Precision

Instrumentation Amplifier

ICD620Data Sheet

feature

- Wide supply voltage range: ±2.3V~±18V
- Input offset voltage: 20μV maximum
- Input offset drift: 0.28μV/°C maximum
- Input bias current: 0.15nA maximum
- Low input voltage noise: 6.5nV/6.5nV maximum√Hz
- Equivalent input noise: 0.2μVpp (0.1Hz~10Hz) CMRR:
- 92dB (DC)/80dB (10kHz) (gain is 1) Small signal -3dB
- bandwidth: 1000kHz (gain is 1) Slew rate: 2.4V/μs
-
- Gain set by single external resistor (gain range 1~1000)
- SOP8 4.9mm × 3.9mm package

application

- Instrumentation
- Sensor Conditioning Circuit
- Data Acquisition System
- Electromagnetic flowmeter
- Medical Devices

Overview

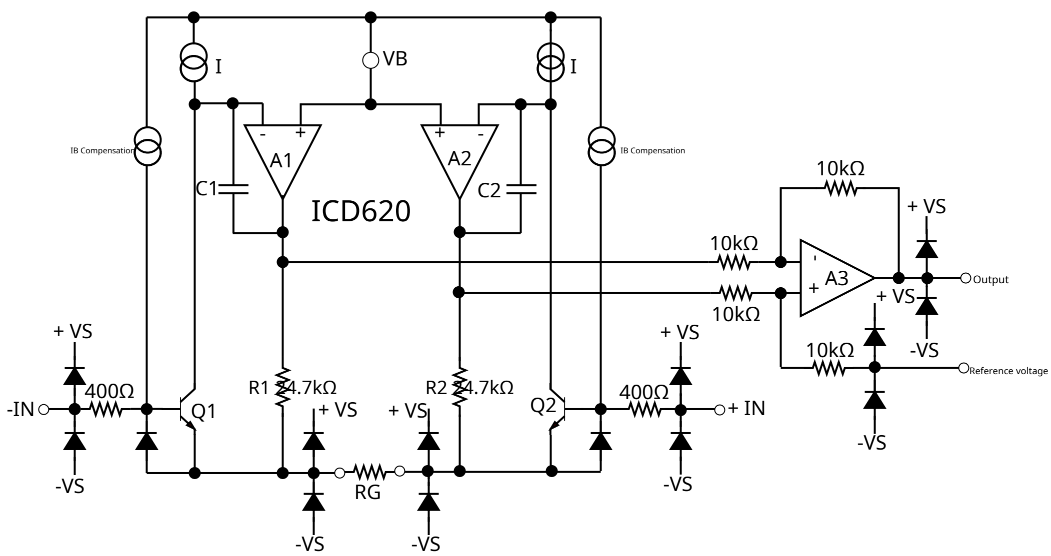
The ICD620 is a gain-programmable, high-performance instrumentation amplifier that provides the industry's highest CMRR over a wide frequency range. The CMRR of traditional instrumentation amplifier products drops at several hundred Hz, while the ICD620 can maintain a high CMRR of more than 80dB within 10kHz when the gain is 1. The excellent CMRR performance enables the ICD620 to suppress broadband interference and harmonics, greatly simplifying the filter requirements.

Low offset voltage, low offset drift, low gain drift, high gain accuracy, and high CMRR make this chip an excellent choice for applications requiring the best DC performance, such as bridge signal conditioning.

Programmable gain provides design flexibility to the user. The gain can be set from 1 to 1000 with a single resistor. The ICD620 operates in single and dual supply modes for ±10V input voltage applications.

ICD620 adopts SOP8 package, and its optimal operating temperature range is − 40°C~85°C. The chip can also work normally in the range of 85℃~125℃, with only slight performance loss.

