TPS7B4253-Q1 Automotive, 300mA, 40V, Voltage-Tracking LDO With 4mV Tracking Tolerance

1 Features

- AEC-Q100 qualified for automotive applications:
  - Temperature grade 1: –40°C to +125°C, T_A
  - Device HBM ESD classification level 3A
  - Device CDM ESD classification level C6
- Wide input-voltage range: –40V to 45V (maximum)
- Output voltage adjusts down to:
  - 1.5V to 40V (HTSSOP)
  - 2V to 40V (HSOIC PowerPAD™)
- Output Current Capability: 300mA
- Very-low output tracking tolerance, ±4mV
- Low-dropout voltage: 320mV for I_{OUT} = 200mA
- Separate pins for enable and tracking inputs (HTSSOP only)
- Low quiescent current (I_Q):
  - < 4µA when EN = low
  - 60µA (typical) at light loads
- Extremely wide ESR range:
  - Stable With 10µF to 500µF ceramic output capacitor, ESR 1mΩ to 20Ω
- Reverse polarity protection
- Current-limit and thermal-shutdown protection
- Output short-circuit proof to ground and supply
- Inductive clamp at OUT pin
- Available in the following packages:
  - 8-pin HSOIC PowerPAD
  - 20-pin HTSSOP
- For a newer drop-in alternative in the HSOIC package, see the TPS7B4260-Q1 device.

2 Applications

- Powertrain pressure sensors
- Powertrain temperature sensors
- Powertrain exhaust sensors
- Powertrain fluid concentration sensors
- Body control modules (BCM)
- Zone control module
- HVAC control module

3 Description

For automotive off-board sensors and low-current off-board modules, the power supply is through a long cable from the main board. In such cases, protection is required in the power devices for the off-board loads to prevent the onboard components from damage during a short to GND or short to battery caused by a broken cable. Off-board sensors require a power supply as consistent as that for onboard components to secure high accuracy of data acquisition.

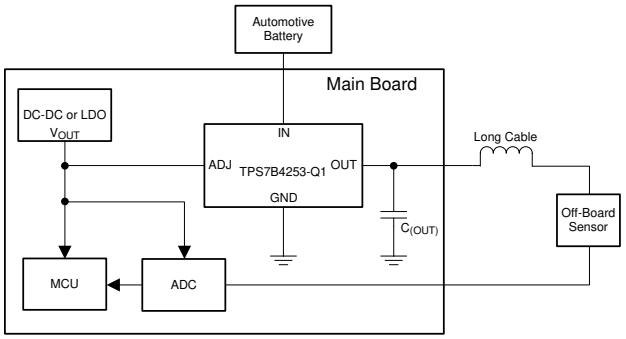
The TPS7B4253-Q1 is designed for automotive applications with a 45V load dump. The device can be used either as a tracking low-dropout (LDO) regulator or as a voltage tracker to build a closed power loop for off-board sensors with an onboard main supply. The output of the device is accurately regulated by a reference voltage at the ADJ pin.

To provide an accurate power supply to off-board modules, the device offers a 4mV ultra-low tracking tolerance between the ADJ and FB pins across temperature. The back-to-back PMOS topology eliminates the need for an external diode in a reverse-polarity condition. The TPS7B4253-Q1 also includes thermal shutdown, inductive clamp, overload, and short-to-battery protection to prevent damage to onboard components during extreme conditions.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
TPS7B4253-Q1	DDA (HSOIC, 8)	4.9mm × 6mm
	PWP (HTSSOP, 20)	6.5mm × 6.4mm

(1) For more information, see the *Mechanical, Packaging, and Orderable Information*.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Typical Application Schematic

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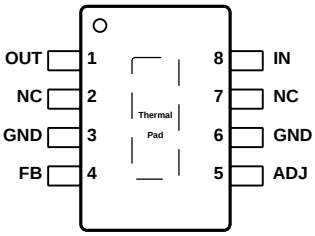
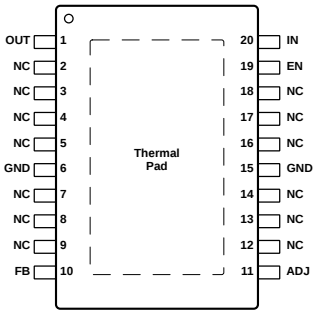
4 Pin Configuration and Functions



NC — No internal connection

Figure 4-1. DDA PowerPAD Package,8-Pin HSOIC With External Thermal Pad (Top View)



NC — No internal connection

Figure 4-2. PWP Package, 20-Pin HTSSOP With Exposed Thermal Pad (Top View)

Table 4-1. Pin Functions

PIN			TYPE[1]	DESCRIPTION
NAME	HSOIC PowerPAD	HTSSOP		
ADJ	5	11	I	Connect the reference to this pin. A low signal disables the device and a high signal enables the device. The reference voltage can be connected directly or by a voltage divider for lower output voltages. To compensate for line influences, connect a capacitor close to the device pins.
EN	—	19	I	This pin is the enable pin. The device goes to the STANDBY state when the enable pin goes lower than the threshold value.
FB	4	10	I	This pin is the feedback pin, which can connect to the external resistor divider to select the output voltage.
GND	3	6	G	Ground reference
	6	15		
IN	8	20	I	This pin is the device supply. To compensate for line influences, connect a capacitor close to the device pins.
NC	2	2-5, 7-9	NC	Not connected
	7	12-14, 16-18		
OUT	1	1	O	Block to GND with a capacitor close to the device pins that meets the capacitance and ESR requirements listed in the *Section 7.2.1.2.2* section.
Exposed thermal pad			—	Connect the thermal pad to the GND pin or leave the pad floating.

(1) I = input, O = output, G = ground, NC = no connect

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
Unregulated input voltage	IN(2) (3)	–40	45	V
Enable input voltage	Enable input voltage(2) (3)	–40	45	V
Regulated output voltage	Regulated output voltage(2) (4)	–1	45	V
Voltage difference between the input and output	IN – OUT	–40	45	V
Reference voltage	ADJ(2) (3)	–0.3	45	V
Feedback input voltage for the tracker	FB(2) (3)	–1	45	V
Reference voltage minus the input voltage	ADJ – IN(5)		18	V
Operating junction temperature, T_J		–40	150	°C
Storage temperature, T_{stg}		–65	150	°C

(1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
(2) All voltage values are with respect to the GND pin.
(3) Absolute maximum voltage.
(4) An internal diode is connected between the OUT and GND pins with 600mA DC current capability for inductive clamp protection.
(5) When the (ADJ – IN) voltage is higher than 18V, the (ADJ – OUT) voltage must maintain lower than 18V, otherwise the device can be damaged.

5.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q100-002(1)	NC pins	±2000	kV
			All pins except for NC pins	±4000	kV
		Charged device model (CDM), per AEC Q100-011		±1000	kV

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)(1)

			MIN	MAX	UNIT
V_{IN}	Unregulated input voltage(2)		4	40	V
V_{EN}	Enable input voltage		0	40	V
V_{ADJ}	Adjust and enable input voltage	HTSSOP package	1.5	18	V
		SO PowerPAD package	2	18	
V_{FB}	Feedback input voltage for the tracker	HTSSOP package	1.5	18	V
		SO PowerPAD package	2	18	
V_{OUT}	Output voltage	HTSSOP package	1.5	40	V
		SO PowerPAD package	2	40	
$C_{(OUT)}$	Output capacitor requirements(3)		10	500	µF
	Output ESR requirements(4)		0.001	20	Ω
T_J	Operating junction temperature range		–40	150	°C

(1) Within the functional range the device operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the related *Electrical Characteristics* table.
(2) $V_{IN} > V_{ADJ} + V_{(DROPOUT)}$
(3) The minimum output capacitance requirement is applicable for a worst-case capacitance tolerance of 30%, when a resistor divider is connected between the OUT and FB pins (the output voltage is higher than reference voltage), a 47nF feedforward capacitor is

required to be connected between the OUT and FB pins for loop stability, and the ESR range of the output capacitor is required to be from 0.001 to 10Ω.

(4) Relevant ESR value at f = 10kHz

5.4 Thermal Information

THERMAL METRIC[1]		TPS7B4253-Q1			UNIT
		DDA (SO PowerPAD)		PWP (HTSSOP)	
		8 PINS		20 PINS	
		ASO: ASE[2]	ASO: FMX[2]		
$R_{\theta JA}$	Junction-to-ambient thermal resistance	45.4	42.6	45.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	51.1	57.5	29.2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	27	17.8	24.7	°C/W
ψ_{JT}	Junction-to-top characterization parameter	8.2	5.6	1.3	°C/W
ψ_{JB}	Junction-to-board characterization parameter	26.9	17.9	24.5	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	6.4	7.5	3.7	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application note.

(2) See nomenclature table for more information regarding ASO.

5.5 Electrical Characteristics

V_{IN} = 13.5V, V_{ADJ} ≥ 1.5V for HTSSOP, V_{ADJ} ≥ 2V for SO PowerPAD, V_{EN} ≥ 2V, T_J = –40°C to 150°C unless otherwise stated

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{I(UVLO)}$	IN undervoltage detection	V_{IN} rising				3.65	V
		V_{IN} falling				2.8	V
ΔVO	Output voltage tracking accuracy[1]	I_{OUT} = 100µA to 300mA, V_{IN} = 4 to 40V V_{ADJ} < V_{IN} – 1V 1.5V < V_{ADJ} < 18V for HTSSOP 2V < V_{ADJ} < 18V for SO PowerPAD		–4		4	mV
$\Delta V_{O(\Delta IO)}$	Load regulation steady-state	I_{OUT} = 0.1 to 300mA, V_{ADJ}= 5V				4	mV
$\Delta V_{O(\Delta VI)}$	Line regulation steady-state	I_{OUT}= 10mA, V_{IN} = 6 to 40V, V_{ADJ} = 5V				4	mV
PSRR	Power supply ripple rejection	f_{rip} = 100Hz, V_{rip} = 0.5V_{PP}, $C_{(OUT)}$ = 10µF, I_{OUT} = 100mA			70		dB
$V_{(DROPOUT)}$	Dropout voltage ($V_{(DROPOUT)}$ = V_{IN} – V_{OUT})	I_{OUT} = 200mA, V_{IN} = V_{ADJ} ≥ 4V[2]			320	520	mV
$I_{O(lim)}$	Output current limitation	V_{ADJ} = 5V, OUT short to GND		301	450	520	mA
$I_{R(IN)}$	Reverse current at IN	V_{IN} = 0V, V_{OUT} = 40V, V_{ADJ} = 5V		–2		0	µA
$I_{R(–IN)}$	Reverse current at negative IN	V_{IN} = –40V, V_{OUT} = 0V, V_{ADJ} = 5V		–10		0	µA
T_{SD}	Thermal shutdown temperature	T_J increases because of power dissipation generated by the IC			175		°C
T_{SD_hys}	Thermal shutdown hysteresis				15		°C
I_Q	Current consumption	4V ≤ V_{IN} ≤ 40V, V_{ADJ} = 0V; V_{EN} = 0V			2	4	µA
		4V ≤ V_{IN} ≤ 40V, V_{EN} ≥ 2V, V_{ADJ} < 0.8V			7	18	
		4V ≤ V_{IN} ≤ 40V, I_{OUT} < 100µA, V_{ADJ} = 5V			60	100	
		4V ≤ V_{IN} ≤ 40V, I_{OUT} < 300mA, V_{ADJ} = 5V			350	400	
$I_{Q(DROPOUT)}$	Current consumption in dropout region	V_{IN} = V_{ADJ} = 5V, I_{OUT} = 100µA			70	140	µA
$I_{I(ADJ)}$	Adjust input current	V_{ADJ} = V_{FB} = 5V	HTSSOP package			0.5	µA
			SO PowerPAD package			5.5	
$V_{(ADJ\_LOW)}$	Adjust low signal valid	V_{OUT} = 0V	HTSSOP package	0		0.8	V
			SO PowerPAD package	0		0.7	
$V_{(ADJ\_HIGH)}$	Adjust high signal valid	|V_{OUT} – V_{ADJ}| < 4mV	HTSSOP package	1.5		18	V
			SO PowerPAD package	2		18	
$V_{(EN\_LOW)}$	Enable low signal valid	V_{OUT} = 0V		0		0.7	V
$V_{(EN\_HIGH)}$	Enable high Signal Valid	OUT settled		2		40	V

5.5 Electrical Characteristics (continued)

V_{IN} = 13.5V, V_{ADJ} ≥ 1.5V for HTSSOP, V_{ADJ} ≥ 2V for SO PowerPAD, V_{EN} ≥ 2V, T_J = –40°C to 150°C unless otherwise stated

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{EN}	Enable pulldown current	2V < V_{EN} < 40V			5	µA
I_{FB}	FB bias current	V_{ADJ} = V_{FB} = 5V			0.5	µA

(1) The tracking accuracy is specified when the FB pin is directly connected to the OUT pin which means V_{ADJ} = V_{OUT}, external resistor divider variance is not included.
(2) Measured when the output voltage, V_{OUT} has dropped 10mV from the nominal value.

