

## LT1009 Series 2.5V Reference

### FEATURES

- Maximum Initial Tolerance: 0.2%
- Guaranteed Temperature Stability
- Maximum 0.6Ω Dynamic Impedance
- Wide Operating Current Range
- Directly Interchangeable with LM136 for Improved Performance
- No Adjustments Needed for Minimum Temperature Coefficient

### APPLICATIONS

- Reference for 5V Systems
- 8-Bit A/D and D/A Reference
- Digital Voltmeters
- Current Loop Measurement and Control Systems
- Power Supply Monitor

### DESCRIPTION

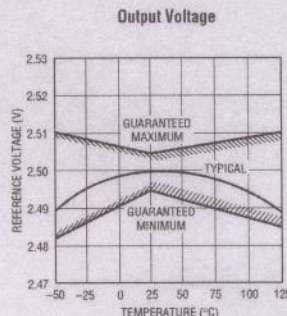
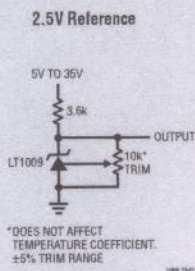
The LT<sup>®</sup>1009 is a precision trimmed 2.5V shunt regulator diode featuring a maximum initial tolerance of only ±5mV. The low dynamic impedance and wide operating current range enhances its versatility. The 0.2% reference tolerance is achieved by on-chip trimming which not only minimizes the initial voltage tolerance but also minimizes the temperature drift.

Even though no adjustments are needed with the LT1009, a third terminal allows the reference voltage to be adjusted ±5% to calibrate out system errors. In many applications, the LT1009 can be used as a pin-to-pin replacement of the LM136 and the external trim network eliminated.

For a lower drift 2.5V reference, see the LT1019 data sheet.

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### TYPICAL APPLICATION



### ABSOLUTE MAXIMUM RATINGS (Note 1)

Reverse Current .....	20mA	Operating Temperature Range	
Forward Current .....	10mA	LT1009/LT1009C .....	0°C to 70°C
Storage Temperature Range .....	-65°C to 150°C	LT1009I .....	-40°C to 85°C
Lead Temperature (Soldering, 10 sec) .....	300°C	<b>LT1009M (OBSOLETE) .....</b>	<b>-55°C to 125°C</b>

### ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are T<sub>A</sub> = 25°C.

SYMBOL	PARAMETER	CONDITIONS	LT1009M			LT1009I			LT1009/LT1009C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>Z</sub>	Reverse Breakdown Voltage	T <sub>A</sub> = 25°C, I <sub>R</sub> = 1mA, H, Z Pkg MS, S Pkg	2.495	2.500	2.505	2.495	2.500	2.505	2.495	2.500	2.505	V
ΔV <sub>Z</sub> /ΔI <sub>R</sub>	Reverse Breakdown Change with Current	400μA ≤ I <sub>R</sub> ≤ 10mA	●	2.6	6	3.0	10	2.6	10	2.6	10	mV
r <sub>Z</sub>	Reverse Dynamic Impedance	I <sub>R</sub> = 1mA	●	0.2	0.6	0.4	1.0	0.2	1.0	0.2	1.0	Ω
	Temperature Stability	T <sub>MIN</sub> ≤ T <sub>A</sub> ≤ T <sub>MAX</sub>	●		15		15		1.8	4		mV
ΔV <sub>Z</sub> /ΔTemp	Average Temperature Coefficient (Notes 2, 3)	0°C ≤ T <sub>A</sub> ≤ 70°C -40°C ≤ T <sub>A</sub> ≤ 85°C -55°C ≤ T <sub>A</sub> ≤ 125°C		15	25		15	25	15	25		ppm/°C
					35			35				ppm/°C
ΔV <sub>Z</sub> /ΔTime	Long-Term Stability	T <sub>A</sub> = 25°C ± 0.1°C, I <sub>R</sub> = 1mA		20			20		20			ppm/kHr

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** Guaranteed by Design.

**Note 3:** Average temperature coefficient is defined as the total voltage change divided by the specified temperature change.

