

Low-Power, Single-Supply Op Amp + Comparator + Reference CN951

General Description

The CN951 features combinations of a low power operational amplifier, comparator and reference in an 8-pin SOP package. In the CN951, the comparator's inverting input is connected to an internal 1.211V $\pm 2\%$ bandgap reference. The CN951 operates from a single 2.5V to 5.5V supply with a typical supply current of 15uA. Both the op amp and comparator feature a common-mode input voltage range that extends from the negative supply rail to the positive supply rail, as well as output stages that swing Rail-to-Rail.

The op amp in the CN951 is internally compensated to be unity-gain stable with 20V/ms slew rate. The op amp has a unique output stage that enables it to operate with a low supply current while maintaining linearity under loaded conditions. In addition, the device has been designed to exhibit good DC characteristics over the entire operating temperature range. In addition, the comparator contains a $\pm 7\text{mV}$ (14mV) internal hysteresis to ensure clean output switching, even with slow-moving input signals.

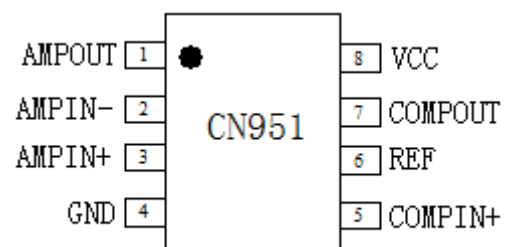
Applications

- Instruments, Terminals, and Bar-Code Readers
- Battery-Powered Systems
- Automotive Keyless Entry
- Low-Frequency, Local-Area Alarms/Detectors
- Photodiode Preamps
- Smart Cards
- Infrared Receivers for Remote Controls
- Smoke Detectors and Safety Sensors

Features

- Op Amp + Comparator + Reference
- Operating Current: 15uA
- Rail-to-Rail Inputs and Outputs
- 2.5V to 5.5V Supply Voltage Range
- Unity-Gain Stable
- Internal 1.211V $\pm 2\%$ Bandgap Reference
- Internal Comparator Hysteresis: $\pm 7\text{mV}$ (14mV)
- Op Amp Capable of Driving up to 1nF Load
- Operating Temperature Range:
-40°C to 85°C
- Available in SOP8 Package
- Lead-free, Rohs-compliant and Halogen-free

Pin Assignment



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Typical Application Circuit

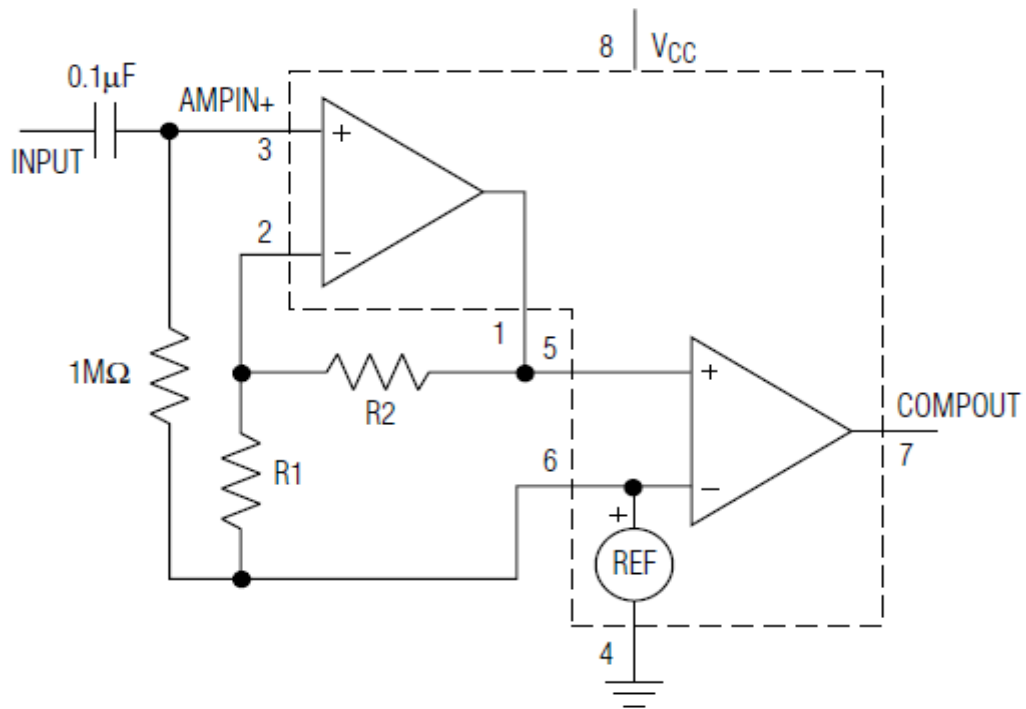


Figure 1 Typical Application Circuit

Ordering Information:

