

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 (TPP361080/2)
 - 1 MHz (TPP361084/5)
 - 2.2 MHz (TPP361081/3)
- Low 2-μA Shutdown, 70-μA Quiescent Current
- Internal Light Load Power-Save Mode for High Efficiency at Light Load (TPP361080/1/4)
- Forced-PWM Mode for Low-Output Ripple (TPP361082/3/5)
- 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 TPP36108x series is a simple, easy-to-use, 1-A output, synchronous, step-down, and switch-mode converter with internal power MOSFETs.

The TPP36108x series integrates low- $R_{DS(ON)}$ power transistors in the TSOT23-6 package with internal soft-start, compensation, and protection features. The TPP36108x offers a very compact solution to achieve a 1-A continuous output current over a wide input supply range, with excellent load and line regulation.

The TPP36108x series has different versions of switching frequencies at 500-kHz, 1MHz and 2.2-MHz, and also supports light load PSM to save quiescent current and forced-PWM mode to maintain the 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

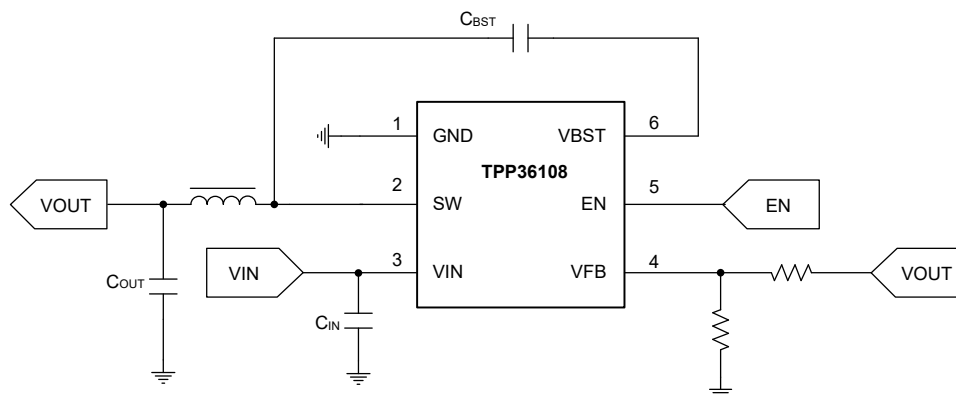


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Revision History

Date	Revision	Notes
2022-03-15	Rev A.0	Initial release.
2022-07-11	Rev A.1	Minor correction. Updated description of EN pin function to internally weak pulled up.
2022-07-31	Rev A.2	Updated order information, automotive grade devices, electrical table rising/ falling timing and block diagrams.
2023-08-03	Rev A.3	Updated typical application diagram, updated recommended operating voltage and abs max voltage.
2024-04-18	Rev A.4	Misc. correction, added 1-MHz option, and EN description.

Pin Configuration and Functions

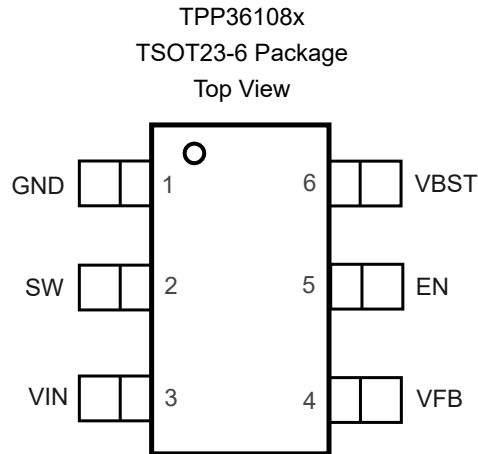


Table 1. Pin Functions: TPP36108x

Pin	Name	I/O	Description
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 $2 \times 10\text{-}\mu\text{F}$ and $1 \times 0.1\text{-}\mu\text{F}$ 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 up.
6	VBST	O	High-side MOSFET gate supply pin. Connect $0.1\text{-}\mu\text{F}$ between VBST and SW pins.

