ANALOG DEVICES

Precision, Low Power, Micropower Dual Operational Amplifier

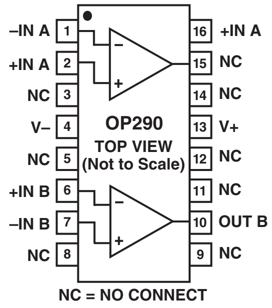
OP290

FEATURES

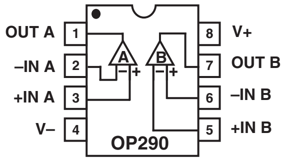
- **Single-/Dual-Supply Operation, 1.6 V to 36 V, ±0.8 V to ±18 V**
- **True Single-Supply Operation; Input and Output Voltage Ranges Include Ground**
- **Low Supply Current (Per Amplifier), 20 µA Max**
- **High Output Drive, 5 mA Min**
- **Low Input Offset Voltage, 200 µV Max**
- **High Open-Loop Gain, 700 V/mV Min**
- **Outstanding PSRR, 5.6 µV/V Max**
- **Industry Standard 8-Lead Dual Pinout**
- **Available in Die Form**

PIN CONNECTIONS

16-Lead SOL
(S-Suffix)



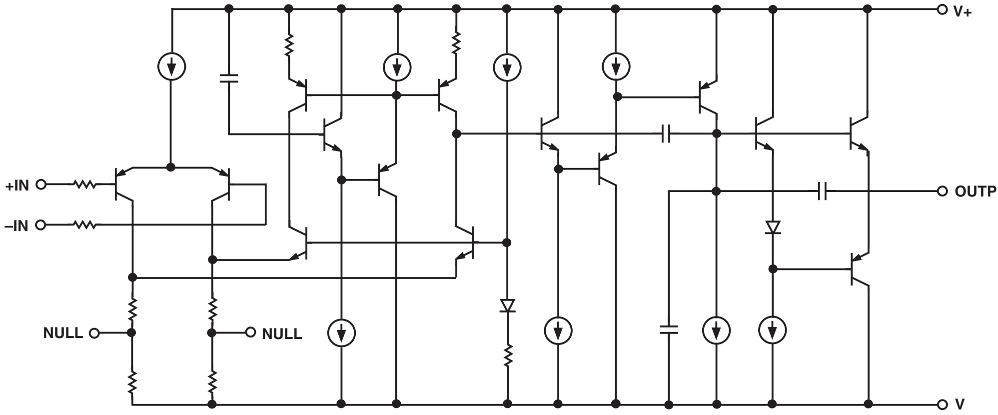
EPOXY MINI-DIP
(P-Suffix)
8-Lead HERMETIC DIP
(Z-Suffix)



GENERAL DESCRIPTION

The OP290 is a high performance micropower dual op amp that operates from a single supply of 1.6 V to 36 V or from dual supplies of ±0.8 V to ±18 V. Input voltage range includes the negative rail allowing the OP290 to accommodate input signals down to ground in single-supply operation. The OP290's output swing also includes ground when operating from a single supply, enabling "zero-in, zero-out" operation.

The OP290 draws less than 20 µA of quiescent supply current per amplifier, while able to deliver over 5 mA of output current to a load. Input offset voltage is below 200 µV eliminating the need for external nulling. Gain exceeds 700,000 and common-mode rejection is better than 100 dB. The power supply rejection ratio of under 5.6 pV/V minimizes offset voltage changes experienced in battery-powered systems. The low offset voltage and high gain offered by the OP290 bring precision performance to micropower applications. The minimal voltage and current requirements of the OP290 suit it for battery- and solar-powered applications, such as portable instruments, remote sensors, and satellites. For a single op amp, see the OP90; for a quad, see the OP490.



ELECTRONICALLY ADJUSTED ON CHIP
FOR MINIMUM OFFSET VOLTAGE

Figure 1. Simplified Schematic (one of two amplifiers is shown)

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OP290–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (@ V_S = ±1.5 V to ±15 V, T_A = 25°C, unless otherwise noted.)