**TL071, TL071A, TL071B, TL072**  
**TL072A, TL072B, TL074, TL074A, TL074B**  
**LOW-NOISE JFET-INPUT OPERATIONAL AMPLIFIERS**

- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion  
0.003% Typ
- Low Noise  
 $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$  Typ at  $f = 1 \text{ kHz}$
- High Input Impedance . . . JFET Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/ $\mu\text{s}$  Typ
- Common-Mode Input Voltage Range  
Includes  $V_{CC+}$

**description**

The JFET-input operational amplifiers in the TL07\_ series are designed as low-noise versions of the TL08\_ series amplifiers with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL07\_ series ideally suited for high-fidelity and audio preamplifier applications. Each amplifier features JFET inputs (for high input impedance) coupled with bipolar output stages integrated on a single monolithic chip.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from -40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of -55°C to 125°C.

**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

Supply voltage, $V_{CC+}$ (see Note 1)	18 V
Supply voltage, $V_{CC-}$ (see Note 1)	-18 V
Differential input voltage, $V_{ID}$ (see Note 2)	$\pm 30 \text{ V}$
Input voltage, $V_I$ (see Notes 1 and 3)	$\pm 15 \text{ V}$
Duration of output short circuit (see Note 4)	unlimited
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, $T_A$ : C suffix	0°C to 70°C
I suffix	-40°C to 85°C
M suffix	-55°C to 125°C
Storage temperature range	-65°C to 150°C
Case temperature for 60 seconds: FK package	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J, JG, or W package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, N, P, or PW package	260°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. All voltage values, except differential voltages, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .
2. Differential voltages are at  $IN+$  with respect to  $IN-$ .
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
4. The output may be shorted to ground or to either supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.

**electrical characteristics,  $V_{CC\pm} = \pm 15 \text{ V}$  (unless otherwise noted)**

PARAMETER	TEST CONDITIONS†	$T_A$ ‡	TL071C TL072C TL074C			TL071AC TL072AC TL074AC			TL071BC TL072BC TL074BC			TL071I TL072I TL074I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$	Input offset voltage $V_O = 0, R_S = 50 \Omega$	25°C	3 10			3 6			2 3			3 6			mV
		Full range	13			7.5			5			8			
$\alpha_{VIO}$	Temperature coefficient of input offset voltage $V_O = 0, R_S = 50 \Omega$	Full range	18			18			18			18			$\mu\text{V}/^\circ\text{C}$
$I_{IO}$	Input offset current $V_O = 0$	25°C	5 100			5 100			5 100			5 100			$\mu\text{A}$
		Full range	10			2			2			2			nA
$I_{IB}$	Input bias current§ $V_O = 0$	25°C	65 200			65 200			65 200			65 200			$\mu\text{A}$
		Full range	7			7			7			20			nA
$V_{ICR}$	Common-mode input voltage range	25°C	$\pm 11$	-12 to 15		$\pm 11$	-12 to 15		$\pm 11$	-12 to 15		$\pm 11$	-12 to 15	V	
$V_{OM}$	Maximum peak output voltage swing $R_L = 10 \text{ k}\Omega$	25°C	$\pm 12$	$\pm 13.5$		$\pm 12$	$\pm 13.5$		$\pm 12$	$\pm 13.5$		$\pm 12$	$\pm 13.5$	V	
			$\pm 12$			$\pm 12$			$\pm 12$			$\pm 12$			
		Full range	$\pm 10$			$\pm 10$			$\pm 10$			$\pm 10$			
$A_{VD}$	Large-signal differential voltage amplification $V_O = \pm 10 \text{ V}, R_L \geq 2 \text{ k}\Omega$	25°C	25	200		50	200		50	200		50	200	V/mV	
		Full range	15			25			25			25			
$B_1$	Unity-gain bandwidth	25°C	3			3			3			3			MHz
$r_i$	Input resistance	25°C	$10^{12}$			$10^{12}$			$10^{12}$			$10^{12}$			$\Omega$
CMRR	Common-mode rejection ratio $V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50 \Omega$	25°C	70	100		75	100		75	100		75	100	dB	
kSVR	Supply-voltage rejection ratio ( $\Delta V_{CC\pm} / \Delta V_{IO}$ ) $V_{CC} = \pm 9 \text{ V to } \pm 15 \text{ V}, V_O = 0, R_S = 50 \Omega$	25°C	70	100		80	100		80	100		80	100	dB	
$I_{CC}$	Supply current (each amplifier) $V_O = 0, \text{ No load}$	25°C	1.4	2.5		1.4	2.5		1.4	2.5		1.4	2.5	mA	
$V_{O1}/V_{O2}$	Crosstalk attenuation $A_{VD} = 100$	25°C	120			120			120			120			dB

† All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified.