Part No.	Package	Shipping	Operating Temperature Range
CN951	SOP-8	Tape and Reel, 4000/Reel	-40°C to +85°C

Block Diagrams

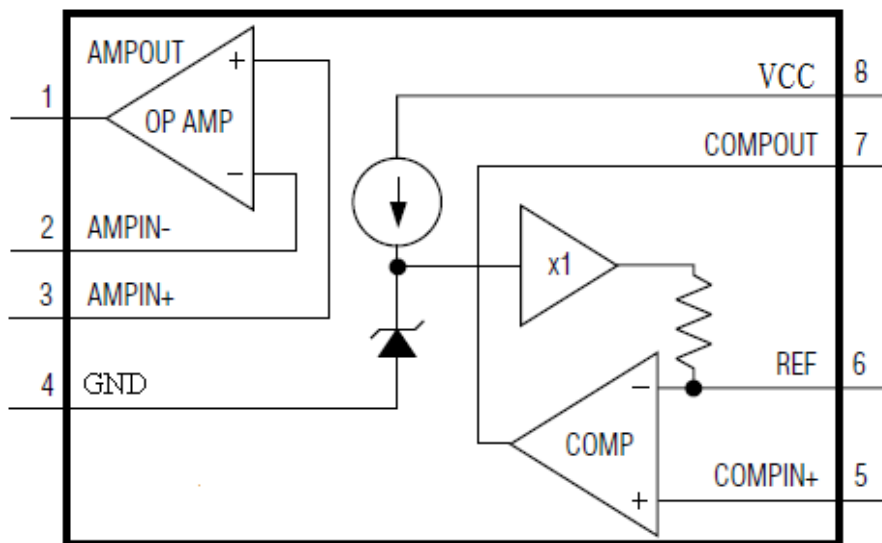


Figure 2 Block Diagram

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Pin Description

Pin No.	Symbol	Description
1	AMPOUT	Op Amp Output.
2	AMPIN-	Inverting Op Amp Input.
3	AMPIN+	Non-inverting Op Amp Input.
4	GND	Negative Terminal of Power Supply or Ground.
5	COMPIN+	Non-inverting Comparator Input.
6	REF	Reference Voltage Output. The reference voltage is 1.211V typical with $\pm 2\%$ accuracy. This pin is also connected to the inverting input of comparator.
7	COMPOUT	Comparator Output.
8	VCC	Positive Terminal of Power Supply.

ABSOLUTE MAXIMUM RATINGS

Terminal Voltage (With Respect to GND)

VCC.....-0.3V to +6.5V

The other Pins.....-0.3V to VCC

Input/Output Current

All Pins.....20mA

Short-Circuit Duration

REF and AMPOUT.....Continuous

COMPOUT.....2s

Maximum Junction Temperatures.....+150°C

Thermal Resistance.....200°C/W

Operating Temperature.....-40 to +85°C

Storage Temperature.....-65 to +150°C

Lead Temperature (soldering, 10s)+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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

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Electrical Characteristics

(VCC=3V, TA= -40°C to 85°C, Typical values are at TA=25°C, unless otherwise noted.)

Parameters	Symbol	Test Conditions	Min	Typ	Max	Unit
Operating Voltage Range	VCC		2.5		5.5	V
Operating Current	IVCC	VCC=3.0V	8	14	20	uA
		VCC=5.0V	9	15	21	
Reference						
Reference Voltage	VREF		1.187	1.211	1.235	V
Load Regulation		IOUT = ±20µA, TA= +25°C		0.1		%
Comparator						
Input Offset Voltage	VOS			1	4	mV
Upper Trip Point	Vup	COMPIN+ rises		VREF + 0.007		V
Lower Trip Point	Vlow	COMPIN+ falls		VREF - 0.007		V
Input Leakage Current			-10	0.01	10	nA
Common-Mode Input Range	CMVR		GND		VCC	V
Common-Mode Rejection Ratio	CMRR	GND to VCC		0.1	1	mV/V
Power-Supply Rejection Ratio	PSRR	VCC = 2.5V to 5.5V		0.05	1	mV/V
Propagation Delay	tpd	CL = 100pF, VCC = 5V, 5mV Overdrive		25		µs
		CL=100pF, VCC=5V, 20mV Overdrive		6		
Output High Voltage	VOH	ISOURCE = 8mA	VCC - 0.4V			V
Output Low Voltage	VOL	ISINK = 10mA			0.4V	V
OP AMP						
Input Offset Voltage	Vos				4	mV
Input Bias Current	IB			0.01	10	nA
Large-Signal Gain (No Load)	Avol	AMPOUT = 0.5V to 5V, VCC - GND = 5V	100	1000		V/mV
Large-Signal Gain (100kΩ Load to GND)	Avol	AMPOUT = 0.5V to 4.5V, VCC - GND = 5V	40	150		V/mV
Gain Bandwidth	GBW	AV = 1V/V, VCC - GND = 5V		40		kHz
Slew Rate	SR	AV = 1V/V, VCC - GND = 5V		20		V/ms
Common-Mode Input Range	CMVR		GND		VCC	V
Common-Mode Rejection Ratio	CMRR	VCM = GND to VCC		0.03	1	V/mV

