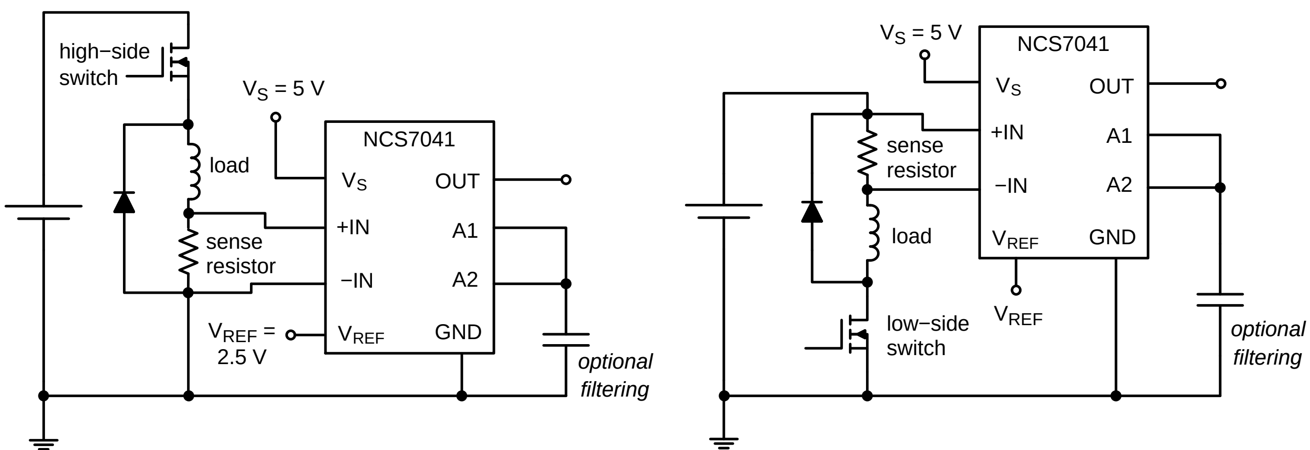
Figure 1. Simplified Representative Block Diagram



Low−Side Current Sensing *High−Side Current Sensing*

Figure 2. Application Schematics

ABSOLUTE MAXIMUM RATINGS

Symbol	Rating	Value	Unit
V_S	Input Voltage Range (Note 1)	−0.3 to 7	V
V_{REF}	Reference Pin Voltage	−0.3 to (V_S + 0.3)	V
V_{CM}			

TYPICAL CHARACTERISTICS

At T_A = 25°C, V

TYPICAL CHARACTERISTICS

At T_A = 25°C, V_S = 5 V, V_{CM} = 12 V, V_{REF} = 2.5 V, R

TYPICAL CHARACTERISTICS

At T_A = 25°C, V_S = 5 V, V_{CM} = 12 V, V_{REF} = 2.5 V, R_L = 10 kΩ, unless otherwise noted

