36V, Femtoampere Input Bias Current, Precision Operational Amplifier

Features

- Ultra-low Input Bias Current:
  ±100 fA (Max) at −40ºC <T_A< +85°C
- Low Input offset Voltage: 150μV (Max)
- Integrated Precision Guard Buffer
- Wide Operation Supply Voltage:
  Single: 4.5 V to 36 V
  Dual: ± 2.25 V to ±18 V
- Low Quiescent Current: 350μA
- Gain Bandwidth Product: 2.5 MHz
- Slew Rate: 4.5V/μs
- Rail-to-Rail Output Swing (RRO)
- Unity Gain Stable
- High EMI Rejection
- Extended Temperature Ranges
  From -40°C to +125°C
- Green Packaging: SOP-8/MSOP-8

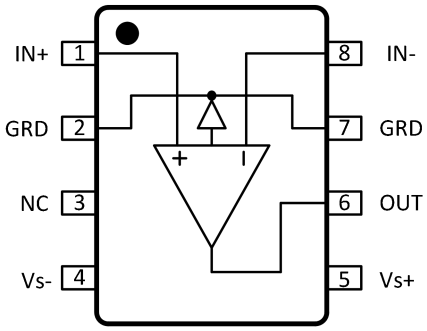
Applications

- Sensor Conditioning
- Lab and Field Instrumentation
- Trans-impedance Amplifier (TIA)
- Electrochemical Meter, pH Meter
- High Impedance Buffering for Sensors

General Description

The COS4530 is an ultr-low input bias current (femtoampere, 10^{-15} A), low-power, precision operational amplifier operating from 4.5V to 36V supply. This device features an internal, high precision guard buffer to protect high impedance input traces from undesirable current leakage in sensitive application.

COS4530 is unity gain stable and has a gain bandwidth product of 2.5 MHz. The output voltage swing extends to within 10mV of each rail, providing the maximum output dynamic range with excellent overdrive recovery. Very low input bias current and temperature offset drift make the devices an ideal choice for portable instrumentation and sensor conditioning applications that require low-bias current analog front-end performance, such as photodiode trans-impedance and chemical sensor interface circuitry.

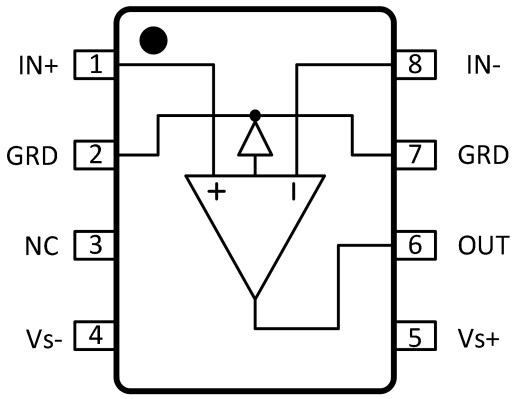


Pin Diagram

Rev1.0

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1. Pin Configuration and Functions



Pin Functions

PIN No.	PIN Name	Description
1	IN+	Positive input
2	GRD	Guard buffer
3	NC	Do not connect, leave floating
4	Vs-	Negative power supply or ground
5	Vs+	Positive power supply
6	OUT	Output
7	GRD	Guard buffer
8	IN-	Negative input

2. Product Specification

2.1 Absolute Maximum Ratings (1)

Parameter	Rating	Units
Power Supply: +Vs to -Vs	40	V
Input Voltage, Common-mode	-Vs -0.5V to +Vs + 0.5V	V
Input Voltage, Differential	±0.5	V
Input Current (2)	±10	mA
Storage Temperature Range	-65 to 150	°C
Junction Temperature	150	°C
ESD Susceptibility, HBM	±4000	V

(1) Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.

