HV7800

High-Side Current Monitor 8V to 450V Voltage Gain of 1

Features

- Supply Voltages from 8V to 450V
- Voltage Output Device
- Typical Gain 1 ±1%
- Maximum V_{SENSE}, 500 mV
- Fast Rise and Fall Time, 700 ns to 2 µs
- Maximum Quiescent Current 50 µA
- Available in 5-Lead SOT-23 Packages

Applications

- Switch Mode Power Supply Current Monitor
- Battery Current Monitor
- Motor Controls
- Telecommunications

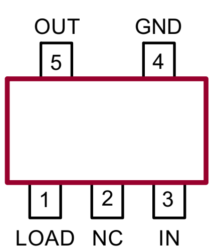
General Description

The HV7800 high-side current monitor IC transfers a high-side current measurement voltage to its ground-referenced output with an accurate voltage gain of one. The measurement voltage typically originates at a current sense resistor which is located in a “high-side” circuit, such as the positive supply line.

This monitor IC features a very wide input voltage range, high accuracy of transfer ratio, small size, low component count, low-power consumption, ease of use, and low cost. Offline, battery and portable applications can be served equally well due to the wide input voltage range and the low quiescent current of the HV7800.

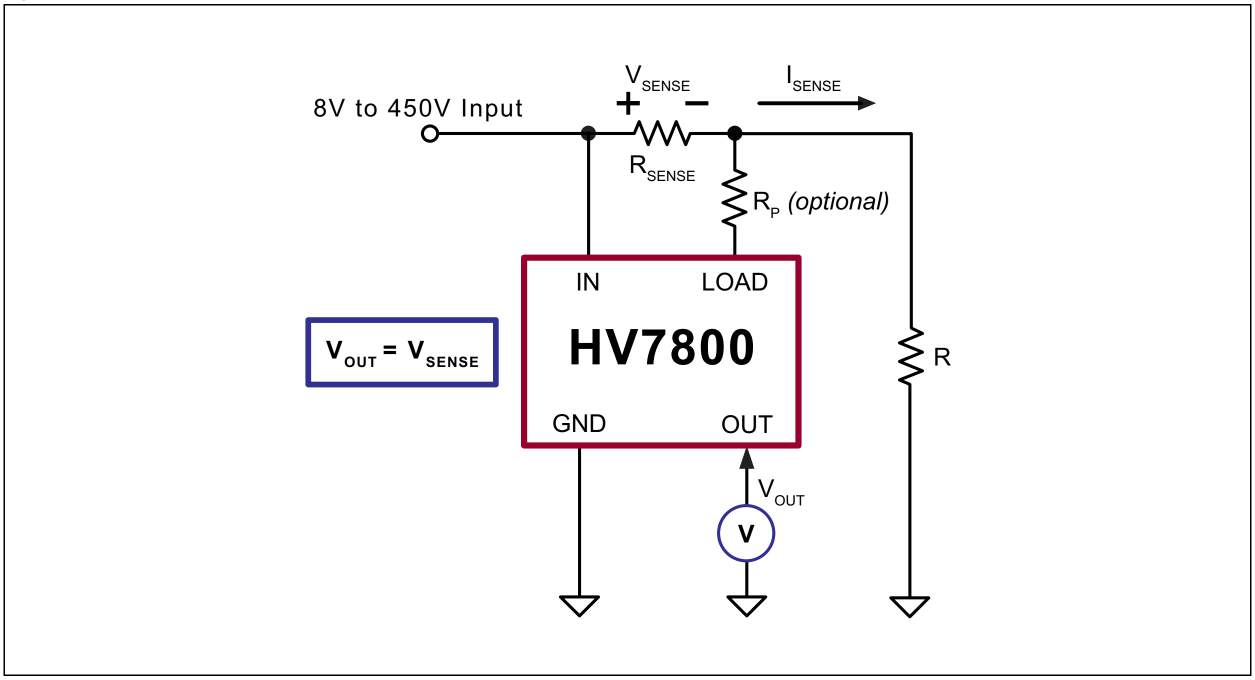
Package Type

5-lead SOT-23
(Top View)

