

## High-Output Drive Rail-to-Rail Op Amp

### Features

- Small Footprint SOT-23-5 and Power MSOP-8 Packages
- >80 mA Peak Output Sink and Source with 5V Supply
- Drives Large Capacitive Loads (6000 pF with 10V Supply)
- Guaranteed 2.2V, 3V, 5V, and 10V Performance
- 500 kHz Gain-Bandwidth Product
- 0.01% Total Harmonic Distortion at 1 kHz (10V, 2 k $\Omega$ )
- 1 mA Typical Power Supply Current at 5V

### Applications

- Battery-Powered Instrumentation
- PCMCIA, USB Peripherals
- Portable Computers and PDAs

### General Description

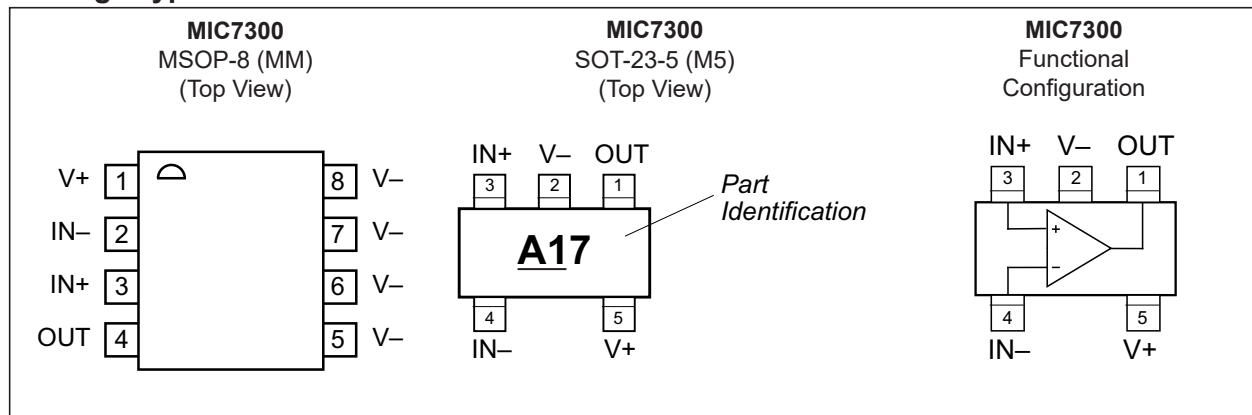
The MIC7300 is a high-performance CMOS operational amplifier featuring rail-to-rail input and output with strong output drive capability. It is able to source and sink in excess of 80 mA into large capacitive loads.

The input common-mode range extends beyond the rails by 300 mV, and the output voltage typically swings to within 150  $\mu$ V of both rails when driving a 100 k $\Omega$  load.

The amplifier operates from 2.2V to 10V and is fully specified at 2.2V, 3V, 5V, and 10V. Gain bandwidth and slew rate are 500 kHz and 0.5 V/ $\mu$ s, respectively.

The MIC7300 is available in the IttyBitty SOT-23-5 package for space-conscious circuits and in high-power MM8 8-lead MSOP for improved heat dissipation in higher power applications.

### Package Types



# MIC7300

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

Supply Voltage, ( $V_{V+} - V_{V-}$ )	12V
Differential Input Voltage ( $V_{IN+} - V_{IN-}$ )	$\pm 12V$
I/O Pin Voltage, ( $V_{IN}, V_{OUT}$ ) (Note 1)	$V_{V+} + 0.3V$ to $V_{V-} - 0.3V$
ESD Protection On All Pins	Note 2

### Operating Ratings ††

Supply Voltage, ( $V_{V+} - V_{V-}$ )	2.2V to 10V
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† Notice: Exceeding the absolute maximum rating may damage the device.

†† Notice: The device is not guaranteed to function outside its operating rating.

Note 1: I/O Pin Voltage is any external voltage to which an input or output is referenced.

2: Devices are ESD protected; however, handling precautions are recommended.

### DC CHARACTERISTICS (2.2V)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +2.2V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ .

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	$V_{OS}$	—	1.0	9	mV	—
Input Offset Voltage Average Drift	$TCV_{OS}$	—	1.0	—	$\mu\text{V}/^\circ\text{C}$	—
Input Bias Current	$I_B$	—	0.5	—	pA	—
Input Offset Current	$I_{OS}$	—	0.25	—	pA	—
Input Resistance	$R_{IN}$	—	>1	—	$\text{T}\Omega$	—
Common-Mode Rejection Ratio	CMRR	45	65	—	dB	$0V \leq V_{CM} \leq 2.2V$ , (Note 1)
Input Common-Mode Voltage	$V_{CM}$	—	-0.3	0.0	V	Input low, CMRR $\geq 45$ dB
		2.2	2.5	—	V	Input high, CMRR $\geq 45$ dB
Power Supply Rejection Ratio	PSRR	55	75	—	dB	$V_{V+} =  V_{V-}  = 1.1V$ to $2.5V$ , $V_{CM} = 0$
Common-Mode Input Capacitance	$C_{IN}$	—	3	—	pF	—

Note 1: CMRR is determined as follows: The maximum  $\Delta V_{OS}$  over the  $V_{CM}$  range is divided by the magnitude of the  $V_{CM}$  range. The measurement points are:  $V_{V-}$ ,  $(V_{V+} - V_{V-})/2$ , and  $V_{V+}$ .

2: Continuous short circuit may exceed absolute maximum  $T_J$  under some conditions.

## DC CHARACTERISTICS (2.2V) (CONTINUED)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +2.2V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ .

