



PRELIMINARY

March 2006

## LMV654

# Quad, 12 MHz, Low Voltage, Low Power Amplifier

### General Description

National's LMV654 is a high performance, low power quad operational amplifier IC implemented with National's advanced VIP50 process. The LMV654 features 12 MHz of bandwidth while consuming only 119  $\mu\text{A}$  of current per amplifier, which is an exceptional bandwidth to power ratio in this op amp class. The LMV654 is unity gain stable and provides an excellent solution for general purpose amplification in low voltage, low power applications.

The LMV654 provides superior performance and economy in terms of power and space usage. The LMV654 has a maximum input offset voltage of 1.8 mV, a rail-to-rail output stage and an input common-mode voltage range that includes ground. The LMV654 provides a PSRR of 95 dB, a CMRR of 100 dB and a total harmonic distortion (THD) of 0.003% at 1 kHz frequency and 600 $\Omega$  load

The LMV654 has an operating supply voltage range from 2.7V to 5.5V. The LMV654 can operate over a wide temperature range ( $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ) making the op amp ideal for automotive applications, sensor applications and portable equipment applications. The LMV654 is offered in the 14-pin TSSOP package

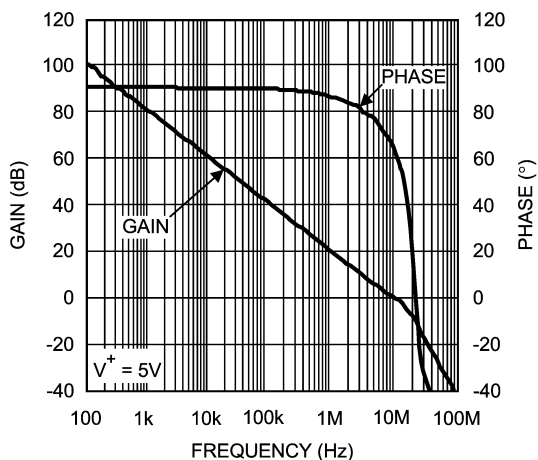
### Features

(Typical 5V supply, unless otherwise noted)

- Guaranteed 3.0V and 5.0V performance
- High unity gain bandwidth 12 MHz
- Low power supply current 119  $\mu\text{A}$  per amplifier
- Max input offset voltage 1.8 mV
- CMRR 100 dB
- PSRR 95 dB
- Input referred voltage noise  $17\text{nV}/\sqrt{\text{Hz}}$
- Output swing with 2 k $\Omega$  load 120 mV from rail
- Total harmonic distortion 0.003% @ 1 kHz, 600 $\Omega$
- Temperature range  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$

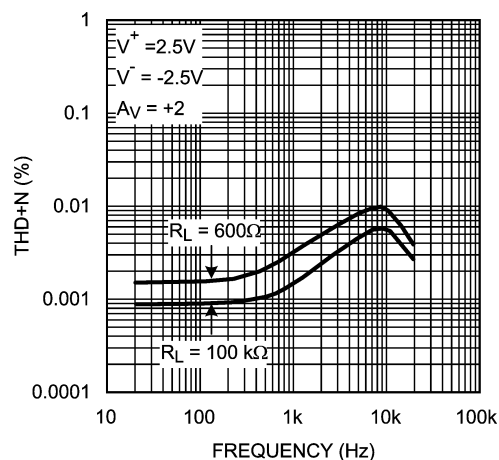
### Applications

- Portable equipment
- Automotive
- Battery powered systems
- Sensors and Instrumentation



Open Loop Gain and phase vs. Frequency

20187306



THD+N vs. Frequency

20187305

LMV654 Quad 12 MHz, Low Voltage, Low Power Amplifier

**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	2000V
Machine Model	100V
Differential Input $V_{ID}$	$\pm 0.3V$
Supply Voltage ( $V_S = V^+ - V^-$ )	6V
Input/Output Pin Voltage	$V^+ + 0.3V, V^- - 0.3V$
Storage Temperature Range	$-65^\circ C$ to $+150^\circ C$

Junction Temperature (Note 3)	$+150^\circ C$
Soldering Information	
Infrared or Convection (20 sec)	$235^\circ C$
Wave Soldering Lead Temp (10 sec)	$260^\circ C$

**Operating Ratings** (Note 1)

Temperature Range	$-40^\circ C$ to $125^\circ C$
Supply Voltage	2.7V to 5.5V
Package Thermal Resistance ( $\theta_{JA}$ )(Note 3)	
14-Pin TSSOP	TBD $^\circ C/W$

**3V DC Electrical Characteristics**

Unless otherwise specified, all limits are guaranteed for  $T_A = 25^\circ C$ ,  $V^+ = 3V$ ,  $V^- = 0V$ ,  $V_O = V_{CM} = V^+/2$ , and  $R_L > 1 M\Omega$ .

**Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 5)	Typ (Note 4)	Max (Note 5)	Units
$V_{OS}$	Input Offset Voltage			-0.1	$\pm 1.8$	mV
TC $V_{OS}$	Input Offset Average Drift			6.6		$\mu V/^\circ C$
$I_B$	Input Bias Current	(Note 6)		80	120	nA
$I_{OS}$	Input Offset Current			2.2	15	nA
CMRR	Common Mode Rejection Ratio	$0 \leq V_{CM} \leq 2.0 V$	87	100		dB
PSRR	Power Supply Rejection Ratio	$3.0 \leq V^+ \leq 5V, V_{CM} = 0.5$	87	95		dB
		$2.7 \leq V^+ \leq 5.5V, V_{CM} = 0.5$	87	95		
CMVR	Input Common-Mode Voltage Range	CMRR $\geq 75$ dB	0		2.1	V
$A_{VOL}$	Large Signal Voltage Gain	$0.3 \leq V_O \leq 2.7, R_L = 2 k\Omega$ to $V^+/2$	80	85		dB
		$0.3 \leq V_O \leq 2.7, R_L = 10 k\Omega$ to $V^+/2$	86	93		
$V_O$	Output Swing High	$R_L = 2 k\Omega$ to $V^+/2$		80	95	mV from rail
		$R_L = 10 k\Omega$ to $V^+/2$		45	50	
	Output Swing Low	$R_L = 2 k\Omega$ to $V^+/2$		95	110	
		$R_L = 10 k\Omega$ to $V^+/2$		60	65	
$I_{SC}$	Output Short Circuit Current	Sourcing to $V^+/2$ $V_{ID} = 100$ mV (Note 8)	14	17		mA
		Sinking from $V^+/2$ $V_{ID} = -100$ mV (Note 8)	45	50		
$I_S$	Supply Current per Amplifier			119		$\mu A$
SR	Slew Rate	$A_V = +1$ , 10% to 90% (Note 7)		3.3		V/ $\mu s$
GBW	Gain Bandwidth Product			12		MHz
$e_n$	Input-Referred Voltage Noise	$f = 100$ kHz		17		nV/ $\sqrt{Hz}$
		$f = 1$ kHz		17		
$i_n$	Input-Referred Current Noise	$f = 100$ kHz		0.15		pA/ $\sqrt{Hz}$
		$f = 1$ kHz		0.1		
THD	Total Harmonic Distortion	$f = 1$ kHz, $A_V = 2$ , $R_L = 600\Omega$		0.003		%

## 5V DC Electrical Characteristics

Unless otherwise specified, all limits are guaranteed for  $T_J = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_O = V_{CM} = V^+/2$ , and  $R_L > 1\text{ M}\Omega$ . **Bold-face** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 5)	Typ (Note 4)	Max (Note 5)	Units
$V_{OS}$	Input Offset Voltage			-0.1	$\pm 1.8$	mV
$TC\ V_{OS}$	Input Offset Average Drift			6.6		$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current	(Note 6)		80	120	nA
$I_{OS}$	Input Offset Current			2.2	15	nA
CMRR	Common Mode Rejection Ratio	$0 \leq V_{CM} \leq 4.0\text{ V}$	90	100		dB
PSRR	Power Supply Rejection Ratio	$3\text{V} \leq V^+ \leq 5\text{V}$ , $V_{CM} = 0.5\text{V}$	87	95		dB
		$2.7\text{V} \leq V^+ \leq 5.5\text{V}$ , $V_{CM} = 0.5\text{V}$	87	95		
CMVR	Input Common-Mode Voltage Range	CMRR $\geq 80\text{ dB}$	0		4.1	V
$A_{VOL}$	Large Signal Voltage Gain	$0.3 \leq V_O \leq 4.7\text{V}$ , $R_L = 2\text{ k}\Omega$ to $V^+/2$	79	84		dB
		$0.3 \leq V_O \leq 4.7\text{V}$ , $R_L = 10\text{ k}\Omega$ to $V^+/2$	87	94		
$V_O$	Output Swing High	$R_L = 2\text{ k}\Omega$ to $V^+/2$		120	140	mV from rail
		$R_L = 10\text{ k}\Omega$ to $V^+/2$		75	90	
	Output Swing Low	$R_L = 2\text{ k}\Omega$ to $V^+/2$		110	130	
		$R_L = 10\text{ k}\Omega$ to $V^+/2$		70	80	
$I_{SC}$	Output Short Circuit Current	Sourcing to $V^+/2$ $V_{ID} = 100\text{ mV}$ (Note 8)	15	18.5		mA
		Sinking from $V^+/2$ $V_{ID} = -100\text{ mV}$ (Note 8)	45	50		
$I_S$	Supply Current per Amplifier			119		$\mu\text{A}$
SR	Slew Rate	$A_V = +1$ , $V_O = 1\text{ V}_{PP}$ 10% to 90% (Note 7)		3.2		$\text{V}/\mu\text{s}$
GBW	Gain Bandwidth Product			12		MHz
$e_n$	Input-Referred Voltage Noise	$f = 100\text{ kHz}$		17		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		17		
$i_n$	Input-Referred Current Noise	$f = 100\text{ kHz}$		0.1		$\text{pA}/\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$		0.15		
THD	Total Harmonic Distortion	$f = 1\text{ kHz}$ , $A_V = 2$ , $R_L = 600\Omega$		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 is  $1.5\text{ k}\Omega$  in series with  $100\text{ pF}$ . Machine Model is  $0\Omega$  in series with  $200\text{ pF}$

