

RC4097 Series Low-Power, High Precision Operational Amplifiers

Features

- Low input offset voltage — 15 μV max
- Low V_{OS} drift — 0.3 $\mu\text{V}/^\circ\text{C}$ max
- Low input bias current —
+25 $^\circ\text{C}$, 100 pA max
-55 $^\circ\text{C}$ to +125 $^\circ\text{C}$, 600 pA max
- High gain — 1000 V/mV min
- High CMRR — 120 dB min
- High PSRR 114 dB min
- Low supply current — 600 μA max
- Low noise — 0.5 μV_{p-p} (0.1 to 10 Hz)
- Replaces OP-97, LT1012

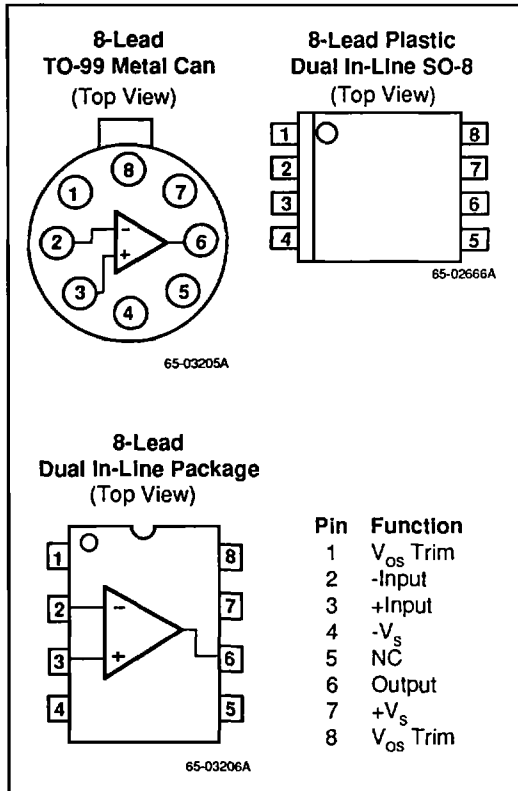
Description

The RC4097 is a micropower device that can be used to improve the performance of a wide range of precision operational amplifier applications. Essentially, a low-power idling current, low I_B version of the popular OP-07 industry type, the RC4097 can replace FET-input op amps in circuits requiring low input bias currents while realizing significant improvements in voltage noise, V_{OS} , and V_{OS} drift. The other input specifications, such as CMRR and PSRR, support the high level of precision performance, allowing upgrading of many instrumentation, low-level signal conditioning, sample-and-hold, and data conversion applications.

The superb performance of the RC4097 is a result of advanced design and processing techniques, including post-package trimming of the input offset voltage, and superbeta processing of the input transistors. Picoampere input bias currents are maintained over the full military temperature range through the use of bias cancellation techniques in the design of the input stage. The RC4097 offers lower V_{OS} drift, lower V_{OS} , higher open-loop gain, and better CMRR than industry-standard OP-97 or LT1012 types.

The RC4097 is available in 8-lead plastic or ceramic DIPs, TO-99 metal cans, and plastic small outline packages. Military, industrial, and commercial temperature ranges can be selected, and Mil-Std-883B processing is available.

Connection Information



Ordering Information

Part Number	Package	Operating Temperature Range
RC4097AN	N	0°C to +70°C
RC4097EN	N	0°C to +70°C
RC4097FN	N	0°C to +70°C
RC4097EM	M	0°C to +70°C
RC4097FM	M	0°C to +70°C
RV4097ET	T	-25°C to +85°C
RV4097FT	T	-25°C to +85°C
RV4097ED	D	-25°C to +85°C
RV4097FD	D	-25°C to +85°C
RM4097AT	T	-55°C to +125°C
RM4097AT/883B	T	-55°C to +125°C
RM4097AD	D	-55°C to +125°C
RM4097AD/883B	D	-55°C to +125°C

Notes:

/883B suffix denotes Mil-Std-883, Level B processing

N = 8-lead plastic DIP

D = 8-lead ceramic DIP

T = 8-lead metal can (TO-99)

