0.9-V to 5.5-V VIN, 600-mA Synchronous Step-up Regulator

Features

- 260-nA Ultra-Low IQ into the VOUT Pin
- 40-nA Ultra-Low IQ into the VIN Pin
- Operating Input Voltage from 0.9 V to 5.5 V
- Adjustable Output Voltage from 2.5 V to 5.5 V
- Fixed Output Voltage Versions Available
- Typical 0.8-A Switch Peak Current Limit
- Regulated Output Voltage in the Down Mode
- True Disconnection During Shutdown
- Up to 80% Efficiency at 10-μA Load with Fixed Output Voltage Versions
- Up to 96% Efficiency from 10-mA to 300-mA Load
- WLCSP-6, DFN2X2-6 packages

Applications

- Battery-Powered Devices
- Battery-Powered Wearable Applications
- Fiber Optical Modules
- Internet of Things Devices
- Battery-Powered Water/Gas Meters

Description

The TPQ05100x series of products are synchronous boost converters with less than 260-nA ultra-low quiescent current. The device has an ultra-low under-voltage lock-out threshold to support different kinds of battery voltages as low as 0.9 V. The ultra-low 260-nA quiescent current increases light load efficiency and thus increases battery life.

The TPQ05100x series of products have various voltage options to support fixed output voltage ranging from 2.5 V to 5 V, and adjustable output voltage ranging from 2.5 V to 5.5 V. The device has a true-shutdown feature that avoids leakage current during the shutdown mode to further save system level quiescent current.

The TPQ05100x series provides the down mode and the pass-through mode to support different scenarios. In the down mode, the device can still regulate output voltage to a desired level. In the pass-through mode, the TPQ05100x devices work as switches that the output voltage follows input voltage.

The TPQ05100x provides both adjustable voltage version and fixed voltage version with DFN2X2-6 and WLCSP-6 packages.

Typical Application Circuit

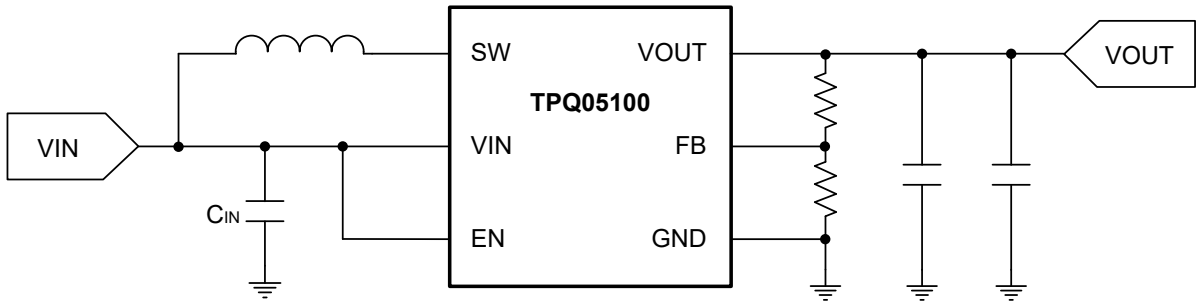


Table of Contents

Product Family Table

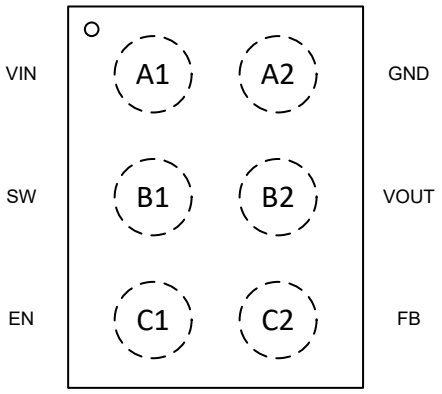
Order Number	Output Voltage (V)	Package
TPQ05100-DFOR	Adjustable	DFN2X2-6
TPQ051007-DFOR	5	DFN2X2-6
TPQ051006-DFOR	4.5	DFN2X2-6
TPQ051005-DFOR	3.6	DFN2X2-6
TPQ051004-DFOR	3.3	DFN2X2-6
TPQ051003-DFOR	3	DFN2X2-6
TPQ051002-DFOR	2.5	DFN2X2-6
TPQ05100-WS4R	Adjustable	WLCSP
TPQ051007-WS4R	5	WLCSP
TPQ051006-WS4R	4.5	WLCSP
TPQ051005-WS4R	3.6	WLCSP
TPQ051004-WS4R	3.3	WLCSP
TPQ051003-WS4R	3	WLCSP
TPQ051002-WS4R	2.5	WLCSP

Revision History

Date	Revision	Notes
2022-11-25	Rev.P.0	Initial Draft
2022-12-19	Rev.A.0	Initial Release. Updated typical characteristics and miscellaneous corrections.
2023-03-13	Rev.A.1	Updated WLCSP marking information.
2023-12-25	Rev.A.2	Misc. correction

