Raytheon RC4077 Series handbook

http://www.manuallib.com/file/2692177

RC4077 Series Precision Operational Amplifiers

Features

- Ultra-low V_{os} — 10 µV max
- Ultra low V_{os} drift – 0.1 µV/°C max (B grade only)
- Outstanding gain linearity
- High gain — 5000 V/mV min
- High CMRR — 120 dB min
- High PSRR – 110 dB min
- Low noise — 0.3 μV_{p-p} (0.1 to 10 Hz)
- Low input bias current — 2.0 nA max
- Low power consumption — 50 mW max
- Replaces OP-07, OP-77, 725, 108, 741 types

Description

The RC4077 is an advanced, ultra-high performance precision bipolar operational amplifier.

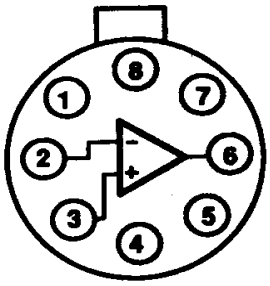
Its high precision performance results from two innovative and unconventional manufacturing steps, plus careful circuit layout and design. Thin-film resistor technology and a novel method of digital offset nulling are the key steps. A low ±10 µV offset voltage is delivered via a patented, proprietary V_{os} nulling adjustment. Devices retain this low offset through the stability and accuracy of Si-Cr thin-film resistors.For applications needing the lowest input offset voltage drift with temperature (TC V_{os}), the "B" grade has a worst-case specification of just 0.1 µV/°C.

Designed to upgrade OP-07 and other low-I_B bipolar precision types, the RC4077 has a well-balanced, mutually supporting set of input specifications. Low V_{os}, low I_B, and high open-loop gain combine to raise the performance level of many instrumentation, low-level signal conditioning, and data conversion applications. PSRR, CMRR, drift, and noise levels also support high precision operation.

The RC4077 is available in LCC, SO-8 (small outline), TO-99 can, plastic mini-DIP and ceramic mini-DIP packages, and can be ordered with Mil-Std-883 Level B processing.

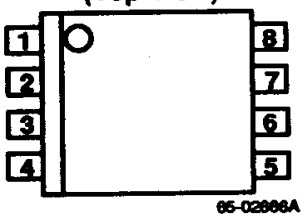
Connection Information

8-Lead TO-99 Metal Can
(Top View)



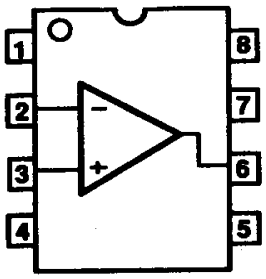
65-03205A

8-Lead Plastic Dual In-Line SO-8
(Top View)



65-02666A

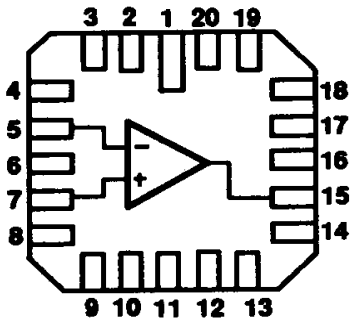
8-Lead Dual In-Line Package
(Top View)



65-03206A

Pin	Function
1	V_{os} Trim
2	-Input
3	+Input
4	$-V_s$
5	NC
6	Output
7	$+V_s$
8	V_{os} Trim

20-Pad LCC
(Top View)



65-02657A

Pin	Function
2	V_{os} Trim
5	-Input
7	+Input
10	$-V_s$
15	Output
17	$+V_s$
20	V_{os} Trim