			OP290E			OP290F			OP290G			
Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
INPUT OFFSET VOLTAGE	V_{OS}			50	200		75	300		125	500	μV
INPUT OFFSET CURRENT	I_{OS}	V_{CM} = 0 V		0.1	3		0.1	5		0.1	5	nA
INPUT BIAS CURRENT	I_B	V_{CM} = 0 V		4.0	15		4.0	20		4.0	25	nA
LARGE-SIGNAL VOLTAGE GAIN	A_{VO}	V_S = ±15 V, V_O = ±10 V										
		R_L = 100 kΩ	700	1200		500	1000		400	600		
		R_L = 10 kΩ	350	600		250	500		200	400		
		R_L = 2 kΩ	125	250		100	200		100	200		V/mV
		V+ = 5V, V– = 0 V, 1 V < V_O < 4 V										
		R_L = 100 kΩ	200	400		125	300		100	250		
		R_L = 10 kΩ	100	180		75	140		70	140		
INPUT VOLTAGE RANGE[1]	IVR	V+ = 5 V, V– = 0 V	0/4			0/4			0/4			V
		V_S = ±5 V[1]	–15/13.5			–15/13.5			–15/13.5			
OUTPUT VOLTAGE SWING	V_O	V_S = ±5 V										
		R_L = 10 kΩ	±13.5	±14.2		±13.5	±14.2		±13.5	±14.2	V	
		R_L = 2 kΩ	±10.5	±11.5		±10.5	±11.5		±10.5	±11.5		
	V_{OH}	V+ = 5 V, V– = 0 V	40	4.2		4.0	4.2		4.0	4.2		V
	V_{OL}	V+ = 5 V, V– = 0 V R_L = 10kn	10	50		10	50		10	50		μV
COMMON-MODE REJECTION	CMR	V+ = 5 V, V– = 0 V 0 V < V_{CM} < 4 V		ttS		80	100		80	100		dB
		V_S = ±15 V, –15 V < V_{CM} < 13.5 V	100	120		90	120		90	120		
POWER SUPPLY REJECTION RATIO	PSRR			10	5.6		10	5.6		3.2	10	μV/V
SUPPLY CURRENT (All Amplifiers)	I_{SY}	V_S = ±1.5 V		19	30		19	30		19	30	μA
		V_S = ±15 V		25	40		25	40		25	40	
CAPACITIVE LOAD STABILITY		A_V = +1 No Oscillations		650			650			650		PF
INPUT NOISE VOLTAGE[1]	e_{np-p}	f_O = 0.1 Hz to 10 Hz V_S = ±15 V		3			3			3		μV_{p-p}
INPUT RESISTANCE DIFFERENTIAL-MODE	R_{IN}	V_S = ±15 V		30			30			30		MΩ
INPUT RESISTANCE COMMON-MODE	R_{INCM}	V_S = ±15 V		20			20			20		GΩ
SLEW RATE	SR	A_V = +1 V_S = ±15 V	5	12		5	12		5	12		V/ms
GAIN BANDWIDTH PRODUCT	GBWP	Vs = +15 V V_S = ±15 V		20			20			20		kHz
CHANNEL SEPARATION[2]	CS	f_O = 10 Hz V_O = 20 Vp-p V_S = ±15 V[2]	120	150		120	150		120	150		dB

NOTES

[1] Guaranteed by CMR test.

[2] Guaranteed but not 100% tested.

Specifications subject to change without notice.

ELECTRICAL CHARACTERISTICS (@ V_S = ±1.5 V to ±15 V, –55°C ≤ T_A ≤ 125°C, unless otherwise noted.)

Parameter	Symbol	Conditions	OP290A			Unit
			Min	Typ	Max	
INPUT OFFSET VOLTAGE	V_{OS}			80	500	µV
AVERAGE INPUT OFFSET VOLTAGE DRIFT	TCV_{OS}	V_S = 15 V		0 3	3	µV/°C
INPUT OFFSET CURRENT	I_{OS}	VCM = 0 V		0.1	5	nA
INPUT BIAS CURRENT	I_B	VCM = 0 V		4.2	20	nA
LARGE-SIGNAL VOLTAGE GAIN	A_{VO}	V_S = 15 V, V_O = ±10 V				V/mV
		R_L = 100 kΩ	225	400		
		R_L = 10 kΩ	125	240		
		R_L = 2 kΩ	50	110		
		V+ = 5 V, V– = 0 V, 1 V < V_O < 4 V				
		R_L = 100 kΩ	100	200		
		R_L = 10 kΩ	50	110		
INPUT VOLTAGE RANGE*	IVR	V+ = 5 V, V– = 0 V	0/3.5			V
		V_S = ±15 V*	–15/13.5			
OUTPUT VOLTAGE SWING	V_O	V_S = ±15 V				
		R_L = 10 kΩ	±13	±14.1		V
		R_L = 2 kΩ	±10	±11		
	V_{OH}	V+ = 5 V, V– = 0 V				
		R_L = 2 kΩ				V
	V_{OL}	V+ = 5 V, V– = 0 V		10	100	µV
		R_L = 10 kΩ				
COMMON-MODE REJECTION	CMR	V+ = 5 V, V– = 0 V, 0 V < V_{CM} < 13.5 V	80	105		dB
		V_S = ±15 V, –15 V < V_{CM} < 13.5 V	90	115		
POWER SUPPLY REJECTION RATIO	PSRR			3.2	10	µV/V
SUPPLY CURRENT (All Amplifiers)	IsY	V_S = ±1.5 V		30	50	µA
		V_S = ±15 V		38	60	

