CMOS Input, RRIO, Low Power, Wide Supply Range, 4.5 MHz Operational Amplifier

Features

- AEC-Q100 qualified:
  - Device ambient temperature: -40°C ≤ T_A ≤ 125°C
  - Device junction temperature: -40°C ≤ T_J ≤ 150°C
- Wide supply range:
  - 2.7 V to 12 V or ±1.35 V to ±6 V
- Rail-to-rail input and output
- Low offset voltage: ±75 µV (typ)
- Supply current (no load): 620 µA
- Low bias current: typical 1 pA at V_{CC} = 3.3 V
- Input voltage noise: 21 nV/√Hz at 1 kHz
- Gain-bandwidth product: 4.5 MHz
- Slew rate: 3 V/µs at V_{CC} = 10 V
- Output short protection

Applications

- Automotive brake systems
- Electric power steering (EPS)
- Battery-powered products
- High-gain amplifiers
- Instrumentation amplifiers
- Active filters
- High-impedance sensor interfaces

Package Information

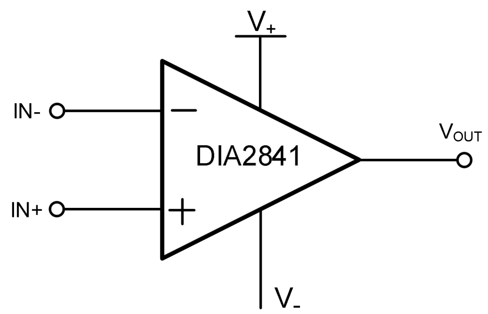
Part Number	Package	Body Size
DIA2841	SC70-5	2.07 mm × 1.26 mm

Description

The DIA2841 is a low voltage, low offset, low power operational amplifier that operates with supply voltage ranging from 2.7 V to 12 V or ±1.35 V to ±6 V and has rail-to-rail input and output capability. The low offset of the device makes it a good choice for instrumentation. The low bias current and CMOS inputs make this product ideal for high-impedance sensor interface and battery-powered applications.

The DIA2841 is available in a space-saving, ultra-small package, SC70-5. The small package provides the perfect solution for space-constrained PCBs and portable products. It is specified over ambient temperature range from -40°C to 125°C, which make it a perfect solution for automotive applications.

Simplified Schematic



Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T_A	Package	
DIA2841SC5	WHDA	1	Green	-40 to 125°C	SC70-5	Tape & Reel, 3000

If you encounter any issue in the process of using the device, please contact our customer service at marketing@dioo.com or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at docs@dioo.com. Your feedback is invaluable for us to provide a better user experience.

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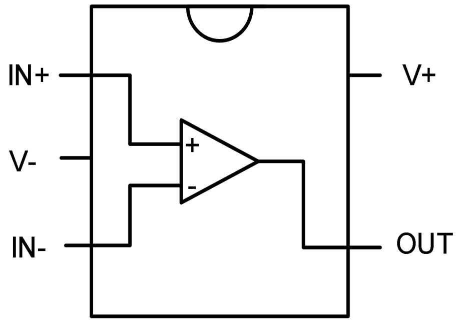
1. Pin Assignment and Functions



SC70-5 (Top view)

Pin Name	I/O	Description
IN+	I	Non-inverting input
IN-	I	Inverting input
OUT	O	Output
V+	P	Positive supply
V-	P	Negative supply

2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Min	Max	Unit
$V_{IN\text{-}DIFF}$	V_{IN} differential	-300	300	mV
V_{CC}	Supply voltage [(V+) - (V-)]		13.2	V
V_I, V_O	Voltage at input and output pins	(V+) + 0.1	(V-) - 0.1	V
I_{IN}	Input current	-10	10	mA
T_J	Junction temperature		150	°C
T_{STG}	Storage temperature	-65	150	°C

3. Recommended Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{CC}	Supply voltage [(V+) - (V-)]	2.7 to 12 or ±1.35 V to ±6 V	V
T_A	Operating free-air temperature	-40 to 125	°C

4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

Model	Metric	Value	Unit
HBM	ANSI/ESDA/JEDEC JS-001	±2500	V
CDM	ANSI/ESDA/JEDEC JS-002	±2000	V

5. Thermal Considerations

The thermal resistance determines the heat insulation property of a material. The higher the thermal resistance is, the lower the heat loss. Accumulation of heat energy degrades the performance of semiconductor components.