Architecture diagram



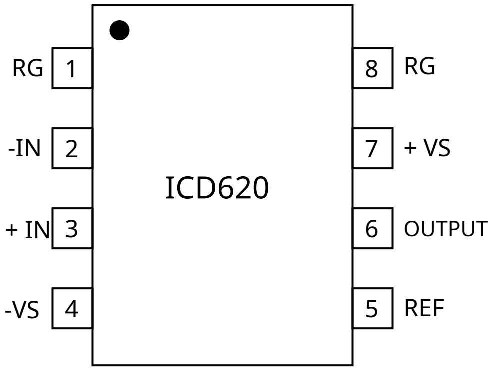
Document History

The following table lists all updates to this document since the product release.

Document Version	Revision Date	Description
V0.1	2024-09-12	Pre-release.

Pin Configuration and Function

Pin Configuration



SOP8

Pin Function

serial number	name	type	illustrate
1	RG	-	Gain Setting. Place a resistor between the RG pins to set the gain. G = 1 + (49.4 kΩ/RG).
2	-IN	AI	Inverting input terminal.
3	+ IN	AI	Non-inverting input terminal.
4	-VS	PWR	Negative power supply.
5	REF	AI	Reference voltage. Use a low resistance voltage source to drive this pin.
6	OUTPUT	AO	Voltage output.
7	+ VS	PWR	Positive power supply.
8	RG	-	Gain Setting. Place a resistor between the RG pins to set the gain. G = 1 + (49.4 kΩ/RG).

Absolute Maximum Ratings

parameter		Minimum	Maximum	unit
temperature				
Operating temperature		- 40	85	°C
Storage temperature		- 65	150	°C
Junction temperature			150	°C
Reflow	Lead-tin soldering temperature (10 seconds to 30 seconds)		240	°C
	Lead-free soldering temperature		260	°C
Pressure resistance				
Supply voltage		- 18	18	V
Power consumption				mW
Common mode input voltage		-VS	VS	V
Differential input voltage		-VS	VS	V
ESD				
HBM		4000		V
CDM		1000		V

Electrical specifications

Default test conditions: VS = ±15V, VREF = 0V, G = 1, RL= 2kΩ, TA = 25°C.

parameter	Test conditions	Minimum	Typical Value	Maximum	unit
CMRR	DC to 60Hz, G = 1, VCM = -10V~10V, input with 1kΩ source internal resistance mismatch	92			dB
	DC to 60Hz, G = 10, VCM = -10V~10V, input with 1kΩ source internal resistance mismatch	110			dB
	DC to 60Hz, G = 100, VCM = -10V~10V, input with 1kΩ source internal resistance mismatch	130			dB
	DC to 60Hz, G = 1000, VCM = -10V~10V, input with 1kΩ source internal resistance mismatch	140			dB
	10kHz, G = 1, VCM = -10V~10V	80			dB
	10kHz, G = 10, VCM = -10V~10V	100			dB
	10kHz, G = 100, VCM = -10V~10V	120			dB
	10kHz, G = 1000, VCM = -10V~10V	120			dB
Noise performance					
Input voltage noise (eNI)	1kHz, VIN+/VIN−/VREF = 0		6.3		nV/ √Hz
Output voltage noise (eNO)	1kHz		72		nV/ √Hz
Equivalent Input Noise (RTI)1	G = 1, 0.1Hz~10Hz		2.9	3.97	μVpp
	G = 10, 0.1Hz~10Hz		0.5		μVpp
	G = 100~1000, 0.1Hz~10Hz		0.16	0.2	μVpp
Current noise	1kHz			164	fA/ √Hz
	0.1Hz~10Hz			6.7	pApp
Offset voltage					
Input offset voltage (VOSI)	VS = ±5V~±15V			19	μV
	VS = ±5V~±15V, TA = -40°C~85°C			twenty two	μV
Input offset voltage temperature drift				0.28	μV/°C
Output offset voltage (VOSO)	VS = ±5V~±15V			141	μV
	VS = ±5V~±15V, TA = -40°C~85°C			0.35	μV
Output offset voltage temperature drift				2.52	μV/°C
PSRR2	G = 1, VS = ±2.3V~±18V	123	128		dB
	G = 10, VS = ±2.3V~±18V	137	140		dB
	G = 100, VS = ±2.3V~±18V	138	140		dB
	G = 1000, VS = ±2.3V~±18V	139	142		dB
Input Current					
Input bias current			0.1	0.127	nA
	TA = -40°C~85°C			0.5	nA