36-V Input, 1-A Synchronous Step-Down Voltage Regulator
Specifications
Absolute Maximum Ratings ⁽¹⁾

Parameter		Min	Max	Unit
V _{IN}	Supply Voltage	-0.3	42	V
SW	Switching Node Voltage	-0.3	V _{IN} + 0.3	V
	Switching Node Voltage (50 ns)	-3	42	V
	Switching Node Voltage (20 ns)	-5	42	V
VBST-SW	Bootstrap Voltage	-0.3	6	V
FB	Feedback Voltage	-0.3	6	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 300 mV 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

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.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V _{IN}	Supply Input Voltage Range	4.5		36	V
EN	EN Input Voltage Range	0		36	V
FB	FB Input Voltage Range	0		5.5	V
BOOT – SW	BOOT Voltage Range	0		5.5	V
SW	FB Input Voltage Range	-1		36	V
T _J	Operating Junction Temperature	-40		150	°C

36-V Input, 1-A Synchronous Step-Down Voltage Regulator**Thermal Information**

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

36-V Input, 1-A Synchronous Step-Down Voltage Regulator
Electrical Characteristics

 All test condition is at $V_{IN} = 12\text{ V}$, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$, unless otherwise noted.

Parameter	Conditions	Min	Typ	Max	Unit		
Power Supply							
V_{IN}	Supply Voltage Range	4.5		36	V		
I_Q	Operating Supply Current	Non-switching, $EN = 5\text{ V}$, $V_{FB} = 1\text{ V}$		70	μA		
I_{QSD}	Shut Down Supply Current	$EN = \text{GND}$		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	1.15	1.28	1.35	V		
V_{ENL}	EN Input Falling Threshold	1	1.17	1.2	V		
I_{ENL}	EN current, $EN = L^{(1)}$	$V_{EN} = 0.9\text{ V}$		1.5	μA		
I_{ENH}	EN current, $EN = H$	$V_{EN} = 1.5\text{ V}$		5.2	μA		
I_{EN_HYS}	EN hysteresis current	$V_{EN} = 1.5\text{ V}$		3.3	μA		
Feedback and Power Stage							
V_{FB}	V_{FB} Feedback Voltage	588	600	612	mV		
$R_{ds(on)_HSD}$	High-side FET On-Resistance	$I_{SW} = 1\text{ A}$		180	$\text{m}\Omega$		
$R_{ds(on)_LSD}$	Low-side FET On-Resistance	$I_{SW} = 1\text{ A}$		90	$\text{m}\Omega$		
f_{SW}	Switching Frequency	TPP362080/2		390	500	590	kHz
		TPP362081/3		1.76	2.2	2.64	MHz
		TPP362084/5		0.8	1	1.2	MHz
t_{SS}	Soft-Start Time		2		ms		
t_{SS}	Soft-Start Transition Time	14	18	24	ms		
I_{skip}	Pulse-Skip Mode Peak Inductor Current Threshold	$V_{IN} = 12\text{ V}$, $V_{OUT} = 5\text{ V}$, $L = 15\ \mu\text{H}$		300	mA		
Current Limit							
I_{Limit_HS}	High-side Current Limit	Inductor peak current		2.5	3.2	3.9	A
I_{Limit_LS}	Low-side 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		%		

36-V Input, 1-A Synchronous Step-Down Voltage Regulator

Parameter		Conditions	Min	Typ	Max	Unit
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