NOTES

*Guaranteed by CMR test.

Specifications subject to change without notice.

ELECTRICAL CHARACTERISTICS

(@ V_S = ±1.5 V to ±15 V, –40±°C ≤ T_A ≤ 85°C for OP290E/OP290F/OP290G, unless otherwise noted.)

			OP290E			OP290F			OP290G			
Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
INPUT OFFSET VOLTAGE	V_{OS}			70	400		115	600		200	750	µV
AVERAGE INPUT OFFSET VOLTAGE DRIFT	TCV_{OS}	V_S = ±15 V		0.3	3		0.6	5		1.2		µV/°C
INPUT OFFSET CURRENT	I_{OS}	V_{CM} = 0 V		01	3		0.1	5		0.1	7	nA
INPUT BIAS CURRENT	I_B	V_{CM} = 0 V		4.2	t5		4.2	20		4.2	25	nA
LARGE-SIGNAL VOLTAGE GAIN	A_{VO}	V_S = ±5 V, V_O = ±0 V										V/mV
		R_L = 100 kΩ	500	800		350	700		300	600		
		R_L = 10 kΩ	250	400		175	350		150	250		
		R_L = 2 kΩ	100	200		75	150		75	125		
		V+ = 5 V, V– = 0 V, 1 V < V_O < 4 V										
		R_L = 100 kΩ	150	280		100	220		80	160		
		R_L = 10 kΩ	75	140		50	110		40	90		
INPUT VOLTAGE RANGE*	IVR	V+ = 5 V, V– = 0 V	0/3.5			0/3.5			0/3.5			V
		V_S = +15 V*	–15/13.5			–15/13.5			–15/13.5			
OUTPUT VOLTAGE SWING	V_O	V_S = ±15 V										
		R_L = 10 kΩ	±13	±14		±13	±14		±13	±14		V
		R_L = 2 kΩ	±10	±11		±10	±11		±10	±11		
	V_{OH}	V+ = 5 V, V– = 0 V										
		R_L = 2 kΩ	3.9	4.1		3.9	4.1		3.9	4.1		V
	V_{OL}	V+ = 5 V, V– = 0 V										
		R_L = 10 kΩ		10	100		10	100		10	100	µV
COMMON-MODE REJECTION	CMR	V+ = 5 V, V– = 0 V, 0 V < V_{CM} < 3.5 V	85	105		80	100		80	100		dB
		V_S = ±15 V, –15 V < V_{CM} < 13.5 V	95	115		90	110		90	110		
POWER SUPPLY REJECTION RATIO	PSRR			3.2	7.5		5.6	10		5.6	15	µV/V
SUPPLY CURRENT (All Amplifiers)	I_{SY}	V_S = ±1.5 V		24	50		24	50		24	50	µA
		V_S = ±15 V		31	60		31	60		31	60	

NOTE

*Guaranteed by CMR test.

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage	±18 V
Differential Input Voltage	[(V–) – 20 V] to [(V+) + 20 V]
Common-Mode Input Voltage	[(V–) – 20 V] to [(V+) + 20 V]
Output Short-Circuit Duration	Indefinite
Storage Temperature Range	
P, S, Z Packages	–65°C to +150°C
Operating Temperature Range	
OP290A	–55°C to +125°C
OP290E, OP290F, OP290G	–40°C to +85°C
Junction Temperature (T_j)	–65°C to +150°C
Lead Temperature Range (Soldering, 60 sec)	300°C

Package Type	θ_{jA}[2]	θ_{jC}	Unit
8-Lead Hermetic DIP (Z)	134	12	°C/W
8-Lead Plastic DIP (P)	96	37	°C/W
16-Lead SOL (S)	92	27	°C/W

NOTES

[1] Absolute Maximum Ratings apply to both DICE and packaged parts, unless otherwise noted.