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Parameters	Symbol	Test Conditions	Min	Typ	Max	Unit
Power-Supply Rejection Ratio	PSRR	VCC = 2.5V to 5.5V		0.07	1.0	V/mV
Output High Voltage	V _{OH}	RL = 100kΩ to GND	VCC – 0.3V			V
Output Low Voltage	V _{OL}	RL = 100kΩ to GND	GND + 0.05			V
Output Source Current	I _{SRC}	VCC – GND= 5V	300	820		uA
Output Sink Current	I _{SNK}	VCC – GND= 5V	200	570		uA

Detailed Description

The CN951 is combinations of a low power op amp, comparator and reference in an 8-pin SO package, as shown in Figure 2. In the CN951, the comparator's negative input is connected to a 1.211V ±2% bandgap reference. The device is optimized to operate from a single supply.

Op Amp

The op amp in the CN951 is internally compensated to be unity-gain stable, 20V/ms slew rate. The op amp features high-impedance differential inputs and a common mode input voltage range that extends from the negative supply rail to within the positive rail. The CMOS output stage can swing rail to rail and is driven by a proprietary high gain stage, which enables it to operate with a low supply current while maintaining linearity under loaded conditions. Careful design results in good DC characteristics over their entire operating temperature range, minimizing input referred errors.

Comparator

The comparator in the CN951 has a high impedance differential input stage with a common mode input voltage range that extends from the negative supply rail to the positive rail. The CMOS output stage swings rail-to-rail and can continuously source as much as 20mA. The comparator eliminates power-supply glitches that commonly occur when changing logic states, minimizing parasitic feedback and making them easier to use. In addition, they include internal ±7mV(14mV) hysteresis to ensure clean output switching, even with slow-moving input signals. The input can be taken above and below the supply rails up to 300mV without damage. Input voltages beyond this range can forward bias the ESD-protection diode and should be avoided. The CN951 comparator output can also swing rail to rail. TTL compatibility is assured by using a 5V ±10% supply. The CN951 comparator continuously outputs source currents or sink current as high as 20mA, while keeping quiescent currents in the microampere range. The output can source or sink 100mA (at VCC = 5V) for short pulses, as long as the package's maximum power dissipation is not exceeded. The output stage does not generate crowbar switching currents during transitions; this minimizes feedback through the supplies and helps ensure stability without bypassing.

Reference

The internal reference in the CN951 has an output of 1.211V with respect to GND. Its accuracy is ±2% in the -40°C to +85°C temperature range. It is comprised of a trimmed bandgap reference fed by a proportional to absolute-temperature (PTAT) current source and buffered by a micropower unity-gain amplifier. The REF output is typically capable of sourcing and sinking 20µA. Do not bypass the reference output. The reference is stable for capacitive loads less than 100pF.

Application Information

Comparator Hysteresis

Hysteresis increases the comparator's noise immunity by increasing the upper threshold and decreasing the

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lower threshold. The comparator in the CN951 contains a $\pm 7\text{mV}$ (14mV) internal hysteresis to ensure clean output switching, even with slow-moving signals. When necessary, hysteresis can be increased by using external resistors to add positive feedback as shown in Figure 3 and Figure 4. The 2 circuits increase the hysteresis at the expense of more supply current and longer response time.