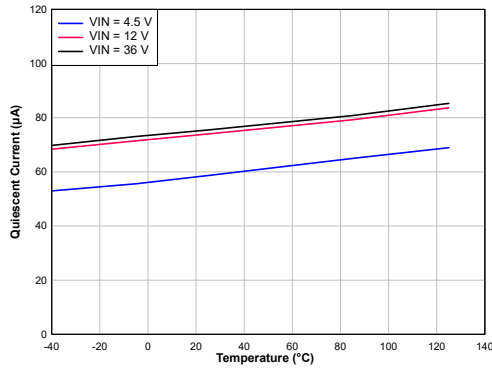


Figure 1. Quiescent Current vs. Supply Voltage

$T_A = 25\text{ }^\circ\text{C}$

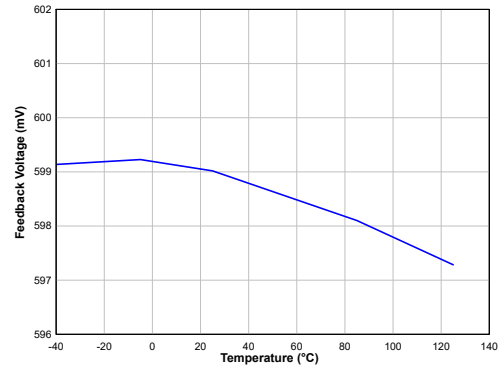


Figure 2. Reference Voltage vs. Temperature

$V_{IN} = 12\text{ V}$

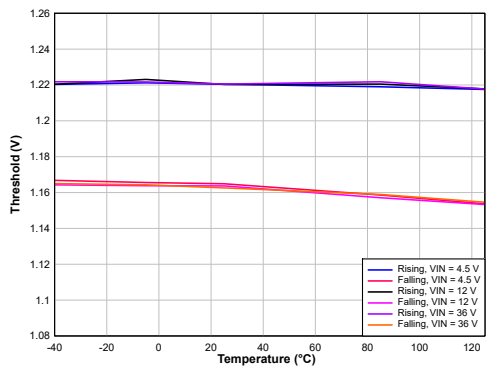


Figure 3. EN Threshold vs. Junction Temperature

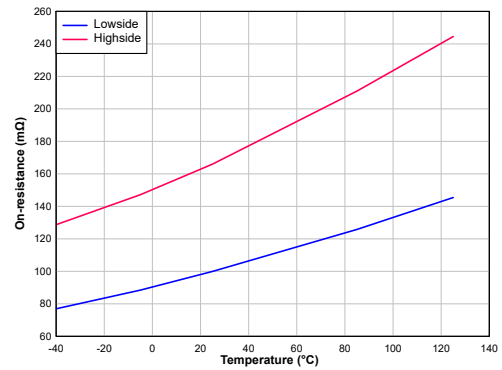


Figure 4. On-Resistance vs Temperature

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

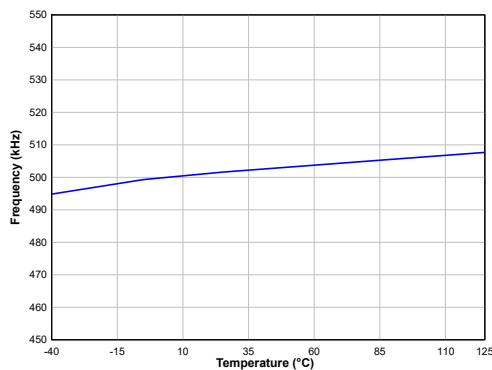


Figure 5. Switching Frequency vs. Temperature

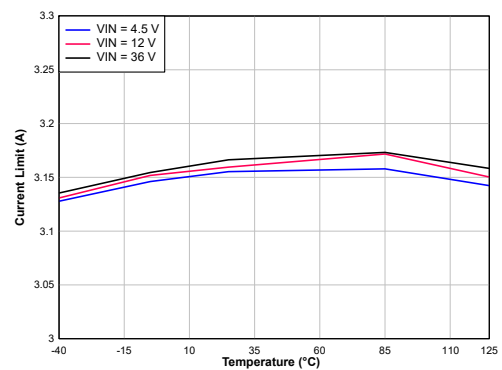


Figure 6. Current Limit vs. Temperature

36-V Input, 1-A Synchronous Step-Down Voltage Regulator