Symbol	Parameter	Value	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	270	°C/W

6. Electrical Characteristics

The values are obtained under these conditions unless otherwise specified: T_A = 25°C, V- = 0 V, V_{CM} = V+ / 2, and R_L > 10 MΩ ~ V+ / 2.

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
At V+ = 3.3 V, unless otherwise noted.							
V_{OS}	Input offset voltage			-400	±75	400	μV
		T_A = -40 to 125°C		-600		600	
$V_{OS}/\Delta T$	Input offset voltage drift	T_A = -40 to 125°C			1		μV/°C
I_B	Input bias current				1		pA
CMRR	Common-mode rejection ratio	0 V ≤ V_{CM} ≤ 3.3 V			108		dB
PSRR	Power supply rejection ratio	2.7 V ≤ V+ ≤ 12 V, V_O = V+ / 2			110		dB
CMVR	Input common-mode voltage range	CMRR ≥ 50 dB		-0.1		3.4	V
A_{VOL}[(1)]	Large signal voltage gain	R_L = 2 kΩ, V_O = 0.3 V to 3 V		120	140		dB
			T_A = -40 to 125°C	91			
		R_L = 10 kΩ, V_O = 0.2 V to 3.1 V		120	140		
			T_A = -40 to 125°C	104			
V_O	Output swing high, (measured from V+)	R_L = 2 kΩ to V+ / 2			12		mV
		R_L = 10 kΩ to V+ / 2			5		
	Output swing low, (measured from V-)	R_L = 2 kΩ to V+ / 2			34		
		R_L = 10 kΩ to V+ / 2			7		
I_O	Output short-circuit current	Sourcing V_O = V+ / 2, V_{IN} = 100 mV			28		mA
		Sinking V_O = V+ / 2, V_{IN} = -100 mV			35		
I_{CC}	Supply current				0.62		mA

SR	Slew rate	A_V = 1, V_O = 2.3 V_{PP} 10% to 90%			2.3		V/µs
GBW	Gain bandwidth product				4.5		MHz
e_n	Input-referred voltage noise	f = 1 kHz			21		nV√Hz
THD+N	Total harmonic distortion + noise	f = 1 kHz , A_V = 1, R_L = 10 kΩ			90		dB
C_{IN}	Input capacitance				6		pF
At V+ = 5 V, unless otherwise noted.							
V_{OS}	Input offset voltage			-400	±75	400	µV
		T_A = -40 to 125°C		-600		600	
$V_{OS}/\Delta T$	Input offset voltage drift	T_A = -40 to 125°C			1		µV/°C
I_B	Input bias current				1		pA
CMRR	Common-mode rejection ratio	0 V ≤ V_{CM} ≤ 3.3 V			108		dB
PSRR	Power supply rejection ratio	2.7 V ≤ V+ ≤ 12 V	V_O = V+ / 2		110		dB
CMVR	Input common-mode voltage range	CMRR ≥ 50 dB		-0.1		3.4	V
A_{VOL}(1)	Large signal voltage gain	R_L = 2 kΩ, V_O = 0.3 V to 3 V		120	140		dB
			T_A = -40 to 125°C	91			
		R_L = 10 kΩ, V_O = 0.2 V to 3.1 V		120	140		
			T_A = -40 to 125°C	104			
V_O	Output swing high, (measured from V+)	R_L = 2 kΩ to V+ / 2			20		mV
		R_L = 10 kΩ to V+ / 2			8		
	Output swing low, (measured from V-)	R_L = 2 kΩ to V+ / 2			53		
		R_L = 10 kΩ to V+ / 2			12		
I_O	Output short-circuit current	Sourcing V_O = V+ / 2, V_{IN} = 100 mV			28		mA
		Sinking V_O = V+ / 2, V_{IN} = -100 mV			33		
I_{CC}	Supply current				0.62		mA
SR	Slew rate	A_V = 1, V_O = 2.3 V_{PP} 10% to 90%			2.7		V/µs
GBW	Gain bandwidth product				4.5		MHz
e_n	Input-referred voltage noise	f = 1 kHz			21		nV√Hz
THD+N	Total harmonic distortion + noise	f = 1 kHz , A_V = 1, R_L = 10 kΩ			95		dB
C_{IN}	Input capacitance				6		pF