2.2 Thermal Data

Parameter	Rating	Unit
Package Thermal Resistance, $R_{\theta JA}$ (Juntion-to-ambient)	155 (SOP8) 206 (MSOP8)	°C/W

2.3 Recommended Operating Conditions

Parameter		Rating	Unit
DC Supply Voltage	Dual Supply	±2.25 ~ ±18	V
	Single Supply	4.5 ~ 36	V
Operating ambient temperature		-40 to +125	°C

2.4 Electrical Characteristics

(+V_S=4.5V to 36V, -V_S=0, V_{CM}=V_S/2, T_A=+25°C, R_L=10 kΩ to V_S/2, RH<50%, unless otherwise noted)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Characteristics						
Input Bias Current	I_B	−40°C < T_A < +85°C		±10	±100	fA
		−40°C < T_A < +125°C			±800	
Input Offset Current	I_{OS}	−40°C < T_A < +85°C		±10	±50	fA
		−40°C < T_A < +125°C			±500	
Input Offset Voltage	V_{OS}	T_A=+25°C		±10	±150	μV
		−40°C < T_A < +125°C		±25	±300	μV
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C < T_A < +125°C			±2	μV/°C
Common-Mode Voltage Range	V_{CM}		V_{-S} -0.1		V_{+S} -1.5	V
Common-Mode Rejection Ratio	CMRR		100	150		dB
Open-Loop Voltage Gain	A_{OL}			150		dB

Output Characteristics						
Output Voltage Swing from Rail		R_L=100kΩ		10		mV
		R_L=10kΩ		90		mV
Short-Circuit Current	I_{SR}	Sourcing		20		mA
	I_{SK}	Sinking		-17		mA
Power Supply						
Operating Voltage Range			4.5		36	V
Quiescent Current	I_Q	V_S = 16V		350		μA
		V_S = 36V		525		
Power Supply Rejection Ratio	PSRR		100	120		dB
Dynamic Performance						
Gain Bandwidth Product	GBWP	G=+1		2.5		MHz
Slew Rate	SR	G = +1 , 2V Output Step		4.5		V/μs
Internal Guard Buffer						
Guard Buffer Input Offset Voltage	V_{OSG}	−40°C < T_A < +85°C		±10	±150	μV
		−40°C < T_A < +125°C		±25	±300	μV
Guard Buffer Input Offset Voltage Drift	$\Delta V_{OSG}/\Delta T$	−40°C < T_A < +125°C			±2	μV/°C
Guard Buffer Output Swing from Rail		No load		2	10	mV
Guard Buffer Output Impedance	V_{OG}	I_O=0A		1		kΩ
Guard Buffer Bandwidth				2.5		MHz
Noise Performance						
Voltage Noise Density	e_n	f=1kHz		20		nV/√Hz

3.0 Application Notes

Overview

The COS4530 is a femtoampere input bias, precision operational amplifier operating on a single +4.5V to +36V supply or dual ±2.25V to ±18V supplies. This device features an internal, high precision guard buffer to protect high impedance input traces from undesirable current leakage in sensitive application.

COS4530 is unity gain stable and has a gain bandwidth product of 2.5MHz. The output voltage swing extends to within 10mV of each rail, providing the maximum output dynamic range with excellent overdrive recovery. Very low input bias current and temperature offset drift make the devices an ideal choice for portable instrumentation and sensor conditioning applications that require low-bias current analog front-end performance, such as photodiode trans-impedance and chemical sensor interface circuitry.

Typical Application Circuits

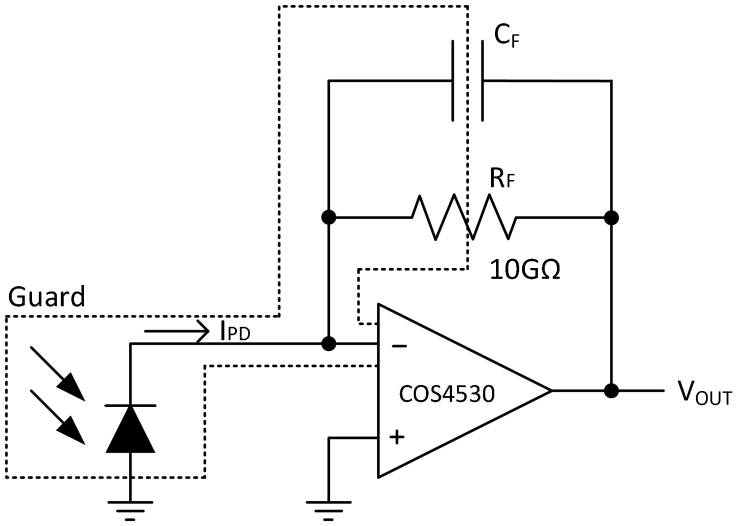


Figure 1. High Gain Transimpedance Amplifier

The low input bias current and low input offset voltage makes the COS4530 an excellent choice for signal conditioning photodiodes at extremely low illumination levels. Figure 1 shows the COS4530 configured in a transimpedance amplifier interfacing with a photodiode operating in photovoltaic mode (photodiode is zero biased). A photodiode produces an output current proportional to the illumination level. The amplifier converts the signal current, I_{PD}, into an output voltage with the following equation:

