TPS61299x/xA 95nA Quiescent Current, 5.5V Boost Converter with Input Current Limit and Fast Transient Performance

1 Features

- Input voltage range: 0.5V to 5.5V
- 0.7V minimum start-up voltage for TPS61299x
- 0.9V minimum start-up voltage for TPS61299xA
- Input operating voltage down to 150mV with signal V_{IN} > 0.7V for TPS61299x
- Input operating voltage down to 150mV with signal V_{IN} > 0.9V for TPS61299xA
- Output voltage range: 1.8V to 5.5V for device with current limit no more than 1.2A
- Output voltage range: 1.8V to 5V for TPS612997/A
- Average input current limit: 5mA; 25mA; 50mA; 100mA; 250mA, 500mA, 1.2A, 1.9A (different versions)
- 95nA typical quiescent current into VOUT
- 60nA typical shutdown current into VIN for TPS61299x
- 30nA typical force pass through current into VIN for TPS61299xA
- Up to 91% efficiency at V_{IN} = 3.6V, V_{OUT} = 5V, and I_{OUT} =10µA
- Up to 94% efficiency at V_{IN} = 3.6V, V_{OUT} = 5V, and I_{OUT} =200mA
- Fast transient performance: setting time ~8µs at V_{IN} = 3.6V, V_{OUT} = 5V, I_{OUT} = 0A -> 200mA
- True disconnection at EN low for TPS61299x
- Force pass through at EN low for TPS61299xA
- Automatic PFM/PWM mode transition
- Auto pass-through at V_{IN} > V_{OUT}
- Output SCP and thermal shutdown protections
- 6-Pin WCSP (1.2mm x 0.8mm) / SOT563 package (1.6mm x 1.6mm)

2 Applications

- Smart watch, Smart band
- Portable medical equipment
- TWS
- Optical module

3 Description

The TPS61299x/xA is a synchronous boost converter with 95nA ultra-low quiescent current and average input current limit. The device provides a power solution for portable equipment with alkaline battery and coin cell battery. This device has high efficiency under light-load condition to achieve long operation time and average input current limit can avoid battery discharging with high current.

The TPS61299x/xA has wide input voltage range from 0.5V to 5.5V and output voltage range from 1.8V to 5.5V. The device has different versions for average input current limit from 5mA to 1.9A. The TPS61299 with 1.2A current limit can support up to 500mA output current from 3V input to 5V output conversion and achieve approximately 94% efficiency at 200mA load.

The TPS61299x/xA has optional fast-load transient performance at output voltage is 4.5V, 5V or 5.5V. In fast-load transient, the typical setting time is 8µs when output current transient from 0A to 200mA.

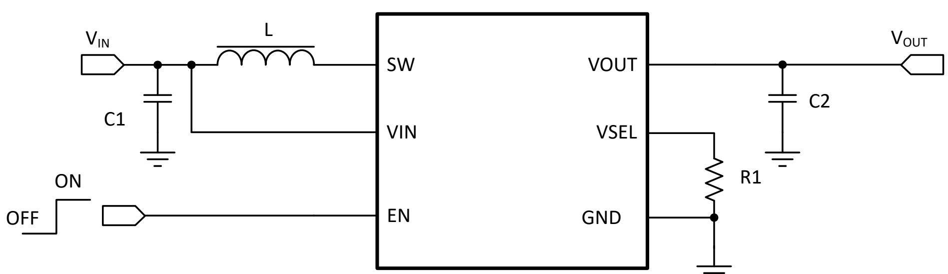
The TPS61299x supports true shutdown function when it is disabled. And TPS61299xA supports force pass through function when it is disabled. Customer could choose either one for specific application.

The TPS61299x/xA offers a very small solution size with 6-ball 1.2mm x 0.8mm WCSP package and 6-pin 1.6mm x 1.6mm SOT563 package.

Device Information

PART NUMBER	PACKAGE [(1)]	BODY SIZE (NOM)
TPS61299YBHR	WCSP	1.2mm x 0.8mm
TPS61299DRLR	SOT563	1.6mm x 1.6mm
TPS61299ADRLR	SOT563	1.6mm x 1.6mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Typical Application

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4 Device Comparison Table

PART NUMBER	INPUT CURRENT LIMIT	EN_LOW	OUTPUT VOLTAGE RANGE
TPS61299	1.2A	True shutdown	1.8V-5.5V
TPS61299-Q1	1.2A	True shutdown	1.8V-5.5V
TPS61299A	1.2A	Force pass through	1.8V-5.5V
TPS612991[(1)]	5mA	True shutdown	1.8V-5.5V
TPS612991A[(1)]	5mA	Force pass through	1.8V-5.5V
TPS612992[(1)]	25mA	True shutdown	1.8V-5.5V
TPS612992A[(1)]	25mA	Force pass through	1.8V-5.5V
TPS612993	50mA	True shutdown	1.8V-5.5V
TPS612993A[(1)]	50mA	Force pass through	1.8V-5.5V
TPS612994	100mA	True shutdown	1.8V-5.5V
TPS612994A[(1)]	100mA	Force pass through	1.8V-5.5V
TPS612995[(1)]	250mA	True shutdown	1.8V-5.5V
TPS612995A[(1)]	250mA	Force pass through	1.8V-5.5V
TPS612996[(1)]	500mA	True shutdown	1.8V-5.5V
TPS612996A[(1)]	500mA	Force pass through	1.8V-5.5V
TPS612997	1.9A	True shutdown	1.8V-5.0V
TPS612997A[(1)]	1.9A	Force pass through	1.8V-5.0V

(1) Product Preview. Contact TI factory for more information.

5 Pin Configuration and Functions

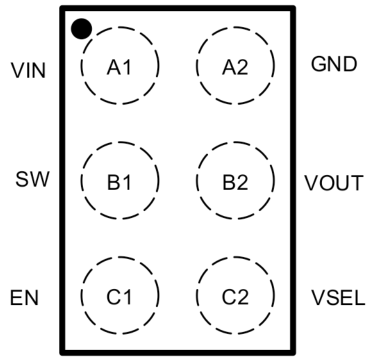


Figure 5-1. YBH Package Top View

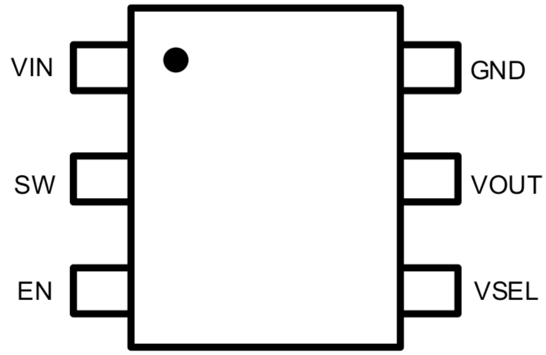


Figure 5-2. DRL Package Top View

Table 5-1. Pin Functions

TERMINAL			I/O	DESCRIPTION
NAME	YBH	DRL		
VIN	A1	1	PWR	IC power supply input
SW	B1	2	PWR	The switch pin of the converter. It is connected to the drain of the internal low-side power MOSFET and source of the internal high-side power MOSFET.
EN	C1	3	I	Enable logic input. Logic high voltage enables the device. True disconnection at EN low for TPS61299x. Force pass through at EN low for TPS61299xA.
VSEL	C2	4	I	Boost output voltage selection pin. Connect a resistor between this pin and ground to select one of 21 output voltages.
VOUT	B2	5	PWR	Boost converter output
GND	A2	6	PWR	Ground

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage	VIN, VOUT, SW, EN, VSEL	-0.3	6.5	V
	SW spike at 10 ns	-0.7	8	V
	SW spike at 1 ns	-0.7	10	V
T_J	Operating Junction Temperature	-40	150	°C
T_{stg}	Storage temperature	-65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Rating* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, allpins[(1)]	±2000	V
		Charged device model (CDM), per JEDEC specificationJESD22-C101, all pins[(2)]	±500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. [Following sentence optional; see the wiki.] Manufacturing with less than 500-V HBM is possible with the necessary precautions.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. [Following sentence optional; see the wiki.] Manufacturing with less than 250-V CDM is possible with the necessary precautions.

6.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted).

		MIN	NOM	MAX	UNIT
V_{IN}	Input voltage	0.5		5.5	V
V_{OUT}	Boost output voltage, for devcie with input current limit no more than 1.2A	1.8		5.5	V
V_{OUT}	Boost output voltage, for TPS612997	1.8		5.0	V
T_J	Junction temperature	-40		125	°C
L	Effective Inductance	0.47*0.7	1	2.2*1.3	µH
C_{OUT}	Effective Output Capacitance at the OUT pin, with output currrent lower than 1A	5*0.8	10		µF
C_{OUT}	Effective Output Capacitance at the OUT pin, with output currrent higher than 1A, or TPS612997 is used		20		
C_{IN}	Effective Input Capacitance at the VIN pin	2.2			µF

6.4 Thermal Information

THERMAL METRIC[(1)]		TPS61299	TPS61299	TPS61299/ TPS61299A	TPS61299/ TPS61299A	UNIT
		YBH 6-BALLS	YBH 6-BALLS	DRL 6-PINS	DRL 6-PINS	
		Standard	EVM	Standard	EVM	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	130.0	107.1	135.6	93.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	0.9	N/A	66.3	N/A	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	39.4	N/A	24.6	N/A	°C/W

6.4 Thermal Information (continued)

THERMAL METRIC[(1)]		TPS61299	TPS61299	TPS61299/ TPS61299A	TPS61299/ TPS61299A	UNIT
		YBH 6-BALLS	YBH 6-BALLS	DRL 6-PINS	DRL 6-PINS	
		Standard	EVM	Standard	EVM	
Ψ_{JT}	Junction-to-top characterization parameter	0.2	4.1	1.6	7.9	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	39.4	62.7	24.4	39.6	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	N/A	N/A	°C/W

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

6.5 Electrical Characteristics

T_J = -40°C to 125°C, V_{IN} = 3.6V and V_{OUT} = 5.0V. Typical values are at T_J = 25°C, unless otherwise noted.

PARAMETER		Version	TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY							
V_{IN}	Input voltage range	All		0.5		5.5	V
V_{IN_UVLO}	Under-voltage lockout threshold	TPS61299, TPS61299X	V_{IN} rising			0.7	V
V_{IN_UVLO}	Under-voltage lockout threshold	TPS61299A, TPS61299XA	V_{IN} rising			0.9	V
V_{IN_UVLO}	Under-voltage lockout threshold	All	V_{IN} falling			0.5	V
Rdson_HS	high-side Rdson	TPS61299A	V_{IN}=0.9V, EN=0.		2.4		Ω
Rdson_HS	high-side Rdson	TPS61299A	V_{IN}=1.8V, EN=0.		0.39		Ω
Rdson_HS	high-side Rdson	TPS61299A	V_{IN}=3.3V, EN=0.		0.22		Ω
Rdson_HS	high-side Rdson	TPS61299A	V_{IN}=5.0V, EN=0.		0.15		Ω
Rdson_HS	high-side Rdson	TPS61299A	V_{IN}=5.5V, EN=0.		0.15		Ω
I_Q	Quiescent current into V_{IN} pin	All	IC enabled, No load, No switching, T_J up to 85°C		1		nA
I_Q	Quiescent current into V_{OUT} pin	All	IC enabled, No load, No switching, T_J up to 85°C		95	300	nA
I_{SD}	Shutdown current into V_{IN} pin	TPS61299, TPS61299X	EN = LOW, V_{IN} = 3.6 V, V_{OUT} = 0 V		60		nA
I_{BY}	Quiescent current into V_{IN} pin at force pass through mode	TPS61299A, TPS61299XA	EN = LOW, V_{IN}=3.6V		30		nA
I_{LKG_SW}	Leakage current into SW pin (from SW pin to VOUT pin)	TPS61299X	V_{SW}=3.0V, V_{OUT}=0V, TJ = 25°C		1	4	nA
I_{LKG_SW}	Leakage current into SW pin (from SW pin to VOUT pin)	TPS61299X(WCSP Package)	V_{SW}=3.0V, V_{OUT}=0V, TJ up to 85°C		1	20	nA
I_{LKG_SW}	Leakage current into SW pin (from SW pin to GND pin)	All	V_{SW}=3.0V, V_{OUT}=0V, TJ = 25°C		1	15	nA
I_{LKG_SW}	Leakage current into SW pin (from SW pin to GND pin)	All	V_{SW}=3.0V, V_{OUT}=0V, TJ up to 85°C		1	200	nA
OUTPUT							
V_{OUT}	Output voltage setting range	All		1.8		5.5	V
V_{OUT_ACY}	Output voltage accuracy	All	PWM, PFM mode	-2		2	%
$V_{OUT\_SNOOZE\_ACY}$		All	Normal mode		V_{OUT_ACY}+37.5mV		V

6.5 Electrical Characteristics (continued)

T_J = -40°C to 125°C, V_{IN} = 3.6V and V_{OUT} = 5.0V. Typical values are at T_J = 25°C, unless otherwise noted.