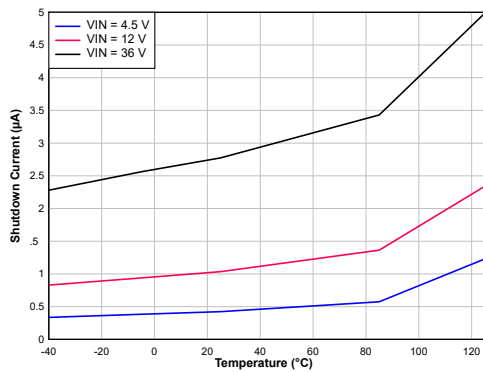


Figure 7. Shutdown Current vs Junction Temperature

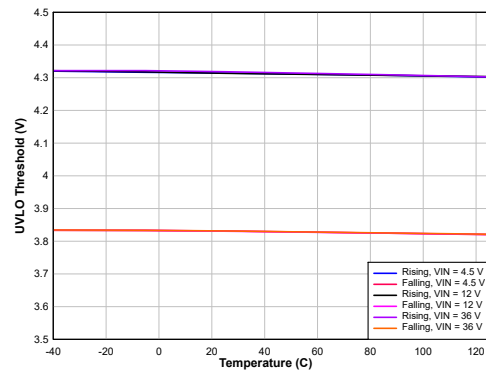


Figure 8. UVLO Threshold vs Temperature

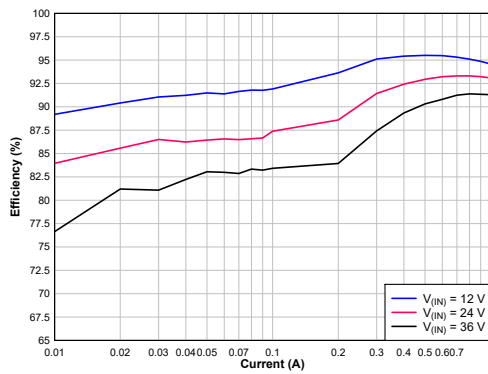


Figure 9. Efficiency vs. Output Current

$V_{OUT} = 5\text{ V}$, $L = 2.2\text{ }\mu\text{H}$, 500 kHz, TPP361080 with Pulse Skip Mode

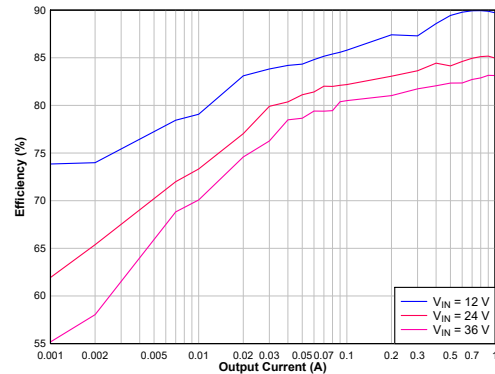


Figure 10. Efficiency vs. Output Current

$V_{OUT} = 5\text{ V}$, $L = 2.2\text{ }\mu\text{H}$, 2.2 MHz, TPP361081 with Pulse Skip Mode

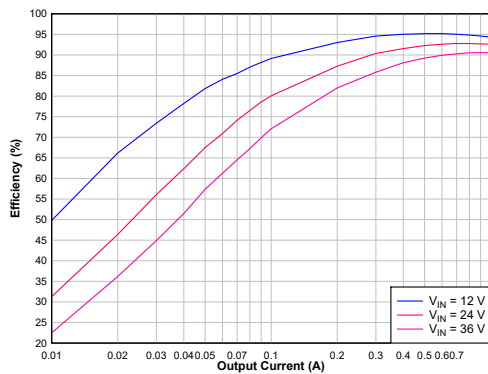


Figure 11. Efficiency vs. Output Current

$V_{OUT} = 5\text{ V}$, $L = 2.2\text{ }\mu\text{H}$, 500 kHz, TPP361082 with Forced-PWM Mode

