

# DATA SHEET

## **NE/SA/AU5232**

Matched dual high-performance  
low-voltage operational amplifier

Product data

2002 May 21

# Matched dual high-performance low-voltage operational amplifier

## NE/SA/AU5232

### DESCRIPTION

The NE/SA/AU5232 is a matched, low voltage, high performance dual operational amplifier. Among its unique input and output characteristics is the capability for both input and output rail-to-rail operation, particularly critical in low voltage applications. The output swings to less than 50 mV of both rails across the entire power supply range. The NE/SA/AU5232 is capable of delivering 5.5 V peak-to-peak across a 600  $\Omega$  load and will typically draw only 700  $\mu$ A per amplifier. The bandwidth is 2.5 MHz and the 1% settling time is 1.4  $\mu$ s.

### FEATURES

- Wide common-mode input voltage range: 250 mV beyond both rails
- Output swing within 50 mV of both rails
- Functionality to 1.8 V typical
- Low current consumption: 700  $\mu$ A per amplifier
- $\pm 15$  mA output current capability
- Unity gain bandwidth: 2.5 MHz
- Slew rate: 0.8 V/ $\mu$ s
- Low noise: 33 nV/ $\sqrt{\text{Hz}}$
- Electrostatic discharge protection
- Short-circuit protection
- Output inversion prevention

### PIN CONFIGURATION

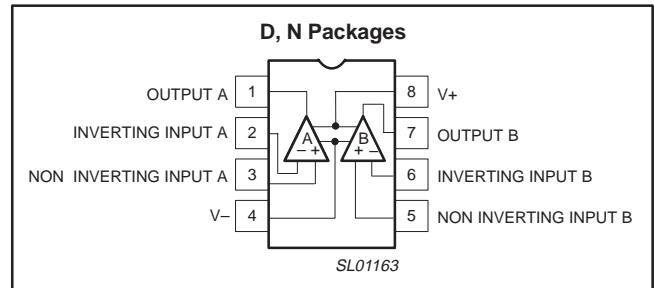


Figure 1. Pin configuration.

### APPLICATIONS

- Automotive electronics
- Signal conditioning and sensing amplification
- Portable instrumentation
  - Test and measurement
  - Medical monitors and diagnostics
  - Remote meters
- Audio equipment
- Security systems
- Communications
  - Pagers
  - Cellular telephone
  - LAN
  - 5 V Datacom bus
- Error amplifier in motor drives
- Transducer buffer amplifier

### ORDERING INFORMATION

ORDER CODE	DESCRIPTION	TEMPERATURE RANGE	DWG #
NE5232D	8-Pin Plastic Small Outline (SO) package	0 °C to +70 °C	SOT96-1
NE5232N	8-Pin Plastic Dual In-Line Package (DIP)	0 °C to +70 °C	SOT97-1
SA5232D	8-Pin Plastic Small Outline (SO) package	–40 °C to +85 °C	SOT96-1
SA5232N	8-Pin Plastic Dual In-Line Package (DIP)	–40 °C to +85 °C	SOT97-1
AU5232N	8-Pin Plastic Dual In-Line Package (DIP)	–40 °C to +125 °C	SOT97-1
AU5232D	8-Pin Plastic Small Outline (SO) package	–40 °C to +125 °C	SOT96-1

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## ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
$V_{CC}$	Single supply voltage	7	V
$V_{ESD}$	ESD protection voltage at any pin <sup>5</sup>		
	human body model	2000	V
	robot model	200	V
$V_S$	Dual supply voltage	$\pm 3.5$	V
$V_{DP}$	Voltage at any device pin <sup>1</sup>	$V_S \pm 0.5$	V
$I_{DP}$	Current into any device pin <sup>1</sup>	$\pm 50$	mA
$V_{i(dif)}$	Differential input voltage <sup>2</sup>	0.5	V
$V_{i(CM)}$	Common-mode input voltage (positive)	$V_{CC} + 0.5$	V
$V_{i(CM)}$	Common-mode input voltage (negative)	$V_{EE} - 0.5$	V
$P_D$	Power dissipation <sup>3</sup>	500	mW
$T_j$	Operating junction temperature <sup>3</sup>	+150	°C
$V_{SC}$	Supply voltage allowing indefinite output short circuit to either rail <sup>3,4</sup>	7	V
$T_{stg}$	Storage temperature range	-65 to +150	°C
$T_{slid}$	Lead soldering temperature (10 sec max)	+230	°C
$\theta_{JA}$	Thermal impedance		
	8-pin plastic DIP		°C/W
	8-pin plastic SO		°C/W

