Precision High Voltage Current Sense Amplifier

Check for Samples: LMP8640, LMP8640HV

FEATURES

- **Typical Values, T_A = 25°C**
- **High Common-Mode Voltage Range**
  - **LMP8640: -2V to 42V**
  - **LMP8640HV: -2V to 76V**
- **Supply Voltage Range: 2.7V to 12V**
- **Gain Options: 20V/V; 50V/V; 100V/V**
- **Max Gain Error: 0.25%**
- **Low Offset Voltage: 900µV**
- **Input Bias Current: 13 µA**
- **PSRR: 85 dB**
- **CMRR (2.1V to 42V): 103 dB**
- **Temperature Range: -40°C to 125°C**
- **6-Pin SOT Package**

APPLICATIONS

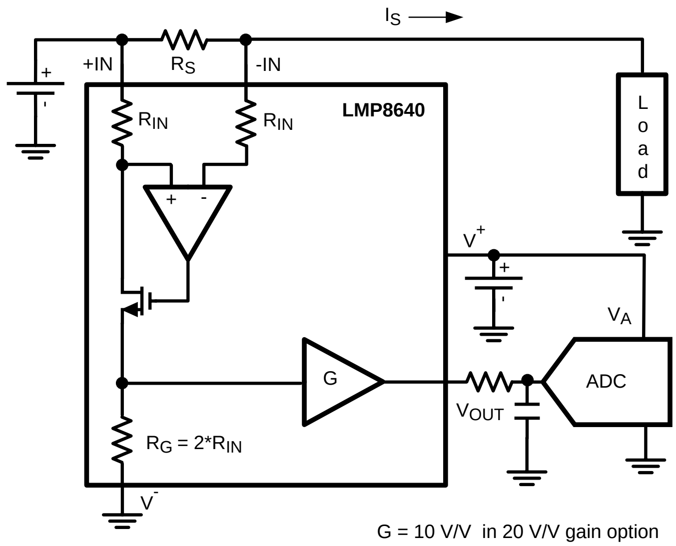
- **High-Side Current Sense**
- **Vehicle Current Measurement**
- **Motor Controls**
- **Battery Monitoring**
- **Remote Sensing**
- **Power Management**

DESCRIPTION

The LMP8640 and the LMP8640HV are precision current sense amplifiers that detect small differential voltages across a sense resistor in the presence of high input common mode voltages with a supply voltage range from 2.7V to 12V.

The LMP8640 accepts input signals with common mode voltage range from -2V to 42V, while the LMP8640HV accepts input signal with common mode voltage range from -2V to 76V. The LMP8640 and LMP8640HV have fixed gain for applications that demand accuracy over temperature. The LMP8640 and LMP8640HV come out with three different fixed gains 20V/V, 50V/V, 100V/V ensuring a gain accuracy as low as 0.25%. The output is buffered in order to provide low output impedance. This high side current sense amplifier is ideal for sensing and monitoring currents in DC or battery powered systems, excellent AC and DC specifications over temperature, and keeps errors in the current sense loop to a minimum. The LMP8640 and LMP8640HV are ideal choice for industrial, automotive and consumer applications, and it is available in SOT-6 package.

Typical Application



G = 10 V/V in 20 V/V gain option
G = 25 V/V in 50 V/V gain option
G = 50 V/V in 100 V/V gain option

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings [1][2][3]

ESD Tolerance [4]	Human Body Model	For input pins +IN, -IN	5000V
		For all other pins	2000V
	Machine Model		200V
	Charge device model		1250V
Supply Voltage ($V_S = V^+ - V^-$)			13.2V
Differential Voltage +IN- (-IN)			6V
Voltage at pins +IN, -IN	LMP8640HV		-6V to 80V
	LMP8640		-6V to 60V
Voltage at V_{OUT} pin			V^- to V^+
Storage Temperature Range			-65°C to 150°C
Junction Temperature [5]			150°C

(1) “Absolute Maximum Ratings” indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Operating Ratings is not implied. Operating Ratings indicate conditions at which the device is functional and the device should not be operated beyond such conditions.
(2) For soldering specifications,see product folder at www.national.com and www.national.com/ms/MS/MS-SOLDERING.pdf
(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(4) Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC) Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC).
(5) The maximum power dissipation must be derated at elevated temperatures and is dictated by $T_{J(MAX)}$, θ_{JA}, and the ambient temperature, T_A. The maximum allowable power dissipation $P_{DMAX} = (T_{J(MAX)} - T_A)/ \theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower.

Operating Ratings [1]

Supply Voltage ($V_S = V^+ - V^-$)	2.7V to 12V
Temperature Range [2]	-40°C to 125°C
Package Thermal Resistance [2]	
SOT-6	96°C/W

(1) “Absolute Maximum Ratings” indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Operating Ratings is not implied. Operating Ratings indicate conditions at which the device is functional and the device should not be operated beyond such conditions.
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2.7V Electrical Characteristics [1]

Unless otherwise specified, all limits guaranteed for at T_A = 25°C, $V_S=V^+ - V^-$, V_{SENSE}= +IN-(-IN), V^+ = 2.7V, V^- = 0V, −2V < V_{CM} < 76V, R_L = 10MΩ. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min [2]	Typ [3]	Max [2]	Unit
V_{OS}	Input Offset Voltage	V_{CM} = 2.1V	-900 **-1160**		900 **1160**	µV
TCV_{OS}	Input Offset Voltage Drift [4] [5]	V_{CM} = 2.1V			2.6	µV/°C
I_B	Input Bias Current [6]	V_{CM} = 2.1V		12	20 **27**	µA
e_{ni}	Input Voltage Noise [5]	f > 10 kHz		117		nV/√Hz
Gain A_V	Fixed Gain LMP8640-T LMP8640HV-T			20		V/V
	Fixed Gain LMP8640-F LMP8640HV-F			50		V/V
	Fixed Gain LMP8640-H LMP8640HV-H			100		V/V
	Gain error	V_{CM} = 2.1V	-0.25 **-0.51**		0.25 **0.51**	%
	Accuracy over temperature [5]	−40°C to 125°C, V_{CM}=2.1V			26.2	ppm/°C
PSRR	Power Supply Rejection Ratio	V_{CM} = 2.1V, 2.7V < V^+ < 12V,	85			dB
CMRR	Common Mode Rejection Ratio	LMP8640HV 2.1V < V_{CM} < 42V LMP8640 2.1V < V_{CM}< 42V	103			dB
		LMP8640HV 2.1V < V_{CM} < 76V	95			
		-2V <V_{CM} < 2V,	60			
BW	Fixed Gain LMP8640-T LMP8640HV-T [5]	DC V_{SENSE} = 67.5 mV, C_L = 30 pF,R_L= 1MΩ		950		kHz
	Fixed Gain LMP8640-F LMP8640HV-F [5]	DC V_{SENSE} =27 mV, C_L = 30 pF, R_L= 1MΩ		450		
	Fixed Gain LMP8640-H LMP8640HV-H [5]	DC V_{SENSE} = 13.5 mV, C_L = 30 pF ,R_L= 1MΩ		230		

(1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute Maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlations using statistical quality control (SQC) method.
(3) Typical values represent the most likely parametric norm at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.
(4) Offset voltage temperature drift is determined by dividing the change in V_{OS} at the temperature extremes by the total temperature change.
(5) This parameter is guaranteed by design and/or characterization and is not tested in production.
(6) Positive Bias Current corresponds to current flowing into the device.