M = 8-lead plastic SOIC

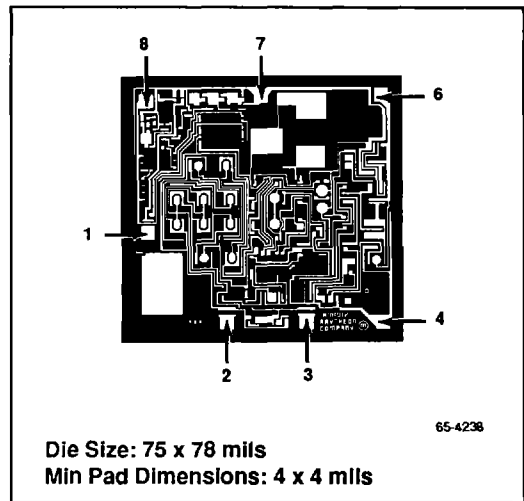
Contact a Raytheon sales office or representative for ordering information on special package/temperature range combinations.

Absolute Maximum Ratings

Supply Voltage±22V
 Input Voltage*±22V
 Differential Input Voltage30V
 Internal Power Dissipation** 500 mW
 Output Short Circuit Duration Indefinite
 Storage Temperature
 Range -65°C to +150°C
 Operating Temperature Range
 RM4097A -55°C to +125°C
 RV4097E,F (Hermetic) -25°C to +85°C
 RC4097A,E,F (Plastic) 0°C to +70°C
 Lead Soldering Temperature
 (SO-8, 10 sec) +260°C
 (DIP, TO-99; 60 sec) +300°C

*For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.
 **Observe package thermal characteristics.

Mask Pattern



Thermal Characteristics

	8-Lead Ceramic DIP	8-Lead TO-99 Metal Can	8-Lead Small Outline	8-Lead Plastic DIP
Max. Junction Temp.	175°C	175°C	125°C	125°C
Max. P _D T _A <50°C	833 mW	658 mW	300 mW	468 mW
Therm. Res θ _{JC}	45°C/W	50°C/W	—	—
Therm. Res. θ _{JA}	150°C/W	190°C/W	240°C/W	160°C/W
For T _A >50°C Derate at	8.33 mW/°C	5.26 mW/°C	4.17 mW/°C	6.25 mW/°C

Electrical Characteristics ($V_s = \pm 15V$ and $T_A = +25^\circ C$ unless otherwise noted)

Parameters	Test Conditions	4097A/E			4097F			Units	
		Min	Typ	Max	Min	Typ	Max		
Input Offset Voltage ³	RC/RM4097A RC4097E		± 7.0 ± 15	± 15 ± 25		± 20 ± 60		μV	
Long Term V_{os} Stability ¹			0.2			0.4		$\mu V/Mo$	
Input Offset Current			30	100		30	150	μA	
Input Bias Current			± 30	± 100		± 30	± 150	μA	
Input Noise Voltage ⁵	0.1 Hz to 10 Hz		0.5			0.5		μV_{pp}	
Input Noise Voltage Density ⁵	$F_o = 10$ Hz		17	30		17	30	$\frac{nV}{\sqrt{Hz}}$	
	$F_o = 1000$ Hz		14	22		14	22	$\frac{nV}{\sqrt{Hz}}$	
Input Noise Current Density ⁵	$F_o = 10$ Hz		20			20		fA/\sqrt{Hz}	
Input Resistance (Diff Mode) ²			30			30		$M\Omega$	
Input Voltage Range ⁴			± 13	± 14		± 13	± 14	V	
Common Mode Rejection Ratio	$V_{CM} = \pm 13V$		120	140		110	130	dB	
Power Supply Rejection Ratio	$V_s = \pm 2.5V$ to $\pm 20V$		114	128		110	128	dB	
Large Signal Voltage Gain	$R_L \geq 2$ k Ω , $V_o = \pm 10V$		1000	2500		600	2500	V/mV	
Output Voltage Swing	$R_L \geq 10$ k Ω		± 13	± 13.5		± 13	± 13.5	V	
Slew Rate			0.1	0.3		0.1	0.3	V/ μS	
Closed Loop Bandwidth ²	$A_{VCL} = +1.0$		0.4	0.8		0.4	0.8	MHz	
Power Consumption	$V_s = \pm 15V$, $R_L = \infty$			12	18		12	18	mW
Supply Voltage Range	Operating		± 2.5	± 20		± 2.5	± 20	V	

Notes:

1. Long Term Input Offset Voltage Stability refers to the averaged trend line of V_{os} vs. Time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in V_{os} during the first 30 operating days are typically 2.5 μV .
2. Guaranteed by design.
3. Input Offset Voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power. The RC/RM4097A grades are tested fully warmed up.
4. The input protection diodes do not allow the device to be removed or inserted into the circuit without first removing power.
5. Sample tested.

