

# DATA SHEET

**NE/SA/SE532**

**LM258/358/A/2904**

Low power dual operational amplifiers

Product data  
Supersedes data of 2002 Jan 22

2002 Jul 12

# Low power dual operational amplifiers

**NE/SA/SE532/  
LM258/358/A/2904**

## DESCRIPTION

The 532/358/LM2904 consists of two independent, high gain, internally frequency-compensated operational amplifiers internally frequency-compensated operational amplifiers designed specifically to operate from a single power supply over a wide range of voltages. Operation from dual power supplies is also possible, and the low power supply current drain is independent of the magnitude of the power supply voltage.

## UNIQUE FEATURES

In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage. The unity gain cross frequency is temperature-compensated. The input bias current is also temperature-compensated.

## FEATURES

- Internally frequency-compensated for unity gain
- Large DC voltage gain: 100 dB
- Wide bandwidth (unity gain): 1 MHz (temperature-compensated)
- Wide power supply range single supply:  $3 V_{DC}$  to  $30 V_{DC}$ , or dual supplies:  $\pm 1.5 V_{DC}$  to  $\pm 15 V_{DC}$
- Very low supply current drain ( $400 \mu A$ )—essentially independent of supply voltage ( $1 mW/op amp$  at  $+5 V_{DC}$ )
- Low input biasing current:  $45 nA_{DC}$  temperature-compensated
- Low input offset voltage:  $2 mV_{DC}$ , and offset current:  $5 nA_{DC}$
- Differential input voltage range equal to the power supply voltage
- Large output voltage:  $0 V_{DC}$  to  $V+ 1.5 V_{DC}$  swing

## PIN CONFIGURATION

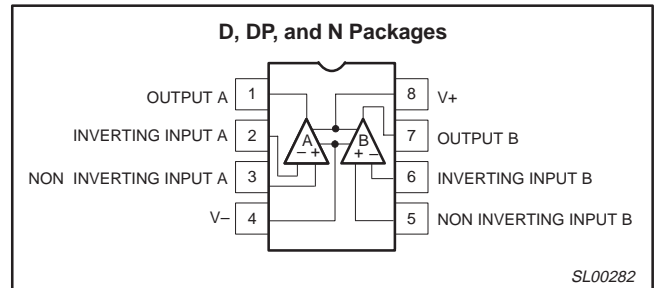


Figure 1. Pin configuration.

