

# LMP7701

## Precision, CMOS Input, RRIO, Wide Supply Range Amplifier

### General Description

The LMP7701 is a single, low offset voltage, rail-to-rail input and output precision amplifier with a CMOS input stage and a wide supply voltage range. The LMP7701 is part of the LMP™ precision amplifier family and is ideal for sensor interface and other instrumentation applications.

The guaranteed low offset voltage of less than  $\pm 200 \mu\text{V}$  along with the guaranteed low input bias current of less than  $\pm 10 \text{ pA}$  make the LMP7701 ideal for precision applications. The LMP7701 is built utilizing VIP50 technology, which allows the combination of a CMOS input stage and a 12V common mode and supply voltage range. This makes the LMP7701 a great choice in many applications where conventional CMOS parts cannot operate under the desired voltage conditions.

The LMP7701 has a rail-to-rail input stage that significantly reduces the CMRR glitch commonly associated with rail-to-rail input amplifiers. This is achieved by trimming both sides of the complimentary input stage, thereby reducing the difference between the NMOS and PMOS offsets. The output of the LMP7701 swings within 40 mV of either rail to maximize the signal dynamic range in applications requiring low supply voltage.

The LMP7701 is offered in space saving SOT23-5. This small package is an ideal solution for area constrained PC boards and portable electronics.

### Features

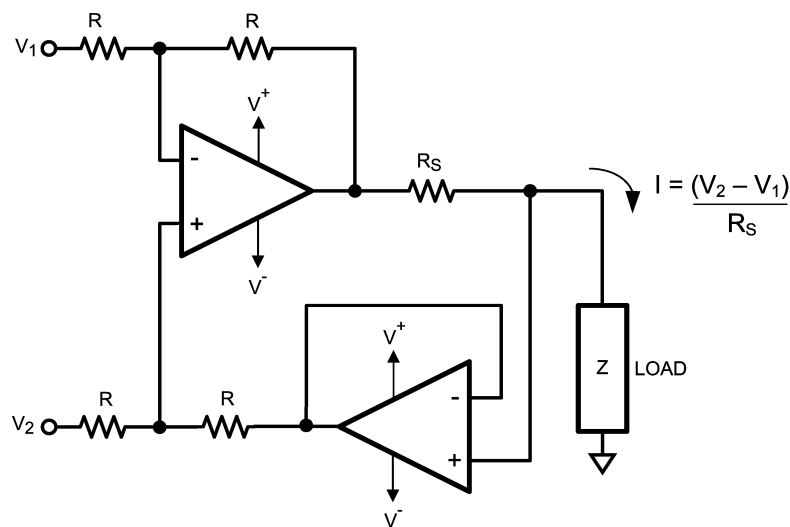
Unless otherwise noted, typical values at  $V_S = 5\text{V}$

- Input offset voltage  $\pm 200 \mu\text{V}$  (max)
- Input bias current 300 fA
- Input voltage noise  $12 \text{ nV}/\sqrt{\text{Hz}}$
- CMRR 100 dB
- Open loop gain 130 dB
- Temperature range  $-40^\circ\text{C}$  to  $125^\circ\text{C}$
- Unity gain bandwidth 2.5 MHz
- Supply current 715  $\mu\text{A}$
- Supply Voltage Range 2.7V to 12V
- Rail-to-rail input and output

### Applications

- High impedance sensor interface
- Battery powered instrumentation
- High gain amplifiers
- DAC buffer
- Instrumentation amplifier
- Active filters

### Typical Application



Precision Current Source

20127305

**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
Machine Model	200V
$V_{IN}$ Differential	$\pm 300$ mV
Supply Voltage ( $V_S = V^+ - V^-$ )	13.2V
Voltage at Input/Output Pins	$V^+ + 0.3V, V^- - 0.3V$
Input Current	10 mA
Storage Temperature Range	$-65^\circ\text{C}$ to $+150^\circ\text{C}$

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

**Operating Ratings** (Note 1)

Temperature Range (Note 3)	$-40^\circ\text{C}$ to $+125^\circ\text{C}$
Supply Voltage ( $V_S = V^+ - V^-$ )	2.7V to 12V
Package Thermal Resistance ( $\theta_{JA}$ (Note 3))	
5-Pin SOT23	$234^\circ\text{C/W}$