Ordering Information

Part Number	Package	Operating Temperature Range
RC4077AN	N	0°C to +70°C
RC4077EN	N	0°C to +70°C
RC4077FN	N	0°C to +70°C
RC4077EM	M	0°C to +70°C
RC4077FM	M	0°C to +70°C
RV4077ET	T	-25°C to +85°C
RV4077FT	T	-25°C to +85°C
RV4077ED	D	-25°C to +85°C
RV4077FD	D	-25°C to +85°C
RM4077AT	T	-55°C to +125°C
RM4077AT/883B	T	-55°C to +125°C
RM4077AD	D	-55°C to +125°C
RM4077AD/883B	D	-55°C to +125°C
RM4077AL/883B	L	-55°C to +125°C
RM4077BT	T	-55°C to +125°C
RM4077BT/883B	T	-55°C to +125°C
RM4077BD	D	-55°C to +125°C
RM4077BD/883B	D	-55°C to +125°C
RM4077BL/883B	L	-55°C to +125°C

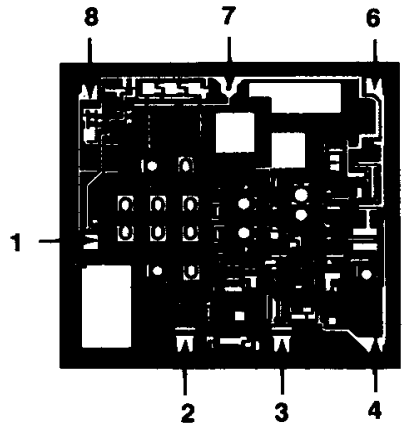
Notes:
/883B suffix denotes Mil-Std-883, Level B processing
N = 8-lead plastic DIP
D = 8 lead ceramic DIP
T = 8-lead metal can (TO-99)
L = 20-pad leadless chip carrier
M = 8-lead plastic SOIC
Contact a Raytheon sales office or representative for ordering information on special package/temperature range combinations.

Absolute Maximum Ratings

Supply Voltage ..... ±22V
Input Voltage* ..... ±22V
Differential Input Voltage 30V
Internal Power Dissipation** ..... 500 mW
Output Short Circuit Duration ..... Indefinite
Storage Temperature
  Range ..... -65°C to +150°C
Operating Temperature Range
  RM4077A ..... -55°C to +125°C
  RV4077A,E,F (Hermetic) ..... -25°C to +85°C
  RC4077A,E,F (Plastic) ..... 0°C to +70°C
Lead Soldering Temperature
  (SO-8, 10 sec) ..... +260°C
  (DIP, LCC, 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



Die Size: 75 x 78 mils
Min Pad Dimensions: 4 x 4 mils
65-03218A

Thermal Characteristics

	20-Pad LCC	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	175°C	125°C	125°C
Max. P_D T_A <50°C	925 mW	833 mW	658 mW	300 mW	468 mW
Therm. Res θ_{JC}	37°C/W	45°C/W	50°C/W	–	–
Therm. Res. θ_{JA}	105°C/W	150°C/W	190°C/W	240°C/W	160°C/W
For T_A >50°C Derate at	7.0 mW/°C	8.33 mW/°C	5.26 mW/°C	4.17 mW/°C	6.25 mW/°C

Electrical Characteristics (V_S = ±15V and T_A = +25°C unless otherwise noted)