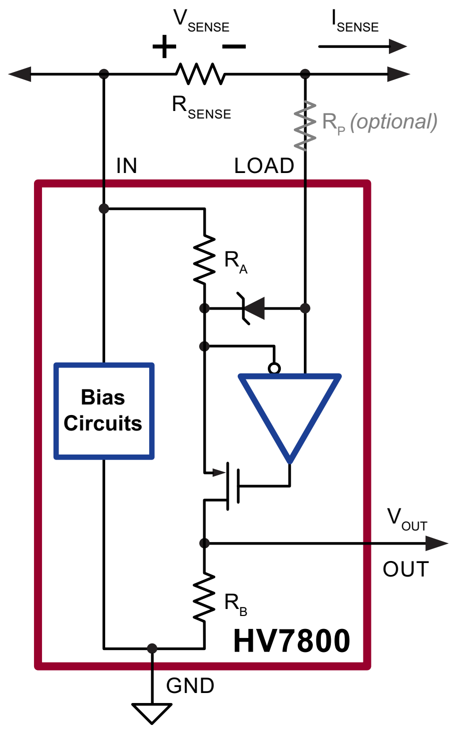


See Table 3-1 for pin information.

Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Supply Voltage, V_{IN}, V_{LOAD} (**Note 1**) ....–0.5V to +460V
Output Voltage, V_{OUT} (**Note 1**)....................–0.5V to +10V
Sense Voltage, V_{SENSE} (**Note 2**)....................–0.5V to +5V
Load Current, I_{LOAD} (**Note 2**) .... ±10 mA
Operating Ambient Temperature, T_A .... –40°C to +85°C
Operating Junction Temperature, T_J .... –40°C to +125°C
Storage Temperature, T_S .... –65°C to +150°C

† Notice: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

Note 1: Referenced to GND
2: $V_{SENSE} = V_{IN} – V_{LOAD}$

ELECTRICAL CHARACTERISTICS

Electrical Specifications: T_A = 25°C unless otherwise noted; V_{IN} = 8V to 450V						
Parameter	**Sym.**	**Min.**	**Typ.**	**Max**	**Unit**	**Conditions**
SUPPLY						
Supply Voltage	V_{IN}	8	—	450	V	**Note 1**
Quiescent Supply Current	I_Q	—	—	50	µA	V_{IN} = 8V to 450V, V_{SENSE} = 0 mV
INPUT AND OUTPUT						
OUT Pin Output Resistance	R_{OUT}	—	3.6	—	kΩ	
Output Voltage	V_{OUT}	0	—	15	mV	V_{SENSE} = 0 mV
		79	—	121		V_{SENSE} = 100 mV
		177	—	223		V_{SENSE} = 200 mV
		470	—	530		V_{SENSE} = 500 mV
DYNAMIC CHARACTERISTICS						
Output Rise Time, 10% to 90%	t_{RISE}	—	0.7	—	µs	V_{SENSE} = Step 5 mV to 500 mV
		—	—	2		V_{SENSE} = Step 0 mV to 500 mV
Output Fall Time, 90% to 10%	t_{FALL}	—	0.7	2	µs	V_{SENSE} = Step 500 mV to 0 mV (**Note 1**)

Note 1: Values apply over the full temperature range.

TEMPERATURE SPECIFICATIONS

Parameter	**Sym.**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
TEMPERATURE RANGE						
Operating Ambient Temperature	T_A	–40	—	+85	°C	
Operating Junction Temperature	T_J	–40	—	+125	°C	
Storage Temperature	T_S	–65	—	+150	°C	
PACKAGE THERMAL RESISTANCE						
5-lead SOT-23	θ_{JA}	—	253	—	°C/W	

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g. outside specified power supply range) and therefore outside the warranted range.

