Voltage Output, High or Low-Side Measurement, Bi-Directional Zero-Drift Series Current Shunt Monitor

Features

- Supply voltage: 3 V to 40 V
- Common-mode voltage: -0.1 V to 75 V
- Low quiescent current: 450 μA (typ)
- High accuracy:
  - Low offset voltage of ±0.1 mV (max)
  - ±0.8% max total output error
- Gain: 50 V/V
- High slew rate: 3 V/μs
- -3 dB bandwidth: 100 kHz
- Operating temperature: -40°C to 125°C

Applications

- Electric power steering (EPS) systems
- Body control modules
- Brake systems
- Electronic stability control (ESC) systems

Package Information

Part Number	Package	Body Size
DIO2213	DFN-6	2 mm × 2 mm
	SOIC-8	4.9 mm × 3.9 mm

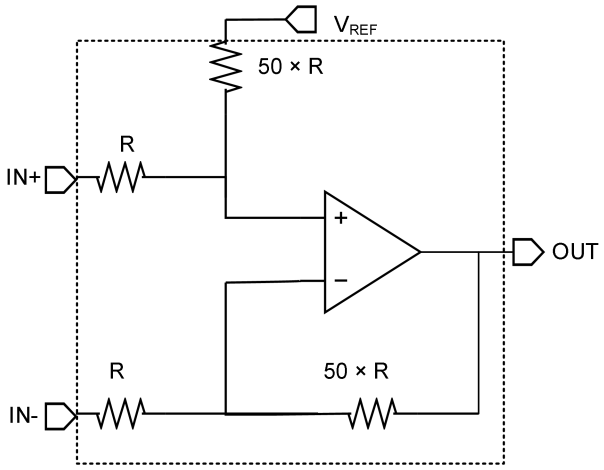
Description

The DIO2213 is a high-side current-sense amplifier with voltage output and can sense drops across shunts at common-mode voltage from -0.1 V to 75 V. The gain is 50 V/V, with the according bandwidths of 100 kHz.

The DIO2213 has a maximum offset voltage of only ±0.1 mV. The DIO2213 total output error is as low as 0.8% over temperature, which greatly improves the accuracy and simplifies the design of system.

The DIO2213 operates from single 3 V to 40 V supply under -40°C to 125°C, with a maximum supply current of 620 μA.

Simplified Schematic



Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T_A	Package	
DIO2213CD6	BB1C	3	Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIO2213CS8	DIOBB1C	3	Green	-40 to 125°C	SOIC-8	Tape & Reel, 2500

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

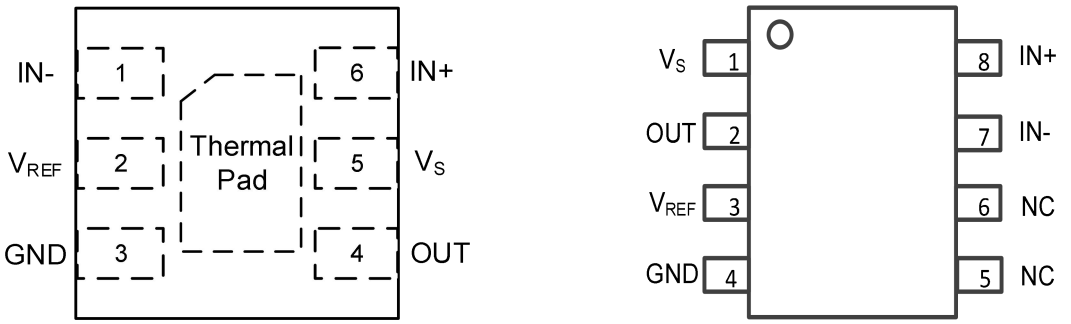


Figure 1. Top view

Name	I/O	Description
IN-	Input	Negative input. Connect to shunt low side
V_{REF}	Input	Reference voltage
GND	-	Ground
OUT	Output	Output voltage of the amplifier
V_S	-	Power supply
IN+	Input	Positive input. Connect to shunt high side
Thermal pad	-	Recommend to connect to the GND plane for improved thermal performance.
NC	-	Not connected

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		Rating	Unit
V_S	Supply voltage		3 to 44	V
V_{IN+}, V_{IN-}	Current-shunt monitor analog inputs	Differential (V_{IN+} ~ V_{IN-})	-18 to 18	V
		Common mode (1)	GND - 0.3 to 80	
	Analog output (1)		GND - 0.3 to (V_S) + 0.3	V
	Input current into any pin (1)		5	mA
T_A	Ambient temperature		-40 to 125	°C
T_J	Junction temperature		150	°C
T_{STG}	Storage temperature		-65 to 150	°C

Note:

(1) This voltage may exceed the ratings shown if the current at that pin is limited to 5 mA.