parameter	Test conditions	Minimum	Typical Value	Maximum	unit
Input bias current temperature drift				1.37	pA/°C
Input offset current			0.1	0.4	nA
	TA = -40°C~85°C			0.6	nA
Input offset current temperature drift			1		pA/°C
Reference Input					
Reference input resistance			20		kΩ
Reference input current	VIN+/VIN−/VREF = 0		30		μA
Reference voltage range	VIN+/VREF = 0	-VS		+ VS	V
Reference to Output Gain			1±0.0001		V/V
power supply					
Power supply operating range		±2.3		±18	V
Quiescent Current			1	1.1	mA
	TA = -40°C~85°C		1.2	1.3	mA
Dynamic performance					
Small Signal -3dB Bandwidth	G = 1		1000		kHz
	G = 10		700		kHz
	G = 100		140		kHz
	G = 1000		15		kHz
Slew rate	G = 1		2.4		V/μs
	G = 5~100		2.5		V/μs
0.01% Settling Time	10V step, G = 1~100		10		μs
	10V step, G = 1000		80		μs
0.001% Settling Time	10V step, G = 1~100		13		μs
	10V step, G = 1000		110		μs
Gain3					
Gain range		1		1000	V/V
Gain Error	G = 1, V = ±10 V		0.02		%
	G = 10, V = ±10 V			0.15	%
	G = 100, V = ±10V			0.15	%
	G = 1000, V = ±10V			0.15	%
Gain Nonlinearity	G = 1~10, VOUT = −10V~10V, R_L= 10kΩ		3		ppm
	G = 100, VOUT = −10V~10V, R_L= 10kΩ		5		ppm
	G = 1000, VOUT = −10V~10V, R_L= 10kΩ		10		ppm
	G = 1~100, VOUT = −10V~10V, R_L= 2kΩ		10		ppm
Gain temperature drift	G = 1		- 0.1		ppm/°C
	G＞1		- 1.2		ppm/°C

parameter	Test conditions	Minimum	Typical Value	Maximum	unit
enter					
Input Impedance	difference		100||2		GΩ||pF
	Common Mode		100||2		GΩ||pF
Input voltage range	VS = ±2.3V~±5V	-VS+1.5		+VS-1.1	V
	VS = ±2.3V~±5V, TA = -40°C~85°C	-VS+2		+ VS-1.2	V
	VS = ±5V~±18V	-VS+1.6		+VS-1.1	V
	VS = ±5V~±18V, TA = -40°C~85°C	-VS+2		+ VS-1.2	V
Output					
Output Swing	VS = ±2.3V~±5V, R_L= 10kΩ	-VS+1		+VS-1.1	V
	VS = ±2.3V~±5V, R_L= 10kΩ, TA = -40°C~85°C	-VS+1.4		+ VS-1.3	V
	VS = ±5V~±18V, R_L= 10kΩ	-VS+1.1		+ VS-1.3	V
	VS = ±5V~±18V, R_L= 10kΩ, TA = -40°C~85°C	-VS+1.6		+ VS-1.5	V

Note 1: RTI Noise = $\sqrt{eNI2 + (eNO/G)^2}$

Note 2: PSRR is defined as the rejection of power supply variation by equivalent input offset voltage. Equivalent input offset voltage = VOSI + VOSO/G

Note 3: G = 1 + 49.4kΩ/RG

Typical features

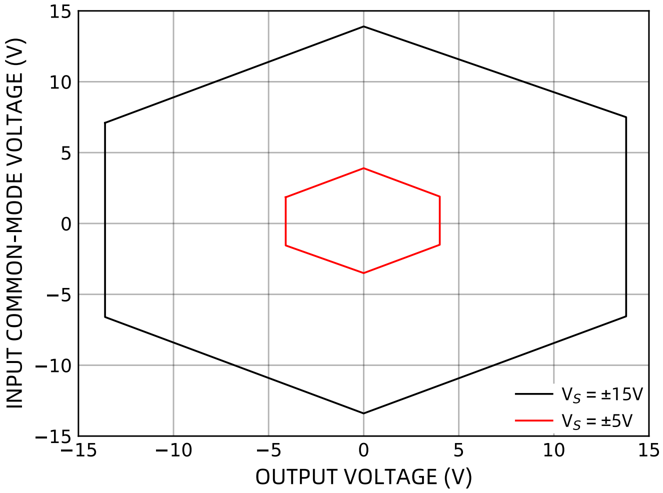


Figure 1 Input common-mode range versus output voltage (G = 1)