$$V_{OUT} = I_{PD} \times R_F$$

Some applications require consideration of the limitations of the guard buffer output swing. One such application is the single-supply inverting amplifier with a common-mode voltage equal to the rail, most commonly ground. The guard buffer cannot drive the guard all the way to the rail. The internal guard buffer features a rail-to-rail output stage and is capable of driving the guard to within 15mV of the rail. The small voltage difference manifests as a differential voltage across the anti-parallel diodes. Even a small differential voltage of 15mV can cause a significant amount of leakage through the diodes at high temperatures. To avoid the input common-mode limitation of the guard buffer in inverting configurations with zero-common mode voltage, connect the guard pins directly to ground as done in Figure 2.

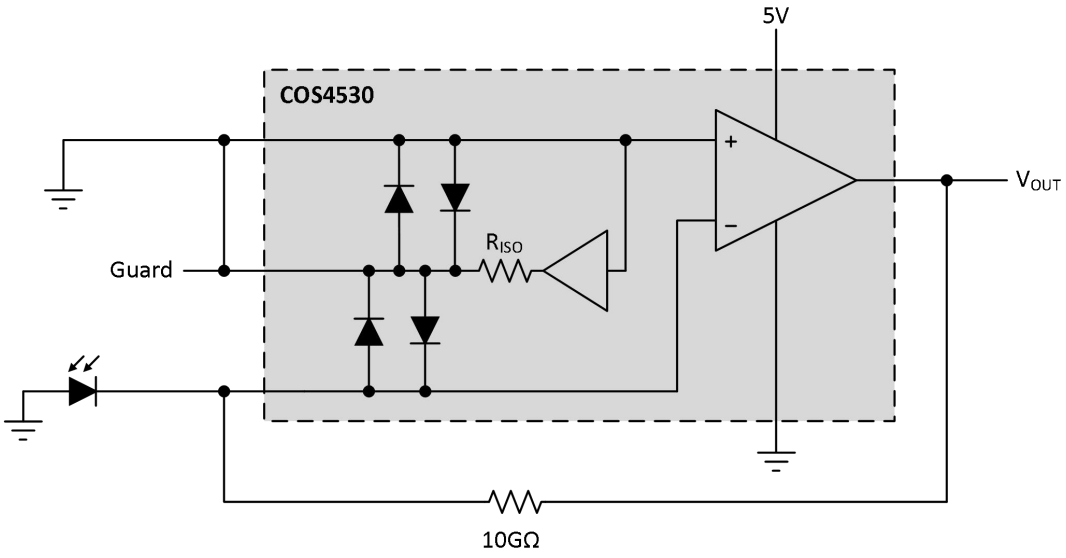


Figure 2. Single-Supply Trans-impedance Amplifier With Grounded Guard Pin

Driving Capacitive Loads

Driving large capacitive loads can cause stability problems for voltage feedback op amps. As the load capacitance increases, the feedback loop's phase margin decreases, and the closed loop bandwidth is reduced. This produces gain peaking in the frequency response, with overshoot and ringing in the step response. A unity gain buffer (G = +1) is the most sensitive to capacitive loads, but all gains show the same general behavior.

When driving large capacitive loads with these op amps (e.g., > 100 pF when G = +1), a small series resistor at the output (R_{ISO} in Figure 3) improves the feedback loop's phase margin (stability) by making the output load resistive at higher frequencies. It does not, however, improve the bandwidth.

To select R_{ISO}, check the frequency response peaking (or step response overshoot) on the bench. If the response is reasonable, you do not need R_{ISO}. Otherwise, start R_{ISO} at 1 kΩ and modify its value until the response is reasonable.