[2] θ_{jA} is specified for worst-case mounting conditions, i.e., θ_{jA} is specified for device in socket for CERDIP and P-DIP packages; θ_{jA} is specified for device soldered to printed circuit board for SOL package.

ORDERING GUIDE

T_A = 25°C V_{OS} Max (mV)	Package		Operating Temperature Range
	Cerdip 8-Lead	Plastic	
200	OP290AZ*		MIL
200	OP290EZ*		XIND
300	OP290FZ*		XIND
500		OP290GP	XIND
500		OP290GS*	XIND

*Not for new designs. Obsolete April 2002.

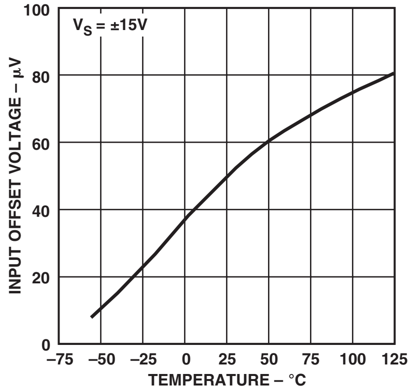
For military processed devices, please refer to the Standard Microcircuit Drawing (SMD) available at www.dscc.dla.mil/programs.milspec./default.asp

SMD Part Number	ADI Part Number
5962-89783012A*	OP290ARCMDA
5962-8978301PA*	OP290AZMDA

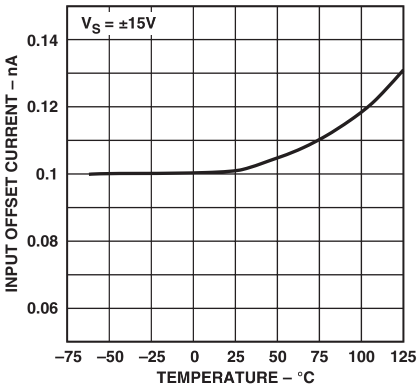
*Not for new designs. Obsolete April 2002.

CAUTION

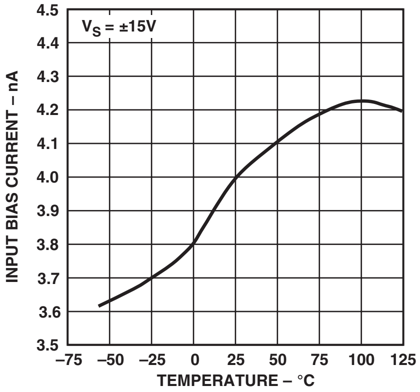
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the OP290 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high-energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



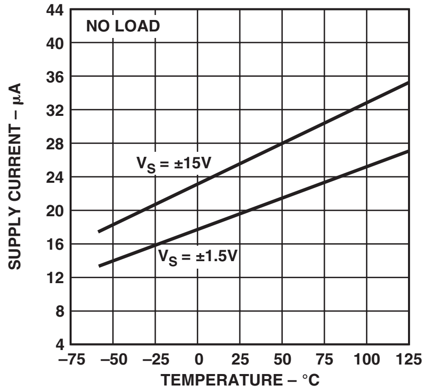
TPC 1. Input Offset Voltage vs. Temperature



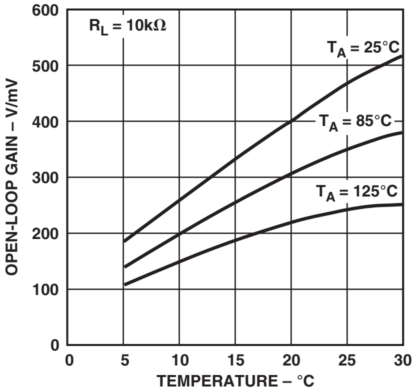
TPC 2. Input Offset Current vs. Temperature



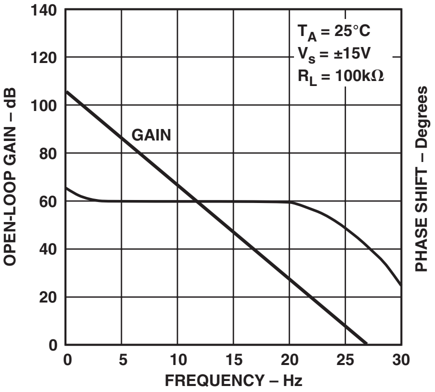
TPC 3. Input Bias Current vs. Temperature