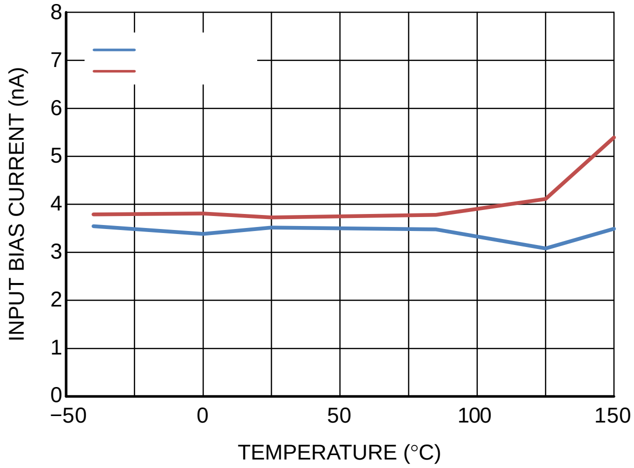


Figure 17. Buffer, Input Bias Current vs. Temperature

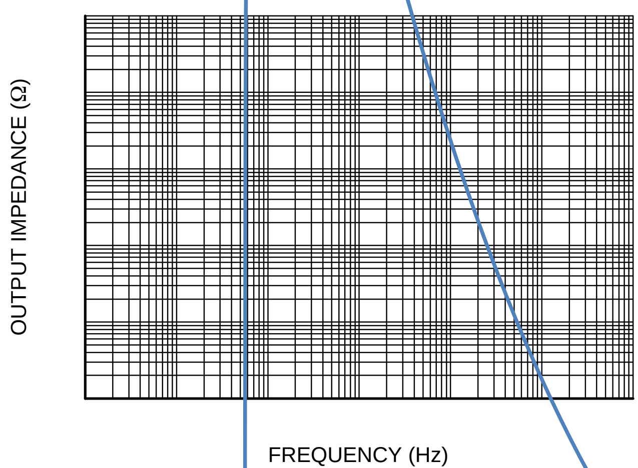


Figure 18. Buffer Output Impedance vs. Frequency

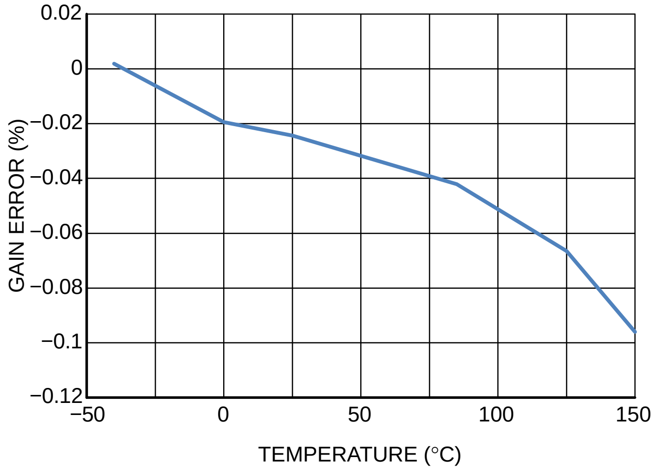


Figure 19. Total Gain Error vs. Temperature

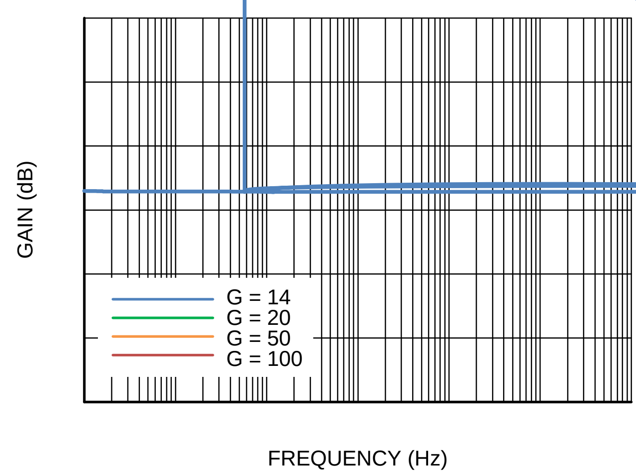


Figure 20. Gain vs. Frequency

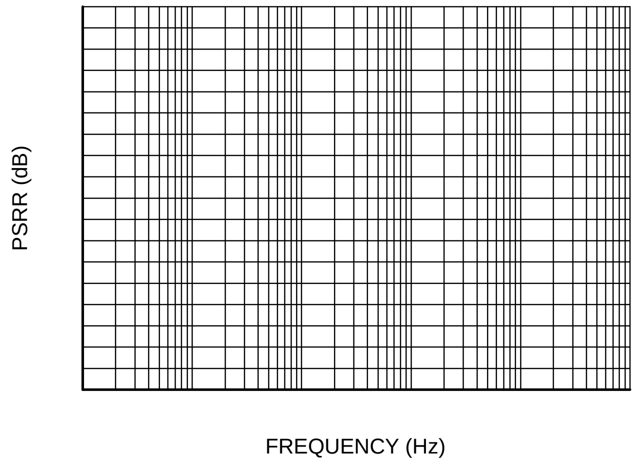


Figure 21. PSRR vs. Frequency

APPLICATION INFORMATION

The NCS7041 and NCV7041 are current sense amplifiers featuring a wide common mode voltage up to 80 V independent of the supply voltage. The NCS7041 series current sense amplifiers can be configured for both low side and high side current sensing.