### NOTES:

- Each pin is protected by ESD diodes. The voltage at any pin is limited by the ESD diodes.
- The differential input of each amplifier is limited by two internal diodes, connected in parallel and opposite to each other. For more differential input range, use differential resistors in series with the input pins.
- The maximum operating junction temperature is +150 °C. At elevated temperatures, devices must be derated according to the package thermal resistance and device mounting conditions. Derates above +25 °C: N package at 9.5 mW/°C; D package at 6.25 mW/°C.
- Simultaneous short circuits of two amplifiers to the positive or negative rail can exceed the power dissipation ratings and cause eventual destruction of the device.
- Guaranteed by design.

## RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	RATING	UNIT
$V_{CC}$	Single supply voltage	+2 to +5.5	V
$V_S$	Dual supply voltage	$\pm 1$ to $\pm 2.75$	V
$V_{i(CM)}$	Common-mode input voltage (positive)	$V_{CC} + 0.25$	V
$V_{i(CM)}$	Common-mode input voltage (negative)	$V_{EE} - 0.25$	V
$T_{amb}$	Temperature		
	NE	0 to +70	°C
	SA	-40 to +85	°C
	AU	-40 to +125	°C

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## DC ELECTRICAL CHARACTERISTICS

 $V_{CC} = 2\text{ V to } 5.5\text{ V}$ ,  $V_{EE} = 0\text{ V}$ ,  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{EE} < V_{i(CM)} < V_{CC}$ ; unless otherwise stated.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS						UNIT	
			NE5232			SA5232				
			MIN	TYP	MAX	MIN	TYP	MAX		
$I_{CC}$	Supply current	$V_{CC} = 5.5\text{ V}$		1.4	2.0		1.4	2.0	mA	
		$V_{CC} = 5.5\text{ V}$ ; over full temp. range		1.5	2.3		1.6	2.4		
$V_{OS}$	Offset voltage			$\pm 0.2$	$\pm 4$		$\pm 0.2$	$\pm 4$	mV	
		Over full temp. range		$\pm 0.4$	$\pm 5$		$\pm 0.6$	$\pm 5$		
$\Delta V_{OS}/\Delta T$	Offset voltage drift with temperature			4			4		$\mu\text{V}/^{\circ}\text{C}$	
$\Delta V_{OS}$	Offset voltage difference between any amplifiers in the same package at the same common mode level <sup>1</sup>			0.4	3		0.4	3	mV	
		Over full temp. range		0.8	4		1.2	4		
$I_{OS}$	Offset current			$\pm 3$	$\pm 20$		$\pm 3$	$\pm 30$	nA	
		Over full temp. range		$\pm 4$	$\pm 30$		$\pm 6$	$\pm 60$		
$\Delta I_{OS}/\Delta T$	Offset current drift with temperature			0.02	$\pm 3$		0.03	$\pm 3$	nA/ $^{\circ}\text{C}$	