At V+ = +5 V, V- = -5 V, V_{CM} = 0 V, and R_L > 10 MΩ ~ V_{CM}, unless otherwise noted.							
V_{OS}	Input offset voltage			-400	±75	400	μV
		T_A = -40 to 125°C		-600		600	
$V_{OS}/\Delta T$	Input offset voltage drift	T_A = -40 to 125°C			1		μV/°C
I_B	Input bias current				3		pA
CMRR	Common-mode rejection ratio	0 V ≤ V_{CM} ≤ 3.3 V			108		dB
PSRR	Power supply rejection ratio	2.7 V ≤ V+ ≤ 12 V	V_O = V+ / 2		110		dB
CMVR	Input common-mode voltage range	CMRR ≥ 50 dB		-0.1		3.4	V
A_{VOL} (1)	Large signal voltage gain	R_L = 2 kΩ, V_O = 0.3 V to 3 V		120	140		dB
			T_A = -40 to 125°C	91			
		R_L = 10 kΩ, V_O = 0.2 V to 3.1 V		120	140		
			T_A = -40 to 125°C	104			
V_O	Output swing high, (measured from V+)	R_L = 2 kΩ to V+ / 2			50		mV
		R_L = 10 kΩ to V+ / 2			8		
	Output swing low, (measured from V-)	R_L = 2 kΩ to V+ / 2			104		
		R_L = 10 kΩ to V+ / 2			23		
I_O	Output short-circuit current	Sourcing V_O = V+ / 2, V_{IN} = 100 mV			25		mA
		Sinking V_O = V+ / 2, V_{IN} = -100 mV			30		
I_{CC}	Supply current				0.62		mA
SR	Slew rate	A_V = 1, V_O = 2.3 V_{PP} 10% to 90%			3		V/μs
GBW	Gain bandwidth product				4.5		MHz
e_n	Input-referred voltage noise	f = 1 kHz			21		nV√Hz
THD+N	Total harmonic distortion + noise	f = 1 kHz , A_V = 1, R_L = 10 kΩ			108		dB
C_{IN}	Input capacitance				6		pF

Note:

(1) Guaranteed by design.

(2) Specifications subject to change without notice.