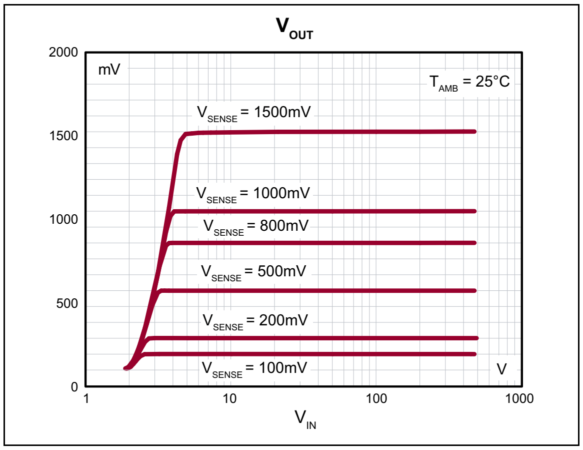


FIGURE 2-1: *Output Voltage vs. Sense Voltage.*

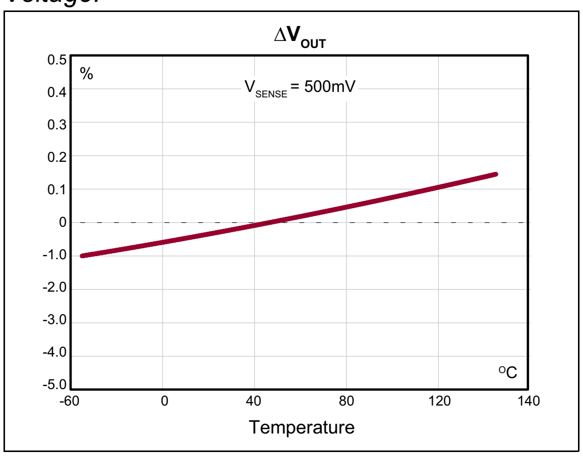


FIGURE 2-2: *Output Variation vs. Temperature.*

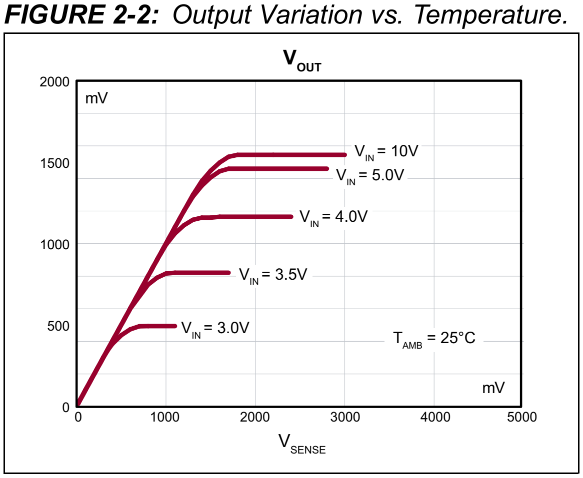


FIGURE 2-3: *Output Voltage vs. Sense Voltage at Low V_{IN} Voltages.*

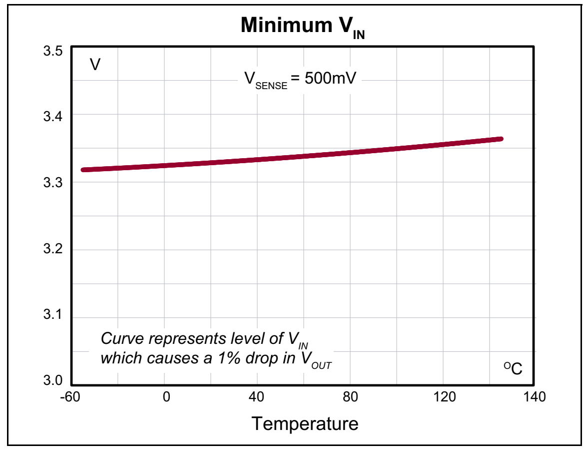


FIGURE 2-4: *Minimum V_{IN} vs. Temperature.*