5.6 Typical Characteristics

V_{IN} = 14V, V_{ADJ} = 5V, V_{FB} = V_{OUT} (unless otherwise noted)

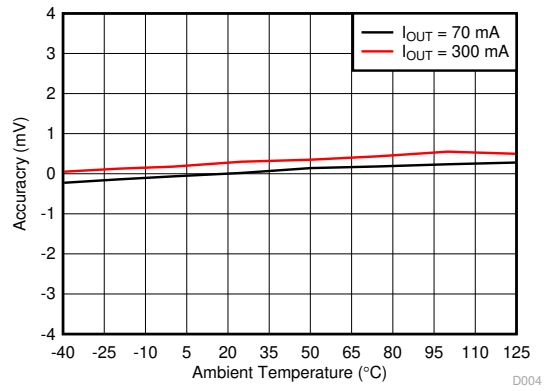


Figure 5-1. Tracking Accuracy vs Ambient Temperature

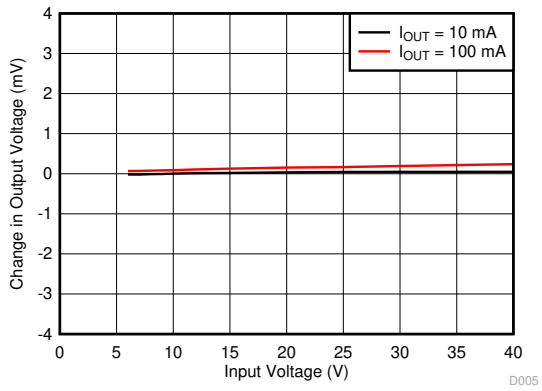


Figure 5-2. Line Regulation

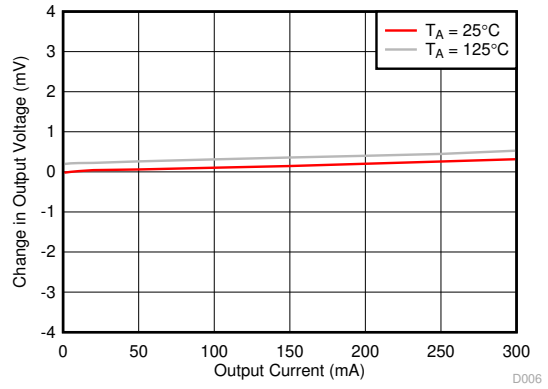
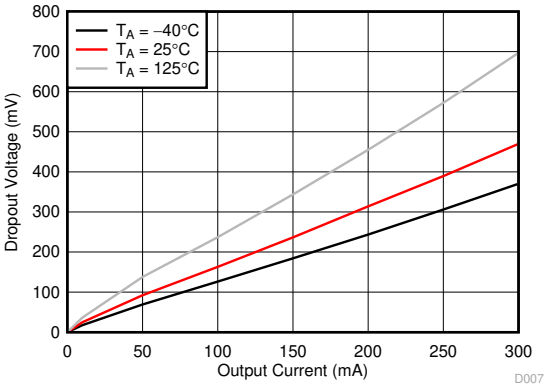


Figure 5-3. Load Regulation

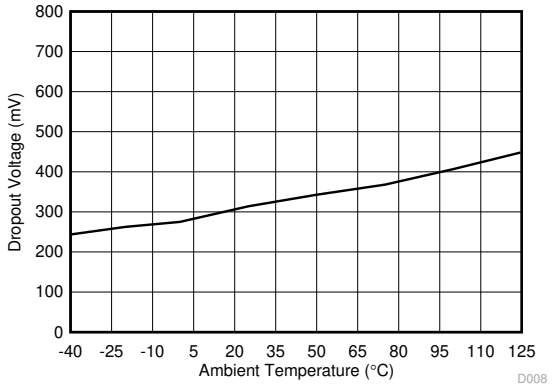


V_{IN} = V_{ADJ} = 4V

Figure 5-4. Dropout Voltage vs Output Current

5.6 Typical Characteristics (continued)

V_{IN} = 14V, V_{ADJ} = 5V, V_{FB} = V_{OUT} (unless otherwise noted)



V_{IN} = V_{ADJ} = 4V, I_{OUT} = 200mA

Figure 5-5. Dropout Voltage vs Ambient Temperature

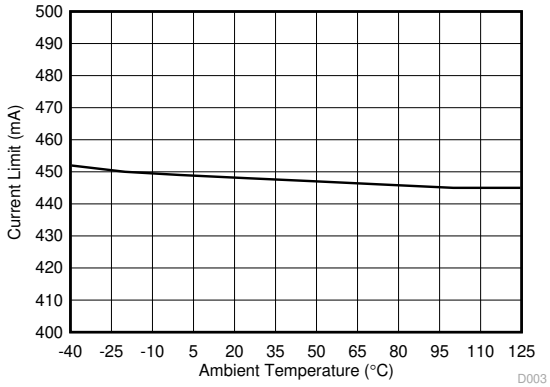


Figure 5-6. Current Limit ($I_{O(lim)}$) vs Ambient Temperature

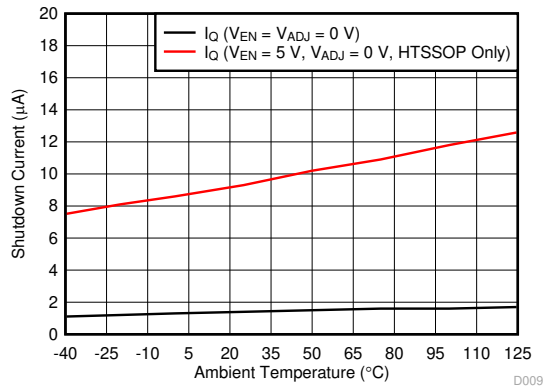


Figure 5-7. Shutdown Current vs Ambient Temperature

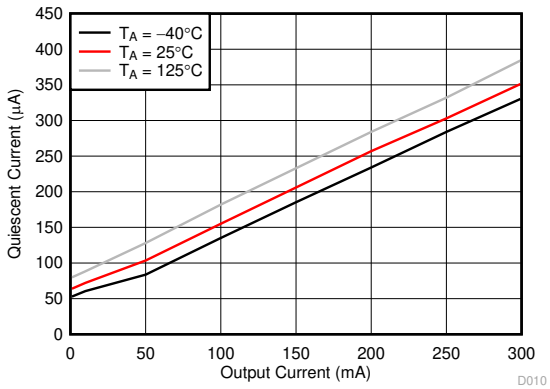


Figure 5-8. Quiescent Current vs Output Current

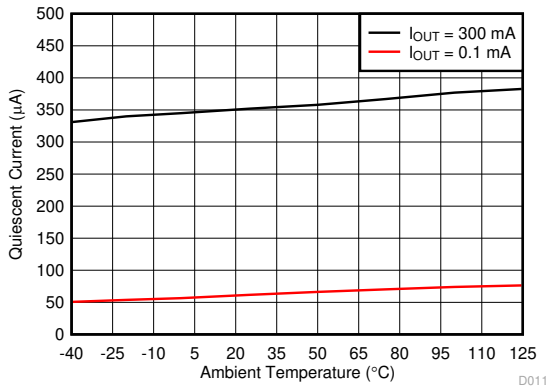
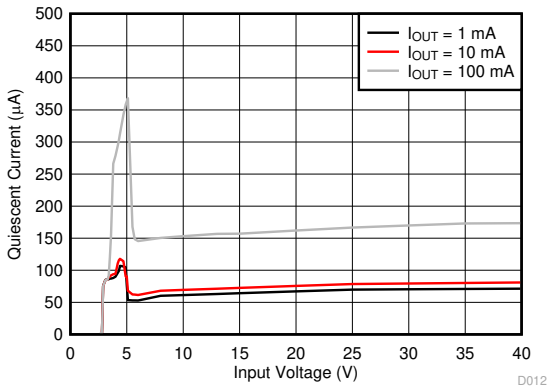


Figure 5-9. Quiescent Current vs Ambient Temperature

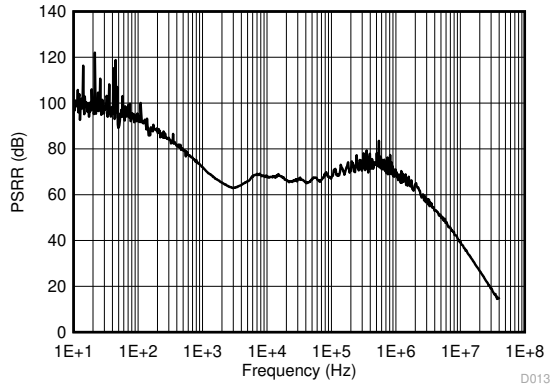


V_{ADJ} = V_{EN} = 5V

Figure 5-10. Quiescent Current vs Input Voltage

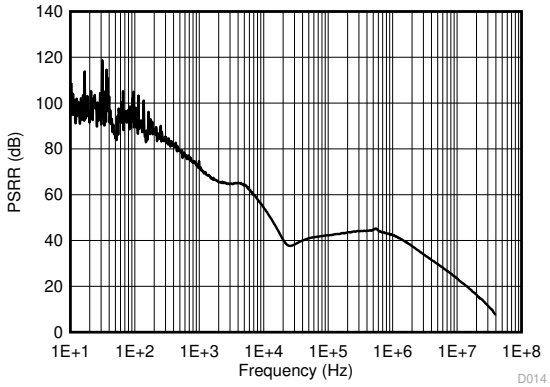
5.6 Typical Characteristics (continued)

V_{IN} = 14V, V_{ADJ} = 5V, V_{FB} = V_{OUT} (unless otherwise noted)



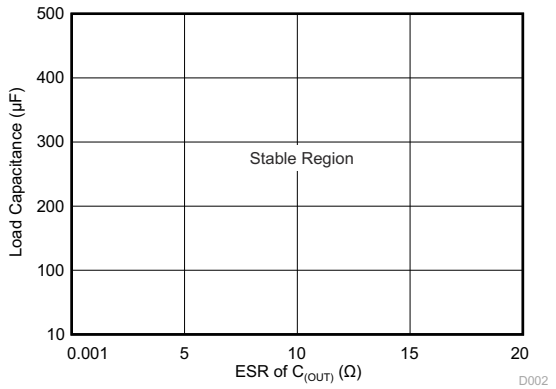
$C_{(OUT)}$ = 10µF, I_{OUT} = 1mA, T_A = 25°C

