National
Semiconductor

October 2007

LMV851/LMV852/LMV854
8 MHz Low Power CMOS, EMI Hardened Operational Amplifiers

General Description

National's LMV851/LMV852/LMV854 are CMOS input, low power op amp ICs, providing a low input bias current, a wide temperature range of −40°C to +125°C and exceptional performance, making them robust general purpose parts. Additionally, the LMV851/LMV852/LMV854 are EMI hardened to minimize any interference so they are ideal for EMI sensitive applications. The unity gain stable LMV851/LMV852/LMV854 feature 8 MHz of bandwidth while consuming only 0.4 mA of current per channel. These parts also maintain stability for capacitive loads as large as 200 pF. The LMV851/LMV852/LMV854 provide superior performance and economy in terms of power and space usage. This family of parts has a maximum input offset voltage of 1 mV, a rail-to-rail output stage and an input common-mode voltage range that includes ground. Over an operating supply range from 2.7V to 5.5V the LMV851/LMV852/LMV854 provide a CMRR of 92 dB, and a PSRR of 93 dB. The LMV851/LMV852/LMV854 are offered in the space saving 5-Pin SC70 package, the 8-Pin MSOP and the 14-Pin TSSOP package.

Features

Unless otherwise noted, typical values at T_A = 25°C, V_{SUPPLY} = 3.3V

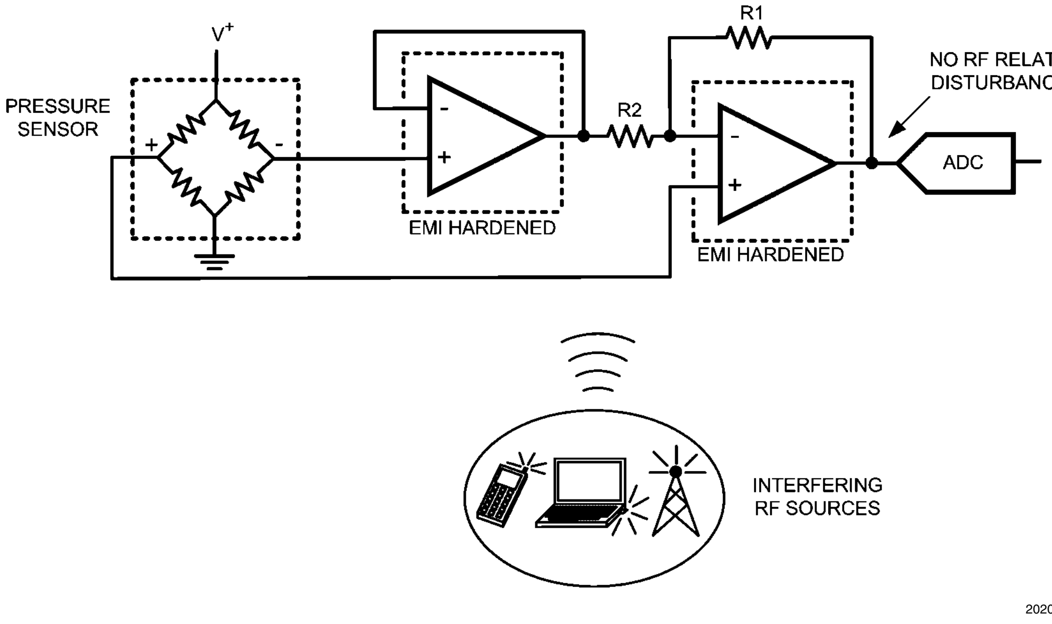
■ Supply voltage	2.7V to 5.5V
■ Supply current (per channel)	0.4 mA
■ Input offset voltage	1 mV max
■ Input bias current	0.1 pA
■ GBW	8 MHz
■ EMIRR at 1.8 GHz	87 dB
■ Input noise voltage at 1 kHz	11 nV/√Hz
■ Slew rate	4.5 V/µs
■ Output voltage swing	Rail-to-Rail
■ Output current drive	30 mA
■ Operating ambient temperature range	−40°C to 125°C

Applications

- Photodiode preamp
- Piezoelectric sensors
- Portable/battery-powered electronic equipment
- Filters/buffers
- PDAs/phone accessories
- Medical diagnosis equipment

Typical Application

Sensor Amplifiers Close to RF Sources



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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

ESD Tolerance (Note 2)	
Human Body Model	2 kV
Charge-Device Model	1 kV
Machine Model	200V
V_{IN} Differential	± Supply Voltage
Supply Voltage ($V^+ – V^-$)	6V
Voltage at Input/Output Pins	V^+ +0.4V V^- −0.4V
Storage Temperature Range	−65°C to +150°C
Junction Temperature (Note 3)	+150°C
Soldering Information	
Infrared or Convection (20 sec)	+260°C

Operating Ratings (Note 1)

Temperature Range (Note 3)	−40°C to +125°C
Supply Voltage ($V^+ – V^-$)	2.7V to 5.5V
Package Thermal Resistance (θ_{JA} (Note 3))	
5-Pin SC70	313 °C/W
8-Pin MSOP	217 °C/W
14-Pin TSSOP	135 °C/W

3.3V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 3.3V, V^- = 0V, V_{CM} = $V^+/2$, and R_L = 10 kΩ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OS}	Input Offset Voltage			±0.26 (Note 9)	±1 **±1.2**	mV
TCV_{OS}	Input Offset Voltage Drift (Note 10)			±0.4 (Note 9)	±2	µV/°C
I_B	Input Bias Current (Note 10)			0.1	10 **500**	pA
I_{OS}	Input Offset Current			1		pA
CMRR	Common Mode Rejection Ratio	−0.2V < V_{CM} < V^+ - 1.2V	76 **75**	92 (Note 9)		dB
PSRR	Power Supply Rejection Ratio	2.7V ≤ V^+ ≤ 5.5V, V_{OUT} = 1V	75 **74**	93 (Note 9)		dB
EMIRR	EMI Rejection Ratio, IN+ and IN− (Note 8)	V_{RFpeak} = 100 mV_P (−20 dBV_P), f = 400 MHz		64		dB
		V_{RFpeak} = 100 mV_P (−20 dBV_P), f = 900 MHz		78		
		V_{RFpeak} = 100 mV_P (−20 dBV_P), f = 1800 MHz		87		
		V_{RFpeak} = 100 mV_P (−20 dBV_P), f = 2400 MHz		90		
CMVR	Input Common-Mode Voltage Range	CMRR ≥ 76 dB	−0.2		2.1	V
A_{VOL}	Large Signal Voltage Gain (Note 11)	R_L = 2 kΩ, V_{OUT} = 0.15V to 1.65V, V_{OUT} = 3.15V to 1.65V	100 **97**	114		dB
		R_L = 10 kΩ, V_{OUT} = 0.1V to 1.65V, V_{OUT} = 3.2V to 1.65V	100 **97**	115		
V_O	Output Swing High, (measured from V^+)	R_L = 2 kΩ to $V^+/2$		31	35 **43**	mV
		R_L = 10 kΩ to $V^+/2$		7	10 **12**	
	Output Swing Low, (measured from V^-)	R_L = 2 kΩ to $V^+/2$		26	32 **43**	mV
		R_L = 10 kΩ to $V^+/2$		6	11 **14**	

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
I_O	Output Short Circuit Current	Sourcing, $V_{OUT} = V_{CM}$, V_{IN} = 100 mV	25 **20**	28		mA
		Sinking, $V_{OUT} = V_{CM}$, V_{IN} = −100 mV	28 **20**	31		
I_S	Supply Current	LMV851		0.42	0.50 **0.58**	mA
		LMV852		0.79	0.90 **1.06**	
		LMV854		1.54	1.67 **1.99**	
SR	Slew Rate (Note 7)	A_V = +1, V_{OUT} = 1 V_{PP}, 10% to 90%		4.5		V/µs
GBW	Gain Bandwidth Product			8		MHz
Φ_m	Phase Margin			62		deg
e_n	Input-Referred Voltage Noise	f = 1 kHz		11		$nV/\sqrt{Hz}$
		f = 10 kHz		10		
i_n	Input-Referred Current Noise	f = 1 kHz		0.005		$pA/\sqrt{Hz}$
R_{OUT}	Closed Loop Output Impedance	f = 6 MHz		400		Ω
C_{IN}	Common-Mode Input Capacitance			11		pF
	Differential-Mode Input Capacitance			6		
THD+N	Total Harmonic Distortion + Noise	f = 1 kHz, A_V = 1, BW = >500 kHz		0.006		%

5V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 5V, V^- = 0V, $V_{CM} = V^+/2$, and R_L = 10 kΩ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OS}	Input Offset Voltage			±0.26 (Note 9)	±1 **±1.2**	mV
TCV_{OS}	Input Offset Voltage Drift (Note 10)			±0.4 (Note 9)	±2	µV/°C
I_B	Input Bias Current (Note 10)			0.1	10 **500**	pA
I_{OS}	Input Offset Current			1		pA
CMRR	Common Mode Rejection Ratio	$-0.2V \le V_{CM} \le V^+ -1.2V$	77 **76**	94 (Note 9)		dB
PSRR	Power Supply Rejection Ratio	$2.7V \le V^+ \le 5.5V$, V_{OUT} = 1V	75 **74**	93 (Note 9)		dB
EMIRR	EMI Rejection Ratio, IN+ and IN− (Note 8)	V_{RFpeak} = 100 mV_P (−20 dBV_P), f = 400 MHz		64		dB
		V_{RFpeak} = 100 mV_P (−20 dBV_P), f = 900 MHz		76		
		V_{RFpeak} = 100 mV_P (−20 dBV_P), f = 1800 MHz		84		
		V_{RFpeak} = 100 mV_P (−20 dBV_P), f = 2400 MHz		89		
CMVR	Input Common-Mode Voltage Range	CMRR ≥ 77 dB	−0.2		3.8	V