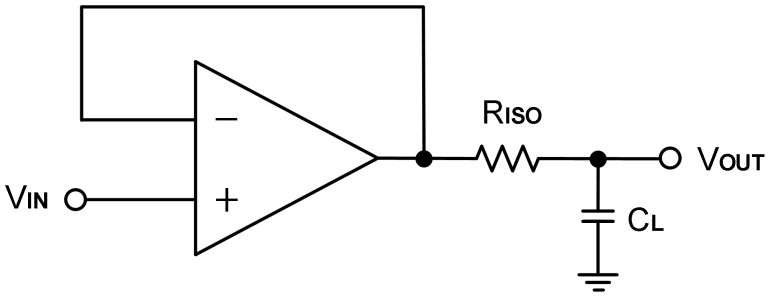


Figure 3. Indirectly Driving Heavy Capacitive Load

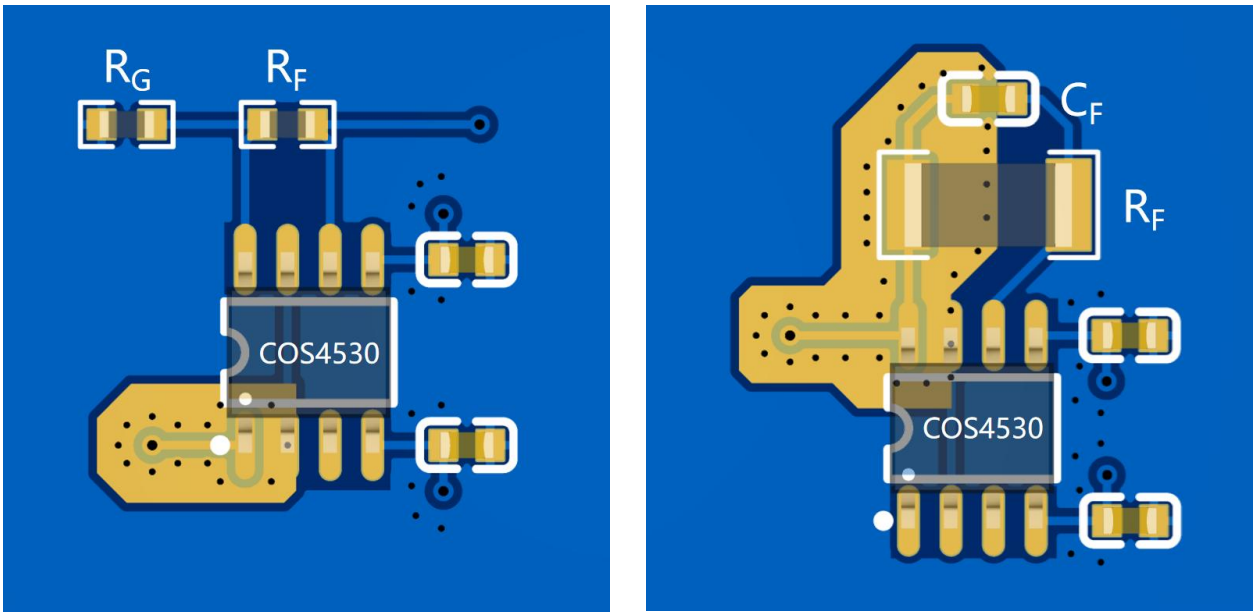
Power-Supply Bypassing and Layout

The COS4530 operates from a single +4.5V to +36V supply or dual ±2.25V to ±18V supplies. For single-supply operation, bypass the power supply +Vs with a 0.1μF ceramic capacitor which should be placed close to the +Vs pin. For dual-supply operation, both the +Vs and the -Vs supplies should be bypassed to ground with separate 0.1μF ceramic capacitors. 2.2μF tantalum capacitor can be added for better performance.

The length of the current path is directly proportional to the magnitude of parasitic inductance and thus the high frequency impedance of the path. High speed currents in an inductive ground return create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance. Thus a ground plane layer is important for high speed circuit design.

In addition to general PCB layout considerations, specific layout techniques must be implemented to achieve femtoampere-level input bias current. Every insulator, including PCB material, has a finite resistance that can become a path for current to leak into input traces and degrade input bias performance. To minimize leakage current paths, implement a guard in the PCB layout. The guard presents a low-impedance path equipotential to the input traces. Leakage current toward the high impedance input path can be diverted to the low-impedance guard path. Current flowing between the input and guard traces is negligible because both traces are at the same potential.

Surround all high-impedance input traces with copper guard traces all the way from the source to the input pins of the COS4530 (see Figure 4). For inverting configurations, extend the guard copper to the middle of the feedback components, separating the low-impedance output from the high-impedance input node. Remove all solder mask and silkscreen from the guard area to reduce surface-charge accumulation and prevent surface-level leakage paths to the input.



