Raytheon

Instrumentation Grade Operational Amplifier

OP-05 Series

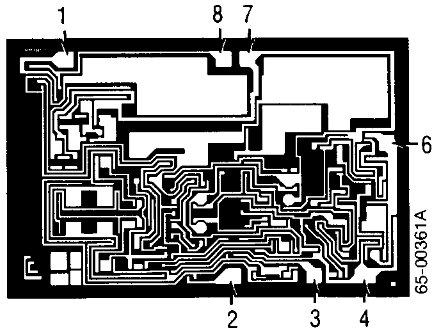
Features

- Low noise 0.1Hz to 10Hz — $0.35\mu V_{p-p}$
- Low V_{OS} — 0.15mV
- Ultra-low V_{OS} drift — $0.2\mu V/°C$
- Fits 725, 108A, 741, and AD510 sockets
- Long term stability — $0.2\mu V$/Month
- Low input bias current — ±1nA
- High CMRR — 126dB
- Wide input voltage range — ±14V

Description

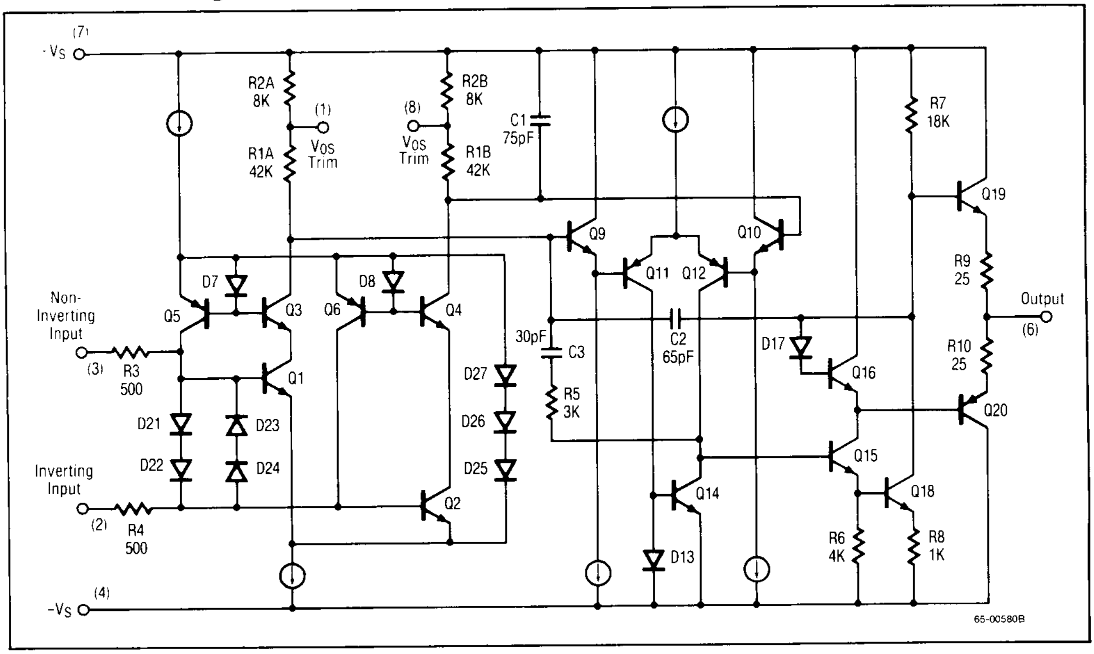
The OP-05 series of instrumentation grade operational amplifiers is designed for low level signal conditioning where ultra low V_{OS} and TCV_{OS} are required along with very low bias currents. Internal compensation eliminates the need for external components. Novel circuit design and tight process controls are used to obtain very low values of V_{OS}. Low frequency noise is minimized. Internal biasing techniques reduce external bias and offset currents to values in the order of ±1nA over the military temperature range. Raytheon's OP-05s are direct replacements for the 108A, 714, 725 and 5507. They can replace chopper stabilized amplifiers in many applications.