## EQUIVALENT CIRCUIT

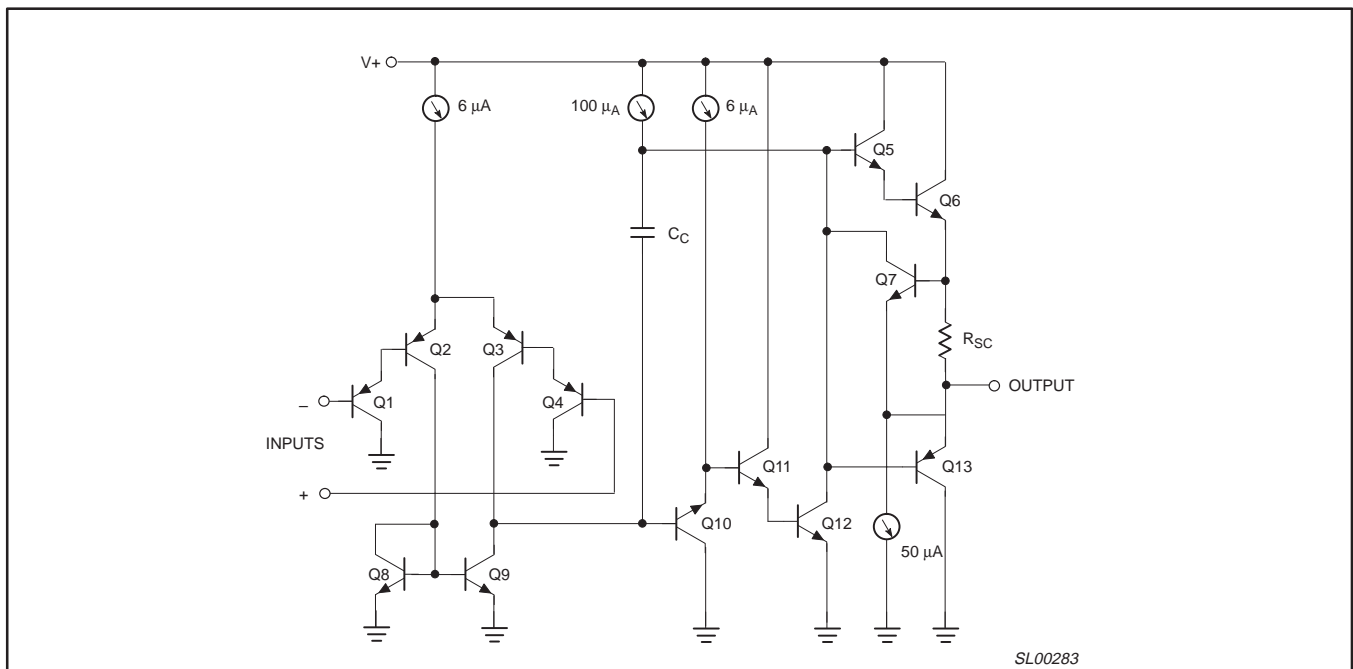


Figure 2. Equivalent circuit.

## Low power dual operational amplifiers

NE/SA/SE532/  
LM258/358/A/2904

## ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Small Outline (SO) Package	0 °C to +70 °C	NE532D	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	0 °C to +70 °C	NE532N	SOT97-1
8-Pin Plastic Small Outline (SO) Package	-40 °C to +85 °C	SA532D	SOT96-1
8-Pin Plastic Small Outline (SO) Package	-40 °C to +125 °C	LM2904D	SOT96-1
8-Pin Plastic Thin Shrink Small Outline Package (TSSOP)	-40 °C to +125 °C	LM2904DP	SOT505-1
8-Pin Plastic Dual In-Line Package (DIP)	-40 °C to +125 °C	LM2904N	SOT97-1
8-Pin Plastic Small Outline (SO) Package	-25 °C to +125 °C	LM258D	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	-25 °C to +125 °C	LM258N	SOT97-1
8-Pin Plastic Small Outline (SO) Package	0 °C to +70 °C	LM358D	SOT96-1
8-Pin Plastic Thin Shrink Small Outline Package (TSSOP)	0 °C to +70 °C	LM358DP	SOT505-1
8-Pin Plastic Dual In-Line Package (DIP)	0 °C to +70 °C	LM358N	SOT97-1
8-Pin Plastic Small Outline (SO) Package	0 °C to +70 °C	LM358AD	SOT96-1
8-Pin Plastic Dual In-Line Package (DIP)	0 °C to +70 °C	LM358AN	SOT97-1
8-Pin Plastic Dual In-Line Package (DIP)	-55 °C to +125 °C	SE532N	SOT97-1

## ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
$V_S$	Supply voltage, V+	32 or $\pm 16$	$V_{DC}$
	Differential input voltage	32	$V_{DC}$
$V_{IN}$	Input voltage	-0.3 to +32	$V_{DC}$
$P_D$	Maximum power dissipation $T_{amb} = 25\text{ °C}$ (Still air) <sup>1</sup> N package D package DP package	1160 780 714	mW mW mW
	Output short-circuit to GND <sup>2</sup> $V_+ < 15 V_{DC}$ and $T_{amb} = 25\text{ °C}$	Continuous	
$T_{amb}$	Operating ambient temperature range NE532/LM358/LM358A LM258 LM2904 SA532 SE532	0 to +70 -25 to +85 -40 to +125 -40 to +85 -55 to +125	°C °C °C °C °C
$T_{stg}$	Storage temperature range	-65 to +150	°C
$T_{sld}$	Lead soldering temperature (10 sec max)	230	°C

## NOTE:

- Derate above 25 °C, at the following rates:  
N package at 9.3 mW/°C  
D package at 6.2 mW/°C  
DP package at 5.72 mW/°C
- Short-circuits from the output to V+ can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of V+. At values of supply voltage in excess of +15  $V_{DC}$ , continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.

