36-V Input, 2-A Synchronous Step-Down Voltage Regulator

Features

- Wide Supply Voltage: 4.5 V to 36 V
- Internal Power FET： 180 mΩ and 90 mΩ
- 0.6 V Reference Voltage with 2% Accuracy
- High-Efficiency Synchronous-Mode Operation
- Fixed Switching Frequency
  - 500 kHz (TPP362080/2)
  - 2.2 MHz (TPP362081/3)
- Low 2-μA Shutdown, 70-μA Quiescent Current
- Internal Light Load Power-Save Mode for High Efficiency at Light Load (TPP362080/1)
- Forced-PWM Mode for Low Output Ripple (TPP362082/3)
- Internal 2-ms Soft-Start Timer
- Internal Loop Compensation
- Over-Current Protection with Hiccup Mode
- Output Over Voltage Protection
- Thermal Shutdown
- Small outline package TSOT23-6
- −40°C to 125°C Operation Ambient Temperature Range

Applications

- 12-V, 24-V Distributed Power Supply
- Industrial Applications
- General Purpose

Description

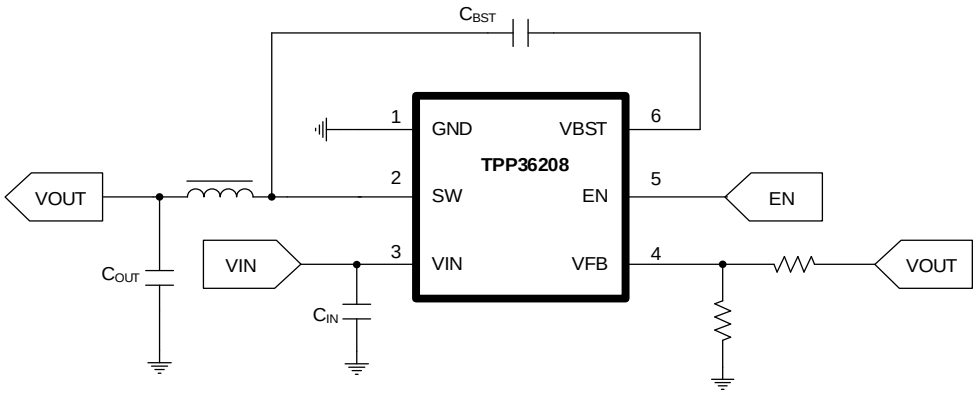
The TPP36208 is a simple, easy-to-use, 2-A output, synchronous, step-down, switch-mode converter with internal power MOSFETs.

The TPP36208 integrates low-RDS(ON) power transistors in the TSOT23-6 package with internal soft-start, compensation, and protection features. TPP36208 offers a very compact solution to achieve a 2-A continuous output current over a wide input supply range, with excellent load and line regulation.

TPP36208 has different versions of switching frequency at 500-kHz and 2.2-MHz, also supports light load PSM to save quiescent current and forced-PWM mode to maintain fixed switching frequency.

The device is available in the 6-pin TSOT23-6 package with the support of a wide operation ambient temperature range from −40 °C to 125 °C.

Typical Application Circuit



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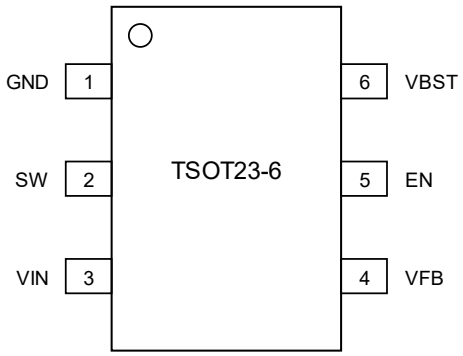
Revision History

Date	Revision	Notes
2022-03-15	Rev.A.0	Initial release

Pin Configuration and Functions

Top View



Pin Functions

Pin		I/O	Description
No.	Name		
1	GND	G	Ground pin. Power and controller circuit ground. Use star connection to GND pin with good contact
2	SW	O	Switching node pin. Voltage switching between high-side FET and low-side FET.
3	VIN	P	Supply input pin. Connect decoupling 2×10-μF and 1×0.1-μF capacitors between VIN and GND pins.
4	VFB	I	Voltage feedback pin. Connect to output voltage with a feedback resistor divider.
5	EN	I	Enable input. Active high. Internally weak pulled down.
6	VBST	O	High-side MOSFET gate supply pin. Connect 0.1-μF between VBST and SW pins.

Specifications

Absolute Maximum Ratings

Parameter		Min	Max	Unit
V_{IN}	Supply Voltage	−0.3	42	V
SW	Switching Node Voltage	−0.3	V_{IN} + 0.3 V	V
VBST-SW	Bootstrap Voltage	−0.3	5.5	V
FB	Feedback Voltage	−0.3	5.5	V
EN	Enable Input	−0.3	42	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.
(2) The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 300mV beyond the power supply, the input current should be limited to less than 10 mA.
(3) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

ESD, Electrostatic Discharge Protection

Symbol	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)	1.5	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.