**3V Electrical Characteristics** (Note 4)

Unless otherwise specified, all limits are guaranteed for  $T_A = 25^\circ\text{C}$ ,  $V^+ = 3V$ ,  $V^- = 0V$ ,  $V_{CM} = V^+/2$ , and  $R_L > 10\text{ k}\Omega$  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			$\pm 37$	$\pm 200$ <b><math>\pm 500</math></b>	$\mu\text{V}$
$TCV_{OS}$	Input Offset Voltage Drift	(Note 7)		$\pm 1$	<b><math>\pm 5</math></b>	$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current	(Notes 7, 8)		0.3	10 <b>300</b>	pA
$I_{OS}$	Input Offset Current			40		fA
CMRR	Common Mode Rejection Ratio	$0V \leq V_{CM} \leq 3V$	86 <b>80</b>	98		dB
PSRR	Power Supply Rejection Ratio	$2.7V \leq V^+ \leq 12V, V_O = V^+/2$	86 <b>82</b>	98		dB
CMVR	Input Common-Mode Voltage Range	CMRR $\geq 80$ dB CMRR $\geq 77$ dB	-0.2 <b>-0.2</b>		3.2 <b>3.2</b>	V
$A_{VOL}$	Large Signal Voltage Gain	$R_L = 2\text{ k}\Omega$ $V_O = 0.3V$ to $2.7V$ $R_L = 10\text{ k}\Omega$ $V_O = 0.2V$ to $2.8V$	100 <b>96</b> 100 <b>96</b>	114 124		dB
$V_O$	Output Swing High	$R_L = 2\text{ k}\Omega$ to $V^+/2$	2.92 <b>2.88</b>	2.96		V
		$R_L = 10\text{ k}\Omega$ to $V^+/2$	2.96 <b>2.94</b>	2.97		
	Output Swing Low	$R_L = 2\text{ k}\Omega$ to $V^+/2$		0.04	0.06 <b>0.08</b>	V
		$R_L = 10\text{ k}\Omega$ to $V^+/2$		0.02	0.04 <b>0.05</b>	
$I_O$	Output Short Circuit Current (Notes 3, 9)	Sourcing $V_O = 0V$ $V_{IN} = 100\text{ mV}$	25 <b>15</b>	42		mA
		Sinking $V_O = 3V$ $V_{IN} = -100\text{ mV}$	25 <b>20</b>	42		
$I_S$	Supply Current			0.670	1.0 <b>1.2</b>	mA
SR	Slew Rate (Note 10)	$A_V = +1, V_O = 2 V_{PP}$ 10% to 90%		0.9		V/ $\mu\text{s}$
GBW	Gain Bandwidth Product			2.5		MHz
THD+N	Total Harmonic Distortion + Noise	$f = 1\text{ kHz}, A_V = 1, R_L = 1\text{ k}\Omega$		0.02		%
$e_n$	Input-Referred Voltage Noise	$f = 1\text{ kHz}$		12		nV/ $\sqrt{\text{Hz}}$

### 3V Electrical Characteristics (Note 4) (Continued)

Unless otherwise specified, all limits are guaranteed for  $T_A = 25^\circ\text{C}$ ,  $V^+ = 3\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V^+/2$ , and  $R_L > 10\text{ k}\Omega$  to  $V^+/2$ .

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

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
$i_n$	Input-Referred Current Noise	$f = 100\text{ kHz}$		1		$\text{fA}/\sqrt{\text{Hz}}$

### 5V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for  $T = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V^+/2$ , and  $R_L > 10\text{ k}\Omega$  to  $V^+/2$ .