PARAMETER		Version	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{OUT\_SNOOZE\_ACY}$	Output voltage accuracy	All	Fast mode		V_{OUT_ACY}+15 mV		V
POWER SWITCH							
$R_{DS(on)}$	High-side MOSFET on resistance	All	V_{OUT} = 5.0 V		150		mΩ
$R_{DS(on)}$	Low-side MOSFET on resistance	All	V_{OUT} = 5.0 V		88		mΩ
I_{LIM}	Input current limit	TPS61299, TPS61299A	V_{IN} = 3.6 V, V_{OUT} = 5.0 V	0.96	1.2	1.44	A
I_{LIM}	Input current limit	TPS612993, TPS612993A	V_{IN} = 3.6 V, V_{OUT} = 5.0 V	38	50	62	mA
I_{LIM}	Input current limit	TPS612994, TPS612994A	V_{IN} = 3.6 V, V_{OUT} = 5.0 V	80	100	120	mA
I_{LIM}	Input current limit	TPS612997,TPS612997A	V_{IN} = 3.6 V, V_{OUT} = 5.0 V	1500	1900	2300	mA
I_{LH}	Inductor current ripple	All			350		mA
LOGIC INTERFACE							
V_{EN_H}	EN logic high threshold	All	V_{IN} >= 1.05 V			0.84	V
V_{EN_L}	EN logic low threshold	All	V_{IN} >= 1.05 V	0.36			V
V_{EN_H}	EN logic high threshold	All	V_{IN} < 1.05 V			0.56	V
V_{EN_L}	EN logic low threshold	All	V_{IN} < 1.05 V	0.14			V
I_{EN_LKG}	Leakage current into EN pin	All	V_{EN}=5V		1	50	nA
R_{EN}	EN pin pulldown resistor	All	EN=low		800		kΩ
PROTECTION							
T_{SD}	Thermal shutdown threshold		T_J rising		150		°C
T_{SD_HYS}	Thermal shutdown hysteresis		T_J falling below T_{SD}		20		°C

6.6 System Characteristics

The following specifications apply to a typical application circuit with nominal component values. Specifications in the typical (TYP) column apply to T_J = 25℃ only. Specifications in the minimum (MIN) and maximum (MAX) columns apply to the case of typical components over the temperature range of T_J = -40℃ to +150℃. *These specifications are not specified by production testing.*

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
R_load	Resistance load capacity to maintain start up,Vout=5V, normal mode	TPS61299A, Vin=0.9V		1k		Ω
		TPS61299A,Vin=1.5V		40		Ω
		TPS61299A,Vin=2.5V		32		Ω
		TPS61299A,Vin=3.3V		26		Ω
		TPS61299A,Vin=3.6V		25		Ω
		TPS61299A,Vin=4.3V		23		Ω

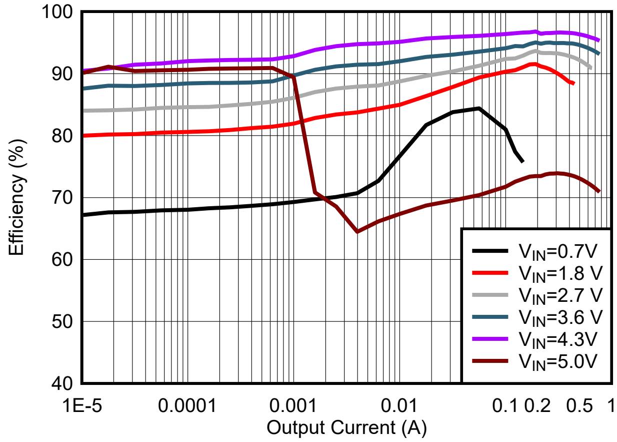
6.6 System Characteristics (continued)

The following specifications apply to a typical application circuit with nominal component values. Specifications in the typical (TYP) column apply to T_J = 25℃ only. Specifications in the minimum (MIN) and maximum (MAX) columns apply to the case of typical components over the temperature range of T_J = -40℃ to +150℃. *These specifications are not specified by production testing.*

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Iin_open	Input current under open load , Vout=5V, normal mode	TPS61299A,Vin=0.9V		650		nA
		TPS61299A,Vin=1.5V		360		nA
		TPS61299A,Vin=1.8V		299		nA
		TPS61299A,Vin=2.5V		223		nA
		TPS61299A,Vin=3.3V		162		nA
		TPS61299A,Vin=3.6V		140		nA
		TPS61299A,Vin=4.3V		124		nA
		TPS61299A,Vin=4.5V		101		nA
		TPS61299A,Vin=5.0V		82		nA

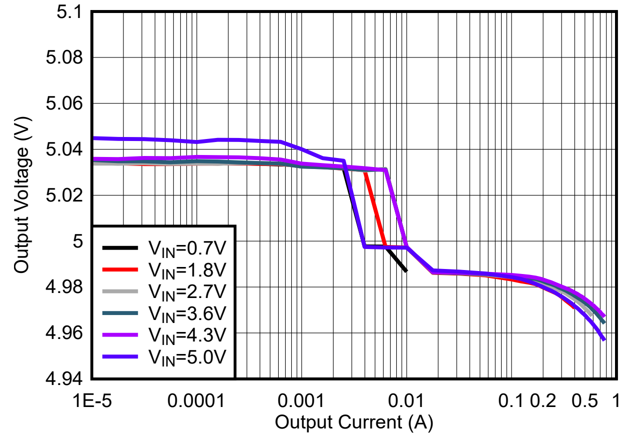
6.7 Typical Characteristics

V_{IN} = 3.6V, V_{OUT} = 5V, Normal Mode, T_J = 25°C, unless otherwise noted



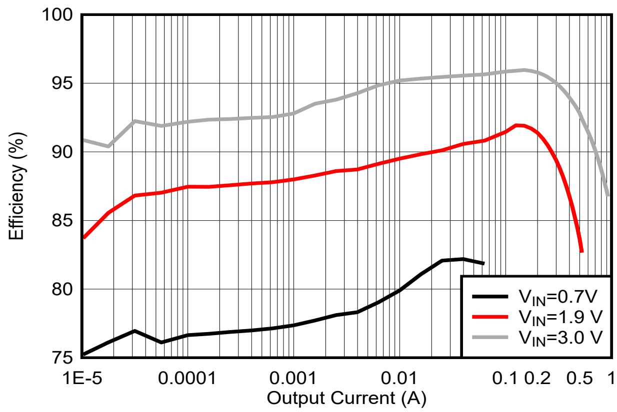
V_{IN} = 0.7V, 1.8V, 2.7V, 3.6V, 4.3V, 5.0V; V_{OUT} = 5.0V

Figure 6-1. 5.0V VOUT Efficiency with Different Inputs Under Normal Mode



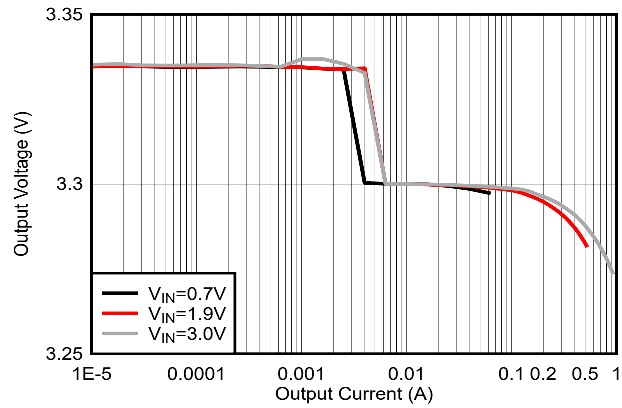
V_{IN} = 0.7V, 1.8V, 2.7V, 3.6V, 4.3V, 5.0V; V_{OUT} = 5.0V

Figure 6-2. 5.0V VOUT Load Regulation with Different Inputs Under Normal Mode



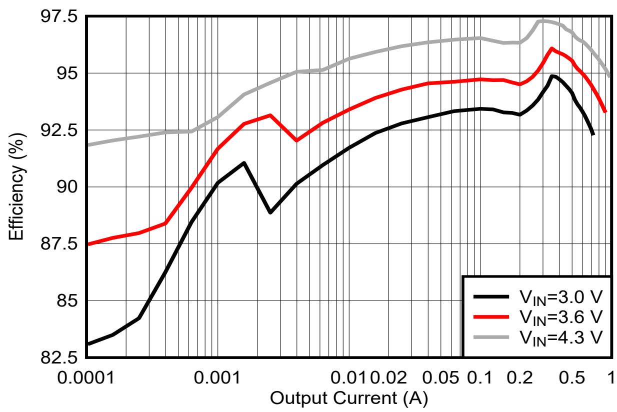
V_{IN} = 0.7V, 1.9V, 3.0V ; V_{OUT} = 3.3V

Figure 6-3. 3.3V VOUT Efficiency with Different Inputs Under Normal Mode



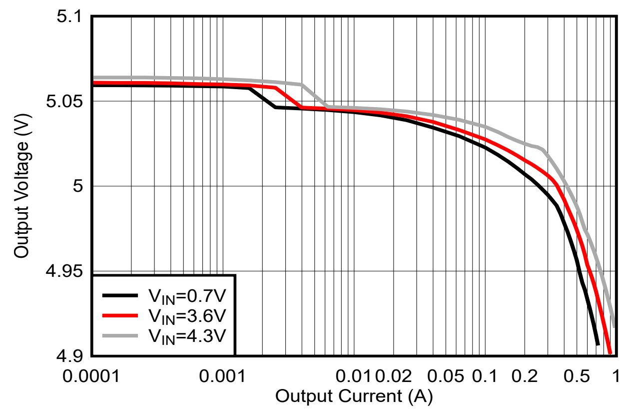
V_{IN} = 0.7V, 1.9V, 3.0V ; V_{OUT} = 3.3V

Figure 6-4. 3.3V VOUT Load Regulation Under Normal Mode



V_{IN} = 3.0V, 3.6V, 4.3V; V_{OUT} = 5.0V

Figure 6-5. 5.0V VOUT Efficiency with Different Inputs Under Fast Mode

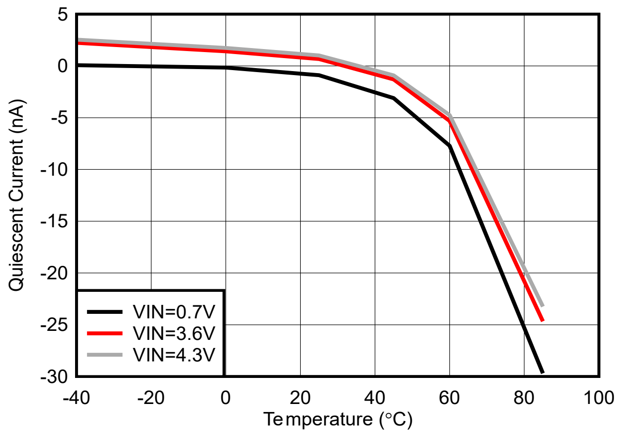


V_{IN} = 3.0V, 3.6V, 4.3V; V_{OUT} = 5.0V

Figure 6-6. 5.0V VOUT Load Regulation with Different InputsUnder Fast Mode

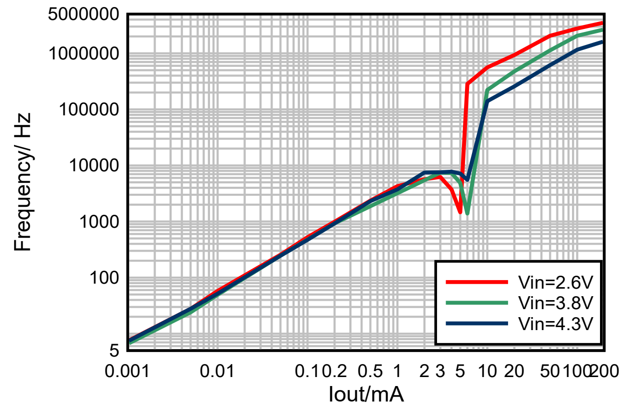
6.7 Typical Characteristics (continued)

V_{IN} = 3.6V, V_{OUT} = 5V, Normal Mode, T_J = 25°C, unless otherwise noted



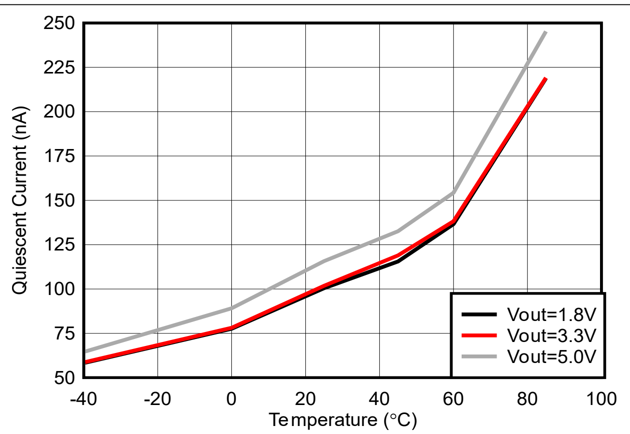
V_{IN} = 0.7V, 3.6V 4.3V; V_{OUT} = 5V, T_J = –40°C to +85 °C, No switching

Figure 6-7. Quiescent Current into VIN vs Temperature



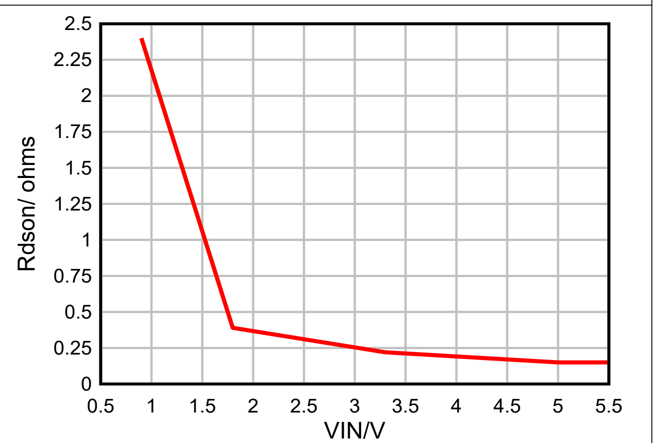
V_{IN} =2.6V, 3.8V, 4.3V; V_{OUT} = 5.0V

Figure 6-8. 5.0V VOUT Frequency Vs output current under Normal Mode



V_{IN} = 1.5V; V_{OUT} = 1.8V , 3.3V , 5V, T_J = –40°C to +85 °C, No switching

Figure 6-9. Quiescent Current into VOUT vs Temperature

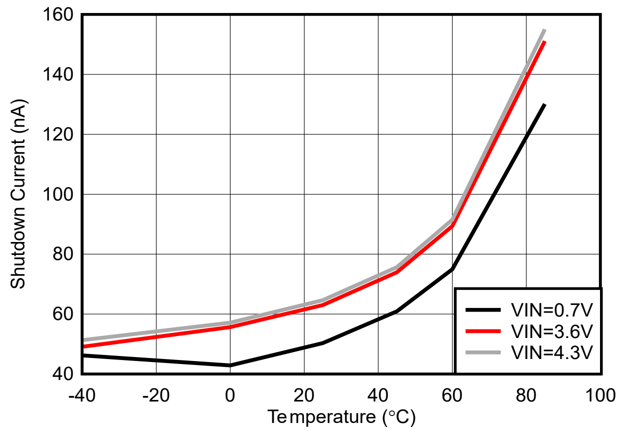


V_{IN} =0.9V, 3.8V, 4.3V; V_{OUT} = 5.0VT_J = 25°C

Figure 6-10. TPS61299A High side Rdson VS Vin

6.7 Typical Characteristics (continued)

V_{IN} = 3.6V, V_{OUT} = 5V, Normal Mode, T_J = 25°C, unless otherwise noted



V_{IN} = 0.7V, 3.6V 4.3V; V_{OUT} = 0V, T_J = –40°C to +85 °C

Figure 6-11. TPS61299 Shutdown Current vs Temperature

7 Detailed Description

7.1 Overview

The TPS61299x/xA is a synchronous step-up converter and operates in a hysteretic current control scheme. The TPS61299x/xA has a wide input voltage supply range between 0.5V and 5.5V (0.7V rising voltage for start-up). It only consumes 95nA quiescent current and can achieve up high efficiency under light load condition.

The TPS61299 family provide wide input current limit from 5 mA to 1.9 A . For device whose input current limit no more than 1.2A, the output voltage could be set ranging from 1.8V to 5.5V. For TPS612997, whose input current limit is 1.9A, the Vout is recommended to set from 1.8V to 5.0V. The non-A version device supports true shutdown function and A version device supports force pass through function at EN is low.