$I_B$	Input bias current <sup>1</sup>	$V_{EE} < V_{i(CM)} < V_{EE} + 0.5\text{ V}$	-200	-90		-200	-90		nA	
		Over full temp. range	-225	-100		-250	-150			
		$V_{EE} + 1\text{ V} < V_{i(CM)} < V_{CC}$		25	70		25	75		
		Over full temp. range		35	100		35	120		
$\Delta I_B/\Delta T$	Input bias current drift with temperature			0.5			0.5		nA/ $^{\circ}\text{C}$	
$\Delta I_B$	Input bias current difference between any amplifier in the same package at the same common mode level.	$V_{EE} < V_{i(CM)} < V_{EE} + 0.5\text{ V}$		10	30		10	30	nA	
		Over full temp. range		25	50		50	70		
		$V_{EE} + 1\text{ V} < V_{i(CM)} < V_{CC}$		5	20		5	20		
		Over full temp. range		15	30		25	50		
$V_{i(CM)}$	Common-mode input range	$V_{OS} \leq 6\text{ mV}$	$V_{EE}-0.25$		$V_{CC}+0.25$	$V_{EE}-0.25$		$V_{CC}+0.25$	V	
		$V_{OS} \leq 6\text{ mV}$ ; Over full temp. range	$V_{EE}-0.1$		$V_{CC}+0.1$	$V_{EE}-0.1$		$V_{CC}+0.1$		
CMRR	Common-mode rejection ratio, small signal	$V_{EE} < V_{i(CM)} < V_{EE} + 0.5\text{ V}$ ; $V_{EE} + 1\text{ V} < V_{i(CM)} < V_{CC}$	80	100		80	100		dB	
		Over full temp. range	75	100		75				
	Common-mode rejection ratio, large signal	$V_{EE} < V_{i(CM)} < V_{CC}$	65	90		65	90			
		Over full temp. range	60	80		60				
PSRR	Power supply rejection ratio	$V_{EE} < V_{i(CM)} < V_{CC}$	80	100		80	100		dB	
		Over full temp. range	80	90		80	90			
$I_L$	Peak load current, sink and source		10	12		10	12		mA	
		Over full temp. range	5	8		5	8			
$A_{VOL}$	Open-loop voltage gain		90	110		90	110		dB	
		Over full temp. range		90			90			
$V_{OUT}$	Output voltage swing	$I_{PEAK} = 0.1\text{ mA}$	$V_{EE}+0.05$		$V_{CC}-0.05$	$V_{EE}+0.1$		$V_{CC}-0.1$	V	
		$I_{PEAK} = 10\text{ mA}$	$V_{EE}+0.25$		$V_{CC}-0.25$	$V_{EE}+0.25$		$V_{CC}-0.25$		
		$I_{PEAK} = 5\text{ mA}$ ; over full temp. range	$V_{EE}+0.22$		$V_{CC}-0.22$	$V_{EE}+0.2$		$V_{CC}-0.2$		
	Output voltage swing for $V_{CC} = 2.75\text{ V}$ , $V_{EE} = -2.75\text{ V}$	$R_L = 2\text{ k}\Omega$	$V_{EE}+0.2$		$V_{CC}-0.2$	$V_{EE}+0.2$		$V_{CC}-0.2$	V	
	$R_L = 600\ \Omega$	$V_{EE}+0.25$		$V_{CC}-0.25$	$V_{EE}+0.25$		$V_{CC}-0.25$			

### NOTE:

- These parameters are measured for  $V_{EE} < V_{CM} < V_{EE} + 0.5\text{ V}$  and for  $V_{EE} + 1\text{ V} < V_{CM} < V_{CC}$ . By design these parameters are intermediate for common mode ranges between the measured regions.