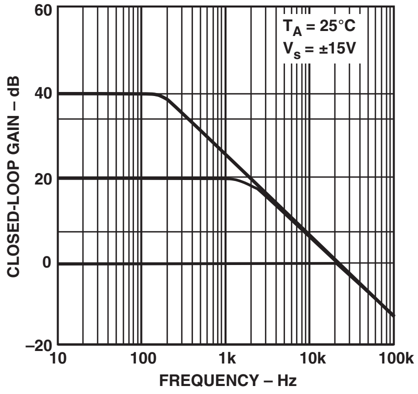
TPC 4. Supply Current vs. Temperature



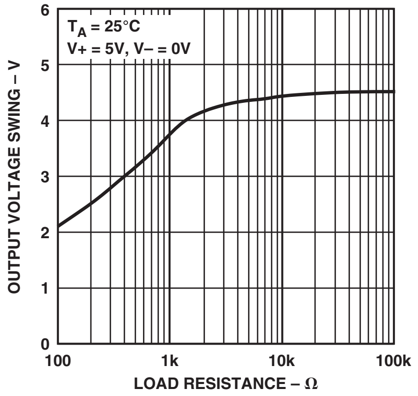
TPC 5. Open-Loop Gain vs. Single-Supply Voltage



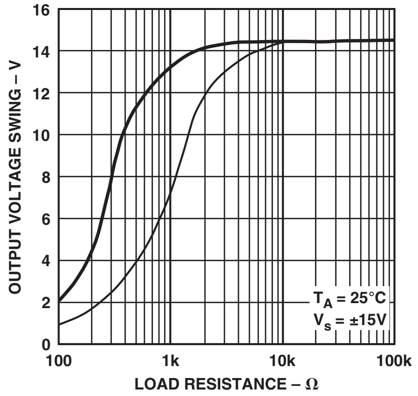
TPC 6. Open-Loop Gain and Phase Shift vs. Frequency



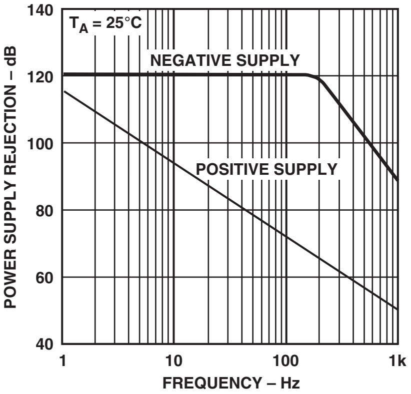
TPC 7. Closed-Loop Gain vs. Frequency



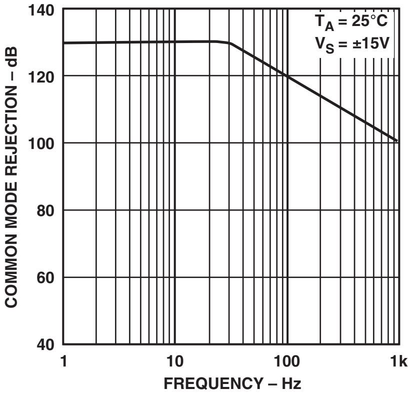
TPC 8. Ouput Voltage Swing vs. Load Resistance



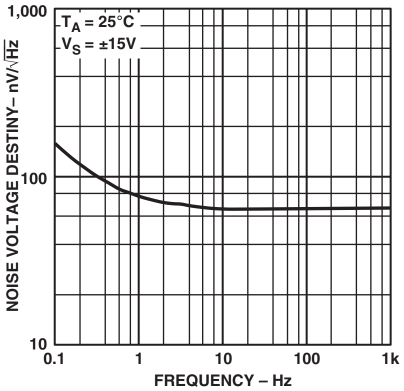
TPC 9. Output Voltage Swing vs. Load Resistance



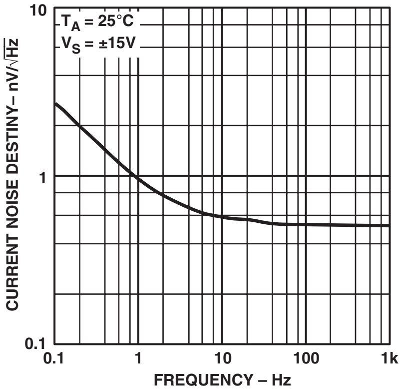
TPC 10. Power Supply Rejection vs. Frequency