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Swing	$V_{OUT}$	—	0.15	1	mV	Output high, $R_L = 100\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	1	mV	Output high, $R_L = 100\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	0.15	1	mV	Output low, $R_L = 100\text{ k}\Omega$
		—	—	1	mV	Output low, $R_L = 100\text{ k}\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	10	33	mV	Output high, $R_L = 2\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	50	mV	Output high, $R_L = 2\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	10	33	mV	Output low, $R_L = 2\text{ k}\Omega$
		—	—	50	mV	Output low, $R_L = 2\text{ k}\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	33	110	mV	Output high, $R_L = 600\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	165	mV	Output high, $R_L = 600\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	33	110	mV	Output low, $R_L = 600\Omega$
		—	—	165	mV	Output low, $R_L = 600\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
Output Short Circuit Current	$I_{SC}$	20	40	—	mA	Sinking or sourcing (Note 2)
Supply Current	$I_S$	—	0.7	2.0	mA	$V_{OUT} = V+/2$

**Note 1:** CMRR is determined as follows: The maximum  $\Delta V_{OS}$  over the  $V_{CM}$  range is divided by the magnitude of the  $V_{CM}$  range. The measurement points are:  $V_{V-}$ ,  $(V_{V+} - V_{V-})/2$ , and  $V_{V+}$ .

**2:** Continuous short circuit may exceed absolute maximum  $T_J$  under some conditions.

## AC CHARACTERISTICS (2.2V)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +2.2V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ , Note 1.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Slew Rate	SR	—	0.5	—	V/ $\mu\text{s}$	—
Gain-Bandwidth Product	GBWP	—	0.55	—	MHz	—
Phase Margin	$\phi_m$	—	80	—	$^\circ$	$C_L = 0\text{ pF}$
		—	40	—	$^\circ$	$C_L = 2500\text{ pF}$
Gain Margin	$G_m$	—	10	—	dB	—

**Note 1:** All limits guaranteed by testing or statistical analysis.

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## DC CHARACTERISTICS (3.0V)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +3.0V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ .

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	$V_{OS}$	—	1.0	9	mV	—
Input Offset Voltage Average Drift	$TCV_{OS}$	—	1.0	—	$\mu\text{V}/^\circ\text{C}$	—
Input Bias Current	$I_B$	—	0.5	—	pA	—
Input Offset Current	$I_{OS}$	—	0.25	—	pA	—
Input Resistance	$R_{IN}$	—	>1	—	T $\Omega$	—
Common-Mode Rejection Ratio	CMRR	50	70	—	dB	$0V \leq V_{CM} \leq 3.0V$ , (Note 1)
Input Common-Mode Voltage	$V_{CM}$	—	-0.3	0.0	V	Input low, CMRR $\geq 50$ dB
		3.0	3.3	—	V	Input high, CMRR $\geq 50$ dB
Power Supply Rejection Ratio	PSRR	55	75	—	dB	$V_{V+} =  V_{V-}  = 1.5V$ to $5.0V$ , $V_{CM} = 0$
Common-Mode Input Capacitance	$C_{IN}$	—	3	—	pF	—
Output Swing	$V_{OUT}$	—	0.2	1	mV	Output high, $R_L = 100\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	1	mV	Output high, $R_L = 100\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	0.2	1	mV	Output low, $R_L = 100\text{ k}\Omega$
		—	—	1	mV	Output low, $R_L = 100\text{ k}\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	10	33	mV	Output high, $R_L = 2\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	50	mV	Output high, $R_L = 2\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	10	33	mV	Output low, $R_L = 2\text{ k}\Omega$
		—	—	50	mV	Output low, $R_L = 2\text{ k}\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	33	110	mV	Output high, $R_L = 600\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	165	mV	Output high, $R_L = 600\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	33	110	mV	Output low, $R_L = 600\Omega$
		—	—	165	mV	Output low, $R_L = 600\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$

**Note 1:** CMRR is determined as follows: The maximum  $\Delta V_{OS}$  over the  $V_{CM}$  range is divided by the magnitude of the  $V_{CM}$  range. The measurement points are:  $V_{V-}$ ,  $(V_{V+} - V_{V-})/2$ , and  $V_{V+}$ .

**2:** Continuous short circuit may exceed absolute maximum  $T_J$  under some conditions.

## DC CHARACTERISTICS (3.0V) (CONTINUED)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +3.0V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ .

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Short Circuit Current	$I_{SC}$	60	95	—	mA	Sinking or sourcing (Note 2)
Supply Current	$I_S$	—	0.8	2.2	mA	—

**Note 1:** CMRR is determined as follows: The maximum  $\Delta V_{OS}$  over the  $V_{CM}$  range is divided by the magnitude of the  $V_{CM}$  range. The measurement points are:  $V_{V-}$ ,  $(V_{V+} - V_{V-})/2$ , and  $V_{V+}$ .

**2:** Continuous short circuit may exceed absolute maximum  $T_J$  under some conditions.

## AC CHARACTERISTICS (3.0V)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +3.0V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = 1.5V$ ,  $V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ . Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Slew Rate	SR	—	0.5	—	V/ $\mu\text{s}$	—
Gain-Bandwidth Product	GBWP	—	0.45	—	MHz	—
Phase Margin	$\phi_m$	—	85	—	$^\circ$	$C_L = 0\text{ pF}$
		—	40	—	$^\circ$	$C_L = 3500\text{ pF}$
Gain Margin	$G_m$	—	10	—	dB	—

**Note 1:** All limits guaranteed by testing or statistical analysis.

## DC ELECTRICAL CHARACTERISTICS (5.0V)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +5.0V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = 1.5V$ ,  $V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ .