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
A_{VOL}	Large Signal Voltage Gain (Note 11)	R_L = 2 kΩ, V_{OUT} = 0.15V to 2.5V, V_{OUT} = 4.85V to 2.5V	105 **102**	118		dB
		R_L = 10 kΩ, V_{OUT} = 0.1V to 2.5V, V_{OUT} = 4.9V to 2.5V	105 **102**	120		
V_O	Output Swing High, (measured from V^+)	R_L = 2 kΩ to $V^+/2$		34	39 **47**	mV
		R_L = 10 kΩ to $V^+/2$		7	11 **13**	
	Output Swing Low, (measured from V^-)	R_L = 2 kΩ to $V^+/2$		31	38 **50**	mV
		R_L = 10 kΩ to $V^+/2$		7	12 **15**	
I_O	Output Short Circuit Current	Sourcing, $V_{OUT} = V_{CM}$, V_{IN} = 100 mV	60 **48**	65		mA
		Sinking, $V_{OUT} = V_{CM}$, V_{IN} = −100 mV	58 **44**	62		
I_S	Supply Current	LMV851		0.43	0.52 **0.60**	mA
		LMV852		0.82	0.93 **1.09**	
		LMV854		1.59	1.73 **2.05**	
SR	Slew Rate (Note 7)	A_V = +1, V_{OUT} = 2 V_{PP}, 10% to 90%		4.5		V/μs
GBW	Gain Bandwidth Product			8		MHz
Φ_m	Phase Margin			64		deg
e_n	Input-Referred Voltage Noise	f = 1 kHz		11		$nV/\sqrt{Hz}$
		f = 10 kHz		10		
i_n	Input-Referred Current Noise	f = 1 kHz		0.005		$pA/\sqrt{Hz}$
R_{OUT}	Closed Loop Output Impedance	f = 6 MHz		400		Ω
C_{IN}	Common-Mode Input Capacitance			11		pF
	Differential-Mode Input Capacitance			6		
THD+N	Total Harmonic Distortion + Noise	f = 1 kHz, A_V = 1, BW = >500 kHz		0.003		%

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics Tables.

Note 2: Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC) Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC).

Note 3: The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A)/\theta_{JA}$. All numbers apply for packages soldered directly onto a PC board.

Note 4: Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.

Note 5: Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

Note 6: Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlations using statistical quality control (SQC) method.

Note 7: Number specified is the slower of positive and negative slew rates.

Note 8: The EMI Rejection Ratio is defined as EMIRR = 20log ($V_{RFpeak}/\Delta V_{OS}$).

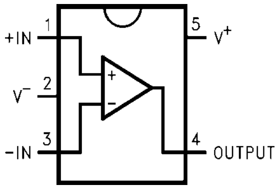
Note 9: The typical value is calculated by applying absolute value transform to the distribution, then taking the statistical average of the resulting distribution

Note 10: This parameter is guaranteed by design and/or characterization and is not tested in production.

Note 11: The specified limits represent the lower of the measured values for each output range condition.

Connection Diagrams

5-Pin SC70



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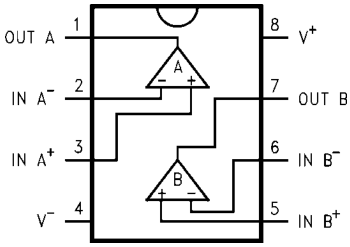
Top View

8-Pin MSOP



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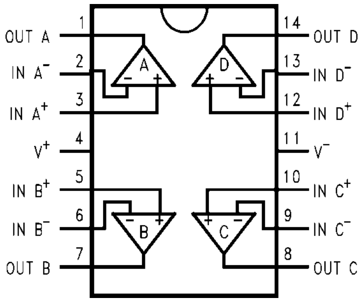
Top View

14-Pin TSSOP



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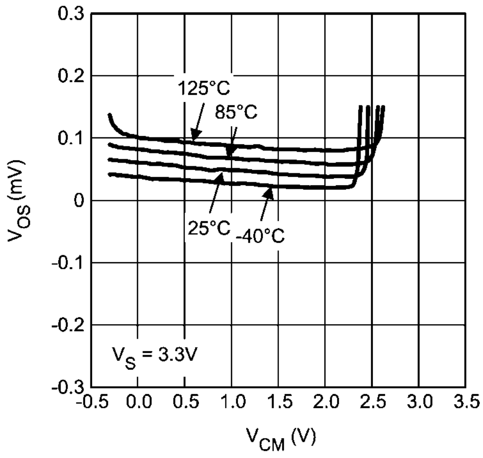
Top View

Ordering Information

Package	Part Number	Package Marking	Transport Media	NSC Drawing
5-Pin SC70	LMV851MG	A98	1k Units Tape and Reel	MAA05A
	LMV851MGX		3k Units Tape and Reel	
8-Pin MSOP	LMV852MM	AB5A	1k Units Tape and Reel	MUA08A
	LMV852MMX		3.5k Units Tape and Reel	
14-Pin TSSOP	LMV854MT	LMV854MT	94 Units/Rail	MTC14
	LMV854MTX		2.5k Units Tape and Reel	

Typical Performance Characteristics

At T_A = 25°C, R_L = 10 kΩ, V_S = 3.3V, unless otherwise specified.



V_{OS} vs. V_{CM} at 3.3V

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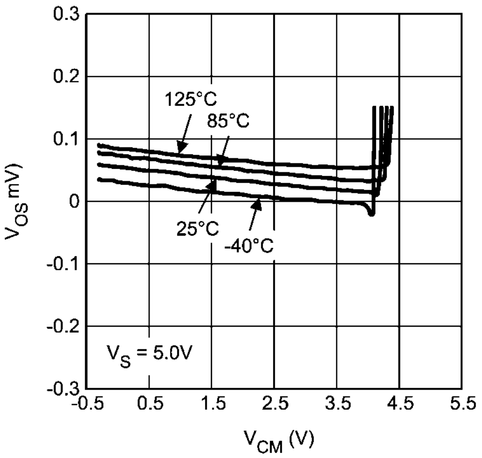

V_{OS} vs. V_{CM} at 5.0V

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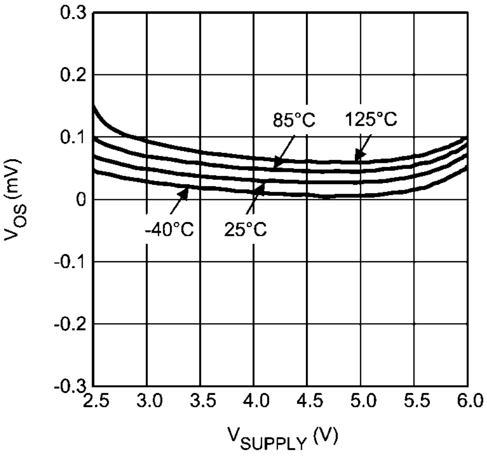

V_{OS} vs. Supply Voltage

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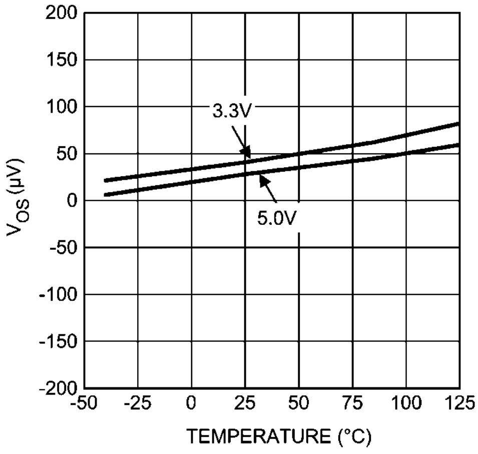

V_{OS} vs. Temperature

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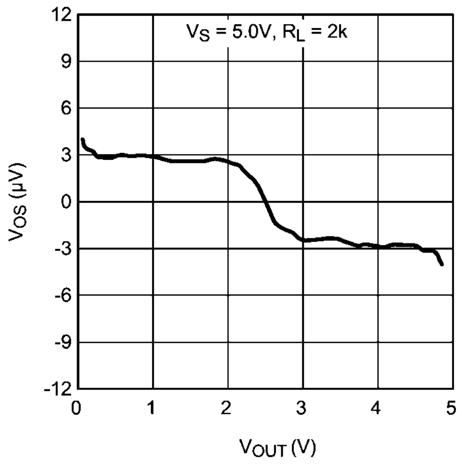

V_{OS} vs. V_{OUT}

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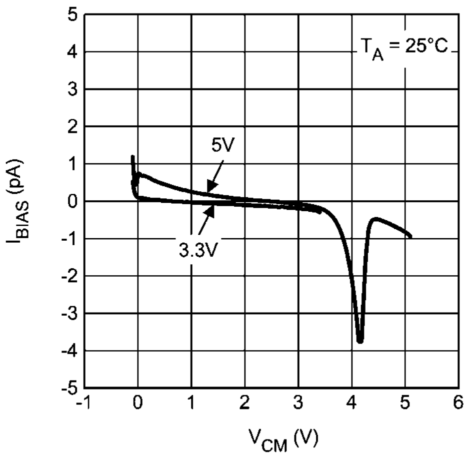

Input Bias Current vs. V_{CM} at 25°C

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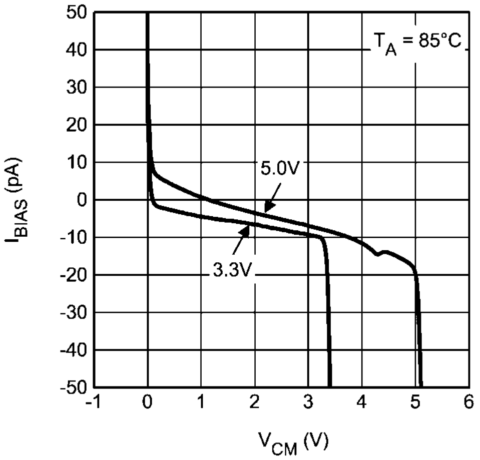
Input Bias Current vs. V_{CM} at 85°C