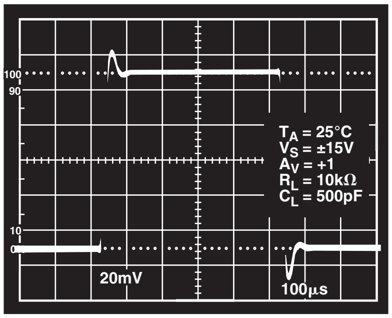
TPC 11. Common-Mode Rejection vs. Frequency



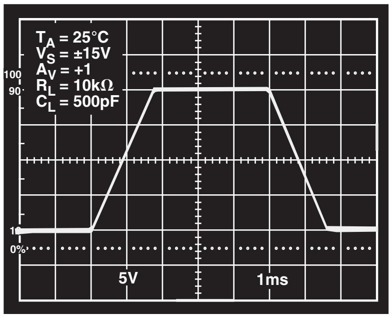
TPC 12. Noise Voltage Density vs. Frequency



TPC 13. Current Noise Density vs. Frequency



TPC 14. Small-Signal Transient Response



TPC 15. Large-Signal Transient Response

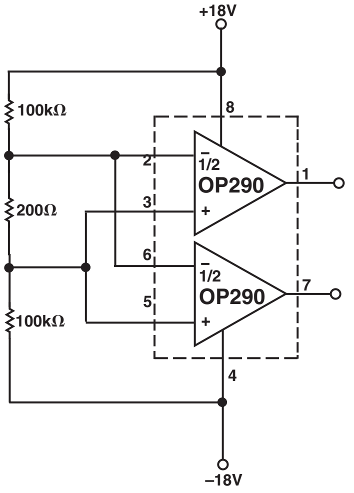


Figure 2. Burn-In Circuit

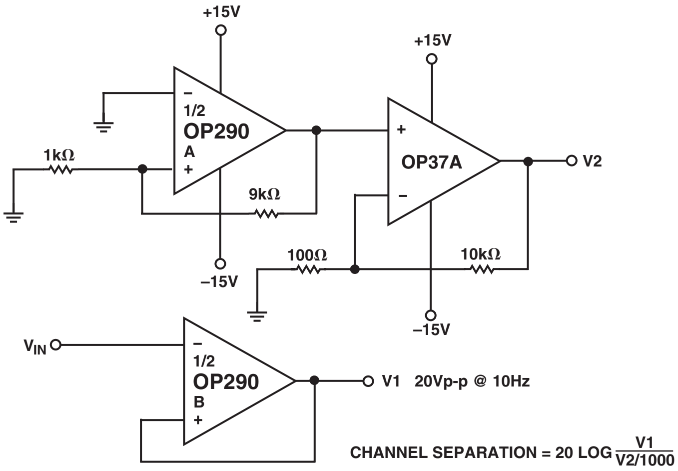


Figure 3. Channel Separation Test Circuit

APPLICATIONS INFORMATION
BATTERY-POWERED APPLICATIONS

The OP290 can be operated on a minimum supply voltage of 1.6 V, or with dual supplies of 0.8 V, and draws only 19 pA of supply current. In many battery-powered circuits, the OP290 can be continuously operated for thousands of hours before requiring battery replacement, reducing equipment downtime and operating cost.

High-performance portable equipment and instruments frequently use lithium cells because of their long shelf-life, light weight, and high energy density relative to older primary cells. Most lithium cells have a nominal output voltage of 3 V and are noted for a flat discharge characteristic. The low supply voltage requirement of the OP290, combined with the flat discharge characteristic of the lithium cell, indicates that the OP290 can be operated over the entire useful life of the cell. Figure 1 shows the typical discharge characteristic of a 1 Ah lithium cell powering an OP290 with each amplifier, in turn, driving full output swing into a 100 kΩ load.

INPUT VOLTAGE PROTECTION

The OP290 uses a PNP input stage with protection resistors in series with the inverting and noninverting inputs. The high breakdown of the PNP transistors coupled with the protection resistors provide a large amount of input protection, allowing the inputs to be taken 20 V beyond either supply without damaging the amplifier.

SINGLE-SUPPLY OUTPUT VOLTAGE RANGE

In single-supply operation the OP290's input and output ranges include ground. This allows true "zero-in, zero-out" operation. The output stage provides an active pull-down to around 0.8 V above ground. Below this level, a load resistance of up to 1 MS2 to ground is required to pull the output down to zero.

In the region from ground to 0.8 V, the OP290 has voltage gain equal to the data sheet specification. Output current source capability is maintained over the entire voltage range including ground.