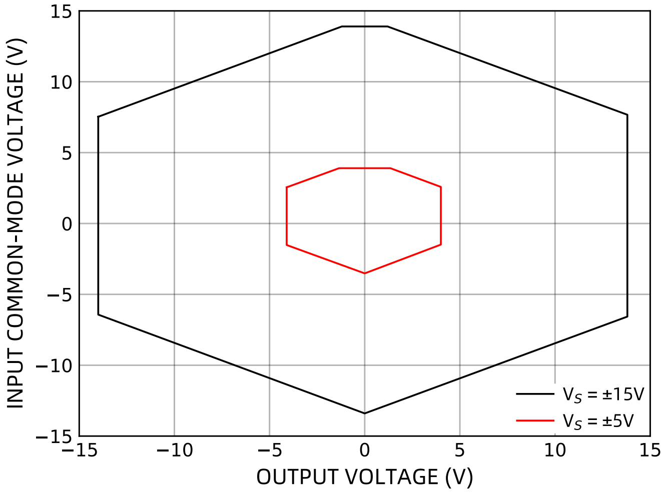


Figure 2 Input common-mode range versus output voltage (G = 100)

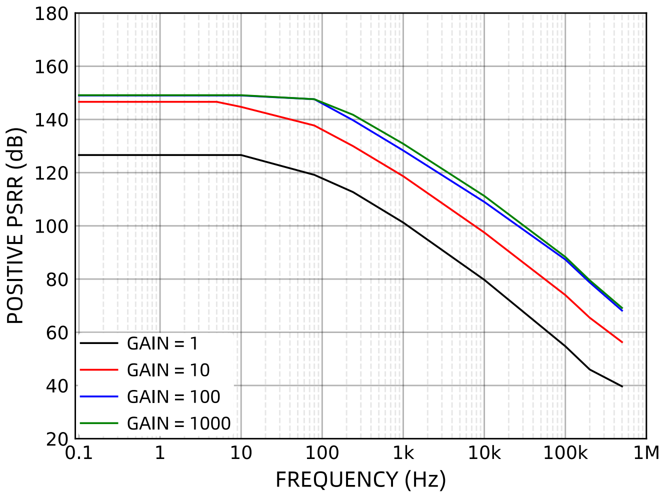


Figure 3 Positive power supply PSRR (G = 1~1000)

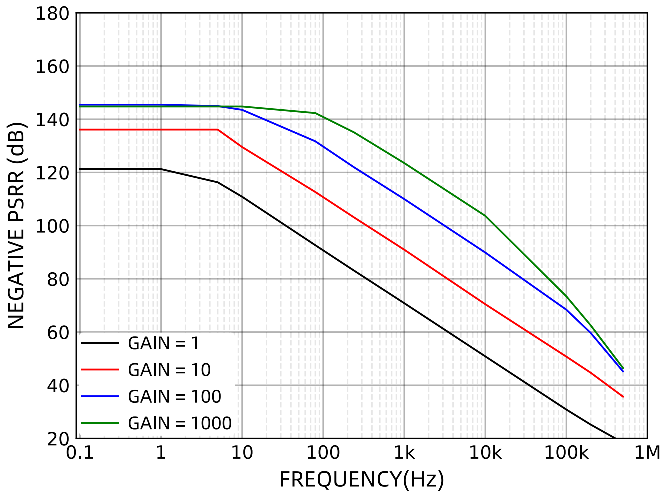


Figure 4 Negative power supply PSRR (G = 1~1000)