Parameters	Test Conditions	4077A/B/E			4077F			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage[3]	RC/RM4077A RM4077B RC4077E		4.0 7.0 15	10 15 25		20	60	µV
Long Term V_{OS} Stability[1]			0.2			0.4		µV/Mo
Input Offset Current			0.1	1.5		0.1	2.8	nA
Input Bias Current			±0.3	±2.0		±1.0	±2.8	nA
Input Noise Voltage[5]	0.1 Hz to 10 Hz		0.35	0.6		0.35	0.65	μV_{p-p}
Input Noise Voltage Density[5]	F_O = 10 Hz		10.3	18		10.3	20	$\frac{nV}{\sqrt{Hz}}$
	F_O = 100 Hz		10	13		10	13.5	
	F_O = 1000 Hz		9.6	11		9.6	11.5	
Input Noise Current[5]	0.1 Hz to 10 Hz		14	30		14	35	pA_{p-p}
Input Noise Current Density[5]	F_O = 10 Hz		0.32	0.8		0.32	0.9	$\frac{pA}{\sqrt{Hz}}$
	F_O = 100 Hz		0.14	0.23		0.14	0.27	
	F_O = 1000 Hz		0.12	0.17		0.12	0.18	
Input Resistance (Diff Mode)[2]		30	80		20	60		MΩ
Input Resistance (Com. Mode)			200			200		GΩ
Input Voltage Range[4]		±13	±14		±13	±14		V
Common Mode Rejection Ratio	V_{CM} = ±11V	120	140		116	130		dB
Power Supply Rejection Ratio	V_S = ±3.0V to ±8.0V	110	125		110	125		dB
Large Signal Voltage Gain	$R_L \geq 2$ kΩ, V_O = ±10V	5000	12,000		2000	8000		V/mV
Output Voltage Swing	$R_L \geq 10$ kΩ	±13	±13.5		±13	±13.5		V
	$R_L \geq 2$ kΩ	±12.5	±13		±12.5	±13		
	$R_L \geq 1$ kΩ	±12	±12.5		±12	±12.5		
Slew Rate	$R_L \geq 2$ kΩ	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
Open Loop Output Resistance	V_O = 0, I_O = 0		60			60		Ω
Power Consumption	V_S = ±15V, R_L = ∞		35	50		35	50	mW
	V_S = ±3.0V, R_L = ∞		3.5	4.5		3.5	4.5	mW

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/RM4077A/RM4077B 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 = ±15V, -25°C ≤ T_A ≤ +85°C for hermetic packages, 0°C ≤ T_A ≤ +70°C for plastic packages unless otherwise noted)

Parameters	Test Conditions	4077A/E			4077F			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	RC4077A		7.0	24				µV
	RC4077EN,EM		10	40				
	RC4077FN,FM					25	90	
	RV4077ET,ED		10	45				
	RV4077FT,FD					30	100	
Average Input Offset Voltage Drift[1]	RC4077A/E		0.1	0.3		0.2	0.6	µV/°C
Input Offset Current			0.8	2.2		1.0	4.5	nA
Average Input Offset Current Drift[2]			±5.0	±40		±5.0	±85	pA/°C
Input Bias Current			±2.4	±4.0		±2.4	±6.0	nA
Average Input Bias Current Drift[2]			±8.0	±40		±15	±60	pA/°C
Input Voltage Range		±13	±13.5		±13	±13.5		V
Common Mode Rejection Ratio	V_{CM} = ±10V	120	130		110	120		dB
Power Supply Rejection Ratio	V_S = ±3.0V to ±18V	110	115		106	115		dB
Large Signal Voltage Gain	$R_L \geq 2$ kΩ, V_O = ±10V	2000	6000		1000	4000		V/mV
Maximum Output Voltage Swing	$R_L \geq 2$ kΩ	±12	±13		±12	±13		V
Power Consumption	$R_L = \infty$		40	60		40	60	mW

Notes:
1. 100% tested for Grade A/E, sample tested for Grade F.
2. Sample tested.

Electrical Characteristics (V_S = ±15V, -55°C ≤ T_A ≤ +125°C unless otherwise noted)

Parameters	Test Conditions	RM4077A/B			Units
		Min	Typ	Max	
Input Offset Voltage	RM4077A RM4077B		20 10	40 25	µV
Average Input Offset Voltage Drift[1]	RM4077A RM4077B		0.1 0.05	0.3 0.1	µV/°C
Input Offset Current			0.8	2.2	nA
Average Input Offset Current Drift[2]			±0.5	±25	pA/°C
Input Bias Current			±2.4	±4.0	nA
Average Input Bias Current Drift[2]			±0.8	±25	pA/°C
Input Voltage Range		±13	±13.5		V
Common Mode Rejection Ratio	V_{CM} = ±10V	120	130		dB
Power Supply Rejection Ratio	V_S = ±4.0V to ±16.5V	110	115		dB
Large Signal Voltage Gain	R_L ≥ 2 kΩ, V_O = ±10V	2000	6000		V/mV
Maximum Output Voltage Swing	R_L ≥ 2 kΩ	±12	±13		V
Power Consumption	R_L = ∞		40	60	mW

Notes:
1. 100% tested for Grade A/E/B, sample tested for Grade F.
2. Sample tested.