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

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
$V_{\text{OS}}$	Input Offset Voltage			$\pm 37$	$\pm 200$ <b><math>\pm 500</math></b>	$\mu\text{V}$
$\text{TCV}_{\text{OS}}$	Input Offset Voltage Drift	(Note 7)		$\pm 1$	<b><math>\pm 5</math></b>	$\mu\text{V}/^\circ\text{C}$
$I_{\text{B}}$	Input Bias Current	(Notes 7, 8)		0.3	10 <b>300</b>	$\text{pA}$
$I_{\text{OS}}$	Input Offset Current			40		$\text{fA}$
CMRR	Common Mode Rejection Ratio	$0\text{V} \leq V_{\text{CM}} \leq 5\text{V}$	88 <b>83</b>	100		$\text{dB}$
PSRR	Power Supply Rejection Ratio	$2.7\text{V} \leq V^+ \leq 12\text{V}$ , $V_{\text{O}} = V^+/2$	86 <b>82</b>	98		$\text{dB}$
CMVR	Input Common-Mode Voltage Range	CMRR $\geq 80\text{ dB}$ CMRR $\geq 78\text{ dB}$	-0.2 <b>-0.2</b>		5.2 <b>5.2</b>	$\text{V}$
$A_{\text{VOL}}$	Large Signal Voltage Gain	$R_L = 2\text{ k}\Omega$ $V_{\text{O}} = 0.3\text{V}$ to $4.7\text{V}$	100 <b>96</b>	119		$\text{dB}$
		$R_L = 10\text{ k}\Omega$ $V_{\text{O}} = 0.2\text{V}$ to $4.8\text{V}$	100 <b>96</b>	130		
$V_{\text{O}}$	Output Swing High	$R_L = 2\text{ k}\Omega$ to $V^+/2$	4.89 <b>4.87</b>	4.94		$\text{V}$
		$R_L = 10\text{ k}\Omega$ to $V^+/2$	4.95 <b>4.93</b>	4.96		
	Output Swing Low	$R_L = 2\text{ k}\Omega$ to $V^+/2$		0.05	0.08 <b>0.09</b>	$\text{V}$
		$R_L = 10\text{ k}\Omega$ to $V^+/2$		0.03	0.04 <b>0.05</b>	
$I_{\text{O}}$	Output Short Circuit Current (Notes 3, 9)	Sourcing $V_{\text{O}} = 0\text{V}$ $V_{\text{IN}} = 100\text{ mV}$	40 <b>28</b>	66		$\text{mA}$
		Sinking $V_{\text{O}} = 5\text{V}$ $V_{\text{IN}} = -100\text{ mV}$	40 <b>28</b>	76		
$I_{\text{S}}$	Supply Current			0.715	1.0 <b>1.2</b>	$\text{mA}$
SR	Slew Rate (Note 10)	$A_V = +1$ , $V_{\text{O}} = 4 V_{\text{PP}}$ 10% to 90%		1.0		$\text{V}/\mu\text{s}$
GBW	Gain Bandwidth Product			2.5		$\text{MHz}$
THD+N	Total Harmonic Distortion + Noise	$f = 1\text{ kHz}$ , $A_V = 1$ , $R_L = 1\text{ k}\Omega$		0.02		$\%$
$e_n$	Input-Referred Voltage Noise	$f = 1\text{ kHz}$		12		$\text{nV}/\sqrt{\text{Hz}}$
$i_n$	Input-Referred Current Noise	$f = 100\text{ kHz}$		1		$\text{fA}/\sqrt{\text{Hz}}$

## ±5V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for  $T_A = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = -5\text{V}$ ,  $V_{\text{CM}} = 0$ , and  $R_L > 10\text{ k}\Omega$  to  $V_{\text{CM}}$ . **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
$V_{\text{OS}}$	Input Offset Voltage			±37	±200 <b>±500</b>	μV
$\text{TCV}_{\text{OS}}$	Input Offset Voltage Drift	(Note 7)		±1	<b>±5</b>	μV/°C
$I_{\text{B}}$	Input Bias Current	(Notes 7, 8)		0.3	10 <b>300</b>	pA
$I_{\text{OS}}$	Input Offset Current			40		fA
CMRR	Common Mode Rejection Ratio	$-5\text{V} \leq V_{\text{CM}} \leq 5\text{V}$	92 <b>88</b>	110		dB
PSRR	Power Supply Rejection Ratio	$2.7\text{V} \leq V^+ \leq 12\text{V}$ , $V_{\text{O}} = V_{\text{CM}}$	86 <b>82</b>	98		dB
CMVR	Input Common-Mode Voltage Range	CMRR ≥ 80 dB CMRR ≥ 78dB	-5.2 <b>-5.2</b>		5.2 <b>5.2</b>	V
$A_{\text{VOL}}$	Large Signal Voltage Gain	$R_L = 2\text{ k}\Omega$ $V_{\text{O}} = -4.7\text{V to } 4.7\text{V}$ $R_L = 10\text{ k}\Omega$ $V_{\text{O}} = -4.8\text{V to } 4.8\text{V}$	100 <b>98</b> 100 <b>98</b>	121 134		dB
$V_{\text{O}}$	Output Swing High	$R_L = 2\text{ k}\Omega$ to $V_{\text{CM}}$	4.85 <b>4.83</b>	4.91		V
		$R_L = 10\text{ k}\Omega$ to $V_{\text{CM}}$	4.92 <b>4.90</b>	4.96		
	Output Swing Low	$R_L = 2\text{ k}\Omega$ to $V_{\text{CM}}$		-4.91	-4.87 <b>-4.85</b>	V
		$R_L = 10\text{ k}\Omega$ to $V_{\text{CM}}$		-4.96	-4.95 <b>-4.94</b>	
$I_{\text{O}}$	Output Short Circuit Current (Notes 3, 9)	Sourcing $V_{\text{O}} = -5\text{V}$ $V_{\text{IN}} = 100\text{ mV}$	50 <b>35</b>	86		mA
		Sinking $V_{\text{O}} = 5\text{V}$ $V_{\text{IN}} = -100\text{ mV}$	50 <b>35</b>	84		
$I_{\text{S}}$	Supply Current			0.790	1.1 <b>1.3</b>	mA
SR	Slew Rate (Note 10)	$A_V = +1$ , $V_{\text{O}} = 9\text{ V}_{\text{PP}}$ 10% to 90%		1.1		V/μs
GBW	Gain Bandwidth Product			2.5		MHz
THD+N	Total Harmonic Distortion + Noise	$f = 1\text{ kHz}$ , $A_V = 1$ , $R_L = 1\text{ k}\Omega$		0.02		%
$e_{\text{n}}$	Input-Referred Voltage Noise	$f = 1\text{ kHz}$		12		nV/√Hz
$i_{\text{n}}$	Input-Referred Current Noise	$f = 100\text{ kHz}$		1		fA/√Hz