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
TSOT23-6	100	67	°C/W

Electrical Characteristics

All test conditions: V_{IN} = 12 V, T_A = −40°C to +125°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power Supply						
V_{IN}	Supply Voltage Range		4.5		36	V
I_Q	Operating supply current	Non-switching, EN = 5 V, V_{FB} = 1 V		70		μA
I_{QSD}	Shut down supply current	EN = GND		2		μA
V_{UVLO_rising}	UVLO rising threshold		3.9	4.3	4.5	V
$V_{UVLO\_falling}$	UVLO falling threshold		3.7	3.9	4.1	V
Enable						
V_{ENH}	EN input rising threshold			1.28	1.35	V
V_{ENL}	EN input falling threshold		1	1.17		V
Feedback and Power Stage						
V_{FB}	V_{FB} feedback voltage		588	600	612	mV
$R_{ds(on)\_HSD}$	High-side FET on-resistance	I_{SW} = 1 A		180		mΩ
$R_{ds(on)\_LSD}$	Low-side FET on-resistance	I_{SW} = 1 A		90		mΩ
f_{SW}	Switching frequency	TPP362080/2	390	500	590	kHz
		TPP362081/3		2.2		MHz
t_{ss}	Soft-start time			2		ms
I_{skip}	Pulse-skip mode peak inductor current threshold	V_{IN} = 12 V, V_{OUT} = 5 V, L = 15 μH		300		mA
Current Limit						
I_{Limit_HS}	Highside current limit	Inductor peak current	2.5	3.2	3.9	A
I_{Limit_LS}	Lowside current limit	Inductor valley current		2.5		A
$I_{Limit\_LS\_neg}$	Negative low-side current limit			0.9		A
Diagnostics and Protection						
$V_{FB\_UVP\_rising}$	FB hiccup protection rising ratio			33		%
$V_{FB\_UVP\_falling}$	FB hiccup protection falling ratio			40		%
$V_{FB\_OVP\_rising}$	FB over voltage protection rising ratio			108		%
$V_{FB\_OVP\_falling}$	FB over voltage protection falling ratio			107		%
t_{HIC_wait}	Hiccup protection wait time			128		Cycles
$t_{HIC\_restart}$	Hiccup protection restart time			60		ms
Thermal Shutdown						
T_{SD}	Thermal shut down temperature			160		°C
T_{SD_hys}	Thermal hysteresis			10		°C