## Low power dual operational amplifiers

NE/SA/SE532/  
LM258/358/A/2904

## DC ELECTRICAL CHARACTERISTICS

 $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{+} = +5\text{ V}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	SE532, LM258			NE/SA532/ LM358/LM2904			UNIT
			Min	Typ	Max	Min	Typ	Max	
$V_{OS}$	Offset voltage <sup>1</sup>	$R_S = 0\ \Omega$		$\pm 2$	$\pm 5$		$\pm 2$	$\pm 7$	mV
		$R_S = 0\ \Omega$ ; over temp.			$\pm 7$			$\pm 9$	mV
$V_{OS}$	Drift	$R_S = 0\ \Omega$ ; over temp.		7			7		$\mu\text{V}/^{\circ}\text{C}$
$I_{OS}$	Offset current	$I_{IN(+)} - I_{IN(-)}$		$\pm 3$	$\pm 30$		$\pm 5$	$\pm 50$	nA
		Over temp.			$\pm 100$			$\pm 150$	nA
$I_{OS}$	Drift	Over temp.		10			10		$\text{pA}/^{\circ}\text{C}$
$I_{BIAS}$	Input current <sup>2</sup>	$I_{IN(+)}$ or $I_{IN(-)}$		45	150		45	250	nA
		$I_{IN(+)}$ or $I_{IN(-)}$ ; Over temp.		40	300		40	500	nA
$I_B$	Drift	Over temp.		50			50		$\text{pA}/^{\circ}\text{C}$
$V_{CM}$	Common-mode voltage range <sup>3</sup>	$V_{+} = 30\text{ V}$	0		$V_{+} - 1.5$	0		$V_{+} - 1.5$	V
		$V_{+} = 30\text{ V}$ ; Over temp.	0		$V_{+} - 2.0$	0		$V_{+} - 2.0$	V
CMRR	Common-mode rejection ratio	$V_{+} = 30\text{ V}$	70	85		65	70		dB
$V_{OH}$	Output voltage swing	$R_L \geq 2\text{ k}\Omega$ ; $V_{+} = 30\text{ V}$ ; over temp.	26			26			V
		$R_L \geq 10\text{ k}\Omega$ ; $V_{+} = 30\text{ V}$ ; over temp.	27	28		27	28		V
$V_{OL}$	Output voltage swing	$R_L \geq 10\text{ k}\Omega$ ; over temp.		5	20		5	20	mV
$I_{CC}$	Supply current	$R_L = \infty$ ; $V_{+} = 30\text{ V}$		0.5	1.0		0.5	1.0	mA
		$R_L = \infty$ on all amplifiers; $V_{+} = 30\text{ V}$ ; over temp.		0.6	1.2		0.6	1.2	mA
$A_{VOL}$	Large-signal voltage gain	$R_L \geq 2\text{ k}\Omega$ ; $V_{OUT} \pm 10\text{ V}$	50	100		25	100		V/mV
		$V_{+} = 15\text{ V}$ (for large $V_O$ swing); over temp.	25			15			V/mV
PSRR	Supply voltage rejection ratio	$R_S = 0\ \Omega$	65	100		65	100		dB
	Amplifier-to-amplifier coupling <sup>4</sup>	$f = 1\text{ kHz}$ to $20\text{ kHz}$ (input referred)		-120			-120		dB
$I_{OUT}$	Output current (Source)	$V_{IN+} = +1\text{ V}_{DC}$ ; $V_{IN-} = 0\text{ V}_{DC}$ ; $V_{+} = 15\text{ V}_{DC}$	20	40		20	40		mA
		$V_{IN+} = +1\text{ V}_{DC}$ ; $V_{IN-} = 0\text{ V}_{DC}$ ; $V_{+} = 15\text{ V}_{DC}$ ; over temp.	10	20		10	20		mA
	Output current (Sink)	$V_{IN-} = +1\text{ V}_{DC}$ ; $V_{IN+} = 0\text{ V}_{DC}$ ; $V_{+} = 15\text{ V}_{DC}$	10	20		10	20		mA
		$V_{IN-} = +1\text{ V}_{DC}$ ; $V_{IN+} = 0\text{ V}_{DC}$ ; $V_{+} = 15\text{ V}_{DC}$ ; over temp.	5	8		5	8		mA
		$V_{IN+} = 0\text{ V}$ ; $V_{IN-} = +1\text{ V}_{DC}$ ; $V_O = 200\text{ mV}$	12	50		12	50		$\mu\text{A}$
$I_{SC}$	Short circuit current <sup>5</sup>		40	60		40	60	mA	
	Differential input voltage <sup>6</sup>			$V_{+}$			$V_{+}$	V	
GBW	Unity gain bandwidth	$T_{amb} = 25\text{ }^{\circ}\text{C}$		1			1		MHz
SR	Slew rate	$T_{amb} = 25\text{ }^{\circ}\text{C}$		0.3			0.3		$\text{V}/\mu\text{s}$
$V_{NOISE}$	Input noise voltage	$T_{amb} = 25\text{ }^{\circ}\text{C}$ ; $f = 1\text{ kHz}$		40			40		$\text{nV}/\sqrt{\text{Hz}}$

(Notes on next page).