Pin Configuration and Functions

TPQ05100x
6-Pin WLCSP Package
Top View



TPQ05100x
DFN2X2-6 Package
Top View

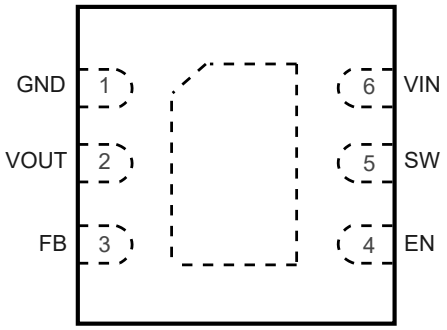


Table 1. Pin Functions: TPQ05100x

Pin		Name	I/O	Description
DFN2X2-6	WLCSP			
1	A2	GND	Ground	Device ground.
2	B2	VOUT	Output	Boost converter voltage output.
3	C2	FB	Input	Voltage feedback input. Connect to resistor divider for adjustable voltage versions; connect to GND for fixed voltage versions.
4	C1	EN	Input	Device enable, active high. Cannot be left floating.
5	B1	SW	Power	Switching output.
6	A1	VIN	Power	Power supply.

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
Input Voltage	VIN, SW, VOUT, FB, EN	−0.3	6	V
T_J	Maximum Junction Temperature		150	°C
T_A	Operating Temperature Range	−40	125	°C
T_{STG}	Storage Temperature Range	−65	150	°C
T_L	Lead Temperature (Soldering 10 sec)		260	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.This data was taken with the JEDEC low effective thermal conductivity test board.This data was taken with the JEDEC standard multilayer test boards.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	±2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	±1	kV

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V_{IN}				5.5	V
V_{OUT}	Output Voltage Range	2.5		5.5	V
L	Inductor	0.7		2.2	μH
C_{IN}	Input Capacitor	1.0		10	μF
C_{OUT}	Output Capacitor	10	20	100	μF
T_J	Operating Junction Temperature	−40		125	°C

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
WLCSP	140	1	°C/W
DFN2X2-6	90	95	°C/W

Electrical Characteristics

All test condition is at T_J = −40°C to 125°C. V_{IN} = 0.9 V to 5.5 V. Typical values are at V_{IN} = 3.7 V, T_J = 25℃, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Supply Voltage and Current						
V_{IN}	Input Voltage Range		0.9		5.5	V
V_{UVLO}	Input under Voltage Lockout Threshold	Rising threshold		0.6	0.7	V
V_{UVLO_hys}	UVLO Hysteresis			50		mV
I_{Q_VIN}	VIN Quiescent Current	IC enabled, no Load, no switching, V_{IN} = V_{SW} = 5 V, T_J = −40 °C to 85 °C		40	200	nA
I_{Q_VOUT}	VOUT Quiescent Current	IC enabled, no Load, no Switching,Boost or Down Mode, T_J = −40 °C to 85 °C		260	600	nA
I_{SD}	VIN Shutdown Current	IC disabled, V_{IN} = 5.5 V, V_{OUT} = 0 V T_J = −40 °C to 85 °C		›0	300	nA
Output						
V_{OUT}	Output Voltage Range		2.5		5.5	V
V_{OUT}	Output Voltage	TPQ051007, 5-V Output	4.9	5	5.1	V
		TPQ051006, 4.5-V Output	4.41	4.5	4.59	V
		TPQ051005, 3.6-V Output	3.528	3.6	3.672	V
		TPQ051004, 3.3-V Output	3.234	3.3	3.366	V
		TPQ051003, 3-V Output	2.94	3	3.06	V
		TPQ051002, 2.5-V Output	2.45	2.5	25.5	V
V_{REF}		TPQ05100, Adjustable Output	0.98	1	1.02	V
V_{OVP}	Output Overvoltage Protection Threshold	V_{OUT} rising threshold	5.55	5.8	6.05	V
V_{OVP_hys}	Over Voltage Protection Hysteresis			130		mV
Power Switch						
$R_{DS(on)\_LS}$	Low Side Power FET On-resistance	V_{OUT} = 5.0 V		130		mΩ
$R_{DS(on)\_HS}$	How Side Power FET On-resistance	V_{OUT} = 5.0 V		240		mΩ
I_L	Inductor Current Ripple	V_{OUT} = 5.0 V		350		mA
I_{LIMIT}	VIN Pin Output Charge Current	Boost operation	0.6	0.8	1	A
I_{SW_LKG}	Leakage Current into SW Pin	V_{SW} = 5.0 V, no switch, T_J = −40 °C to 85 °C		40	200	nA

Parameter		Conditions	Min	Typ	Max	Unit
I_{FB_LKG}	Leakage Current into FB Pin	V_{FB} = 1.0 V		0.75	50	nA
T_{OTP}	Over-temperature Protection Threshold			150		℃
T_{HYS}	Over-temperature Protection Hysteresis			25		℃
Input						
V_{IL}	EN Input Low Voltage Threshold	V_{IN} ≤ 1.5 V	0.1 × VIN			V
		V_{IN} > 1.5 V	0.4			V
V_{IH}	EN Input High Voltage Threshold	V_{IN} ≤ 1.5 V			0.8 × VIN	V
		V_{IN} > 1.5 V			1.2	V
I_{EN_LKG}	Leakage Current into EN Pin	V_{EN} = 5.0 V, T_J = −40 °C to 125 °C			50	nA

Typical Performance Characteristics

All test condition: T_A = 25°C, unless otherwise noted.