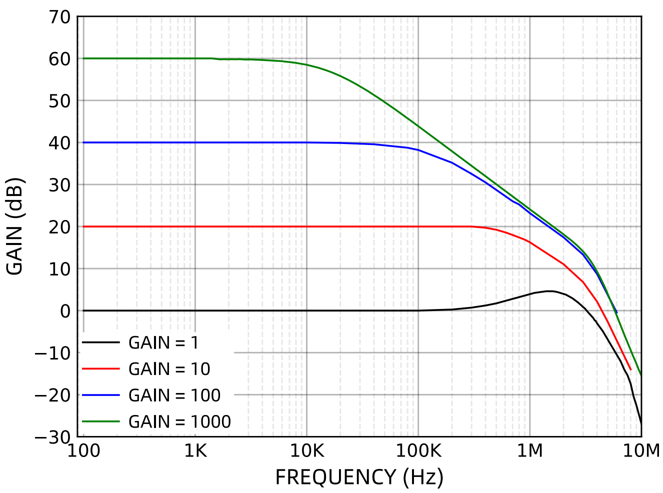


Figure 5 Gain (G = 1~1000)

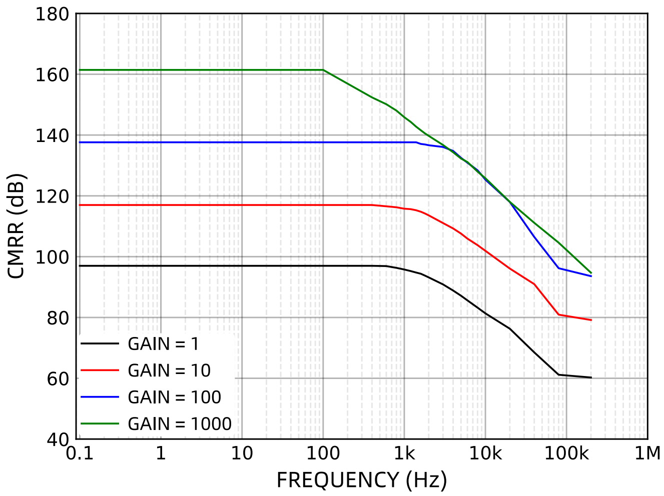


Figure 6 CMRR (G = 1~1000)

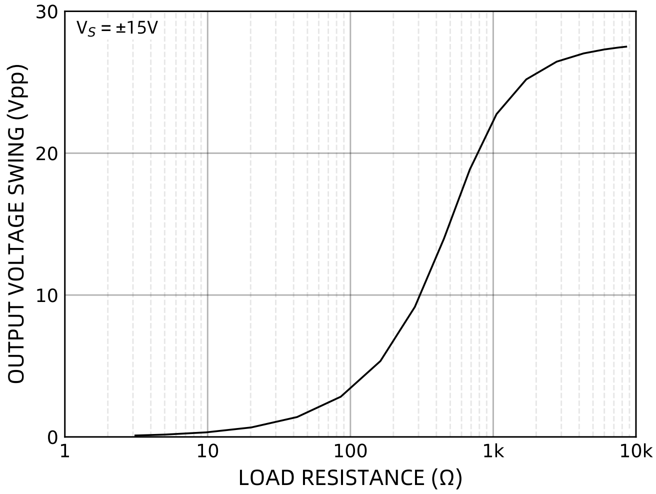


Figure 7 Output voltage swing versus load resistance (G = 1)

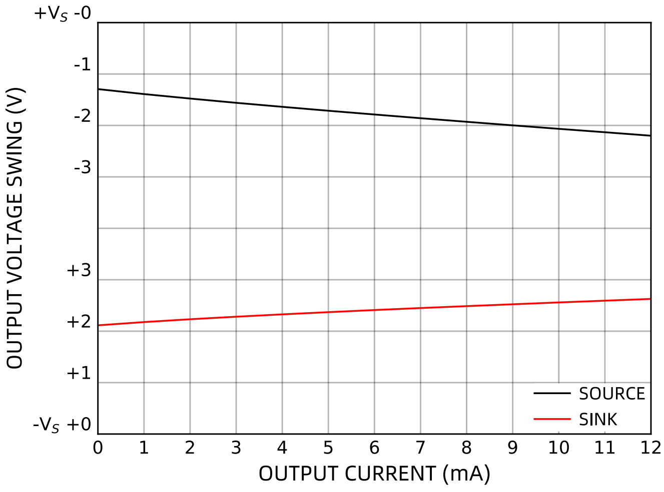


Figure 8 Output voltage swing versus output current (G = 1)