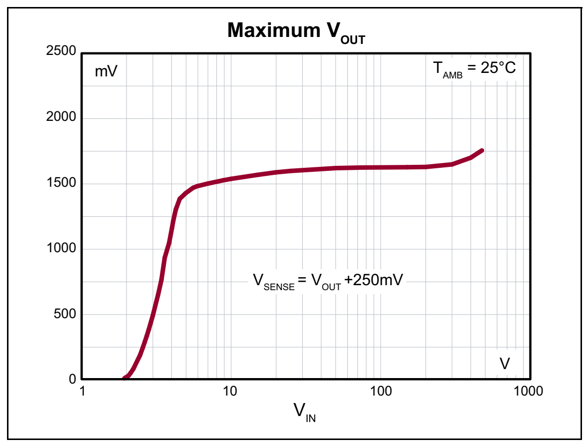


FIGURE 2-5: *Maximum Output Voltage vs. V_{IN}.*

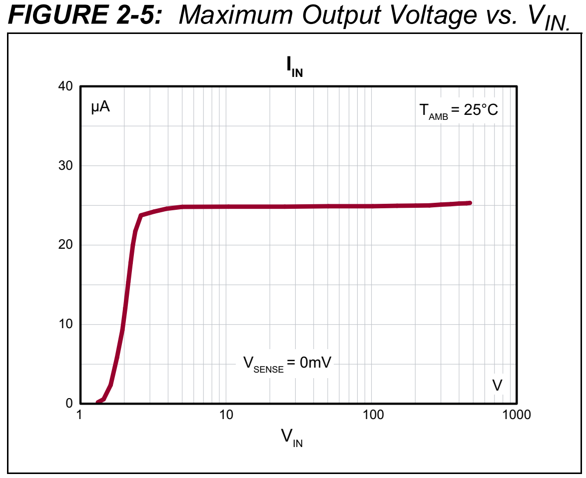


FIGURE 2-6: *I_{IN} Current vs. V_{IN} Voltage.*

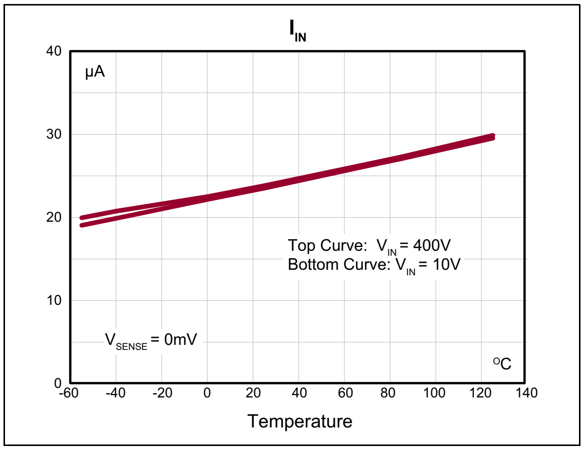


FIGURE 2-7: V_{IN} Current vs. Temperature.

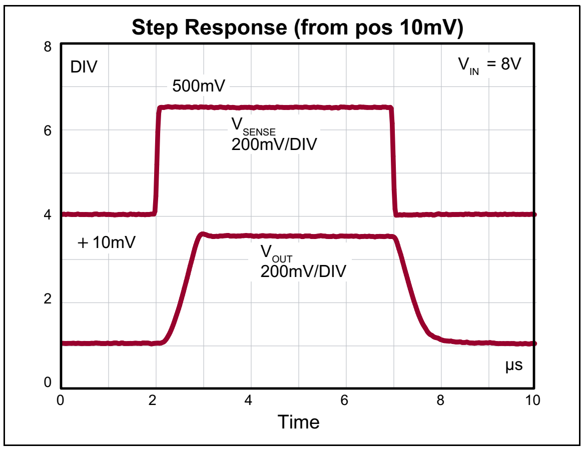


FIGURE 2-8: Step Response (From Positive 10 mV).