Typical Performance Characteristics

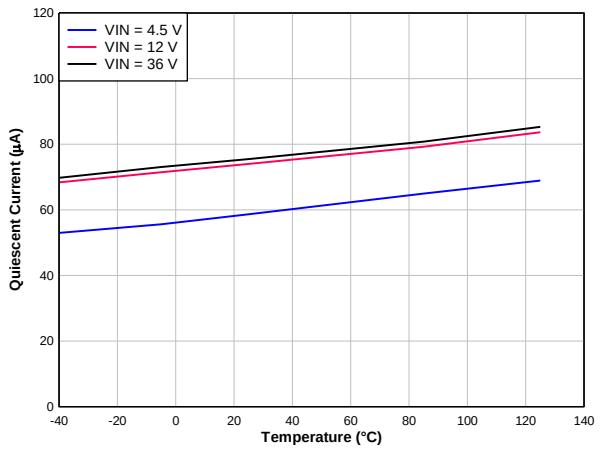


Figure 1. Quiescent Current vs. Supply Voltage

T_A = 25 °C

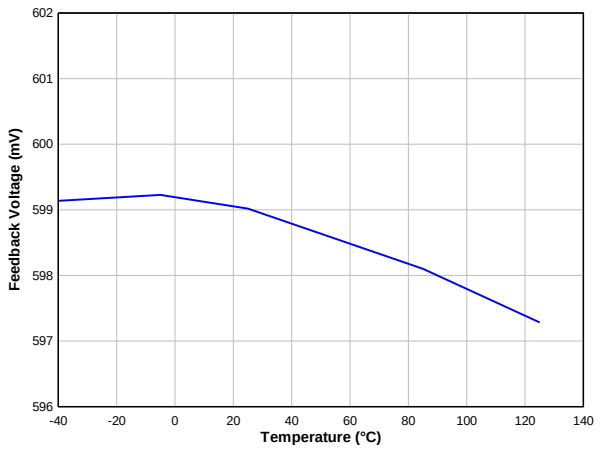


Figure 2. Feedback Voltage vs. Temperature

V_{IN} = 12 V

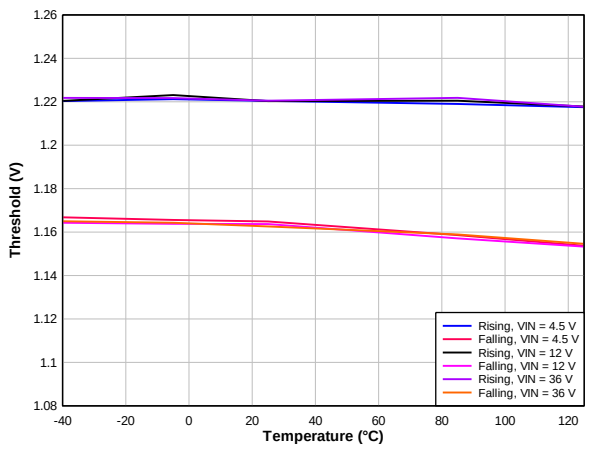


Figure 3. EN Threshold vs. Junction Temperature

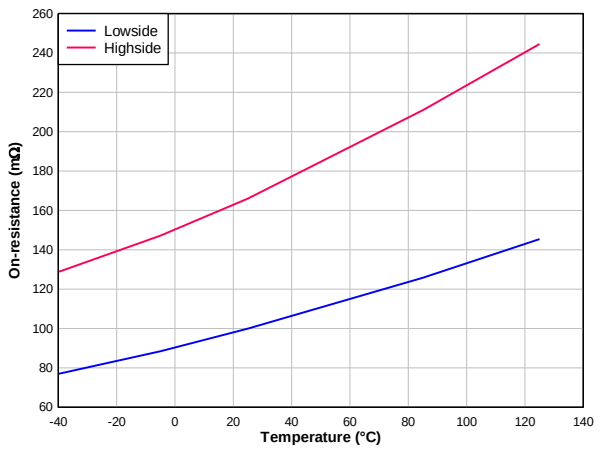


Figure 4. On-Resistance vs Temperature

V_{IN} = 12 V, I_{OUT} = 0.5 A

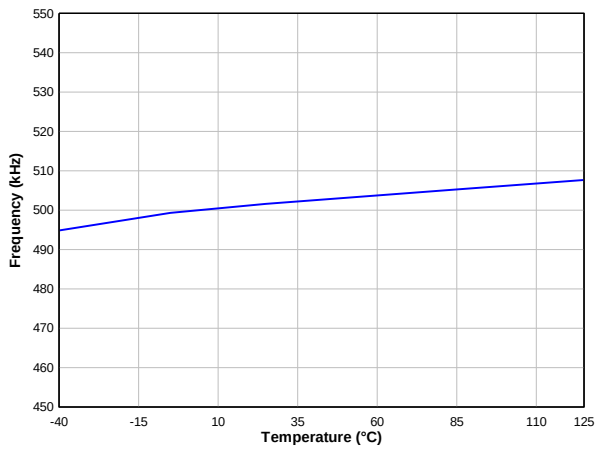


Figure 5. Switching Frequency vs. Temperature

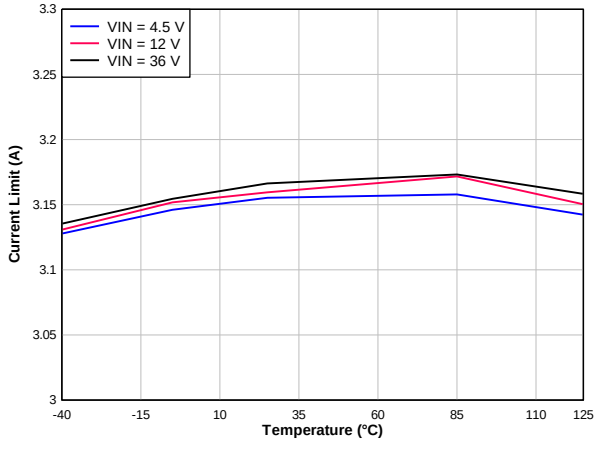


Figure 6. Current Limit vs. Temperature

Typical Performance Characteristics (Continued)