Figure 5-11. PSRR



$C_{(OUT)}$ = 10µF, I_{OUT} = 100mA, T_A = 25°C

Figure 5-12. PSRR



V_{FB} = V_{OUT}

Figure 5-13. ESR Stability vs Load Capacitance

V_{FB} < V_{OUT}

Figure 5-14. ESR Stability vs Load Capacitance

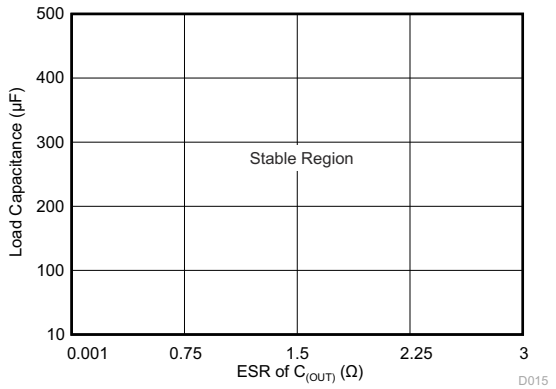
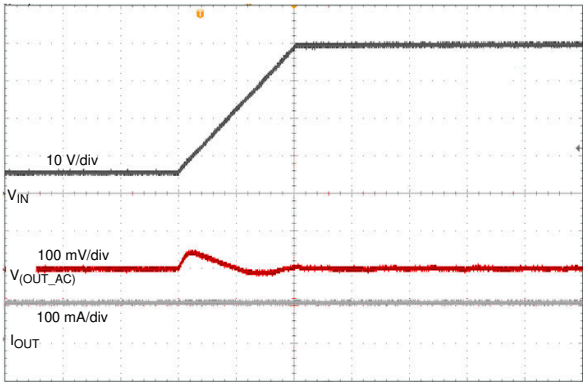


Figure 5-15. ESR Stability vs Load Capacitance (Multiple Output Capacitors)

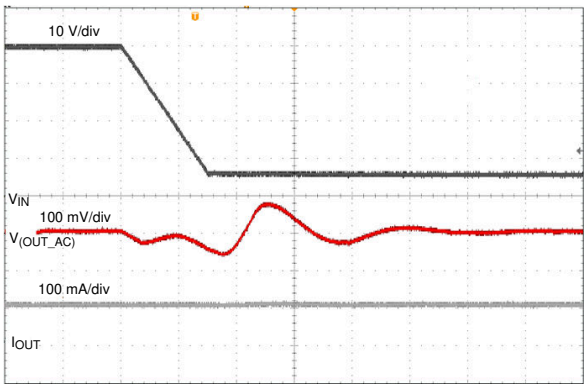


V_{IN} = 6V to 40V, V_{ADJ} = 5V, $C_{(OUT)}$ = 10µF, I_{OUT} = 100mA, 20µs/div

Figure 5-16. 6V to 40V Line Transient

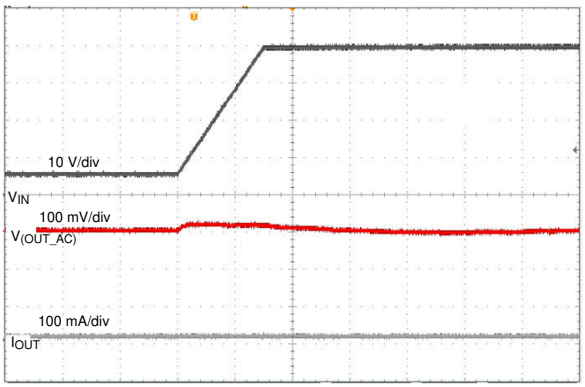
5.6 Typical Characteristics (continued)

V_{IN} = 14V, V_{ADJ} = 5V, V_{FB} = V_{OUT} (unless otherwise noted)



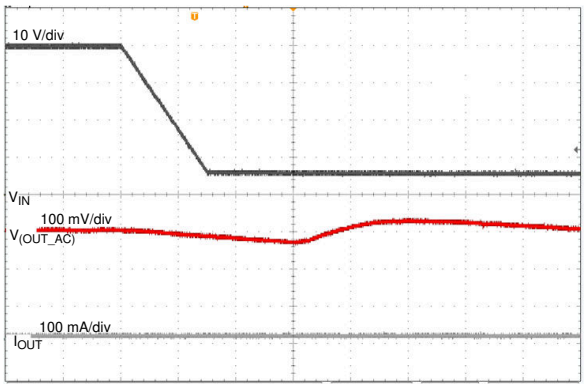
V_{IN} = 40V to 6V, V_{ADJ} = 5V, $C_{(OUT)}$ = 10µF, I_{OUT} = 100mA, 20µs/div

Figure 5-17. 40V to 6V Line Transient



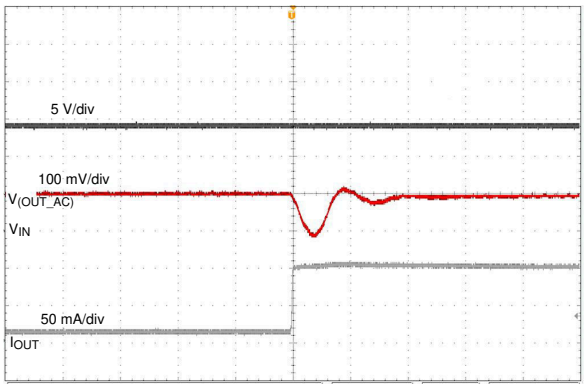
V_{IN} = 6V to 40V, V_{ADJ} = 5V, $C_{(OUT)}$ = 10µF, I_{OUT} = 10mA, 20µs/div

Figure 5-18. 6V to 40V Line Transient



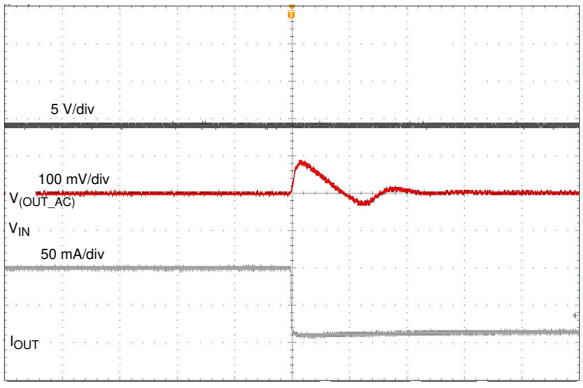
V_{IN} = 40V to 6V, V_{ADJ} = 5V, $C_{(OUT)}$ = 10µF, I_{OUT} = 10mA, 20µs/div

Figure 5-19. 40V to 6V Line Transient



V_{IN} = 14V, V_{ADJ} = 5V, $C_{(OUT)}$ = 10µF, I_{OUT} = 10 to 100mA, 40µs/div

Figure 5-20. 10mA to 100mA Load Transient



V_{IN} = 14V, V_{ADJ} = 5V, $C_{(OUT)}$ = 10µF, I_{OUT} = 100 to 10mA, 40µs/div

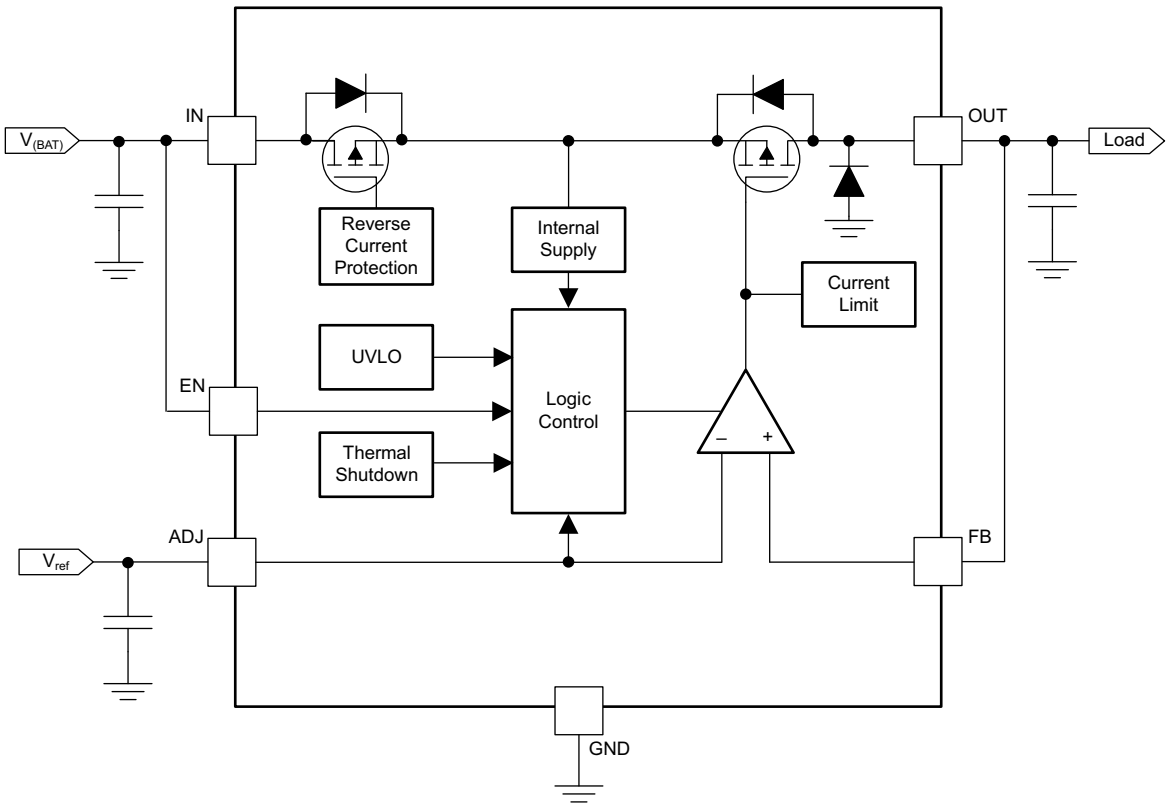
Figure 5-21. 100mA to 10mA Load Transient

6 Detailed Description

6.1 Overview

The TPS7B4253-Q1 device is a monolithic integrated low-dropout voltage tracker with an ultralow tracking tolerance. Key protection circuits are integrated in the device, including output current limitation, reverse polarity protection, inductive load clamp, output short-to-battery protection, and thermal shutdown in case of an overtemperature event.

6.2 Functional Block Diagram



6.3 Feature Description

6.3.1 Short Circuit and Overcurrent Protection

The TPS7B4253-Q1 device features integrated fault protection, which makes the device a convinient choice for automotive applications. To keep the device in a safe area of operation during certain fault conditions, internal current-limit protection is used to limit the maximum output current. This protection protects the device from excessive power dissipation. For example, during a short-circuit condition on the output, the current through the pass element is limited to $I_{O(lim)}$ to protect the device from excessive power dissipation.

6.3.2 Integrated Inductive Clamp Protection

During output turnoff, the cable inductance continues to source the current from the output of the device. The device integrates an inductive clamp at the OUT pin to help to dissipate the inductive energy stored in the cable. An internal diode is connected between the OUT and GND pins with a dc-current capability of 600mA for inductive clamp protection.

6.3.3 OUT Short to Battery and Reverse Polarity Protection

The TPS7B4253-Q1 device can withstand a short to battery, as shown in Figure 6-1. Therefore, no damage to the device occurs.