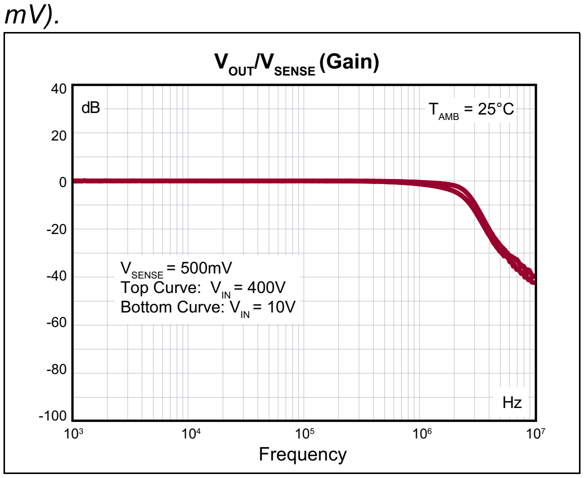


FIGURE 2-9: V_{OUT}/V_{SENSE} (Gain).

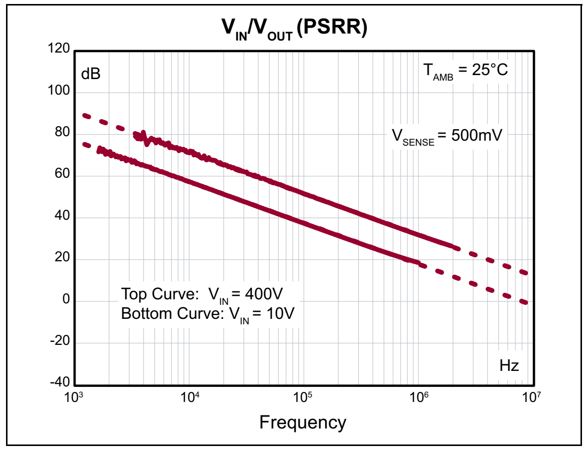


FIGURE 2-10: V_{IN}/V_{OUT} (PSSR).

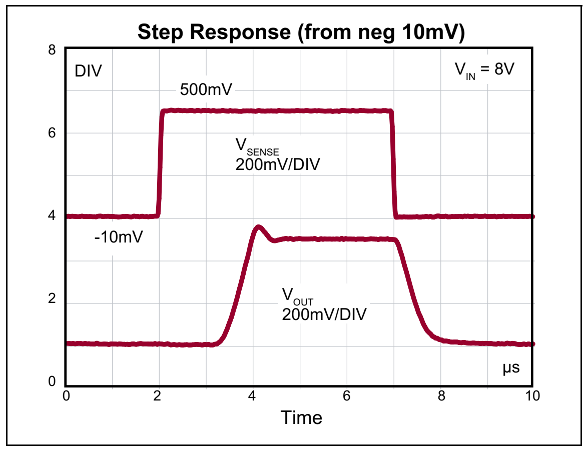


FIGURE 2-11: Step Response (From Negative 10 mV).

3.0 PIN DESCRIPTION

The details on the pins of HV7800 are listed in Table 3-1. Refer to **Package Type** for the location of pins.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	LOAD	Sense amplifier input. High-impedance input with Zener diode protection. Add an external protection resistor in series with LOAD if V_{SENSE} exceeds the range of –600 mV to +5V.
2	NC	No connect. This pin must be left floating for proper operation.
3	IN	Sense amplifier input and supply
4	GND	Supply return
5	OUT	Output with a nominal output resistance of 3.6 kΩ. Preservation of accuracy may require an external buffer amplifier to prevent excessive loading.

4.0 APPLICATION INFORMATION

4.1 General

The HV7800 high-side current monitor IC features accurate current sensing, small size, low component count, low power consumption, exceptional input voltage range, ease of use and low cost.

The part typically performs the measurement of line or load current for overcurrent protection, metering, or current regulation.