Electrical Characteristics ($V_s = \pm 15V$, $0^\circ C \leq T_A \leq +70^\circ C$ unless otherwise noted)

Parameters	Test Conditions	4097A/E			4097F			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	RC4097A RC4097E/F	10	30			35	115	μV
Average Input Offset Voltage Drift ¹	RC4097A RC4097E/F	0.1	0.3			0.4	1.2	$\mu V/C$
Input Offset Current		60	250			80	500	μA
Average Input Offset Current Drift ²		0.6	7.8			1.1	15	$\mu A/C$
Input Bias Current		± 60	± 250			± 80	± 500	μA
Average Input Bias Current Drift ²		0.6	7.8			2.8	15	$\mu A/C$
Input Voltage Range		± 13	± 13.5			± 13	± 13.5	V
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	114	128			108	126	dB
Power Supply Rejection Ratio	$V_s = \pm 3.0V$ to $\pm 20V$	108	126			108	126	dB
Large Signal Voltage Gain	$R_L \geq 2 k\Omega$, $V_o = \pm 10V$	600	1500			400	1200	V/mV
Maximum Output Voltage Swing	$R_L \geq 10 k\Omega$	± 12	± 13			± 12	± 13	V
Power Consumption	$R_L = \infty$		14	24		14	24	mW
Supply Voltage Range	Operating	± 3		± 20		± 3	± 20	V

Notes:

- 100% tested for A Grade .
- Sample tested.

Electrical Characteristics ($V_S = \pm 15V, -25^\circ C \leq T_A \leq +85^\circ C$ unless otherwise noted)

Parameters	Test Conditions	4097E			4097F			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage			25	60		40	130	μV
Average Input Offset Voltage Drift ¹			0.2	0.6		0.4	1.2	$\mu V/^\circ C$
Input Offset Current			100	600		200	750	μA
Average Input Offset Current Drift ²			1.1	11.7		2.8	15	$\mu A/^\circ C$
Input Bias Current			± 100	± 600		± 200	± 750	μA
Average Input Bias Current Drift ²			1.1	11.7		2.8	15	$\mu A/^\circ C$
Input Voltage Range		± 13	± 13.5		± 13	± 13.5		V
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	114	128		108	126		dB
Power Supply Rejection Ratio	$V_S = \pm 3.0V$ to $\pm 20V$	108	126		108	126		dB
Large Signal Voltage Gain	$R_L \geq 2 k\Omega, V_O = \pm 10V$	600	1500		400	1200		V/mV
Maximum Output Voltage Swing	$R_L \geq 10 k\Omega$	± 12	± 13		± 12	± 13		V
Power Consumption	$R_L = \infty$		14	24		14	24	mW
Supply Voltage Range	Operating	± 3		± 20	± 3		± 20	V

Notes:

- 100% tested for A Grade.
- Sample tested.

Electrical Characteristics ($V_S = \pm 15V$, $-55^\circ C \leq T_A \leq +125^\circ C$ unless otherwise noted)

Parameters	Test Conditions	RM4097A			Units
		Min	Typ	Max	
Input Offset Voltage			20	45	μV
Average Input Offset Voltage Drift ¹			0.1	0.3	$\mu V/^\circ C$
Input Offset Current			100	600	pA
Average Input Offset Current Drift ²			0.7	7.0	$pA/^\circ C$
Input Bias Current			± 100	± 600	pA
Average Input Bias Current Drift ²			0.7	7.0	$pA/^\circ C$
Input Voltage Range		± 13	± 13.5		V
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	114	130		dB
Power Supply Rejection Ratio	$V_S = \pm 4.0V$ to $\pm 20V$	108	126		dB
Large Signal Voltage Gain	$R_L \geq 2 k\Omega$, $V_O = \pm 10V$	600	1200		V/mV
Maximum Output Voltage Swing	$R_L \geq 10 k\Omega$	± 13	± 13.5		V
Power Consumption	$R_L = \infty$		15	24	mW
Supply Voltage Range		± 3.0		± 20	V

Notes:

1. 100% tested for A Grade.
2. Sample tested.