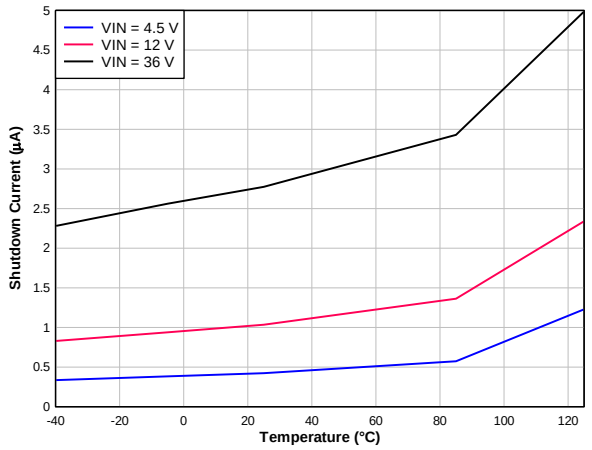


Figure 7. Shutdown Current vs Junction Temperature

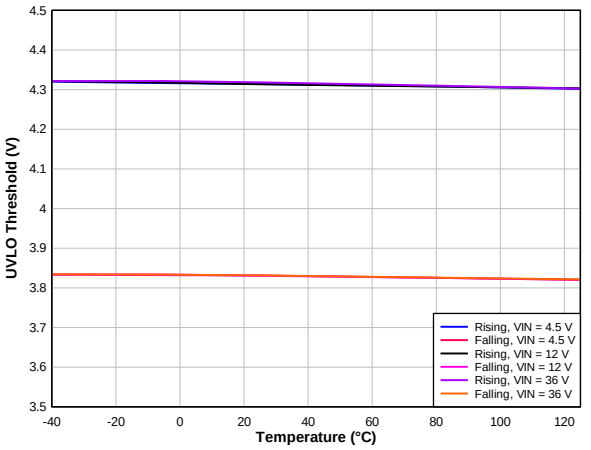


Figure 8. UVLO Threshold vs Temperature

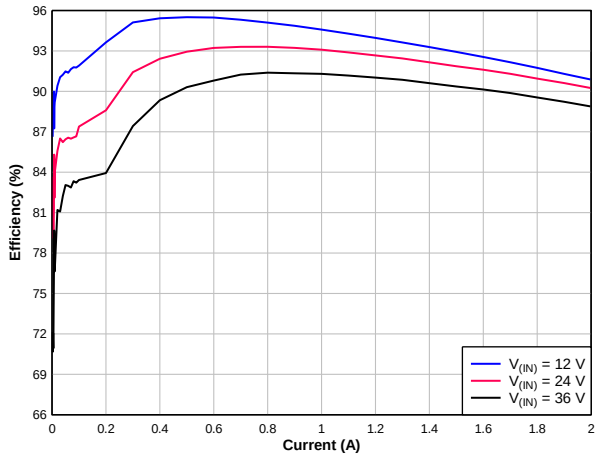


Figure 9. Efficiency vs. Output Current

V_{OUT} = 5 V, L = 2.2 µH

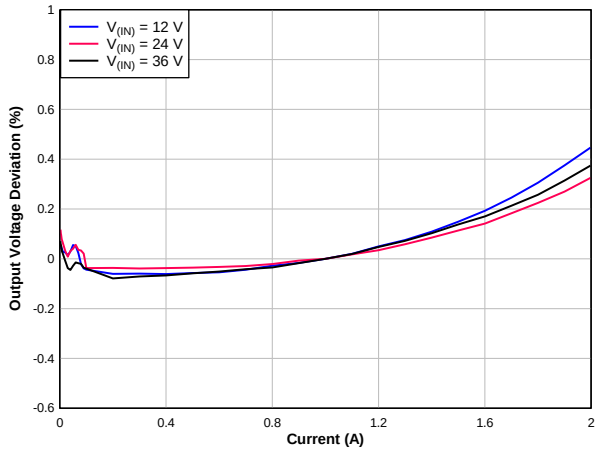


Figure 10. Load Regulation

V_{OUT} = 5 V

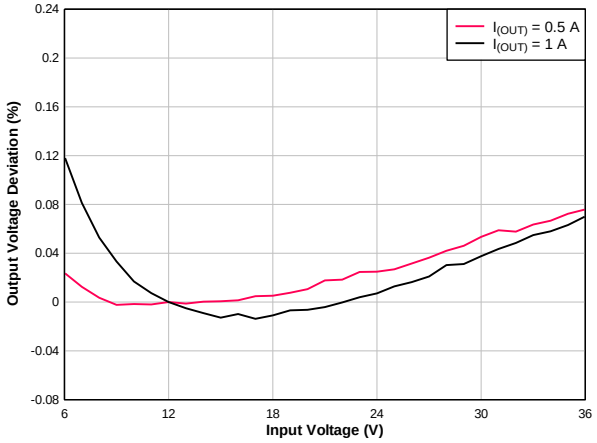


Figure 11. Line Regulation

V_{OUT} = 5 V

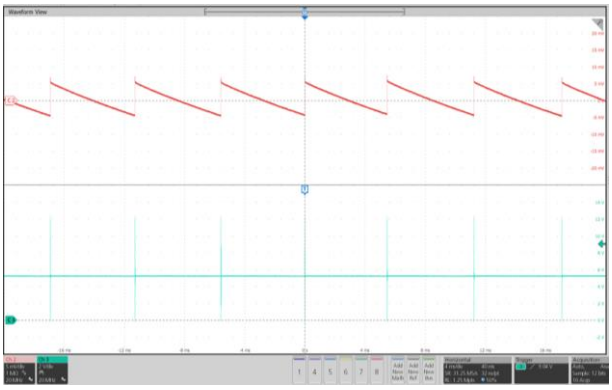


Figure 12. Pulse Skip Mode Output Voltage Ripple

CH2: SW CH3: V_{OUT} Ripple

V_{IN} = 12 V V_{OUT} = 5 V I_L = 0 A

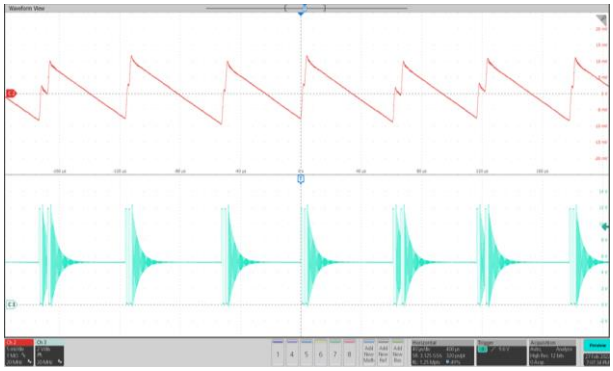


Figure 13. Pulse Skip Mode Output Voltage Ripple

CH2: V_{OUT} Ripple CH3: SW

V_{IN} = 12 V V_{OUT} = 5 V I_L = 10 mA

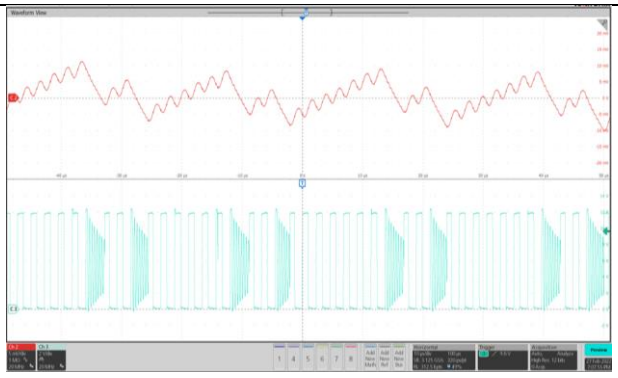


Figure 14. Pulse Skip Mode Output Voltage Ripple

CH2: V_{OUT} CH3: SW

V_{IN} = 12 V V_{OUT} = 5 V I_L = 0.1 A

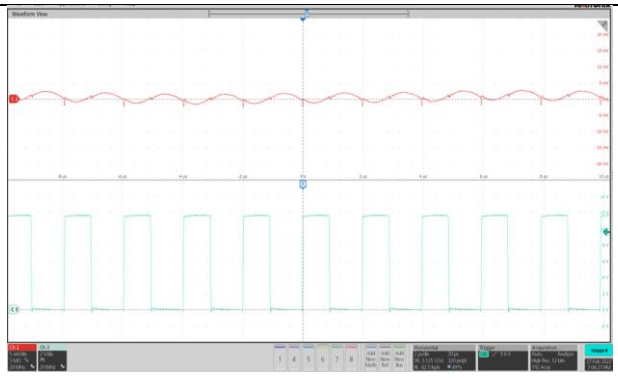


Figure 15. Output Voltage Ripple

CH2: V_{OUT} CH3: SW

V_{IN} = 12 V V_{OUT} = 5 V I_L = 1 A

Typical Performance Characteristics (Continued)