High-side current sensing, as opposed to ground-referenced or low-side current sensing, is desirable or required when:

- The current to be measured does not flow in a circuit associated with ground.
- The measurement at ground level can lead to ambiguity due to changes in the grounding arrangement during field use.
- Introduction of a sense resistor in the system ground is undesirable due to issues with safety, EMI, or signal degradation caused by common impedance coupling.

4.2 Principle of Operation

The operational amplifier and MOSFET force the voltage across RA to track V_{SENSE} within the limit of the offset voltage of the opamp, i.e. $V_{RA} = V_{SENSE}$.

The current through R_A returns to ground through R_B. R_A and R_B are integrated, exhibiting tight matching and excellent tracking. By design, R_A and R_B have the same resistance. Consequently, V_{RA} is equal to V_{RB}, resulting in a voltage gain of one.

4.3 OUT Pin Loading Effects

Note that the OUT pin has a typical output resistance of 3.6 kΩ. Loading the output causes the voltage gain to drop and the rise/fall time to increase.

For example, if given an output resistance of 3.6 kΩ, the load resistance should exceed 3.6 MΩ to limit the drop in gain to 1 part in 1000.

Again, assuming an output resistance of 3.6 kΩ, capacitive loading of 30 pF results in a response pole with a time constant of 100 ns, which is not yet high enough to materially affect the output rise and fall time of about 700 ns.

4.4 Sense Resistor Considerations

Choose a sense resistor that will not exceed 500 mV during normal operating conditions. Limit the power dissipation in the sense resistor to whatever is practical. A high-sense voltage benefits accuracy, but increases power dissipation.

Consider the use of Kelvin connections for applications where significant voltage drops may occur in the PCB traces that carry the current to be measured to the sense resistor. A layout pattern that minimizes voltage across the sense lines is shown in Figure 4-1 below:

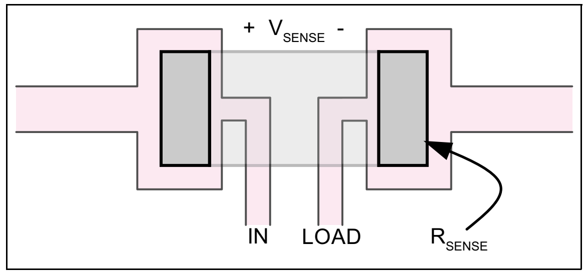


FIGURE 4-1: Kelvin Connection for the Sense Resistor.

Choose a low-inductance type of sense resistor if preservation of bandwidth is important. The use of Kelvin connections helps by excluding the inductive voltage drop across the traces leading to the sense resistor. The inductive voltage drop may be substantial when operating at high frequencies.

A trace or component inductance of just 10 nH contributes an impedance of 6.2 mΩ at 100 kHz, which constitutes a 6% error when using a 100 mΩ sense resistor.

4.5 Transient Protection

Add a protection resistor (R_P) in series with the LOAD pin if V_{SENSE} can exceed 5V in a positive sense or 600 mV in a negative sense, whether in a Steady state or in transient conditions.

A large V_{SENSE} may occur during system startup or shutdown due to the charging and discharging of bulk storage capacitors. V_{SENSE} may be large due to fault conditions, such as a Short circuit condition, or a broken or missing sense resistor.

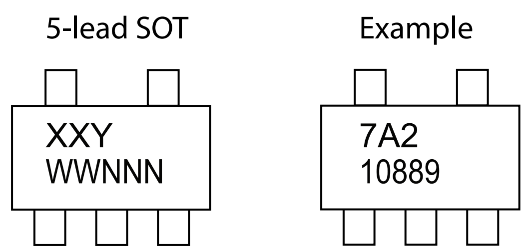
An internal 5V Zener diode with a current rating of 10 mA protects the sense amplifier inputs. The block diagram shows the orientation of this diode. The Zener diode provides clamping at 5V for a positive V_{SENSE} and at 600 mV for a negative V_{SENSE}.

Under worst-case conditions, limit the Zener current to 10 mA. A 100 kΩ resistor limits the Zener diode current to 4.5 mA when V_{SENSE} is 450V, whether positive or negative. Note that the protection resistor may affect the bandwidth. The resistor forms an RC network with the trace and pin capacitance at the LOAD pin. A capacitance of 5 pF results in a time constant of 500 ns.