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_{CM}	Common-mode input voltage	-0.1 to 75	V
V_S	Supply voltage	3 to 40	V
T_A	Ambient 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	Standard	Value	Unit
Human-body model	ANSI/ESDA/JEDEC JS-001	±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
		SOIC-8	DFN2*2-6	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	130	TBD	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	50	TBD	°C/W

6. Electrical Characteristics

The values are obtained under these conditions unless otherwise specified: The values are obtained under these conditions unless otherwise specified: T_A = 25°C, V_S = 12 V, V_{CM} = 12 V, V_{SENSE} = 100 mV.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input						
V_{SENSE}	Sense input voltage in full-scale	$V_{SENSE} = V_{IN+} - V_{IN-}$		0.15	$(V_S-0.25)/G$	V
V_{CM}	Common-mode input range	T_A = -40°C to 125°C	-0.1		75	V
CMR	Common-mode rejection	V_{IN+} = 0 to 80 V	80	100		dB
V_{OS}	Offset voltage, RTI	T_A = 25°C		±20	±50	μV
		T_A = -40°C to 125°C			±100	μV
dV_{OS}/dT	Offset voltage, RTI, versus temperature	T_A = -40°C to 125°C		0.3		μV/°C
PSR	Offset voltage, RTI, versus power supply	V_{OUT} = 2 V, V_{IN+} = 18 V, 2.7 V, T_A = -40°C to 125°C		±20		μV/V
I_B	Input bias current, V_{IN-} pin	T_A = -40°C to 125°C		±220		μA
Output (V_{SENSE} ≥ 20 mV)						
G	Gain			50		V/V

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
	Total output error (1)	V_{SENSE} = 120 mV, V_S = 16 V, T_A = -40°C to 125°C		±0.4	±0.8	%
C_{LOAD}	Maximum capacitive load	No sustained oscillation		0.5		nF
Voltage output						
	Output swing to the positive rail(3)	V_{IN-} = 11 V, V_{IN+} = 12 V, T_A = –40°C to 125°C		V_S - 0.12	V_S - 0.25	V
	Output swing to GND (2)	V_{IN-} = 0 V, V_{IN+} = -0.5 V, T_A = –40°C to 125°C		6	50	mV
Frequency response						
BW	Bandwidth	C_{LOAD} = 5 pF		100		kHz
	Phase margin (2)	C_{LOAD} = 500 pF		40		Degrees
SR	Slew rate			3		V/μs
	Settling time (1%)	V_{SENSE} = 10 mV_{PP} to 100 mV_{PP}, C_{LOAD} = 5 pF		35		μs
Noise, RTI						
	Voltage noise density (2)			70		nV/$\sqrt{\text{Hz}}$
Power supply						
I_Q	Quiescent current	V_{OUT} = 2 V, no load		450	620	μA

Note:

(1) Total output error includes effects of gain error, V_{OS} and non-linearity error.

(2) Guaranteed by design.

(3) Specifications subject to change without notice.

7. Typical Characteristics

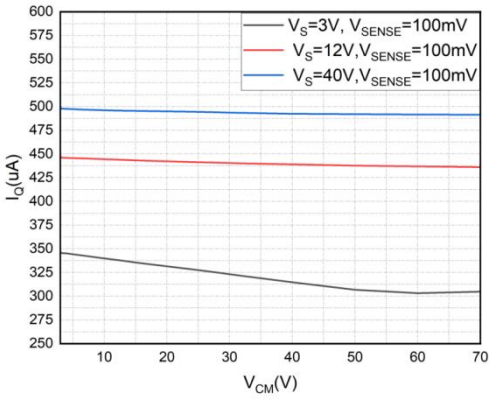


Figure 2. I_Q vs. V_{CM}

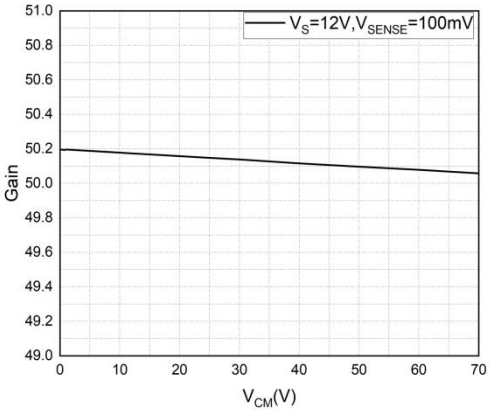


Figure 3. Gain vs. V_{CM}

8. 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.