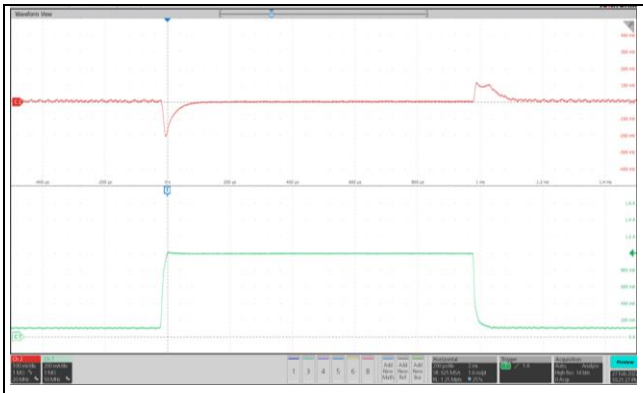


Figure 16. Load Transient

CH2: V_{OUT} CH4: Load Current

V_{IN} = 12 V V_{OUT} = 5 V I_L = 0.1 A to 1 A

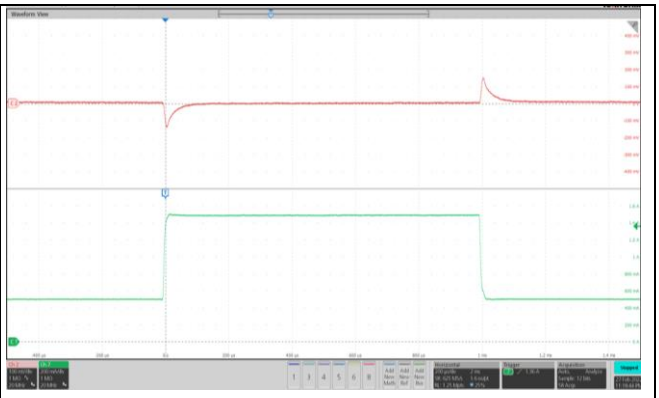


Figure 17. Load Transient

CH2: V_{OUT} CH4: Load Current

V_{IN} = 12 V V_{OUT} = 5 V I_L = 0.5 A to 1.5 A

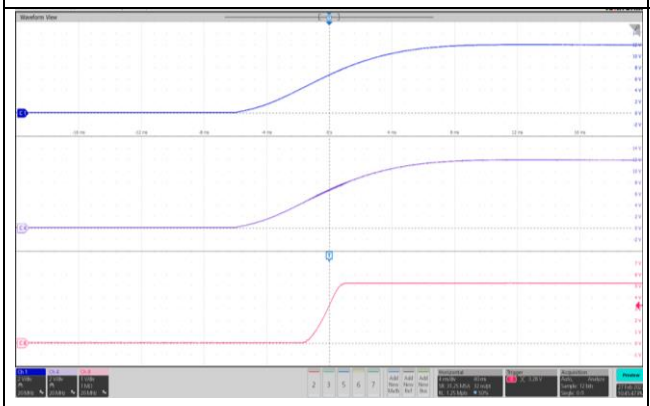


Figure 18. Start Up by VIN

CH1: V_{IN} CH4: EN CH8: V_{OUT}

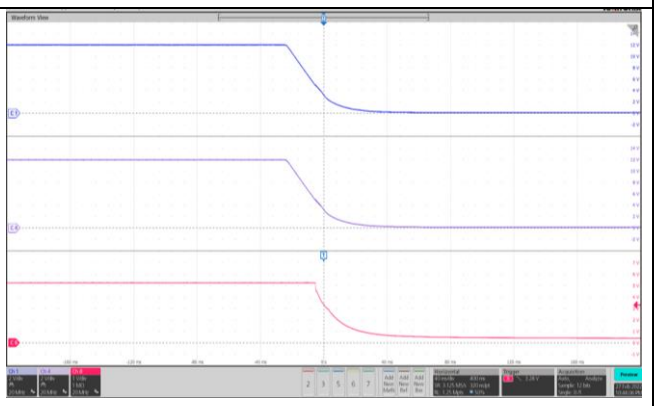


Figure 19. Power-Down by VIN

CH1: V_{IN} CH4: EN CH8: V_{OUT}

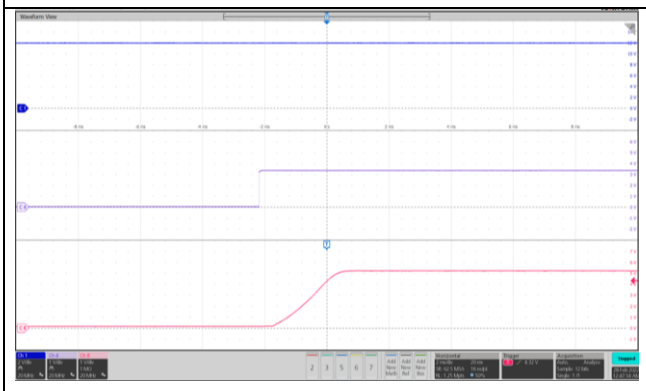


Figure 20. Start Up by EN

CH1: V_{IN} CH4: EN CH8: V_{OUT}

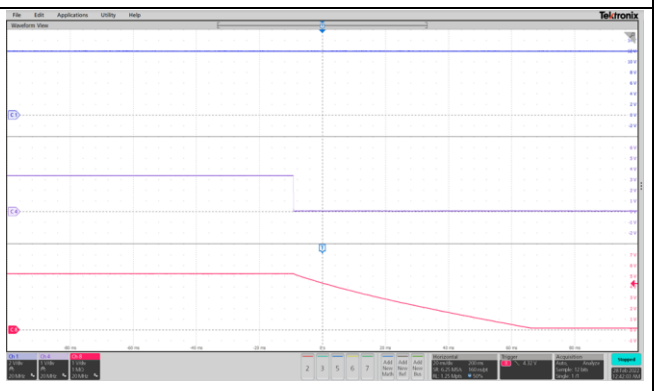


Figure 21. Power-Down by EN

CH1: V_{IN} CH4: EN CH8: V_{OUT}

Detailed Description

Overview

The TPP36208x is 2-A synchronous step-down converter. The Current Mode control topology provides fast transient response and supports low ESR output capacitors, such as specialty polymer capacitors and multi-layer ceramic capacitors, without extra compensation circuitry.