Mask Pattern



Die Size: 65 x 101 mils
Min. Pad Dimensions: 4 x 4 mils

Schematic Diagram

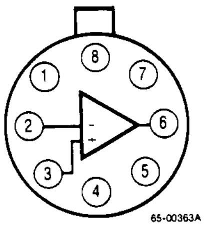


OP-05 Series

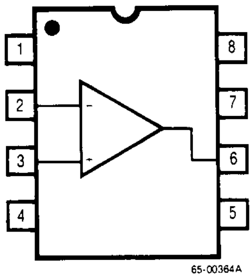
Instrumentation Grade Operational Amplifier

Connection Information

TO-99
Metal Can
(Top View)



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



Pin	Function
1	V_{OS} Trim
2	-Input
3	+Input
4	$-V_S$ (Case)
6	Output
7	$+V_S$
8	V_{OS} Trim

Absolute Maximum Ratings

Supply Voltage .... ±22V
Input Voltage[1] .... ±22V
Differential Input Voltage 30V
Internal Power Dissipation[2] 500mW
Output Short Circuit Duration .... Indefinite
Storage Temperature
Range .... -65°C to +150°C
Operating Temperature Range
OP-05A .... -55°C to +125°C
OP-05E/C/D .... 0°C to +70°C
Lead Soldering Temperature
(60 Sec) .... +300°C

Notes: 1. For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.
2. Maximum power dissipation vs. ambient temperature.

Thermal Characteristics

	8-Lead Ceramic DIP	8-Lead TO-99 Metal Can
Max. Junction Temp.	175°C	175°C
Max. P_D $T_A < 50°C$	833mW	658mW
Therm. Res. θ_{JC}	45°C/W	50°C/W
Therm. Res. θ_{JA}	150°C/W	190°C/W
For $T_A > 50°C$ Derate at	8.33mW per °C	5.26mW per °C

Ordering Information

Part Number	Package	Operating Temperature Range
OP-05CT	TO-99	0°C to +70°C
OP-05ET	TO-99	0°C to +70°C
OP-05CDE	Ceramic	0°C to +70°C
OP-05EDE	Ceramic	0°C to +70°C
OP-05CNB	Plastic	0°C to +70°C
OP-05ENB	Plastic	0°C to +70°C
OP-05T	TO-99	-55°C to +125°C
OP-05T/883B*	TO-99	-55°C to +125°C
OP-05AT	TO-99	-55°C to +125°C
OP-05AT/883B*	TO-99	-55°C to +125°C
OP-05DE	Ceramic	-55°C to +125°C
OP-05DE/883B*	Ceramic	-55°C to +125°C
OP-05ADE	Ceramic	-55°C to +125°C
OP-05ADE/883B*	Ceramic	-55°C to +125°C

*MIL-STD-883, Level B Processing

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

Parameters	Test Conditions	OP-05A Min	OP-05A Typ	OP-05A Max	OP-05 Min	OP-05 Typ	OP-05 Max	Units
Input Offset Voltage[4]			70	150		200	500	μV
Long Term Input Offset Voltage Stability[1 2]			0.2	1.0		0.2	1.0	μV/Mo
Input Offset Current			0.3	2.0		0.4	2.8	nA
Input Bias Current			±0.7	±2		±1	±3	nA
Input Noise Voltage[2]	0.1Hz to 10Hz		0.35	0.6		0.35	0.6	μV_{p-p}
Input Noise Voltage Density[2]	f_O = 10Hz		10.3	18		10.3	18	$nV/\sqrt{Hz}$
	f_O = 100Hz		10	13		10	13	
	f_O = 1000Hz		9.6	11		9.6	11	
Input Noise Current[2]	0.1Hz to 10Hz		14	30		14	30	pA_{p-p}
Input Noise Current Density[2]	f_O = 10Hz		0.32	0.80		0.32	0.80	$pA/\sqrt{Hz}$
	f_O = 100Hz		0.14	0.23		0.14	0.23	
	f_O = 1000Hz		1.12	0.17		0.12	0.17	
Input Resistance (Diff. Mode)[3]		30	80		20	60		MΩ
Input Resistance (Com. Mode)			200			200		GΩ
Input Voltage Range		±13.5	±14		±13.5	±14		V
Common Mode Rejection Ratio	V_{CM} = ±13.5V	114	126		114	126		dB
Power Supply Rejection Ratio	V_S = ±3V to ±18V	100	110		100	110		dB
Large Signal Voltage Gain	R_L ≥ 2kΩ, V_O = ±10V	300	500		200	500		V/mV
Large Signal Voltage Gain[3]	R_L ≥ 500kΩ, V_O = ±0.5V, V_S = ±3V	150	500		150	500		
Output Voltage Swing	R_L ≥ 10kΩ	±12.5	±13		±12.5	±13		V
	R_L ≥ 2kΩ	±12	±12.8		±12	±12.8		
	R_L ≥ 1kΩ	±10.5	±12		±10.5	±12		
Slew Rate[2]	R_L ≥ 2kΩ	0.1	0.17		0.1	0.17		V/μS
Unity Gain Bandwidth[2]			0.5			0.5		MHz
Open Loop Output Resistance	V_O = 0, I_O = 0		60			60		Ω
Power Consumption	V_S = ±15V		75	120		75	120	mW
	V_S = ±3V		4	6		4	6	
Offset Adjustment Range	R_p = 20kΩ		±4			±4		mV