Current Sensing Techniques

Low side sensing gives the impression of having the advantage of being straightforward to implement with a simple op amp circuit. However, a current sense amplifier such as NCS7041 provides the full differential input necessary to get accurate shunt connections, while also providing a built in gain network with precision difficult to obtain with external resistors. The NCS7041 is shown in a low side configuration in Figure 27 below.

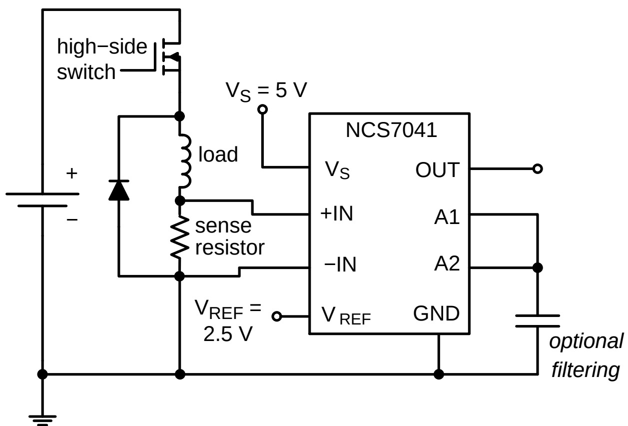


Figure 27. Low side Current Sensing

Although certain applications require low side sensing, only high side sensing can detect a short from the positive supply line to ground. Furthermore, high side sensing avoids adding resistance to the groundnala battery is being charged or discharged. Bidirectional operation requires the output to swing both positive and negative around a bias voltage applied to the V_{REF} pin. The voltage applied to the V_{REF} pin depends on the application. However, most often it is biased to either half of the supply voltage or to half the value of the measurement system reference.

Figure 29 shows bidirectional operation with two different circuit choices that can be connected to the V_{REF} pin to provide a voltage reference to the NCS7041. The V_{REF} pin must always be connected to a low i.8851 Tmtion with two

Increasing the Gain with A1 and A2

The gain can be increased by adding an external resistor in positive feedback as shown in Figure 31.

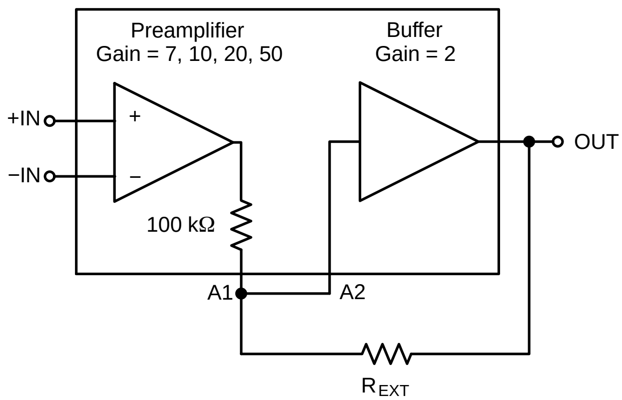


Figure 31. Increasing the Gain Using an External Resistor in Positive Feedback

$$G_{ADJ} = \frac{G \times R_{EXT}}{R_{EXT} - 100\ k\Omega} \qquad \text{(eq. 4)}$$

Filtering with A1 and A2

In some applications, the current being measured may be inherently noisy. A low pass filter can be created by connecting A1 and A2 together and adding a capacitor from the net to GND as shown in Figure 32. This creates a simple RC filter with the internal 100 kΩ resistor. This single pole filter has a 20 dB/decade attenuation.