Device	Frequency	Low Output Current Mode
TPP362080-T6TR	500 kHz	Pulse-Skip Mode
TPP362081-T6TR	2.2 MHz	Pulse-Skip Mode
TPP362082-T6TR	500 kHz	Forced-PWM Mode
TPP362083-T6TR	2.2 MHz	Forced-PWM Mode

Functional Block Diagram

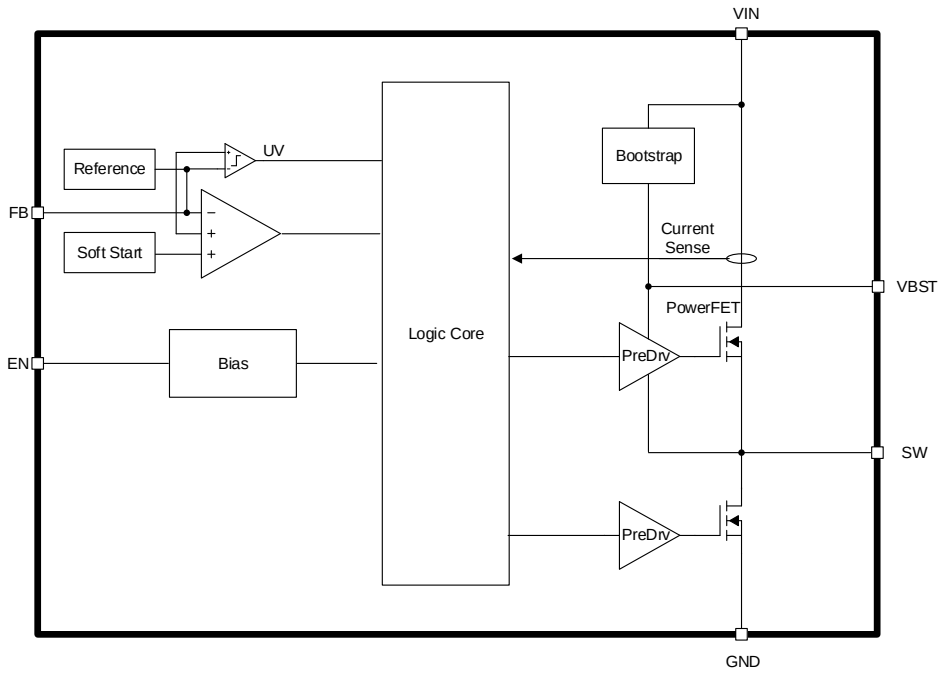


Figure 22. Functional Block Diagram

Feature Description

Current Mode Control

The TPP36208x uses current mode control topology. The current mode topology supports fixed frequency operation thus optimizing ripple performance. With integrated low $R_{ds(on)}$, the device can achieve high efficiency in a small physical footprint.

Pulse-Skip Mode

To improve light-load efficiency, the TPP362080/2 will automatically enter improved light-load mode when the

inductor ripple valley current reaches zero. The controller keeps the on-time of the high-side switch the same. With light-load, the decay of voltage takes longer time and lowers switching frequency accordingly.

Forced-PWM Mode

The TPP362081/3 has Forced-PWM mode to support low-noise applications. When inductor ripple valley current reaches zero, the device will automatically enter forced-PWM Mode with a fixed switching frequency. In this mode, the negative current limit of low-side FET is enabled.

Soft-Start with Pre-Biased Capability

Once EN becomes high, the device ramps up its internal reference voltage with a fixed 2-ms rise time. When the output capacitor is pre-charged, the soft-start ramp will only enable output switching after internal reference ramps above FB voltage.

Over Current Protection

The device has a cycle-by-cycle current limit. During OFF state, once overcurrent is detected at ripple current valley by measuring low-side FET current, the device keeps the low-side FET OFF until the current falls below over current protection (OCP) threshold.

Output Undervoltage Hiccup Protection

When the device output voltage falls below the hiccup voltage threshold, the device gets into hiccup mode by turning off the device and restarts after the hiccup timer (typically 60 ms) expires.

Undervoltage Lockout (UVLO) Protection

Once the input voltage falls below the UVLO threshold, the device is shut off. Once the device recovers above the UVLO threshold, the device returns to normal operation.

Over-Temperature Shutdown

Once the junction temperature rises across the internal over-temperature shutdown threshold, the device shuts off and recovers when the temperature falls below the threshold with hysteresis.

Application and Implementation

NOTE

Information in the following applications 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.

Application Information

As an easy-to-use step-down voltage regulator, also known as a buck regulator, TPP36208 usually coverts a higher input voltage to the desired output voltage set by the VFB resistor divider. The maximum output current is 2 A. The below section depicts a simplified design flow of circuitry for TPP36208.

Typical Application

In most 12-V systems, lower voltage rail such as 5 V/3.3 V is a typical need for microcontrollers, I/Os and other low voltage components. The below application lists the typical schematic for a 5-V buck regulator.

