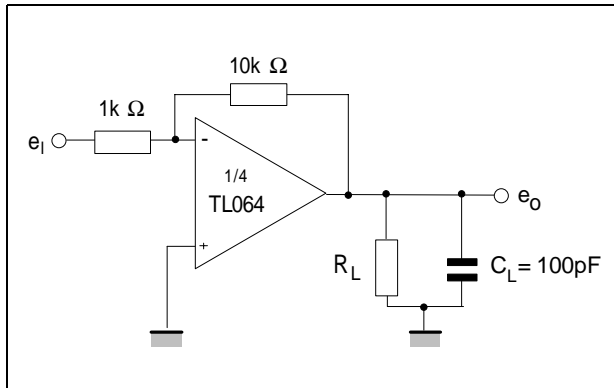
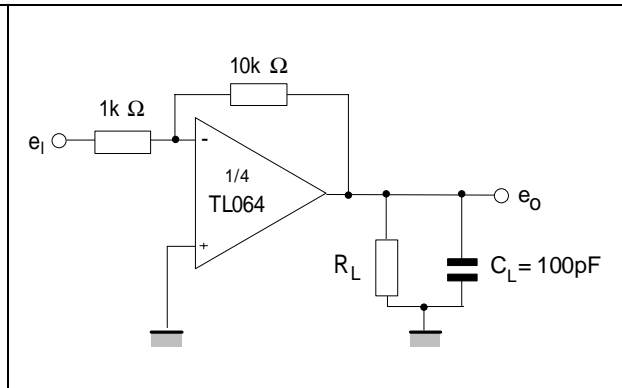
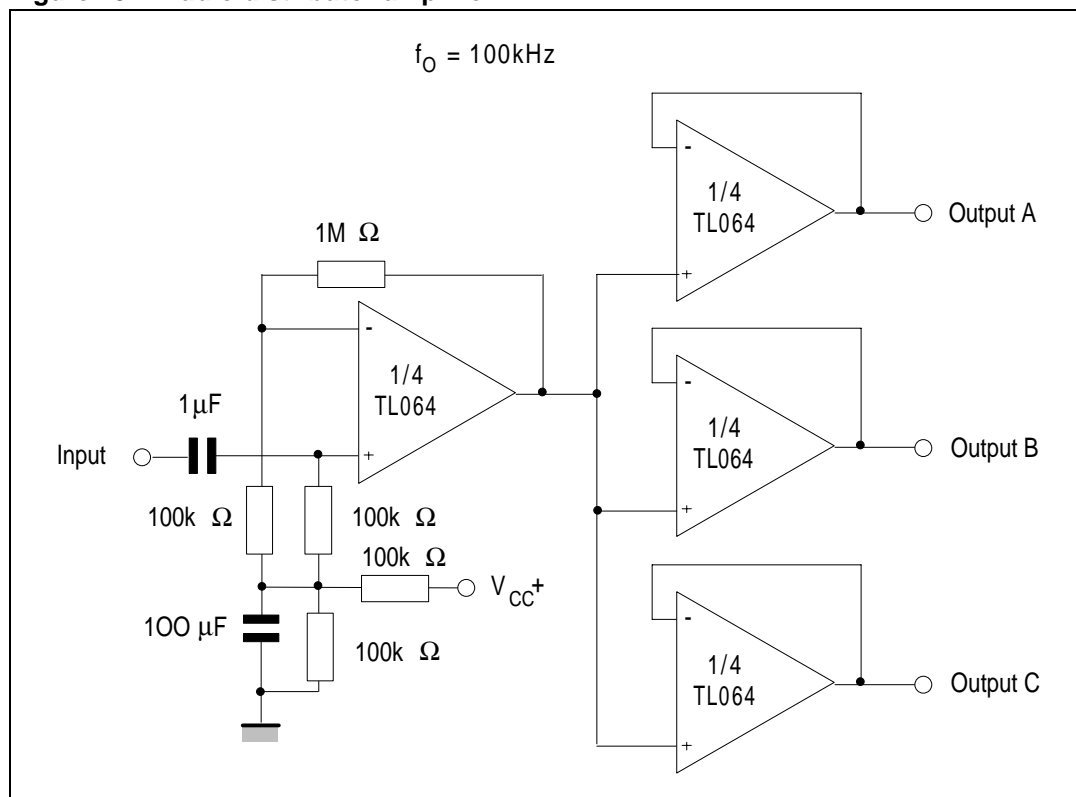