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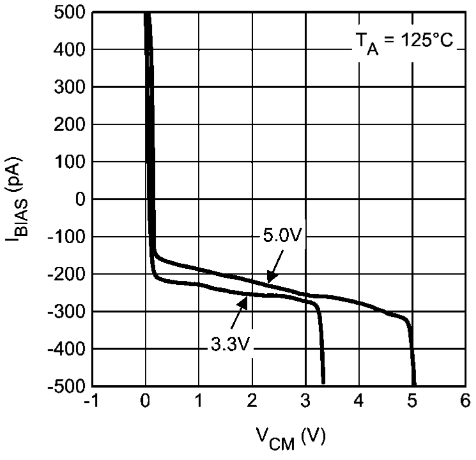
Input Bias Current vs. V_{CM} at 125°C



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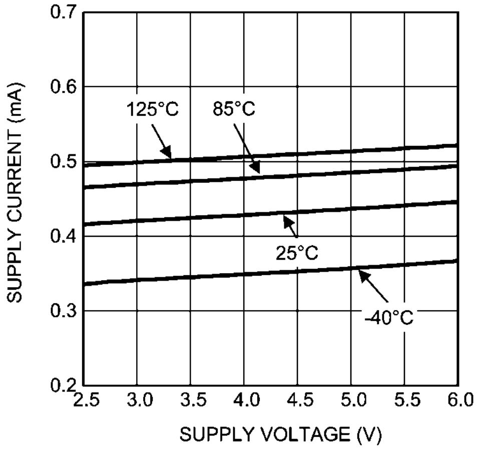
Supply Current vs. Supply Voltage Single LMV851



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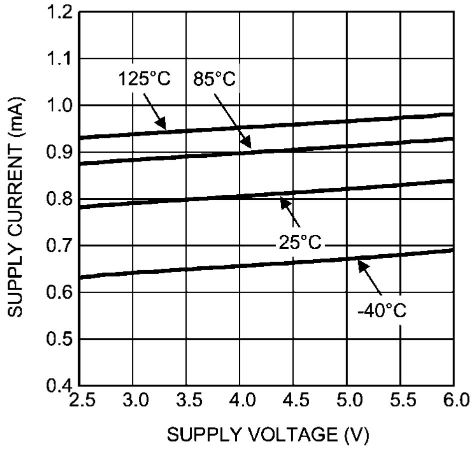
Supply Current vs. Supply Voltage Dual LMV852



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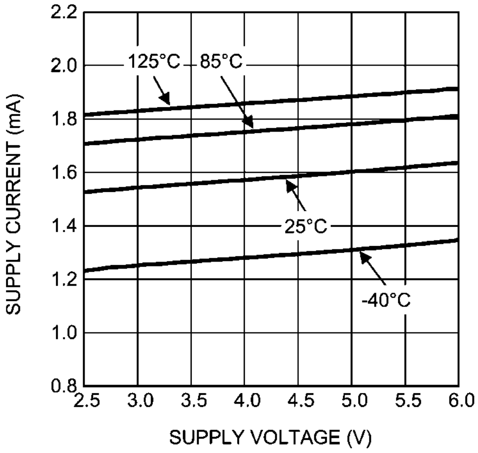
Supply Current vs. Supply Voltage Quad LMV854



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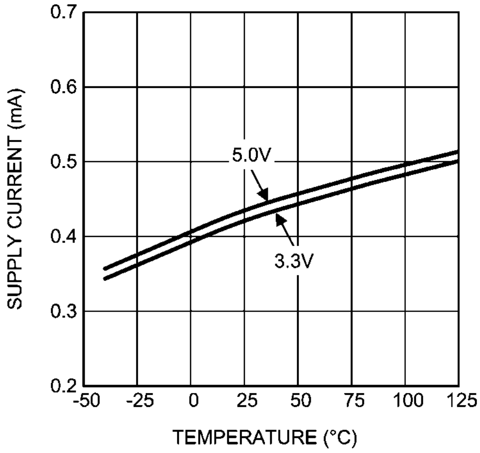
Supply Current vs. Temperature Single LMV851



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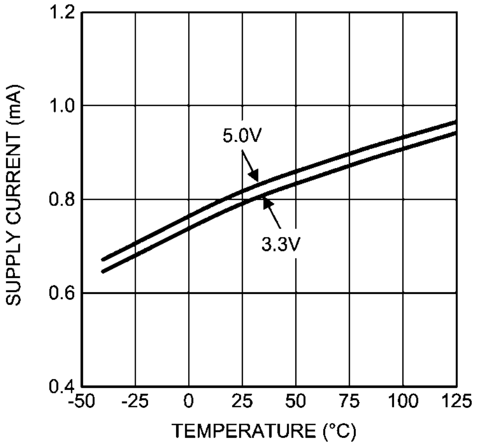
Supply Current vs. Temperature Dual LMV852



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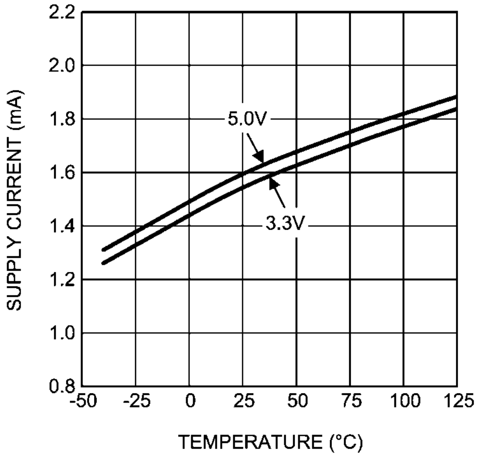
Supply Current vs. Temperature Quad LMV854



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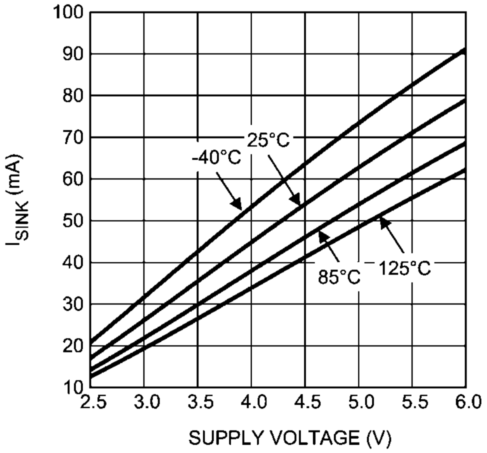
Sinking Current vs. Supply Voltage



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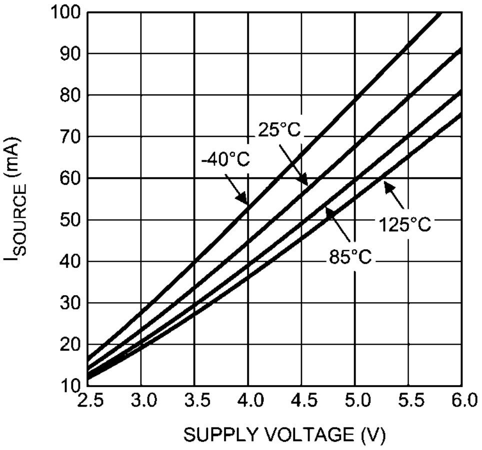
Sourcing Current vs. Supply Voltage



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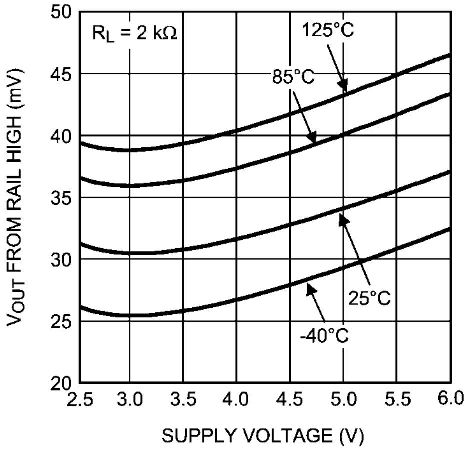
Output Swing High vs. Supply Voltage $R_L = 2\ k\Omega$



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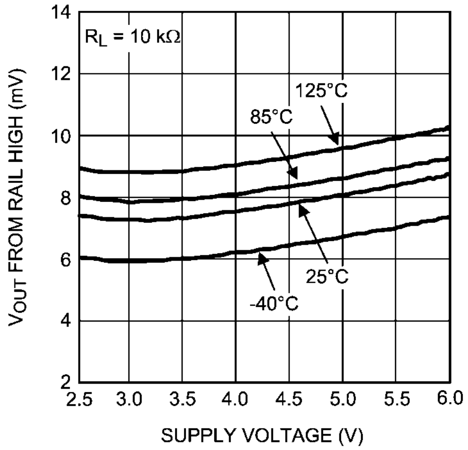
Output Swing High vs. Supply Voltage $R_L = 10\ k\Omega$



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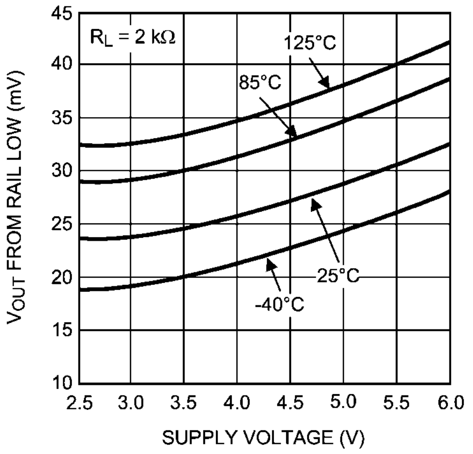
Output Swing Low vs. Supply Voltage R_L = 2 kΩ