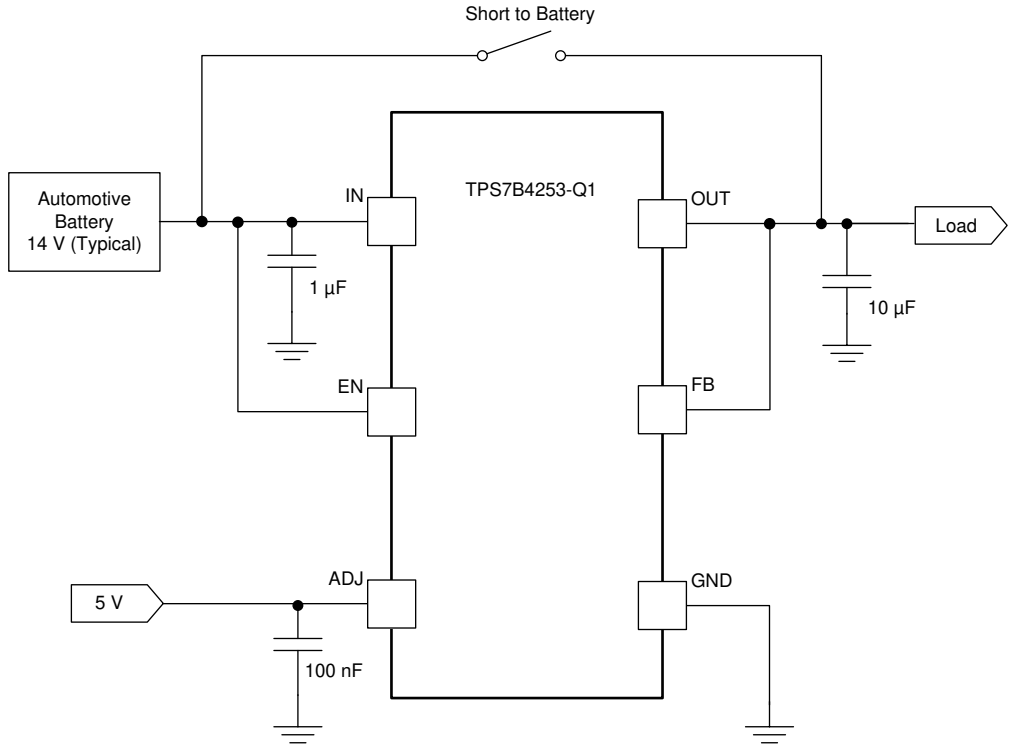


Figure 6-1. OUT Short to Battery, $V_{IN} = V_{(BAT)}$

A short to the battery can also occur when the device is powered by an isolated supply at lower voltage, as shown in Figure 6-2. In this case, the TPS7B4253-Q1 supply-input voltage is set to 7V when a short to battery (14V typical) occurs on the OUT pin which operates at 5V. The internal back-to-back PMOS remains on for 1ms, during which the input voltage of the TPS7B4253-Q1 device charges up to the battery voltage. A diode connected between the output of the dc-dc converter and the input of the TPS7B4253-Q1 device is required in case the other loads connected behind the dc-dc converter cannot withstand the voltage of an automotive battery. To achieve a lower dropout voltage, TI recommends using a Schottky diode. This diode can be eliminated if the output of the dc-dc converter and the loads the converter powers, are able to withstand automotive battery voltage.

The internal back-to-back PMOS is switched to OFF when reverse polarity or a short to battery occurs for 1ms. After that, the reverse current flows out through the IN pin with less than 10µA. Meanwhile, a special ESD structure implemented at the input helps the device withstand –40V.

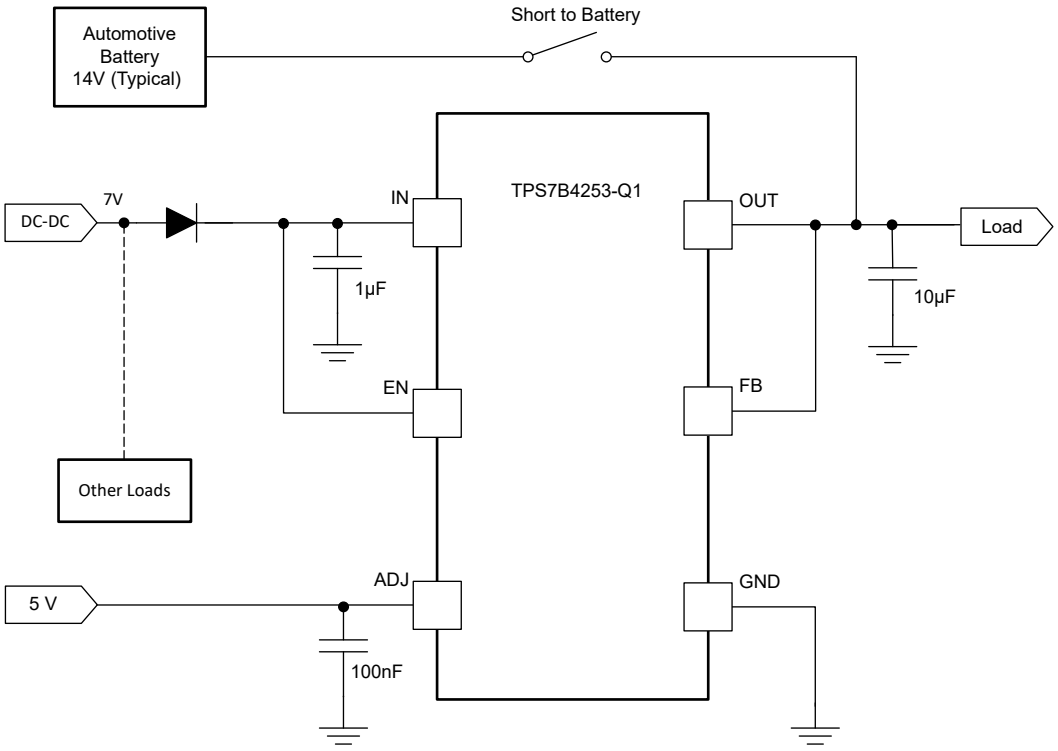


Figure 6-2. OUT Short to Battery, $V_{IN} < V_{(BAT)}$

In most cases, the output of the TPS7B4253-Q1 device is shorted to the battery through an automotive cable. The parasitic inductance on the cable results in LC oscillation at the output of the TPS7B4253-Q1 device when the short to battery occurs. Ideally, the peak voltage at the output of the TPS7B4253-Q1 device must be lower than the absolute-maximum voltage rating (45 V) during LC oscillation.

6.3.4 Undervoltage Shutdown

The device has an internally fixed undervoltage-shutdown threshold. Undervoltage shutdown activates when the input voltage on IN drops below UVLO. This activation helps prevent the regulator from getting latched into an unknown state during a low-input-supply voltage condition. If the input voltage has a negative transient that drops below the UVLO threshold and then recovers, the regulator shuts down and then powers up with a standard power-up sequence when the input voltage is above the required levels.

6.3.5 Thermal Protection

The device incorporates a thermal shutdown (TSD) circuit as a protection from overheating. During continuous normal operation, the junction temperature must not exceed the TSD trip point. If the junction temperature exceeds the TSD trip point, the output turns off. When the junction temperature decreases to 15°C (typical) lower than the TSD trip point, the output turns on.

Note

The purpose of the design of the internal protection circuitry of the TPS7B4253-Q1 device is to protect against overload conditions and is not intended as a replacement for proper heat-sinking. Continuously running the device into thermal shutdown degrades device reliability.

6.3.6 Regulated Output (OUT)

The OUT pin is the regulated output based on the required voltage. The output has current limitation. During initial power up, the regulator has an incorporated soft-start feature to control the initial current through the pass element.

6.3.7 Enable (EN)

The EN pin is a high-voltage-tolerant pin. A high input on the EN pin activates the device and turns on the regulator. The device consumes a maximum shutdown current of 4µA when the EN pin is low. The EN pin has a maximum internal pulldown of 5µA.

6.3.8 Adjustable Output Voltage (FB and ADJ)

6.3.8.1 OUT Voltage Equal to the Reference Voltage

With the reference voltage applied directly at the ADJ pin and the FB pin connected to the OUT pin, the voltage at the OUT pin equals the reference voltage at the ADJ pin, as shown in Figure 6-3.

$$V_{OUT} = V_{ADJ} \quad (1)$$

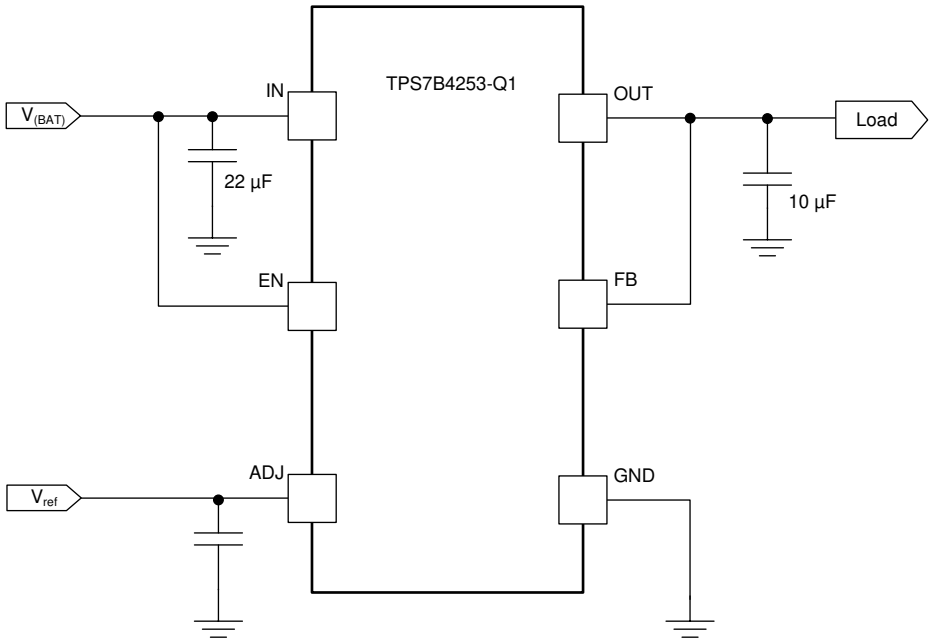


Figure 6-3. OUT Voltage Equal to the Reference Voltage

6.3.8.2 OUT Voltage Higher Than Reference Voltage

By using an external resistor divider connected between the OUT and FB pins, an output voltage higher than reference voltage can be generated as shown in Figure 6-4. Use Equation 2 to calculate the value of the output voltage. The recommended range for R1 and R2 is from 10kΩ to 100kΩ.

$$V_{OUT} = \frac{V_{ADJ} \times (R1 + R2)}{R2} \quad (2)$$

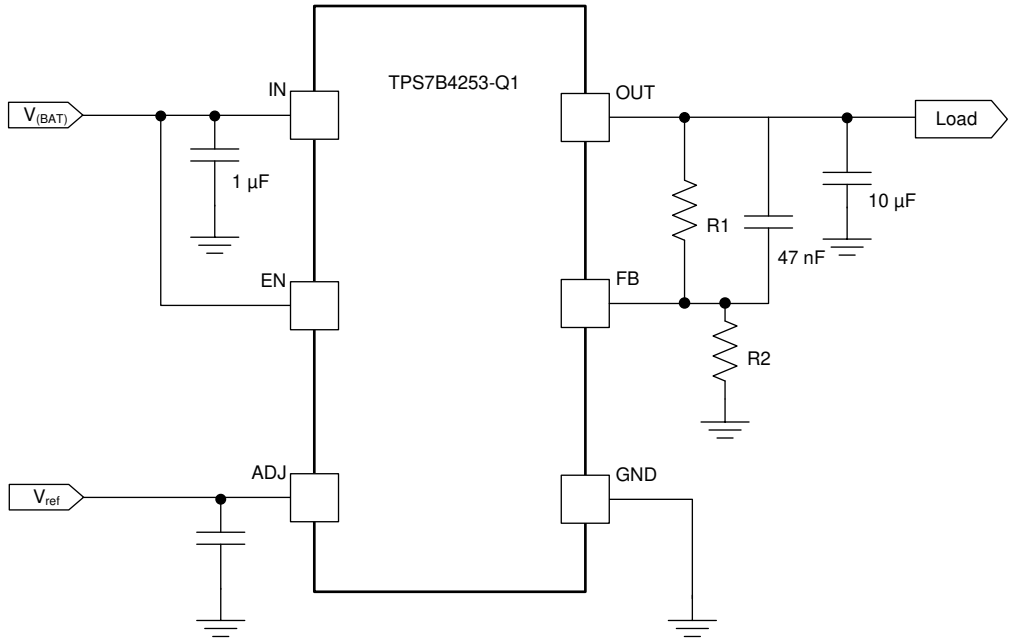


Figure 6-4. OUT Voltage Higher Than the Reference Voltage

6.3.8.3 Output Voltage Lower Than Reference Voltage

By using an external resistor divider connected at the ADJ pin, an output voltage lower than reference voltage can be generated as shown in Figure 6-5. Use Equation 3 to calculate the output voltage. The recommended value for both R1 and R2 is less than 100kΩ.