TPS61299x/xA provides a fast transient performance mode and accurate load regulation mode for different system.

7.2 Functional Block Diagram

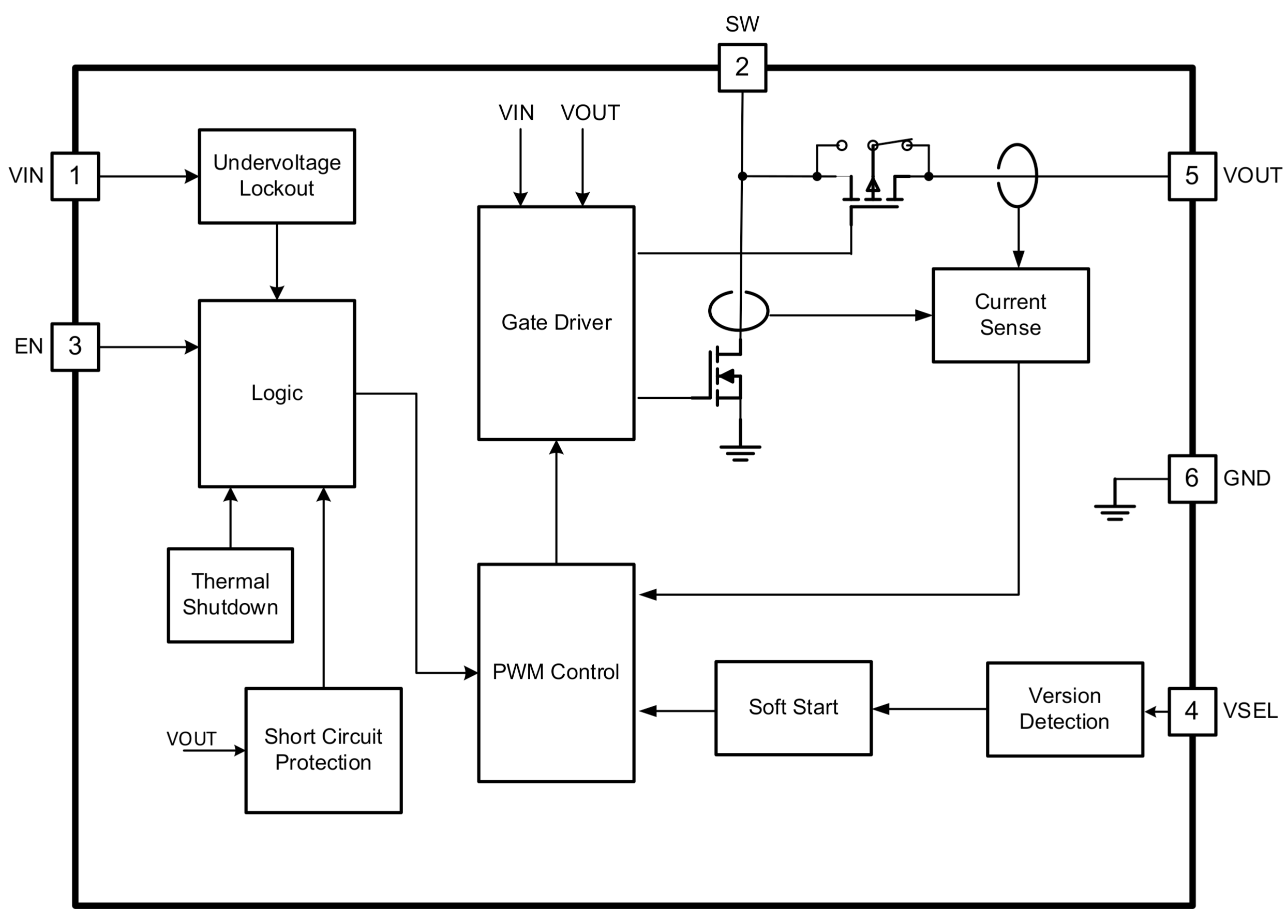


Figure 7-1. Functional Block Diagram

7.3 Feature Description

7.3.1 Boost Control Operation

The TPS61299x/xA boost converter is controlled by a hysteretic current mode controller. This controller regulates the output voltage by keeping the inductor ripple current constant in the range of 350mA and adjusting the valley current of this inductor depending on the output load. Since the input voltage, output voltage and inductor value all affect the rising and falling slopes of inductor ripple current, the switching frequency is not fixed and is determined by the operation condition. If the required average input current is lower than the average inductor current defined by this constant ripple, the inductor current goes discontinuously to keep the efficiency high under light load condition. If the load current is reduced further, the boost converter enters into Burst mode. In Burst mode, the boost converter ramps up the output voltage with several switching cycles. Once the output voltage exceeds a setting threshold (Vout_target + 50mV in normal mode and Vout_target + 25mV in fast load transient mode), the device stops switching and goes into a sleep status. In sleep status, the device consumes less quiescent current, 95nA. The boost converter resumes switching when the output voltage is below the setting threshold (Vout_target + 25mV in normal mode and Vout_target + 10mV in fast load transient mode). The device exits the Burst mode when the output current can no longer be supported in this mode.

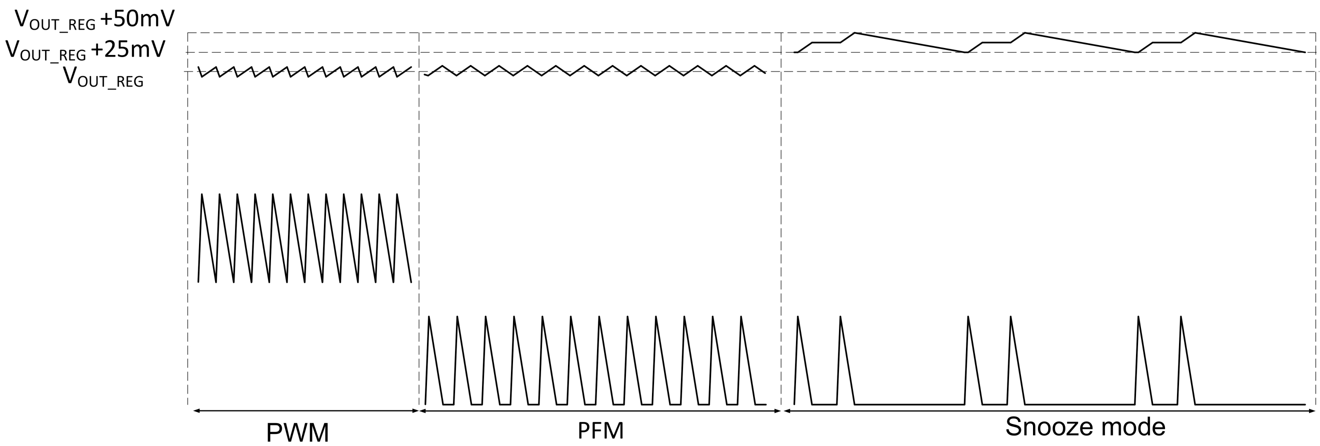


Figure 7-2. Control Modes under Different Load

7.3.2 Version Detection

The TPS61299x/xA supports 21 internal output voltage setting options by connecting a resistor between the VSEL pin and ground.

During start-up, when output voltage reaches close to 1.8V, the device starts to detect the configuration

conditions of the VSEL pin. The TPS61299x/xA checks the VSEL pin by lowering resistance setting options to higher setting options until the user finds the setting configuration by a 10μs clock. After detecting the configuration, the TPS61299x/xA latches the setting output regulation voltage.

The TPS61299x/xA does not detect the VSEL pins during operation, so changing the resistor during operation does not change the VSEL setting. Toggling the EN pin during operation is one way to refresh it.

For proper operation, TI suggests that the setting resistance accuracy must be 1% and the parasitic capacity of

the VSEL pin be less than 10pF.

Table 7-1. VSEL Pin Configuration

Resistance (kΩ)	VOUT_REG (V)	Resistance (kΩ)	VOUT_REG (V)	Resistance (kΩ)	VOUT_REG (V)	Resistance (kΩ)	VOUT_REG (V)
0(GND)	3.3	12.1	4.5	49.9	3.6	191	2.5
3.01	5.5	14.7	4.5(fast)	75	3.5	237	2.2
4.75	5.5(fast)	18.2	4.3	100	3.2	294	2
6.19	5.2	22.6	4	124	3	365	1.8
7.87	5	28.7	3.8	154	2.8	442/ VOUT pin	5(fast)
9.76	4.8						

7.3.3 Under-voltage Lockout

The TPS61299x/xA has a built-in under-voltage lockout (UVLO) circuit to ensure the device working properly. For non-A version devices, when the input voltage is above the UVLO rising threshold of 0.7V (for non-A version devices) and 0.9V (for A version devices), the TPS61299x/xA can be enabled to boost the output voltage. After the TPS61299x/xA starts up and the output voltage is above 1.8V, the TPS61299x/xA can work with the input voltage as low as 0.5V.

7.3.4 Switching Frequency

The TPS61299x/xA boost converter does not have fixed frequency and it maintains a constant inductor ripple current in the range of 350mA, so the frequency is determined by the operation condition. The frequency is approximately 3MHz, when the input is 3.6V, output is 5V, inductor is 1μH. Refer to to calculate the efficiency. The estimated switching frequency f in continuous current mode can be calculated by Equation 1. The switching frequency is not a constant value, but is determined by inductance, input voltage, and output voltage.

$$f = \frac{V_{IN} \times (V_{OUT} - V_{IN} \times \eta)}{L \times I_{LH} \times V_{OUT}} \tag{1}$$

where

- L is the inductor value
- V_{IN} is the input voltage
- V_{OUT} is the output voltage
- η is the converting efficiency
- f is the switching frequency

7.3.5 Average Input Current Limit

The TPS61299x/xA employs the input average current protection (OCP) function. If the inductor average current reaches the current limit threshold ILIM, the control loop can limit the inductor average current. In this case the output voltage decreases until the power balance between input and output is achieved. If the output drops below the input voltage, the TPS61299x/xA enters into Down Mode. If the output drops below 1.6V, the TPS61299x/xA enters into startup process again. In Pass-Through operation, input current limit function is not enabled.

7.3.6 Enable and Disable

When the input voltage is above UVLO rising threshold and the EN pin is pulled to high voltage, the TPS61299x/xA is enabled. When the EN pin is pulled to low voltage, the non-A version device goes into true shutdown mode. In true shutdown mode, the device stops switching and the high-side MOSFET fully turns off, providing the completed disconnection between input and output. Less than 60nA input current is consumed in shutdown mode. When the EN pin is pulled to low voltage, the A version device goes into pass through mode. In pass through mode, the device stops switching and the high-side MOSFET fully turns on, providing the completed connection between input and output. TI recommend to apply Vin no less than 0.9V to fully turn on the high side MOSFET. Less than 30nA input current is consumed in this auto pass through mode.

7.3.7 Soft-Start Timing

After the EN pin is tied to high voltage, the TPS61299x/xA begins to start up. Refer to Figure 7-3 to see the total process. The input current limit might be marginally distinct from defined value during soft start process, which should be taken into special account when doing the system design.

When output voltage is lower than 0.5V, TPS61299x/xA works in short circuit protection mode, at which time the input current limit is roughly 20mA to mitigate the power loss. As the output voltage ramps higher than 0.5V, whereas before reaching 1.8V, the device operates at the boundary of Discontinuous Conduction Mode (DCM) and Continuous Conduction Mode (CCM). As a result, the inductor peak current is limited to around 350mA during this stage, and the average inductor current is limited to 80mA. After the output voltage rises to 1.8V and higher, the TPS61299x starts to detect the output voltage configuration of the VSEL pin, then latches the configuration. The version detection time depends on the resistance at VSEL pin, the higher resistance, the longer version detection time. E.g. for 5V normal version, the TPS61299x needs approximately 170µs for version detection. After version detection, TPS61299x continues switching and output rises further. The internal soft-start time is approximately 1.3ms, and the output soft start time varies with the different output capacitance, load condition, and configuration conditions. The average input current limits after version detection stage are slightly different among TPS61299x family devices. In terms of the higher input current limit version device, TPS61299/6/7 and TPS61299/6/7, the actual average inductor current limit is smaller than defined input current limit, when output voltage is lower than 2.5V and higher than 1.8V, in order to reduce the inrush current during start up. For instance, the TPS61299 and TPS612997 limit the inductor average current lower than 500mA and TPS612996 limits the inductor average current lower than 250mA, when output voltage is ranging between 1.8V and 2.5V. After output voltage increases to 2.5V, the input current limit is back to normal defined value, namely TPS61299 back to 1.2A, TPS612996 back to 500mA, and TPS612997 back to 1.9A. For the low input current limit versions TPS612991/2/3/4/5, the input current limit is the same as the defined value once the output voltage is higher than 1.8V. Typically the device works at DCM during start up.

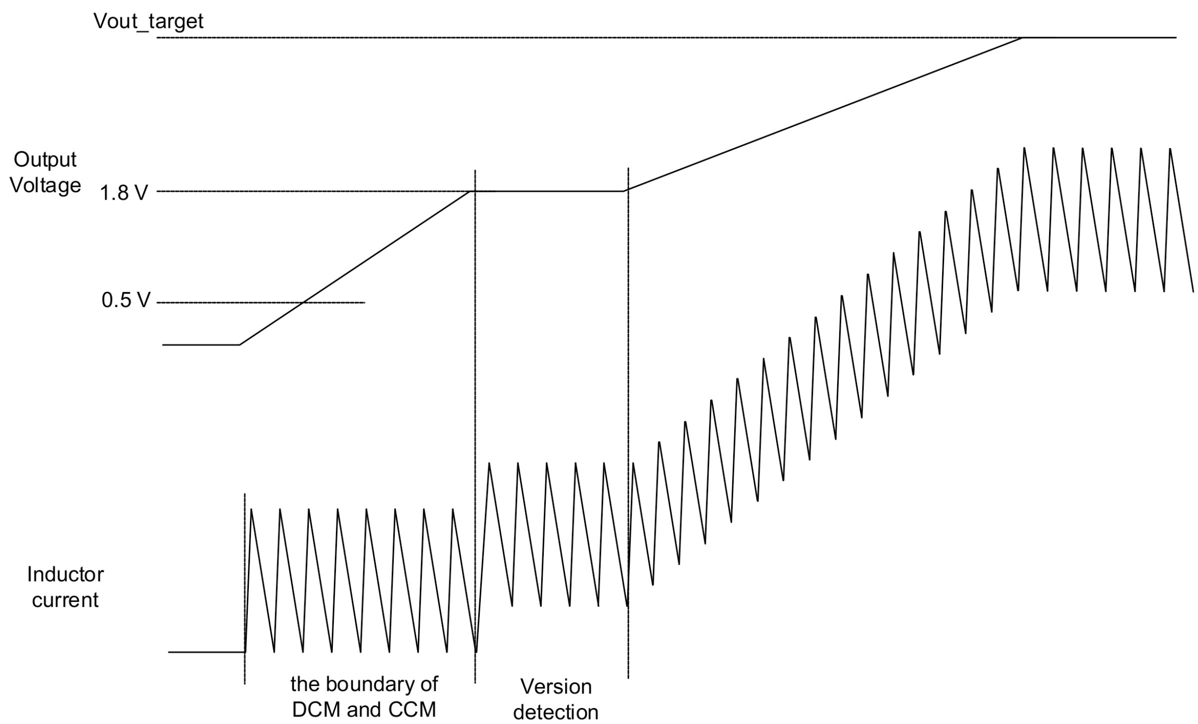


Figure 7-3. Soft-Start Timing

7.3.8 Down Mode

During the start-up, when the input voltage is higher than the output voltage, the TPS61299x/xA works at the down mode to keep the switching. In the Down Mode, the behavior of the rectifying PMOS by pulling its gate to input voltage instead of to ground. In this way, the voltage drop across the PMOS is increasing as high as to regulate the output voltage. The high side PMOS works under saturation area, thus the efficiency is much lower than boost mode. The power loss also increases in this mode, which needs to be taken into account for thermal consideration. Moreover, the current limit decreases as well under down mode, with TPS612994/A decreasing by 40% and TPS61299/A decreasing by 20%.