The DIO2213 can detect overcurrent conditions and monitor current in an application through easy configuration. Designers can use the device alone to detect the overcurrent of a single threshold or pair it with other devices and circuitry to build more complex monitoring functional blocks.

8.1. Device functional mode

The DIO2213 has a single functional mode and its function is guaranteed even when V_S exceeds 3 V. Note that the common-mode voltage must be between -0.1 V and 75 V. The maximum V_S is 40 V.

8.2. Basic connections

To minimize the resistance in series with the shunt resistance, connect V_{IN+} and V_{IN-} as close as possible to the shunt resistor. Power-supply bypass capacitors can increase stability. To reject power supply noise in applications with noisy or high-impedance power supplies, add decoupling capacitors. Connect bypass capacitors close to the device pins (See Figure 4).

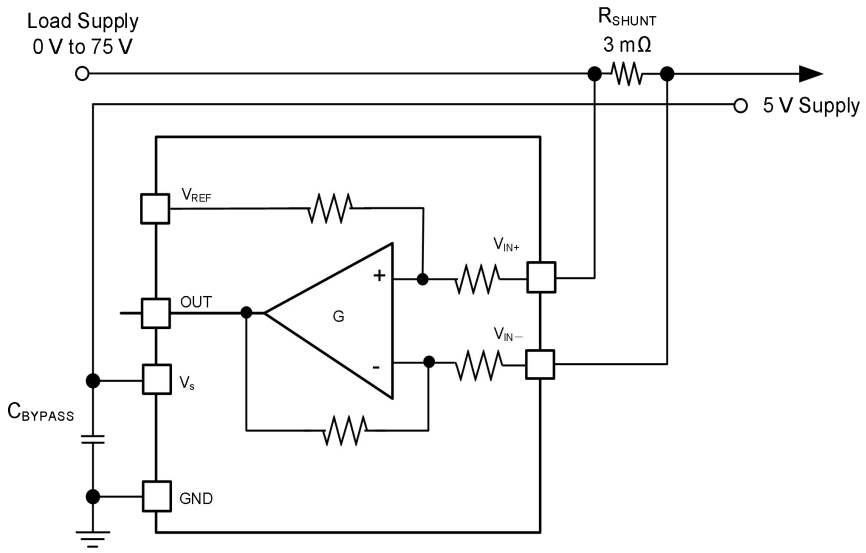


Figure 4. DIO2213 basic connections

8.3. Choosing shunt resistor

The value for the shunt resistor or R_{SHUNT} varies from application to application. The higher the R_{SHUNT} value is, the smaller the offset effects are. Likewise, the lower the value is, the smaller the supply voltage loss is. Users should find a balance between maximum permissible voltage loss and the accuracy of small input signals. Normally, R_{SHUNT} with a range of 50 mV to 100 mV can help the application achieve the best performance.

8.4. Input filtering

One possible location for filtering is at the output of the DIO2213 series, in which case the output impedance of the internal buffer increases. Adding a filter at the input pins of the DIO2213 series is a better option although the input impedance makes the input filtering more complicated as shown in Figure 5. To minimize the initial shift in gain and effects of tolerance, use the lowest resistor values. Equation (1) tells the effect on initial gain.

$$\text{Gain Error \%} = 100 - (100 \times \frac{5\text{k}\Omega}{5\text{k}\Omega + R_{FILTER}}) \quad (1)$$