$$V_{OUT} = \frac{V_{ref} \times R2}{R1 + R2} \quad (3)$$

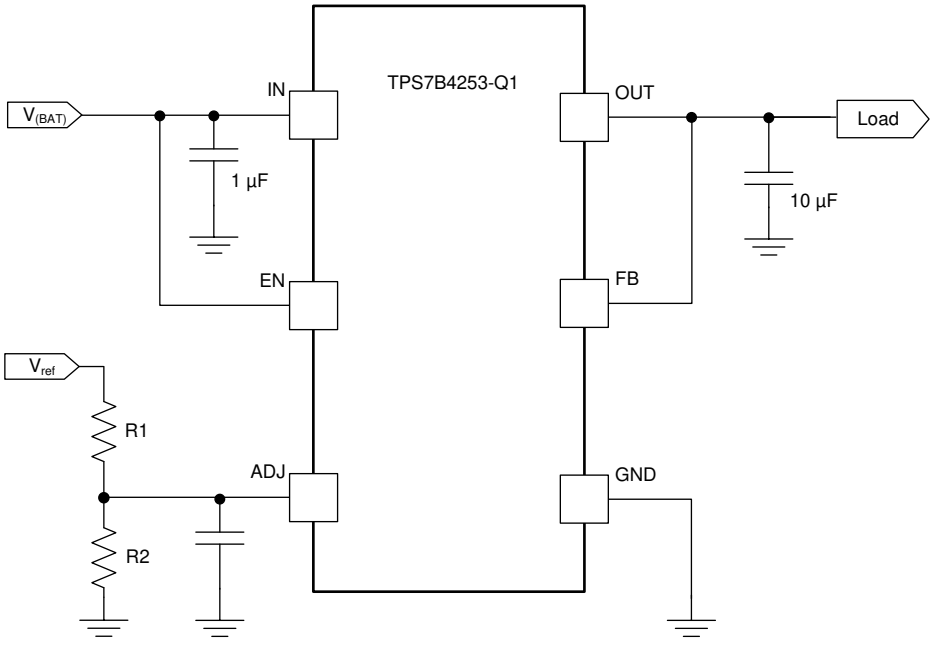


Figure 6-5. OUT Voltage Lower Than the Reference Voltage

6.4 Device Functional Modes

6.4.1 Operation With V_{IN} < 4V

The maximum UVLO voltage is 3.65V, and the device generally operates at an input voltage above 4V. The device can also operate at a lower input voltage; no minimum UVLO voltage is specified. At an input voltage below the actual UVLO voltage, the device does not operate.

6.4.2 Operation With EN Control

The enable rising-edge threshold is 2V (maximum). With the EN pin held above that voltage and the input voltage above 4V, the device becomes active. The falling edge of the EN pin is 0.7V (minimum). Holding the EN pin below that voltage disables the device, thus reducing the quiescent current of the device.

7 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

7.1 Application Information

The TPS7B4253-Q1 device is a 300mA low-dropout tracking regulator with ultralow tracking tolerance. The PSpice transient model is available for download on the product folder and can be used to evaluate the basic function of the device.

7.2 Typical Applications

7.2.1 Application With Output Voltage Equal to the Reference Voltage

Figure 7-1 shows the typical application circuit for the TPS7B4253-Q1 device (using the HTSSOP package as an example). Different values of external components can be used depending on the end application. Some applications require a larger output capacitor during fast load steps to prevent a large drop on the output voltage. TI recommends using a low-ESR ceramic capacitor with a dielectric of type X5R or X7R.

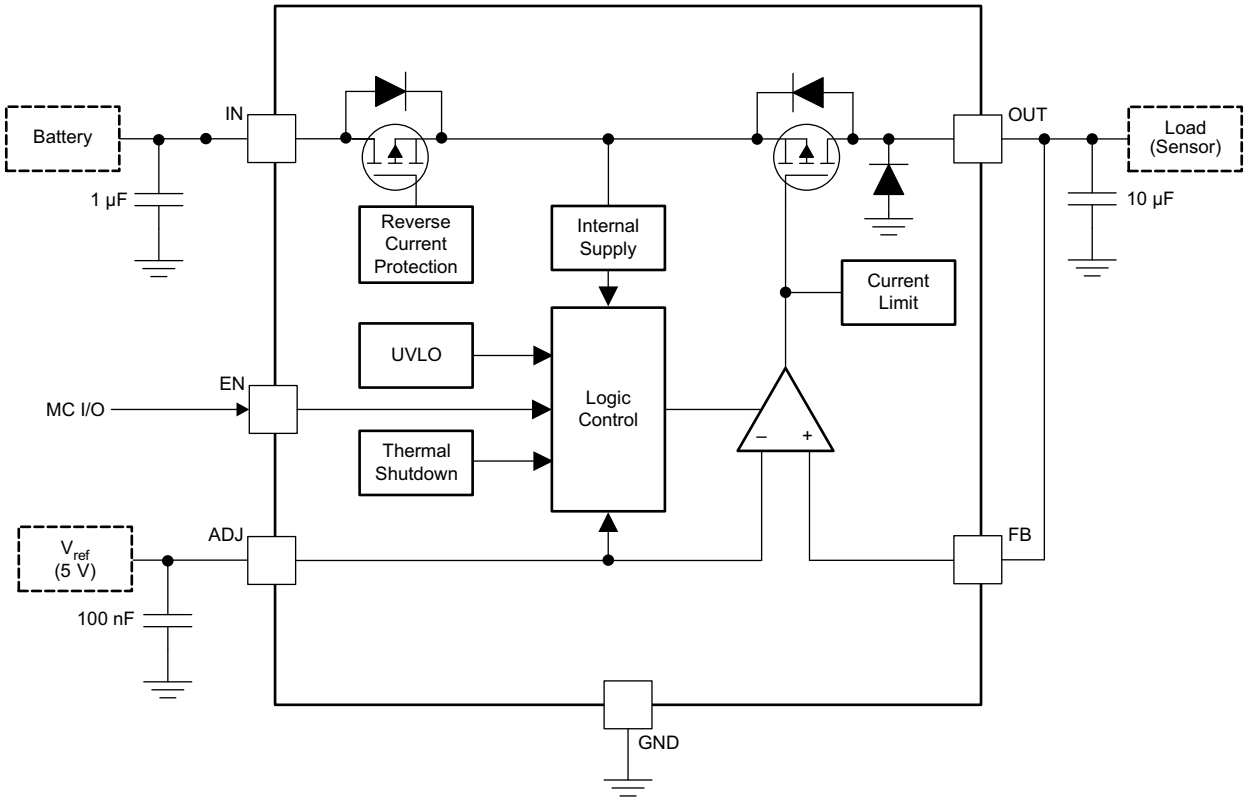


Figure 7-1. Output Voltage Equals the Reference Voltage

7.2.1.1 Design Requirements

For this design example, use the parameters listed in Table 7-1 as the design parameters.

Table 7-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input voltage	4V to 40V
Output voltage	1.5V to 40V
Enable voltage	2V to 40V
ADJ voltage	1.5V to 18V
Output capacitor	10 µF to 500 µF
Output capacitor ESR range	0.001Ω to 20Ω

7.2.1.2 Detailed Design Procedure

To begin the design process, determine the following:

- Input voltage range
- Output voltage
- Reference voltage
- Output current
- Current limit

7.2.1.2.1 Input Capacitor

The device requires an input decoupling capacitor, the value of which depends on the application. The typical recommended value for the decoupling capacitor is 2.2µF. The voltage rating must be greater than the maximum input voltage.

7.2.1.2.2 Output Capacitor

For stable operation, the TPS7B4253-Q1 device requires an output capacitor with a value in the range from 10µF to 500µF and with an ESR range from 0.001Ω to 20Ω when the FB pin is directly connected to the OUT pin. TI recommends selecting a ceramic capacitor with low ESR to improve the load transient response.

To achieve an output voltage higher than the reference voltage, a resistor divider is connected between the OUT pin and the FB pin. In this case, a 47nF feed-forward capacitor must be connected between the OUT and FB pins for loop stability. The ESR of the output capacitor must be from 0.001Ω to 10Ω.

When multiple capacitors (two or more) are connected in parallel at the OUT pin, the ESR range of each output capacitor must be from 0.001Ω to 3Ω for loop stability.

In case the FB pin is shorted to ground, the TPS7B4253-Q1 device functions as a power switch with no need for the output capacitor.

7.2.1.3 Application Curve

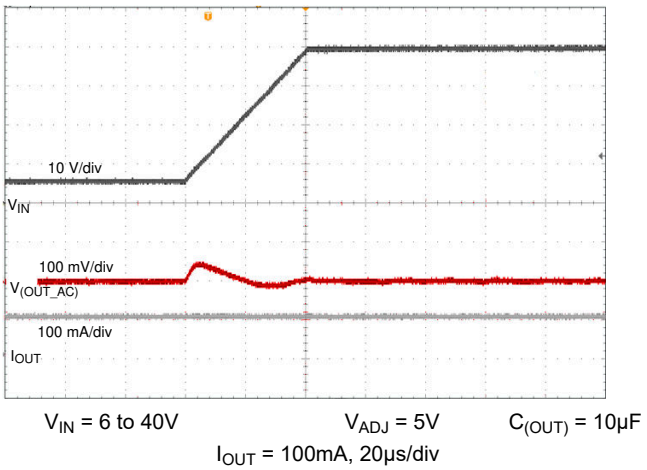


Figure 7-2. 6- to 40V Line Transient

7.2.2 High-Side Switch Configuration

As shown in Figure 7-3, by connecting the FB pin to the GND pin, the TPS7B4253-Q1 device can be used as a high-side switch with current-limit, thermal shutdown, output short-to-battery, and reverse polarity protection. The switching on and off of the device is then controlled through the EN and ADJ pins.

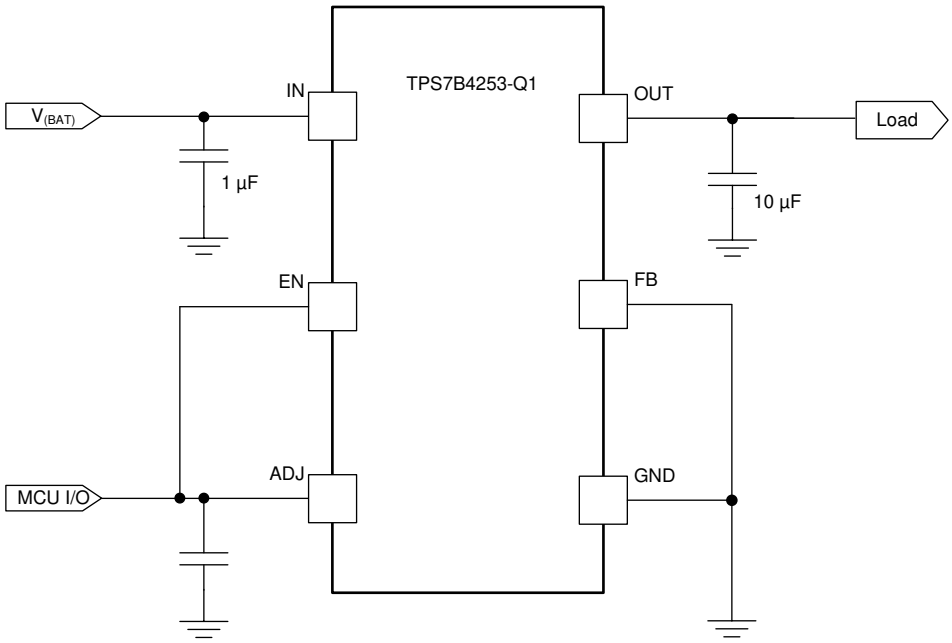


Figure 7-3. High-Side Switch Application

7.2.3 High Accuracy LDO

With an accurate voltage rail, the TPS7B4253-Q1 device can be used as an LDO with ultrahigh-accuracy output voltage by configuring the device as shown in Figure 7-4.