7.3.9 Pass-Through Operation

The TPS61299x/xA features down mode and pass-through operation when input voltage is close to or higher than output voltage.

During down mode operation, the device regulates the output voltage to the target voltage even when the input voltage is higher than the output voltage. The control circuit changes the behavior of the rectifying P-channel MOSFET by pulling its gate to input voltage instead of to ground. In this way, the voltage drop across the P-channel MOSFET is increasing as high as to regulate the output voltage.

In pass through mode, the TPS61299x/xA stops switching and turns on the high-side P-channel MOSFET. The output voltage is the input voltage minus the voltage drop across the DCR of the inductor and the on-resistance ($R_{DS(on)}$) of the P-channel MOSFET. During pass though operation, the device disables the input current limit function, reverse current protection, and thermal shutdown.

For the input current limit is equal or higher than 250mA version, TPS61299/A, TPS612995/A, TPS612996/A and TPS612997/A. With input voltage ramping up, the device goes into down mode when Vin >Vout-35mV. The device stays in down mode until Vin >Vout+100mV and then goes automatically into pass through operation. In the pass through operation, output voltage follows input voltage. The TPS61299x/xA exits pass though operation and goes back to boost mode when the output voltage drops below the setting target voltage minus 75mV.

For the input current limit equal or lower than 100mA version, TPS612991/A, TPS612992/A, TPS612993/A and TPS612994/A. With input voltage ramping up, the device goes into down mode when Vin >Vout-35mV(Vboost_down). It stays in down mode until Vin >Vout+38mV(Vdown_pass) and then goes automatically into pass through operation. In the pass through operation, output voltage follows input voltage. The TPS61299x/xA exits pass though operation and goes back to boost mode when the output voltage drops below the setting target voltage minus 67mV(Vpass_boost)device.

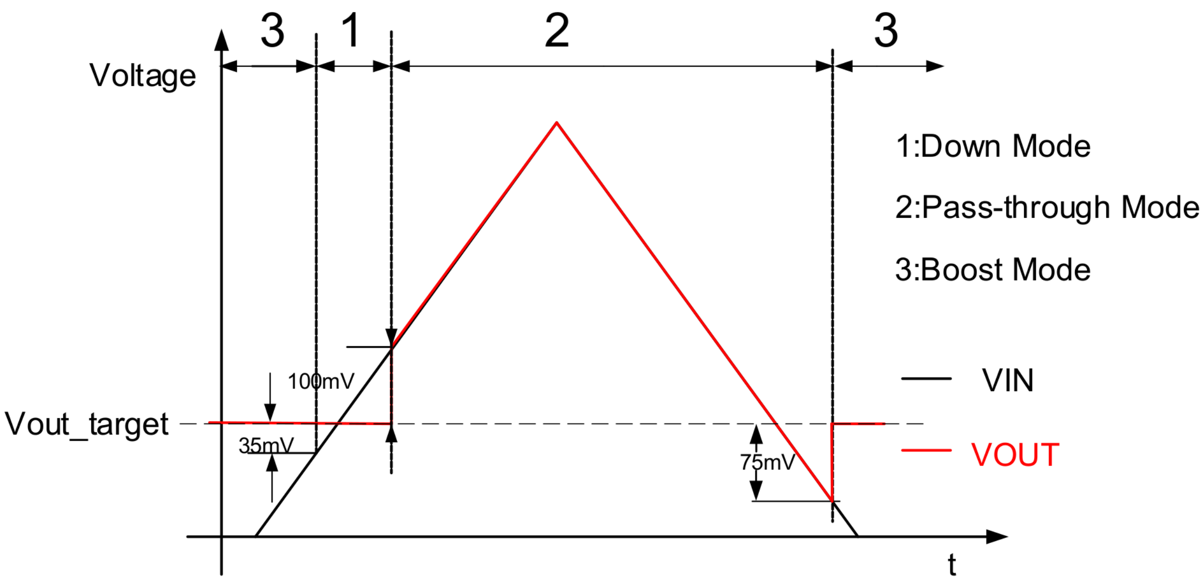


Figure 7-4. Mode Transition for 250mA and Higher Input Current Limit Version

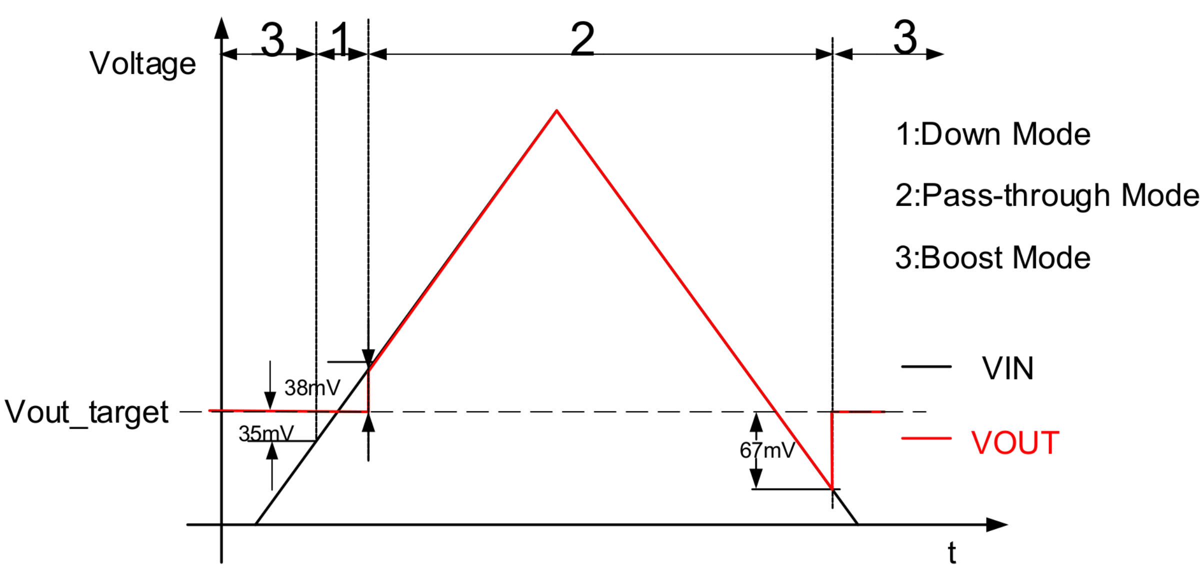


Figure 7-5. Mode Transition for 100mA and Lower Input Current Limit Version

7.3.10 Output Short-to-Ground Protection

When the VOUT pin is short to ground and the output voltage decreases to less than 0.5V, the TPS61299x/xA device begins to limit the inductor current, the same with soft-start operation. The TPS61299x/xA works at the boundary of discontinuous conduction mode (DCM) and continuous conduction mode (CCM) when the input voltage is lower than 1.8V and works at DCM at input voltage is higher than 1.8V.

After the short circuit is released, the TPS61299x/xA goes through the soft-start sequence again to the regulated output voltage.

7.3.11 Thermal Shutdown

The TPS61299x/xA goes into thermal shutdown once the junction temperature exceeds 150°C. When the junction temperature drops below the thermal shutdown temperature threshold less the hysteresis, typically 130°C, the device starts operating again.

7.4 Device Functional Modes

7.4.1 Fast Load Transient Mode and Normal Mode

The TPS61299x/xA has two modes, fast load transient mode and normal mode, which is selected by VSEL pin.

In the fast load transient mode, the loop response speed is fast. E.g. the load transient settling time is about 8 µs when output current transient from 0A to 200mA at 3.6V VIN to 5V VOUT condition. But the trade-off is the load regulation. Normal mode has the better load regulation.

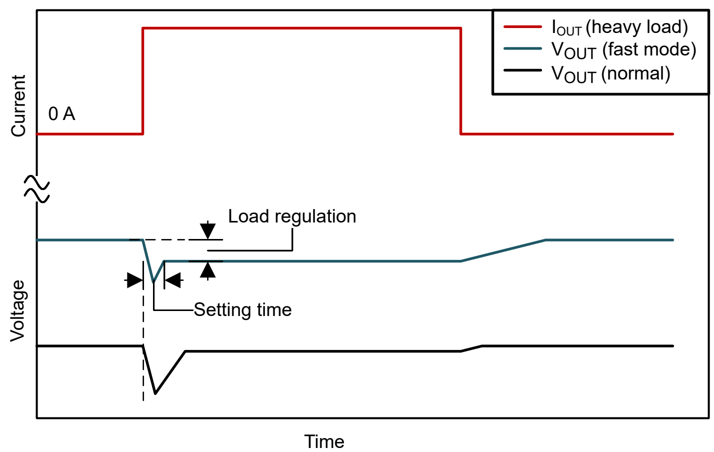


Figure 7-6. Transient Performance Comparison Under Fast Mode and Normal Mode

8 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.

8.1 Application Information

The TPS61299x/xA is a synchronous step-up converter and operates in a hysteretic current control scheme. The TPS61299x/xA has a wide input voltage supply range between 0.5V and 5.5V(0.7V rising of start up for TPS61299x and 0.9V rising of start up for TPS61299xA). The device only consumes 95nA quiescent current and can achieve up high efficiency under light load condition.

The TPS61299x/xA family provide wide input current limit from 5mA to 1.9A and support optional true shutdown function or force pass through function at EN is low.

TPS61299x/xA provides a fast transient performance mode and accurate load regulation mode for different system.

8.2 Typical Application-Li-ion Battery to 5V Boost Converter Under Fast Mode

The TPS61299x/xA can operate under fast transient mode with 8µs settling time under 0 to 200mA load step. Set the VSEL according to Table 8-1 to select different target VOUT under fast mode.

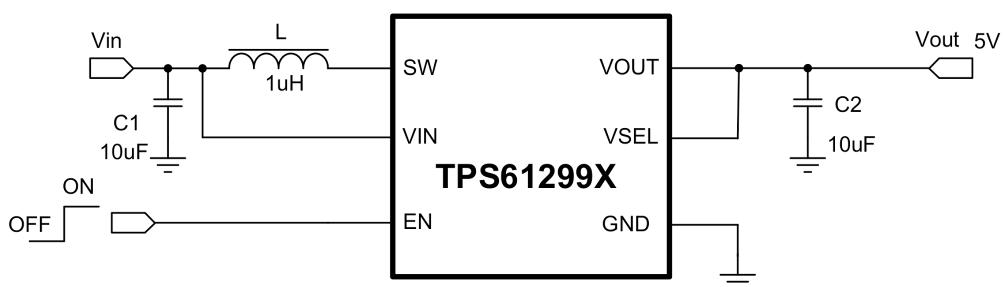


Figure 8-1. 3.6V Input Source to 5V Boost Converter Under Fast Mode

8.2.1 Design Requirements

The design parameters are listed in Table 8-1.

Table 8-1. Design Requirements

PARAMETERS	VALUES
Input Voltage	2.7V ~ 4.3V
Output Voltage	5V (fast mode)
Output Current	200mA
Output Voltage Ripple	± 50mV

8.2.2 Detailed Design Procedure

8.2.2.1 Maximum Output Current

The maximum output capability of the TPS61299x/xA is determined by the input-to-output ratio and the current limit of the boost converter. The maximum output current can be estimated by Equation 2.

$$I_{OUT\,(max)} = \frac{V_{IN}\,I_{LIM}}{V_{OUT}}\eta \tag{2}$$

where

- η is the conversion efficiency, use 85% for estimation.
- I_{LIM} is the average switch current limit.
- V_{OUT} is the output voltage.
- V_{IN} is the input voltage.

Minimum input voltage, maximum boost output voltage, and minimum current limit I_{LIM} are used as the worst case condition for the estimation.

8.2.2.2 Inductor Selection

The TPS61299x/xA boost converter does not have fixed frequency and it keeps the inductor ripple current constant in the range of 350mA, so the frequency is determined by the inductance and working voltage.

The TPS61299x/xA is designed to work with inductor value of 1µH.

Table 8-2. Recommended Inductors for the TPS61299x/xA

PART NUMBER	L (µH)	DCR MAX (mΩ)	SATURATION CURRENT (A)	SIZE (LxWxH)	VENDOR (1)
HTTH16080H-1R0MSR-99	1	110	2.3	1.6 × 0.8 × 0.8	Cyntec
WIP252010P-1R0ML	1	54	3.5	2.5 x 2.0 x 1.0	INPAQ
WPN252010H1R0MT	1	76	3.5	2.5 x 2.0 x 1.0	Sunlord

(1) See the Third-Party Products disclaimer

8.2.2.3 Output Capacitor Selection

The output capacitor is mainly selected to meet the requirements for output ripple and loop stability. The ripple voltage is related to capacitor capacitance and its equivalent series resistance (ESR). Assuming a ceramic capacitor with zero ESR, the minimum capacitance needed for a given ripple voltage can be calculated by Equation 3.

$$C_{OUT} = \frac{I_{OUT} \times D_{MAX}}{f_{SW} \times V_{RIPPLE}} \quad (3)$$

where

- D_{MAX} is the maximum switching duty cycle.
- V_{RIPPLE} is the peak-to-peak output ripple voltage.
- I_{OUT} is the maximum output current.
- f_{SW} is the switching frequency.