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	$V_{OS}$	—	1.0	9	mV	—
Input Offset Voltage Average Drift	$TCV_{OS}$	—	1.0	—	$\mu\text{V}/^\circ\text{C}$	—
Input Bias Current	$I_B$	—	0.5	—	pA	—
Input Offset Current	$I_{OS}$	—	0.25	—	pA	—
Input Resistance	$R_{IN}$	—	>1	—	T $\Omega$	—
Common-Mode Rejection Ratio	CMRR	55	80	—	dB	$0V \leq V_{CM} \leq 5V$ , Note 1
Input Common-Mode Voltage	$V_{CM}$	—	−0.3	−0.0	V	Input low, CMRR $\geq 55\text{ dB}$
		5.0	5.3	—	V	Input high, CMRR $\geq 55\text{ dB}$
Power Supply Rejection Ratio	$\pm\text{PSRR}$	55	75	—	dB	$V_{V+} =  V_{V-}  = 2.5V\text{ to }5.0V$ , $V_{CM} = 0$
Common-Mode Input Capacitance	$C_{IN}$	—	3	—	pF	—

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## DC ELECTRICAL CHARACTERISTICS (5.0V) (CONTINUED)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +5.0V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = 1.5V$ ,  $V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ .

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Output Swing	$V_{OUT}$	—	0.3	1.0	mV	Output high, $R_L = 100\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	1.5	mV	Output high, $R_L = 100\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	0.3	1.0	mV	Output low, $R_L = 100\text{ k}\Omega$
		—	—	1.5	mV	Output low, $R_L = 100\text{ k}\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	15	50	mV	Output high, $R_L = 2\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	75	mV	Output high, $R_L = 2\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	15	50	mV	Output low, $R_L = 2\text{ k}\Omega$
		—	—	75	mV	Output low, $R_L = 2\text{ k}\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	50	165	mV	Output high, $R_L = 600\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	250	mV	Output high, $R_L = 600\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	50	165	mV	Output low, $R_L = 600\Omega$
		—	—	250	mV	Output low, $R_L = 600\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
Output Short Circuit Current	$I_{SC}$	85	105	—	mA	Sinking or sourcing (Note 2)
Supply Current	$I_S$	—	1.0	2.8	mA	$V_{OUT} = V+ / 2$

**Note 1:** CMRR is determined as follows: The maximum  $\Delta V_{OS}$  over the  $V_{CM}$  range is divided by the magnitude of the VCM range. The measurement points are:  $V_{V-}$ ,  $(V_{V+} - V_{V-})/2$ , and  $V_{V+}$ .

**2:** Continuous short circuit may exceed absolute maximum  $T_J$  under some conditions.

## AC ELECTRICAL CHARACTERISTICS (5V)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +5.0V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = 1.5V$ ,  $V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ , Note 1.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Total Harmonic Distortion	THD	—	0.05	—	%	$f = 1\text{ kHz}$ , $A_V = -2$ , $R_L = 2\text{ k}\Omega$ , $V_{OUT} = 4.0V_{PP}$
Slew Rate	SR	—	0.5	—	V/ $\mu\text{s}$	—
Gain-Bandwidth Product	GBWP	—	0.4	—	MHz	—
Phase Margin	$\phi_m$	—	85	—	$^\circ$	$C_L = 0\text{ pF}$
		—	40	—	$^\circ$	$C_L = 4500\text{ pF}$
Gain Margin	$G_m$	—	10	—	dB	—

**Note 1:** All limits guaranteed by testing or statistical analysis.

## DC ELECTRICAL CHARACTERISTICS (10V)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +10V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = 1.5V$ ,  $V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ , [Note 1](#).

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Input Offset Voltage	$V_{OS}$	—	1.0	9	mV	—
Input Offset Voltage Average Drift	$TCV_{OS}$	—	1.0	—	$\mu\text{V}/^\circ\text{C}$	—
Input Bias Current	$I_B$	—	0.5	—	pA	—
Input Offset Current	$I_{OS}$	—	0.25	—	pA	—
Input Resistance	$R_{IN}$	—	>1	—	T $\Omega$	—
Common-Mode Rejection Ratio	CMRR	60	85	—	dB	$0V \leq V_{CM} \leq 10V$ , <a href="#">Note 2</a>
Input Common-Mode Voltage	$V_{CM}$	—	-0.3	-0.0	V	Input low, $V_+ = 10V$ , CMRR $\geq 60$ dB
		10.0	10.3	—	V	Input high, $V_+ = 10V$ , CMRR $\geq 60$ dB
Power Supply Rejection Ratio	PSRR	55	75	—	dB	$V_{V+} =  V_{V-}  = 2.5V$ to $5.0V$ , $V_{CM} = 0$
Large Signal Voltage Gain	$A_V$	80	340	—	V/mV	Sourcing or sinking, $R_L = 2\text{ k}\Omega$ , <a href="#">Note 3</a>
		15	300	—	V/mV	Sourcing or sinking, $R_L = 600\Omega$ , <a href="#">Note 3</a>
Common-Mode Input Capacitance	$C_{IN}$	—	3	—	pF	—
Output Swing	$V_{OUT}$	—	0.5	1.5	mV	Output high, $R_L = 100\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	2.5	mV	Output high, $R_L = 100\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	0.5	1.5	mV	Output low, $R_L = 100\text{ k}\Omega$
		—	—	2.5	mV	Output low, $R_L = 100\text{ k}\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	24	80	mV	Output high, $R_L = 2\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	120	mV	Output high, $R_L = 2\text{ k}\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	24	80	mV	Output low, $R_L = 2\text{ k}\Omega$
		—	—	120	mV	Output low, $R_L = 2\text{ k}\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	80	270	mV	Output high, $R_L = 600\Omega$ , specified as $V_{V+} - V_{OUT}$
		—	—	400	mV	Output high, $R_L = 600\Omega$ , specified as $V_{V+} - V_{OUT}$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$
		—	80	270	mV	Output low, $R_L = 600\Omega$
		—	—	400	mV	Output low, $R_L = 600\Omega$ , $-40^\circ\text{C} \leq T_J \leq +85^\circ\text{C}$

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## DC ELECTRICAL CHARACTERISTICS (10V) (CONTINUED)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = +10V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = 1.5V$ ,  $V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ , [Note 1](#).

