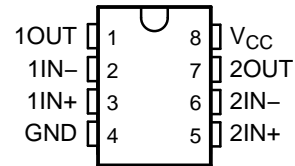


## FEATURES

- Low Supply Current . . . 85  $\mu$ A Typ
- Low Offset Voltage . . . 2 mV Typ
- Low Input Bias Current . . . 2 nA Typ
- Input Common Mode to GND
- Wide Supply Voltage . . . 3 V <  $V_{CC}$  < 32 V
- Pin Compatible With LM358

D OR DGK PACKAGE  
(TOP VIEW)



## APPLICATIONS

- LCD Displays
- Portable Instrumentation
- Sensor/Metering Equipment
- Consumer Electronics (MP3 Players, Toys)
- Power Supplies

## DESCRIPTION/ORDERING INFORMATION

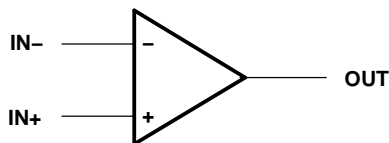
The LP358 and LP2904 are dual low-power operational amplifiers especially suited for battery-operated applications. Good input specifications and wide supply-voltage range still are achieved, despite the ultra-low supply current. Single-supply operation is achieved with an input common-mode range that includes GND.

The LP358 and LP2904 are ideal in applications where wide supply voltage and low power are more important than speed and bandwidth. These applications include portable instrumentation, LCD displays, consumer electronics (MP3 players, toys, etc.), and power supplies.

## ORDERING INFORMATION

$T_A$	PACKAGE <sup>(1)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	SOIC – D	Tube of 75	LP358D	LP358
		Reel of 2500	LP358DR	
	VSSOP – DGK	Tube of 100	LP358DGK	PREVIEW
		Reel of 250	LP358DGKT	
Reel of 2500	LP358DGKR			
–40°C to 85°C	SOIC – D	Tube of 75	LP2904D	PREVIEW
		Reel of 2500	LP2904DR	
	VSSOP – DGK	Tube of 100	LP2904DGK	PREVIEW
		Reel of 250	LP2904DGKT	
		Reel of 2500	LP2904DGKR	

## SYMBOL (EACH AMPLIFIER)



- (1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**SCHEMATIC (EACH AMPLIFIER)**



**Absolute Maximum Ratings<sup>(1)</sup>**

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

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage range <sup>(2)</sup>		±16 or 32	V
V <sub>ID</sub>	Differential input voltage <sup>(3)</sup>		±32	V
V <sub>I</sub>	Input voltage (either input)	-0.3	32	V
Duration of output short circuit (one amplifier) to ground at (or below) T <sub>A</sub> = 25°C, V <sub>CC</sub> ≤ 15 V <sup>(4)</sup>			Unlimited	
θ <sub>JA</sub>	Package thermal impedance <sup>(5)(6)</sup>	D package		°C/W
		DGK package		
T <sub>J</sub>	Operating virtual junction temperature		150	°C
T <sub>stg</sub>	Storage temperature range	-65	150	°C

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values (except differential voltages and V<sub>CC</sub> specified for the measurement of I<sub>OS</sub>) are with respect to the network GND.
- (3) Differential voltages are at IN+, with respect to IN-.
- (4) Short circuits from outputs to V<sub>CC</sub> can cause excessive heating and eventual destruction.
- (5) Maximum power dissipation is a function of T<sub>J(max)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J(max)</sub> - T<sub>A</sub>)/θ<sub>JA</sub>. Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.
- (6) The package thermal impedance is calculated in accordance with JESD 51-7.

**ESD Protection**

TEST CONDITIONS	TYP	UNIT
Human-Body Model	±2	kV

### Electrical Characteristics

$T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V}$ ,  $V_{IC} = V_{CC}/2$ ,  $R_L = 100\text{ k}\Omega$  to GND (unless otherwise noted)