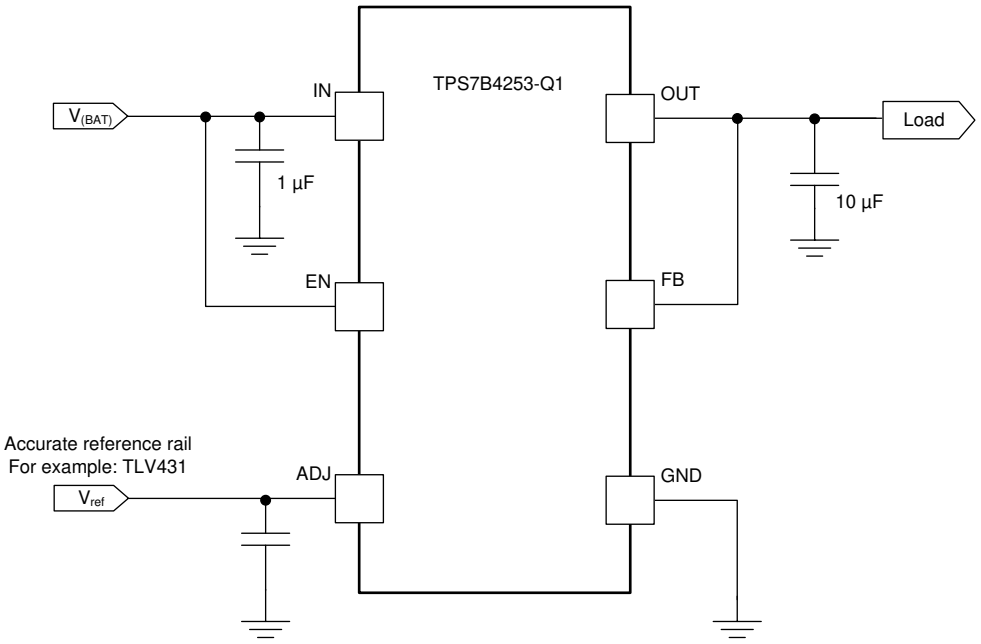


Figure 7-4. High-Accuracy LDO Application

For example, assume the reference voltage is a 5V rail with 0.5% accuracy. Because the tracking accuracy between the ADJ and OUT pins is specified below 4mV across temperature, the output accuracy of the TPS7B4253-Q1 device can be calculated with Equation 4.

$$\text{Accuracy of } V_{OUT} = \frac{V_{ADJ} \times 0.5\% + 4\text{ mV}}{V_{ADJ}} \times 100\% = \frac{5 \times 0.5\% + 0.004}{5} \times 100\% = 0.58\% \quad (4)$$

7.3 Power Supply Recommendations

The device is designed to operate with an input voltage supply from 4V to 40V. This input supply must be well regulated. If the input supply is more than a few inches away from the TPS7B4253-Q1, TI recommends adding an electrolytic capacitor with a value of 2.2µF and a ceramic bypass capacitor at the input.

7.4 Layout

7.4.1 Layout Guidelines

For the layout of the TPS7B4253-Q1 device, place the input and output capacitors close to the devices as shown in the *Section 6.2*. To enhance the thermal performance, TI recommends surrounding the device with some vias.

Minimize equivalent series inductance (ESL) and ESR to maximize performance and verify stability. Place every capacitor as close as possible to the device and on the same side of the PCB as the regulator.

Do not place any of the capacitors on the opposite side of the PCB from where the regulator is installed. TI strongly discourages the use of vias and long traces for the path between the output capacitor and the OUT pins because vias can negatively impact system performance and even cause instability.

If possible, and to verify the maximum performance specified in this data sheet, use the same layout pattern used for the TPS7B4253-Q1 evaluation board, TPS7B4253EVM, which is available at www.ti.com/tool/TPS7B4253EVM.

7.4.1.1 Power Dissipation and Thermal Considerations

Use Equation 5 to calculate the device power dissipation.

$$P_D = I_O \times (V_I - V_O) + I_Q \times V_I \quad (5)$$

where

- P_D = continuous power dissipation
- I_O = output current
- V_I = input voltage
- V_O = output voltage
- I_Q = quiescent current

As I_Q « I_O, the term $I_Q \times V_I$ in Equation 5 can be ignored.

For a device under operation at a given ambient air temperature (T_A), calculate the junction temperature (T_J) with Equation 6.

$$T_J = T_A + (\theta_{JA} \times P_D) \quad (6)$$

where

- θ_{JA} = junction-to-junction-ambient air thermal impedance

A rise in junction temperature because of power dissipation can be calculated with Equation 7.

$$\Delta T = T_J - T_A = (\theta_{JA} \times P_D) \quad (7)$$

For a given maximum junction temperature ($T_J$max), the maximum ambient air temperature ($T_A$max) at which the device can operate can be calculated with Equation 8.

$$T_A\,\text{max} = T_J\,\text{max} - (\theta_{JA} \times P_D) \quad (8)$$

7.4.2 Layout Example

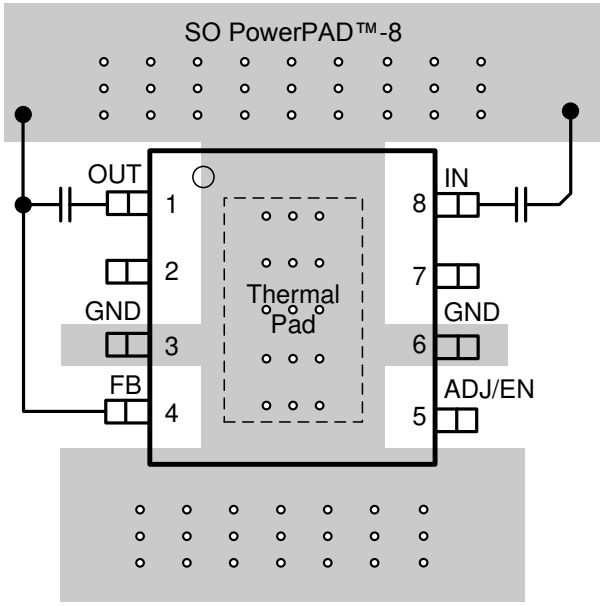


Figure 7-5. SO PowerPAD Package TPS7B4253-Q1 Layout Example

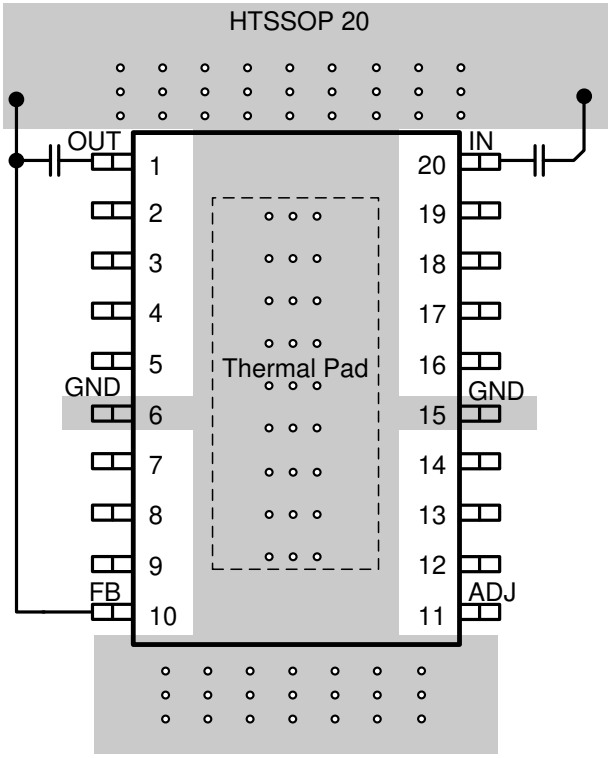


Figure 7-6. HTSSOP Package TPS7B4253-Q1 Layout Example

8 Device and Documentation Support

8.1 Device Support

8.1.1 Device Nomenclature

Table 8-1. Device Nomenclature

PRODUCT	V_{OUT}
TPS7B4253QyyyRQ1	**Q** indicates that this device is a grade-1 device in accordance with the AEC-Q100 standard. **yyy** is the package designator (DDA = HSOIC & PWP = HTSSOP). **Q1** indicates that this device is an automotive grade (AEC-Q100) device. For the DDA package, this device potentially ships with multiple leadframes. The reel packaging label provides ASO information to distinguish which leadframe is used. ASO : FMX label denotes material from the new manufacturing site and ASO : ASE label denotes material from the legacy manufacturing site.

8.1.2 Development Support

For the TPS7B4253 PSpice Transient Model, go to .

8.2 Documentation Support

8.2.1 Related Documentation

For related documentation see the following:

- Texas Instruments, *LDO Parallel Solution Reference Design With TPS7B4253-Q1* design guide
- Texas Instruments, *TPS7B4253-Q1 Evaluation Module* user's guide
- Texas Instruments, *TPS7B4253-Q1 Pin FMEA* functional safety

8.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.4 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

8.5 Trademarks

PowerPAD™ is a trademark of Texas Instruments.
TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

8.6 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.7 Glossary

TI Glossary — This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision C (July 2016) to Revision D (November 2025)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Changed SO to HSOIC throughout document	1
• Changed data sheet title	1
• Changed automotive-specific bullets in *Features* section	1
• Updated the Thermal Information table to include the thermal information for the DDA package from the multiple manufacturing sites (ASE, FMX)	5
• Updated the Device nomenclature to include a note that describes the method to distinguish the DDA material from different assembly sites	22
• Updated the mechanical drawings from DDA0008J to DDA0008J-C02	24

Changes from Revision B (January 2016) to Revision C (July 2016)	Page
• Changed the following parameters in the *Recommended Operating Conditions* table to show values for HTSSOP and SO PowerPAD packages: V_{ADJ}, V_{FB}, and V_{OUT}	4
• Corrected the *Functional Block Diagram*	10
• Added the HTSSOP package as the example for the *Application With Output Voltage Equal to the Reference Voltage* section	16
• Corrected the *Output Voltage Equals the Reference Voltage* figure	16

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

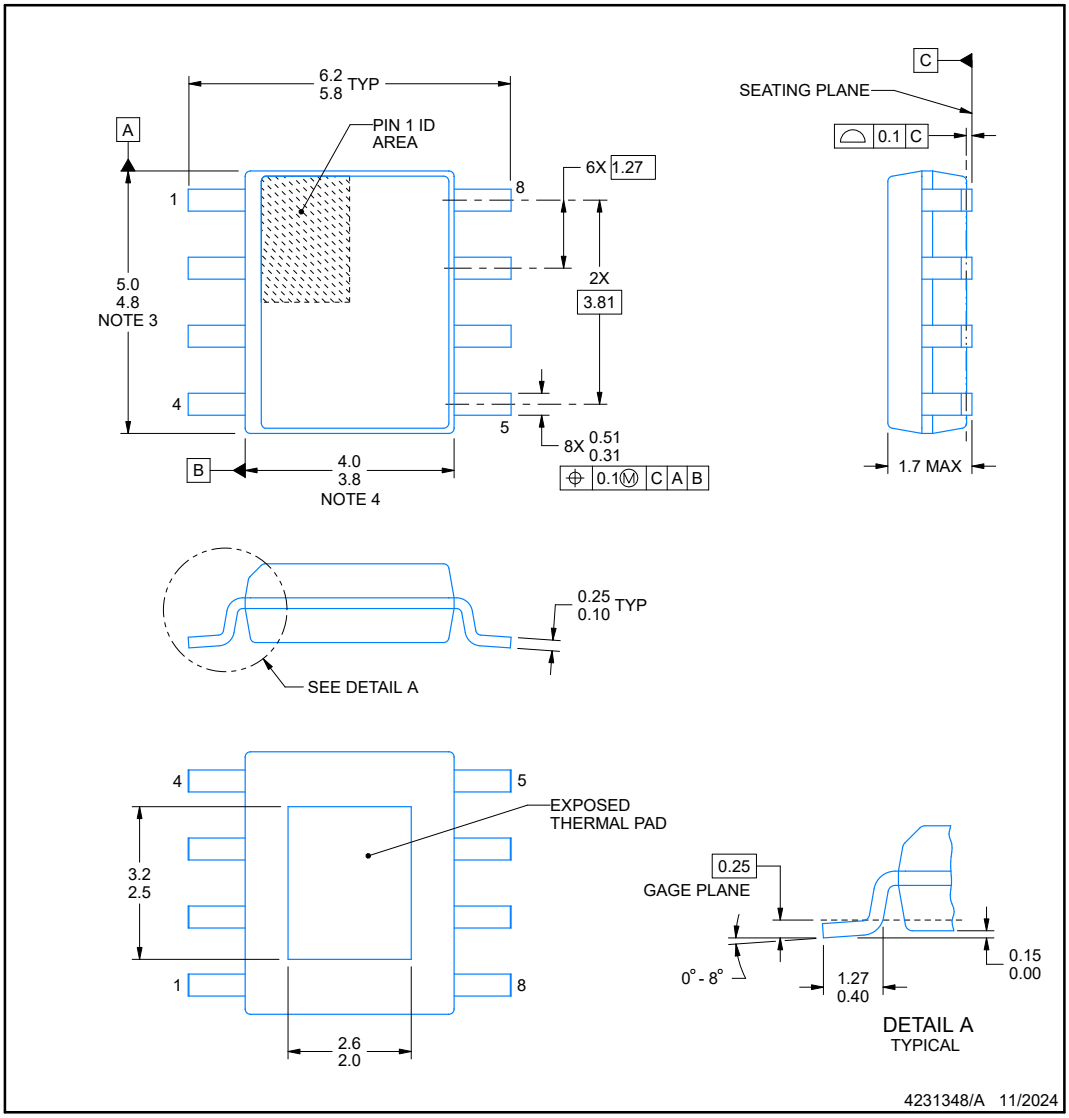
10.1 Mechanical Data

DDA0008J-C02

PACKAGE OUTLINE

PowerPAD™ SOIC - 1.7 mm max height

PLASTIC SMALL OUTLINE



PowerPAD is a trademark of Texas Instruments.