Figure 18. Gain-of-10 inverting amplifier



## 4 Typical applications

Figure 19. Audio distributor amplifier



## 5 Package information

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

Figure 20. DIP14 package mechanical data

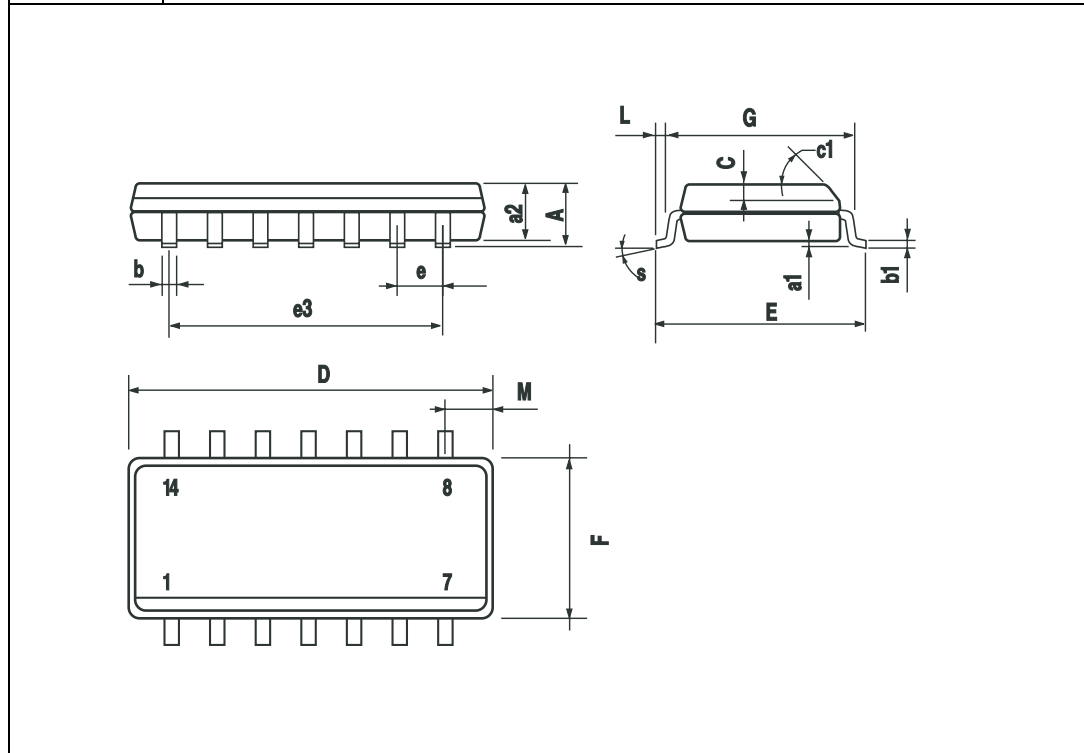
Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
l			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

The figure includes three mechanical drawings of the DIP14 package. The top drawing is a side view showing dimensions a1 (lead height), B (lead spacing), b (lead thickness), e (lead pitch), e3 (total lead length), and Z (lead width). The middle drawing is a front view showing dimensions b1 (lead thickness) and E (package width). The bottom drawing is a top view showing dimensions D (package length) and F (package height), and pin numbers 1, 7, 8, and 14.

Figure 21. SO-14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.149		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.019		0.050
M			0.68			0.026
S	8° (max.)					



## 6 Ordering information

Table 5. Order codes

Part number	Temperature range	Package	Packing	Marking
TL064MN TL064AMN TL064BMN	-55°C, +125°C	DIP14	Tube	TL064MN TL064AMN TL064BMN
TL064MD/MDT TL064AMD/AMDT TL064BMD/BMDT		SO-14	Tube or tape & reel	064M 064AM 064BM
TL064IN TL064AIN TL064BIN	-40°C, +105°C	DIP14	Tube	TL064IN TL064AIN TL064BIN
TL064ID/IDT TL064AID/AIDT TL064BID/BIDT		SO-14	Tube or tape & reel	064I 064AI 064BI
TL064CN TL064ACN TL064BCN	0°C, +70°C	DIP14	Tube	TL064CN TL064ACN TL064BCN
TL064CD/CDT TL064ACD/ACDT TL064BCD/BCDT		SO-14	Tube or tape & reel	064C 064AC 064BC

## 7 Revision history

Table 6. Document revision history

Date	Revision	Changes
13-Nov-2001	1	Initial release.
25-Jul-2007	2	Added $R_{thja}$ , $R_{thjc}$ and ESD values in <a href="#">Table 2: Operating conditions</a> . Added <a href="#">Table 2: Operating conditions</a> . Expanded <a href="#">Table 5: Order codes</a> . Format update.

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