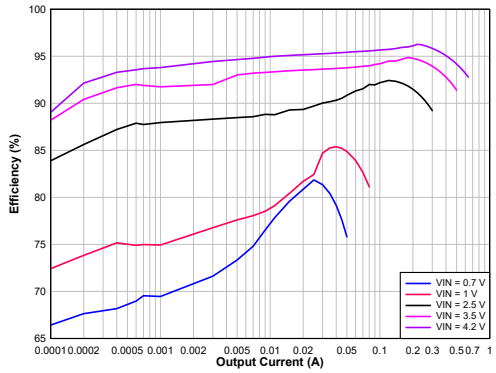


Figure 1. Efficiency with Different Inputs, TPQ05100

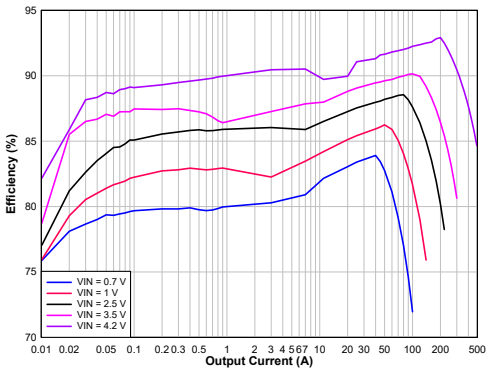


Figure 2. Efficiency with Different Inputs, TPQ051002

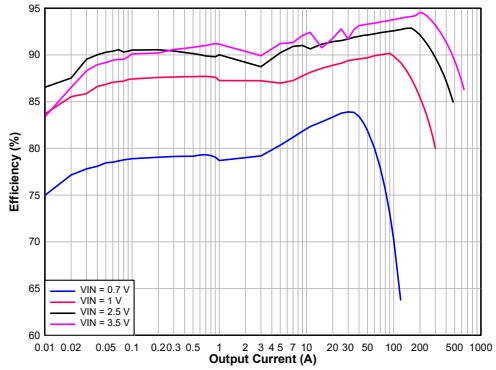


Figure 3. Efficiency with Different Inputs, TPQ051003

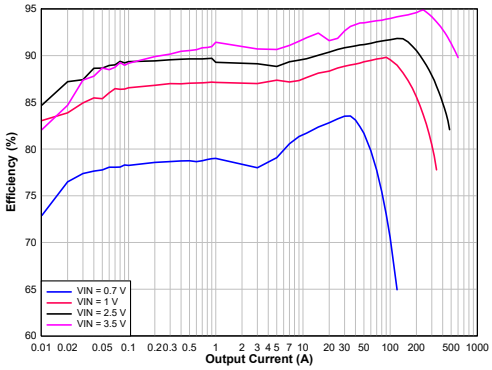


Figure 4. Efficiency with Different Inputs, TPQ051004

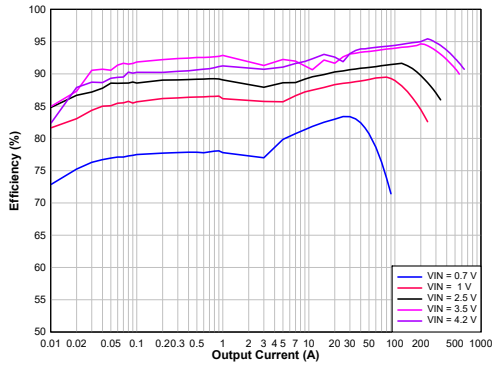


Figure 5. Efficiency with Different Inputs, TPQ051005

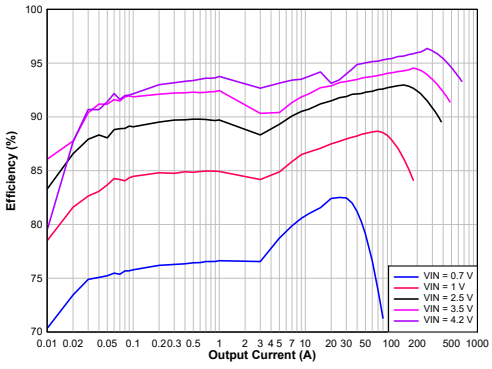


Figure 6. Efficiency with Different Inputs, TPQ051006

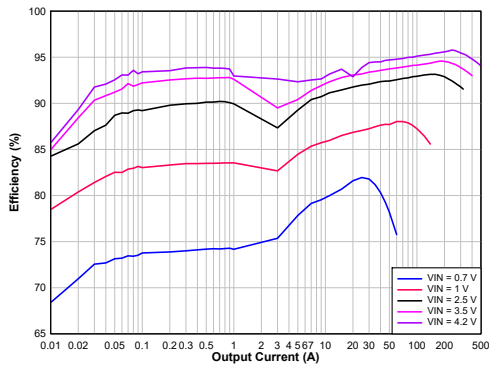


Figure 7. Efficiency with Different Inputs, TPQ051007

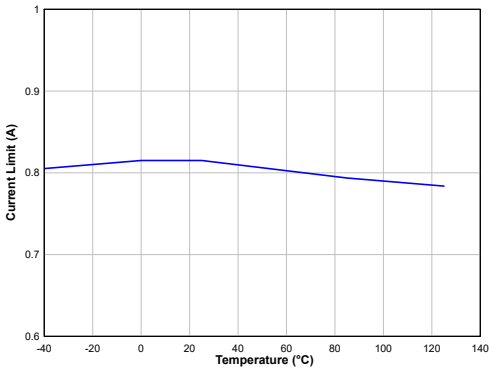


Figure 8. Current Limit vs. Temperature

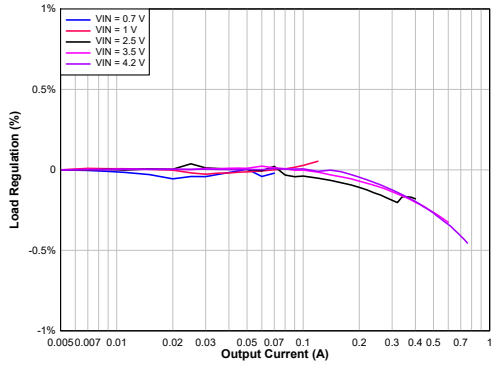


Figure 9. Load Regulation

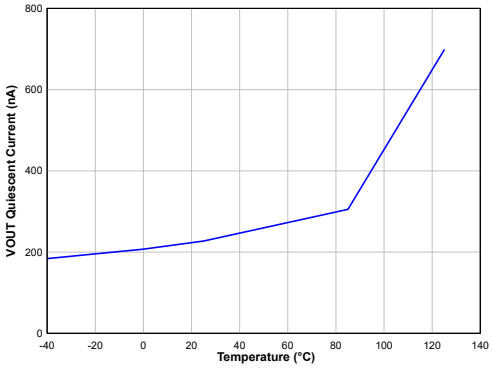


Figure 10. Quiescent Current into V_{OUT} vs. Temperature

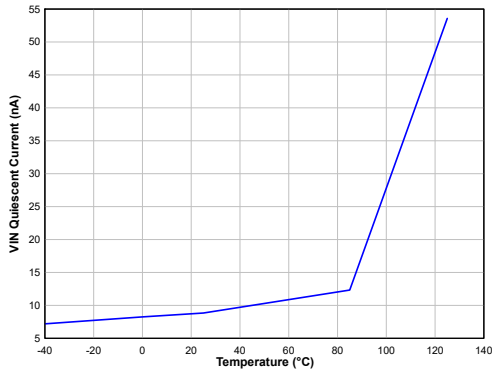