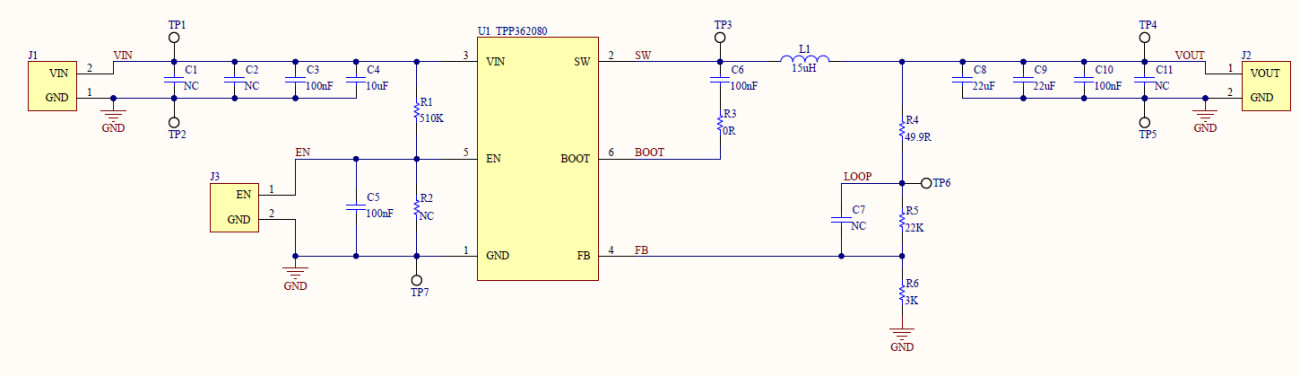


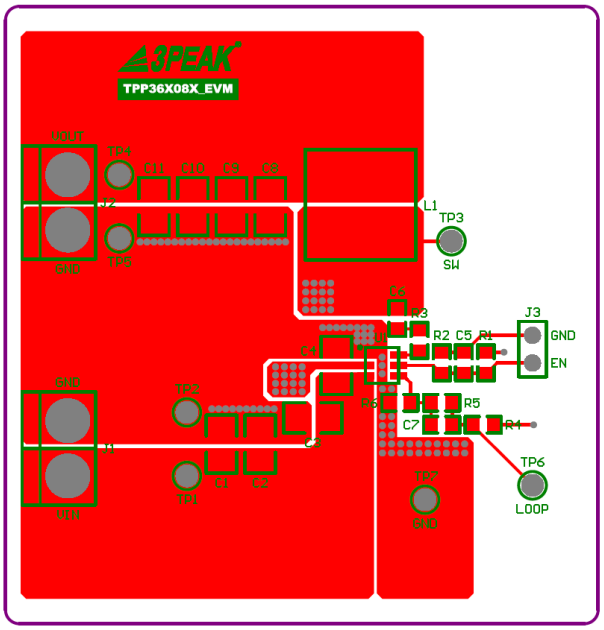
Figure 23. Application Diagram

Component Selection

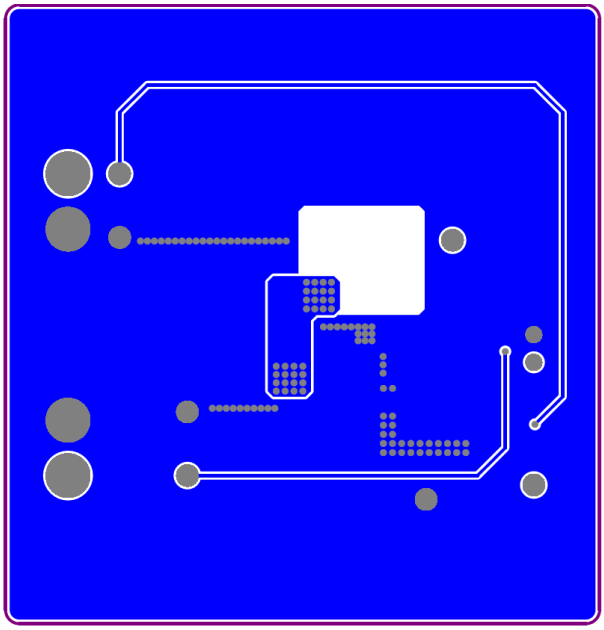
	EVM: F_{sw} = 500 kHz, MODE = Pulse-Skip, I_{OUT} = 2 A, t_{SS} = 2 ms, V_{OUT} = 5 V					
Designator	**Value**	**Quantity**	**Part No.**	**Package**	**Manufacturer**	**Description**
U1	TPP362080	1	TPP362080-T6TR	SOT23-6	3PEAK	Buck Converter, 36 V, 2 A, 500 kHz, PFM
C1	NC	0				
C2	NC	0				
C3	100 nF	1	GGD21BR71H104KA02	0805	muRata	Capacitor, 100 nF, 50VDC, X7R, ±15%
C4	10 µF	1	GCM32EC71H106MA03L	1210	muRata	Capacitor, 10 µF, 50VDC, X7S, ±22%
R1	510 K	1	ARG03FTC5103	0603	Viking	Resistor, 510 K, ±1%, 0.1 W
C5	NC	0				
R2	100 K	1	ARG03FTC1003	0603	Viking	Resistor, 100 K, ±1%, 0.1 W
C6	100 nF	1	GRM188R71C104KA01D	0603	muRata	Capacitor, 100 nF, 16VDC, X7R, ±15%
C7	NC	0				
R3	0 R	1	ERJ-3GEY0R00V	0603	Panasonic	Resistor, 0 Ω, 5%, 0.1 W
L1	15 µH	1	7447714150	10mm × 5mm × 10mm	Wurth Elektronik eiSos	Inductor, 15 µH, 3.5 A, 36ohm, ±20%
C8	22 µF	1	GRM32ER71E226ME15L	1210	muRata	Capacitor, 22 µF, 25VDC, X7R, ±15%
C9	22 µF	1	GRM32ER71E226ME15L	1210	muRata	Capacitor, 22 µF, 25VDC, X7R, ±15%
C10	100 nF	1	GGD21BR71H104KA02	0805	muRata	Capacitor, 100 nF, 50VDC, X7R, ±15%
C11	NC	0				
R4	49.9 R	1	ARG03FTC49R9	0603	Viking	Resistor, 49.9 Ω, ±1%, 0.1 W
R5	22 K	1	ARG03FTC2202	0603	Viking	Resistor, 22 K, ±1%, 0.1 W
R6	3 K	1	ARG03FTC3001	0603	Viking	Resistor, 3 K, ±1%, 0.1 W