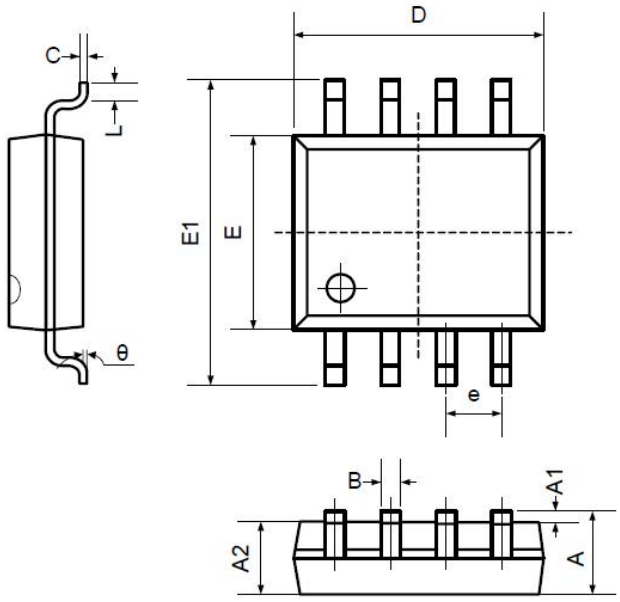
(a) (b)

Figure 4. Layout Example: (a) Noninverting Configuration, (b) Inverting Configuration

Applications requiring femtoampere-level performance are extremely sensitive to contamination. Contaminants in the form of solder flux, salts, oils, organic acids, and more can form conductive paths over printed circuit board (PCB) traces and allow small currents to leak into input traces or other sensitive nodes, severely degrading performance. Proper handling and cleaning is required to achieve femtoampere level input bias performance in a PCB featuring the COS4530.

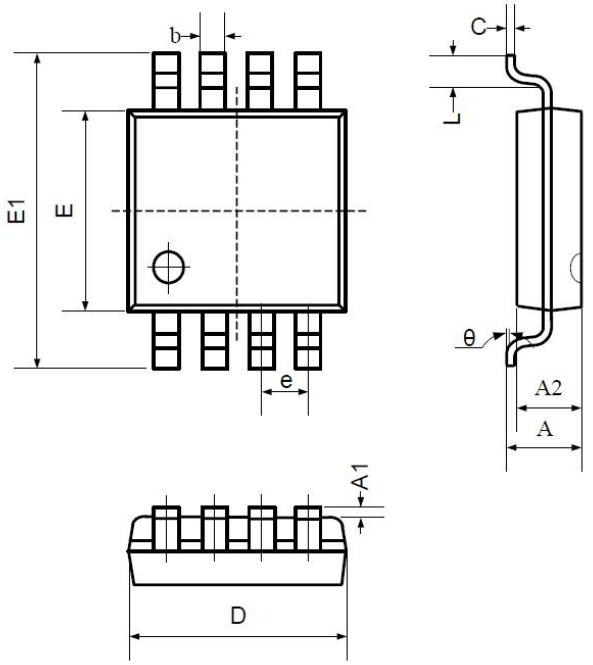
4. Package Information

4.1 SOP-8 (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	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

4.2 MSOP-8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
c	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
θ	0°	6°	0°	6°

5. Ordering Information

Channel	Model	Order Number	Package	Package Option	Marking Information
1	COS4530	COS4530-1ARZ	SOP-8	Tape and Reel, 4000	COS4530
		COS4530MR	MSOP-8	Tape and Reel, 3000	COS4530

6. Related Parts

Part Number	Description
COS6042	24kHz, 0.5μA, Nano-Power Op Amps, 1.4V to 5.5V Supply
COS8042	160MHz, 5.5mA, High Speed Op Amps, 3V to 12V Supply
COS2172	10MHz, 1.2mA, RRIO Op Amps, 4.5 to 40V Supply
COS2333	350kHz, 18μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS8552	1.5MHz, 55μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS2388	9MHz, 570μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS2227	10MHz, 1.3mA, Precision Op Amps, 4.5 to 36V Supply, Vos<50μV
COS2182	8.5MHz, 580μA, RRIO Precision Op Amps, 4.5 to 36V Supply, Vos<50μV
COS620	1.5MHz, 1.3mA, Instrumentation Amps, 4.5 to 36V Supply, Vos<50μV
COSINA333	150kHz, 65μA, Instrumentation Amps, 1.8 to 5.5V Supply, Vos<25μV