7. Typical Characteristics

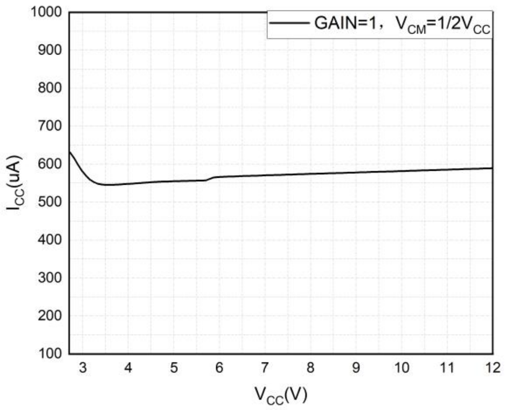


Figure 1. I_{CC} vs. V_{CC}

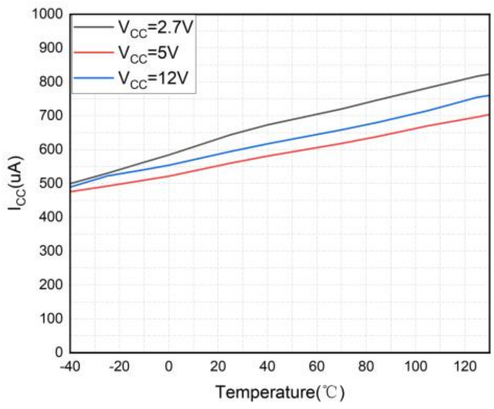


Figure 2. I_{CC} vs. Temperature

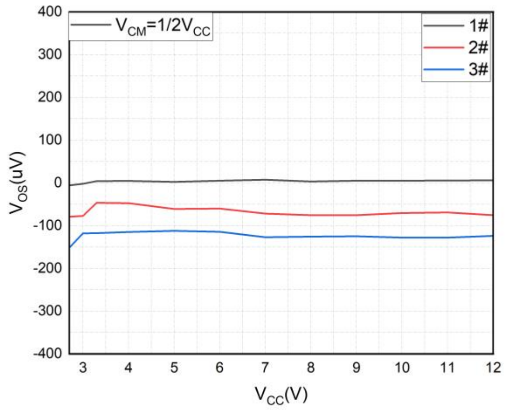


Figure 3. V_{OS} vs. V_{CC}

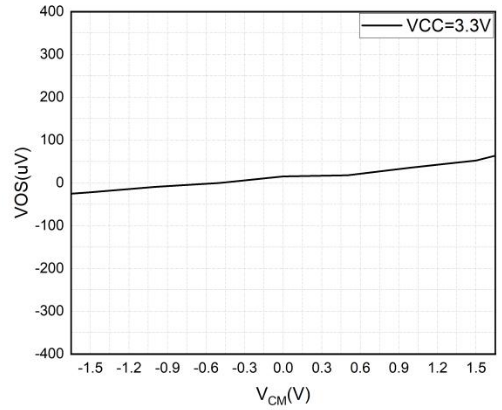
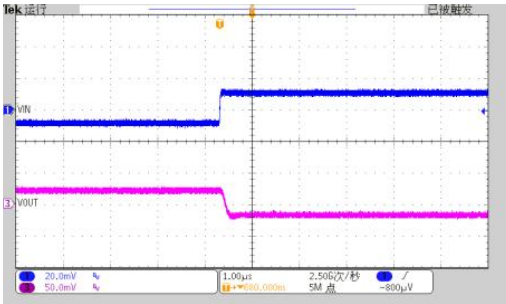