PARAMETER	TEST CONDITIONS <sup>(1)</sup>	$T_A$ <sup>(2)</sup>	LP358			LP2904			UNIT
			MIN	TYP <sup>(3)</sup>	MAX	MIN	TYP <sup>(3)</sup>	MAX	
$V_{IO}$ Input offset voltage		25°C	2		4	2		4	mV
		Full range			9			10	
$I_{IB}$ Input bias current		25°C	2		10	2		20	nA
		Full range			20			40	
$I_{IO}$ Input offset current		25°C	0.2		2	0.5		4	nA
		Full range			4			8	
$A_V$ Large-signal voltage gain	$R_L = 10\text{ k}\Omega$ to GND, $V_{CC} = 30\text{ V}$	25°C	50	100		40	70		V/mV
		Full range	40			30			
CMRR Common-mode rejection ratio	$V_{CC} = 30\text{ V}$ , $V_{IC} = 0\text{ V}$ to $V_{CC} - 1.5\text{ V}$	25°C	80	90		80	90		dB
		Full range	75			75			
$k_{VSR}$ Power-supply rejection ratio	$V_{CC} = 5\text{ V}$ to $30\text{ V}$	25°C	80	90		80	90		V
		Full range	75			75			
$I_{CC}$ Supply current	$R_L = \infty$	25°C		85	150		85	150	$\mu\text{A}$
		Full range			250			275	
$V_{OH}$ Output voltage swing (high)	$I_L = 0.35\text{ mA}$ to GND, $V_{IC} = 0\text{ V}$	25°C	3.4	3.6		3.4	3.6		V
		Full range			$V_{CC} - 1.9$			$V_{CC} - 1.9$	
$V_{OL}$ Output voltage swing (low)	$I_L = 0.35\text{ mA}$ from $V_{CC}$ , $V_{IC} = 0\text{ V}$	25°C	0.82	0.7		0.82	0.7		V
		Full range	1			1			
$I_O$ Output source current	$V_O = 3\text{ V}$ , $V_{ID} = 1\text{ V}$	25°C	7	10		7	10		mA
		Full range	4			4			
$I_O$ Output sink current	$V_O = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$	25°C	4	5		4	5		mA
		Full range	3			3			
	$V_O = 1.5\text{ V}$ , $V_{ID} = -1\text{ V}$ , $V_{IC} = 0\text{ V}$	25°C	2	4		2	4		
		Full range	1			1			
$I_{OS,GND}$ Output short to GND	$V_{ID} = 1\text{ V}$	25°C		20	35		20	35	mA
		Full range			40			40	
$I_{OS,VCC}$ Output short to $V_{CC}$	$V_{ID} = -1\text{ V}$	25°C		15	30		15	30	mA
		Full range			45			45	
$\alpha V_{IO}$ Input offset voltage drift		25°C		10			10	$\mu\text{V}/^\circ\text{C}$	
$\alpha I_{IO}$ Input offset current drift		25°C		10			10	$\text{pA}/^\circ\text{C}$	

(1) For full-range temperature limits:  $V_{CC} = 3\text{ V}$  to  $32\text{ V}$ ,  $V_{ICR} = 0\text{ V}$  to  $V_{CC} - 1.5\text{ V}$  (unless otherwise noted)

(2) Full range is  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for LP358 and  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  for LP2904.

(3) All typical values are at  $T_A = 25^\circ\text{C}$ .

### Operating Conditions

$V_{CC} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$

PARAMETER		TYP	UNIT
GBW	Gain bandwidth product	100	kHz
SR	Slew rate	50	V/ms

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Low Power Wireless	<a href="http://www.ti.com/lpw">www.ti.com/lpw</a>	Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
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**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
LP2904D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2904DE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2904DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2904DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP2904DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP358D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP358DE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP358DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP358DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP358DRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LP358DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

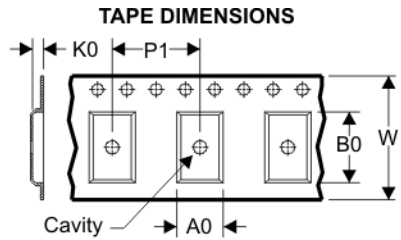
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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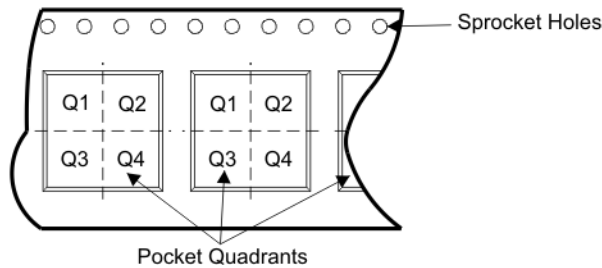
to Customer on an annual basis.