The ESR impact on the output ripple must be considered if tantalum or aluminum electrolytic capacitors are used. The output peak-to-peak ripple voltage caused by the ESR of the output capacitors can be calculated by Equation 4.

$$V_{RIPPLE(ESR)} = I_{L(P)} \times R_{ESR} \quad (4)$$

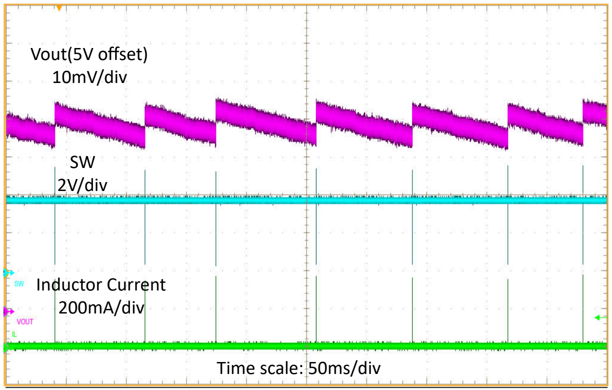
Take care when evaluating the derating of a ceramic capacitor under DC bias voltage, aging, and AC signal. For example, the DC bias voltage can significantly reduce capacitance. A ceramic capacitor can lose more than 50% of its capacitance at its rated voltage. Therefore, always leave margin on the voltage rating to make sure there is adequate capacitance at the required output voltage. Increasing the output capacitor makes the output ripple voltage smaller in PWM mode.

TI recommends using the X5R or X7R ceramic output capacitor in the range of 4μF to 1000μF effective capacitance. The output capacitor affects the small signal control loop stability of the boost regulator. Effective output capacitance should be no less than 20μF as soon as output current is higher than 1A or the TPS612997, the 1.9A input current limit version device is used. If the output capacitor is below the range, the boost regulator can potentially become unstable.

8.2.2.4 Input Capacitor Selection

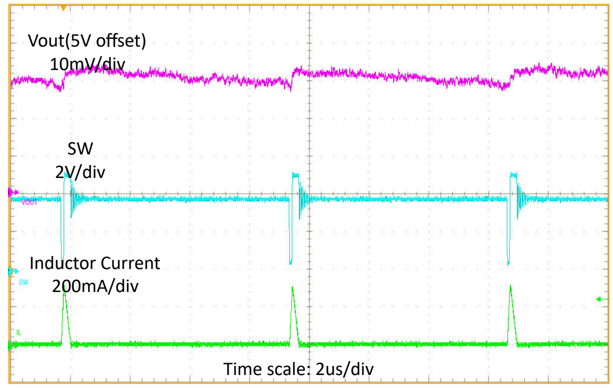
Multilayer X5R or X7R ceramic capacitors are excellent choices for the input decoupling of the step-up converter as they have extremely low ESR and are available in small footprints. Input capacitors must be located as close as possible to the device. While a 10μF input capacitor is sufficient for most applications, larger values can be used to reduce input current ripple without limitations. Take care when using only ceramic input capacitors. When a ceramic capacitor is used at the input and the power is being supplied through long wires, a load step at the output can induce ringing at the VIN pin. This ringing can couple to the output and be mistaken as loop instability or can even damage the part. In this circumstance, place additional bulk capacitance (tantalum or aluminum electrolytic capacitor) between ceramic input capacitor and the power source to reduce ringing that can occur between the inductance of the power source leads and ceramic input capacitor.

8.2.3 Application Curves



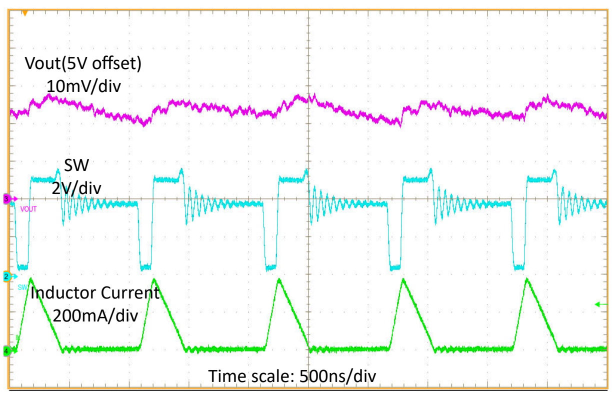
V_{IN} = 3.6V V_{OUT} = 5V | I_{OUT} = 0A

Figure 8-2. Switching Waveform at Open Load



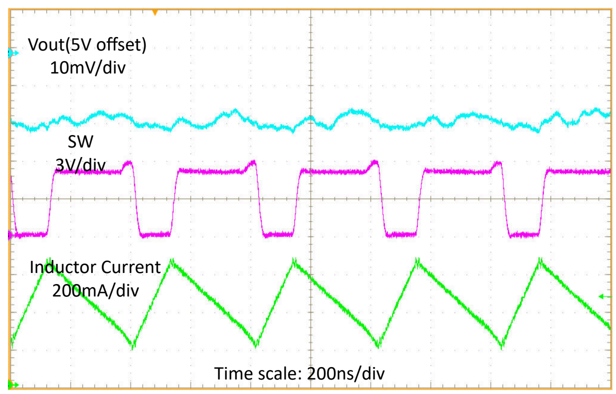
V_{IN} = 3.6V V_{OUT} = 5V | I_{OUT} = 5mA

Figure 8-3. Switching Waveform at Light Load



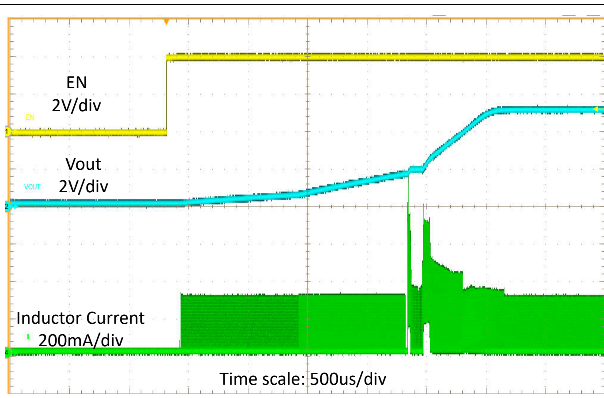
V_{IN} = 3.6V V_{OUT} = 5V | I_{OUT} = 50mA

Figure 8-4. Switching Waveform at Medium Load



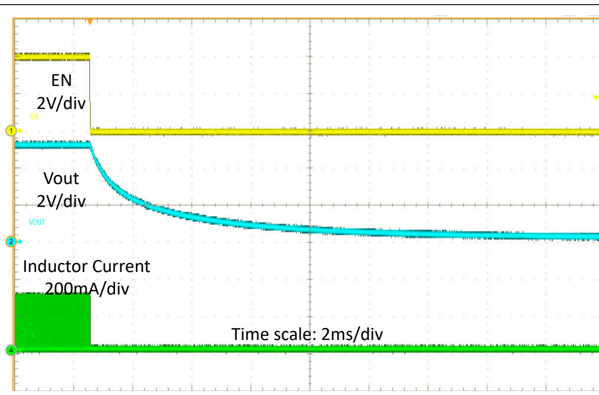
V_{IN} = 3.6V V_{OUT} = 5V | I_{OUT} = 300mA

Figure 8-5. Switching Waveform at Heavy Load



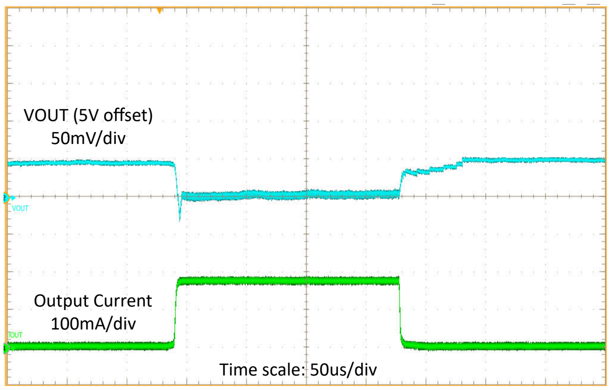
V_{IN} = 3.6V V_{OUT} = 5V | R_{load} = 500Ω

Figure 8-6. Start-Up by EN



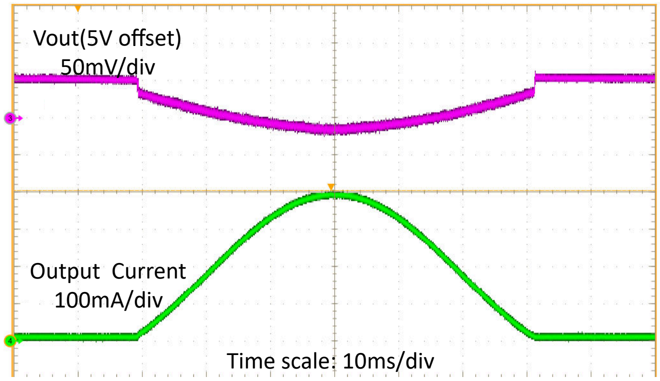
V_{IN} = 3.6V V_{OUT} = 5V | R_{load} = 500Ω

Figure 8-7. Shutdown by EN



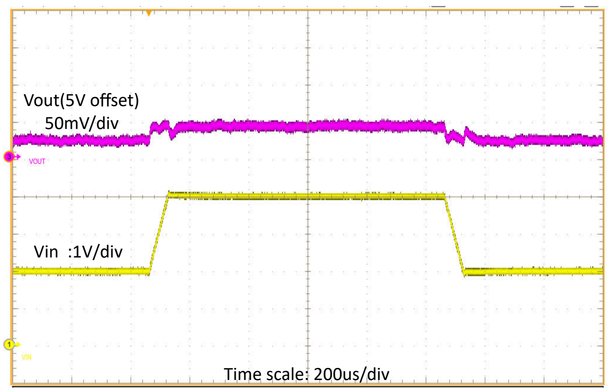
V_{IN} = 3.6V, V_{OUT} = 5V, I_{OUT} = 0 to 200mA with 20-μs slew rate

Figure 8-8. Load Transient



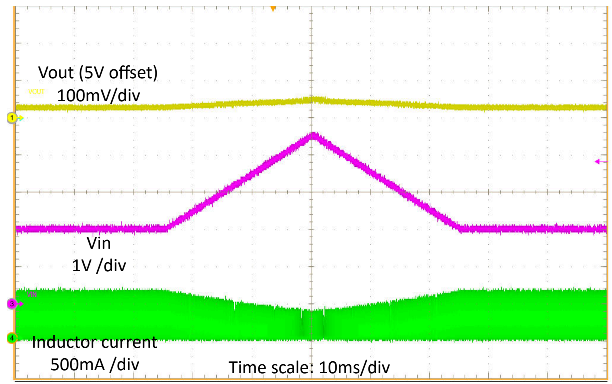
V_{IN} = 3.6V, V_{OUT} = 5V, I_{OUT} = 0 to 400mA sweep

Figure 8-9. Load Sweep



V_{IN} = 2V to 4V with 20-us slew rate, V_{OUT} = 5V, R_{load} = 50Ω

Figure 8-10. Line Transient



V_{IN} = 2V to 4.5V Sweep, V_{OUT} = 5V, R_{load} = 25Ω

Figure 8-11. Line Sweep

8.3 Typical Application-Li-ion Battery to 5V Boost Converter Under Normal Mode

The TPS61299x/xA family can also operate under normal mode with slightly slower transient performance than fast mode. Set the VSEL according to Table 8-3 to select different target output voltage during fast mode operation. Table 8-3lists the design parameters.

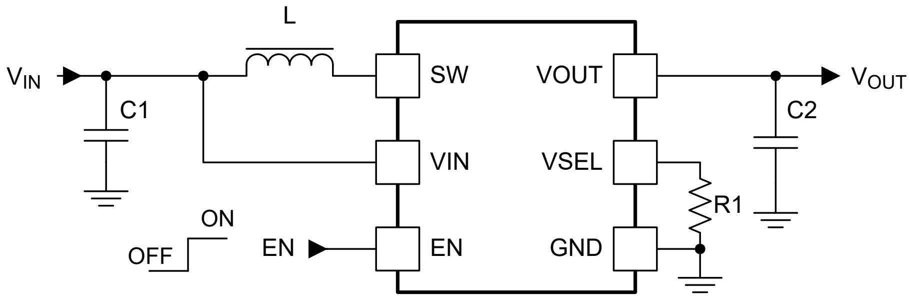


Figure 8-12. 3.6V Input Source to 5V Boost Converter Under Normal Mode

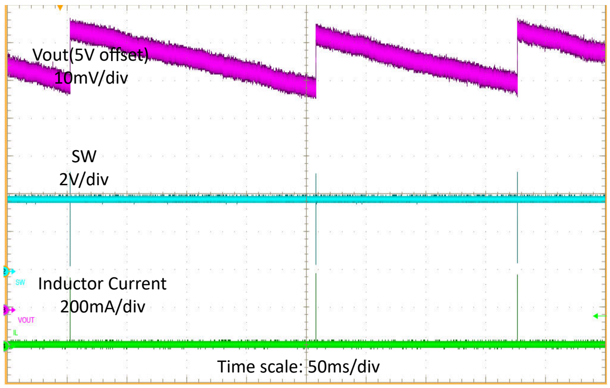
8.3.1 Design Requirements

The design parameters are listed in Table 8-1.