(1) In the circuit of Figure 3:

The upper trip point of the comparator:

$$V_{\text{up}} = \frac{R1+R2}{R2} \times (V_{\text{ref}}+0.007)$$

The lower trip point of the comparator:

$$V_{\text{low}} = \frac{R1+R2}{R2} \times (V_{\text{ref}}-0.007) - \frac{R1}{R2} \times V_{\text{CC}}$$

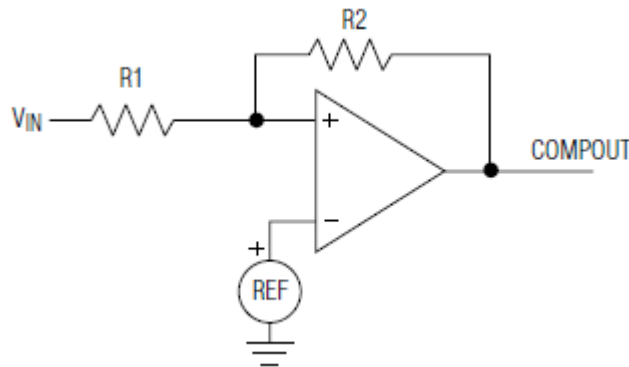


Figure 3 External Hysteresis

R2's value can be chosen between $1\text{M}\Omega$ and $2\text{M}\Omega$ for smaller supply current, then calculate R1's value based on the above 2 equations and the hysteresis needed.

(2) In the circuit in Figure 4

The upper trip point of the comparator:

$$V_{\text{up}} = \left(1 + \frac{R_A}{R_B} + \frac{R_A}{R_2}\right) \times (V_{\text{ref}}+0.007)$$

The lower trip point of the comparator:

$$V_{\text{low}} = \left(1 + \frac{R_A}{R_B} + \frac{R_A}{R_2}\right) \times (V_{\text{ref}}-0.007) - \frac{R_A}{R_2} \times V_{\text{CC}}$$

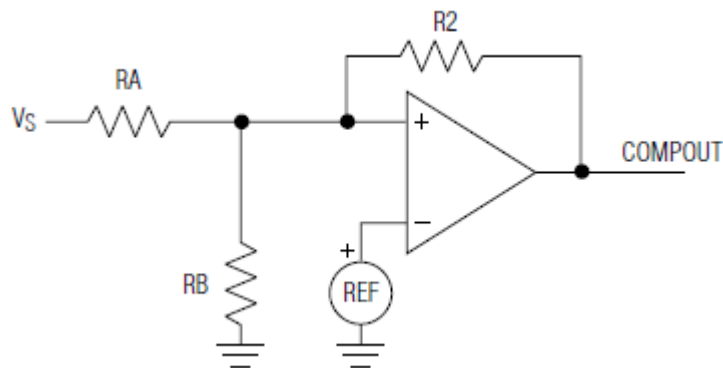


Figure 4 External Hysteresis

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R2's value can be chosen between $1M\Omega$ and $2M\Omega$ for smaller supply current, then calculate RA and RB's values based on the above 2 equations and the hysteresis needed.

Input Noise Considerations

Because low power requirements often demand high impedance circuits, effects from radiated noise are more significant. Thus, traces between the op amp or comparator inputs and any resistor networks attached should be kept as short as possible.

Crosstalk-Reference

There may be crosstalk to the reference from the comparator in the CN951. Applications using the reference for the op amp or external circuitry can eliminate this crosstalk by using a simple RC low-pass filter, as shown in Figure 5. In figure 5, R1 and C1 serve the purpose.