## Low power dual operational amplifiers

NE/SA/SE532/  
LM258/358/A/2904**DC ELECTRICAL CHARACTERISTICS** (continued) $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_+ = +5\text{ V}$ ; unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LM358A			UNIT
			Min	Typ	Max	
$V_{OS}$	Offset voltage <sup>1</sup>	$R_S = 0\ \Omega$		$\pm 2$	$\pm 3$	mV
		$R_S = 0\ \Omega$ ; over temp.			$\pm 5$	mV
$V_{OS}$	Drift	$R_S = 0\ \Omega$ ; over temp.		7	20	$\mu\text{V}/^{\circ}\text{C}$
$I_{OS}$	Offset current	$I_{IN(+)} - I_{IN(-)}$		5	$\pm 30$	nA
		Over temp.			$\pm 75$	nA
$I_{OS}$	Drift	Over temp.		10	300	$\text{pA}/^{\circ}\text{C}$
$I_{BIAS}$	Input current <sup>2</sup>	$I_{IN(+)} \text{ or } I_{IN(-)}$		45	100	nA
		$I_{IN(+)} \text{ or } I_{IN(-)}$ ; Over temp.		40	200	nA
$I_B$	Drift	Over temp.		50		$\text{pA}/^{\circ}\text{C}$
$V_{CM}$	Common-mode voltage range <sup>3</sup>	$V_+ = 30\text{ V}$	0		$V_+ - 1.5$	V
		$V_+ = 30\text{ V}$ ; Over temp.	0		$V_+ - 2.0$	V
CMRR	Common-mode rejection ratio	$V_+ = 30\text{ V}$	65	85		dB
$V_{OH}$	Output voltage swing	$R_L \geq 2\text{ k}\Omega$ ; $V_+ = 30\text{ V}$ ; over temp.	26			V
		$R_L \geq 10\text{ k}\Omega$ ; $V_+ = 30\text{ V}$ ; over temp.	27	28		V
$V_{OL}$	Output voltage swing	$R_L \geq 10\text{ k}\Omega$ ; over temp.		5	20	mV
$I_{CC}$	Supply current	$R_L = \infty$ , $V_+ = 30\text{ V}$		0.5	1.0	mA
		$R_L = \infty$ on all amplifiers; $V_+ = 30\text{ V}$ ; over temp.		0.6	1.2	mA
$A_{VOL}$	Large-signal voltage gain	$R_L \geq 2\text{ k}\Omega$ ; $V_{OUT} \pm 10\text{ V}$	25	100		V/mV
		$V_+ = 15\text{ V}$ (for large $V_O$ swing); over temp.	15			V/mV
PSRR	Supply voltage rejection ratio	$R_S = 0\ \Omega$	65	100		dB
	Amplifier-to-amplifier coupling <sup>4</sup>	$f = 1\text{ kHz to } 20\text{ kHz}$ (input referred)		-120		dB
$I_{OUT}$	Output current (Source)	$V_{IN+} = +1\text{ V}_{DC}$ ; $V_{IN-} = 0\text{ V}_{DC}$ ; $V_+ = 15\text{ V}_{DC}$	20	40		mA
		$V_{IN+} = +1\text{ V}_{DC}$ ; $V_{IN-} = 0\text{ V}_{DC}$ ; $V_+ = 15\text{ V}_{DC}$ ; over temp.	10	20		mA
	Output current (Sink)	$V_{IN-} = +1\text{ V}_{DC}$ ; $V_{IN+} = 0\text{ V}_{DC}$ ; $V_+ = 15\text{ V}_{DC}$	10	20		mA
		$V_{IN-} = +1\text{ V}_{DC}$ ; $V_{IN+} = 0\text{ V}_{DC}$ ; $V_+ = 15\text{ V}_{DC}$ ; over temp.	5	8		mA
		$V_{IN+} = 0\text{ V}$ ; $V_{IN-} = +1\text{ V}_{DC}$ ; $V_O = 200\text{ mV}$	12	50		$\mu\text{A}$
$I_{SC}$	Short circuit current <sup>5</sup>		40	60		mA
	Differential input voltage <sup>6</sup>			$V_+$		V
GBW	Unity gain bandwidth	$T_{amb} = 25\text{ }^{\circ}\text{C}$		1		MHz
SR	Slew rate	$T_{amb} = 25\text{ }^{\circ}\text{C}$		0.3		V/ $\mu\text{s}$
$V_{NOISE}$	Input noise voltage	$T_{amb} = 25\text{ }^{\circ}\text{C}$ ; $f = 1\text{ kHz}$		40		nV/ $\sqrt{\text{Hz}}$