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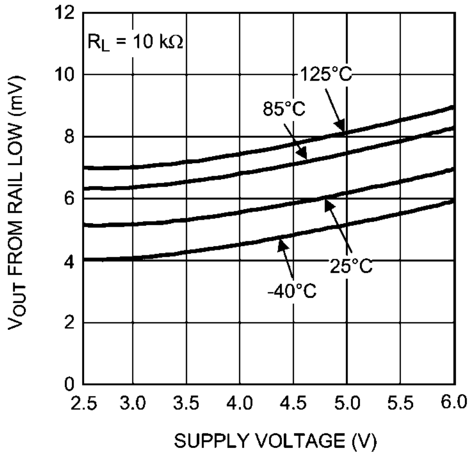
Output Swing Low vs. Supply Voltage R_L = 10 kΩ



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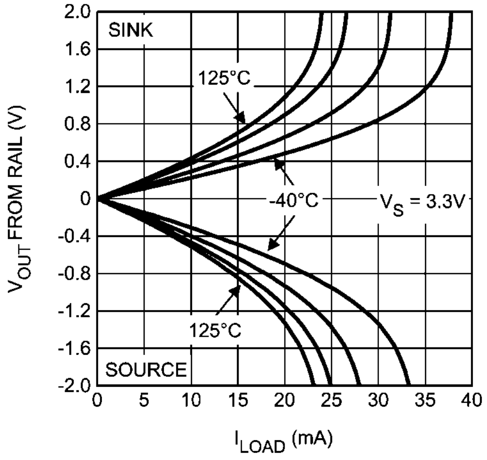
Output Voltage Swing vs. Load Current at 3.3V



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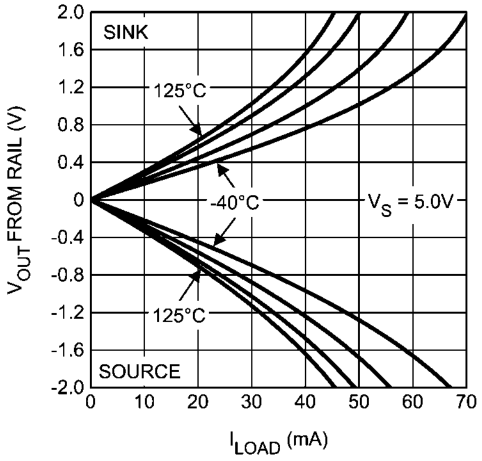
Output Voltage Swing vs. Load Current at 5.0V



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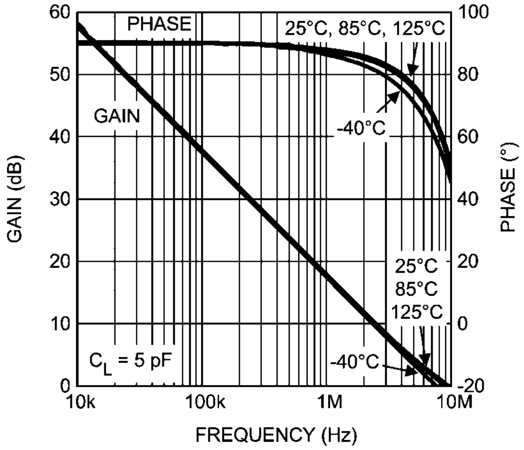
Open Loop Frequency Response vs. Temperature



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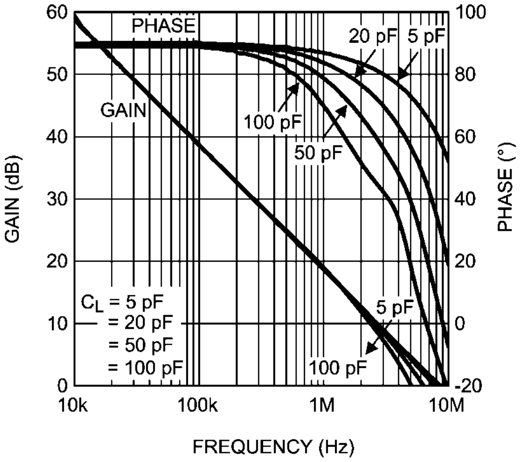
Open Loop Frequency Response vs. Load Conditions



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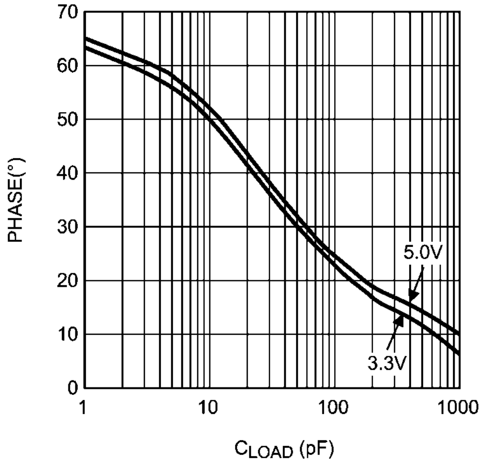
Phase Margin vs. Capacitive Load



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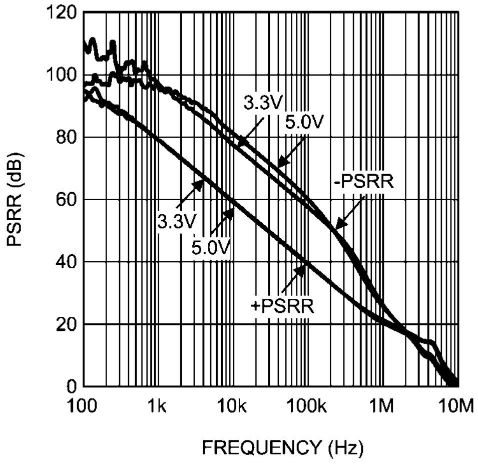
PSRR vs. Frequency



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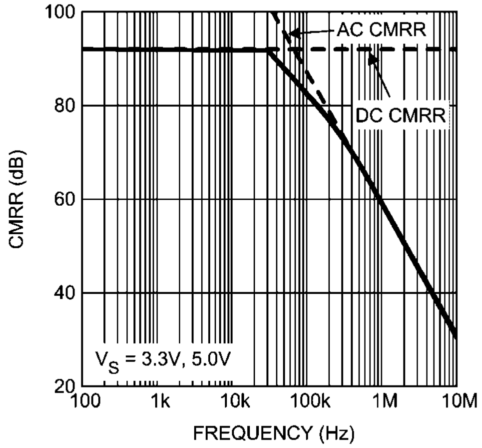
CMRR vs. Frequency



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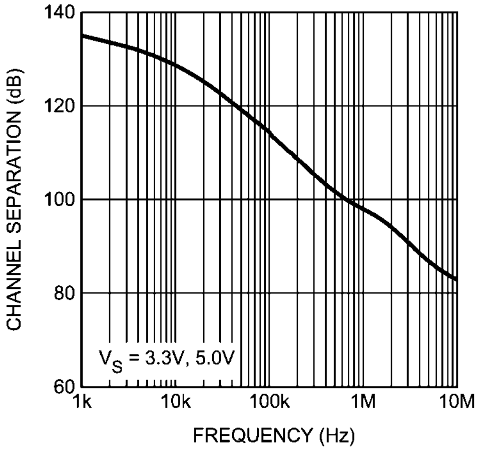
Channel Separation vs. Frequency



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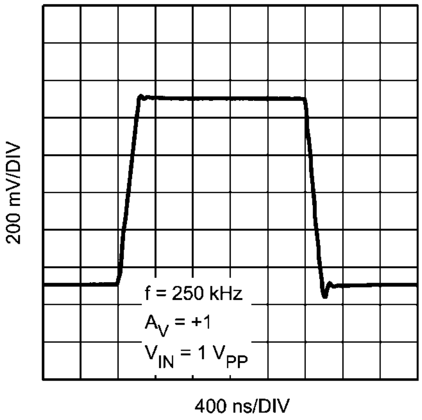
Large Signal Step Response with Gain = 1



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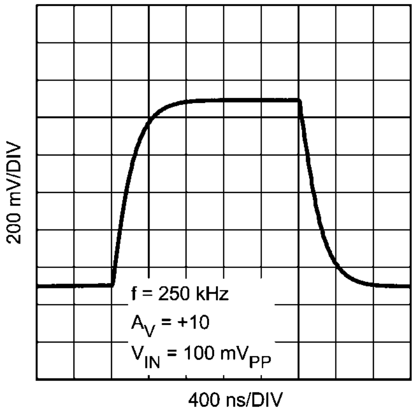
Large Signal Step Response with Gain = 10



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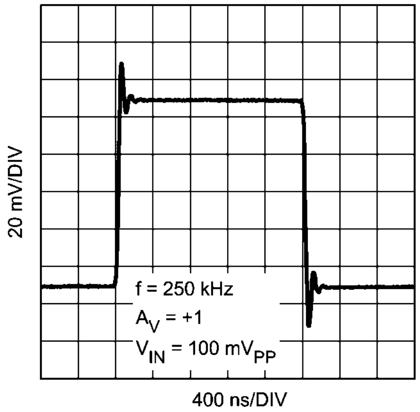
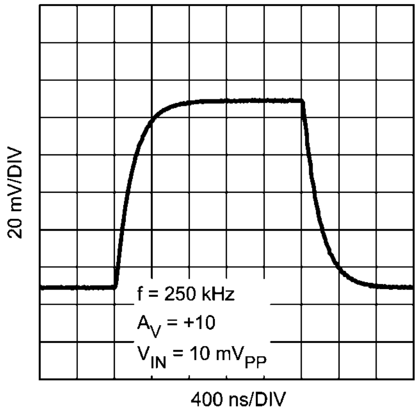
Small Signal Step Response with Gain = 1