2.7V Electrical Characteristics [(1)] (continued)

Unless otherwise specified, all limits guaranteed for at T_A = 25°C, V_S=V^+ – V^-, V_{SENSE}= +IN-(-IN), V^+ = 2.7V, V^- = 0V, −2V < V_{CM} < 76V, R_L = 10MΩ. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min [(2)]	Typ [(3)]	Max [(2)]	Unit
SR	Slew Rate [(7)] [(5)]	V_{CM} =5V, C_L = 30 pF, R_L = 1MΩ, LMP8640-T LMP8640HV-T V_{SENSE} =100mVpp, LMP8640-F LMP8640HV-F V_{SENSE} =40mVpp, LMP8640-H LMP8640HV-H V_{SENSE} =20mVpp,		1.4		V/µs
R_{IN}	Differential Mode Input Impedance [(5)]			5		kΩ
I_S	Supply Current	V_{CM} = 2.1V		420	600 **800**	µA
		V_{CM} = −2V		2000	2500 **2750**	
V_{OUT}	Maximum Output Voltage	V_{CM} = 2.1V	2.65			V
	Minimum Output Voltage	LMP8640-T LMP8640HV-T V_{CM} = 2.1V			18.2	mV
		LMP8640-F LMP8640HV-F V_{CM} = 2.1V			40	
		LMP8640-H LMP8640HV-H V_{CM} = 2.1V			80	
C_{LOAD}	Max Output Capacitance Load [(5)]			30		pF

(7) The number specified is the average of rising and falling slew rates and measured at 90% to 10%.

5V Electrical Characteristics [(1)]

Unless otherwise specified, all limits guaranteed for at T_A = 25°C, V_S=V^+ – V^-, V_{SENSE}= +IN-(-IN), V^+ = 5V, V^- = 0V, −2V < V_{CM} < 76V, R_L = 10MΩ. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min [(2)]	Typ [(3)]	Max [(2)]	Unit
V_{OS}	Input Offset Voltage	V_{CM} = 2.1V	-900 **-1160**		900 **1160**	µV
TCV_{OS}	Input Offset Voltage Drift [(4)] [(5)]	V_{CM} = 2.1V			2.6	µV/°C
I_B	Input Bias Current [(6)]	V_{CM} = 2.1V		13	21 **28**	µA
e_{ni}	Input Voltage Noise [(5)]	f > 10 kHz		117		nV/√Hz
Gain A_V	Fixed Gain LMP8640-T LMP8640HV-T			20		V/V
	Fixed Gain LMP8640-F LMP8640HV-F			50		V/V
	Fixed Gain LMP8640-H LMP8640HV-H			100		V/V
	Gain error	V_{CM} = 2.1V	-0.25 **-0.51**		0.25 **0.51**	%
	Accuracy over temperature [(5)]	−40°C to 125°C, V_{CM}=2.1V			26.2	ppm/°C
PSRR	Power Supply Rejection Ratio	V_{CM} = 2.1V, 2.7V < V^+ < 12V,	85			dB

(1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that T_J = T_A. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where T_J > T_A. Absolute Maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlations using statistical quality control (SQC) method.
(3) Typical values represent the most likely parametric norm at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.
(4) Offset voltage temperature drift is determined by dividing the change in V_{OS} at the temperature extremes by the total temperature change.
(5) This parameter is guaranteed by design and/or characterization and is not tested in production.
(6) Positive Bias Current corresponds to current flowing into the device.

5V Electrical Characteristics [(1)] (continued)

Unless otherwise specified, all limits guaranteed for at T_A = 25°C, V_S=V^+ – V^-, V_{SENSE}= +IN-(-IN), V^+ = 5V, V^- = 0V, −2V < V_{CM} < 76V, R_L = 10MΩ. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min[(2)]	Typ[(3)]	Max[(2)]	Unit
CMRR	Common Mode Rejection Ratio	LMP8640HV 2.1V < V_{CM} < 42V LMP8640 2.1V < V_{CM}< 42V	103			dB
		LMP8640HV 2.1V < V_{CM} < 76V	95			
		-2V <V_{CM} < 2V,	60			
BW	Fixed Gain LMP8640-T LMP8640HV-T [(5)]	DC V_{SENSE} = 67.5 mV, C_L = 30 pF ,R_L= 1MΩ		950		kHz
	Fixed Gain LMP8640-F LMP8640HV-F[(5)]	DC V_{SENSE} =27 mV, C_L = 30 pF ,R_L= 1MΩ		450		
	Fixed Gain LMP8640-H LMP8640HV-H[(5)]	DC V_{SENSE} = 13.5 mV, C_L = 30 pF ,R_L= 1MΩ		230		
SR	Slew Rate [(7)] [(5)]	V_{CM} =5V, C_L = 30 pF, R_L = 1MΩ, LMP8640-T LMP8640HV-T V_{SENSE} =200mVpp, LMP8640-F LMP8640HV-F V_{SENSE} =80mVpp, LMP8640-H LMP8640HV-H V_{SENSE} =40mVpp,		1.6		V/µs
R_{IN}	Differential Mode Input Impedance[(5)]			5		kΩ
I_S	Supply Current	V_{CM} = 2.1V		500	722 **922**	µA
		V_{CM} = −2V		2050	2500 **2750**	
V_{OUT}	Maximum Output Voltage	V_{CM} = 2.1V	4.95			V
	Minimum Output Voltage	LMP8640-T LMP8640HV-T V_{CM} = 2.1V			18.2	mV
		LMP8640-F LMP8640HV-F V_{CM} = 2.1V			40	
		LMP8640-H LMP8640HV-H V_{CM} = 2.1V			80	
C_{LOAD}	Max Output Capacitance Load[(5)]			30		pF

(7) The number specified is the average of rising and falling slew rates and measured at 90% to 10%.

12V Electrical Characteristics[(1)]

Unless otherwise specified, all limits guaranteed for at T_A = 25°C, V_S=V^+ – V^-, V_{SENSE}= +IN-(-IN), V^+ = 12V, V^- = 0V, −2V < V_{CM} < 76V, R_L = 10MΩ. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min[(2)]	Typ[(3)]	Max[(2)]	Unit
V_{OS}	Input Offset Voltage	V_{CM} = 2.1V	-900 **-1160**		900 **1160**	µV
TCV_{OS}	Input Offset Voltage Drift[(4)] [(5)]	V_{CM} = 2.1V			2.6	µV/°C
I_B	Input Bias Current [(6)]	V_{CM} = 2.1V		13	22 **28**	µA
e_{ni}	Input Voltage Noise [(5)]	f > 10 kHz		117		nV/√Hz

(1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that T_J = T_A. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where T_J > T_A. Absolute Maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlations using statistical quality control (SQC) method.
(3) Typical values represent the most likely parametric norm at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.
(4) Offset voltage temperature drift is determined by dividing the change in V_{OS} at the temperature extremes by the total temperature change.
(5) This parameter is guaranteed by design and/or characterization and is not tested in production.
(6) Positive Bias Current corresponds to current flowing into the device.