Table 8-3. Design Requirements

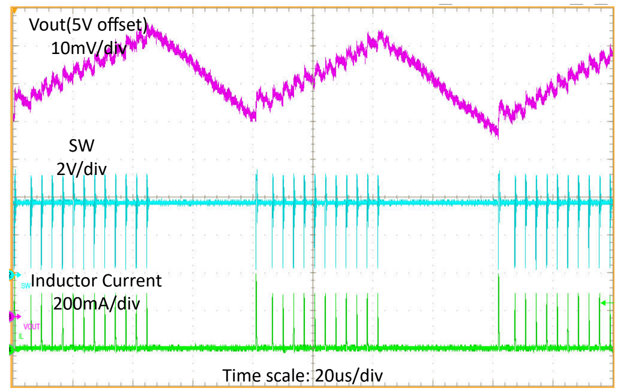
PARAMETERS	VALUES
Input Voltage	2.7V to approximately 4.3V
Output Voltage	5V (normal mode)
Output Current	200mA
Output Voltage Ripple	± 50mV

8.3.2 Application Curves



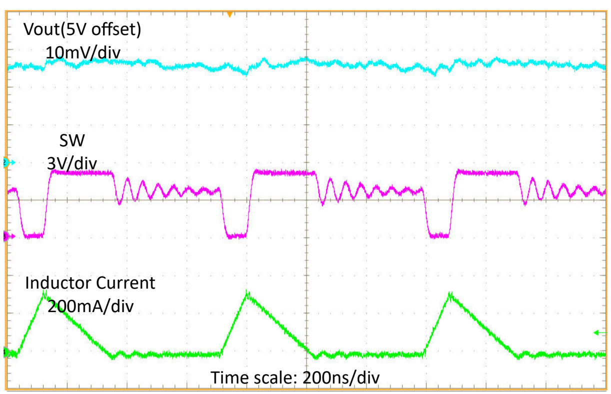
V_{IN} = 3.6V V_{OUT} = 5V | I_{OUT} = 0A

Figure 8-13. Switching Waveform at Open Load



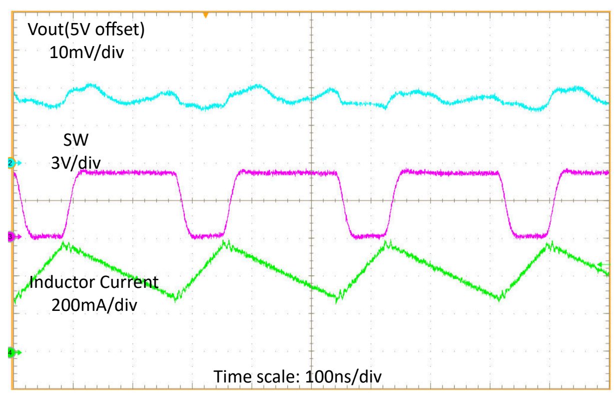
V_{IN} = 3.6V V_{OUT} = 5V | I_{OUT} = 5mA

Figure 8-14. Switching Waveform at Light Load



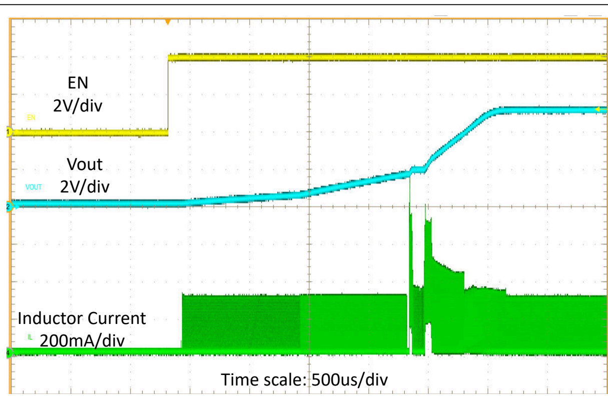
V_{IN} = 3.6V V_{OUT} = 5V | I_{OUT} = 50mA

Figure 8-15. Switching Waveform at Medium Load



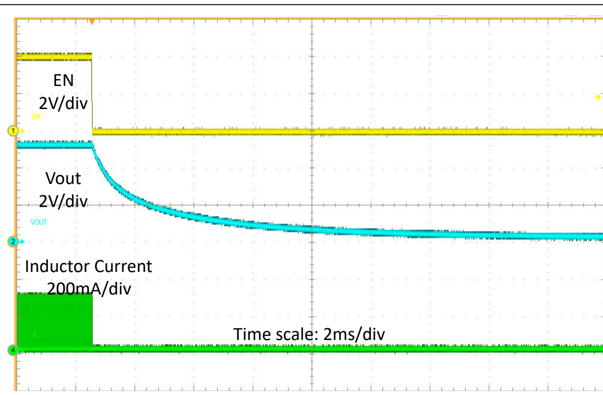
V_{IN} = 3.6V V_{OUT} = 5V | I_{OUT} = 300mA

Figure 8-16. Switching Waveform at Heavy Load



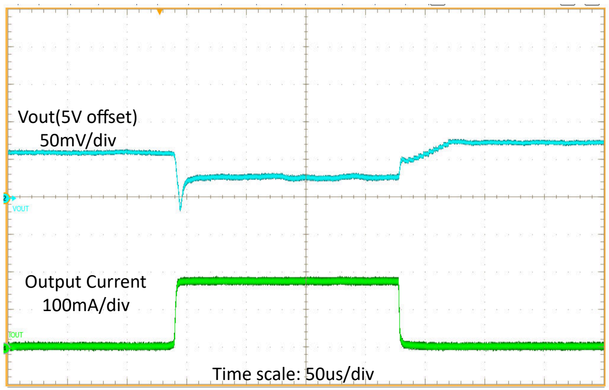
V_{IN} = 3.6V V_{OUT} = 5V | R_{load} = 500Ω

Figure 8-17. Start-Up by EN



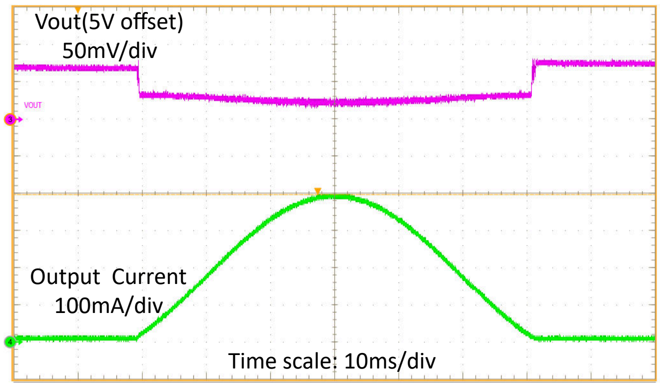
V_{IN} = 3.6V V_{OUT} = 5V | R_{load} = 500Ω

Figure 8-18. Shutdown by EN



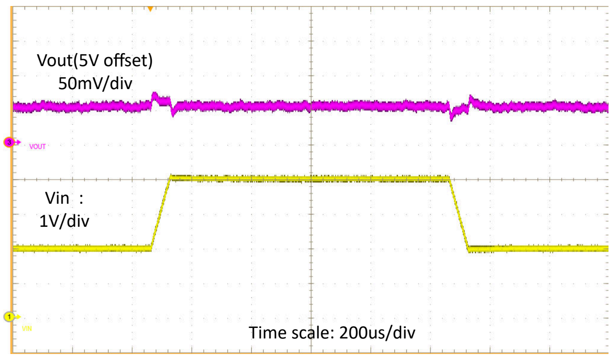
V_{IN} = 3.6V, V_{OUT} = 5V, I_{OUT} = 0 to 200mA with 20µs slew rate

Figure 8-19. Load Transient



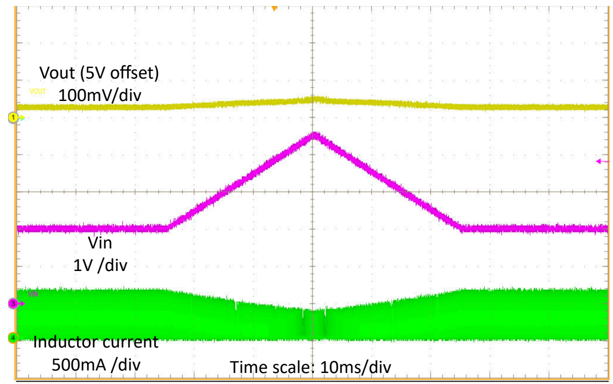
V_{IN} = 3.6V, V_{OUT} = 5V, I_{OUT} = 0 to 400mA sweep

Figure 8-20. Load Sweep



V_{IN} = 2V to 4V with 20-us slew rate, V_{OUT} = 5V, R_{load} = 50Ω

Figure 8-21. Line Transient



V_{IN} = 2V to 4.5V Sweep, V_{OUT} = 5V, R_{load} = 25Ω

Figure 8-22. Line Sweep

8.4 TPS61299xA Typical Application-Li-ion Battery to 5V Boost Converter Under Normal Mode

TPS61299xA is auto pass through when disabled, but after start up, the function is the same with TPS61299x device.The A version device also support normal mode and fast mode operation. Set the VSEL according to Table 8-4 to select different target output voltage during fast mode operation. TI recommends to add a tantalum electrolytic capacitor of 150µF to 220µF to depress the inverse current during the shutdown process. Table 8-4 lists the design parameters.

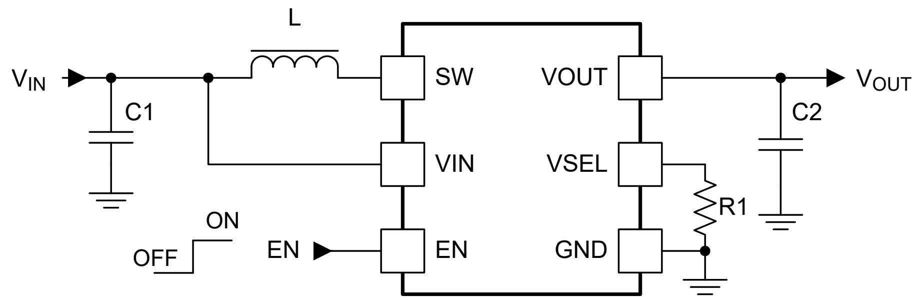


Figure 8-23. TPS61299A 3.6V Input Source to 5V Boost Converter Under Normal Mode

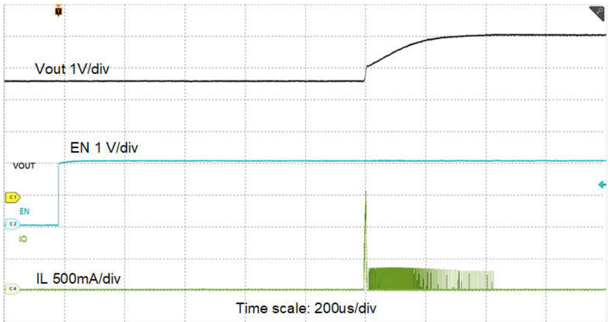
8.4.1 Design Requirements

The design parameters are listed in Table 8-4.

Table 8-4. Design Requirements

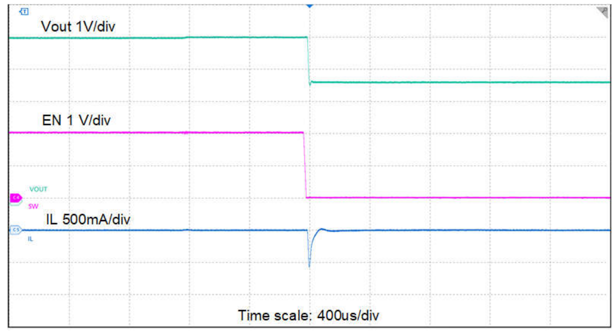
PARAMETERS	VALUES
Input Voltage	2.7V - 4.3V
Output Voltage	5V (normal mode)
Output Current	200mA
Output Voltage Ripple	± 50mV

8.4.2 Application Curves



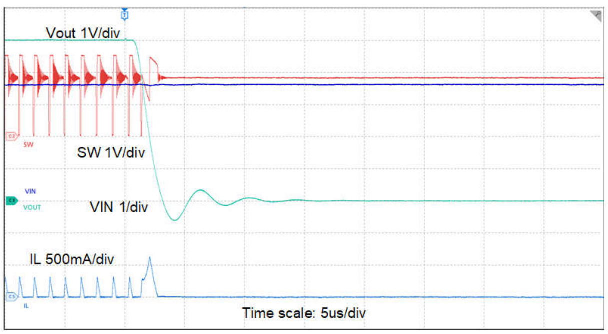
V_{IN} = 3.6V V_{OUT} = 5V | R_{load} = 500Ω

Figure 8-24. Start-Up by EN



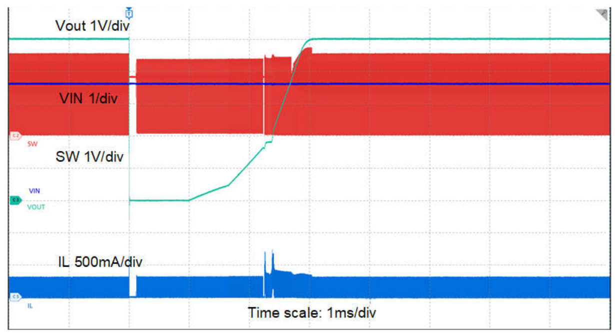
V_{IN} = 3.6V V_{OUT} = 5V | R_{load} = 500Ω

Figure 8-25. Shutdown by EN



V_{IN} = 3.6V V_{OUT} = 5V | R_{load} = 166Ω

Figure 8-26. Short Circuit Protection



V_{IN} = 3.6V V_{OUT} = 5V | R_{load} = 166Ω

Figure 8-27. Short Circuit Recovery

8.5 Power Supply Recommendations

The device is designed to operate from an input voltage supply range between 0.5V to 5.5V. This input supply must be well regulated. If the input supply is located more than a few inches from the converter, additional bulk capacitance can be required in addition to the ceramic bypass capacitors. A typical choice is a tantalum or aluminum electrolytic capacitor with a value of 100µF. Output current of the input power supply must be rated according to the supply voltage, output voltage, and output current of the TPS61299x/xA.

8.6 Layout

8.6.1 Layout Guidelines

As for all switching power supplies, the layout is an important step in the design, especially at high peak currents and high switching frequencies. If the layout is not carefully done, the regulator can show stability problems as well as EMI problems. Therefore, use wide and short traces for the main current path and for the power ground paths. The input and output capacitors , as well as the inductor are placed as close as possible to the device.

8.6.2 Layout Example

The bottom layer is a large GND plane connected by vias.