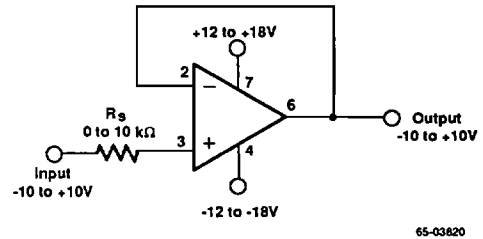
Offset Voltage Adjustment

The input offset voltage of the RC4097, and its drift with temperature, are permanently trimmed at wafer test to a low level. However, if further adjustment of V_{OS} is necessary, nulling with a 10K or 20K potentiometer will not degrade drift with temperature. Trimming to a value other than zero creates a drift of $(V_{OS}/300) \mu V/^{\circ}C$, e.g., if V_{OS} is adjusted to $300 \mu V$, the change in drift will be $1 \mu V/^{\circ}C$. The adjustment range with a 10K or 20K potentiometer is approximately 4.0 mV. If less adjustment range is needed, the sensitivity and resolution of the nulling can be improved by using a smaller pot in conjunction with fixed resistors. The example on page 9 has an approximate null range of $\pm 100 \mu V$.

Unless proper care is exercised, thermocouple effects caused by temperature gradients across dissimilar metals at the contacts to the input terminals, can exceed the inherent drift of the amplifier. Air currents over device leads should be minimized, package leads should be short, and the two input leads should be as close together as possible and maintained at the same temperature.

RC4097 series units may be inserted directly into OP-07, OP-05, 725, 108A or 101A sockets with or without removal of external frequency compensation or nulling components. The RC4097 can also be used in 741 applications provided that the nulling circuitry is removed.

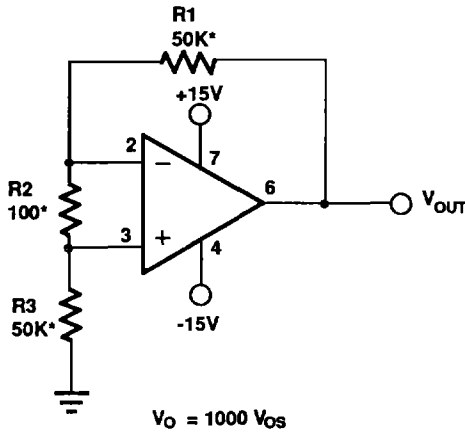
The voltage follower is an ideal example illustrating the overall excellence of the RC4097. The contributing error terms are due to offset voltage, input bias current, voltage gain, common-mode and power-supply rejections. Worst-case summation of guaranteed specifications is tabulated below.



**Large Signal Voltage Follower With
0.00065% Worst-Case Accuracy Error**

Output Accuracy

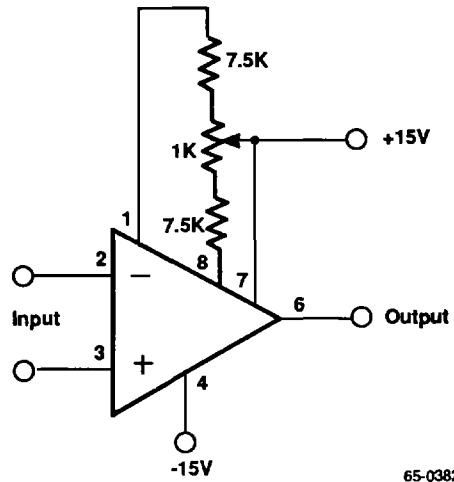
Error	RM4097A 25°C Max (μV)	RM4097A -55 to +125°C Max (μV)	RC4097A 0°C to +70°C Max (μV)
Offset Voltage	15	45	30
Bias Current	1.0	6	2.5
CMRR	20	40	40
PSRR	12	24	24
Voltage Gain	20	33	33
Worst Case Sum	68	148	129.5
Percent of Full Scale (= 20V)	.00034%	.00074%	.00065%