12V Electrical Characteristics(1) (continued)

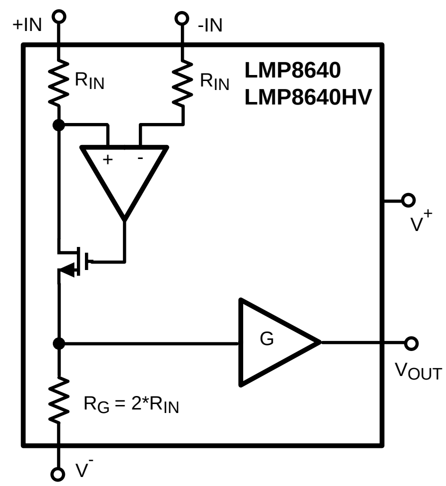
Unless otherwise specified, all limits guaranteed for at T_A = 25°C, $V_S = V^+ – V^-$, V_{SENSE}= +IN-(-IN), V^+ = 12V, $V^−$ = 0V, −2V < V_{CM} < 76V, R_L = 10MΩ. **Boldface** limits apply at the temperature extremes.

Parameter		Test Conditions	Min(2)	Typ(3)	Max(2)	Unit
Gain A_V	Fixed Gain LMP8640-T LMP8640HV-T			20		V/V
	Fixed Gain LMP8640-F LMP8640HV-F			50		V/V
	Fixed Gain LMP8640-H LMP8640HV-H			100		V/V
	Gain error	V_{CM} = 2.1V	-0.25 **-0.51**		0.25 **0.51**	%
	Accuracy over temperature(5)	−40°C to 125°C, V_{CM}=2.1V			26.2	ppm/°C
PSRR	Power Supply Rejection Ratio	V_{CM} = 2.1V, 2.7V < V^+ < 12V,	85			dB
CMRR	Common Mode Rejection Ratio	LMP8640HV 2.1V < V_{CM} < 42V LMP8640 2.1V < V_{CM}< 42V	103			dB
		LMP8640HV 2.1V < V_{CM} < 76V	95			
		-2V <V_{CM} < 2V,	60			
BW	Fixed Gain LMP8640-T LMP8640HV-T (5)	DC V_{SENSE} = 67.5 mV, C_L = 30 pF ,R_L= 1MΩ		950		kHz
	Fixed Gain LMP8640-F LMP8640HV-F (5)	DC V_{SENSE} =27 mV, C_L = 30 pF ,R_L= 1MΩ		450		
	Fixed Gain LMP8640-H LMP8640HV-H (5)	DC V_{SENSE} = 13.5 mV, C_L = 30 pF ,R_L= 1MΩ		230		
SR	Slew Rate (7) (5)	V_{CM} =5V, C_L = 30 pF, R_L = 1MΩ, LMP8640-T LMP8640HV-T V_{SENSE} =500mVpp, LMP8640-F LMP8640HV-F V_{SENSE} =200mVpp, LMP8640-H LMP8640HV-H V_{SENSE} =100mVpp,		1.8		V/µs
R_{IN}	Differential Mode Input Impedance(5)			5		kΩ
I_S	Supply Current	V_{CM} = 2.1V		720	1050 **1250**	µA
		V_{CM} = −2V		2300	2800 **3000**	
V_{OUT}	Maximum Output Voltage	V_{CM} = 2.1V	11.85			V
	Minimum Output Voltage	LMP8640-T LMP8640HV-T V_{CM} = 2.1V			18.2	mV
		LMP8640-F LMP8640HV-F V_{CM} = 2.1V			40	
		LMP8640-H LMP8640HV-H V_{CM} = 2.1V			80	
C_{LOAD}	Max Output Capacitance Load(8)			30		pF

(7) The number specified is the average of rising and falling slew rates and measured at 90% to 10%.
(8) This parameter is guaranteed by design and/or characterization and is not tested in production.

DEVICE INFORMATION

Block Diagram



Connection Diagram

Top View

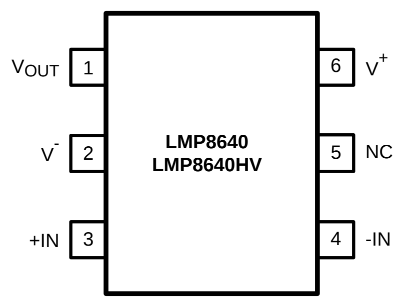


Figure 1. 6-Pin SOT Package see package number DDC0006A

Table 1. Pin Descriptions

Pin	Name	Description
1	V_{OUT}	Single Ended Output
2	V^-	Negative Supply Voltage
3	+IN	Positive Input
4	-IN	Negative Input
5	NC	Not Connected
6	V^+	Positive Supply Voltage

Typical Performance Characteristics

Unless otherwise specified: T_A = 25°C, V_S=V^+-V^-, V_{SENSE}= +IN - (-IN), R_L = 10 MΩ.

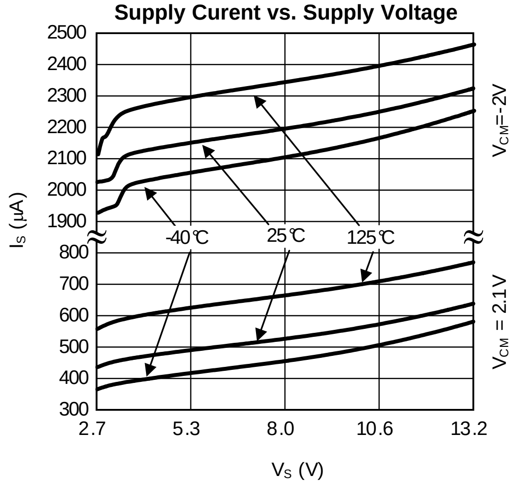


Figure 2.

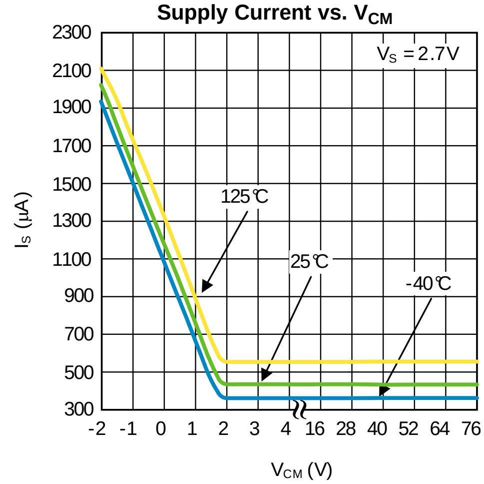


Figure 3.

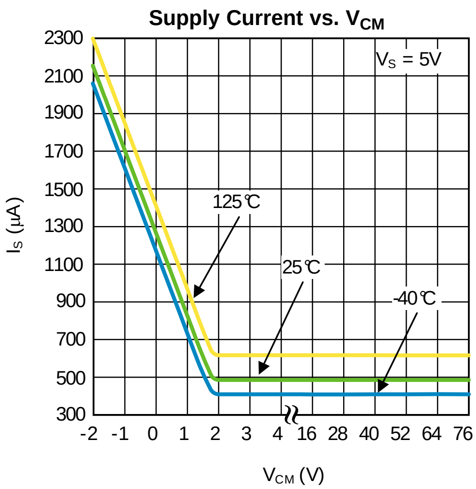


Figure 4.

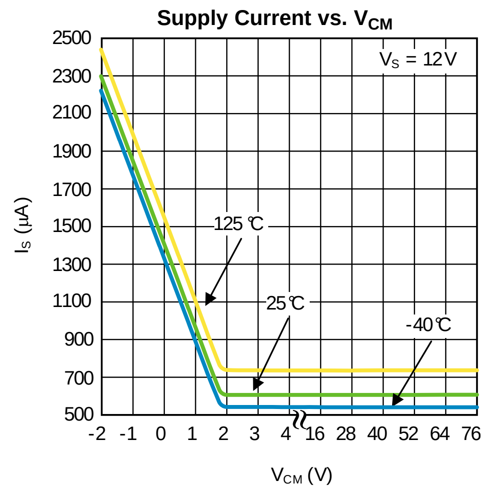


Figure 5.