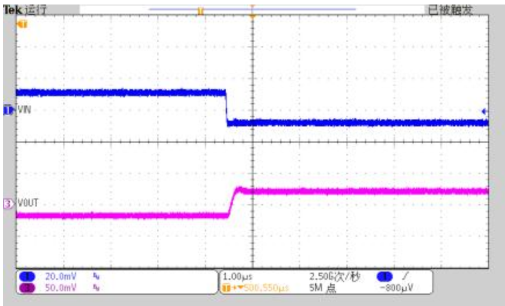
Figure 4. V_{OS} vs. V_{CM}



V+ = 1.65 V, V- = -1.65 V, G = -2, V_{IN} = 20 mVpp at 1 kHz,

C_L = 47 μF

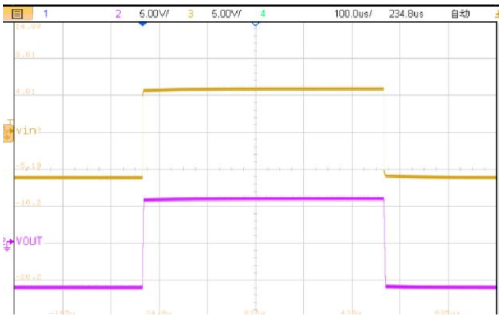
Figure 5. Small-signal response up



V+ = 1.65 V, V- = -1.65 V, G = -2, V_{IN} = 20 mVpp at 1 kHz,

C_L = 47 μF

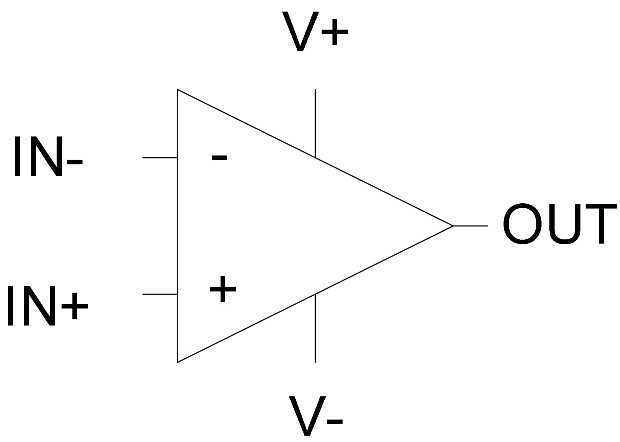
Figure 6. Small-signal response down



V+ = 6 V, V- = -6 V, G = 1, R_L = 1 MΩ, V_{IN} = 12Vpp at 1 kHz, V_{bias} = 0 V

Figure 7. Large-signal response

8. Block Diagram



9. Function Description

9.1. Input protection

The DIA2841 incorporates a clamp circuit between the two input pins, IN+ and IN-, implemented by a set of anti-parallel-connected diodes D1 / D2 in series with resistors R1 and R2, as shown in Figure 8. This clamping circuit is used to protect the input stage of the amplifier.

When the voltage differential between the two input pins IN+ and IN- is greater than approximately 0.7 V, the diodes D1 and D2 are turned on and the clamping circuit starts operating. The greater the voltage differential, the greater the current in the clamp circuit, which may damage the internal clamp diode. Therefore, the application needs to be limited to ±300 mV of input differential signal, or less than ±10 mA of input current.

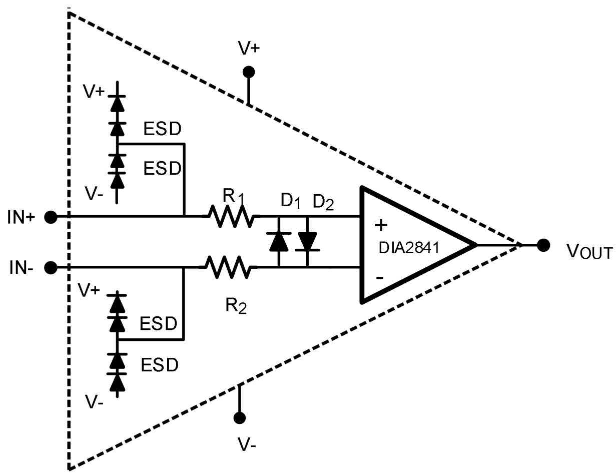


Figure 8. Input protection

9.2. Input stage

The DIA2841 supports the rail-to-rail common-mode input range. The input stage internally contains a PMOS input pair and an NMOS input pair. When the input common-mode voltage is close to the negative rail, only the PMOS input pair conducts, and when the input common-mode voltage is close to the positive rail, only the NMOS input pair conducts. Both PMOS and NMOS input pairs are active when the common-mode voltage transits from [(V+) - 2 V] to [(V+) - 1 V] transition region. As the common-mode voltage increases, the PMOS input pair is gradually taken over by the NMOS input pair.

In this transition region, the input reference offset voltage gradually transitions from being dominated by the PMOS input pair to being dominated by the NMOS input pair. However, the internal common-mode conversion offset circuitry ensures an input offset voltage of less than 0.4 mV at room temperature over the entire rail-to-rail input range. The CMRR of the op-amp in the transition region is significantly improved with a small offset voltage.

10. Application Information

Important notice: Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.

10.1. Driving capacitive load

The DIA2841 supports non-inverting unity-gain amplifier applications. The loop is stable at unity gain, and the DIA2841 can directly drive capacitive loads up to 100 pF without causing any stability issues. To drive larger capacitive loads, use an isolation resistor (R_{ISO}), as shown in Figure 9. By using this isolation resistor, the capacitive load will be isolated from the output of the amplifier, weakening the pole in the feedback loop introduced by C_L. The larger the value of R_{ISO}, the more stable the output voltage. However, a larger R_{ISO} value reduces output swing and output current drive capability.