* Resistors must have low thermoelectric potential

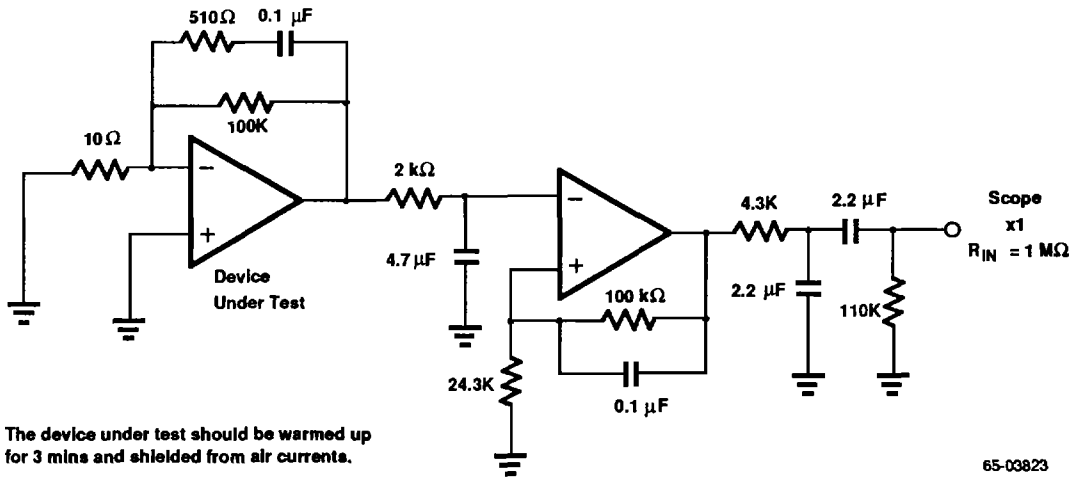
65-03821

Test Circuit for Offset Voltage and Its Drift With Temperature



65-03822

Improved Sensitivity V_{OS} Adjustment

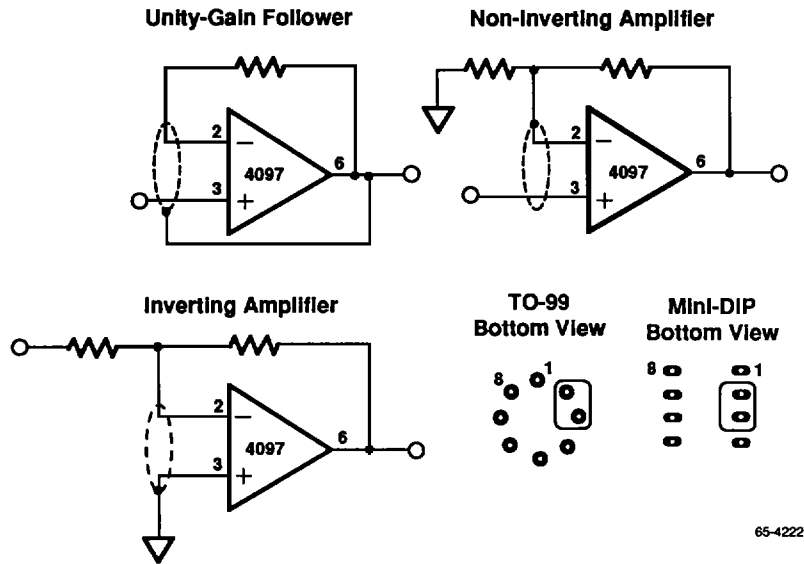


The device under test should be warmed up for 3 mins and shielded from air currents.