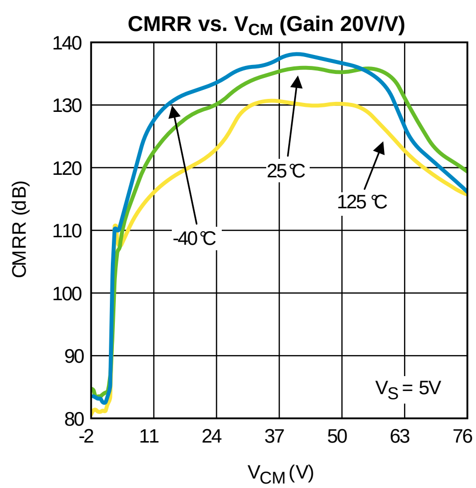


Figure 6.

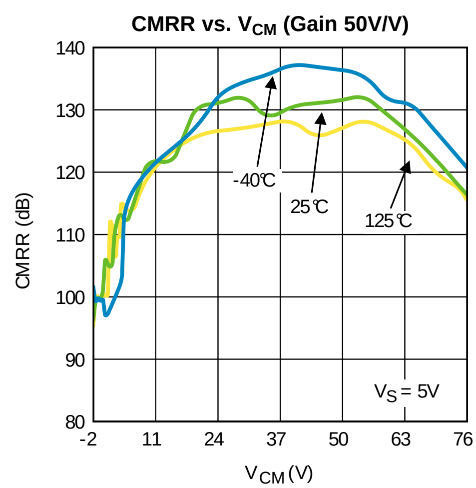


Figure 7.

Typical Performance Characteristics (continued)

Unless otherwise specified: T_A = 25°C, $V_S=V^+-V^-$, V_{SENSE}= +IN - (-IN), R_L = 10 MΩ.

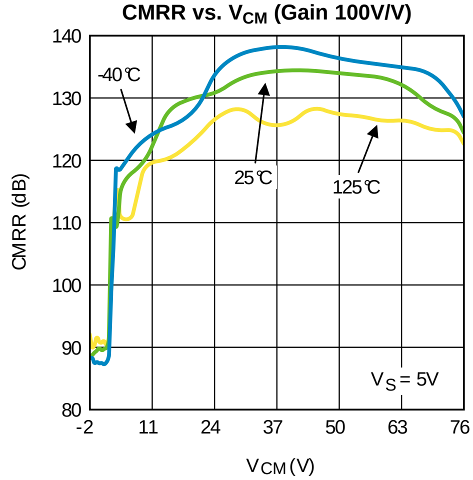


Figure 8.

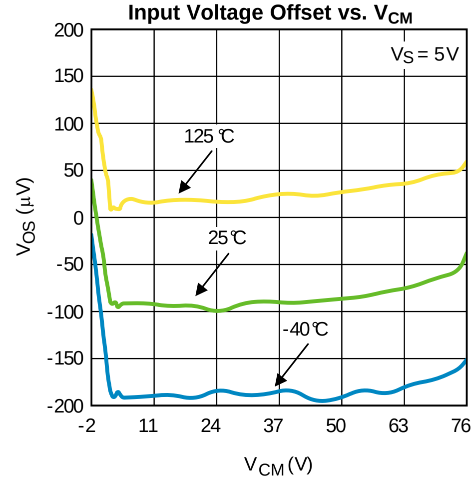


Figure 9.

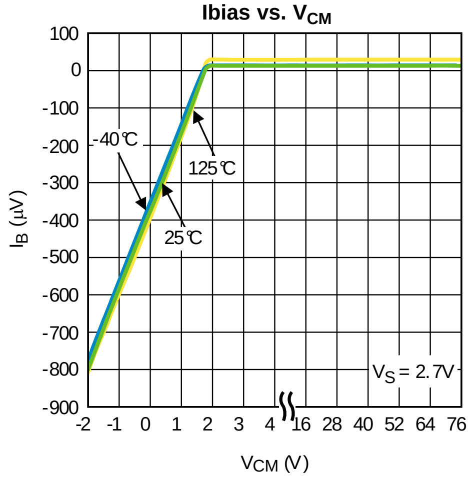


Figure 10.

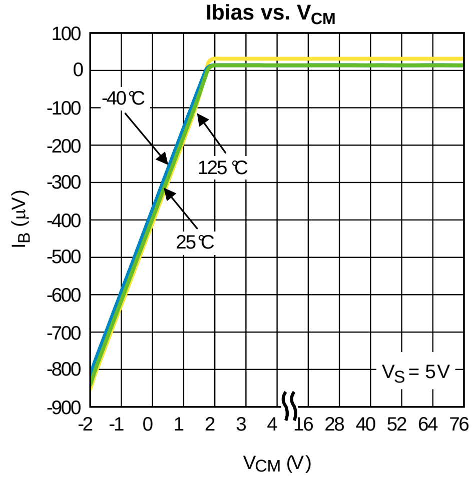


Figure 11.

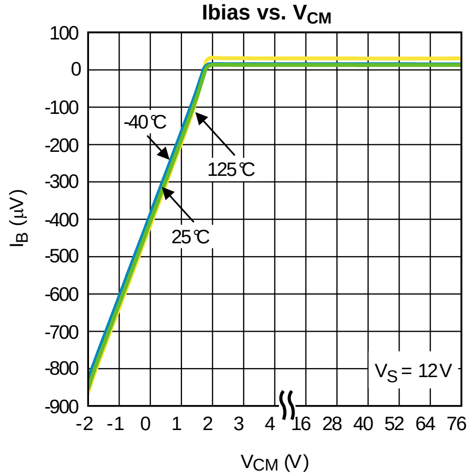


Figure 12.

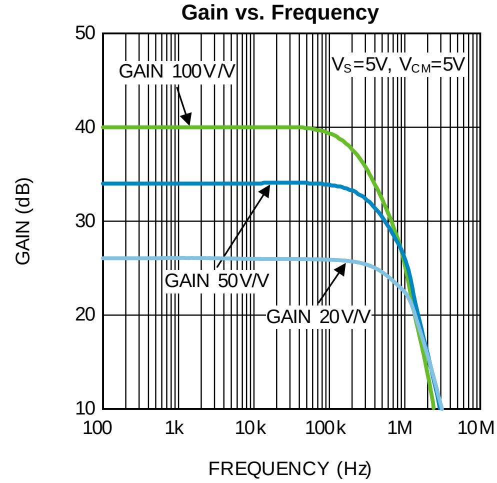


Figure 13.

Typical Performance Characteristics (continued)

Unless otherwise specified: T_A = 25°C, V_S=V^+-V^-, V_{SENSE}= +IN - (-IN), R_L = 10 MΩ.