**NOTES:**

- $V_O \approx 1.4\text{ V}$ ,  $R_S = 0\ \Omega$  with  $V_+$  from  $5\text{ V}$  to  $30\text{ V}$ ; and over the full input common-mode range ( $0\text{ V}$  to  $V_+ - 1.5\text{ V}$ ).
- The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
- The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than  $0.3\text{ V}$ . The upper end of the common-mode voltage range is  $V_+ - 1.5\text{ V}$ , but either or both inputs can go to  $+32\text{ V}$  without damage.
- Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance coupling increases at higher frequencies.
- Short-circuits from the output to  $V_+$  can cause excessive heating and eventual destruction. The maximum output current is approximately  $40\text{ mA}$  independent of the magnitude of  $V_+$ . At values of supply voltage in excess of  $+15\text{ V}_{DC}$ , continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.
- The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than  $0.3\text{ V}$ . The upper end of the common-mode voltage range is  $V_+ - 1.5\text{ V}$ , but either or both inputs can go to  $+32\text{ V}_{DC}$  without damage.

# Low power dual operational amplifiers

NE/SA/SE532/  
LM258/358/A/2904

## TYPICAL PERFORMANCE CHARACTERISTICS

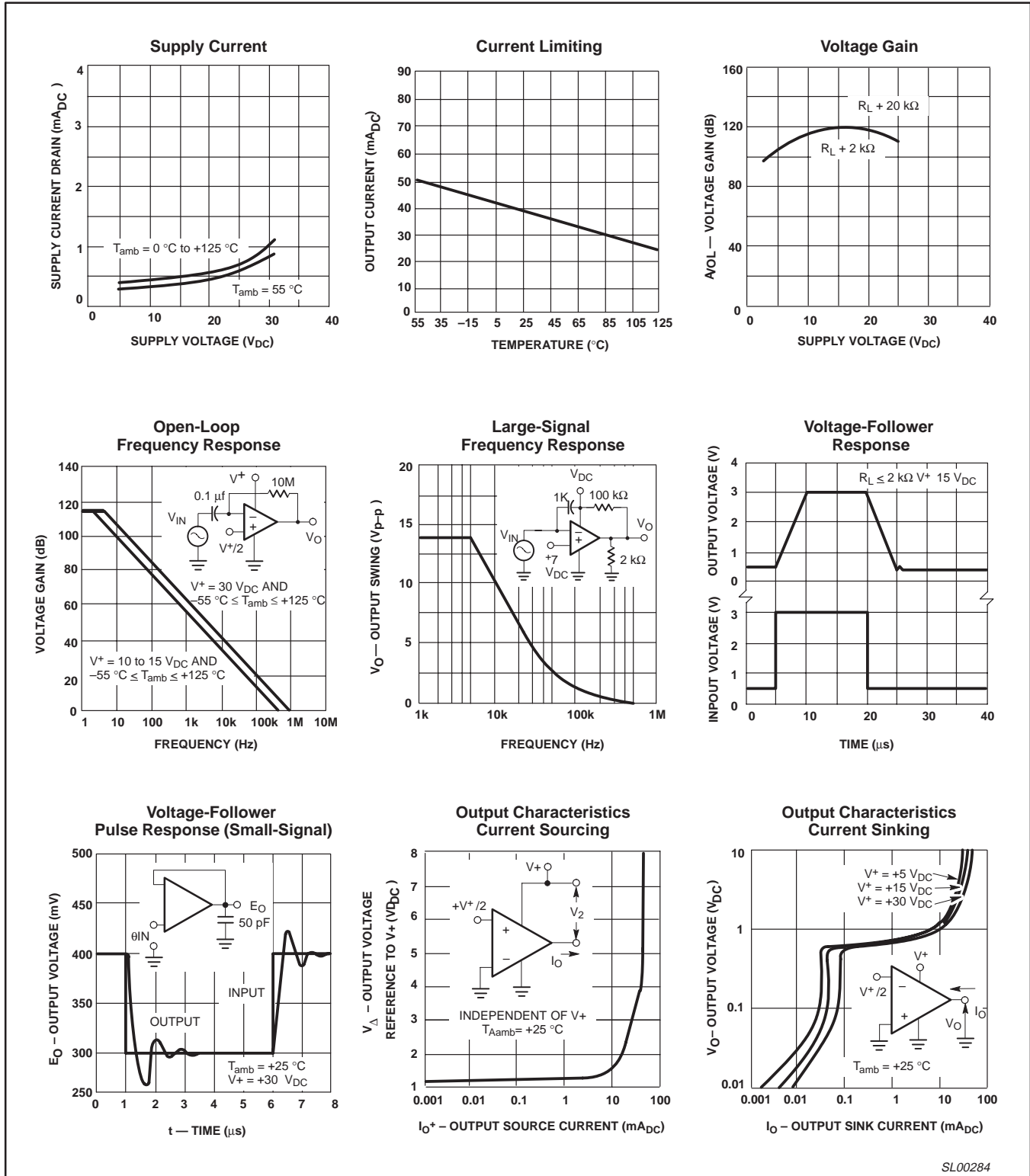


Figure 3. Typical performance characteristics.

# Low power dual operational amplifiers

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## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

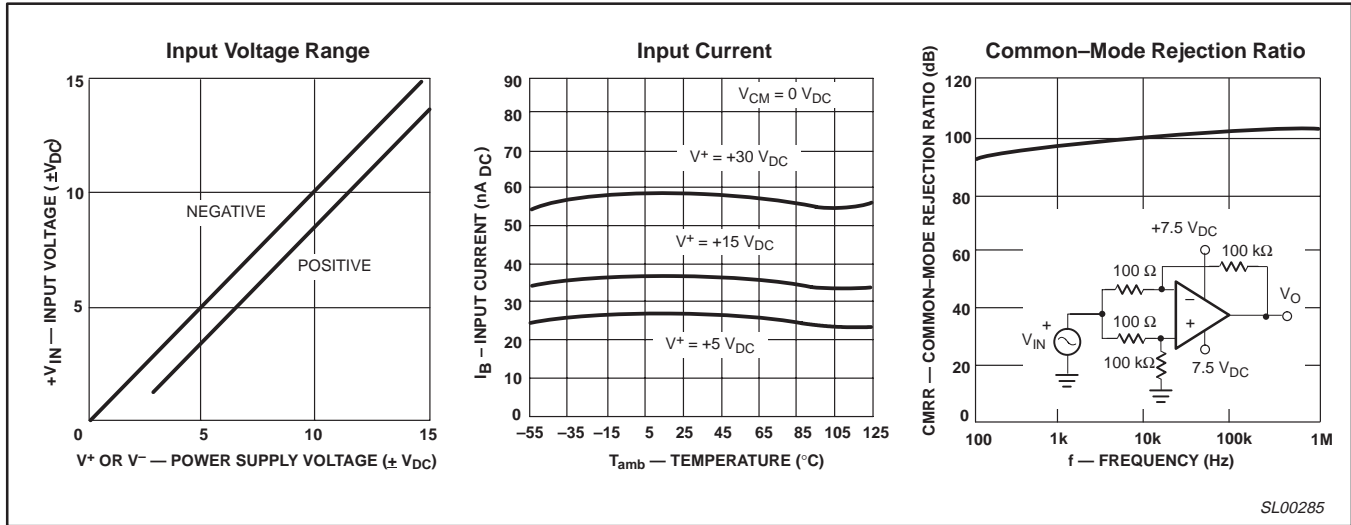


Figure 4. Typical performance characteristics (continued).