**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: 1.5 kΩ in series with 100 pF. Machine Model: 0Ω in series with 200 pF.

**Note 3:** The maximum power dissipation is a function of  $T_{\text{J(MAX)}}$ ,  $\theta_{\text{JA}}$ , and  $T_{\text{A}}$ . The maximum allowable power dissipation at any ambient temperature is  $P_{\text{D}} = (T_{\text{J(MAX)}} - T_{\text{A}}) / \theta_{\text{JA}}$ . 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 parametric norm at the time of characterization.

**Note 6:** Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlations using the Statistical Quality Control (SQC) method.

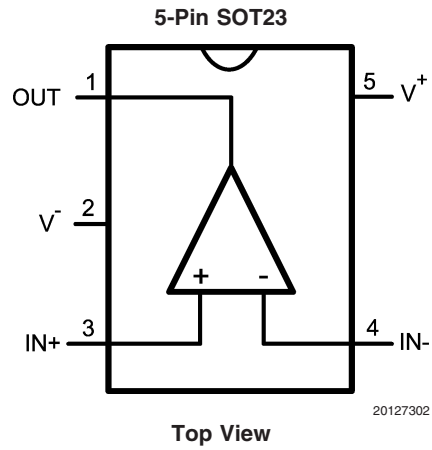
**Note 7:** Guaranteed by design.

**Note 8:** Positive current corresponds to current flowing into the device.

**Note 9:** The short circuit test is a momentary test.

**Note 10:** The number specified is the slower of positive and negative slew rates.

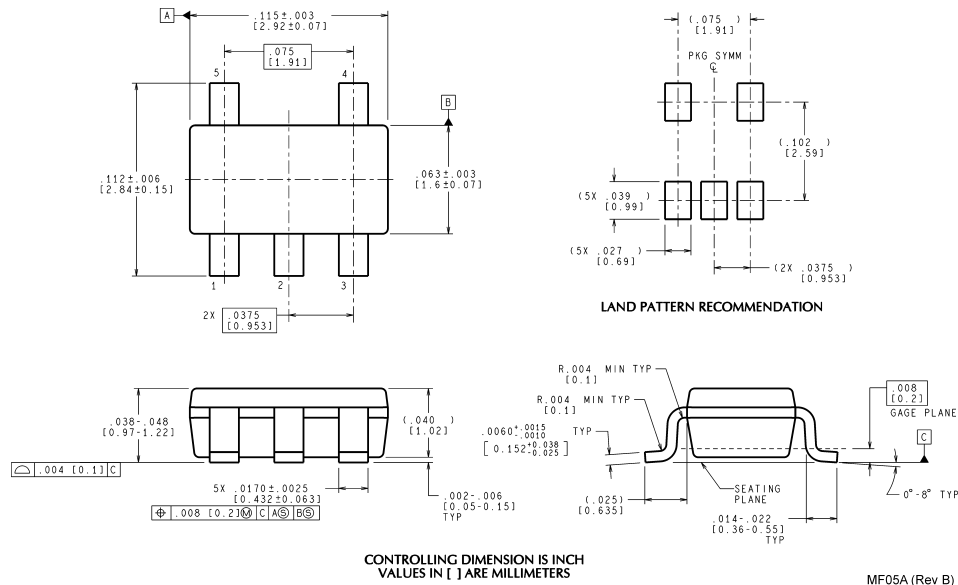
## Connection Diagram



## Ordering Information

Package	Part Number	Package Marking	Transport Media	NSC Drawing
5-Pin SOT-23	LMP7701MF	AC2A	1k Units Tape and Reel	MF05A
	LMP7701MFX		3k Units Tape and Reel	

## Physical Dimensions inches (millimeters) unless otherwise noted



**5-Pin SOT23**  
**NS Package Number MF05A**

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