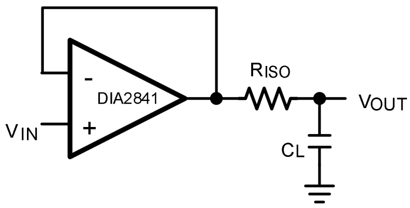


Figure 9. Isolating capacitive load

10.2. High-impedance sensor amplifier

The DIA2841 is a CMOS input operational amplifier. The input pin is connected to the MOS gate of the input pair. Because the gate is insulated, the leakage I_B is very small at a picoampere level, making the device especially suitable for a high-impedance sensor interface. However, many sensors have source impedance that can be as high as 10 MΩ. A normal amplifier has a high input bias current, I_B, that flows into the sensor source impedance, creating a voltage drop across the source resistor, as shown in Figure 10. The DIA2841 has a low input bias current, making it ideal for high-impedance sensors.

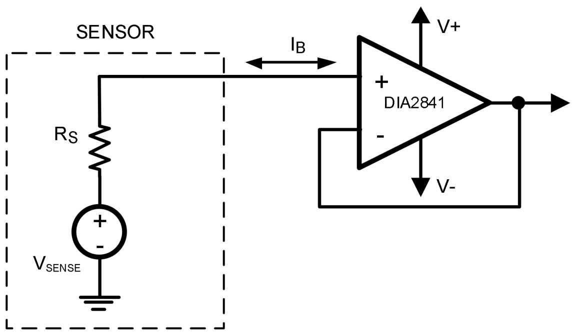


Figure 10. High-impedance sensor interface

10.3. Low-pass active filter

The circuit in Figure 11. is a design example of the active low-pass filter. The DC gain is equal to $-R_2 / R_1$ and the -3 dB corner frequency is equal to $1/2\pi R_2 C$. In this design, the filter bandwidth must be less than the bandwidth of the amplifier. The resistor values must be selected as low as possible to reduce ringing or oscillation generated by the parasitic parameters in the PCB layout.

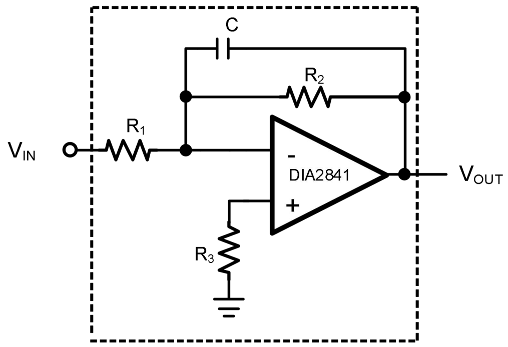


Figure 11. Low-bypass active filter

10.4. High-side current detection circuit

Suppose to measure a current between 0 A and 2 A by using a 100 mΩ sense resistor and convert the current to an output voltage of 0 V to 5 V. A current of 2 A flows through the load and the sense resistor, creating a voltage of 200 mV across the sense resistor. The op-amp amplifies the 200 mV input voltage to produce a corresponding output voltage.

To measure the load current, connect a sense resistor in series with the load, as shown in Figure 12. The current flowing through the sense resistor creates a voltage drop, which is amplified by an operational amplifier. The rail-to-rail input and low V_{OS} make the DIA2841 an ideal amplifier for high-side current sensing applications.

The relation between the input and output of the circuit is shown in Equation (1):

$$V_{OUT} = R_F/R_G \times V_{SENSE} \quad (1)$$

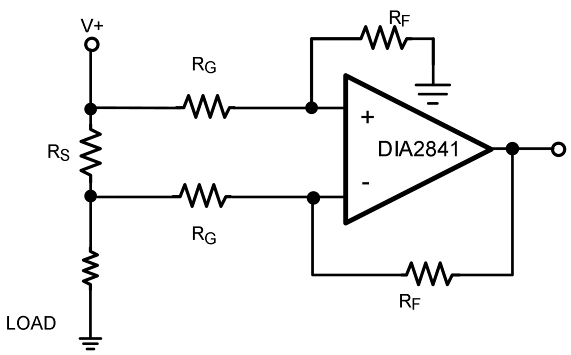


Figure 12. High-voltage current detection circuit

10.5. Interfacing to the thermocouple sensor

A thermocouple senses a temperature and convert it into a voltage. The DIA2841 amplifies this signal. The ADC converts the amplified signal to a digital signal, which then enters the MCU for further processing.