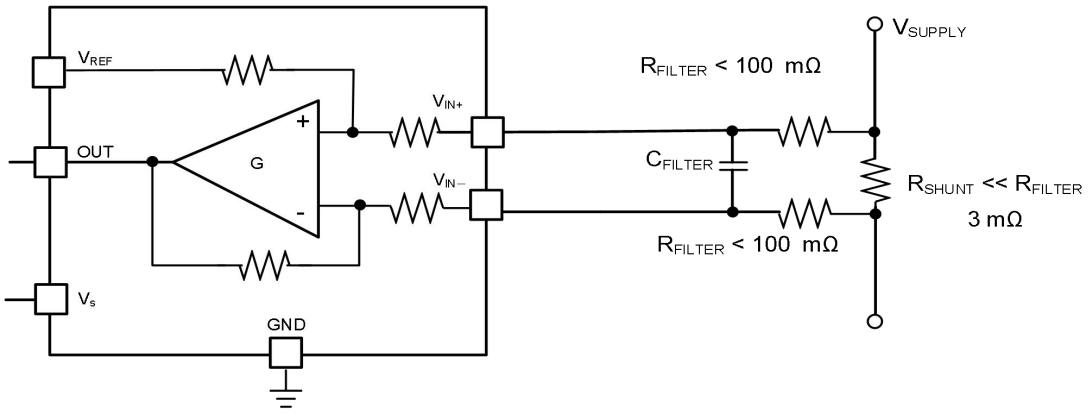


Figure 5. Input filter

Calculate the total effect on gain error by substituting the 5 kΩ term with 5 kΩ - 30% or 5 kΩ + 30%. Put the tolerance extremes of R_{FILTER} into equation (1). For instance, two resistors of 100 Ω 1% near the input pins, making a gain error of 1.96%. The worst case approach is using an internal 5 kΩ resistor and R_{FILTER} + 3%, which will offer an error gain larger than the normal value.

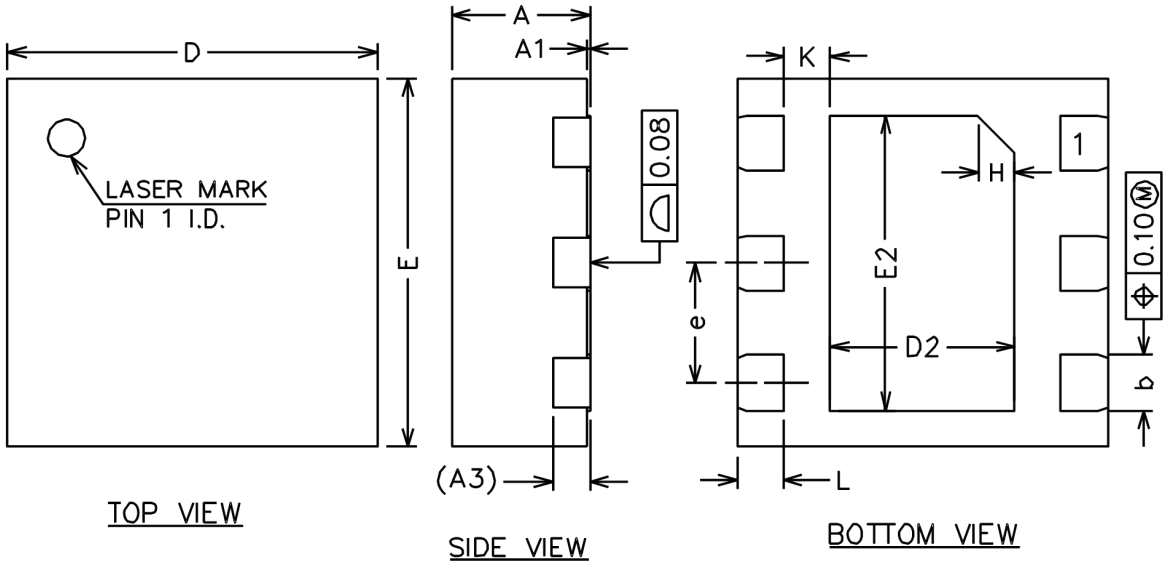
The specified accuracy of the DIO2213 is another important factor to consider apart from these tolerances. Geometric-mean and root-sum-square mean are another two recommended ways to calculate the variations of accuracy.

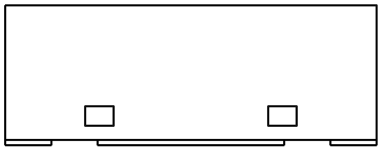
9. Layout

Use four wire connection, also known as Kelvin connection, to connect the input pins and the sensing resistor together so as to ensure only the current sensing resistance is detected. Inappropriate layout often results in additional resistance between the input pins, causing erroneous measuring. Locate the power-supply bypass capacitor, 0.1 μF recommended, as close as possible to the V_S and GND pins. Use an additional decoupling capacitor to lessen the impacts of noisy or high-impedance power supplies.