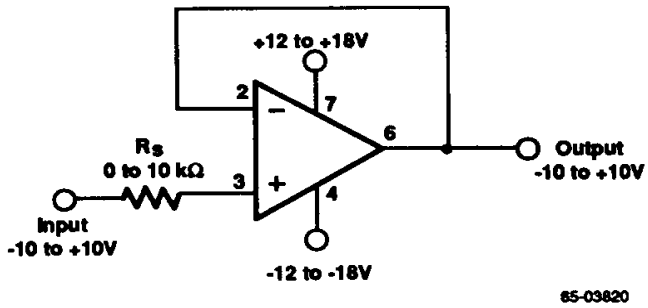
Offset Voltage Adjustment

The input offset voltage of the RC4077, 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) µV/°C, e.g., if V_{os} is adjusted to 300 µV, the change in drift will be 1 µV/°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 the next page has an approximate null range of ±100 µV.

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.

RC4077 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 RC4077 can also be used in 741 applications provided that the nulling circuitry is removed.

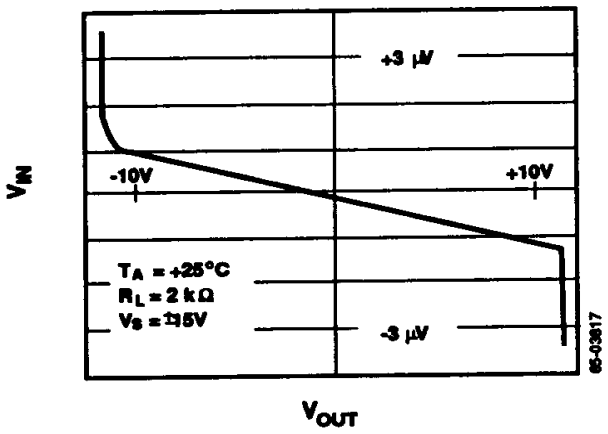
The voltage follower is an ideal example illustrating the overall excellence of the RC4077. The contributing error terms are due to offset voltage, input bias current, voltage gain, common-mode and power-supply rejections. Worst-case summation of guaranteed specifications is tabulated below.



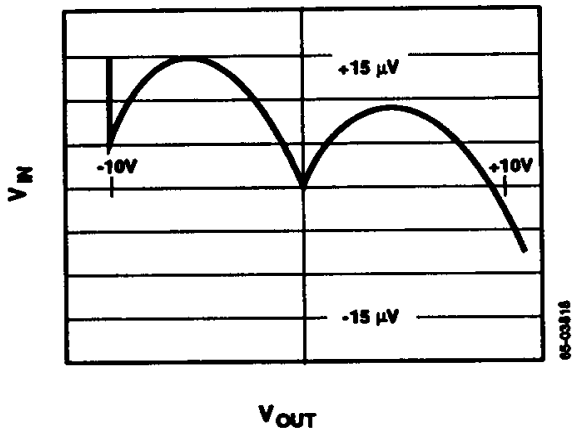
Large Signal Voltage Follower With 0.00063% Worst-Case Accuracy Error