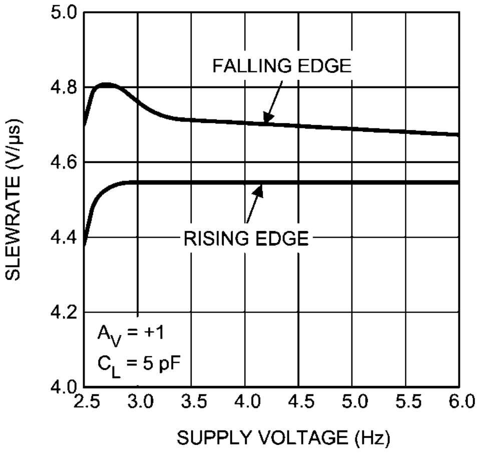
20202140

Small Signal Step Response with Gain = 10



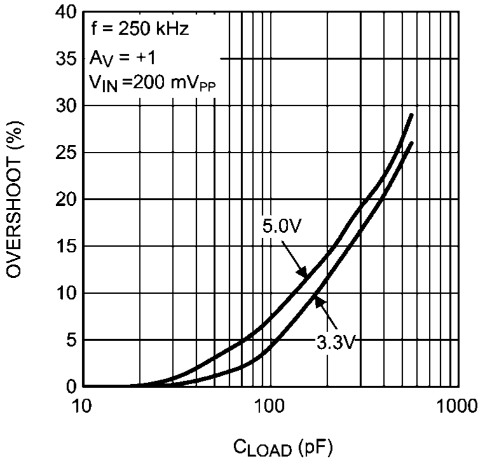
20202141

Slew Rate vs. Supply Voltage



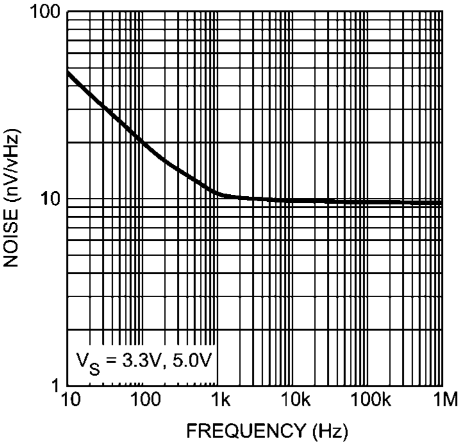
20202142

Overshoot vs. Capacitive Load



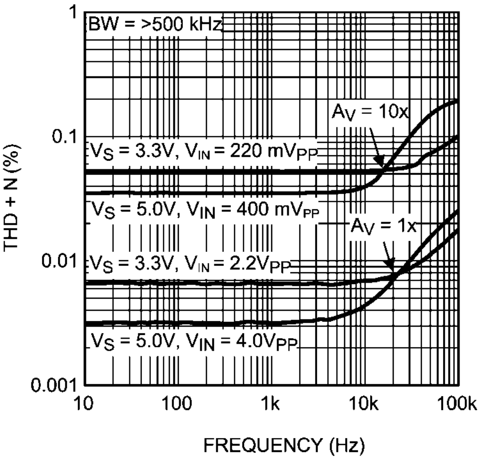
20202143

Input Voltage Noise vs. Frequency



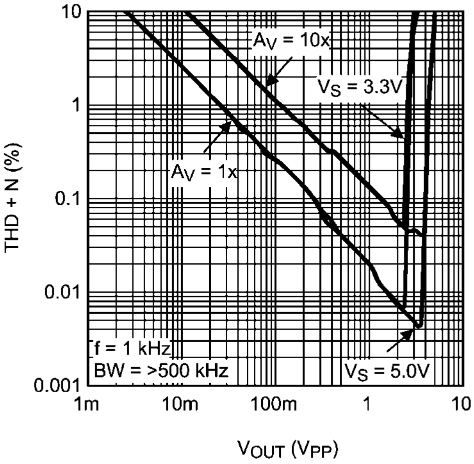
20202144

THD+N vs. Frequency



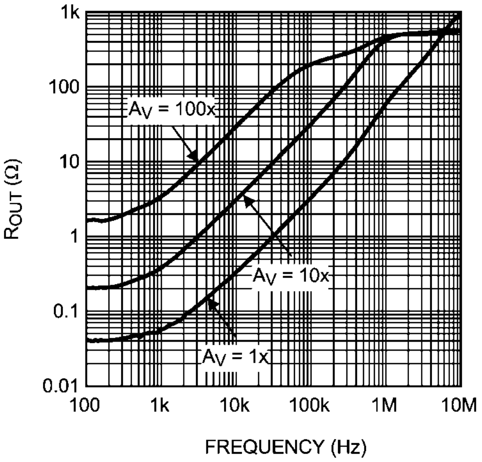
20202145

THD+N vs. Amplitude



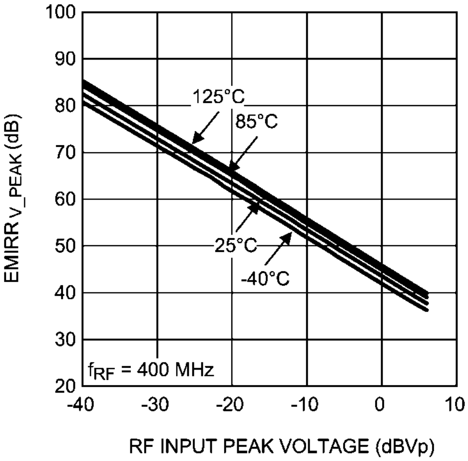
20202146

R_{OUT} vs. Frequency



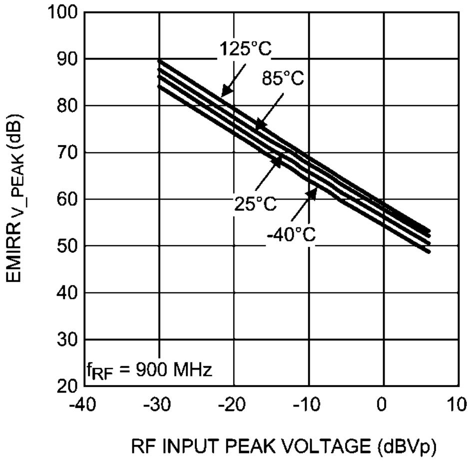
20202148

EMIRR IN+ vs. Power at 400 MHz



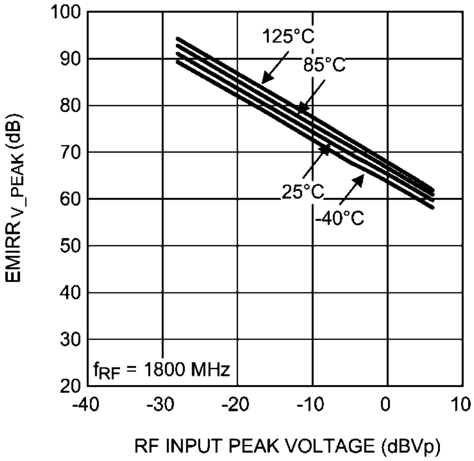
20202149

EMIRR IN+ vs. Power at 900 MHz



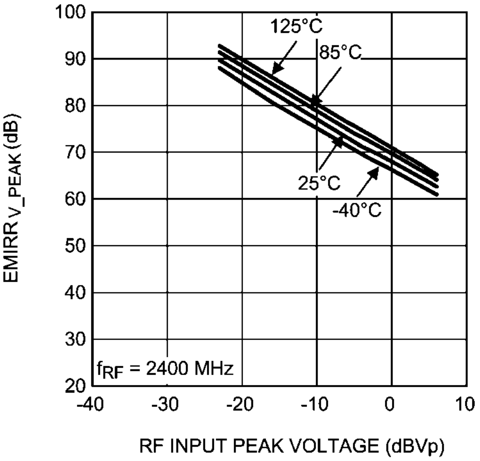
20202150

EMIRR IN+ vs. Power at 1800 MHz



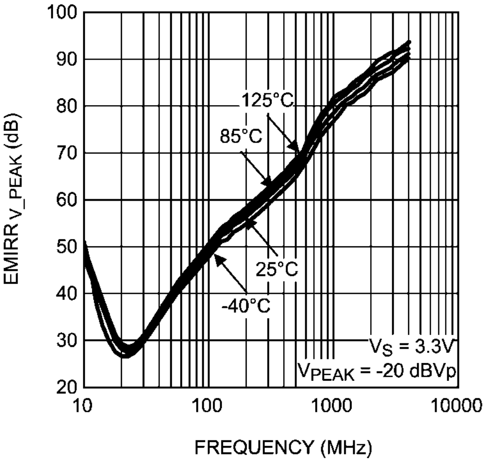
20202151

EMIRR IN+ vs. Power at 2400 MHz



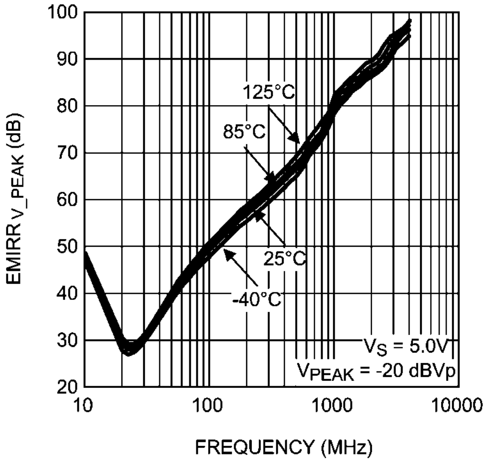
20202152

EMIRR IN+ vs. Frequency at 3.3V



20202153

EMIRR IN+ vs. Frequency at 5.0V



20202154

Application Information

INTRODUCTION

The LMV851/LMV852/LMV854 are operational amplifiers with very good specifications, such as low offset, low noise and a rail-to-rail output. These specifications make the LMV851/LMV852/LMV854 great choices to use in areas such as medical and instrumentation. The low supply current is perfect for battery powered equipment. The small packages, SC-70 package for the LMV851, the MSOP package for the dual LMV852 and the TSSOP package for the quad LMV854, make any of these parts a perfect choice for portable electronics. Additionally, the EMI hardening makes the LMV851/ LMV852 or LMV854 a must for almost all op amp applications. Most applications are exposed to Radio Frequency (RF) signals such as the signals transmitted by mobile phones or wireless computer peripherals. The LMV851/LMV852/ LMV854 will effectively reduce disturbances caused by RF signals to a level that will be hardly noticeable. This again reduces the need for additional filtering and shielding. Using this EMI resistant series of op amps will thus reduce the number of components and space needed for applications that are affected by EMI, and will help applications, not yet identified as possible EMI sensitive, to be more robust for EMI.