Layout

Layout Recommendations



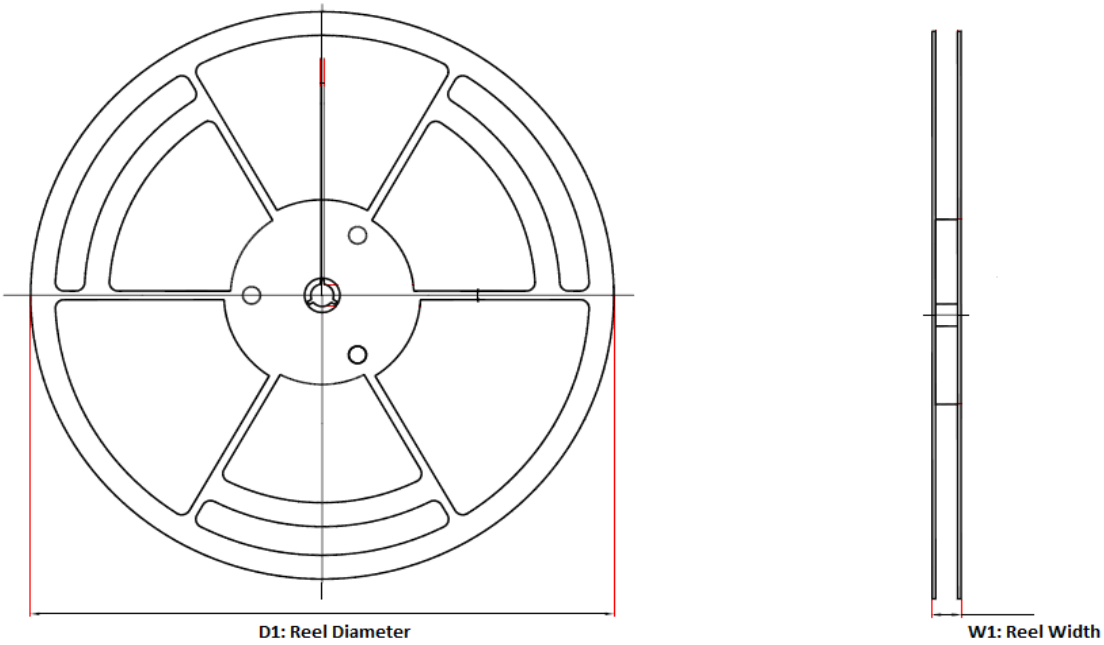
Top Layer



Bottom Layer

Figure 24. Layout Recommendation

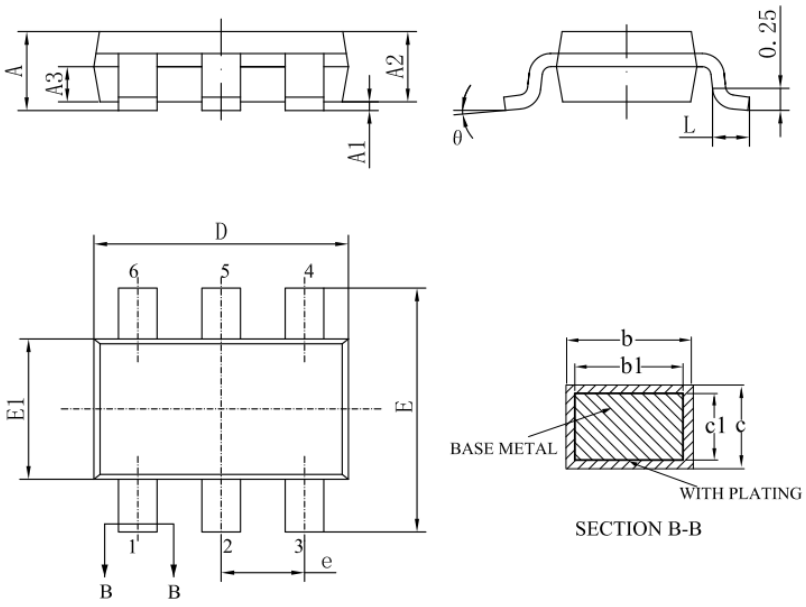
Tape and Reel Information



Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPP362080-T6TR	TSOT23-6	178.0	12.3	3.2	3.2	1.4	4.0	8.0	Q3
TPP362081-T6TR	TSOT23-6	178.0	12.3	3.2	3.2	1.4	4.0	8.0	Q3
TPP362082-T6TR	TSOT23-6	178.0	12.3	3.2	3.2	1.4	4.0	8.0	Q3
TPP362083-T6TR	TSOT23-6	178.0	12.3	3.2	3.2	1.4	4.0	8.0	Q3

Package Outline Dimensions

TSOT23-6



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	0.95
A1	0	—	0.10
A2	0.75	0.80	0.85
A3	0.35	0.40	0.45
b	0.30	0.44	0.50
b1	0.30	0.40	0.45
c	0.11	0.16	0.20
c1	0.11	0.13	0.15
D	2.70	2.90	3.10
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
e	0.95BSC		
L	0.30	0.40	0.50
θ	0	—	8°

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPP362080-T6TR	−40 to 125°C	TSOT23-6	320	MSL3	Tape and Reel, 3000	Green
TPP362081-T6TR	−40 to 125°C	TSOT23-6	321	MSL3	Tape and Reel, 3000	Green
TPP362082-T6TR	−40 to 125°C	TSOT23-6	322	MSL3	Tape and Reel, 3000	Green
TPP362083-T6TR	−40 to 125°C	TSOT23-6	323	MSL3	Tape and Reel, 3000	Green

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