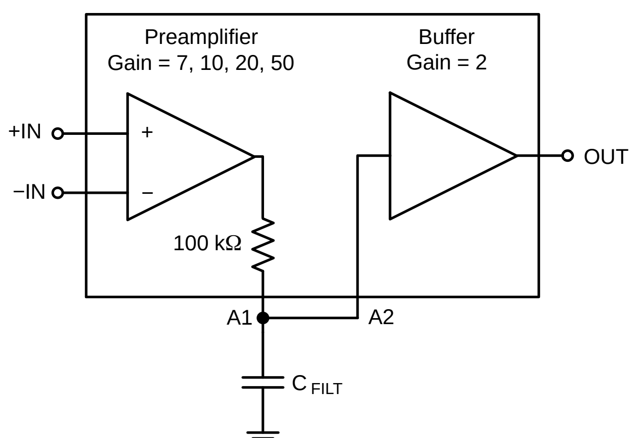


Figure 32. Implementing a Single-pole, Low-pass RC Filter

$$f_{FILT} = \frac{1}{2\pi (100\ k\Omega)\ C_{FILT}} \qquad \text{(eq. 5)}$$

A two-pole filter with 40 dB/decade attenuation can be created with a Sallen-Key topology as shown in Figure 33.

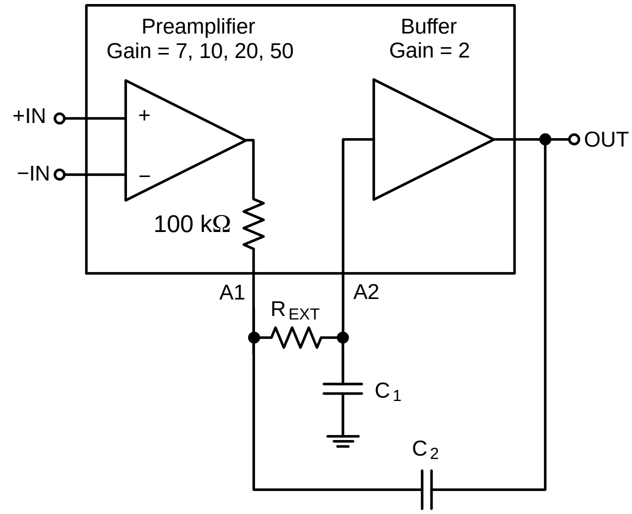


Figure 33. Implementing a Two-pole, Low-pass Filter Using the Sallen-Key Topology

Input Filtering

Some applications may require filtering at the input of the current sense amplifier. Figure 34 shows the recommended schematic for input filtering. Possible reasons for adding input filtering include the elimination of noise before it enters the current sense signal path or counteracting shunt inductance effects.

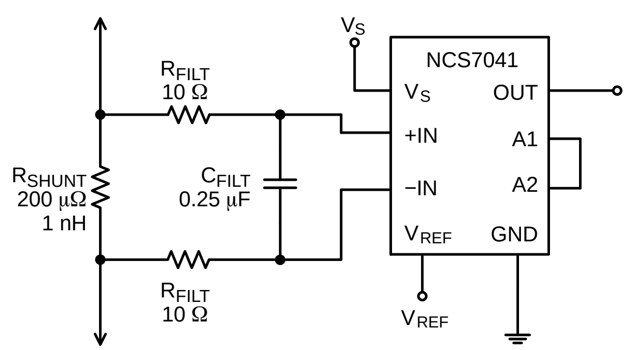


Figure 34. Input Filtering Compensates for Shunt Inductance on Shunts Less than 1 mΩ, as Well as High Frequency Noise in Any Application

Input filtering is complicated by the fact that the added resistance of the filter resistors and the associated resistance mismatch between them can adversely affect gain, CMRR, and V_{OS}. The effect on V_{OS} is partly due to input bias currents as well. As a result, the value of the input resistors should be limited to 10 Ω or less.

As the shunt resistors decrease in value, shunt inductance can significantly affect frequency response. At values below 1 mΩ, the shunt inductance causes a zero in the transfer function that often results in corner frequencies in the low 100's of kHz. This inductance increases the amplitude of high frequency spike transient events on the current sensing line that can overload the front end of any shunt current sensing IC. This problem must be solved by filtering at the input of the amplifier. Note that all current sensing IC's are vulnerable to this problem, regardless of manufacturer claims. Filtering is required at the input of the device to resolve this problem, even if the spike frequencies are above the rated bandwidth of the device.