APPLICATIONS
TEMPERATURE TO 4–20 mA TRANSMITTER

A simple temperature to 4–20 mA transmitter is shown in Figure 5. After calibration, the transmitter is accurate to +0.5°C over the –50°C to +150°C temperature range. The transmitter operates from 8 V to 40 V with supply rejection better than 3 ppm/V. One half of the OP290 is used to buffer the V_{TEMP} pins while the other half regulates the output current to satisfy the current summation at its noninverting input.

$$I_{OUT} = \frac{V_{TEMP}\left(R6+R7\right)}{R2\,R10} - V_{SET}\left(\frac{R2\,R6\,R7}{R2\,R10}\right)$$

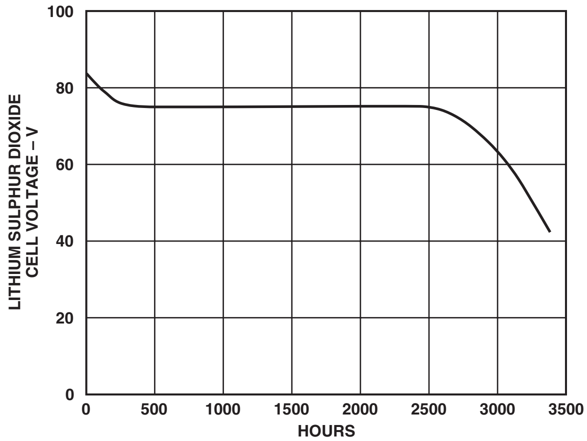


Figure 4. Lithium Sulphur Dioxide Cell Discharge Characteristic with OP290 and 100 kΩ Loads

The change in output current with temperature is the derivative of the transfer function:

$$\frac{\Delta I_{OUT}}{\Delta T} = \frac{\frac{\Delta V_{TEMP}}{\Delta T}\left(R6+R7\right)}{R2\,R10}$$

From the formulas, it can be seen that if the span trim is adjusted before the zero trim, the two trims are not interactive, which greatly simplifies the calibration procedure.

Calibration of the transmitter is simple. First, the slope of the output current versus temperature is calibrated by adjusting the span trim, R7. A couple of iterations may be required to be sure the slope is correct.

Once the span trim has been completed, the zero trim can be made. Remember that adjusting the offset trim will not affect the gain.

The offset trim can be set at any known temperature by adjusting R_5 until the output current equals:

$$I_{OUT} = \left(\frac{\Delta I_{FS}}{\Delta T_{OPERATING}}\right)\left(T_{AMBIENT} - T_{MIN}\right) + 4\,mA$$

Table I shows the values of R6 required for various temperature ranges.

Table I.

Temperature Range	R6 (kΩ)
0°C to +70°C	10
–40°C to +85°C	6.2
–55°C to +150°C	3

VARIABLE SLEW RATE FILTER

The circuit shown in Figure 6 can be used to remove pulse noise from an input signal without limiting the response rate to a genuine signal. The nonlinear filter has use in applications where the input signal of interest is known to have physical limitations. An example of this is a transducer output where a change of temperature or pressure cannot exceed a certain rate due to physical limitations of the environment. The filter consists of a comparator which drives an integrator. The comparator compares the input voltage to the output voltage and forces the integrator output to equal the input voltage. A1 acts as a comparator with its output high or low. Diodes D1 and D2 clamp the voltage across R3 forcing a constant current to flow in or out of C2. R3, C2, and A2 form an integrator with A2's output slewing at a maximum rate of:

$$\text{Maximum slew rate} = \frac{V_D}{R3\,C2} \approx \frac{0.6\,V}{R3\,C2}$$

For an input voltage slewing at a rate under this maximum slew rate, the output simply follows the input with A1 operating in its linear region.