**TAPE AND REEL BOX INFORMATION**



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



Device	Package	Pins	Site	Reel Diameter (mm)	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LP2904DR	D	8	SITE 27	330	12	6.4	5.2	2.1	8	12	Q1
LP358DR	D	8	SITE 27	330	12	6.4	5.2	2.1	8	12	Q1

**TAPE AND REEL BOX DIMENSIONS**

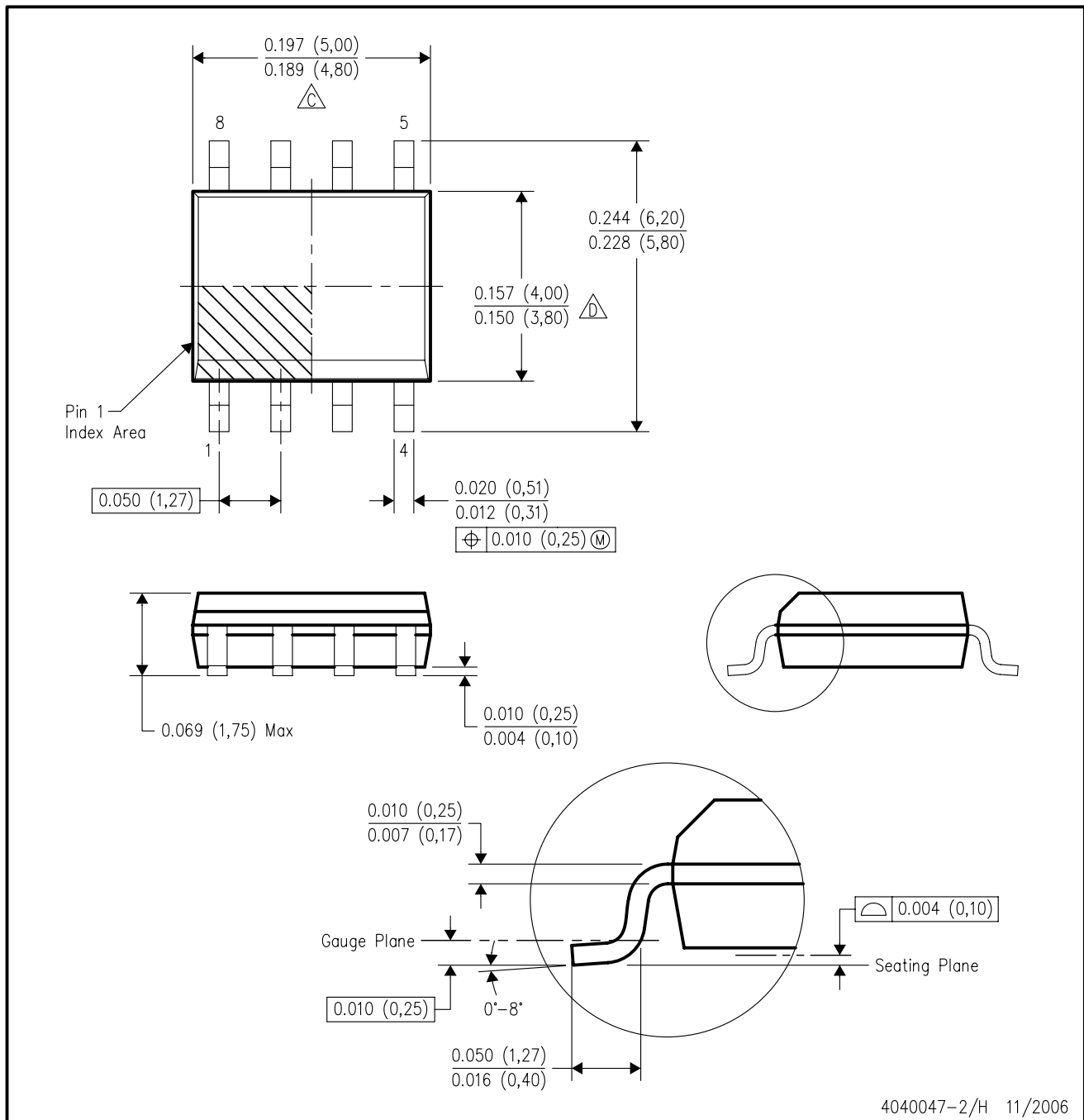


Device	Package	Pins	Site	Length (mm)	Width (mm)	Height (mm)
LP2904DR	D	8	SITE 27	342.9	336.6	20.64
LP358DR	D	8	SITE 27	342.9	336.6	20.64



D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
  - E. Reference JEDEC MS-012 variation AA.