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Output Short Circuit Current	$I_{SC}$	90	115	—	mA	Sinking or sourcing ( <a href="#">Note 4</a> )
Supply Current	$I_S$	—	1.5	4.0	mA	$V_{OUT} = V+/2$

**Note 1:** All limits guaranteed by testing or statistical analysis.

**2:** CMRR is determined as follows: The maximum  $\Delta V_{OS}$  over the  $V_{CM}$  range is divided by the magnitude of the  $V_{CM}$  range. The measurement points are:  $V_{V-}$ ,  $(V_{V+} - V_{V-})/2$ , and  $V_{V+}$ .

**3:**  $R_L$  connected to 5V. Sourcing:  $5V \leq V_{OUT} \leq 10V$ . Sinking:  $2.5V \leq V_{OUT} \leq 5V$ .

**4:** Continuous short circuit may exceed absolute maximum  $T_J$  under some conditions..

## AC ELECTRICAL CHARACTERISTICS (10V)

**Electrical Characteristics:** Unless otherwise indicated,  $V_{V+} = 10V$ ,  $V_{V-} = 0V$ ,  $V_{CM} = 1.5V$ ,  $V_{OUT} = V_{V+}/2$ ;  $R_L = 1\text{ M}\Omega$ ;  $T_J = 25^\circ\text{C}$ , [Note 1](#).

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Total Harmonic Distortion	THD	—	0.01	—	%	$f = 1\text{ kHz}$ , $A_V = -2$ , $R_L = 2\text{ k}\Omega$ , $V_{OUT} = 8.5V_{PP}$
Slew Rate	SR	—	0.5	—	V/ $\mu\text{s}$	$V+ = 10V$ , <a href="#">Note 2</a>
Gain-Bandwidth Product	GBWP	—	0.37	—	MHz	—
Phase Margin	$\phi_m$	—	85	—	$^\circ$	$C_L = 0\text{ pF}$
		—	40	—	$^\circ$	$C_L = 6000\text{ pF}$
Gain Margin	$G_m$	—	10	—	dB	—
Input-Referred Voltage Noise	$e_n$	—	37	—	nV/ $\sqrt{\text{Hz}}$	$f = 1\text{ kHz}$ , $V_{CM} = 1V$
Input-Referred Current Noise	$i_n$	—	1.5	—	fA/ $\sqrt{\text{Hz}}$	$f = 1\text{ kHz}$

**Note 1:** All limits guaranteed by testing or statistical analysis.

**2:** Device connected as a voltage follower with a 10V step input. The value is the positive or negative slew rate, whichever is slower.

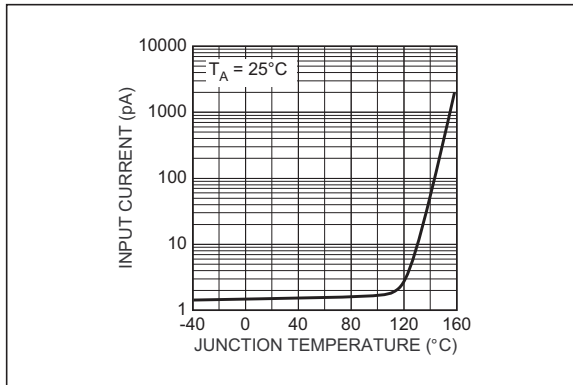
## TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Junction Operating Temperature	$T_J$	-40	—	+85	$^\circ\text{C}$	—
Maximum Junction Temperature	$T_J$	—	—	+150	$^\circ\text{C}$	—
Storage Temperature Range	$T_S$	-65	—	+150	$^\circ\text{C}$	—
Lead Temperature	—	—	+260	—	$^\circ\text{C}$	soldering, 10 sec.
<b>Package Thermal Resistances</b>						
Thermal Resistance, SOT-23-5Ld	$\theta_{JA}$	—	260	—	$^\circ\text{C/W}$	—
Thermal Resistance, MSOP-8Ld	$\theta_{JA}$	—	85	—	$^\circ\text{C/W}$	—

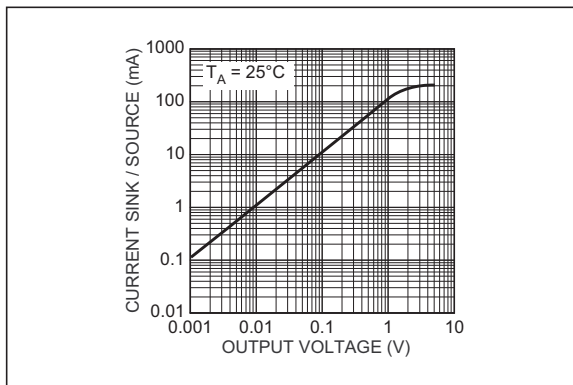


## 2.0 TYPICAL PERFORMANCE CURVES

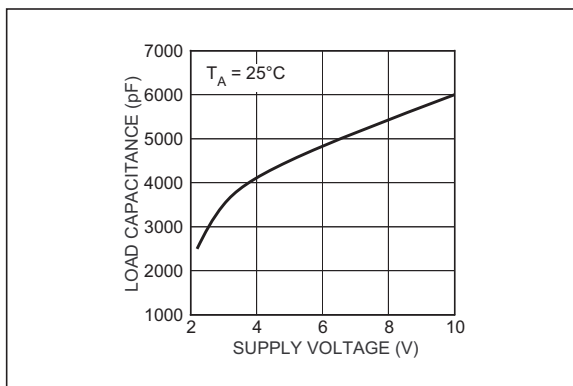
**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.



**FIGURE 2-1:** *Input Current vs. Junction Temperature.*



**FIGURE 2-2:** *Sink/Source Currents vs. Output Voltage.*



**FIGURE 2-3:** *Capacitive Load Capability vs. Supply Voltage.*

# MIC7300

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## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in [Table 3-1](#).