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

**Note 4:** Typical values represent the most likely parametric norm at the time of characterization.

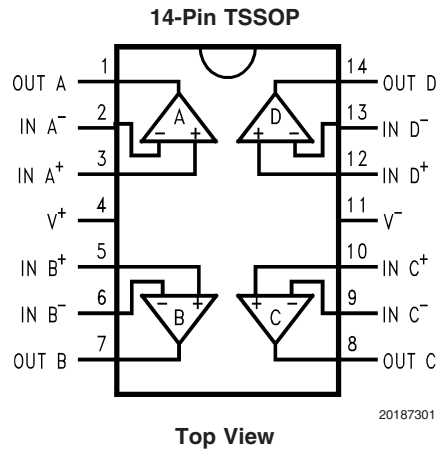
**Note 5:** Limits are 100% production tested at  $25^\circ\text{C}$ . Limits over the operating temperature range are guaranteed through correlations using Statistical Quality Control (SQC) method.

**Note 6:** Positive current corresponds to current flowing into the device.

**Note 7:** Slew rate is the average of the rising and falling slew rates.

**Note 8:** Short circuit test is a momentary test. Continuous source or sink currents higher than  $10\text{ mA}$  are not recommended as they might permanently disable the part.

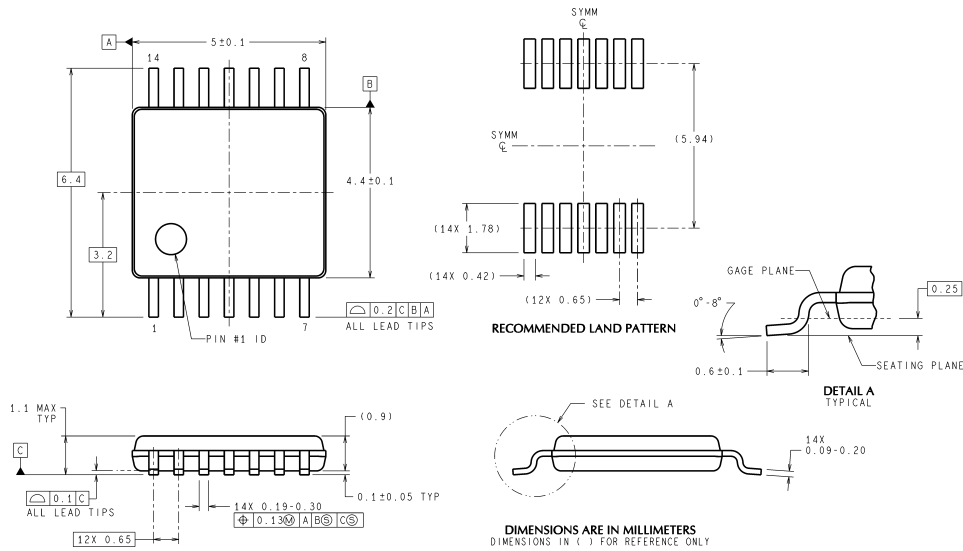
### Connection Diagram



### Ordering Information

Package	Part Number	Package marking	Transport Media	NSC Drawing
14-Pin TSSOP	LMV654MT	LMV654MT	94 Units/Rail	MTC14
	LMV654MTX		2.5k Units Tape and Reel	

## Physical Dimensions

 inches (millimeters) unless otherwise noted


**14-Pin TSSOP**  
**NS Package Number MTC14**

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

For the most current product information visit us at [www.national.com](http://www.national.com).

### LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

- Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
- A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

### BANNED SUBSTANCE COMPLIANCE

National Semiconductor manufactures products and uses packing materials that meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.

Leadfree products are RoHS compliant.



**National Semiconductor**  
Americas Customer  
Support Center  
Email: [new.feedback@nsc.com](mailto:new.feedback@nsc.com)  
Tel: 1-800-272-9959

**National Semiconductor**  
Europe Customer Support Center  
Fax: +49 (0) 180-530 85 86  
Email: [europe.support@nsc.com](mailto:europe.support@nsc.com)  
Deutsch Tel: +49 (0) 69 9508 6208  
English Tel: +44 (0) 870 24 0 2171  
Français Tel: +33 (0) 1 41 91 8790

**National Semiconductor**  
Asia Pacific Customer  
Support Center  
Email: [ap.support@nsc.com](mailto:ap.support@nsc.com)

**National Semiconductor**  
Japan Customer Support Center  
Fax: 81-3-5639-7507  
Email: [jpn.feedback@nsc.com](mailto:jpn.feedback@nsc.com)  
Tel: 81-3-5639-7560

[www.national.com](http://www.national.com)