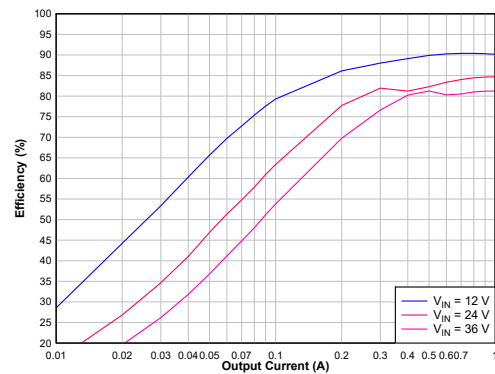
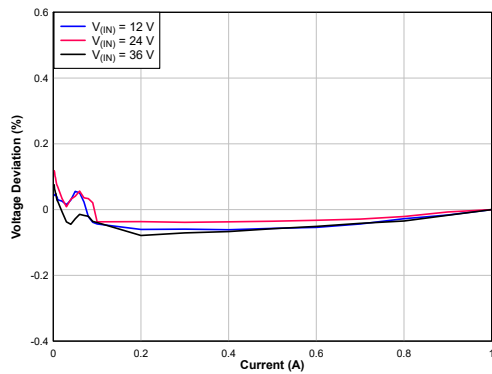
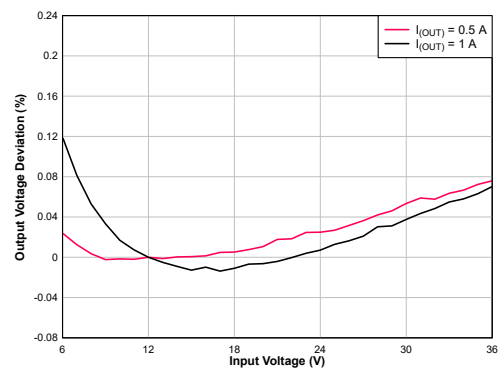
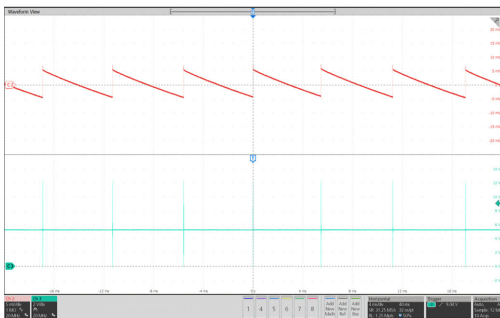
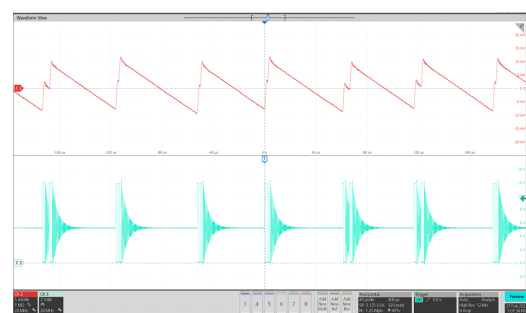
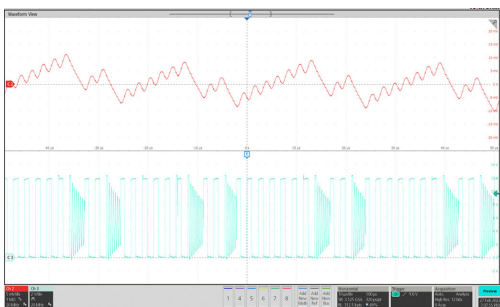


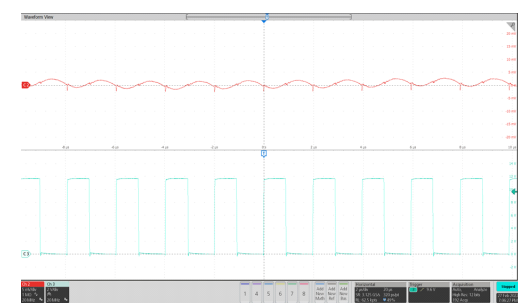
Figure 12. Efficiency vs. Output Current

$V_{OUT} = 5\text{ V}$, $L = 2.2\text{ }\mu\text{H}$, 2.2 MHz, TPP361083 with Forced-PWM Mode

36-V Input, 1-A Synchronous Step-Down Voltage Regulator

Figure 13. Load Regulation
 $V_{OUT} = 5\text{ V}$

Figure 14. Line Regulation
 $V_{OUT} = 5\text{ V}$

Figure 15. Pulse Skip Mode Output Voltage Ripple

 CH2: SW, CH3: V_{OUT} Ripple
 $V_{IN} = 12\text{ V}$, $V_{OUT} = 5\text{ V}$, $I_L = 0\text{ A}$

Figure 16. Pulse Skip Mode Output Voltage Ripple

 CH2: V_{OUT} Ripple, CH3: SW
 $V_{IN} = 12\text{ V}$, $V_{OUT} = 5\text{ V}$, $I_L = 10\text{ mA}$

Figure 17. Pulse Skip Mode Output Voltage Ripple

 CH2: V_{OUT} , CH3: SW
 $V_{IN} = 12\text{ V}$, $V_{OUT} = 5\text{ V}$, $I_L = 0.1\text{ A}$

Figure 18. Output Voltage Ripple

 CH2: V_{OUT} , CH3: SW
 $V_{IN} = 12\text{ V}$, $V_{OUT} = 5\text{ V}$, $I_L = 1\text{ A}$

36-V Input, 1-A Synchronous Step-Down Voltage Regulator

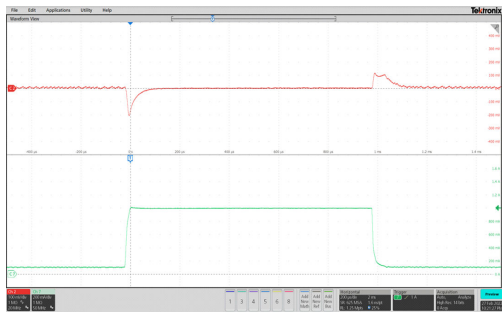


Figure 19. Load Transient

CH2: V_{OUT} , CH4: Load Current
 $V_{IN} = 12\text{ V}$, $V_{OUT} = 5\text{ V}$, $I_L = 0.1\text{ A}$ to 1 A