Notes:
1. Long Term Input Offset Voltage Stability refers to the average 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 2.5μV.
2. This parameter is tested on a sample basis only, and guaranteed to an LTPD of 10.
3. Guaranteed by design.
4. Input Offset Voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power.

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

Parameters	Test Conditions	OP-05E Min	OP-05E Typ	OP-05E Max	OP-05C Min	OP-05C Typ	OP-05C Max	Units
Input Offset Voltage[4]			200	500		300	1300	μV
Long Term Input Offset Voltage Stability[1 2]			0.3	1.5		0.4	2.0	μV/Mo
Input Offset Current			0.5	3.8		0.8	6.0	nA
Input Bias Current			±1.2	±4.0		±1.8	±7.0	nA
Input Noise Voltage[2]	0.1Hz to 10Hz		0.35	0.6		0.38	0.65	μV_{p-p}
Input Noise Voltage Density[2]	f_O = 10Hz		10.3	18		10.5	20	$\frac{nV}{\sqrt{Hz}}$
	f_O = 100Hz		10	13		10.2	13.5	
	f_O = 1000Hz		9.6	11		9.8	11.5	
Input Noise Current[2]	0.1Hz to 10Hz		14	30		15	35	pA_{p-p}
Input Noise Current Density[2]	f_O = 10Hz		0.32	0.8		0.35	0.9	$\frac{pA}{\sqrt{Hz}}$
	f_O = 100Hz		0.14	0.23		0.15	0.27	
	f_O = 1000Hz		1.12	0.17		0.13	0.18	
Input Resistance (Diff. Mode)[3]		15	50		8.0	33		MΩ
Input Resistance (Com. Mode)			160			120		GΩ
Input Voltage Range		±13.5	±14		±13	±14		V
Common Mode Rejection Ratio	V_{CM} = ±13.5V	110	123		100	120		dB
Power Supply Rejection Ratio	V_S = ±3V to ±18V	94	105		90	104		dB
Large Signal Voltage Gain	$R_L \geq 2k\Omega$, V_O = ±10V	200	500		120	400		V/mV
Large Signal Voltage Gain[3]	$R_L \geq 500k\Omega$, V_O = ±0.5V, V_S = ±3V	150	500		100	400		
Output Voltage Swing	$R_L \geq 10k\Omega$	±12.5	±13		±12	±13		V
	$R_L \geq 2k\Omega$	±12	±12.8		±11.5	±12.8		
	$R_L \geq 1k\Omega$	±10.5	±12		±10.5	±12		
Slew Rate[2]	$R_L \geq 2k\Omega$	0.1	0.17		0.1	0.17		V/μS
Unity Gain Bandwidth[2]			0.5			0.5		MHz
Open Loop Output Resistance	V_O = 0, I_O = 0		60			60		Ω
Power Consumption	V_S = ±15V		75	120		80	150	mW
	V_S = ±3V		4.0	6.0		4.0	8.0	
Offset Adjustment Range	R_p = 20kΩ		±4.0			±4.0		mV

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 2.5μV.
2. This parameter is tested on a sample basis only, and guaranteed to an LTPD of 10.
3. Guaranteed by design.
4. Input Offset Voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power.