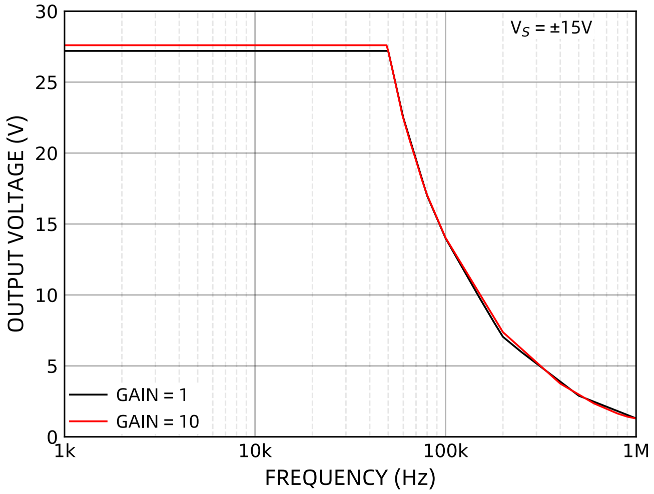


Figure 9 Large signal frequency response (G = 1~10)

How it works

The ICD620 is an instrumentation amplifier based on a classic three-op-amp topology. The input transistors Q1 and Q2 are biased with fixed currents, so any differential input signal forces a corresponding change in the output voltage of A1 and A2. The signal at the input generates a current through RG, R1, and R2, which generates a corresponding voltage at the output of A1 and A2. From a topological perspective, Q1, A1, R1 and Q2, A2, R2 can be considered as precision current feedback amplifiers. The amplified differential and common-mode signals are applied to the differential amplifier, which suppresses the common-mode voltage but amplifies the differential voltage. The differential amplifier uses innovative technology to achieve low output offset voltage and low output offset voltage drift. Laser-trimmed resistors ensure that the ICD620 has a gain error of less than 20ppm and a CMRR of greater than 90dB (G = 1). The user can easily and accurately set the gain using a single standard resistor.

ICD620 adopts high-precision base current compensation scheme to provide extremely high input impedance, Low I_B, low I_BDrift, Low I_{OS}, low input bias current noise and extremely low voltage noise of 6.3nV/$\sqrt{Hz}$.

The transfer function of ICD620 is:

$$G = 1 + \frac{49.4k\Omega}{RG}$$

Because the input amplifier uses a current feedback architecture, the gain-bandwidth product of the ICD620 increases with gain, so the system suffers less bandwidth loss at higher gains than a voltage feedback architecture.

The ICD620 maintains accuracy even at low input levels, providing performance to meet the most demanding applications.

The unique pinout enables the ICD620 to meet CMRR specifications of 80dB at 10kHz (G = 1) and 120dB at 1kHz (G = 1000).Pin ConfigurationThe symmetrical pinout shown reduces parasitic effects that have historically adversely affected CMRR performance. In addition, this arrangement simplifies board layout, with the gain setting resistor pins close to the inputs and the REF pin close to the output.

Place a resistor across the RG pin to set the gain of the ICD620.Table 1 The gain is calculated using the following formula:

$$RG = \frac{49.4k\Omega}{G-1}$$

Table 1. Gain calculated using 1% precision resistors

RG 1% Standard table value (Ω)	Expected gain/gain setting
49.9k	1.99
12.4k	4.984
5.49k	9.998
2.61k	19.93
1k	50.4
499	100
249	199.4
100	495
49.9	991

When no gain resistor is used, the ICD620 defaults to G = 1. Gain accuracy is determined by the absolute tolerance of RG. Temperature drift of the external gain resistor increases the gain drift of the instrumentation amplifier. When no gain resistor is used, gain error and gain drift are kept to a minimum.