**TABLE 3-1: PIN FUNCTION TABLE**

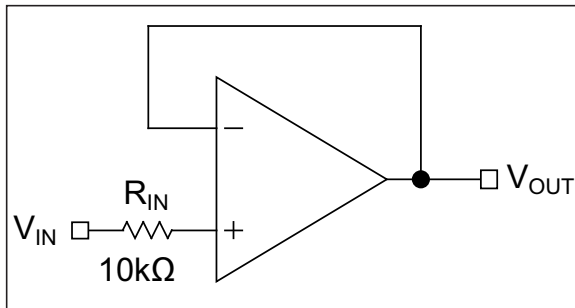
MIC7300 MSOP-8	MIC7300 SOT-23-5	Symbol	Description
4	1	OUT	Amplifier Output.
5-8	2	V-	Negative Supply. Negative supply for split-supply application or ground for single-supply application.
3	3	IN+	Noninverting Input.
2	4	IN-	Inverting Input.
1	5	V+	Positive Supply.

## 4.0 APPLICATION INFORMATION

### 4.1 Input Common-Mode Voltage

The MIC7300 tolerates input overdrive by at least 300 mV beyond either rail without producing phase inversion.

If the absolute maximum input voltage is exceeded, the input current should be limited to  $\pm 5$  mA maximum to prevent reducing reliability. A 10 k $\Omega$  series input resistor, used as a current limiter, will protect the input structure from voltages as large as 50V above the supply or below ground. See [Figure 4-1](#).



**FIGURE 4-1:** Input Current-Limit Protection.

### 4.2 Output Voltage Swing

Sink and source output resistances of the MIC7300 are equal. Maximum output voltage swing is determined by the load and the approximate output resistance. The output resistance is shown in [Equation 4-1](#).

#### EQUATION 4-1:

$$R_{OUT} = \frac{V_{DROP}}{I_{LOAD}}$$

V<sub>DROP</sub> is the voltage dropped within the amplifier output stage. V<sub>DROP</sub> and I<sub>LOAD</sub> can be determined from the V<sub>O</sub> (output swing) portion of the appropriate [Electrical Characteristics](#) table. I<sub>LOAD</sub> is equal to the typical output high voltage minus V<sub>+/2</sub> and divided by R<sub>LOAD</sub>. For example, using the 5V table, the typical output high voltage using a 2 k $\Omega$  load (connected to V<sub>+/2</sub>) is 4.985V, which produces an I<sub>LOAD</sub> of:

#### EQUATION 4-2:

$$\left( \frac{4.985V - 2.5V}{2k\Omega} \right) = 1.243mA$$

Voltage drop in the amplifier output stage is:

#### EQUATION 4-3:

$$V_{DROP} = 5.0V - 4.985V = 0.015V$$

Because of output stage symmetry, the corresponding typical output low voltage (0.015V) also equals V<sub>DROP</sub>. Then:

#### EQUATION 4-4:

$$R_{OUT} = \frac{0.015V}{0.001243A} = 12\Omega$$

### 4.3 Power Dissipation

The MIC7300 output drive capability requires considering power dissipation. If the load impedance is low, it is possible to damage the device by exceeding the maximum junction temperature rating.

On-chip power consists of two components: supply power and output stage power. Supply power (P<sub>S</sub>) is the product of the supply voltage (V<sub>S</sub> = V<sub>V+</sub> - V<sub>V-</sub>) and supply current (I<sub>S</sub>).

Output stage power (P<sub>O</sub>) is the product of the output stage voltage drop (V<sub>DROP</sub>) and the output (load) current (I<sub>OUT</sub>). Total on-chip power dissipation is:

#### EQUATION 4-5:

$$P_D = P_S + P_O$$

Where:

P<sub>D</sub> = Total on-chip power

P<sub>S</sub> = Supply power dissipation

P<sub>O</sub> = Output power dissipation

#### EQUATION 4-6:

$$P_D = V_S I_S + V_{DROP} I_{OUT}$$

Where:

V<sub>S</sub> = V<sub>V+</sub> - V<sub>V-</sub>

I<sub>S</sub> = Power supply current

V<sub>DROP</sub> = V<sub>V+</sub> - V<sub>OUT</sub> (sourcing current)

V<sub>DROP</sub> = V<sub>OUT</sub> - V<sub>V-</sub> (sinking current)

[Equation 4-5](#) and [4-6](#) address only steady state (DC) conditions. For non-DC conditions the user must estimate power dissipation based on the RMS value of the signal.

The task is one of determining the allowable on-chip power dissipation for operation at a given ambient temperature and power supply voltage. From this

# MIC7300

determination, one may calculate the maximum allowable power dissipation and, after subtracting  $P_S$ , determine the maximum allowable load current, which in turn can be used to determine the minimum load impedance that may safely be driven. The calculation is summarized below.

## EQUATION 4-7:

$$P_{D(max)} = \frac{T_{J(max)} - T_A}{\theta_{JA}}$$

$$\theta_{JA(SOT-23-5)} = 260^\circ\text{C/W}$$

$$\theta_{JA(MSOP-8)} = 85^\circ\text{C/W}$$

## 4.4 Driving Capacitive Loads

Driving a capacitive load introduces phase-lag into the output signal, and this in turn reduces op-amp system phase margin. The application that is least forgiving of reduced phase margin is a unity gain amplifier. The MIC7300 can typically drive a 2500 pF capacitive load connected directly to the output when configured as a unity-gain amplifier and powered with a 2.2V supply. At 10V operation the circuit typically drives 6000 pF. Phase margin is typically 40 degrees.

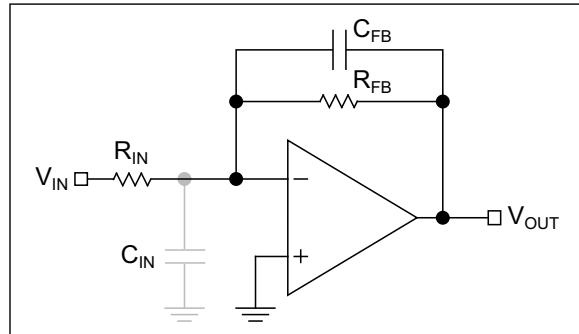
## 4.5 Using Large-Value Feedback Resistors

A large-value feedback resistor ( $> 500 \text{ k}\Omega$ ) can reduce the phase margin of a system. This occurs when the feedback resistor acts in conjunction with input capacitance to create phase lag in the feedback signal. Input capacitance is usually a combination of input circuit components and other parasitic capacitance, such as amplifier input capacitance and stray printed circuit board capacitance.