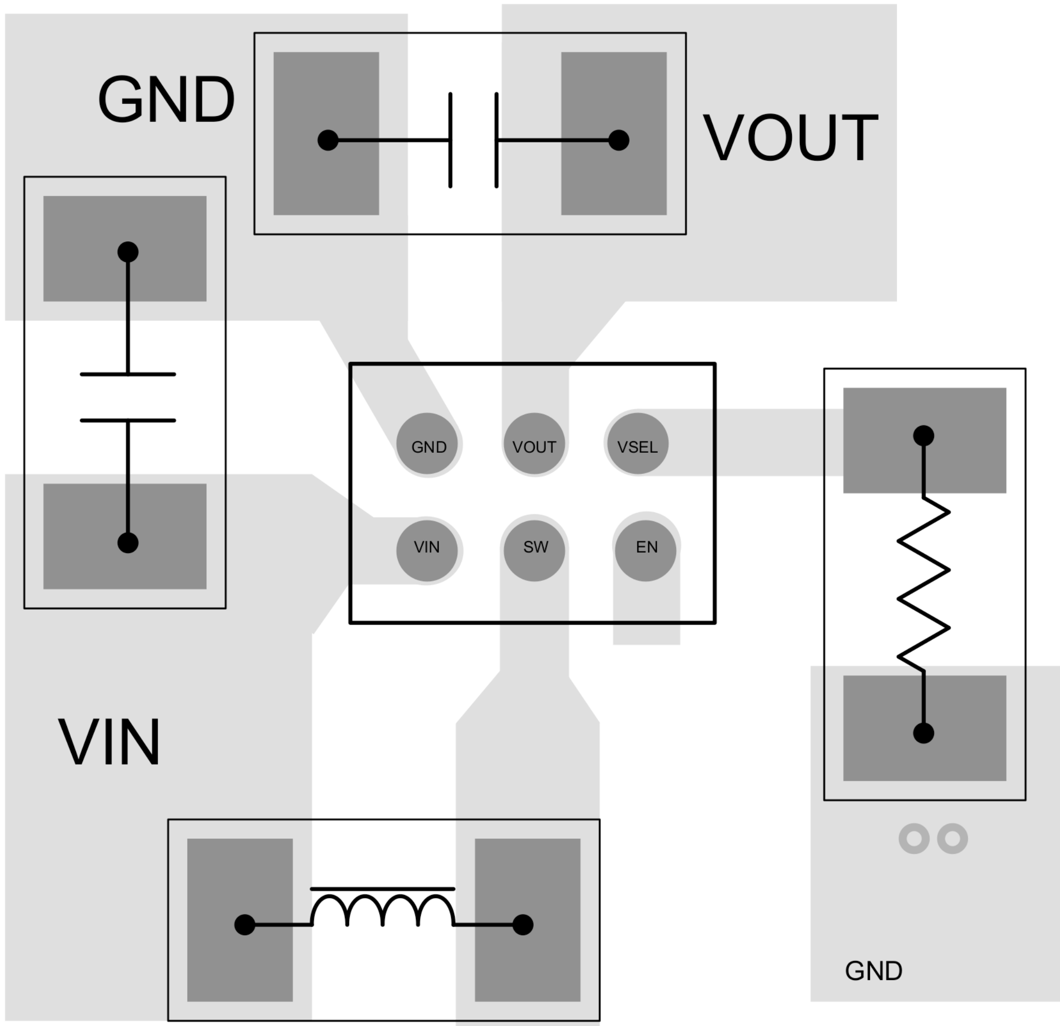


Figure 8-28. Layout Example-YBH

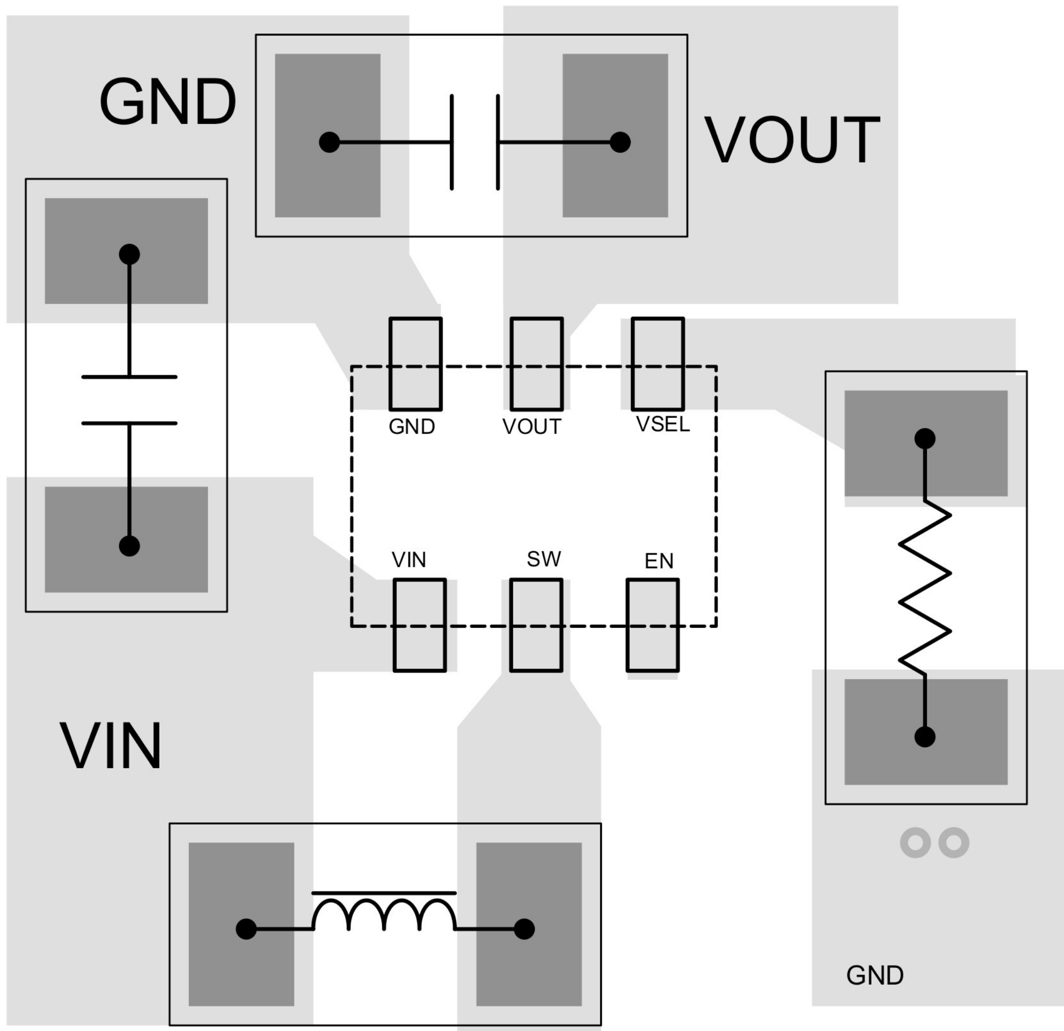


Figure 8-29. Layout Example-DRL

8.7 Thermal Information

The maximum junction temperature is restricted to 125°C under normal operating conditions. Calculate the maximum allowable dissipation, $P_{D(max)}$, and maintain the actual power dissipation less than or equal to $P_{D(max)}$. The maximum-power-dissipation limit is determined using Equation 5.

$$P_{D(max)} = \frac{125 - T_A}{R_{\theta JA}} \tag{5}$$

where

- T_A is the maximum ambient temperature for the application
- Θ_{JA} is the junction-to-ambient thermal resistance given in the Thermal Information table.

The TPS61299x/xA comes in a WCSP or SOT563 package. The real junction-to-ambient thermal resistance of the package greatly depends on the PCB type and layout. Using thick PCB copper and soldering GND pin to a large ground plate enhances the thermal performance. Using more vias connects the ground plate on the top layer and bottom layer around the IC without solder mask also improves the thermal capability.

9 Device and Documentation Support

9.1 Device Support

9.1.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

9.2 Documentation Support

9.2.1 Related Documentation

For related documentation see the following:

- Texas Instruments, *Performing Accurate PFM Mode Efficiency Measurements Application Report*
- Texas Instruments, *Accurately Measuring Efficiency of Ultra-low-IQ Devices Technical Brief*
- Texas Instruments, *IQ: What it is, What it isn’t, and How to Use it Techanical Brief*

9.3 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.

9.4 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.

9.5 Trademarks

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

9.6 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.

9.7 Glossary

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

10 Revision History

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

Changes from Revision E (June 2024) to Revision F (July 2025)	Page
• Changed the description of quiescent current from "95nA typical quiescent current from VOUT " to "95nA typical quiescent current into VOUT"	1
• Changed the description of shutdown current from "60nA typical shutdown current from VIN and SW" to "60nA typical shutdown current into VIN "	1
• Added optical module	1
• Deleted note for TPS612993 to reflect the release of the device	3
• Changed maximum boost output voltage for the TPS612997 from: 5.5V to: 5V	5
• Changed output voltage accuracy symbol from: V~OUT_PWM_ACY to: V~OUT_ACY	6
• Added TPS612993/A information to the Electrical Characteristics table	6
• Changed input current units in the System Characteristics table from: ohms to: Ω	7
• Updated the current limit description during the soft start stage	15
• Changed the output current from 500mA to 200mA	20
• Changed the output current from 10mA to 200mA	24
• Changed the output current from 10mA to 200mA	27

Changes from Revision D (March 2024) to Revision E (June 2024)	Page
• Updated to include A version device	6
• Updated to include A version device	7
• Updated to include A version device	9
• Updated to include A version device	25

Changes from Revision C (February 2024) to Revision D (March 2024)	Page
• Updated the title of Figure 6-2	9
• Updated equation	14

11 Mechanical, Packaging, and Orderable Information

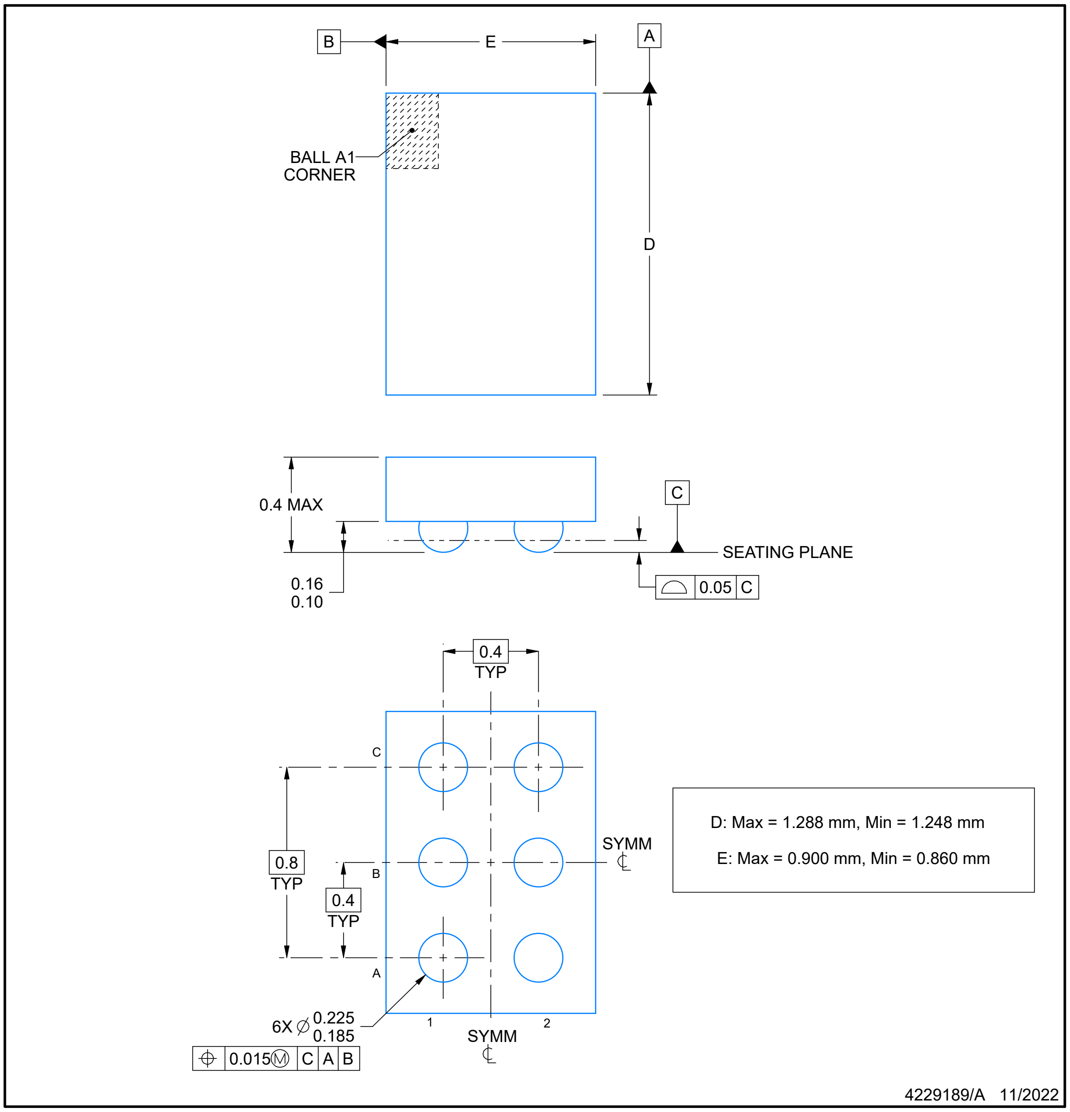
The following pages include mechanical packaging and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand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

PACKAGE OUTLINE

YBH0006-C03

DSBGA - 0.4 mm max height

DIE SIZE BALL GRID ARRAY



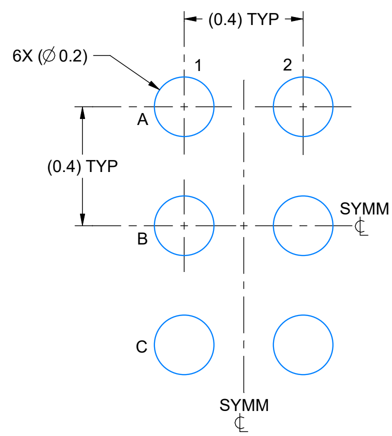
NOTES:

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.

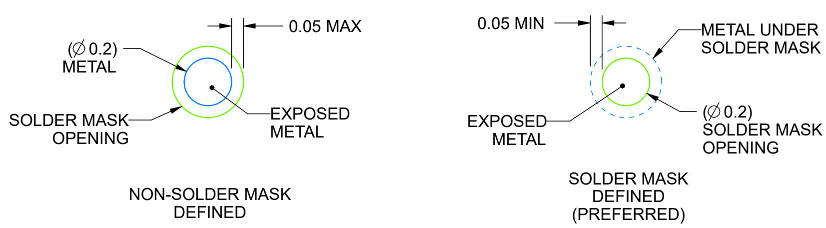
EXAMPLE BOARD LAYOUT

YBH0006-C03 **DSBGA - 0.4 mm max height**

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 50X



SOLDER MASK DETAILS
NOT TO SCALE

4229189/A 11/2022

NOTES: (continued)