Output voltage vs. V_{SENSE}

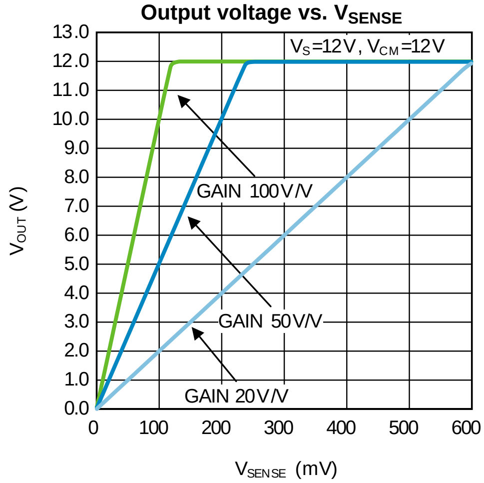


Figure 14.

Output voltage vs. V_{SENSE} (ZOOM close to 0V)

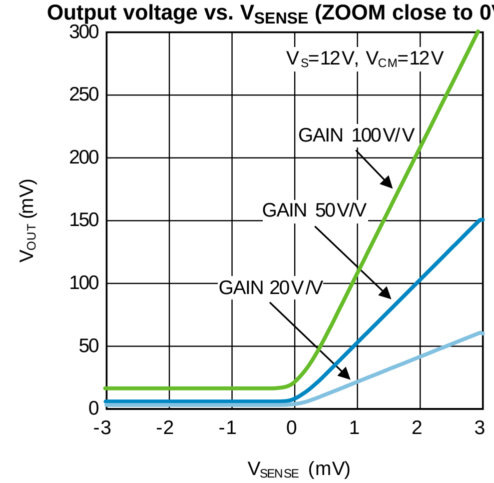


Figure 15.

Large Step response

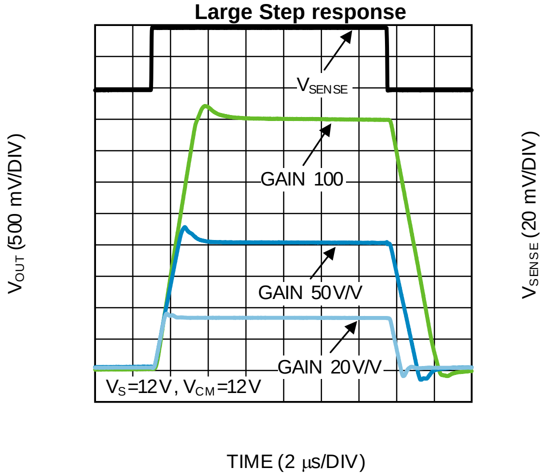


Figure 16.

Small Step response

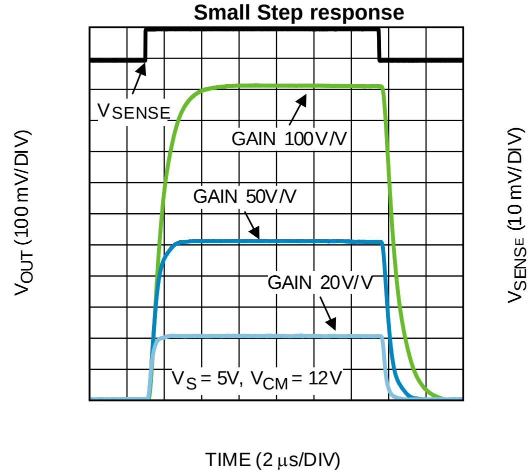


Figure 17.

Settling time (fall)

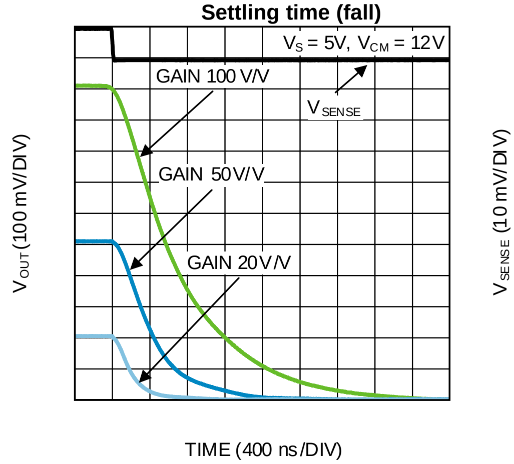


Figure 18.

Settling time (rise)

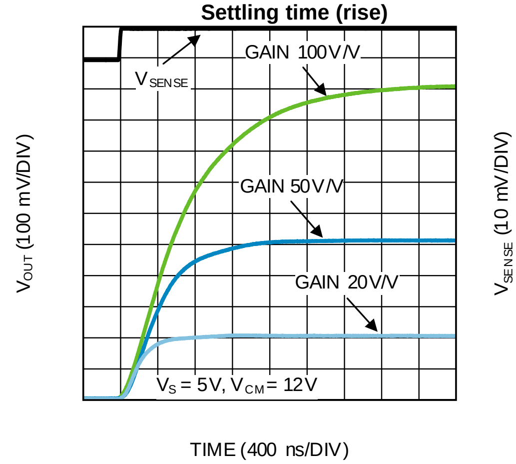


Figure 19.

Typical Performance Characteristics (continued)

Unless otherwise specified: T_A = 25°C, V_S=V^+-V^-, V_{SENSE}= +IN - (-IN), R_L = 10 MΩ.

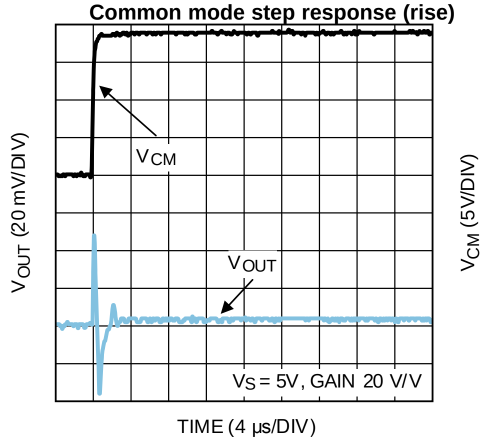


Figure 20.

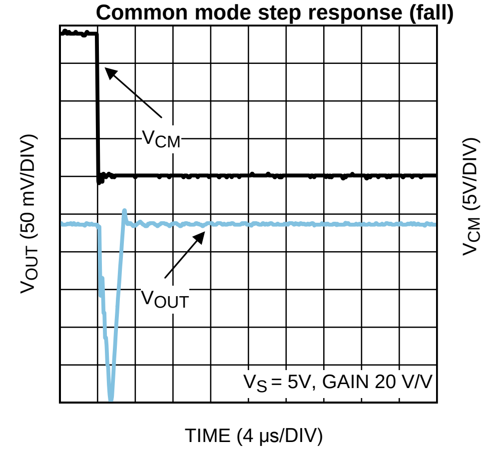


Figure 21.

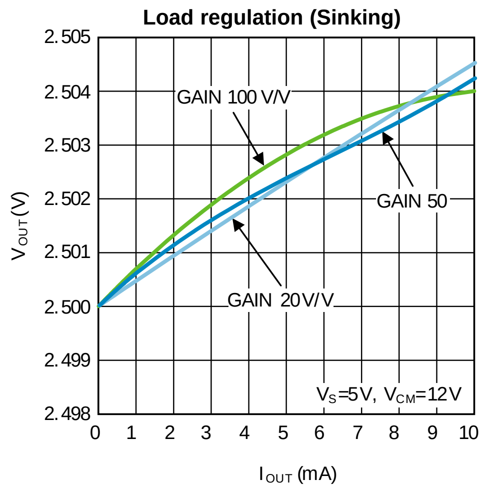


Figure .