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

Parameters	Test Conditions	OP-05A Min	OP-05A Typ	OP-05A Max	OP-05 Min	OP-05 Typ	OP-05 Max	Units
Input Offset Voltage[3]			100	240		300	700	μV
Average Input Offset Voltage Drift Without External Trim[2]			0.3	0.9		0.7	2.0	μV/°C
With External Trim[2]	R_P = 20kΩ		0.2	0.5		0.3	1.0	
Input Offset Current			0.8	4		1.2	5.6	nA
Average Input Offset Current Drift[1]			5	25		8	50	pA/°C
Input Bias Current			±1	±4		±2	±6	nA
Average Input Bias Current Drift[1]			8	25		13	50	pA/°C
Input Voltage Range		±13	±13.5		±13	±13.5		V
Common Mode Rejection Ratio	V_{CM} = ±13V	110	123		110	123		dB
Power Supply Rejection Ratio	V_S = ±3V to ±18V	94	106		94	106		dB
Large Signal Voltage Gain	R_L ≥ 2kΩ, V_O = ±10V	200	400		150	400		V/mV
Output Voltage Swing	R_L ≥ 2kΩ	±12	±12.6		±12	±12.6		V

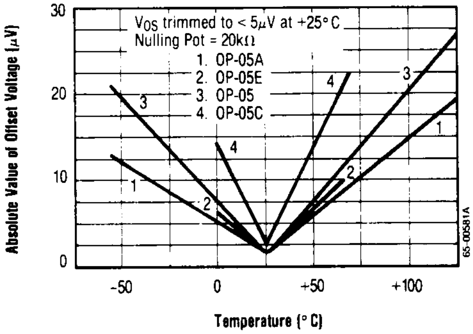
Electrical Characterisstics (V_S = ±15V and 0°C ≤ T_A ≤ +70°C unless otherwise noted)

Parameters	Test Conditions	OP-05E Min	OP-05E Typ	OP-05E Max	OP-05C Min	OP-05C Typ	OP-05C Max	Units
Input Offset Voltage[3]			250	600		350	1600	μV
Average Input Offset Voltage Drift Without External Trim[2]			0.7	2.0		1.3	4.5	μV/°C
With External Trim[2]	R_P = 20kΩ		0.2	0.6		0.4	1.5	
Input Offset Current			0.9	5.3		1.6	8.0	nA
Average Input Offset Current Drift[1]			8.0	35		12	50	pA/°C
Input Bias Current			±1.5	±5.5		±2.2	±9.0	nA
Average Input Bias Current Drift[1]			13	35		18	50	pA/°C
Input Voltage Range		±13	±13.5		±13	±13.5		V
Common Mode Rejection Ratio	V_{CM} = ±13V	107	123		97	120		dB
Power Supply Rejection Ratio	V_S = ±3V to ±18V	90	104		86	100		dB
Large Signal Voltage Gain	R_L ≥ 2kΩ, V_O = ±10V	180	450		100	400		V/mV
Output Voltage Swing	R_L ≥ 2kΩ	±12	±12.6		±11	±12.6		V

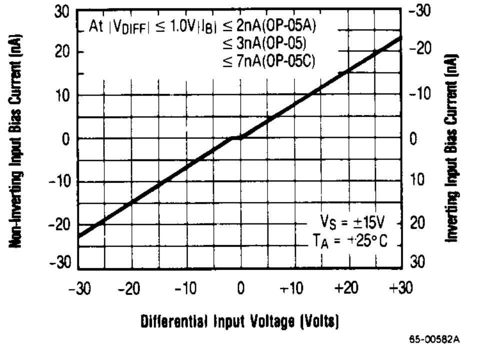
Notes: 1. This parameter is tested on a sample basis only, and guaranteed to an LTPD of 10.
2. Guaranteed by design.
3. Input Offset Voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power.

Typical Performance Characteristics

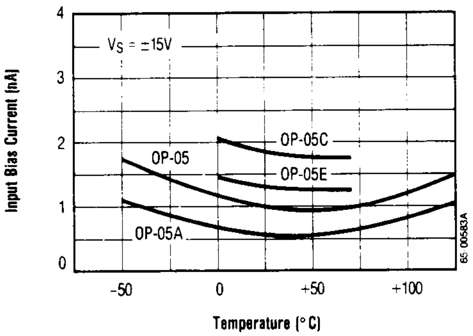
Trimmed Offset Voltage vs. Temperature



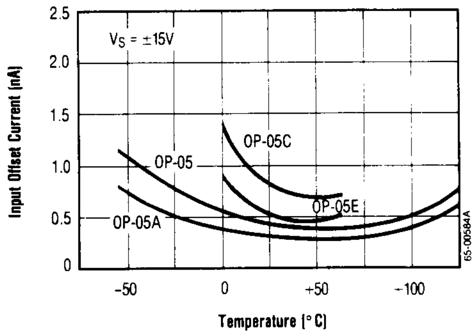
Input Bias Current vs. Differential Input Voltage