Figure 4-2 illustrates a method of compensating phase lag caused by using a large-value feedback resistor. Feedback capacitor  $C_{FB}$  introduces sufficient phase lead to overcome the phase lag caused by feedback resistor  $R_{FB}$  and input capacitance  $C_{IN}$ . The value of  $C_{FB}$  is determined by first estimating  $C_{IN}$  and then applying the following formula shown in Equation 4-8:

## EQUATION 4-8:

$$R_{IN} \times C_{IN} \leq R_{FB} \times C_{FB}$$

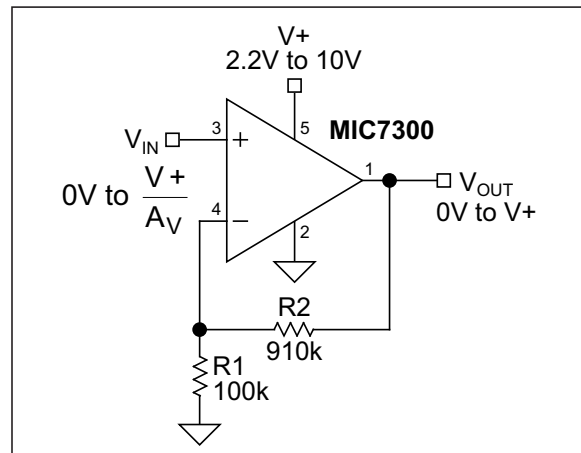


**FIGURE 4-2:** Canceling Feedback Phase Lag.

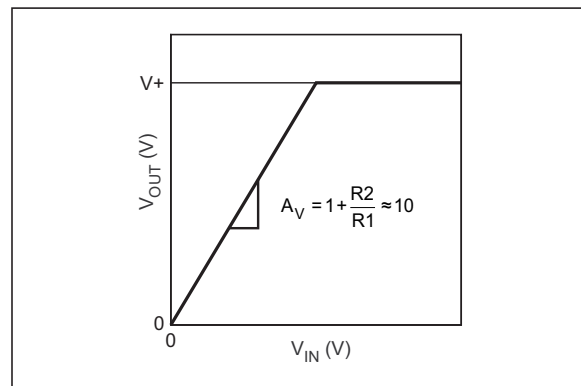
Because a significant percentage of  $C_{IN}$  may be caused by board layout, it is important to note that the correct value of  $C_{FB}$  may change when changing from a breadboard to the final circuit layout.

## 4.6 Typical Circuits

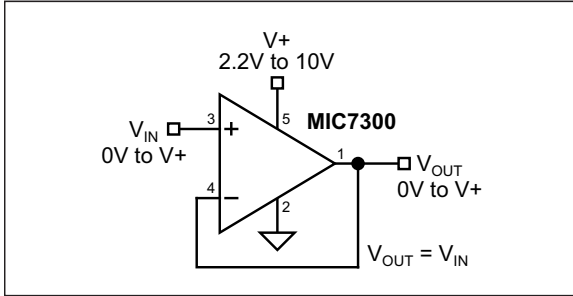
Some single-supply, rail-to-rail applications for which the MIC7300 is well suited are shown in the circuit diagrams of Figure 4-3 through Figure 4-8.



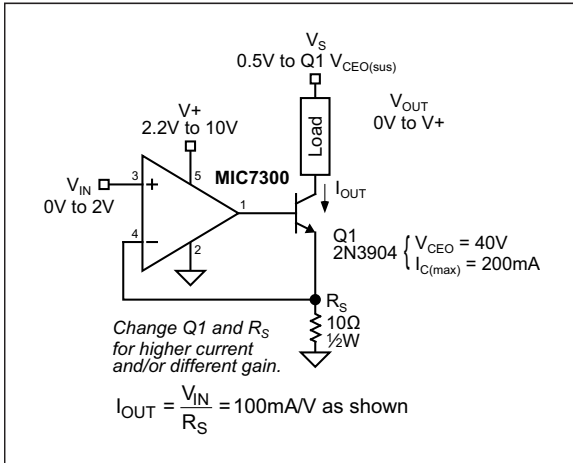
**FIGURE 4-3:** Non-Inverting Amplifier.



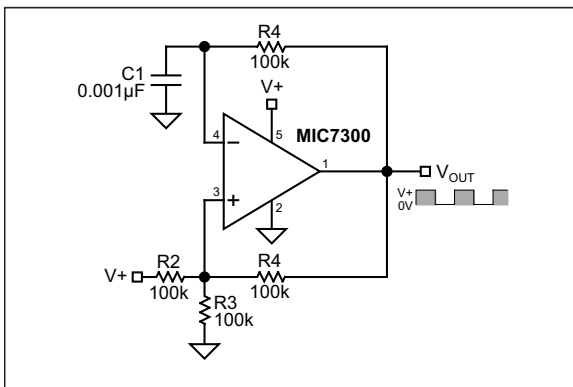
**FIGURE 4-4:** Non-Inverting Amplifier Behavior.



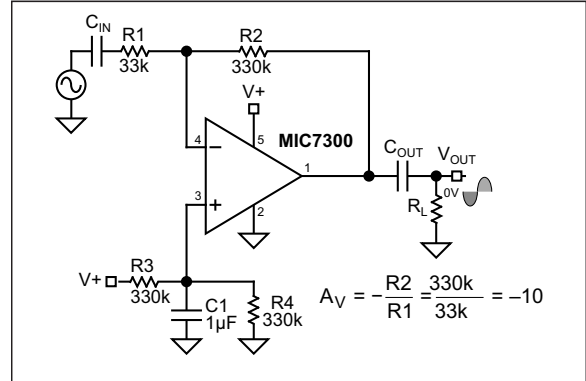
**FIGURE 4-5:** Voltage Follower/Buffer.