‡ Full range is  $T_A = 0^\circ\text{C to } 70^\circ\text{C}$  for TL07\_C, TL07\_AC, TL07\_BC and is  $T_A = -40^\circ\text{C to } 85^\circ\text{C}$  for TL07\_I.

§ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 4. Pulse techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

# ADC0802, ADC0803, ADC0804

Microprocessor- Compatible, A/D Converters

### Features

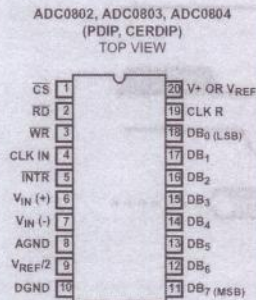
- 80C48 and 80C80/85 Bus Compatible - No Interfacing Logic Required
- Conversion Time < 100 $\mu$ s
- Easy Interface to Most Microprocessors
- Will Operate in a "Stand Alone" Mode
- Differential Analog Voltage Inputs
- Works with Bandgap Voltage References
- TTL Compatible Inputs and Outputs
- On-Chip Clock Generator
- 0V to 5V Analog Voltage Input Range (Single +5V Supply)
- No Zero-Adjust Required

### Description

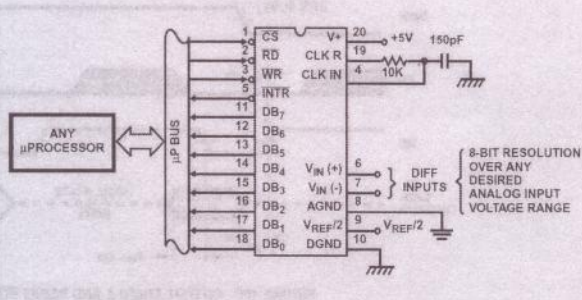
The ADC0802 family are CMOS 8-Bit, successive-approximation A/D converters which use a modified potentiometric ladder and are designed to operate with the 8080A control bus via three-state outputs. These converters appear to the processor as memory locations or I/O ports, and hence no interfacing logic is required.

The differential analog input has good common-mode-rejection and permits offsetting the analog zero-input-voltage value. In addition, the voltage reference input can be adjusted to allow encoding any smaller analog voltage span to the full 8 bits of resolution.