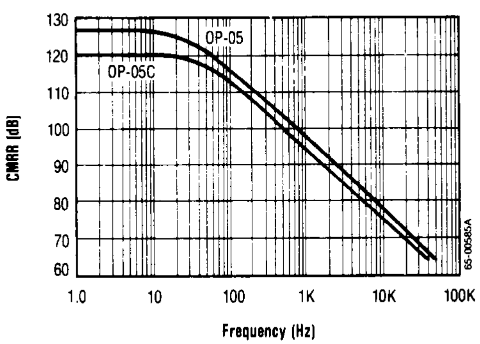
Input Bias Current vs. Temperature



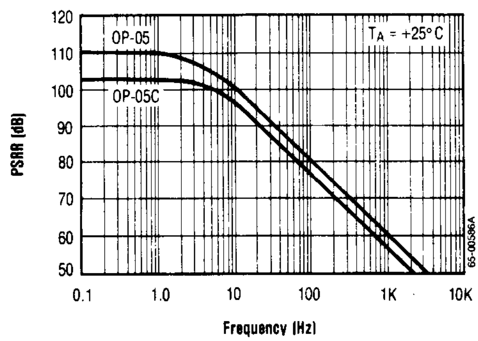
Input Offset Current vs. Temperature



CMRR vs. Frequency

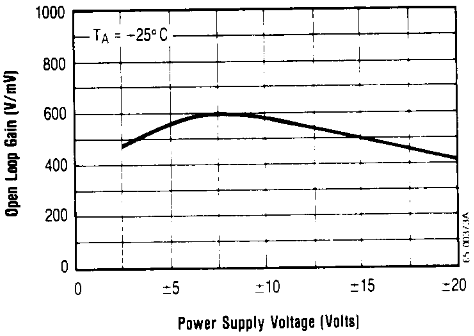


PSRR vs. Frequency

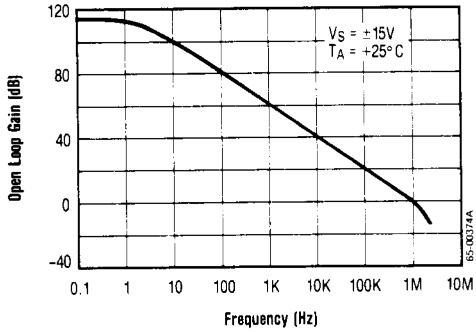


Typical Performance Characteristics (Continued)

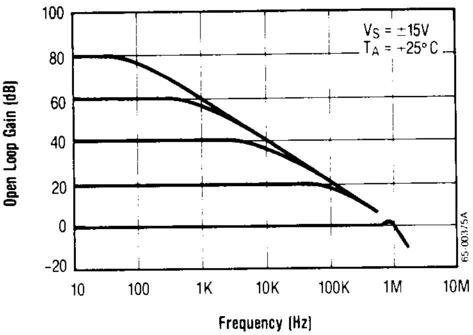
Open Loop Gain vs. Supply Voltage



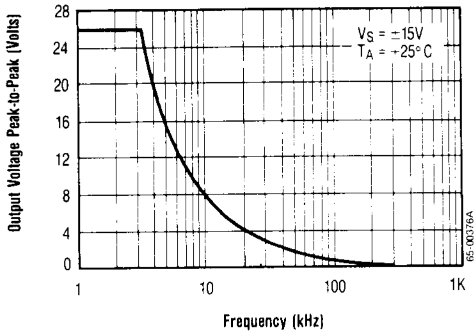
Open Loop Frequency Response



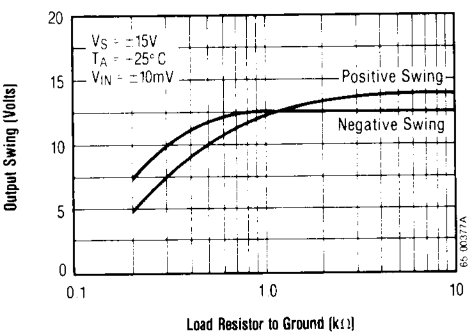
Closed Loop Response for Various Gain Configurations