# Matched dual high-performance low-voltage operational amplifier

NE/SA/AU5232

## DC ELECTRICAL CHARACTERISTICS

 $V_{CC} = 2\text{ V to } 5.5\text{ V}$ ,  $V_{EE} = 0\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$ ;  $V_{EE} < V_{i(CM)} < V_{CC}$ ; unless otherwise stated.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			AU5232			
			MIN	TYP	MAX	
$I_{CC}$	Supply current	$V_{CC} = 5.5\text{ V}$		1.4	2.0	mA
		$V_{CC} = 5.5\text{ V}$ ; over full temp. range		1.6	2.4	
$V_{OS}$	Offset voltage			$\pm 0.2$	$\pm 4$	mV
		Over full temp. range		$\pm 0.6$	$\pm 5$	
$\Delta V_{OS}/\Delta T$	Offset voltage drift with temperature			4		$\mu\text{V}/^\circ\text{C}$
$\Delta V_{OS}$	Offset voltage difference between any amplifiers in the same package at the same common mode level <sup>1</sup>			0.4	3	mV
		Over full temp. range		1.2	4	
$I_{OS}$	Offset current			$\pm 3$	$\pm 30$	nA
		Over full temp. range		$\pm 6$	$\pm 60$	
$\Delta I_{OS}/\Delta T$	Offset current drift with temperature			0.03	$\pm 3$	$\text{nA}/^\circ\text{C}$
$I_B$	Input bias current <sup>1</sup>	$V_{EE} < V_{i(CM)} < V_{EE} + 0.5\text{ V}$	-200	-90		nA
		Over full temp. range	-250	-150		
		$V_{EE} + 1\text{ V} < V_{i(CM)} < V_{CC}$		25	75	
		Over full temp. range		35	120	
$\Delta I_B/\Delta T$	Input bias current drift with temperature			0.5		$\text{nA}/^\circ\text{C}$
$\Delta I_B$	Input bias current difference between any amplifier in the same package at the same common mode level.	$V_{EE} < V_{i(CM)} < V_{EE} + 0.5\text{ V}$		10	30	nA
		Over full temp. range		50	70	
		$V_{EE} + 1\text{ V} < V_{i(CM)} < V_{CC}$		5	20	
		Over full temp. range		25	50	
$V_{i(CM)}$	Common-mode input range	$V_{OS} \leq 6\text{ mV}$	$V_{EE}-0.25$		$V_{CC}+0.25$	V
		$V_{OS} \leq 6\text{ mV}$ ; Over full temp. range	$V_{EE}-0.1$		$V_{CC}+0.1$	
CMRR	Common-mode rejection ratio, small signal	$V_{EE} < V_{i(CM)} < V_{EE}+0.5\text{ V}$ ; $V_{EE}+1\text{ V} < V_{i(CM)} < V_{CC}$	80	100		dB
		Over full temp. range	70			
	Common-mode rejection ratio, large signal	$V_{EE} < V_{i(CM)} < V_{CC}$	65	90		
		Over full temp. range	55			
PSRR	Power supply rejection ratio	$V_{EE} < V_{i(CM)} < V_{CC}$	80	100		dB
		Over full temp. range	75	90		
$I_L$	Peak load current, sink and source		10	12		mA
		Over full temp. range	5	8		
$A_{VOL}$	Open-loop voltage gain		90	110		dB
		Over full temp. range		90		
$V_{OUT}$	Output voltage swing	$I_{PEAK} = 0.1\text{ mA}$	$V_{EE}+0.1$		$V_{CC}-0.1$	V
		$I_{PEAK} = 10\text{ mA}$	$V_{EE}+0.25$		$V_{CC}-0.25$	
		$I_{PEAK} = 5\text{ mA}$ ; over full temp. range	$V_{EE}+0.2$		$V_{CC}-0.2$	
	Output voltage swing for $V_{CC} = 2.75\text{ V}$ , $V_{EE} = -2.75\text{ V}$	$R_L = 2\text{ k}\Omega$	$V_{EE}+0.2$		$V_{CC}-0.2$	V
$R_L = 600\ \Omega$	$V_{EE}+0.25$		$V_{CC}-0.25$			

### NOTE:

1. These parameters are measured for  $V_{EE} < V_{CM} < V_{EE}+0.5\text{ V}$  and for  $V_{EE}+1\text{ V} < V_{CM} < V_{CC}$ . By design these parameters are intermediate for common mode ranges between the measured regions.

# Matched dual high-performance low-voltage operational amplifier

NE/SA/AU5232

## AC ELECTRICAL CHARACTERISTICS

$T_{amb} = +25\text{ }^\circ\text{C}$ ;  $V_{CC} = 2\text{ V to } 5.5\text{ V}$ ;  $R_L = 10\text{ k}\Omega$ ;  $C_L = 100\text{ pF}$ ; unless otherwise stated.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS						UNIT
			NE5232			SA/AU5232			
			MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate	Over full temperature range	0.5	0.8		0.5	0.8		V/ $\mu$ s
BW	Unity gain bandwidth: -3 dB	Over full temperature range	2	2.5	4.0	2	2.5	4.0	MHz
$\theta_M$	Phase Margin	$C_L = 50\text{ pF}$		55			55		deg
$t_S$	1% settling time	$A_V = 1$ , 1 V step		1.4			1.4		$\mu$ s
$V_N$	Input referred voltage noise	$A_V = 1$ , $R_S = 0\text{ }\Omega$ , at 1 kHz		33			33		nV/Hz <sup>1/2</sup>
THD	Total harmonic distortion	10 kHz, 1V <sub>P-P</sub> , $A_V = 1$		0.1			0.1		%