3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

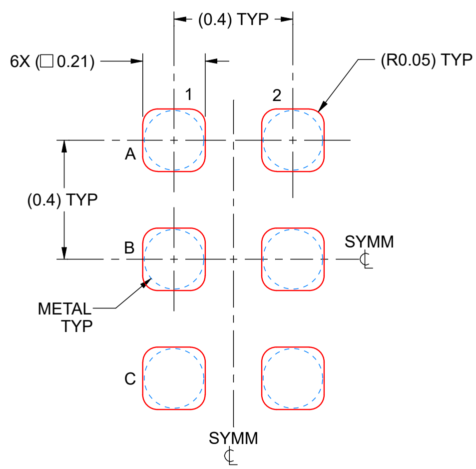
TEXAS INSTRUMENTS
www.ti.com

EXAMPLE STENCIL DESIGN

YBH0006-C03

DSBGA - 0.4 mm max height

DIE SIZE BALL GRID ARRAY

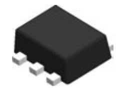


SOLDER PASTE EXAMPLE
BASED ON 0.075 mm THICK STENCIL
SCALE: 50X

4229189/A 11/2022

NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

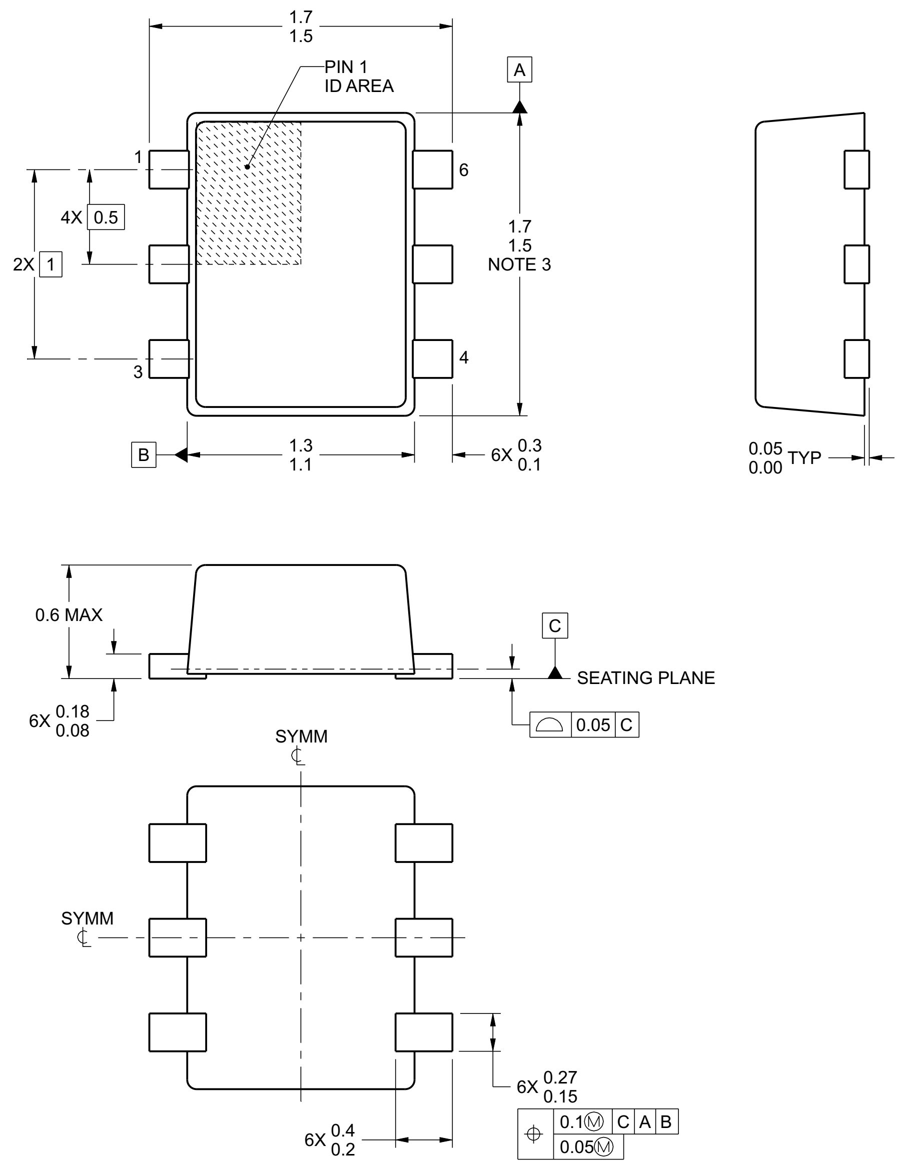


DRL0006A

PACKAGE OUTLINE

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



NOTES:

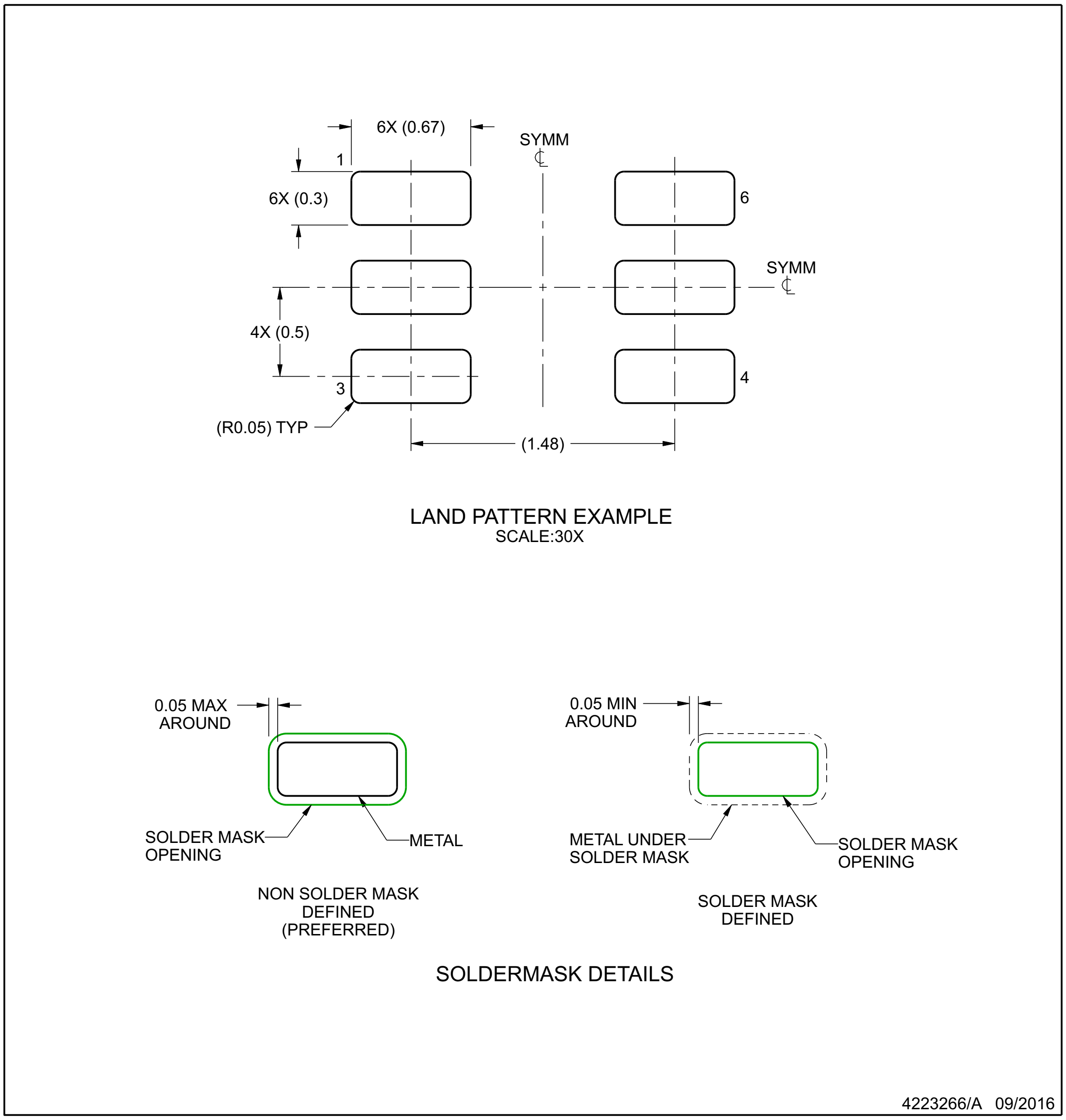
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or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

EXAMPLE BOARD LAYOUT

DRL0006A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



NOTES: (continued)

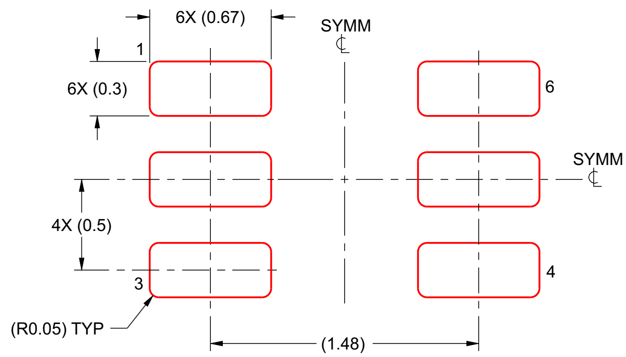
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DRL0006A

SOT - 0.6 mm max height

PLASTIC SMALL OUTLINE



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:30X

4223266/A 09/2016

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
7. 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)
TPS612993YBHR	Active	Production	DSBGA (YBH) | 6	6000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	93
TPS612993YBHR.A	Active	Production	DSBGA (YBH) | 6	6000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	93
TPS612994YBHR	Active	Production	DSBGA (YBH) | 6	6000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	994
TPS612994YBHR.A	Active	Production	DSBGA (YBH) | 6	6000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	994
TPS612997YBHR	Active	Production	DSBGA (YBH) | 6	6000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	997
TPS612997YBHR.A	Active	Production	DSBGA (YBH) | 6	6000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	997
TPS61299ADRLR	Active	Production	SOT-5X3 (DRL) | 6	4000 | LARGE T&R	Yes	Call TI | Sn	Level-1-260C-UNLIM	-40 to 125	299A
TPS61299ADRLR.A	Active	Production	SOT-5X3 (DRL) | 6	4000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	299A
TPS61299ADRLR.B	Active	Production	SOT-5X3 (DRL) | 6	4000 | LARGE T&R	-	SN	Level-1-260C-UNLIM	-40 to 125	299A
TPS61299DRLR	Active	Production	SOT-5X3 (DRL) | 6	4000 | LARGE T&R	Yes	Call TI | Sn	Level-1-260C-UNLIM	-40 to 125	61299
TPS61299DRLR.A	Active	Production	SOT-5X3 (DRL) | 6	4000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	61299
TPS61299YBHR	Active	Production	DSBGA (YBH) | 6	6000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	299
TPS61299YBHR.A	Active	Production	DSBGA (YBH) | 6	6000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 125	299

(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.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

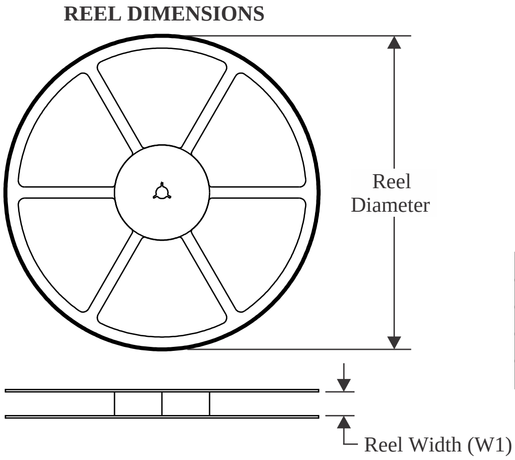
OTHER QUALIFIED VERSIONS OF TPS61299 :

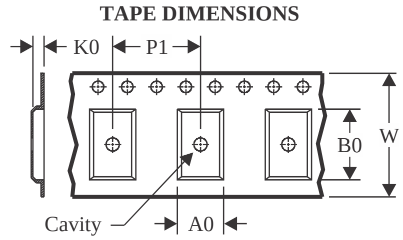
- Automotive : TPS61299-Q1

NOTE: Qualified Version Definitions:

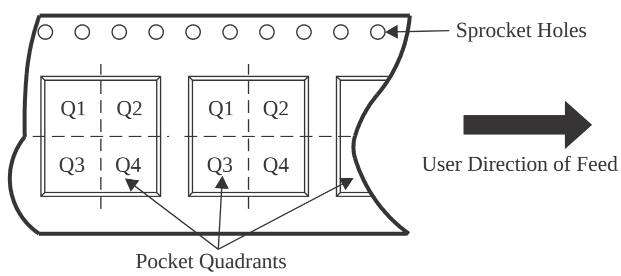
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION





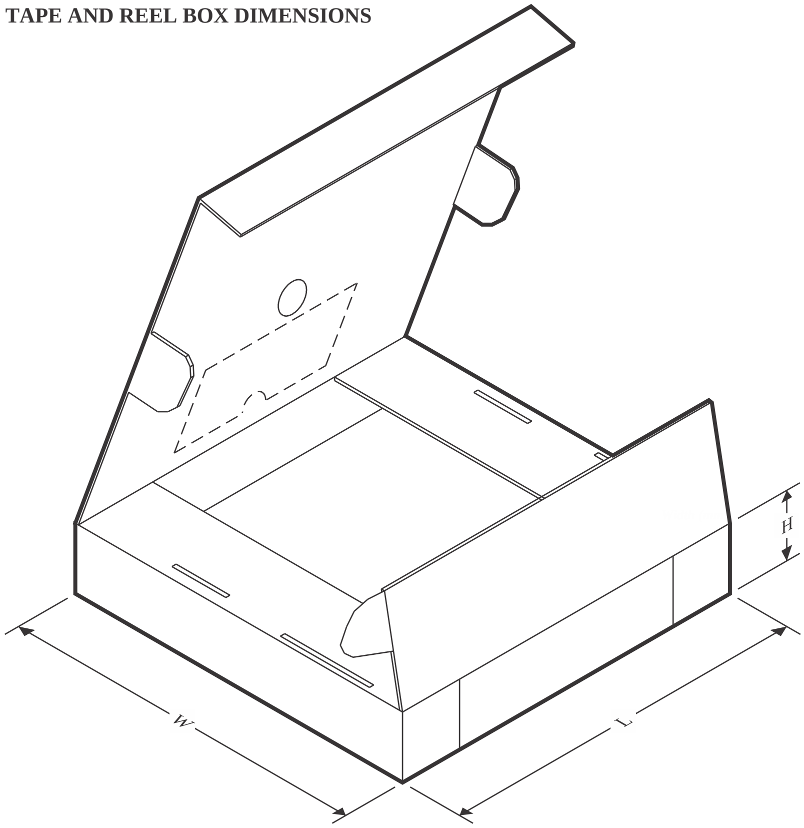
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*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
TPS612993YBHR	DSBGA	YBH	6	6000	180.0	8.4	0.98	1.39	0.46	2.0	8.0	Q1
TPS612994YBHR	DSBGA	YBH	6	6000	180.0	8.4	0.98	1.39	0.46	2.0	8.0	Q1
TPS612997YBHR	DSBGA	YBH	6	6000	180.0	8.4	0.98	1.39	0.46	2.0	8.0	Q1
TPS61299ADRLR	SOT-5X3	DRL	6	4000	180.0	8.4	2.0	1.8	0.75	4.0	8.0	Q3
TPS61299DRLR	SOT-5X3	DRL	6	4000	180.0	8.4	2.0	1.8	0.75	4.0	8.0	Q3
TPS61299YBHR	DSBGA	YBH	6	6000	180.0	8.4	0.98	1.39	0.46	2.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS612993YBHR	DSBGA	YBH	6	6000	182.0	182.0	20.0
TPS612994YBHR	DSBGA	YBH	6	6000	182.0	182.0	20.0
TPS612997YBHR	DSBGA	YBH	6	6000	182.0	182.0	20.0
TPS61299ADRLR	SOT-5X3	DRL	6	4000	210.0	185.0	35.0
TPS61299DRLR	SOT-5X3	DRL	6	4000	210.0	185.0	35.0
TPS61299YBHR	DSBGA	YBH	6	6000	182.0	182.0	20.0

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265