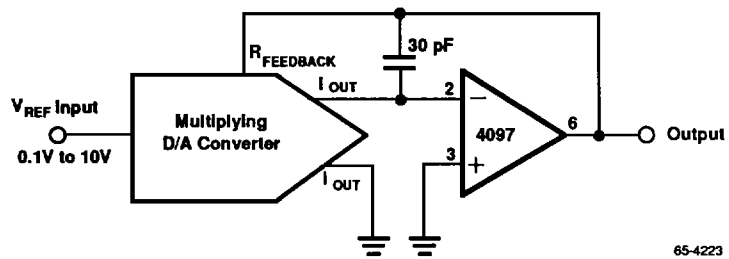
65-03823

0.1 Hz to 10 Hz Noise Test Circuit (peak-to-peak noise measured in 10-sec intervals)

Typical Applications

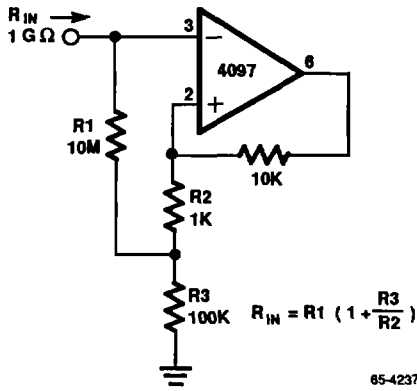


Guard Ring Layout and Connections

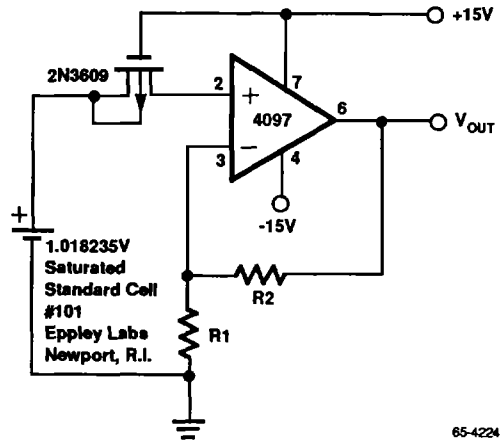


Wide Dynamic Range Multiplying DAC

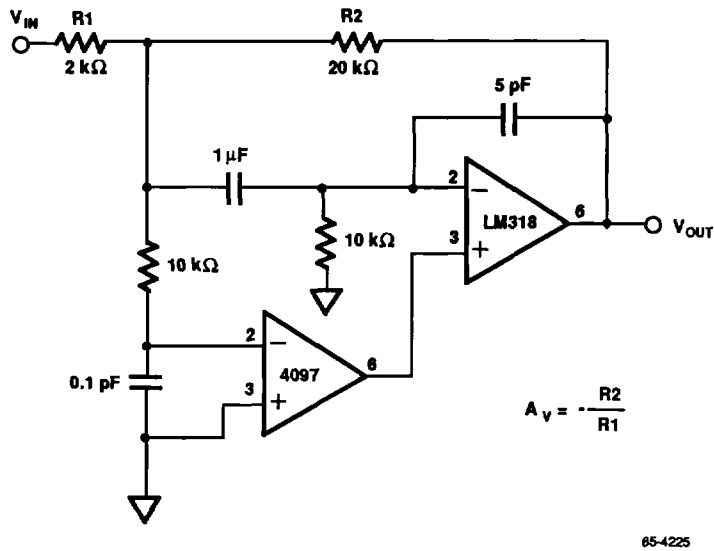
Typical Applications (Continued)



Resistor Multiplier

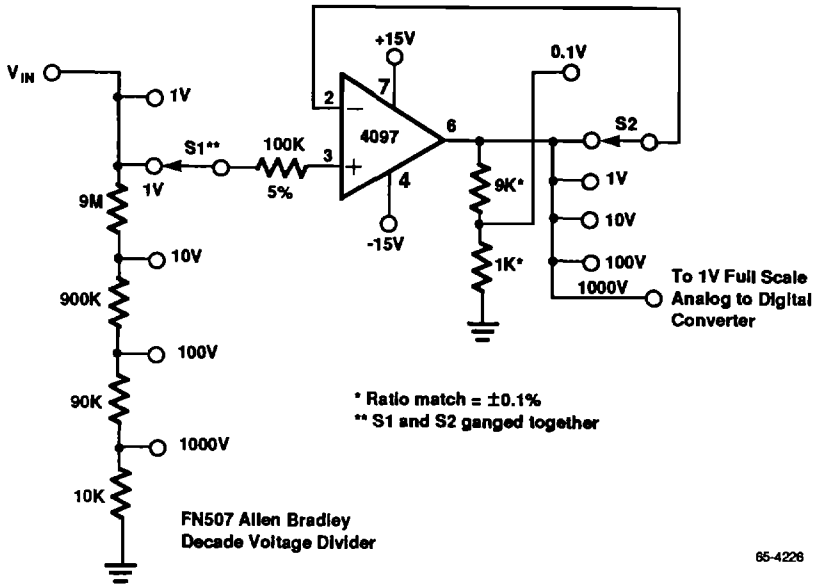


Long-Life Standard Cell Amplifier

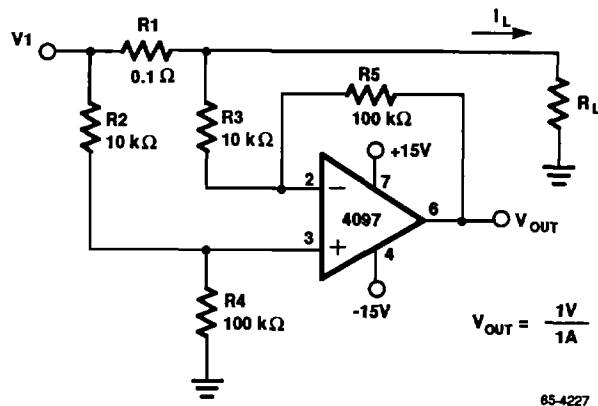


Composite High-Speed, Precision Amplifier

Typical Applications (Continued)