## OUTPUT INVERSION PREVENTION

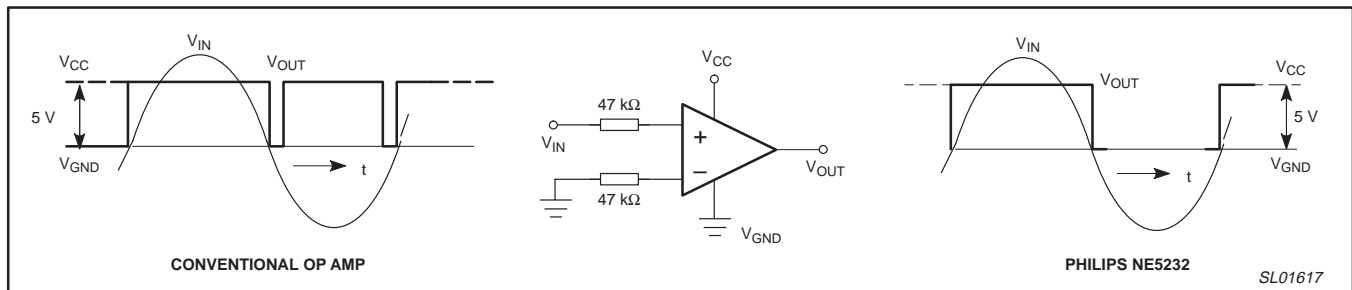


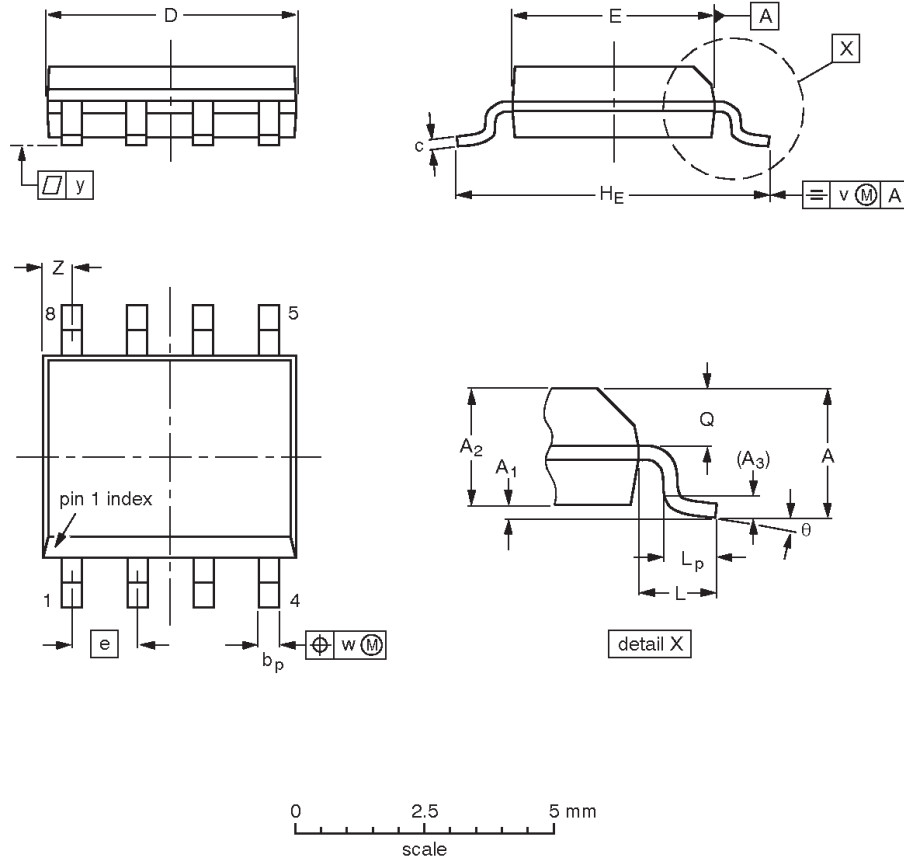
Figure 2. Output inversion prevention.