Figure 11. Quiescent Current into V_{IN} vs. Temperature

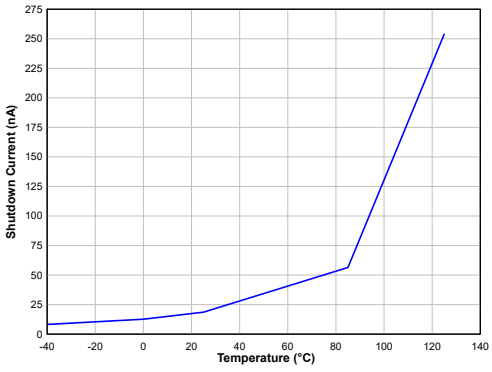


Figure 12. Shutdown Current vs. Temperature

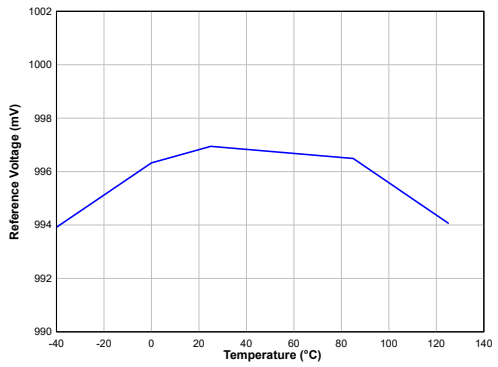


Figure 13. Reference Voltage vs. Temperature

Detailed Description

Overview

The TPQ05100x step-up converter series of products are synchronous high-efficiency, low-quiescent current converters for battery-powered systems. The wide voltage range of TPQ05100x supports 0.9 V to 5.5 V with only 260-nA quiescent current and increases the system battery lifetime. The devices support low-input voltage once they are powered up down to 0.7 V.

The TPQ05100x integrates a true-shutdown power MOSFET, allowing the load to completely shutdown and disconnect with the input. When the input voltage is close to or higher than the expected output voltage, the device can get into the down mode and the pass-through mode.

The TPQ05100x provides different versions to support fixed voltage options and adjustable voltage options.