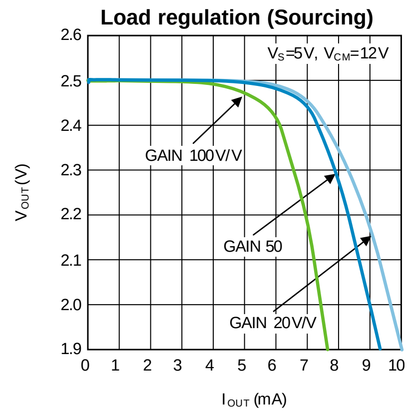


Figure 22.

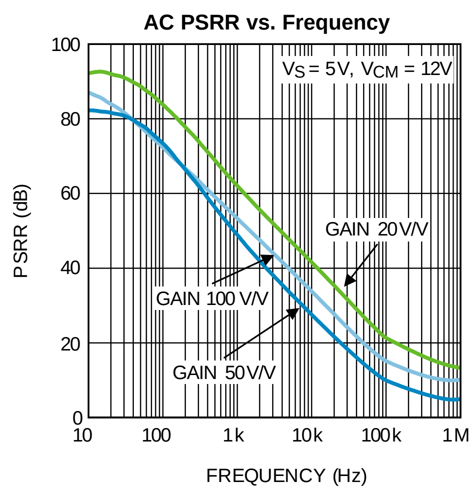


Figure 23.

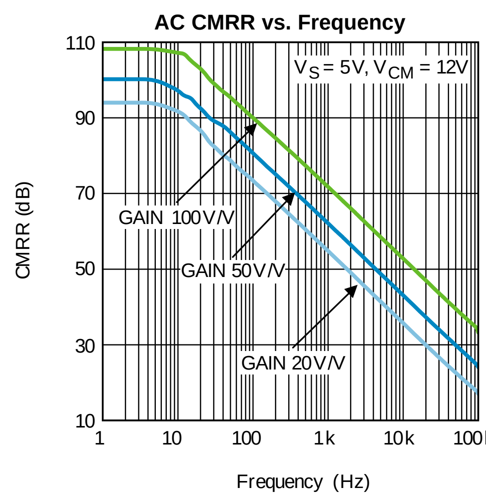


Figure 24.

APPLICATION INFORMATION

GENERAL

The LMP8640 and LMP8640HV are single supply high side current sense amplifiers with a fixed gain of 20V/V, 50V/V, 100V/V and a common mode voltage range of -2V to 42V or -2V to 76V depending on the grade.

THEORY OF OPERATION

As seen from the picture below, the current flowing through R_S develops a voltage drop equal to V_{SENSE} across R_S. The high impedance inputs of the amplifier doesn't conduct this current and the high open loop gain of the sense amplifier forces its non-inverting input to the same voltage as the inverting input. In this way the voltage drop across R_{IN} matches V_{SENSE}. A current proportional to I_S according to the following relation:

$$I_G = V_{SENSE}/R_{IN} = R_S*I_S/R_{IN}\ , \tag{1}$$

flows entirely in the internal gain resistor R_G developing a voltage drop equal to

$$V_{RG} = I_G *R_G = (V_{SENSE}/R_{IN}) *R_G = ((R_S*I_S)/R_{IN})*R_G \tag{2}$$

This voltage is buffered and showed at the output with a very low impedance allowing a very easy interface of the LMP8640 with other ICs (ADC, µC…).

$$V_{OUT} = 2*(R_S*I_S)*G, \tag{3}$$

where $G=R_G/R_{IN}$ = 10V/V, 25V/V, 50V/V, according to the gain options.

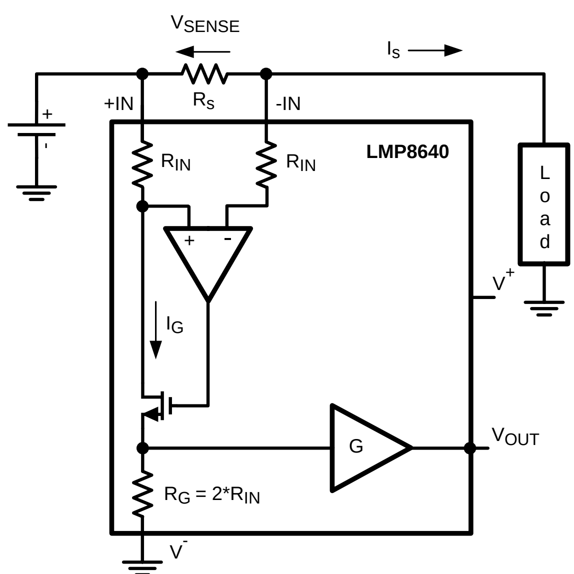


Figure 25. Current Monitor

SELECTION OF THE SHUNT RESISTOR

The value chosen for the shunt resistor, R_S, depends on the application. It plays a big role in a current sensing system and must be chosen with care. The selection of the shunt resistor needs to take in account the small-signal accuracy, the power dissipated and the voltage loss across the shunt itself. In applications where a small current is sensed, a bigger value of R_S is selected to minimize the error in the proportional output voltage. Higher resistor value improves the SNR at the input of the current sense amplifier and hence gives an accurate output. Similarly when high current is sensed, the power losses in R_S can be significant so a smaller value of R_S is suggested. In this condition is required to take in account also the power rating of R_S resistor. The low input offset of the LMP8640 allows the use of small sense resistors to reduce power dissipation still providing a good input dynamic range. The input dynamic range is the ratio expressed in dB between the maximum signal that can be measured and the minimum signal that can be detected, usually the input offset is the principal limiting factor.

DRIVING ADC

The input stage of an Analog to Digital converter can be modeled with a resistor and a capacitance versus ground. So if the voltage source doesn't have a low impedance an error in the amplitude's measurement will occur. In this case a buffer is needed to drive the ADC. The LMP8640 has an internal output buffer able to drive a capacitance load up to 30 pF or the input stage of an ADC. If required an external low pass RC filter can be added at the output of the LMP8640 to reduce the noise and the bandwidth of the current sense.

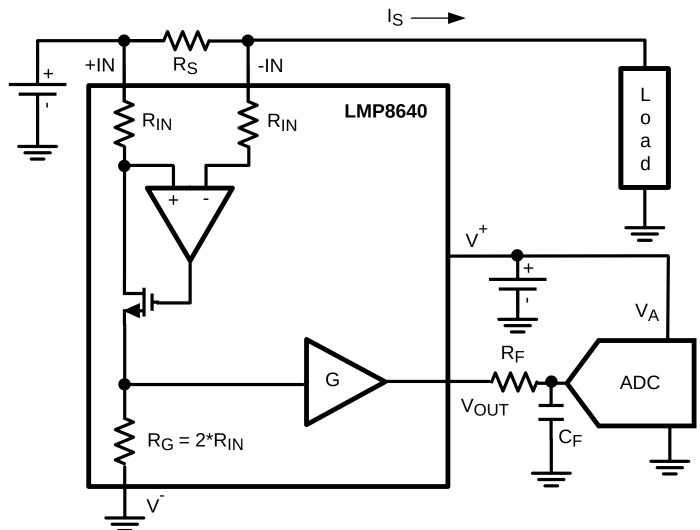


Figure 26. LMP8640 to ADC Interface

DESIGN EXAMPLE

For example in a current monitor application is required to measure the current sunk by a load (peak current 10A) with a resolution of 10mA and 0.5% of accuracy. The 10bit analog to digital converter accepts a max input voltage of 4.1V. Moreover in order to not burn much power on the shunt resistor it needs to be less than 10mΩ. In the table below are summarized the other working condition.