**FIGURE 4-6:** Voltage-Controlled Current Sink.



**FIGURE 4-7:** Square Wave Oscillator.

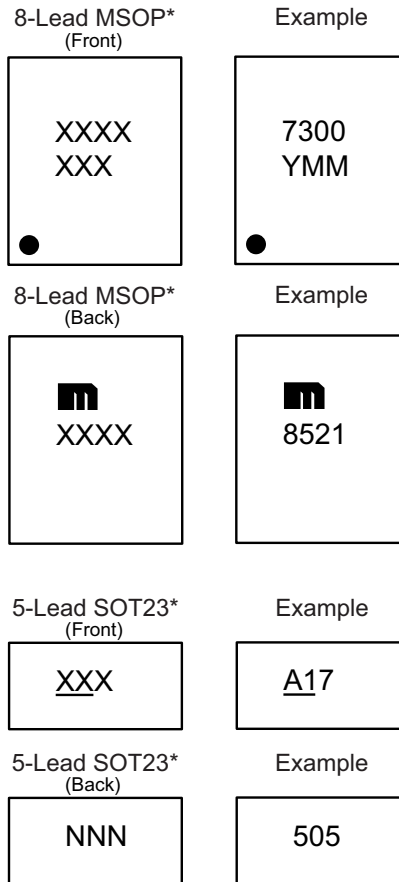


**FIGURE 4-8:** AC-Coupled Inverting Amplifier.

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## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information



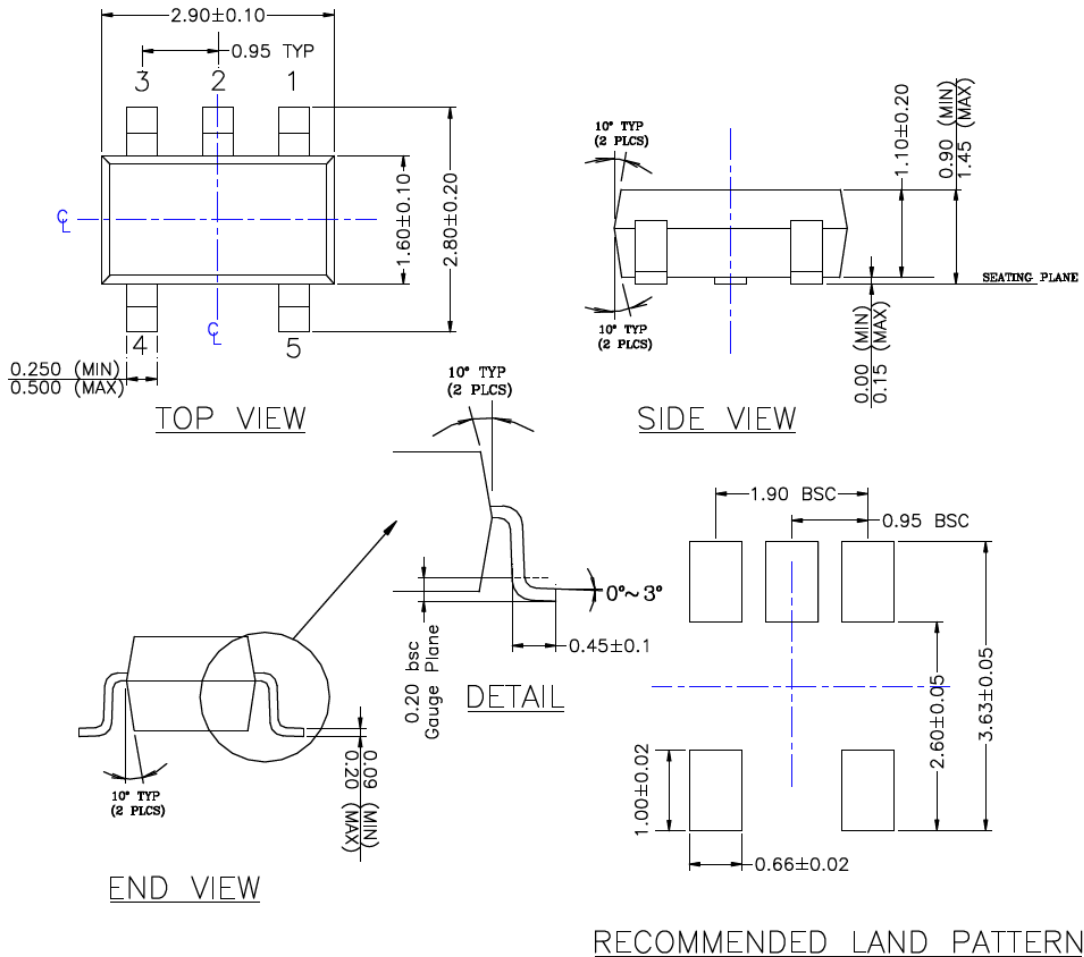
<p><b>Legend:</b> XX...X Product code or customer-specific information Y Year code (last digit of calendar year) YY Year code (last 2 digits of calendar year) WW Week code (week of January 1 is week '01') NNN Alphanumeric traceability code (e3) Pb-free JEDEC® designator for Matte Tin (Sn) * This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.</p> <p>●, ▲, ▼ Pin one index is identified by a dot, delta up, or delta down (triangle mark).</p>
<p><b>Note:</b> In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.</p> <p>Underbar ( _ ) and/or Overbar ( ^ ) symbol may not be to scale.</p>