10. Physical Dimensions

10.1. DFN2*2-6

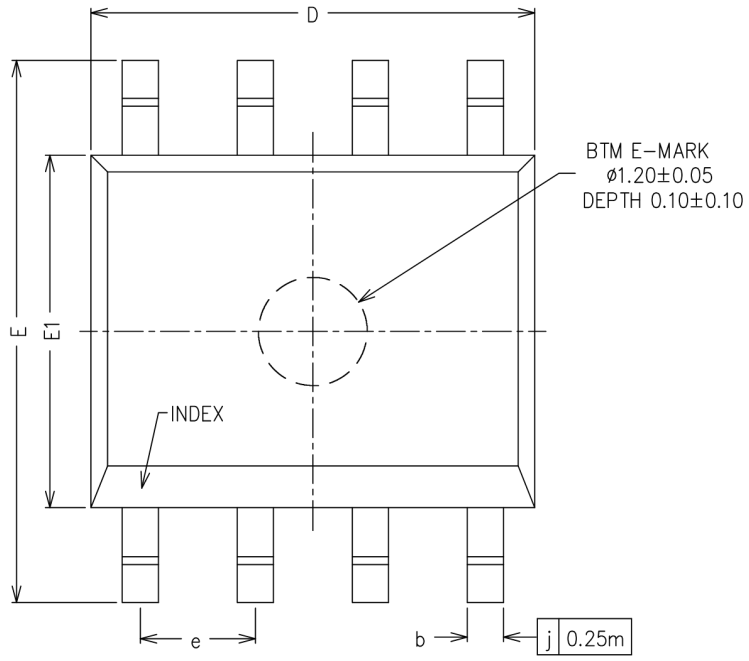


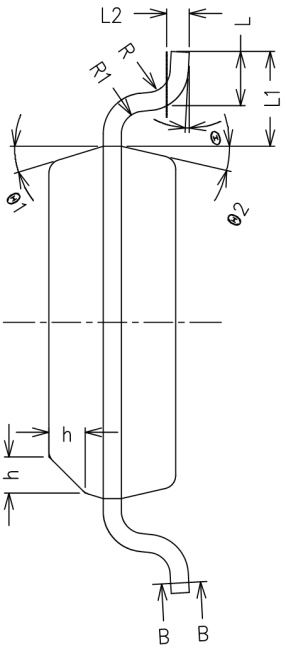


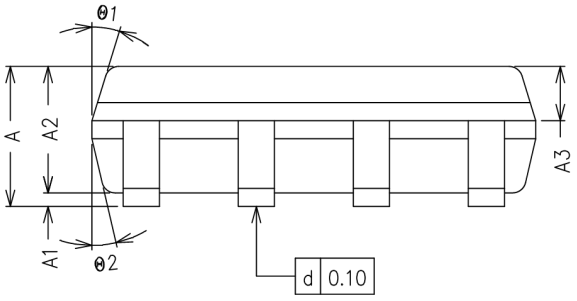
SIDE VIEW

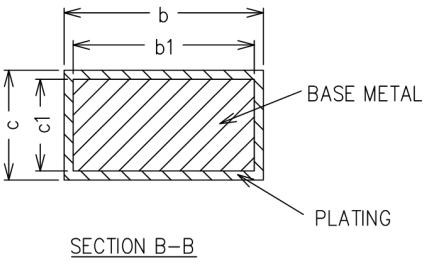
Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.20 REF	
b	0.25	0.30	0.35
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	0.90	1.00	1.10
E2	1.50	1.60	1.70
e	0.55	0.65	0.75
K	0.15	0.25	0.35
L	0.20	0.25	0.30
H		0.20 REF	

10.2. SOIC-8









SECTION B–B

Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	1.35	1.55	1.75
A1	0.10	-	0.25
A2	1.30	1.40	1.50
A3	0.50	0.60	0.70
b	0.38	-	0.47
b1	0.37	0.40	0.43
c	0.17	-	0.25
c1	0.17	0.20	0.23
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.17	1.27	1.37
L	0.45	0.60	0.80
L1	1.04 REF		
L2	0.25 BSC		
R	0.07	-	-
R1	0.07	-	-
h	0.30	0.40	0.50
θ	0°	-	8°
θ1	15°	17°	19°
θ2	11°	13°	15°

Disclaimer

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