Ideally, select the capacitor to exactly match the time constant of the shunt resistor and its inductance; alternatively, select the capacitor to provide a pole below that point. Make the input filter time constant equal to or

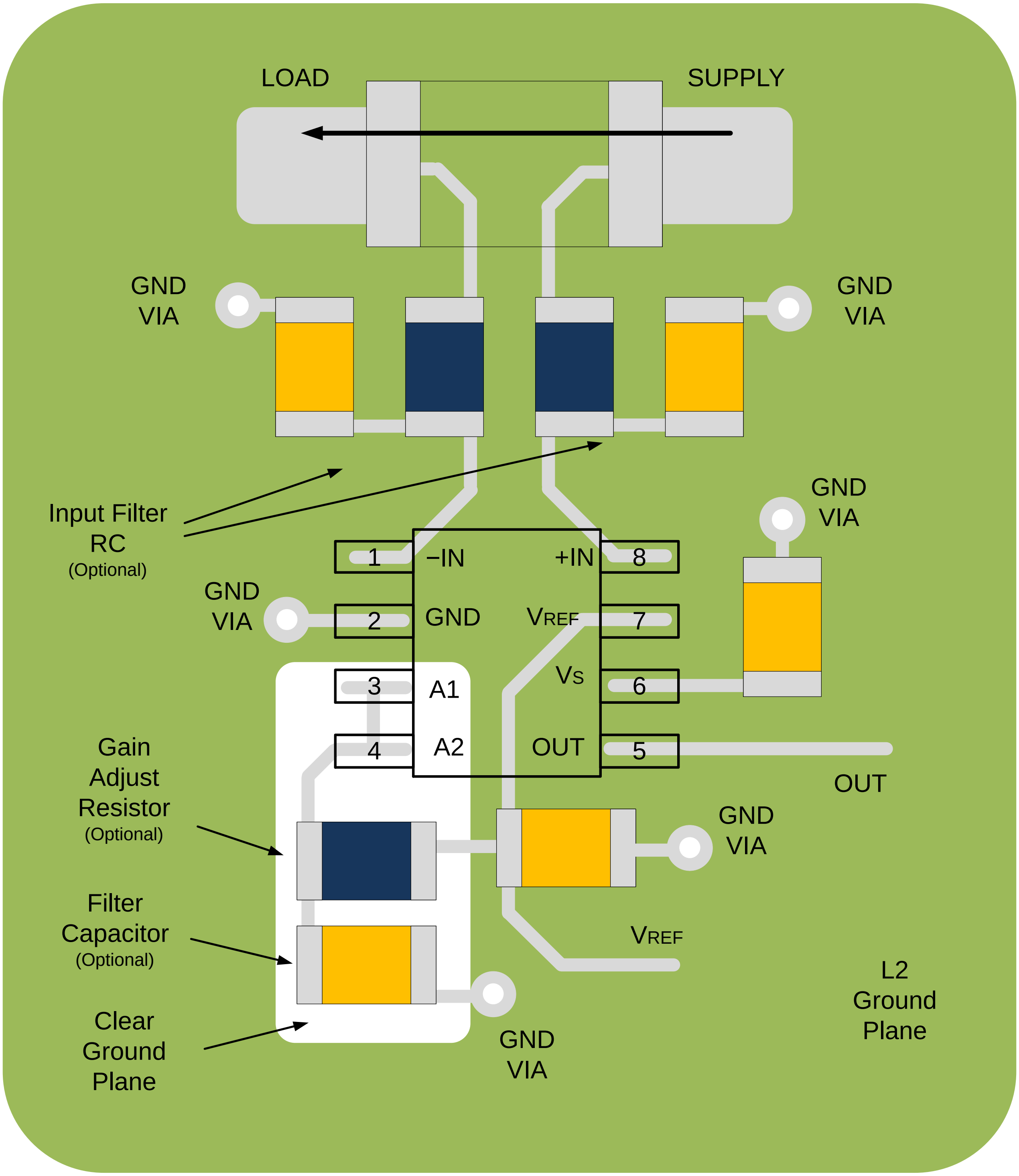


Figure 35. Example Layout for Filtering and Gain Adjustment

ORDERING INFORMATION

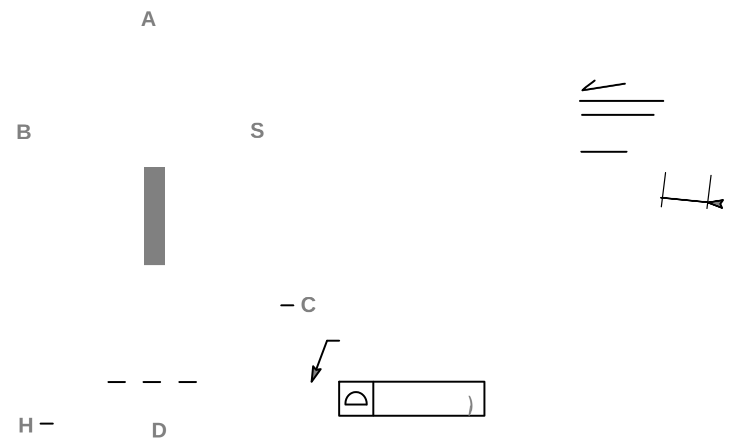
Device	Marking	Package	Gain	Shipping†
INDUSTRIAL AND COMMERCIAL				
NCS7041D3G014R2G*	7041014	SOIC−8 (Pb−Free)	14	2500 / Tape & Reel
NCS7041DM3G014R2G	4114	Micro8 (Pb−Free)		4000 / Tape & Reel
NCS7041D3G020R2G	7041020	SOIC−8 (Pb−Free)	20	2500 / Tape & Reel
NCS7041DM3G020R2G	4120	Micro8 (Pb−Free)		4000 / Tape & Reel
NCS7041D3G050R2G	7041050	SOIC−8 (Pb−Free)	50	2500 / Tape & Reel
NCS7041DM3G050R2G	4150	Micro8 (Pb−Free)		4000 / Tape & Reel
NCS7041D3G100R2G	7041100	SOIC−8 (Pb−Free)	100	2500 / Tape & Reel
NCS7041DM3G100R2G	4100	Micro8 (Pb−Free)		4000 / Tape & Reel
AUTOMOTIVE				