Reference voltage

The REF pin of the ICD620 is used to set the reference level of the output, which is very useful when the output signal needs to be biased to a precise mid-supply level. For example, a voltage source can be connected to the REF pin, and the level-converted output can be directly connected to the ADC. The allowable reference voltage range is a function of the gain, input, and supply voltages. The REF pin voltage should not exceed +VS or –VS by more than 0.5V.

For best performance, the source impedance driving the REF pin should be kept low because parasitic resistance affects CMRR and gain accuracy.

Power Supply Conditioning and Filtering

The instrumentation amplifier should be powered with a stable DC voltage. Noise on the supply pins can adversely affect performance. Bypass capacitors should be used to decouple the amplifier.

A 0.1μF capacitor should be placed near each power pin.Fig.10As shown, a 10μF tantalum capacitor can be used further away from the ICD620. In most cases, this tantalum capacitor can be shared with other precision integrated circuits.

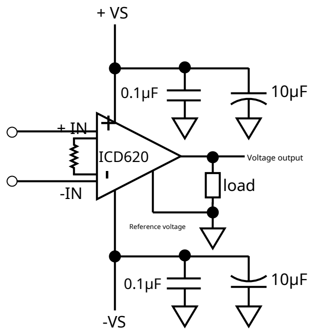


Figure 10 Power supply coupling, reference voltage and output to ground

layout

Careful PCB layout can maximize system performance and keep the ICD620 high CMRR over the entire frequency range. The trace from the gain setting resistor to the RG pin should be as short as possible to minimize parasitic inductance. To ensure the most accurate output, the trace from the REF pin should be connected to the local ground of the ICD620, or to a voltage referenced to the local ground of the ICD620.

Common Mode Rejection

One benefit of the ICD620's high CMRR over the entire frequency range is that it is more immune to interference such as line noise and related harmonics. Typically, typical instrumentation amplifiers have a drop in CMRR at 200Hz, and common-mode filters are often used to compensate for this shortcoming. The ICD620 is able to suppress CMRR over a wider frequency range, reducing the need for filtering.

The input source impedance and capacitance should be accurately matched. In addition, the source resistance and source capacitance should be as close to the input as possible.

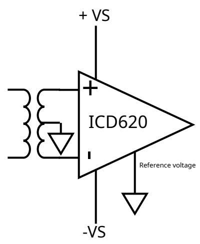
Grounding

The absolute value of the output voltage of ICD620 depends on the voltage of REF pin, so special attention should be paid to the grounding of the reference voltage on REF pin.

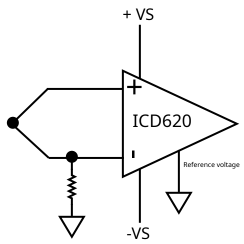
In a mixed signal environment, low-level analog signals need to be isolated from the noisy digital environment. Many ADCs have separate analog and digital ground pins. Although it is convenient to connect both grounds to a separate ground plane, currents flowing through the grounds and the PCB board can cause hundreds of millivolts of error. Therefore, separate analog and digital ground returns should be used to minimize current flowing from sensitive points to the system ground.

Input Bias Current Return Path

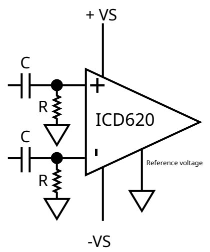
The input bias current of the ICD620 must have a return path to the common terminal. When a source such as a thermocouple cannot provide a return current path, a return current path should be created, such asFig.11As shown:



transformer



Thermocouple



Capacitive coupling

Figure 11 Creating IBIASpath

Radio Frequency Interference

When the amplifier is used in applications with strong RF signals, it is common to encounter the problem of RF signal rectification and small DC offset voltage. A low-pass RC network can be added to the input of the ICD620 to filter out high-frequency signals, such asFig.12shown.