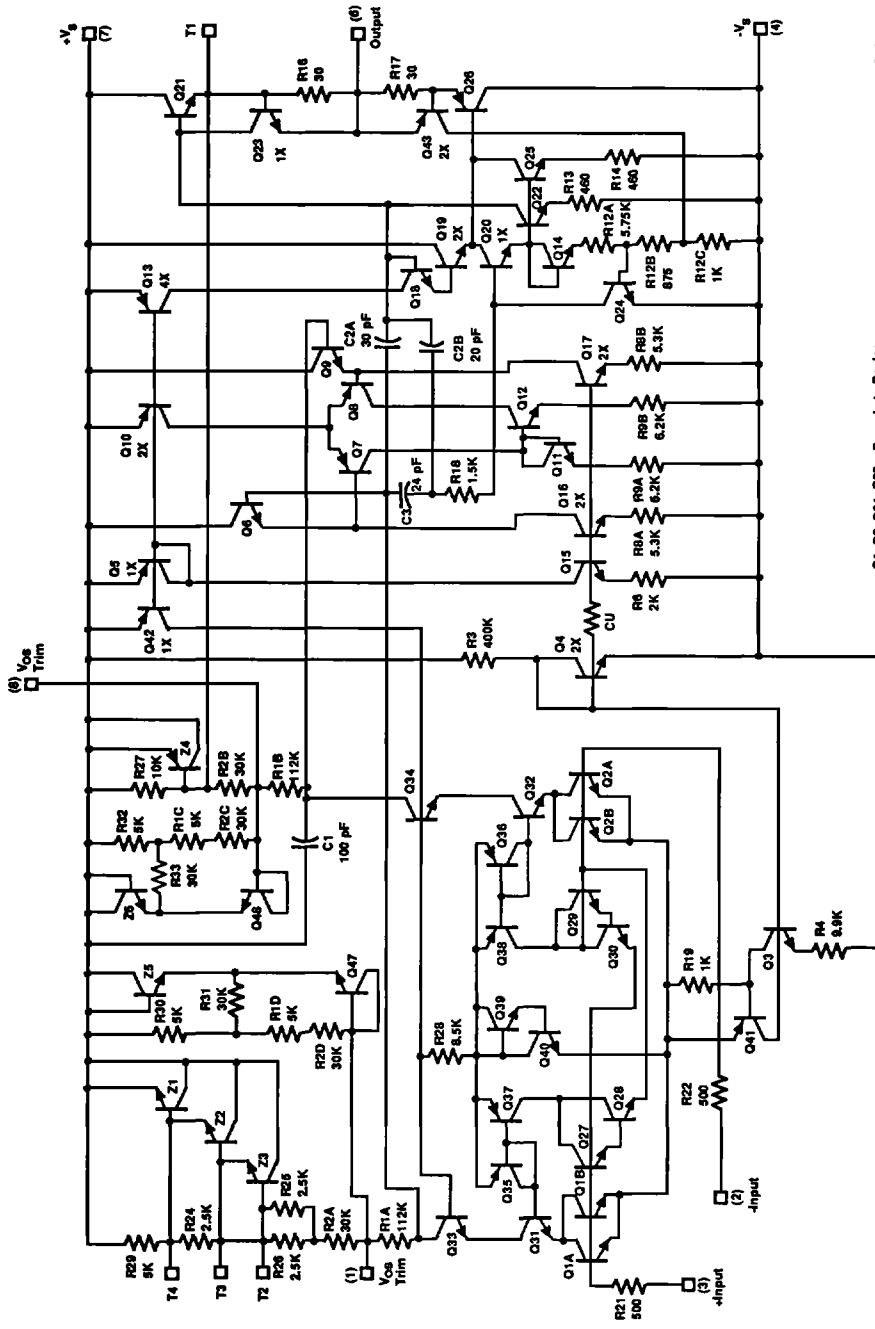


Input Amplifier for 4-1/2 Digit Voltmeter



Precision Current Monitor

Schematic Diagram



Q1, Q2, Q31, Q32 = Superbeta Devices
65-03433C