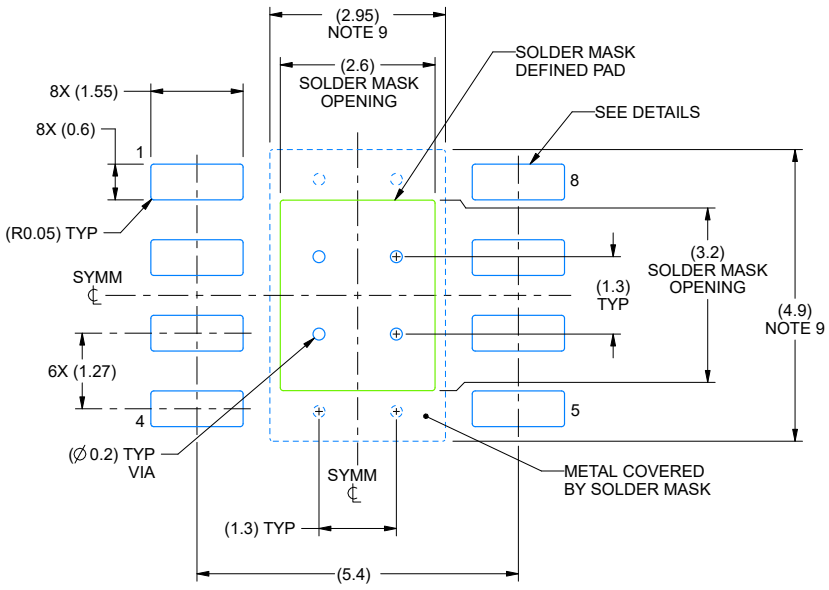
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MS-012, variation BA.

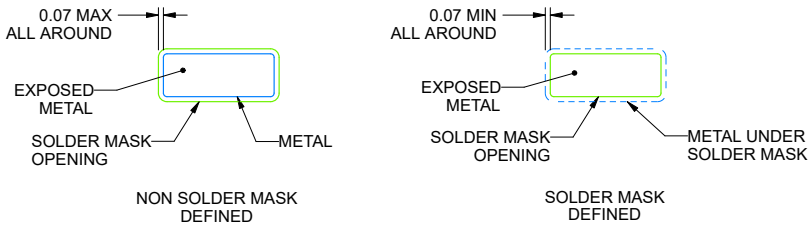
EXAMPLE BOARD LAYOUT

DDA0008J-C02 — **PowerPAD ™ SOIC - 1.7 mm max height**

PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:10X



SOLDER MASK DETAILS

4231348/A 11/2024

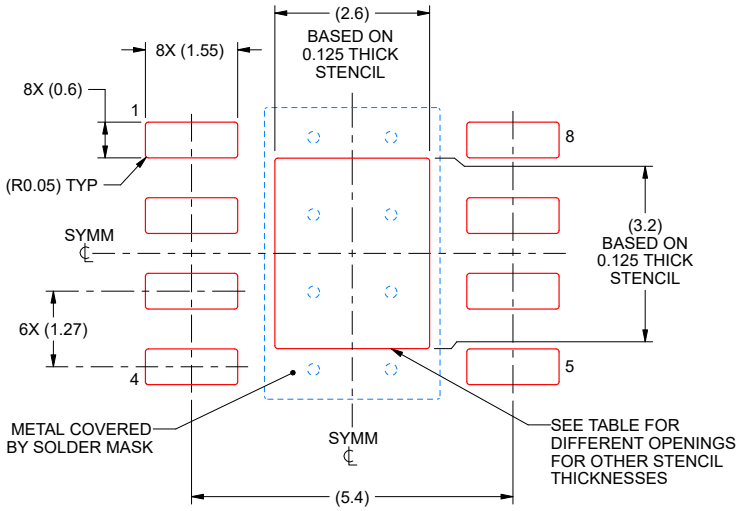
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Size of metal pad may vary due to creepage requirement.

EXAMPLE STENCIL DESIGN

DDA0008J-C02 **PowerPAD ™ SOIC - 1.7 mm max height**

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE
EXPOSED PAD
100% PRINTED SOLDER COVERAGE BY AREA
SCALE:10X

STENCIL THICKNESS	SOLDER STENCIL OPENING
0.1	2.91 X 3.58
0.125	2.6 X 3.2 (SHOWN)
0.150	2.37 X 2.92
0.175	2.20 X 2.70

4231348/A 11/2024

NOTES: (continued)

10. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
11. Board assembly site may have different recommendations for stencil design.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS7B4253QDDARQ1	Active	Production	SO PowerPAD (DDA) | 8	2500 | LARGE T&R	Yes	NIPDAU | NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	4253
TPS7B4253QDDARQ1.A	Active	Production	SO PowerPAD (DDA) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	4253
TPS7B4253QPWPRQ1	Active	Production	HTSSOP (PWP) | 20	2000 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	7B4253Q
TPS7B4253QPWPRQ1.A	Active	Production	HTSSOP (PWP) | 20	2000 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	7B4253Q

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

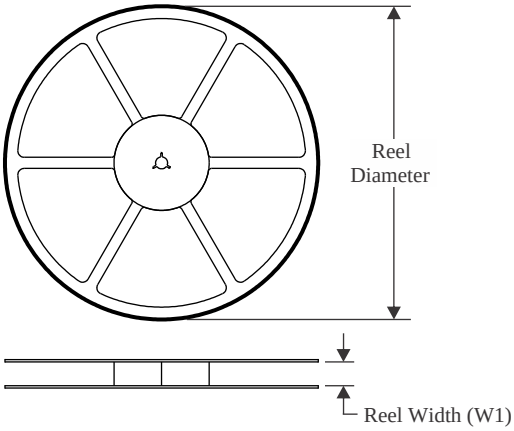
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

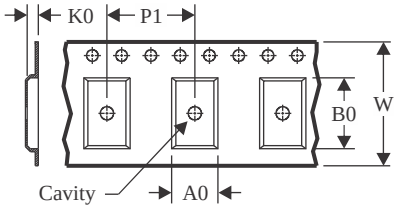
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

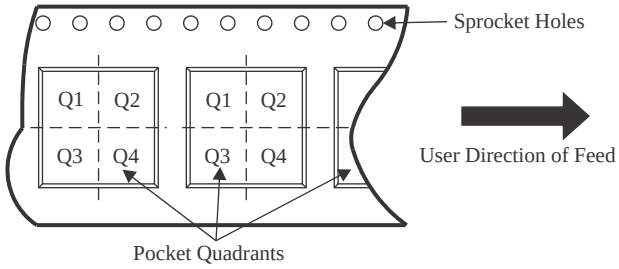


TAPE DIMENSIONS



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

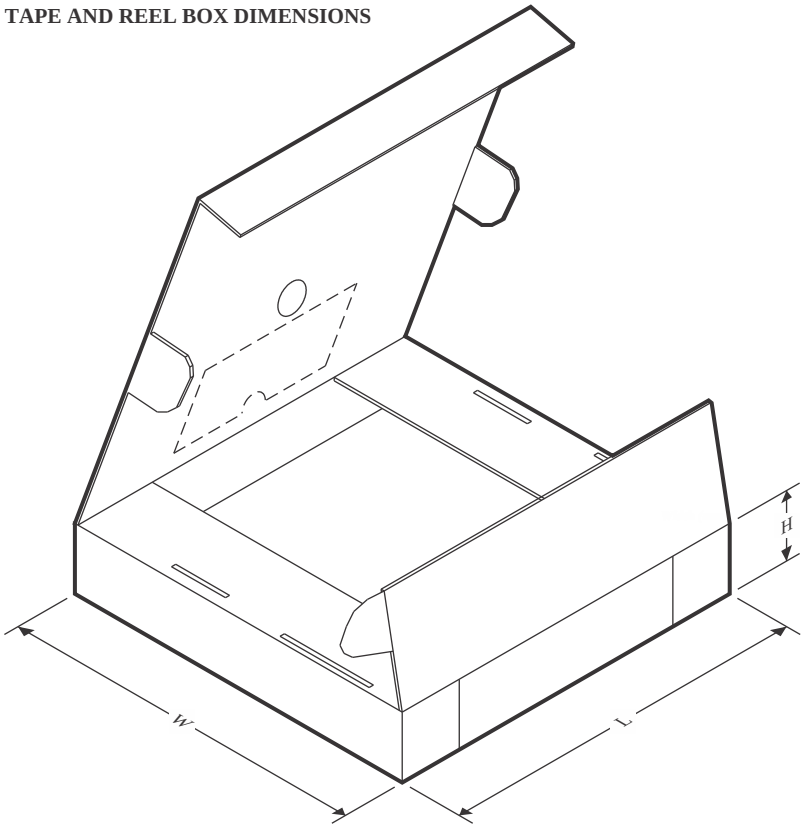
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS7B4253QDDARQ1	SO PowerPAD	DDA	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
TPS7B4253QPWPRQ1	HTSSOP	PWP	20	2000	330.0	16.4	6.95	7.1	1.6	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS7B4253QDDARQ1	SO PowerPAD	DDA	8	2500	366.0	364.0	50.0
TPS7B4253QPWPRQ1	HTSSOP	PWP	20	2000	350.0	350.0	43.0