## TYPICAL APPLICATIONS

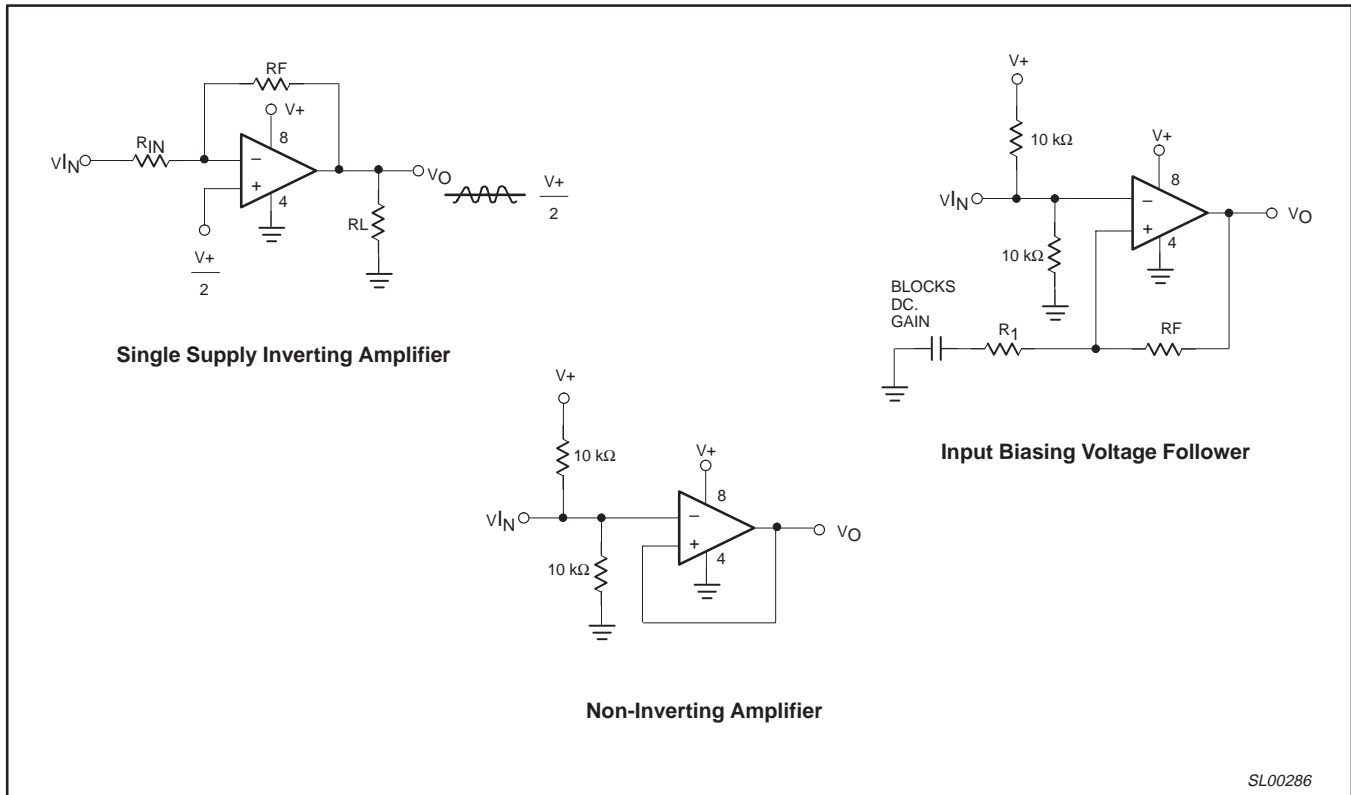


Figure 5. Typical applications.

Low power dual operational amplifiers

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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	HE	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