Working Condition	Value	
	Min	Max
Supply Voltage	5V	5.5V
Common mode Voltage	48V	70V
Temperature	0°C	70°C
Signal BW		50kHz

First step – LMP8640 / LMP8640HV selection

The required common mode voltage of the application implies that the right choice is the LMP8640HV (High common mode voltage up tp 76V).

Second step – Gain option selection

We can choose between three gain option (20V/V, 50V/V, 100V/V). considering the max input voltage of the ADC (4.1V) , the max Sense voltage across the shunt resistor is evaluated according the following formula:

V_{SENSE}= (MAX Vin ADC) / Gain;

hence the max V_{SENSE} will be 205mV, 82mV, 41mV respectively. The shunt resistor are then evaluated considering the maximum monitored current :

R_S = (max V_{SENSE}) / I_MAX

For each gain option the max shunt resistors are the following : 20.5mΩ, 8.2mΩ, 4.1mΩ respectively.

One of the project constraints requires RS<10mΩ, it means that the 20.5mΩ will be discarded and hence the 50V/V and 100V/V gain options are still in play.

Third step – Shunt resistor selection

At this point an error budget calculation, considering the calibration of the Gain, Offset, CMRR, and PSRR, helps in the selection of the shunt resistor. In the table below the contribution of each error source is calculated considering the values of the Electrical Characteristics table at 5V supply.

Table 2. Resolution Calculation

ERROR SOURCE	R_S = 4.1mΩ	R_S = 8.1mΩ
CMRR calibrated ad mid VCM range	77.9µV	77.9µV
PSRR calibrated at 5V	8.9µV	8.9µV
Total error (squared sum of contribution)	78µV	78µV
Resolution (Total error / R_S)	19.2mA	9.6mA

Table 3. Accuracy Calculation

ERROR SOURCE	R_S = 4.1mΩ	R_S = 8.1mΩ
Tc Vos	182µV	182µV
Nosie	216µV	216µV
Gain drift	75.2µV	151µV
Total error (squared sum of contribution)	293µV	320µV
Accuracy 100*(Max_V_{SENSE} / Total Error)	0.7%	0.4%

From the tables above is clear that the 8.2mΩ shunt resistor allows the respect of the project's constraints. The power burned on the Shunt is 820mW at 10A.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LMP8640HVMK-F/NOPB	ACTIVE	SOT	DDC	6	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AD6A	Samples
LMP8640HVMK-H/NOPB	ACTIVE	SOT	DDC	6	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AF6A	Samples
LMP8640HVMK-T/NOPB	ACTIVE	SOT	DDC	6	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AB6A	Samples
LMP8640HVMKE-F/NOPB	ACTIVE	SOT	DDC	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AD6A	Samples
LMP8640HVMKE-H/NOPB	ACTIVE	SOT	DDC	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AF6A	Samples
LMP8640HVMKE-T/NOPB	ACTIVE	SOT	DDC	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AB6A	Samples
LMP8640HVMKX-F/NOPB	ACTIVE	SOT	DDC	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AD6A	Samples
LMP8640HVMKX-H/NOPB	ACTIVE	SOT	DDC	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AF6A	Samples
LMP8640HVMKX-T/NOPB	ACTIVE	SOT	DDC	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AB6A	Samples
LMP8640MK-F/NOPB	ACTIVE	SOT	DDC	6	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC6A	Samples
LMP8640MK-H/NOPB	ACTIVE	SOT	DDC	6	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AE6A	Samples
LMP8640MK-T/NOPB	ACTIVE	SOT	DDC	6	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AA6A	Samples
LMP8640MKE-F/NOPB	ACTIVE	SOT	DDC	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC6A	Samples
LMP8640MKE-H/NOPB	ACTIVE	SOT	DDC	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AE6A	Samples
LMP8640MKE-T/NOPB	ACTIVE	SOT	DDC	6	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AA6A	Samples
LMP8640MKX-F/NOPB	ACTIVE	SOT	DDC	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC6A	Samples
LMP8640MKX-H/NOPB	ACTIVE	SOT	DDC	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AE6A	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LMP8640MKX-T/NOPB	ACTIVE	SOT	DDC	6	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	AA6A	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Only one of markings shown within the brackets will appear on the physical device.

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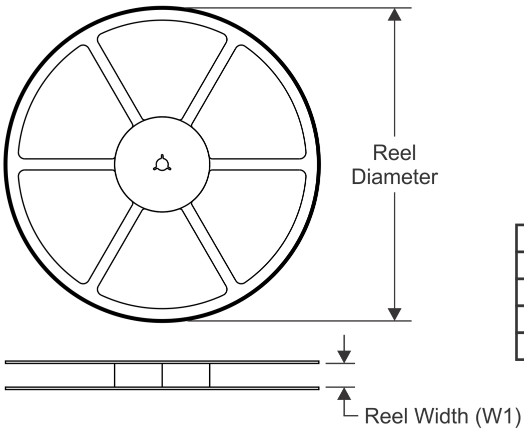
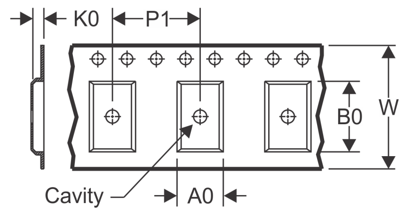
TAPE AND REEL INFORMATION