GENERIC PACKAGE VIEW

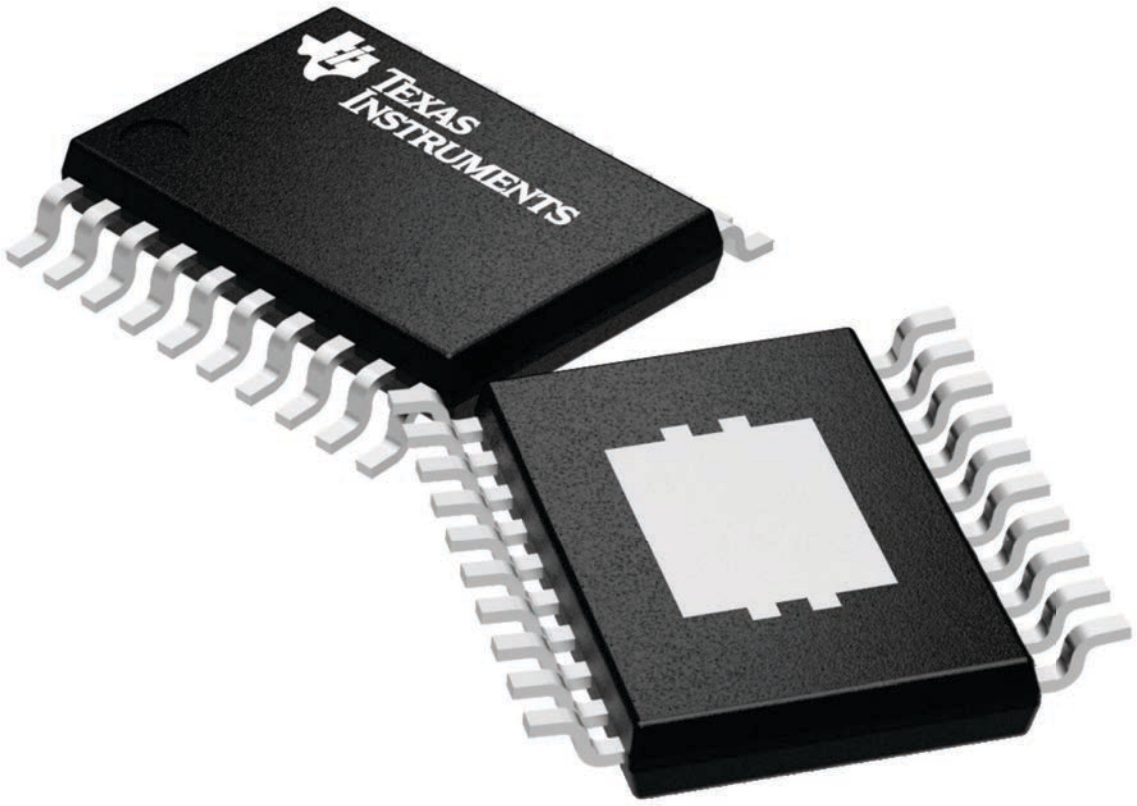
PWP 20

HTSSOP - 1.2 mm max height

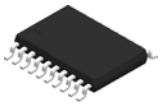
6.5 x 4.4, 0.65 mm pitch

SMALL OUTLINE PACKAGE

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4224669/A

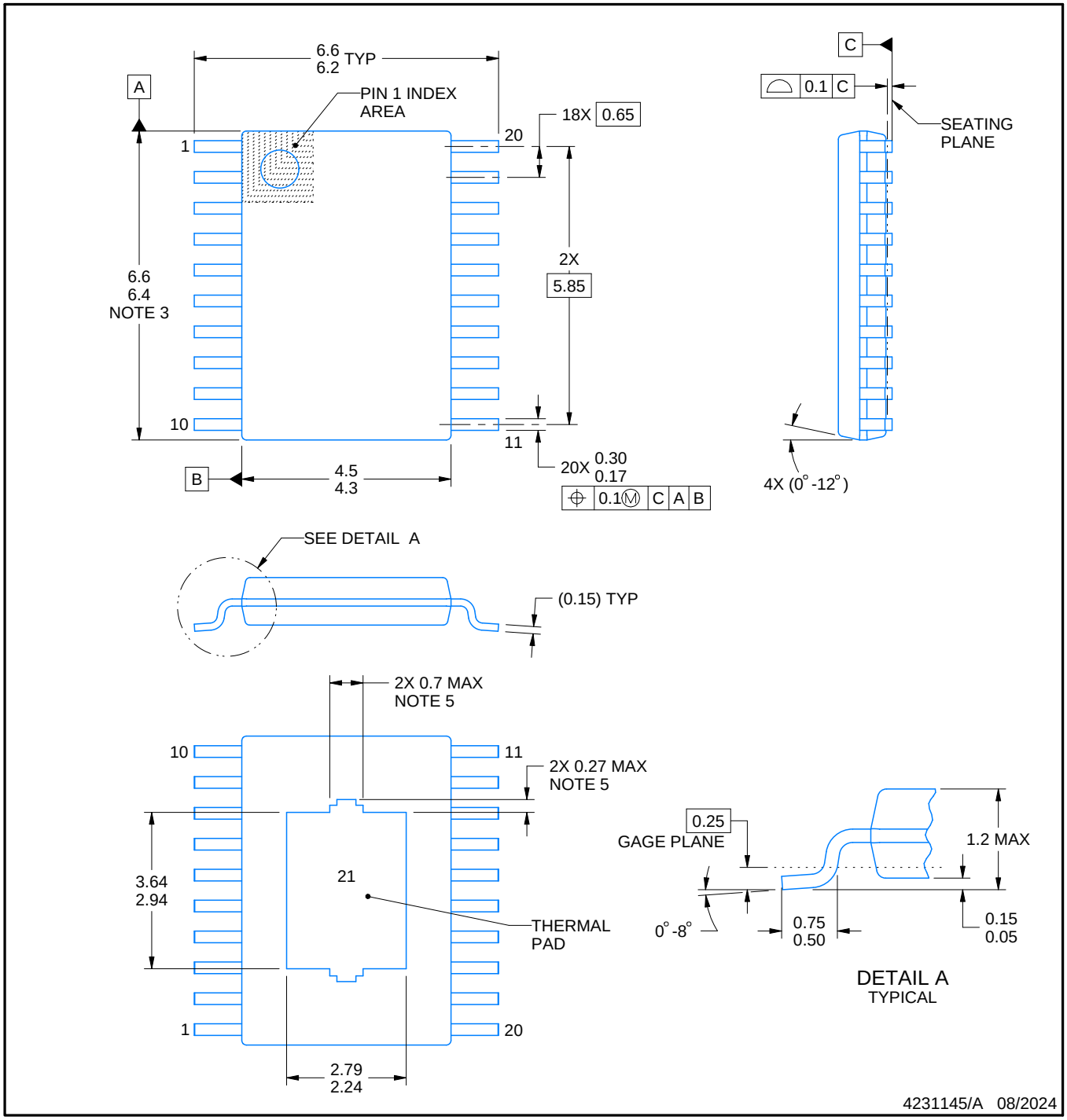


PACKAGE OUTLINE

PWP0020W

PowerPAD™ TSSOP - 1.2 mm max height

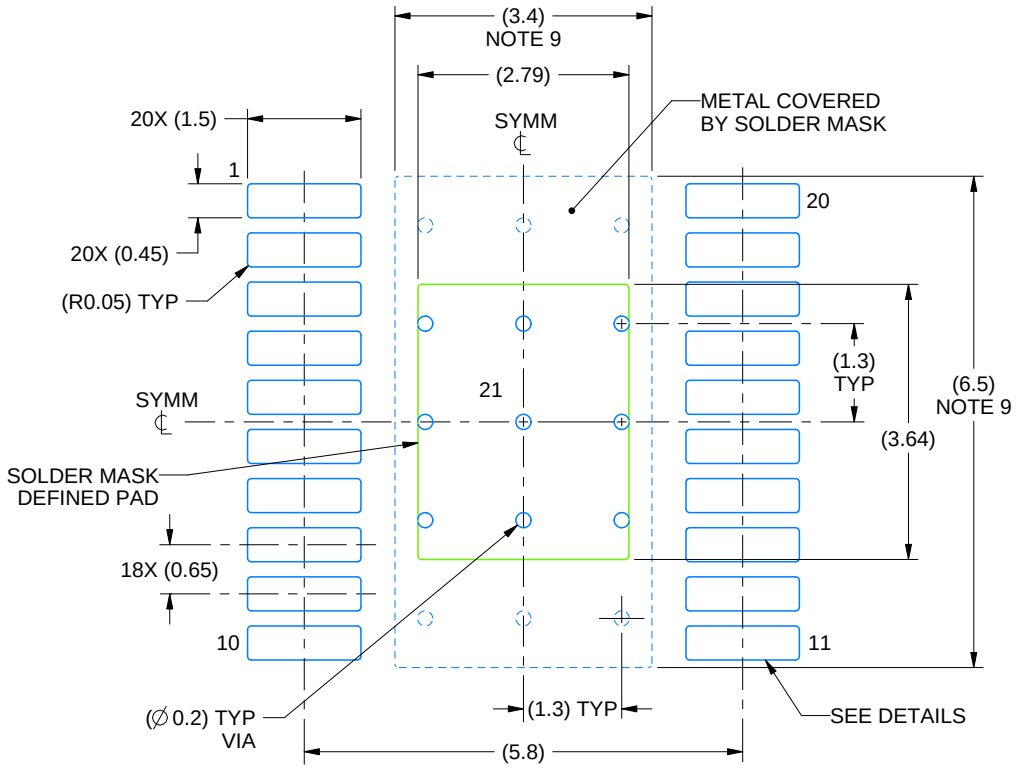
SMALL OUTLINE PACKAGE



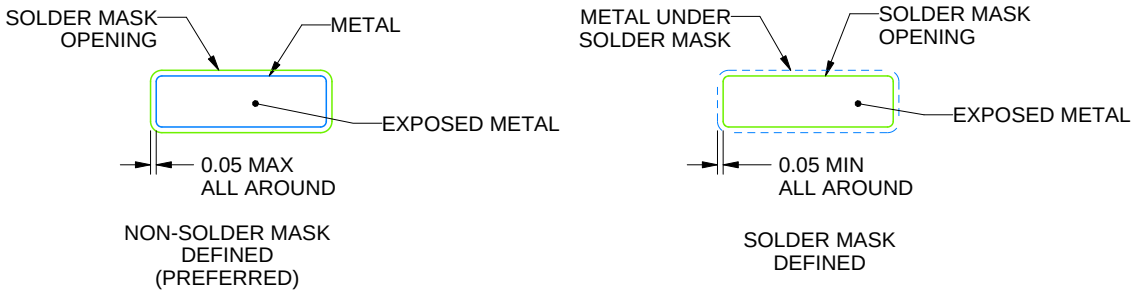
PowerPAD is a trademark of Texas Instruments.

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-153.
5. Features may differ or may not be present.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

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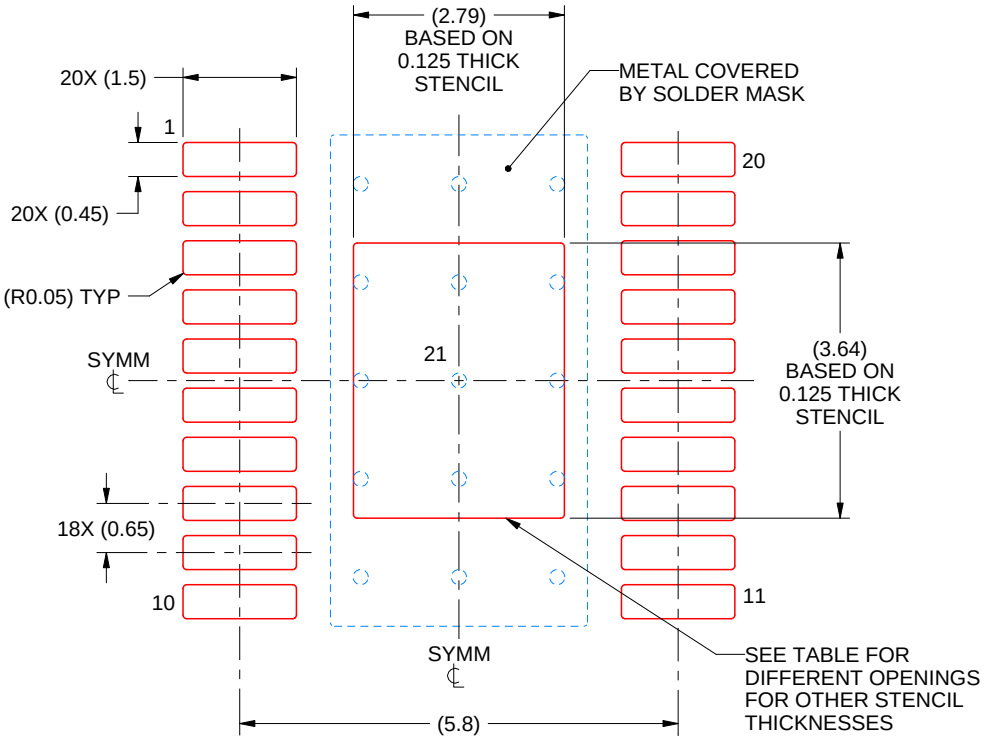
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Size of metal pad may vary due to creepage requirement.
10. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

STENCIL THICKNESS	SOLDER STENCIL OPENING
0.1	3.12 X 4.07
0.125	2.79 X 3.64 (SHOWN)
0.15	2.55 X 3.32
0.175	2.36 X 3.08

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NOTES: (continued)

11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

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Last updated 10/2025