## 5-Lead SOT-23 Package Outline and Recommended Land Pattern

**TITLE**

5 LEAD SOT23 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

<b>DRAWING #</b>	SOT23-5LD-PL-1	<b>UNIT</b>	MM
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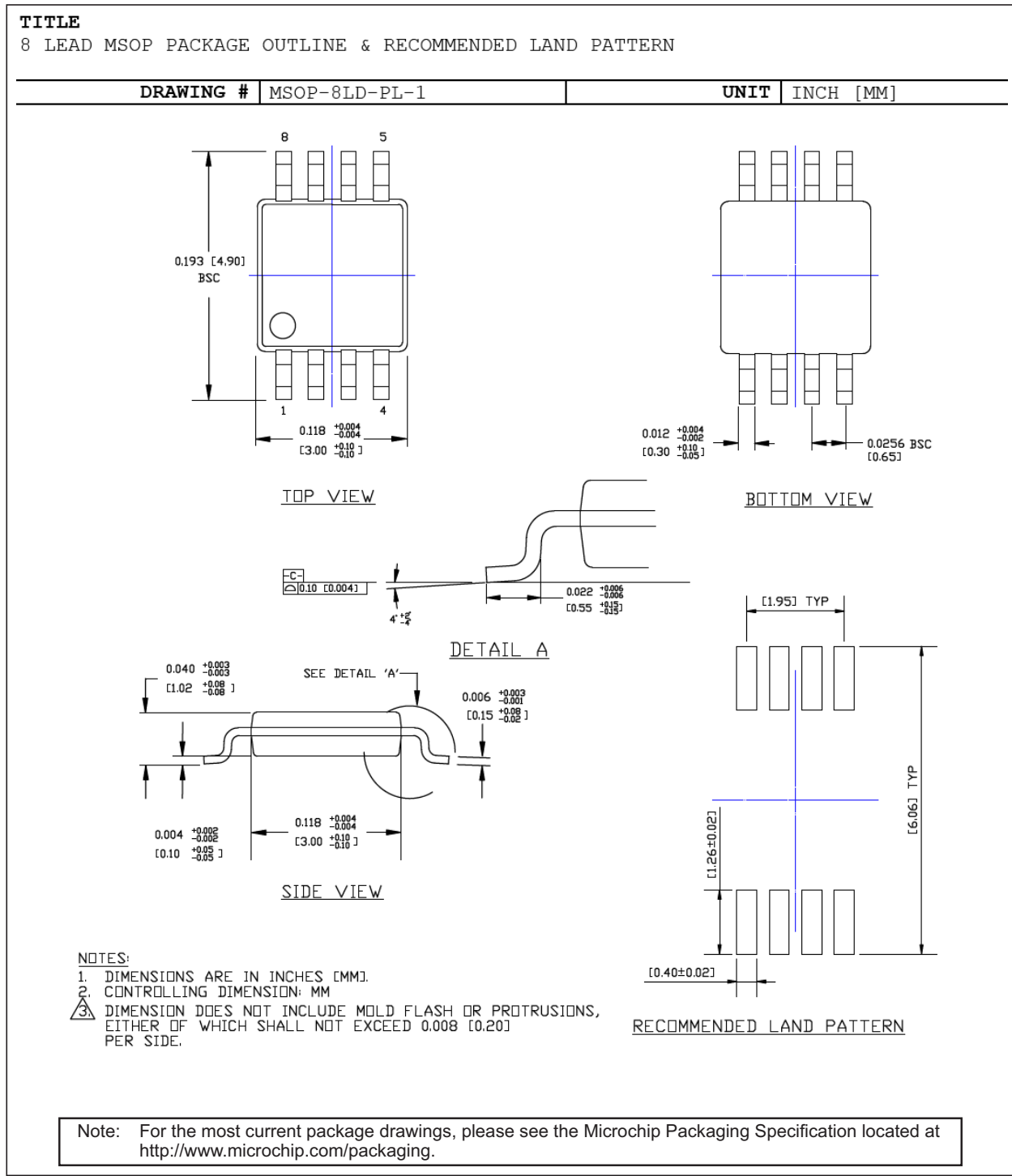


- NOTE:
1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & BURR.
  2. PACKAGE OUTLINE INCLUSIVE OF SOLER PLATING.
  3. DIMENSION AND TOLERANCE PER ANSI Y14.5M, 1982.
  4. FOOT LENGTH MEASUREMENT BASED ON GAUGE PLANE METHOD.
  5. DIE FACES UP FOR MOLD, AND FACES DOWN FOR TRIM/FORM.
  6. ALL DIMENSIONS ARE IN MILLIMETERS.

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>.

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## 8-Lead MSOP Package Outline and Recommended Land Pattern





## APPENDIX A: REVISION HISTORY

### Revision A (February 2020)

- Converted Micrel document MIC7300 to Microchip data sheet template DS20006305A.
- Minor text changes throughout.

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NOTES:

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To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

<u>PART NO.</u>	<u>X</u>	<u>XX</u>	<u>-XX</u>
Device	Temperature Range	Package Option	Media Type
<b>Device:</b>	MIC7300:	High-Output Drive Rail-to-Rail Op Amp	
<b>Temperature Range:</b>	Y =	-40°C to +85°C (RoHS Compliant)	
<b>Package Option:</b>	M5 =	5-Lead SOT-23	
	MM =	8-Lead MSOP	
<b>Media Type:</b>	<blank>=	100/Tube (MSOP only)	
	TR =	2,500/Reel (MSOP only)	
	TR =	3,000/Reel (SOT-23 only)	
<b>Examples:</b>			
a) MIC7300YM5-TR: MIC7300, -40°C to +85°C Temperature Range, 5-Lead SOT-23, 3,000/Reel			
b) MIC7300YMM: MIC7300, -40°C to +85°C Temperature Range, 8-Lead MSOP, 100/Tube			
c) MIC7300YMM-TR: MIC7300, -40°C to +85°C Temperature Range, 8-Lead MSOP, 2,500/Reel			
<b>Note 1:</b> Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.			

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NOTES:

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