NCV7041D3G014R2G*	7041014	SOIC−8 (Pb−Free)	14	2500 / Tape & Reel
NCV7041DM3G014R2G	4114	Micro8 (Pb−Free)		4000 / Tape & Reel
NCV7041D3G020R2G	7041020	SOIC−8 (Pb−Free)	20	2500 / Tape & Reel
NCV7041DM3G020R2G	4120	Micro8 (Pb−Free)		4000 / Tape & Reel
NCV7041D3G050R2G	7041050	SOIC−8 (Pb−Free)	50	2500 / Tape & Reel
NCV7041DM3G050R2G	4150	Micro8 (Pb−Free)		4000 / Tape & Reel
NCV7041D3G100R2G	7041100	SOIC−8 (Pb−Free)	100	2500 / Tape & Reel
NCV7041DM3G100R2G	4100	Micro8 (Pb−Free)		4000 / Tape & Reel

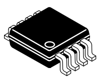
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*In development. Contact local sales office for more information.

SCALE 1:1

SOIC 8 NB
CASE 751–07
ISSUE AK

DATE 16 FEB 2011

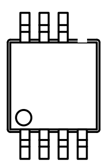




SCALE 2:1

Micro8
CASE 846A−02
ISSUE K

DATE 16 JUL 2020



S

1:S
1.S
2.S
3.
4. A
5. A
6. A
7. A
8. A

S

2:S
1. 1
2.S A 1
3. 2
4. A 2
5. A 2
6. A 2
7. A 1
8. A 1

S

3: S
1.
2. S A
3.
4. – A
5. – A
6. – A
7. – A
8. – A