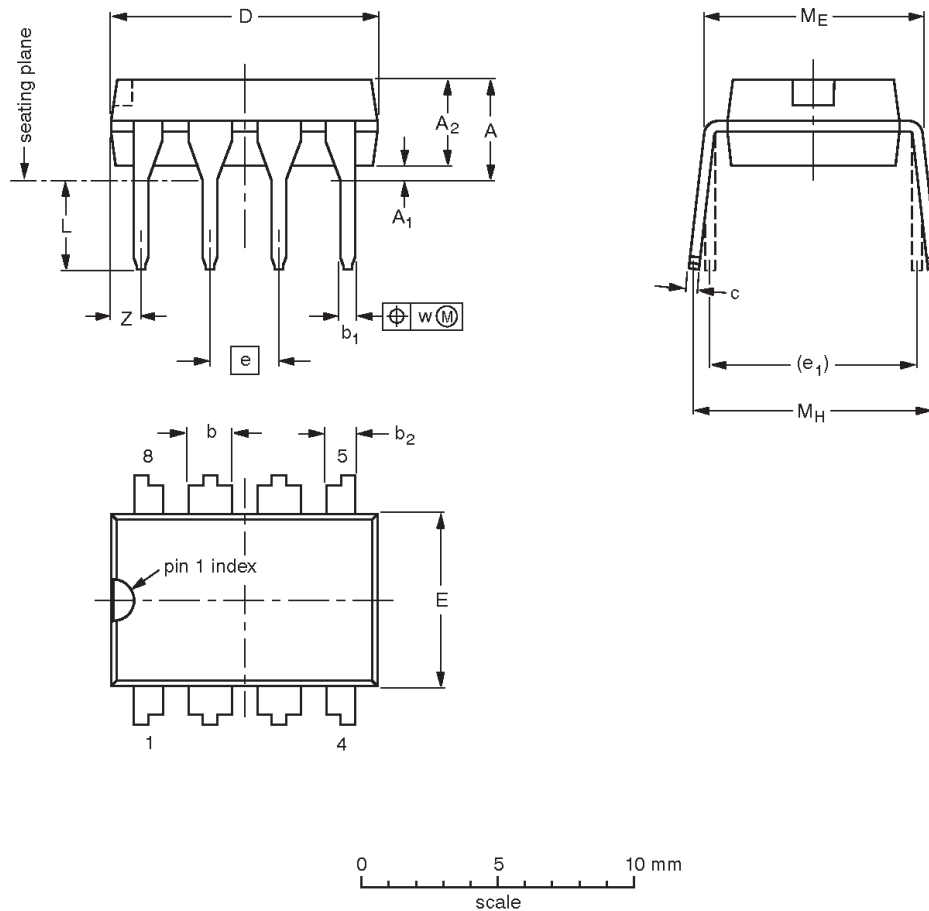


Low power dual operational amplifiers

NE/SA/SE532/  
LM258/358/A/2904

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.

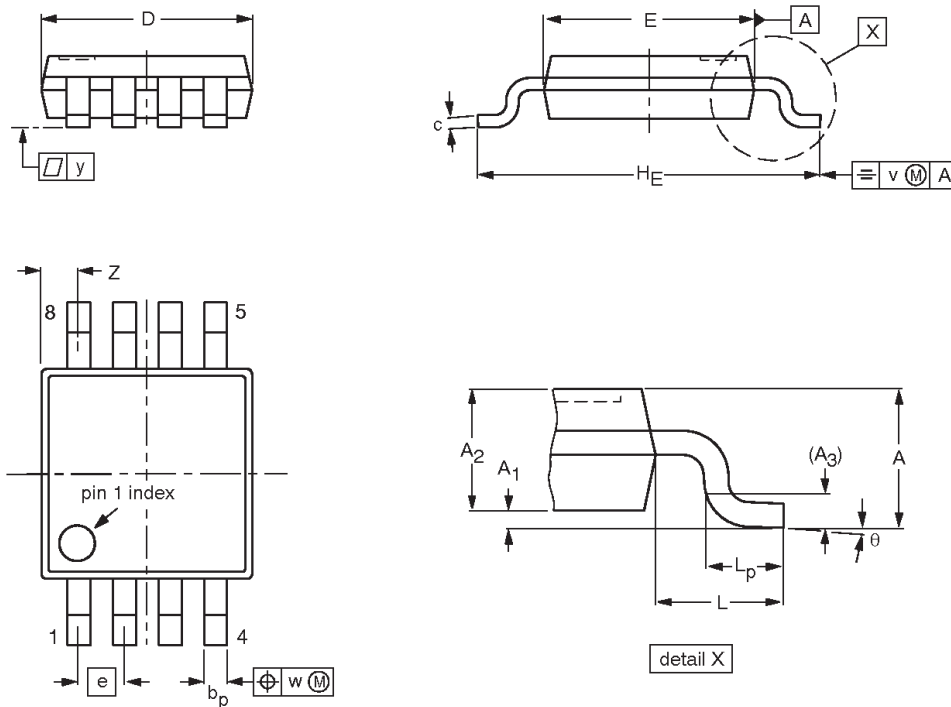
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT97-1	050G01	MO-001	SC-504-8			95-02-04 99-12-27

Low power dual operational amplifiers

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TSSOP8: plastic thin shrink small outline package; 8 leads; body width 3 mm

SOT505-1



**DIMENSIONS (mm are the original 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>	v	w	y	Z <sup>(1)</sup>	θ
mm	1.10	0.15 0.05	0.95 0.80	0.25	0.45 0.25	0.28 0.15	3.10 2.90	3.10 2.90	0.65	5.10 4.70	0.94	0.70 0.40	0.1	0.1	0.1	0.70 0.35	6° 0°

**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			
SOT505-1						99-04-09

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Low power dual operational amplifiers

NE/SA/SE532/  
LM258/358/A/2904

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**NOTES**

## Low power dual operational amplifiers

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LM258/358/A/2904

## Data sheet status

Data sheet status <sup>[1]</sup>	Product status <sup>[2]</sup>	Definitions
Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
Preliminary data	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
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