Functional Block Diagram

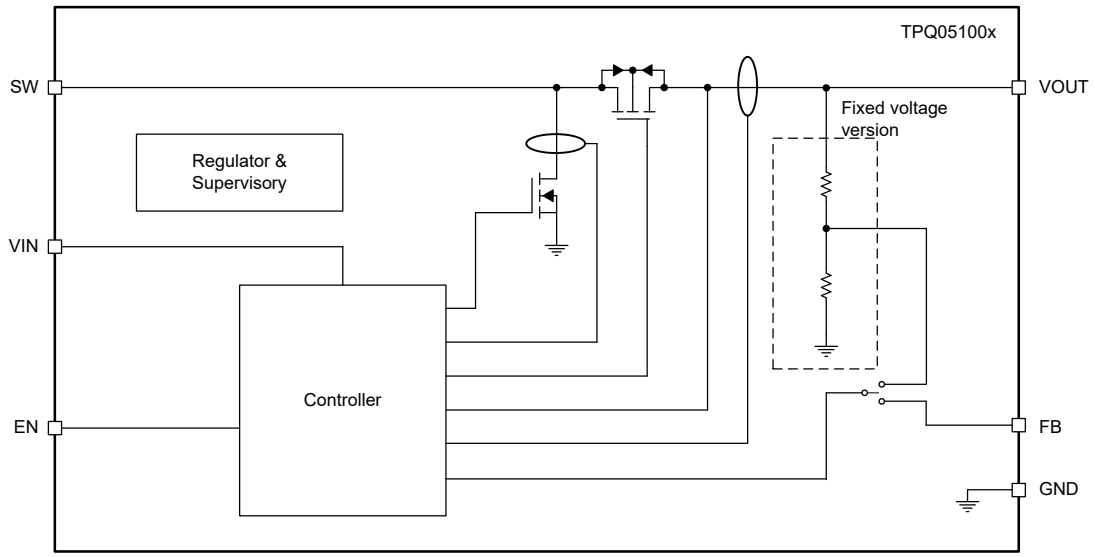


Figure 14. Functional Block Diagram

Feature Description

Boost Operation

The TPQ05100x boost converters are featured with an advanced hysteretic current mode controller topology. The devices sense and regulate inductor ripple current to 300 mA and adjust the inductor current to regulate the output voltage. The slewrate of the inductor current is determined by the input voltage, output voltage and output inductance, thus the operating frequency is also determined by its operation condition. The TPQ05100x has the discontinuous conduction mode (DCM) and the pulse skipping mode (PSM). When the load is light, the device will automatically enter the DCM mode; when the load is even lighter, the device will enter the PSM mode and minimize the quiescent current accrodingly.

Under-Voltage Lockout (UVLO)

The TPQ05100x has an under-voltage lockout feature that stops the operation of the converter when the input voltage is below the UVLO threshold. When the input voltage rises above the threshold with hystereis, the device starts to resume operation.

Device Enable

The TPQ05100x enters the disable mode when the EN voltage is at a low state; the device is enabled when EN is pulled high. When the device is disabled, the output is completely disconnected with the input.

Soft Start

The TPQ05100x enters the soft start mode when EN rises above the threshold with the soft start feature. The output voltage gradually rises with the reduced output current limit within the first 500 μs. When the output voltage reaches the target value, the device automatically enters normal operation.

Over-Current Protection (OCP)

The TPQ05100x has a cycle-by-cycle over-current protection feature (OCP). When the device senses inductor peak current higher than its current limit threshold I_{LIM}, the device will turn off its power FET to prevent further increase of the inductor current. The output voltage will drop accordingly. If the output voltage drops below the input voltage, the device enters the down mode. When the output voltage further drops to below 2.3 V, the device will start up again. The OCP feature is not enabled during pass-through mode operation.

Output Short to Ground Protection

The TPQ05100x has output short to ground protection when the output voltage is below 2.3 V, and limits switching current to 200 mA. Once the output voltage rises above 2.3 V, the device will go back to the soft start mode and normal operation.

Over-Voltage Protection (OVP)

The TPQ05100x has over-voltage protection to prevent output from damage. When the output voltage exceeds the over-voltage protection threshold, the device stops power FET switching. When the output voltage falls below the falling threshold, the device starts to switch again.

Down Mode Regulation

The TPQ05100x enters the down-mode operation when the output voltage target is set below the input voltage, $V_{IN} > V_{OUT} –$ 50 mV. The power PFET gate will be pulled to the input voltage. During down mode operation, the voltage across the power PFET will be significantly higher than normal operation, thus the thermal effect must be taken into consideration to prevent the device from overheating. It will get back to boost operation when the input voltage is 100-mV below the output voltage.

Pass-Through Operation

The TPQ05100x enters pass-through operation when $V_{IN} > V_{OUT}$ + 0.5 V, and turns on the power PFET completely. The output voltage is determined by the input voltage minus voltage drop across the power FET, which equals to the output current times on-resistance of the power PFET and inductor DC resistance. When the input voltage falls below the target output voltage + 150 mV, the device exits the pass-through mode and enters the down mode.

Over-Temperature Protection (OTP)

The TPQ05100x will shut down the device when the junction temperature rises above the over-temperature protection rising threshold. When the junction temperature falls below the over-temperature falling threshold, the device starts operation.