The protection resistor may cause an offset due to bias current at the LOAD input. Under worst-case bias current (1 nA), a 100 kΩ protection resistor could cause an offset of 100 µV or 0.2% of full scale. Note that the bias current is nominally zero as the LOAD is a high-impedance CMOS input.

5.0 PACKAGE MARKING INFORMATION

5.1 Packaging Information

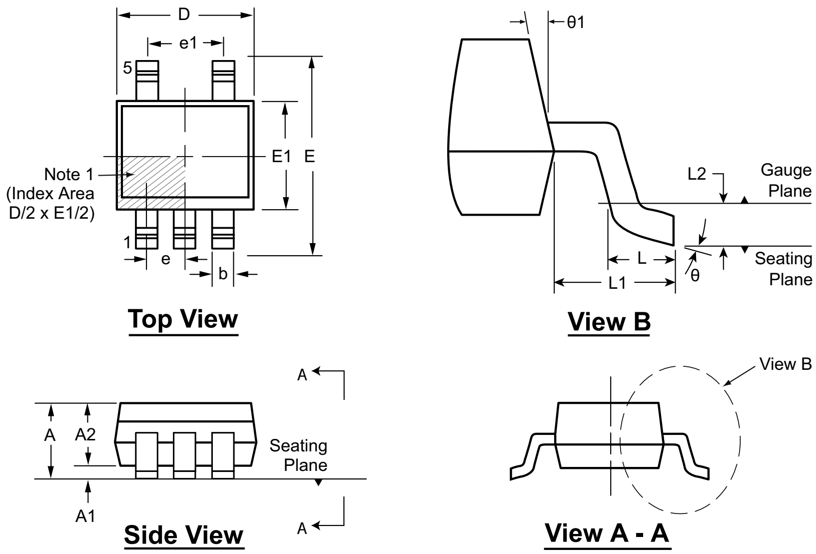


Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for product code or customer-specific information. Package may or not include the corporate logo.

5-Lead SOT-23 Package Outline (K1)

2.90x1.60mm body, 1.45mm height (max), 0.95mm pitch



Note: For the most current package drawings, see the Microchip Packaging Specification at www.microchip.com/packaging.

Note:

1. *A Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/identifier; an embedded metal marker; or a printed indicator.*

Symbol		A	A1	A2	b	D	E	E1	e	e1	L	L1	L2	θ	θ1
Dimension (mm)	MIN	0.90*	0.00	0.90	0.30	2.75*	2.60*	1.45*	0.95 BSC	1.90 BSC	0.30	0.60 REF	0.25 BSC	0°	5°
	NOM	-	-	1.15	-	2.90	2.80	1.60			0.45			4°	10°
	MAX	1.45	0.15	1.30	0.50	3.05*	3.00*	1.75*			0.60			8°	15°

JEDEC Registration MO-178, Variation AA, Issue C, Feb. 2000.
** This dimension is not specified in the JEDEC drawing.*
Drawings not to scale.

APPENDIX A: REVISION HISTORY

Revision A (October 2022)

- Converted Supertex Doc# DSFP-HV7800 to Microchip DS20005631A
- Changed the quantity of the K1 package from 2500/Reel to 3000/Reel to align packaging specifications with the actual BQM
- Made minor text changes throughout the document

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	XX	-	X	-	X
Device	Package Options		Environmental		Media Type

Device:	HV7800	=	High-Side Current Monitor 8V to 450V Voltage Gain of 1
Package:	K1	=	5-lead SOT-23
Environmental:	G	=	Lead (Pb)-free/RoHS-compliant Package
Media Type:	(blank)	=	3000/Reel for a K1 Package

Example:

a) HV7800K1-G: High-Side Current Monitor 8V to 450V Voltage Gain of 1, 5-lead SOT-23, 3000/Reel

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