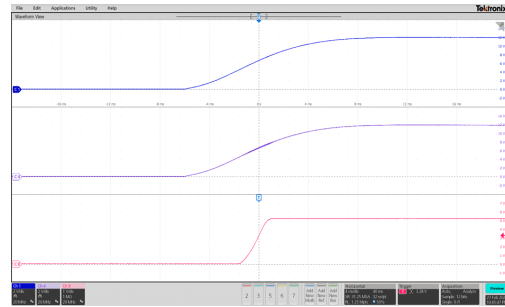


Figure 20. Start Up by VIN

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

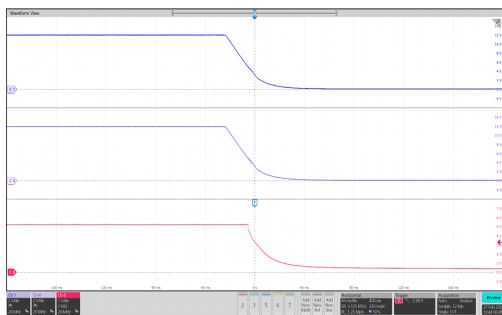


Figure 21. Power-Down by VIN

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

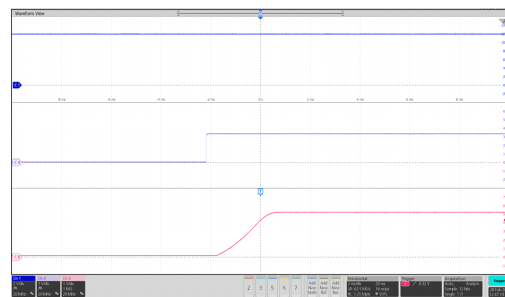


Figure 22. Start Up by EN

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

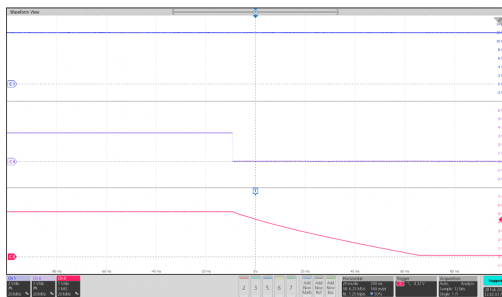


Figure 23. Power-Down by EN

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

Detailed Description

Overview

The TPP36108x is a 1-A synchronous step-down converter. The current mode control topology provides a 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
TPP361080-T6TR	500 kHz	Pulse-Skip Mode
TPP361081-T6TR	2.2 MHz	Pulse-Skip Mode
TPP361082-T6TR	500 kHz	Forced-PWM Mode
TPP361083-T6TR	2.2 MHz	Forced-PWM Mode
TPP361084-T6TR	1 MHz	Pulse-Skip Mode
TPP361085-T6TR	1 MHz	Forced-PWM Mode