Application and Implementation

> Note
>
> Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Typical Application

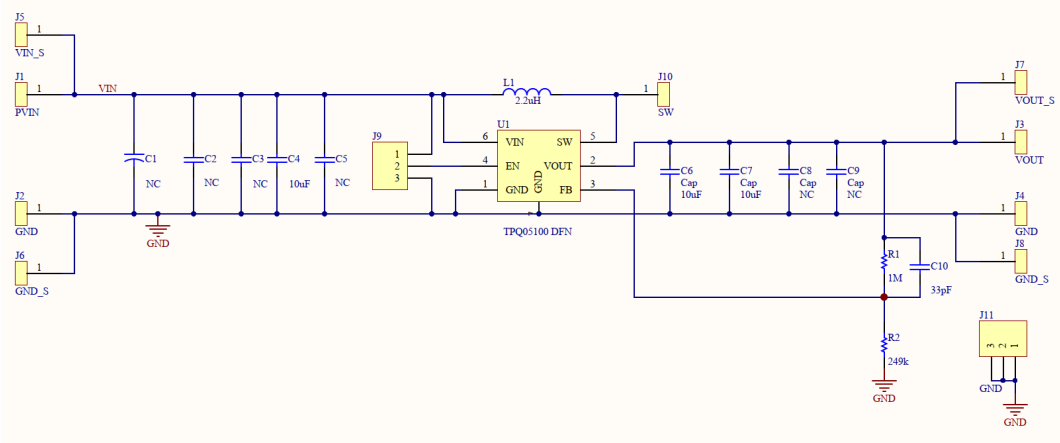
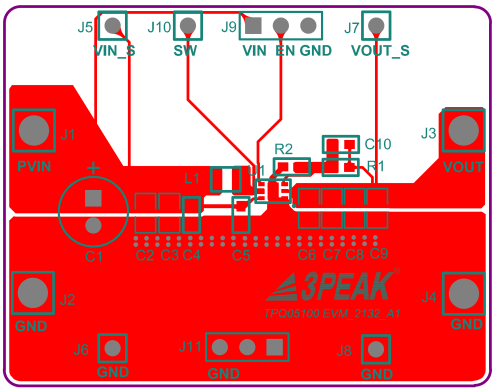


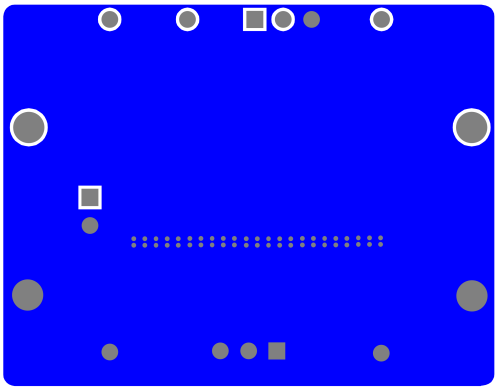
Figure 15. Typical Application Circuit

Comment	Description	Designator	Footprint	LibRef	Quantity
Cap	Capacitor	C1	CAP-150uF/25V	Cap2	1
Cap	Capacitor	C2, C3, C6, C7, C8, C9	RES0805	Capacitor	6
Cap	Capacitor	C4, C5, C10	0603CAP	Cap	3
PVIN		J1	HDR1*1BIG	Header1	1
GND		J2, J4	HDR1*1BIG	Header1	2
VOUT		J3	HDR1*1BIG	Header1	1
VIN_S		J5	HDR1*1SMALL	Header1	1
GND_S		J6, J8	HDR1*1SMALL	Header1	2
VOUT_S		J7	HDR1*1SMALL	Header1	1
Header 3	Header, 3-Pin	J9	HDR1X3	Header 3	1
SW		J10	HDR1*1SMALL	Header1	1
GND	Header, 3-Pin	J11	HDR1X3	Header 3	1
Inductor	Inductor	L1	L 2.5*2 -2PIN	Inductor	1
Res1	Resistor	R1, R2	0603CAP	Res1	2
TPQ05100 DFN		U1	WSON 2*2mm	TPQ05100 DFN	1