INPUT CHARACTERISTICS

The input common mode voltage range of the LMV851/ LMV852/LMV854 includes ground, and can even sense well below ground. The CMRR level does not degrade for input levels up to 1.2V below the supply voltage. For a supply voltage of 5V, the maximum voltage that should be applied to the input for best CMRR performance is thus 3.8V.

When not configured as unity gain, this input limitation will usually not degrade the effective signal range. The output is rail-to-rail and therefore will introduce no limitations to the signal range.

The typical offset is only 0.26 mV, and the TCV_{OS} is 0.4 μV/°C, specifications close to precision op amps.

CMRR MEASUREMENT

The CMRR measurement results may need some clarification. This is because different setups are used to measure the AC CMRR and the DC CMRR.

The DC CMRR is derived from ΔV_{OS} versus ΔV_{CM}. This value is stated in the tables, and is tested during production testing.

The AC CMRR is measured with the test circuit shown in *Figure 1*.

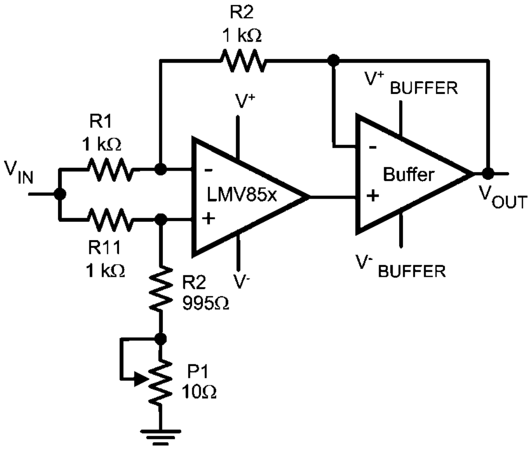


FIGURE 1. AC CMRR Measurement Setup

The configuration is largely the usually applied balanced configuration. With potentiometer P1, the balance can be tuned to compensate for the DC offset in the DUT. The main difference is the addition of the buffer. This buffer prevents the open-loop output impedance of the DUT from affecting the balance of the feedback network. Now the closed-loop output impedance of the buffer is a part of the balance. But as the closed-loop output impedance is much lower, and by careful selection of the buffer also has a larger bandwidth, the total effect is that the CMRR of the DUT can be measured much more accurately. The differences are apparent in the larger measured bandwidth of the AC CMRR.

One artifact from this test circuit is that the low frequency CMRR results appear higher than expected. This is because in the AC CMRR test circuit the potentiometer is used to compensate for the DC mismatches. So, mainly AC mismatch is all that remains. Therefore, the obtained DC CMRR from this AC CMRR test circuit tends to be higher than the actual DC CMRR based on DC measurements.

The CMRR curve in *Figure 2* shows a combination of the AC CMRR and the DC CMRR.

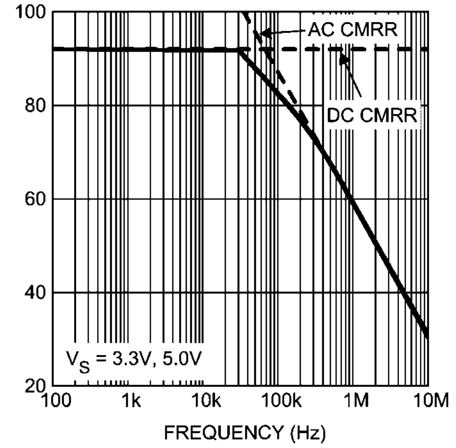


FIGURE 2. CMRR Curve

OUTPUT CHARACTERISTICS

As already mentioned the output is rail to rail. When loading the output with a 10 kΩ resistor the maximum swing of the output is typically 7 mV from the positive and negative rail

The LMV851/LMV852/LMV854 can be connected as non-inverting unity gain amplifiers. This configuration is the most sensitive to capacitive loading. The combination of a capacitive load placed at the output of an amplifier along with the amplifier's output impedance creates a phase lag, which reduces the phase margin of the amplifier. If the phase margin is significantly reduced, the response will be under damped which causes peaking in the transfer and, when there is too much peaking, the op amp might start oscillating. The LMV851/LMV852/LMV854 can directly drive capacitive loads up to 200 pF without any stability issues. In order to drive heavier capacitive loads, an isolation resistor, R_{ISO}, should be used, as shown in *Figure 3*. By using this isolation resistor, the capacitive load is isolated from the amplifier's output, and hence, the pole caused by C_L is no longer in the feedback loop. The larger the value of R_{ISO}, the more stable the amplifier will be. If the value of R_{ISO} is sufficiently large, the feedback loop will be stable, independent of the value of C_L. However, larger values of R_{ISO} result in reduced output swing and reduced output current drive.

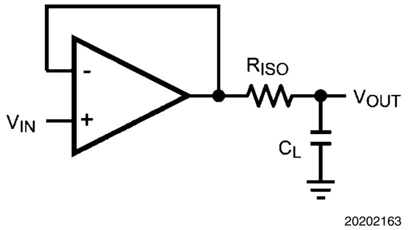


FIGURE 3. Isolating Capacitive Load

EMIRR

With the increase of RF transmitting devices in the world, the electromagnetic interference (EMI) between those devices and other equipment becomes a bigger challenge. The LMV851/LMV852/LMV854 are EMI hardened op amps which are specifically designed to overcome electromagnetic interference. Along with EMI hardened op amps, the EMIRR parameter is introduced to unambiguously specify the EMI performance of an op amp. This section presents an overview of EMIRR. A detailed description on this specification for EMI hardened op amps can be found in Application Note AN-1698.

The dimensions of an op amp IC are relatively small compared to the wavelength of the disturbing RF signals. As a result the op amp itself will hardly receive any disturbances. The RF signals interfering with the op amp are dominantly received by the PCB and wiring connected to the op amp. As a result the RF signals on the pins of the op amp can be represented by voltages and currents. This representation significantly simplifies the unambiguous measurement and specification of the EMI performance of an op amp.

RF signals interfere with op amps via the non-linearity of the op amp circuitry. This non-linearity results in the detection of the so called out-of-band signals. The obtained effect is that the amplitude modulation of the out-of-band signal is down-converted into the base band. This base band can easily overlap with the band of the op amp circuit. As an example *Figure 4* depicts a typical output signal of a unity-gain connected op amp in the presence of an interfering RF signal. Clearly the output voltage varies in the rhythm of the on-off keying of the RF carrier.

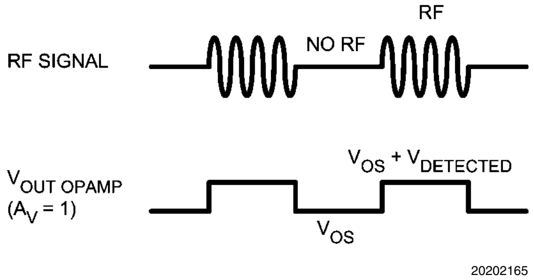


FIGURE 4. Offset Voltage Variation Due to an Interfering RF Signal

EMIRR Definition

To identify EMI hardened op amps, a parameter is needed that quantitatively describes the EMI performance of op amps. A quantitative measure enables the comparison and the ranking of op amps on their EMI robustness. Therefore the EMI Rejection Ratio (EMIRR) is introduced. This parameter describes the resulting input-referred offset voltage shift of an op amp as a result of an applied RF carrier (interference) with a certain frequency and level. The definition of EMIRR is given by:

$$\mathrm{EMIRR}_{V_{RF\_PEAK}} = 20 \log \left(\frac{V_{RF\_PEAK}}{\Delta V_{OS}} \right)$$

In which V_{RF_PEAK} is the amplitude of the applied un-modulated RF signal (V) and ΔV_{OS} is the resulting input-referred offset voltage shift (V). The offset voltage depends quadratically on the applied RF level, and therefore, the RF level at which the EMIRR is determined should be specified. The standard level for the RF signal is 100 mV_P. Application Note AN-1698 addresses the conversion of an EMIRR measured for an other signal level than 100 mV_P. The interpretation of the EMIRR parameter is straightforward. When two op amps have an EMIRR which differ by 20 dB, the resulting error signals when used in identical configurations, differs by 20 dB as well. So, the higher the EMIRR, the more robust the op amp.

Coupling an RF Signal to the IN^+ Pin

Each of the op amp pins can be tested separately on EMIRR. In this section the measurements on the IN^+ pin (which, based on symmetry considerations, also apply to the IN− pin) are discussed. In Application Note AN-1698 the other pins of the op amp are treated as well. For testing the IN^+ pin the op amp is connected in the unity gain configuration. Applying the RF signal is straightforward as it can be connected directly to the IN^+ pin. As a result the RF signal path has a minimum of components that might affect the RF signal level at the pin. The circuit diagram is shown in *Figure 5*. The PCB trace from RF_{IN} to the IN^+ pin should be a 50Ω stripline in order to match the RF impedance of the cabling and the RF generator. On the PCB a 50Ω termination is used. This 50Ω resistor is also used to set the bias level of the IN+ pin to ground level. For determining the EMIRR, two measurements are needed: one is measuring the DC output level when the RF signal is off; and the other is measuring the DC output level when the RF signal is switched on. The difference of the two DC levels is the output voltage shift as a result of the RF signal. As the op amp is in the unity gain configuration, the input referred offset voltage shift corresponds one-to-one to the measured output voltage shift.