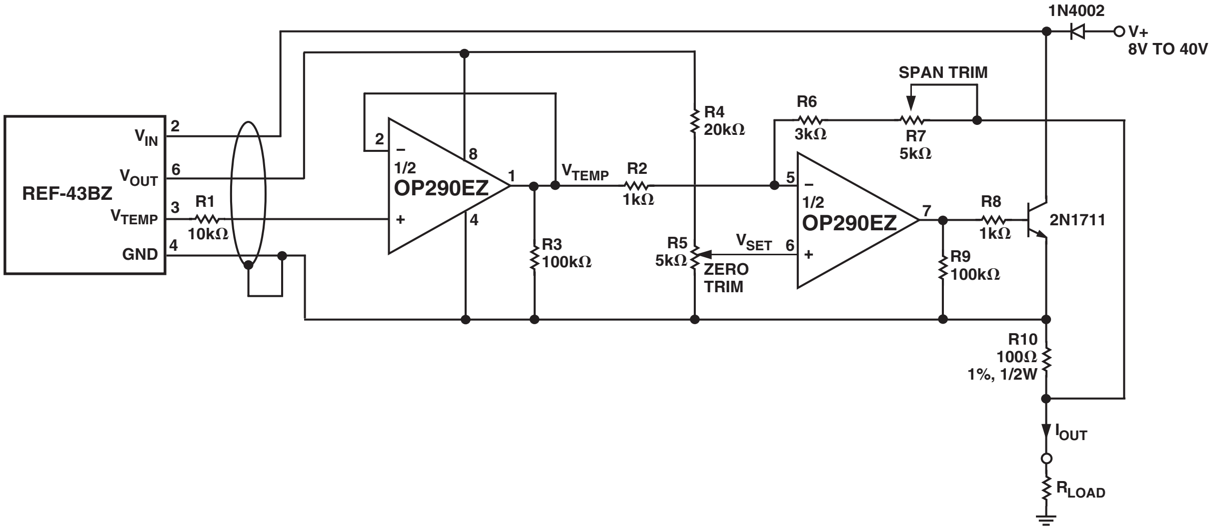


Figure 5. Temperature to 4-20 mA Transmitter

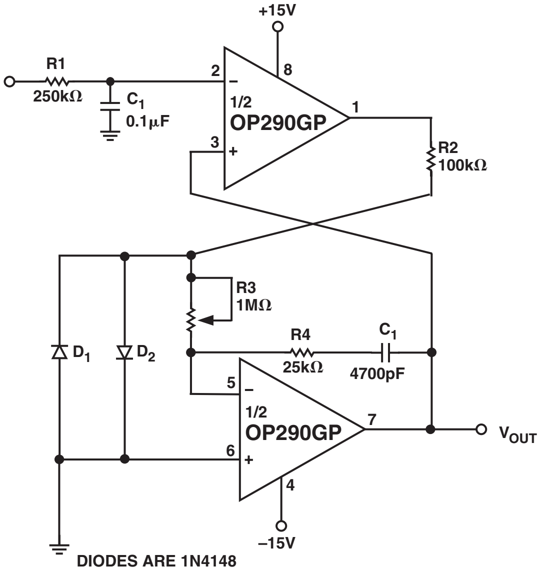


Figure 6. Variable Slew Rate Filter

LOW OVERHEAD VOLTAGE REFERENCE

Figure 7 shows a voltage reference that requires only 0.1 V of overhead voltage. As shown, the reference provides a stable 4.5 V output with a 4.6 V to 36 V supply. Output voltage drift is only 12 ppm/°C. Line regulation of the reference is under 5 HV/V with load regulation better than 10 µV/mA with up to 50 mA of output current.

The REF-43 provides a stable 2.5 V which is multiplied by the OP290. The PNP output transistor enables the output voltage to approach the supply voltage.

Resistors R1 and R2 determine the output voltage.

$$V_{OUT} = 2.5\,V\left(1+\frac{R2}{R1}\right)$$

The 200 Ω variable resistor is used to trim the output voltage. For the lowest temperature drift, parallel resistors can be used in place of the variable resistor and taken out of the circuit as required to adjust the output voltage.

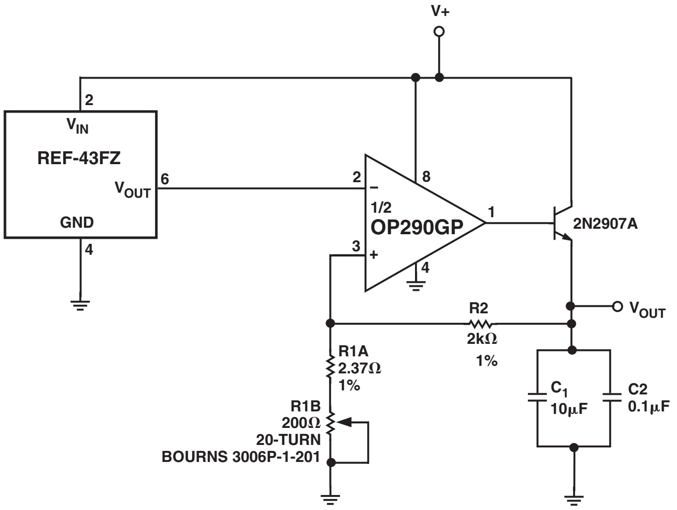


Figure 7. Low Overhead Voltage Reference

Revision History

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