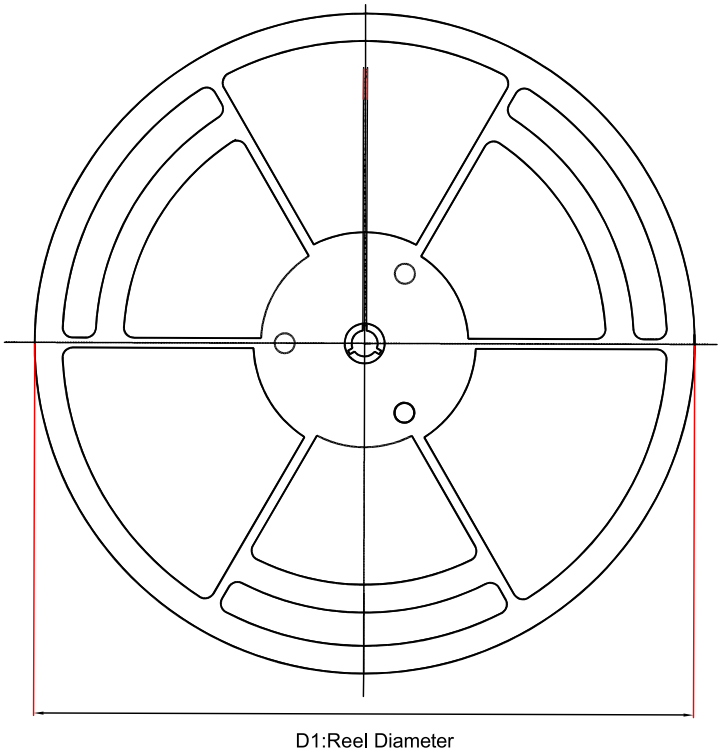
Layout

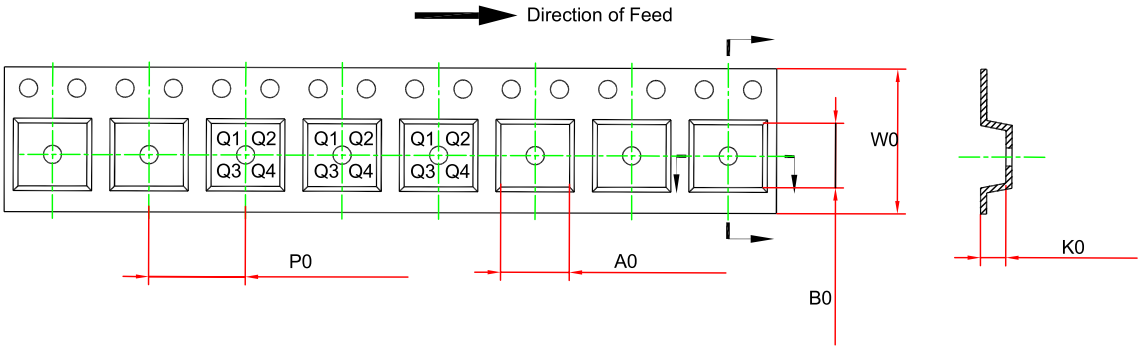
Layout Example





Tape and Reel Information



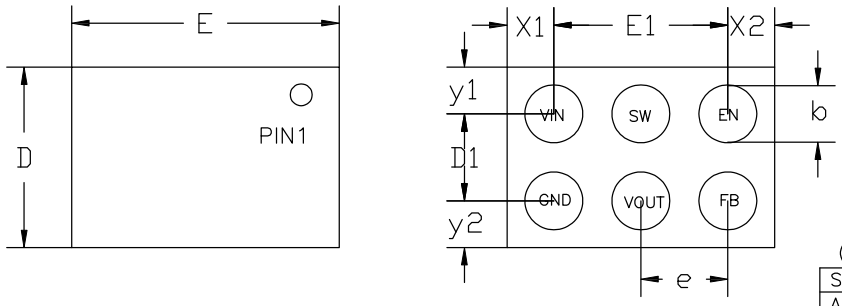


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPQ05100-DFOR	DFN2X2-6	178	10	2.3	2.3	1	4.0	8.0	Q2
TPQ051007-DFOR	DFN2X2-6	178	10	2.3	2.3	1	4.0	8.0	Q2
TPQ051006-DFOR	DFN2X2-6	178	10	2.3	2.3	1	4.0	8.0	Q2
TPQ051005-DFOR	DFN2X2-6	178	10	2.3	2.3	1	4.0	8.0	Q2
TPQ051004-DFOR	DFN2X2-6	178	10	2.3	2.3	1	4.0	8.0	Q2
TPQ051003-DFOR	DFN2X2-6	178	10	2.3	2.3	1	4.0	8.0	Q2
TPQ051002-DFOR	DFN2X2-6	178	10	2.3	2.3	1	4.0	8.0	Q2

Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPQ05100-WS4R	WLCSP	180.0	13.1	1.0	1.34	0.7	4.0	8.0	Q1
TPQ05100-WS4R	WLCSP	180.0	13.1	1.0	1.34	0.7	4.0	8.0	Q1
TPQ051007-WS4R	WLCSP	180.0	13.1	1.0	1.34	0.7	4.0	8.0	Q1
TPQ051006-WS4R	WLCSP	180.0	13.1	1.0	1.34	0.7	4.0	8.0	Q1
TPQ051005-WS4R	WLCSP	180.0	13.1	1.0	1.34	0.7	4.0	8.0	Q1
TPQ051004-WS4R	WLCSP	180.0	13.1	1.0	1.34	0.7	4.0	8.0	Q1
TPQ051003-WS4R	WLCSP	180.0	13.1	1.0	1.34	0.7	4.0	8.0	Q1
TPQ051002-WS4R	WLCSP	180.0	13.1	1.0	1.34	0.7	4.0	8.0	Q1

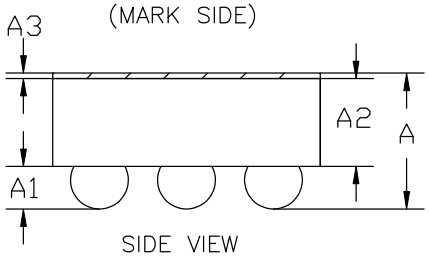
Package Outline Dimensions

WLCSP



TOP VIEW
(MARK SIDE)