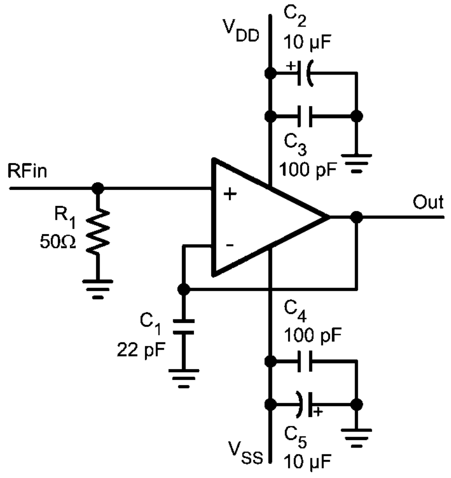


FIGURE 5. Circuit for Coupling the RF Signal to IN$^+$

Cell Phone Call

The effect of electromagnetic interference is demonstrated in a setup where a cell phone interferes with a pressure sensor application (*Figure 7*). This application needs two op amps and therefore a dual op amp is used. The experiment is performed on two different dual op amps: a typical standard op amp and the LMV852, EMI hardened dual op amp. The op amps are placed in a single supply configuration. The cell phone is placed on a fixed position a couple of centimeters from the op amps.

When the cell phone is called, the PCB and wiring connected to the op amps receive the RF signal. Subsequently, the op amps detect the RF voltages and currents that end up at their pins. The resulting effect on the output of the second op amp is shown in *Figure 6*.

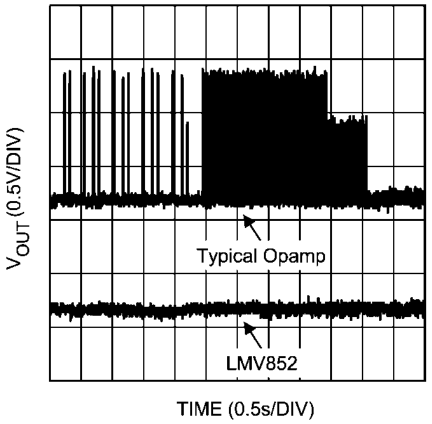


FIGURE 6. Comparing EMI Robustness

The difference between the two types of dual op amps is clearly visible. The typical standard dual op amp has an output shift (disturbed signal) larger than 1V as a result of the RF signal transmitted by the cell phone. The LMV852, EMI hardened op amp does not show any significant disturbances.

DECOUPLING AND LAYOUT

Care must be given when creating a board layout for the op amp. For decoupling the supply lines it is suggested that 10 nF capacitors be placed as close as possible to the op amp. For single supply, place a capacitor between V$^+$ and V$^-$. For dual supplies, place one capacitor between V$^+$ and the board ground, and a second capacitor between ground and V$^-$. Even with the LMV851/LMV852/LMV854 inherent hardening against EMI, it is still recommended to keep the input traces short and as far as possible from RF sources. Then the RF signals entering the chip are as low as possible, and the remaining EMI can be, almost, completely eliminated in the chip by the EMI reducing features of the LMV851/ LMV852/LMV854.

PRESSURE SENSOR APPLICATION

The LMV851/LMV852/LMV854 can be used for pressure sensor applications. Because of their low power the LMV851/ LMV852/LMV854 are ideal for portable applications, such as blood pressure measurement devices, or portable barometers. This example describes a universal pressure sensor that can be used as a starting point for different types of sensors and applications.

Pressure Sensor Characteristics

The pressure sensor used in this example functions as a Wheatstone bridge. The value of the resistors in the bridge change when pressure is applied to the sensor. This change of the resistor values will result in a differential output voltage, depending on the sensitivity of the sensor and the applied pressure. The difference between the output at full scale pressure and the output at zero pressure is defined as the span of the pressure sensor. A typical value for the span is 100 mV. A typical value for the resistors in the bridge is 5 kΩ. Loading of the resistor bridge could result in incorrect output voltages of the sensor. Therefore the selection of the circuit configuration, which connects to the sensor, should take into account a minimum loading of the sensor.

Pressure Sensor Example

The configuration shown in *Figure 7* is simple, and is very useful for the read out of pressure sensors. With two op amps in this application, the dual LMV852 fits very well.

The op amp configured as a buffer and connected at the negative output of the pressure sensor prevents the loading of the bridge by resistor R2. The buffer also prevents the resistors of the sensor from affecting the gain of the following gain stage. Given the differential output voltage V_S of the pressure sensor, the output signal of this op amp configuration, V_{OUT}, equals:

$$V_{OUT} = \frac{V_{DD}}{2} - \frac{V_S}{2}\left(1 + 2 \times \frac{R1}{R2}\right)$$

To align the pressure range with the full range of an ADC, the power supply voltage and the span of the pressure sensor are needed. For this example a power supply of 5V is used and the span of the sensor is 100 mV.

When a 100Ω resistor is used for R2, and a 2.4 kΩ resistor is used for R1, the maximum voltage at the output is 4.95V and the minimum voltage is 0.05V. This signal is covering almost the full input range of the ADC. Further processing can take place in the microprocessor following the ADC.

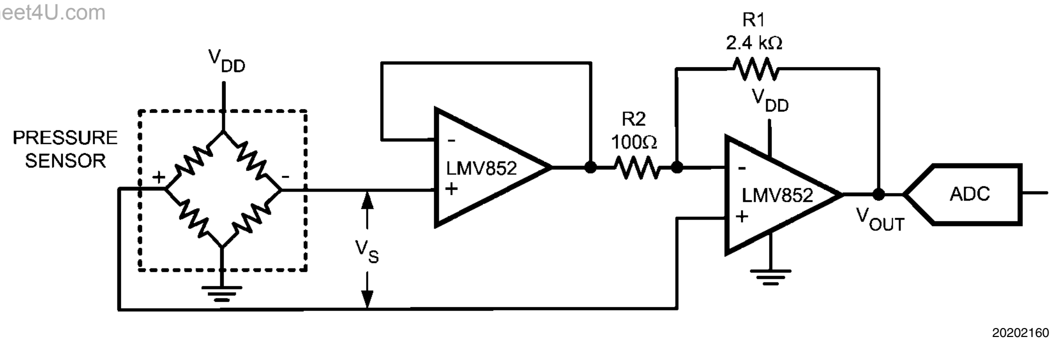


FIGURE 7. Pressure Sensor Application

THERMOCOUPLE AMPLIFIER

The following circuit is a typical example for a thermocouple amplifier application using an LMV851/LMV852, or LMV854. A thermocouple converts a temperature into a voltage. This signal is then amplified by the LMV851/LMV852, or LMV854. An ADC can convert the amplified signal to a digital signal. For further processing the digital signal can be processed by a microprocessor and used to display or log the temperature. The temperature data can for instance be used in a fabrication process.

Characteristics of a Thermocouple

A thermocouple is a junction of two different metals. These metals produce a small voltage that increases with temperature.

The thermocouple used in this application is a K-type thermocouple. A K-type thermocouple is a junction between Nickel-Chromium and Nickel-Aluminum. This is one of the most commonly used thermocouples. There are several reasons for using the K-type thermocouple, these include: temperature range, the linearity, the sensitivity, and the cost.

A K-type thermocouple has a wide temperature range. The range of this thermocouple is from approximately –200°C to approximately 1200°C, as can be seen in *Figure 8*. This covers the generally used temperature ranges.

Over the main part of the temperature range the output voltage depends linearly on the temperature. This is important for easily converting the measured signal levels to a temperature reading.

The K-type thermocouple has good sensitivity when compared to many other types; the sensitivity is about 41 uV/°C. Lower sensitivity requires more gain and makes the application more sensitive to noise.

In addition, a K-type thermocouple is not expensive, many other thermocouples consist of more expensive materials or are more difficult to produce.

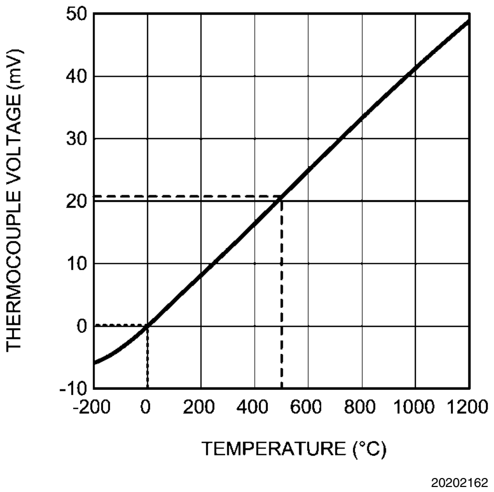


FIGURE 8. K-Type Thermocouple Response

Thermocouple Example

For this example, suppose the range of interest is 0°C to 500°C, and the resolution needed is 0.5°C. The power supply for both the LMV851/LMV852, or LMV854 and the ADC is 3.3V.

The temperature range of 0°C to 500°C results in a voltage range from 0 mV to 20.6 mV produced by the thermocouple. This is indicated in *Figure 8* by the dotted lines.

To obtain the highest resolution, the full ADC range of 0 to 3.3V is used. The gain needed for the full range can be calculated as follows:

$$A_V = 3.3V / 0.0206V = 160$$

If R_G is 2 kΩ, then the value for R_F can be calculated for a gain of 160. Since $A_V = R_F / R_G$, RF can be calculated as follows:

$$R_F = A_V \times R_G = 160 \times 2\ k\Omega = 320\ k\Omega$$

To get a resolution of 0.5°C, the LSB of the ADC should be smaller then 0.5°C / 500°C = 1/1000. A 10-bit ADC would be sufficient as this gives 1024 steps. A 10-bit ADC such as the two channel 10-bit ADC102S021 can be used.

Unwanted Thermocouple Effect

At the point where the thermocouple wires are connected to the circuit, usually copper wires or traces, an unwanted thermocouple effect will occur.

At this connection, this could be the connector on a PCB, the thermocouple wiring forms a second thermocouple with the connector. This second thermocouple disturbs the measurements from the intended thermocouple.

Using an isothermal block as a reference enables correction for this unwanted thermocouple effect. An isothermal block is a good heat conductor. This means that the two thermocouple connections both have the same temperature. The temperature of the isothermal block can be measured, and thereby the temperature of the thermocouple connections. This is usually called the cold junction reference temperature.