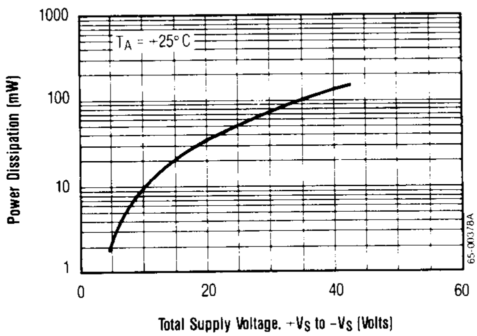
Maximum Undistorted Output vs. Frequency



Output Voltage vs. Load Resistance

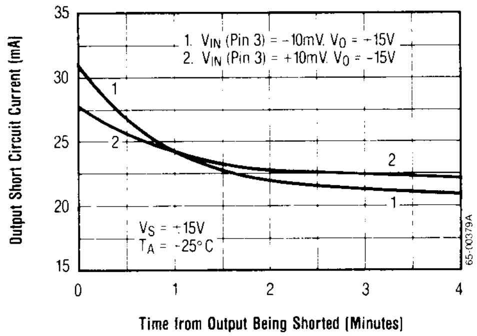


Power Consumption vs. Supply Voltage



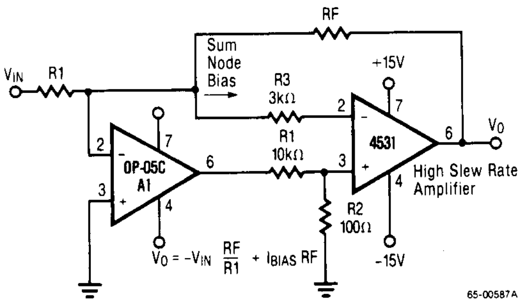
Typical Performance Characteristics (Continued)

Output Short Circuit Current vs. Time

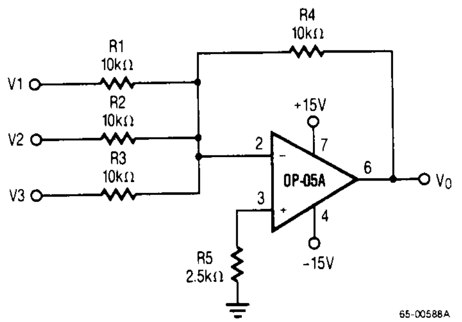


Typical Applications

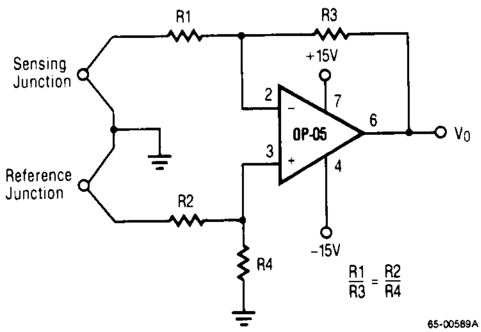
High Speed, Low V_{OS} Composite Amplifier*



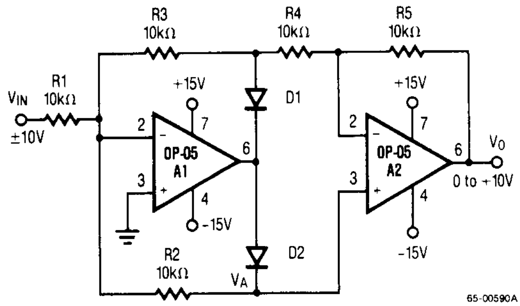
Adjustment-Free Precision Summing Amplifier*



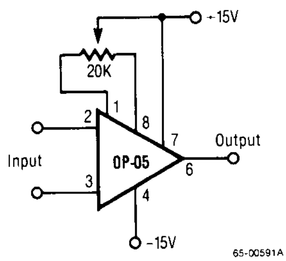
High Stability Thermocouple Amplifier*



Precision Absolute Value Circuit*



Offset Nulling Circuit



*Pin Outs Shown for Metal Can Packages