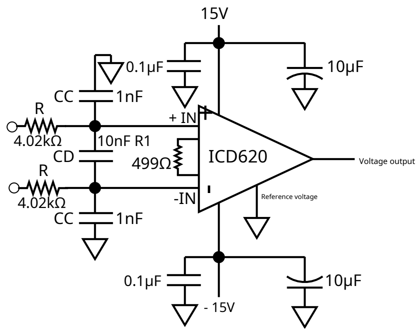


Figure 12 RFI suppression

Determine the signal bandwidth according to the following formula:

$$\text{Differential signal bandwidth} = \frac{1}{2\pi R(2Cd + Cc)}$$

$$\text{Common mode signal bandwidth} = \frac{1}{2\pi RCc}$$

Where Cd ⩾ 10Cc. Cd affects the differential signal and Cc affects the common-mode signal. The values of R and Cc should be chosen to minimize RFI. Mismatch between R×Cc at the noninverting input and R×Cc at the inverting input degrades CMRR. By using a Cd value that is an order of magnitude larger than Cc, the effect of the mismatch can be reduced, thereby improving performance.

Input protection

All pins of ICD620 provide 1000V HBM protection. In addition, a 400Ω current limiting resistor is connected in series with each of the two input terminals.

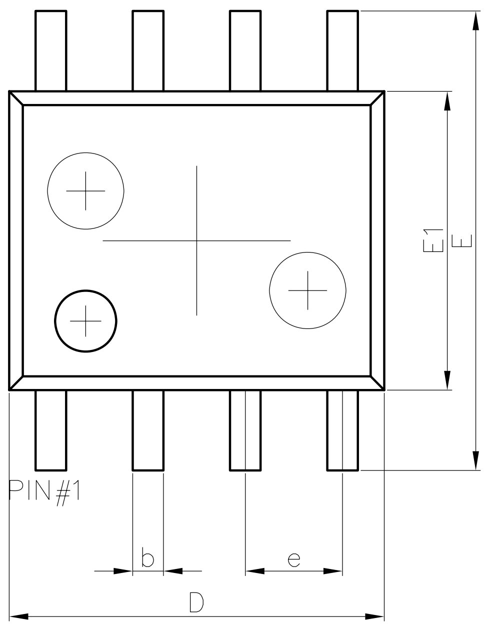
+VS or lower than the negative power supply -VS, large current will flow directly to the power rail through the ESD diode. Therefore, in this scenario, an external resistor needs to be connected in series at the input to limit the current. The input current during overvoltage is I = VIN/REXT, and a suitable external resistor value REXT needs to be selected to ensure that the input current is within the safe value of 6mA.

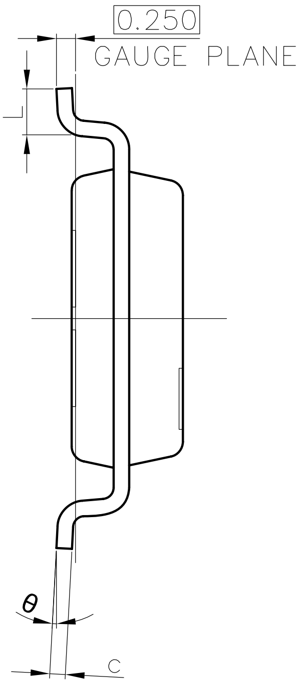
Packaging and Ordering Information

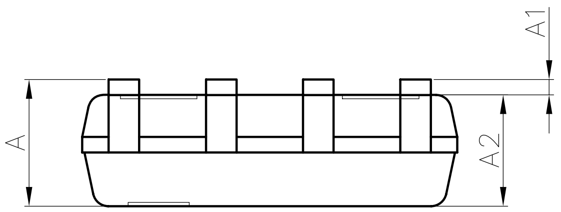
Package

ICD620 adopts SOP8 package.

Product appearance







Logo	Dimensions (mm)		
	Minimum	Typical Value	Maximum
A	1.45	1.60	1.75
A1	0.10	0.18	0.25
A2	1.35	1.45	1.55
b	0.33	0.42	0.51
c	0.17	0.21	0.25
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27 (BSC)		
L	0.40	0.84	1.27
θ	0°	4°	8°

Ordering Information

model	Temperature range	Encapsulation	Package	Packing quantity
ICD620	- 40℃~85℃	SOP8	Reel	4000