BOTTOM VIEW
(BALL SIDE)



SIDE VIEW

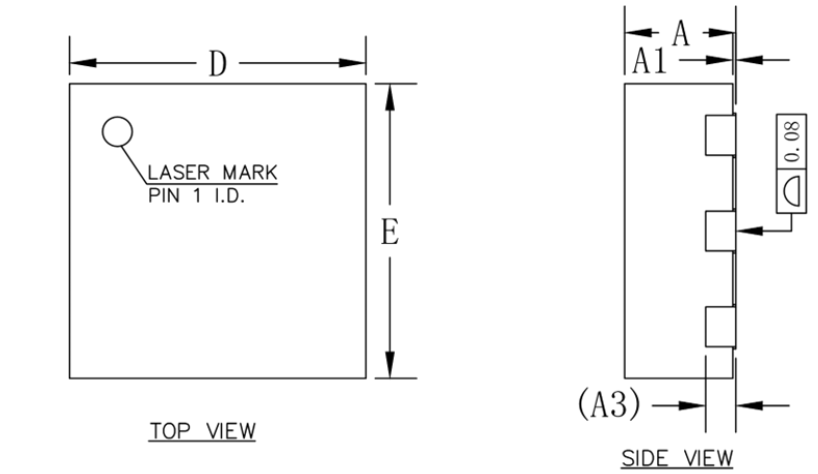
ALL WAFER ORIENTATION NOTCH DOWN

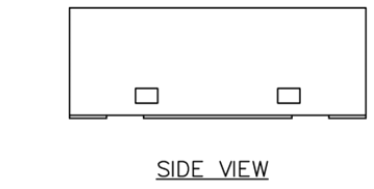
COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

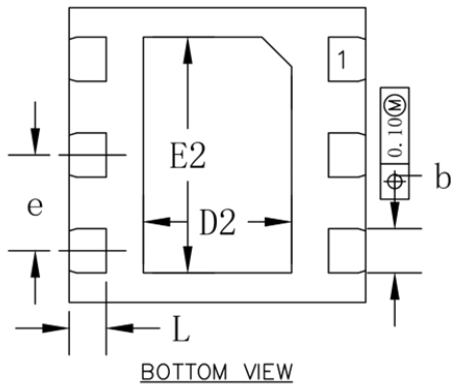
SYMBOL	MIN	NOM	MAX
A	0.513	0.561	0.609
A1	0.176	0.196	0.216
A2	0.315	0.340	0.365
A3	0.022	0.025	0.028
D	0.810	0.830	0.850
D1	0.400BSC		
E	1.210	1.230	1.250
E1	0.800BSC		
b	0.246	0.266	0.286
e	0.400BSC		
x1	0.215 REF		
x2	0.215 REF		
y1	0.215 REF		
y2	0.215 REF		

DFN2X2-6

Package Outline Dimensions DFO(DFN2X2-6-A)







NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.250	0.350	0.010	0.014
A3	0.150	0.250	0.006	0.010
D	1.900	2.100	0.075	0.083
E	1.900	2.100	0.075	0.083
D2	0.900	1.100	0.035	0.043
E2	1.500	1.700	0.059	0.067
e	0.650 BSC		0.026 BSC	
L	0.200	0.300	0.008	0.012

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPQ05100-DFOR	−40 to 125°C	QFN2X2-6	510	3	Tape and Reel, 3000	Green
TPQ051007-DFOR	−40 to 125°C	QFN2X2-6	517	3	Tape and Reel, 3000	Green
TPQ051006-DFOR	−40 to 125°C	QFN2X2-6	516	3	Tape and Reel, 3000	Green
TPQ051005-DFOR	−40 to 125°C	QFN2X2-6	515	3	Tape and Reel, 3000	Green
TPQ051004-DFOR	−40 to 125°C	QFN2X2-6	514	3	Tape and Reel, 3000	Green
TPQ051003-DFOR	−40 to 125°C	QFN2X2-6	513	3	Tape and Reel, 3000	Green
TPQ051002-DFOR	−40 to 125°C	QFN2X2-6	512	3	Tape and Reel, 3000	Green
TPQ05100-WS4R (1)	−40 to 125°C	WLCSP	0	1	Tape and Reel, 3000	Green
TPQ051007-WS4R (1)	−40 to 125°C	WLCSP	7	1	Tape and Reel, 3000	Green
TPQ051006-WS4R (1)	−40 to 125°C	WLCSP	6	1	Tape and Reel, 3000	Green
TPQ051005-WS4R (1)	−40 to 125°C	WLCSP	5	1	Tape and Reel, 3000	Green
TPQ051004-WS4R (1)	−40 to 125°C	WLCSP	4	1	Tape and Reel, 3000	Green
TPQ051003-WS4R (1)	−40 to 125°C	WLCSP	3	1	Tape and Reel, 3000	Green
TPQ051002-WS4R (1)	−40 to 125°C	WLCSP	2	1	Tape and Reel, 3000	Green

(1) For future products, contact the 3PEAK factory for more information and sample.

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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