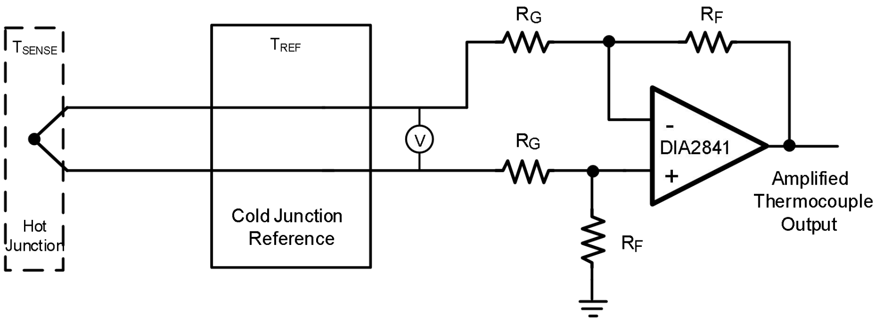
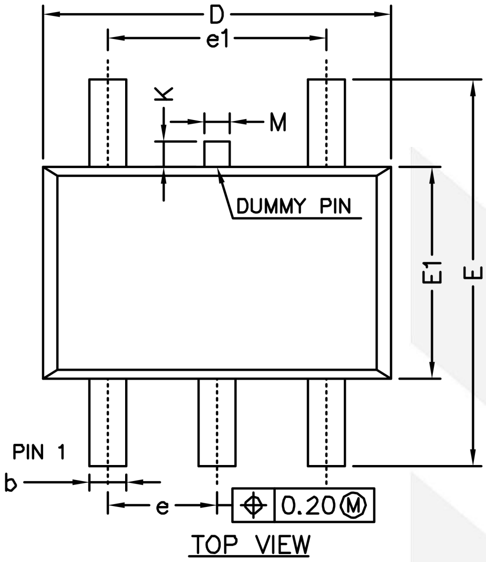
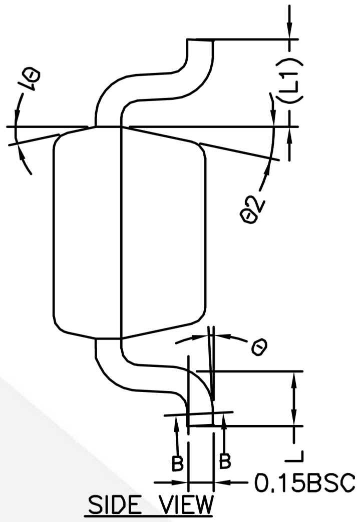
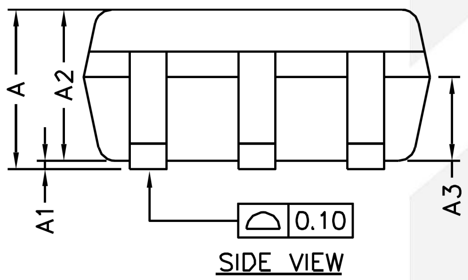


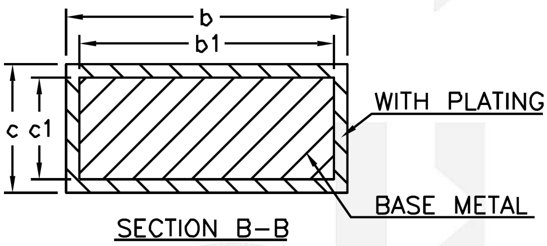
Figure 13. Thermocouple sensor interface

11. Physical Dimension: SC70-5









Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.80	-	1.10
A1	0	-	0.10
A2	0.80	0.90	1.00
A3	0.40	0.50	0.60
b	0.17	-	0.30
b1	0.17	0.22	0.25
c	0.12	-	0.20
c1	0.12	0.15	0.16
D	2.02	2.07	2.12
E	2.20	2.30	2.40
E1	1.21	1.26	1.31
e	0.60	0.65	0.70
e1	1.20	1.30	1.40
L	0.26	0.33	0.46
L1	0.52 REF		
M	0.10	0.15	0.20
K	0	-	0.20
θ	0°	-	8°
θ1	10°	12°	14°
θ2	10°	12°	14°

Disclaimer

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