REEL DIMENSIONS

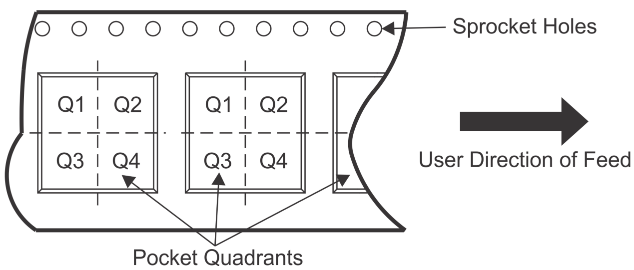


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

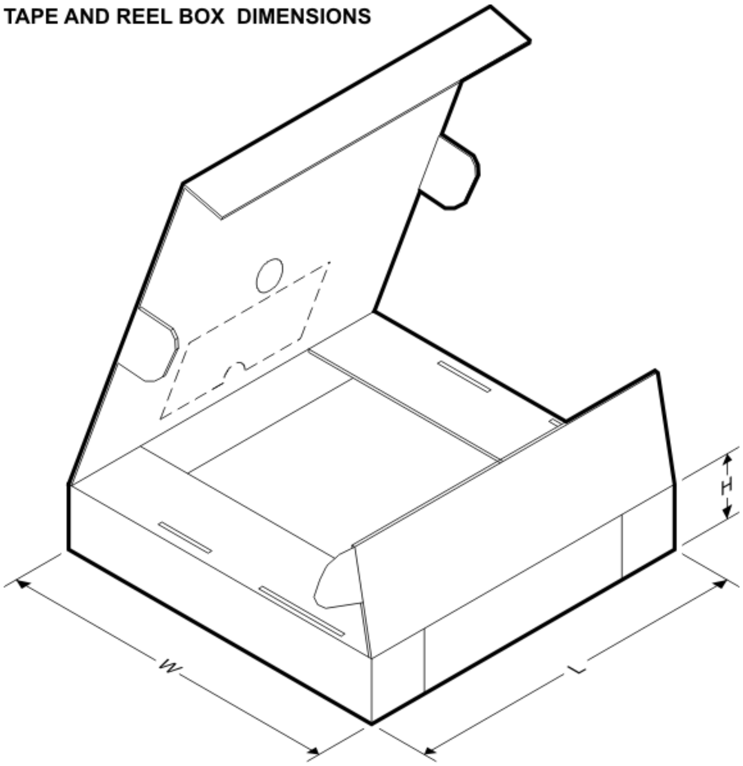


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LMP8640HVMK-F/NOPB	SOT	DDC	6	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640HVMK-H/NOPB	SOT	DDC	6	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640HVMK-T/NOPB	SOT	DDC	6	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640HVMKE-F/NOPB	SOT	DDC	6	250	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640HVMKE-H/NOPB	SOT	DDC	6	250	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640HVMKE-T/NOPB	SOT	DDC	6	250	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640HVMKX-F/NOPB	SOT	DDC	6	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640HVMKX-H/NOPB	SOT	DDC	6	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640HVMKX-T/NOPB	SOT	DDC	6	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640MK-F/NOPB	SOT	DDC	6	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640MK-H/NOPB	SOT	DDC	6	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640MK-T/NOPB	SOT	DDC	6	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640MKE-F/NOPB	SOT	DDC	6	250	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640MKE-H/NOPB	SOT	DDC	6	250	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640MKE-T/NOPB	SOT	DDC	6	250	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640MKX-F/NOPB	SOT	DDC	6	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMP8640MKX-H/NOPB	SOT	DDC	6	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LMP8640MKX-T/NOPB	SOT	DDC	6	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS

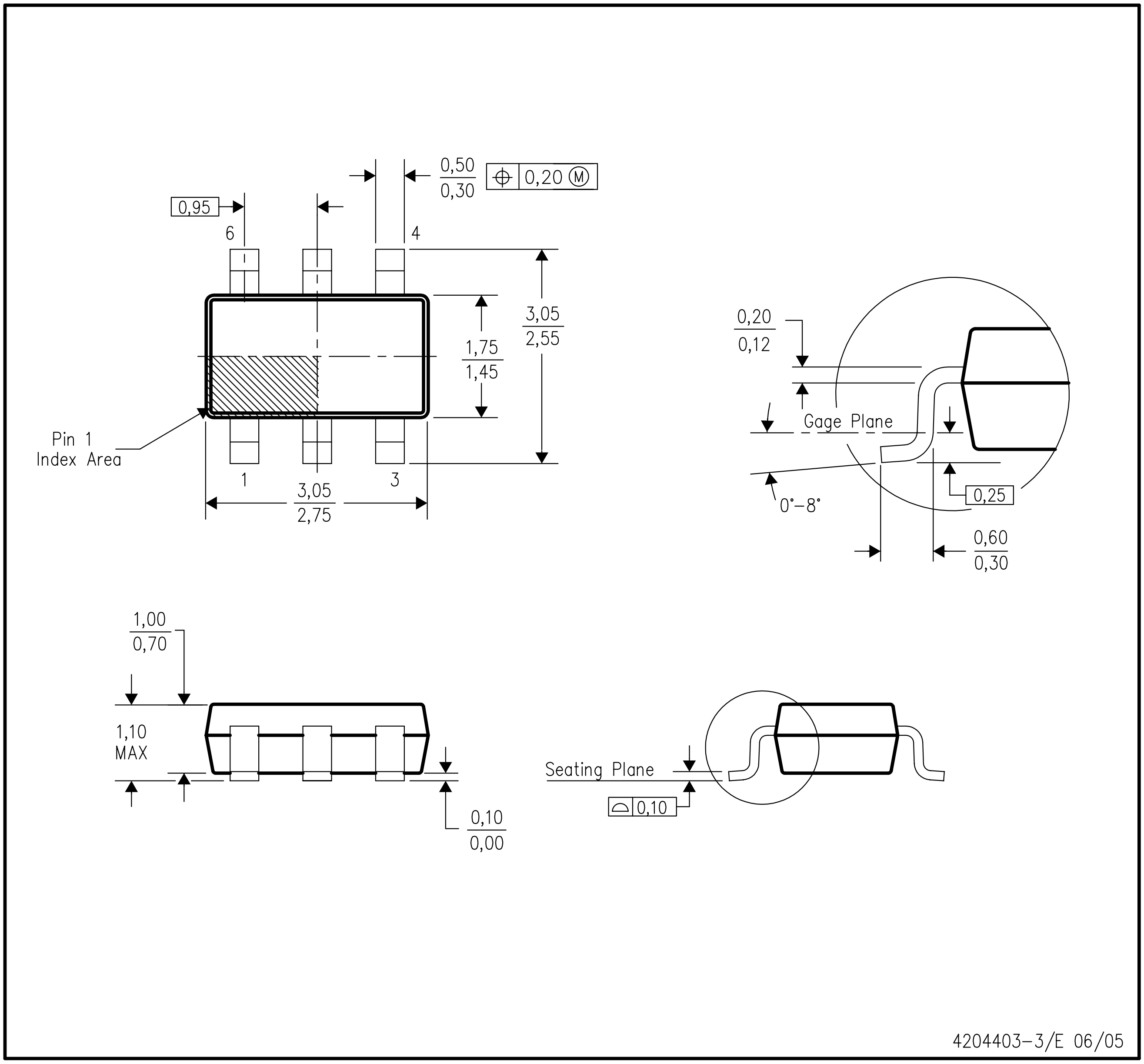


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMP8640HVMK-F/NOPB	SOT	DDC	6	1000	203.0	190.0	41.0
LMP8640HVMK-H/NOPB	SOT	DDC	6	1000	203.0	190.0	41.0
LMP8640HVMK-T/NOPB	SOT	DDC	6	1000	203.0	190.0	41.0
LMP8640HVMKE-F/NOPB	SOT	DDC	6	250	203.0	190.0	41.0
LMP8640HVMKE-H/NOPB	SOT	DDC	6	250	203.0	190.0	41.0
LMP8640HVMKE-T/NOPB	SOT	DDC	6	250	203.0	190.0	41.0
LMP8640HVMKX-F/NOPB	SOT	DDC	6	3000	206.0	191.0	90.0
LMP8640HVMKX-H/NOPB	SOT	DDC	6	3000	206.0	191.0	90.0
LMP8640HVMKX-T/NOPB	SOT	DDC	6	3000	206.0	191.0	90.0
LMP8640MK-F/NOPB	SOT	DDC	6	1000	203.0	190.0	41.0
LMP8640MK-H/NOPB	SOT	DDC	6	1000	203.0	190.0	41.0
LMP8640MK-T/NOPB	SOT	DDC	6	1000	203.0	190.0	41.0
LMP8640MKE-F/NOPB	SOT	DDC	6	250	203.0	190.0	41.0
LMP8640MKE-H/NOPB	SOT	DDC	6	250	203.0	190.0	41.0
LMP8640MKE-T/NOPB	SOT	DDC	6	250	203.0	190.0	41.0
LMP8640MKX-F/NOPB	SOT	DDC	6	3000	206.0	191.0	90.0

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMP8640MKX-H/NOPB	SOT	DDC	6	3000	206.0	191.0	90.0
LMP8640MKX-T/NOPB	SOT	DDC	6	3000	206.0	191.0	90.0

DDC (R–PDSO–G6) PLASTIC SMALL–OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.
D. Falls within JEDEC MO–193 variation AA (6 pin).

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