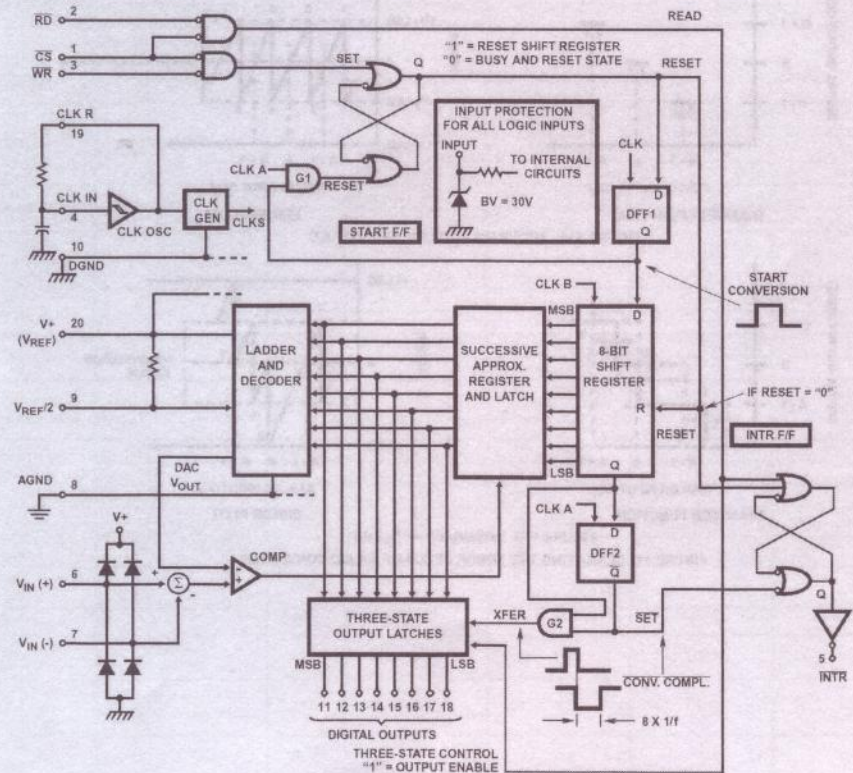
### Pinout



### Typical Application Schematic



### Functional Diagram



**Timing Waveforms**

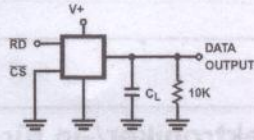


FIGURE 1A.  $t_{1H}$

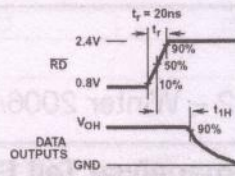


FIGURE 1B.  $t_{1H}$ ,  $C_L = 10\text{pF}$

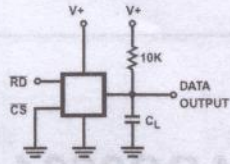


FIGURE 1C.  $t_{0H}$

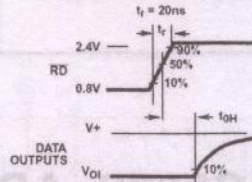


FIGURE 1D.  $t_{0H}$ ,  $C_L = 10\text{pF}$

FIGURE 1. THREE-STATE CIRCUITS AND WAVEFORMS

**Timing Diagrams**

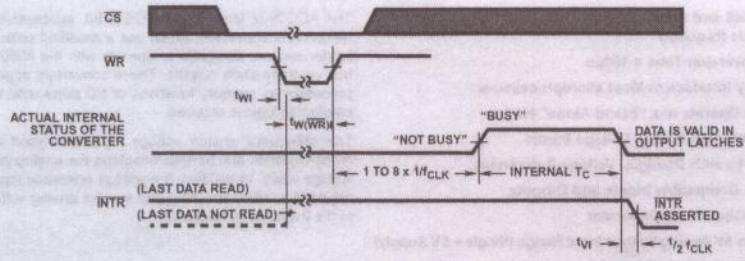


FIGURE 10A. START CONVERSION

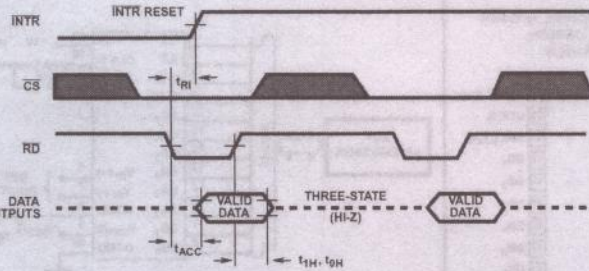


FIGURE 10B. OUTPUT ENABLE AND RESET INTR

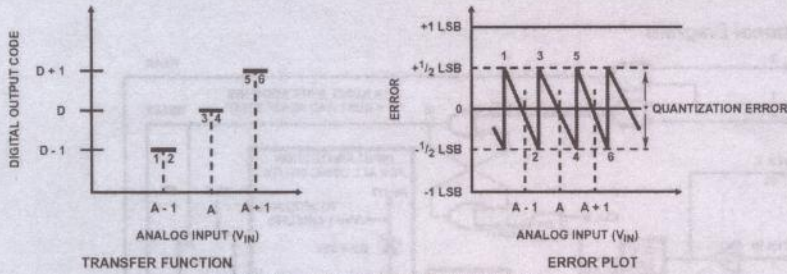


FIGURE 11A. ACCURACY =  $\pm 0$  LSB; PERFECT A/D

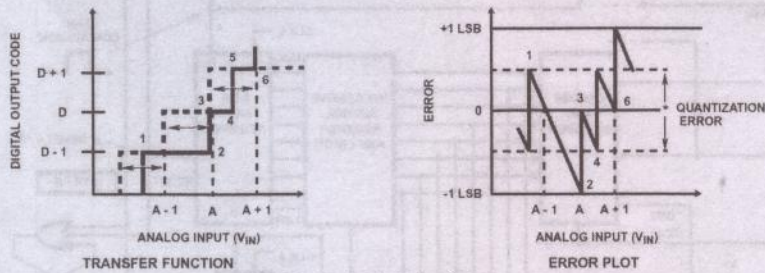


FIGURE 11B. ACCURACY =  $\pm 1/2$  LSB

FIGURE 11. CLARIFYING THE ERROR SPECS OF AN A/D CONVERTER