# Matched dual high-performance low-voltage operational amplifier

NE/SA/AU5232

S08: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1



**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(2)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

**Notes**

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

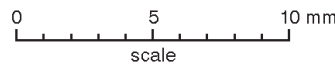
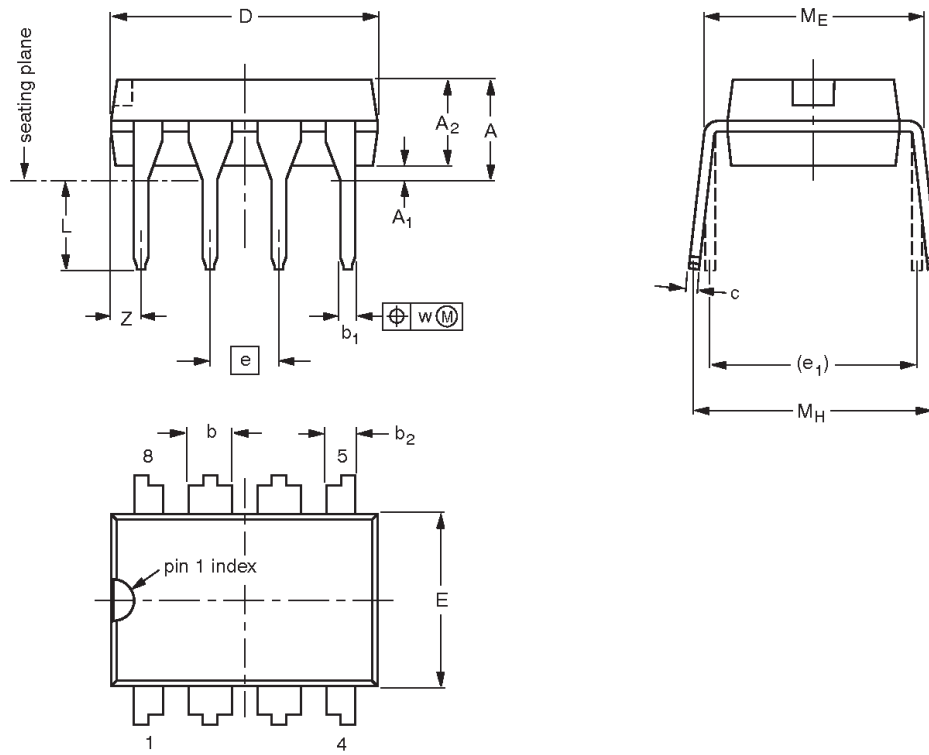
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT96-1	076E03	MS-012				97-05-22 99-12-27

# Matched dual high-performance low-voltage operational amplifier

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DIP8: plastic dual in-line package; 8 leads (300 mil)

SOT97-1



**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

UNIT	A max.	A <sub>1</sub> min.	A <sub>2</sub> max.	b	b <sub>1</sub>	b <sub>2</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	e <sub>1</sub>	L	M <sub>E</sub>	M <sub>H</sub>	w	Z <sup>(1)</sup> max.
mm	4.2	0.51	3.2	1.73 1.14	0.53 0.38	1.07 0.89	0.36 0.23	9.8 9.2	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	1.15
inches	0.17	0.020	0.13	0.068 0.045	0.021 0.015	0.042 0.035	0.014 0.009	0.39 0.36	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.045

**Note**

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT97-1	050G01	MO-001	SC-504-8			95-02-04 99-12-27

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Matched dual high-performance  
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**NOTES**

# Matched dual high-performance low-voltage operational amplifier

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## Data sheet status

Data sheet status <sup>[1]</sup>	Product status <sup>[2]</sup>	Definitions
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[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.

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