In the example, an LM35 is used to measure this temperature. This semiconductor temperature sensor can accurately measure temperatures from −55°C to 150°C.

The two channel ADC in this example also converts the signal from the LM35 to a digital signal. Now the microprocessor can compensate the amplified thermocouple signal, for the unwanted thermocouple effect.

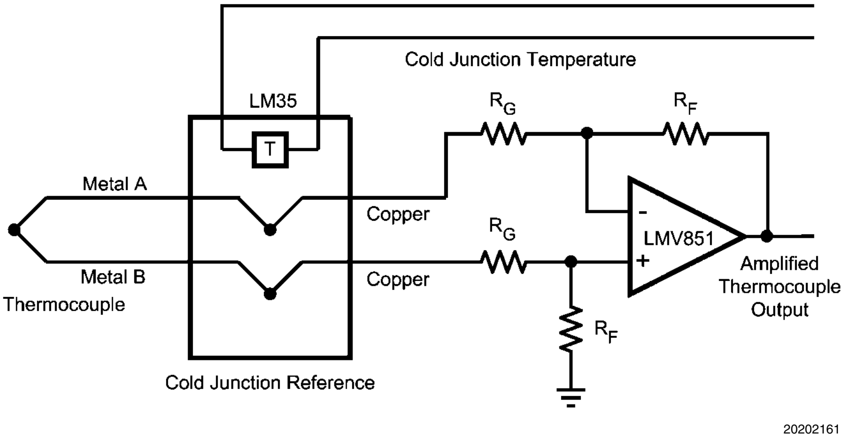
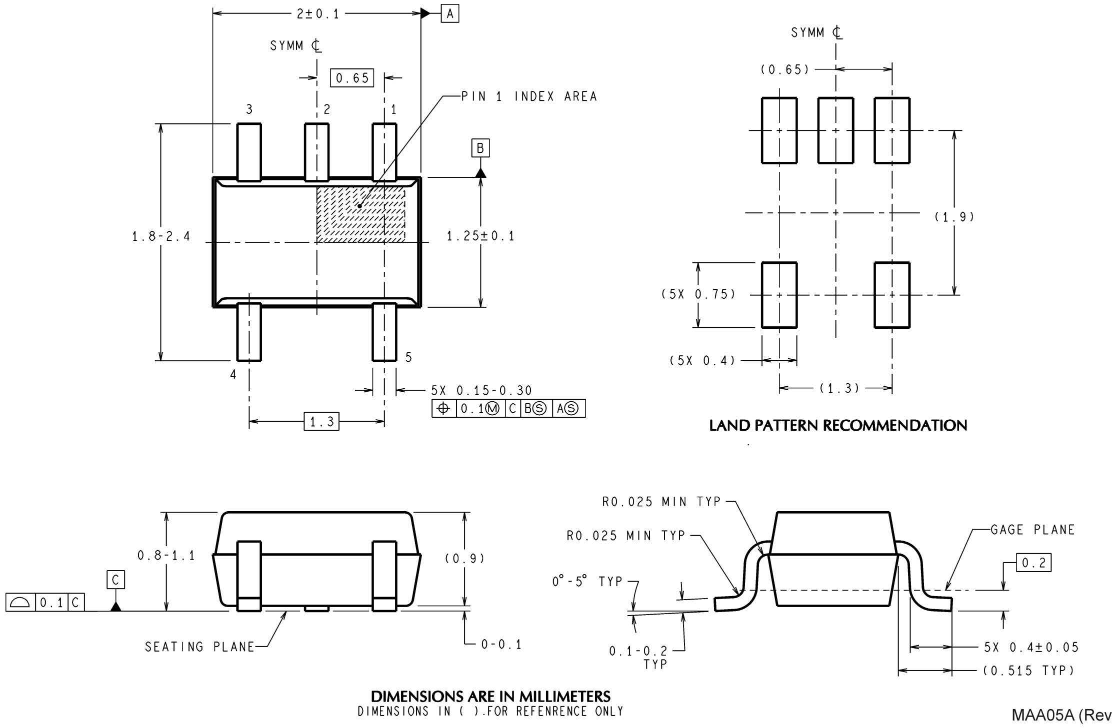


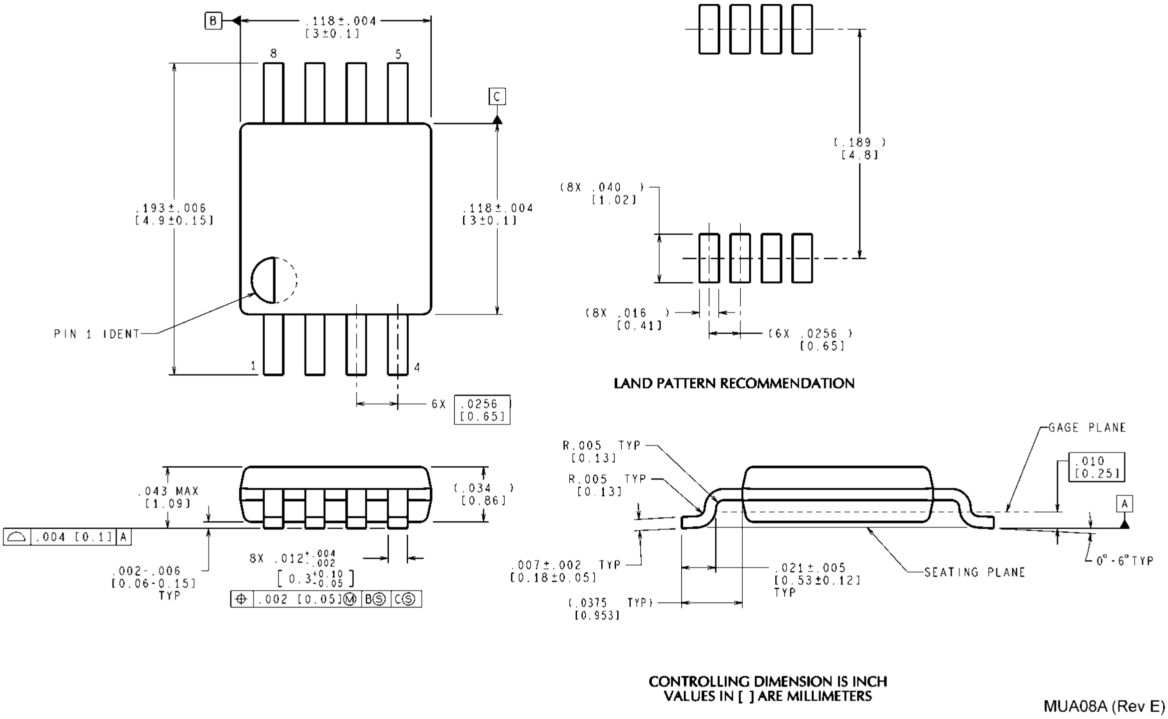
FIGURE 9. Thermocouple Read Out Circuit

Physical Dimensions inches (millimeters) unless otherwise noted



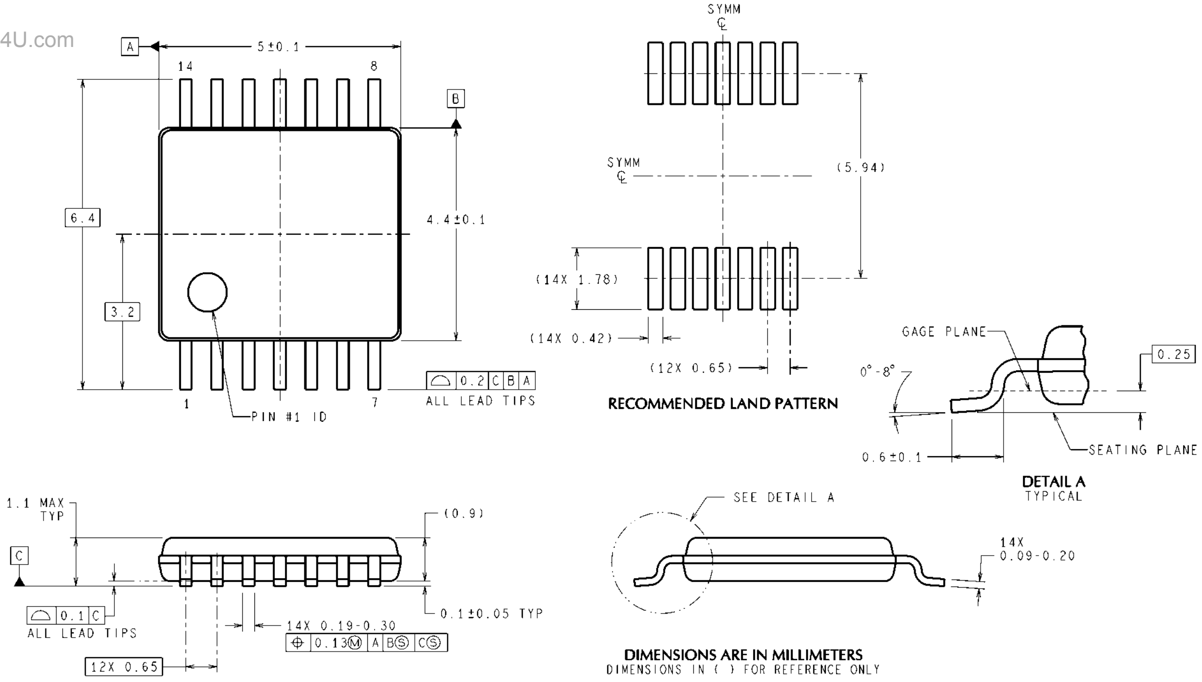
MAA05A (Rev D)

5-Pin SC70
NS Package Number MAA05A



MUA08A (Rev E)

8-Pin MSOP
NS Package Number MUA08A



MTC14 (Rev D)

14-Pin TSSOP
NS Package Number MTC14

Notes

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Notes

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