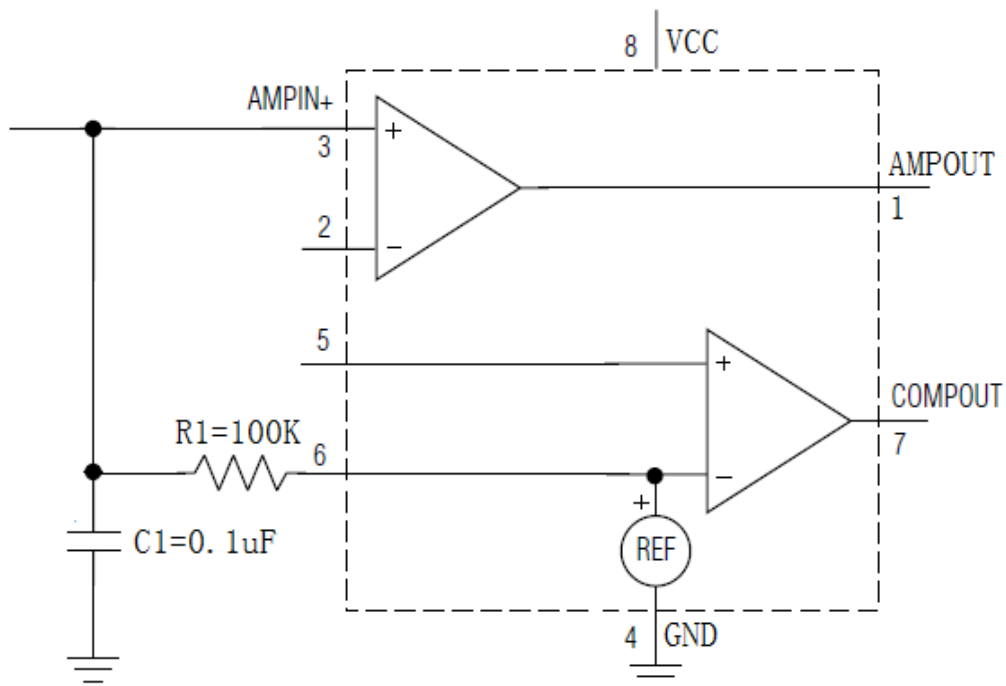


Figure 5 RC Filter to Eliminate Crosstalk at REF

Op Amp Stability and Board Layout Considerations

The op amp in the CN951 maintains stability in their minimum gain configuration while driving heavy capacitive loads. Although this family is primarily designed for low frequency applications, good layout is extremely important. Low-power, high-impedance circuits may increase the effects of board leakage and stray capacitance. For example, the combination of a $10M\Omega$ resistance (from leakage between traces on a contaminated, poorly designed PC board) and a $1pF$ stray capacitance provides a pole at approximately $16kHz$, which is near the amplifier's bandwidth. Board routing and layout should minimize leakage and stray capacitance. In some cases, stray capacitance may be unavoidable and it may be necessary to add a $2pF$ to $10pF$ capacitor across the feedback resistor to compensate; select the smallest capacitor value that ensures stability.

Power-Supply Bypassing

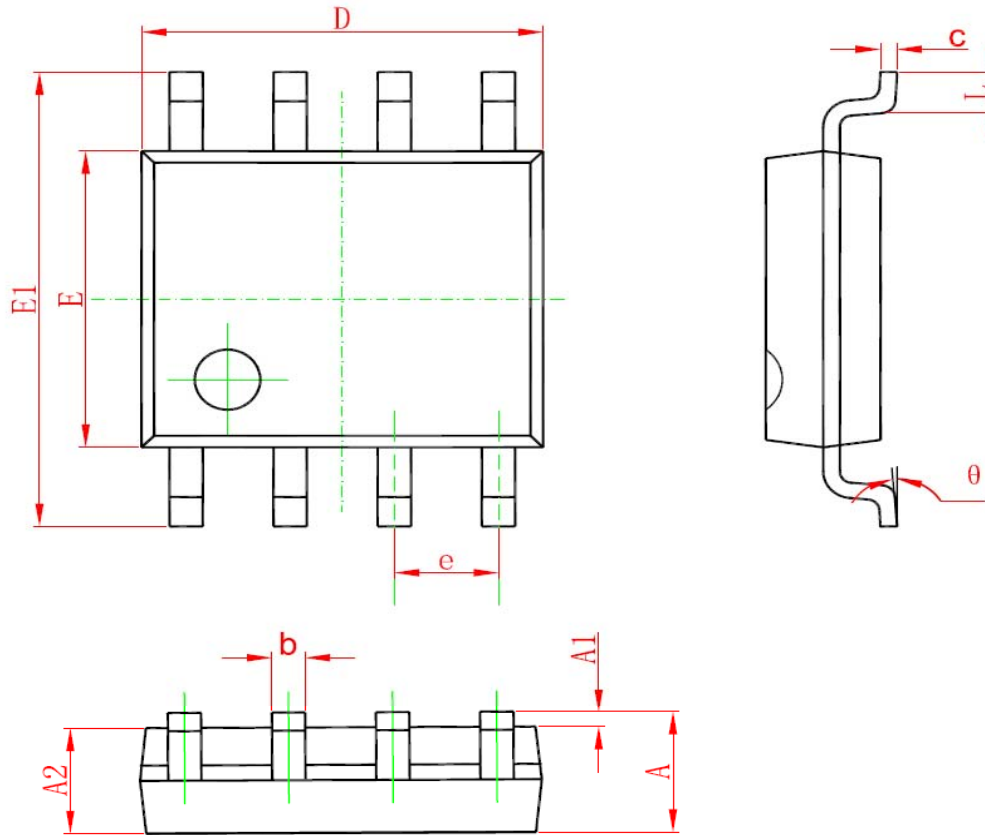
Power-supply bypass capacitor is not required if the supply impedance is low. For single-supply applications, it is good practice to bypass VCC with a $0.1\mu F$ capacitor to ground.

Do not bypass the reference output.

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Package Information

SOP8 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

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