Output Accuracy

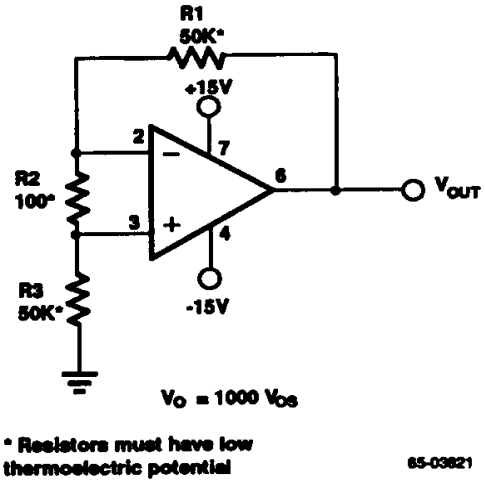
Error	RM4077A 25°C Max (µV)	RV4077F 25°C Max (µV)	RM4077A -55 to +125°C Max (µV)	RV4077F -25 to +85°C Max (µV)
Offset Voltage	10	60	40	100
Bias Current	15	28	40	60
CMRR	20	32	20	60
PSRR	18	18	18	30
Voltage Gain	7	8	8	20
Worst Case Sum	70	146	126	270
Percent of Full Scale (= 20V)	.00035%	.00073%	.00063%	.0013%



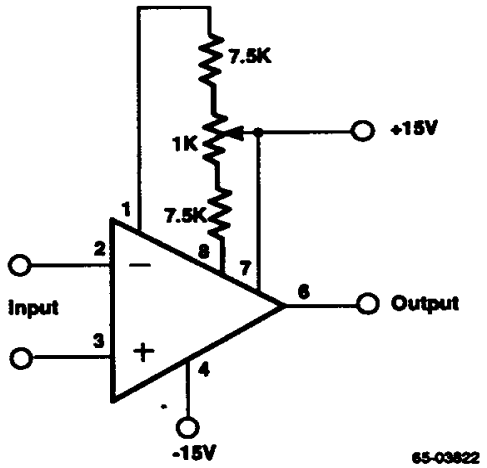
RC4077 Open-Loop Gain Linearity



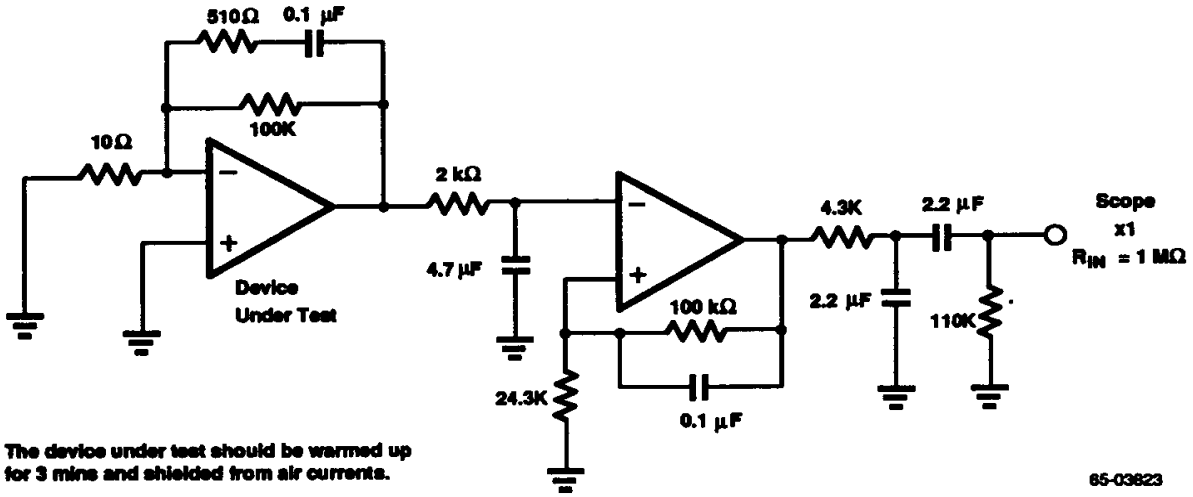
Typical Precision Op Amp Gain Linearity



Test Circuit for Offset Voltage and Its Drift With Temperature



Improved Sensitivity Adjustment



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

Schematic Diagram