Functional Block Diagram

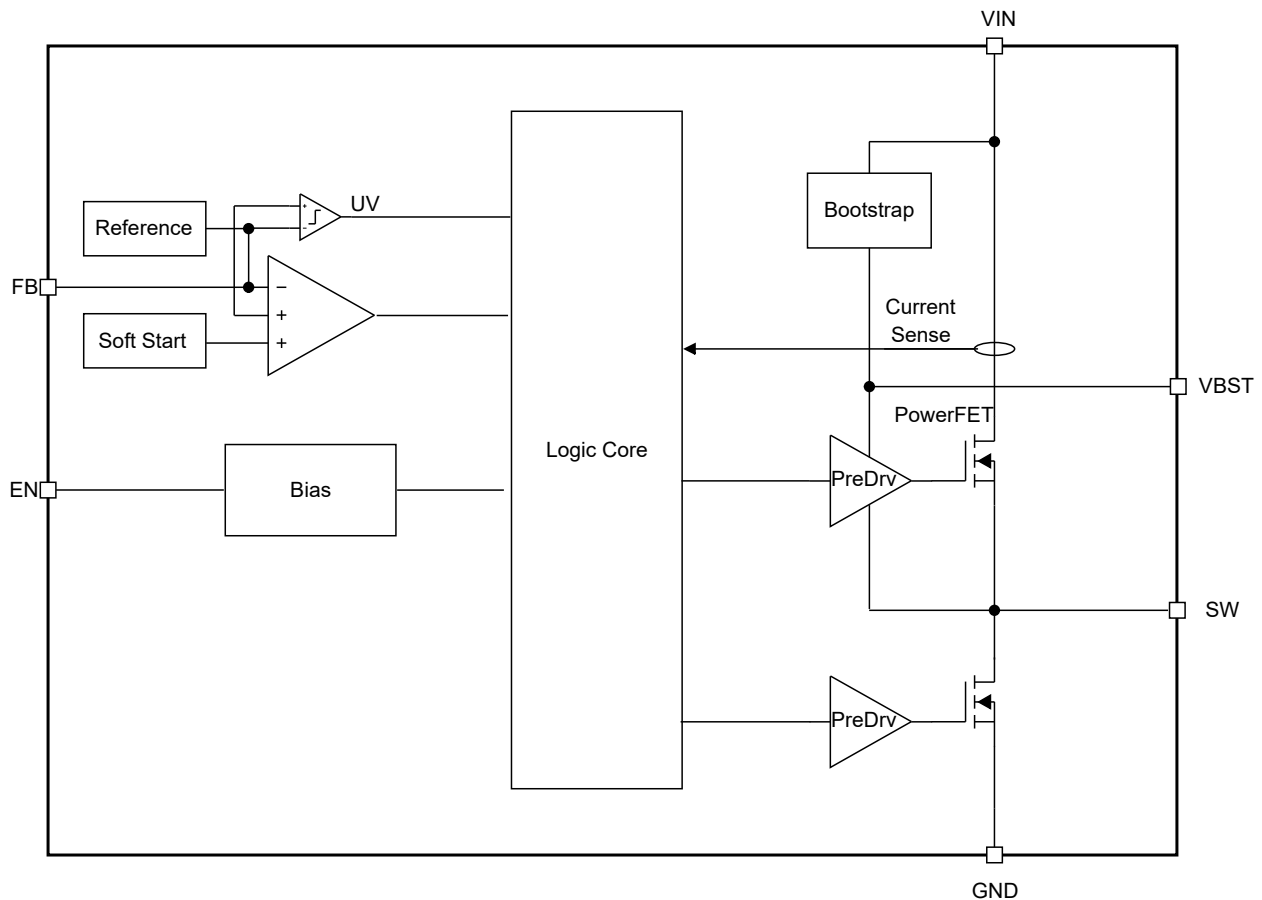


Figure 24. Functional Block Diagram

Feature Description

Current Mode Control

The TPP36108x uses the 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.

Switching Frequency

TPP36108x supports both 500-kHz(TPP361080/TPP361082), 1-MHz (TPP361084/5) and 2.2-MHz switching frequency(TPP361081/TPP361083). 500-kHz has better efficiency due to less switching loss, while 2.2-MHz supports high frequency inductor with small form factor, and 1-MHz is a good balance in between. 3PEAK recommends to evaluate thermal performance in 1-MHz and 2.2-MHz scenarios especially at high temperature conditions.

Pulse-Skip Mode

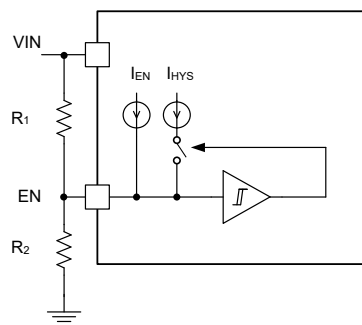
To improve light-load efficiency, the TPP361080/1/4 will automatically enter improved light-load mode when the inductor ripple valley current reaches zero. The controller keeps the on-time of the high-side switch unchanged. With a light load, the decay of voltage takes a longer time and lowers the switching frequency accordingly.

Forced-PWM Mode

The TPP361082/3/5 has forced-PWM mode to support low-noise applications. When the inductor ripple valley current reaches zero, the device will automatically enter the forced-PWM mode with a fixed switching frequency. In this mode, the negative current limit of low-side FET is enabled.

Enable Input

The device EN has two current sources to pull EN up high. I_{EN} and I_{HYS} . When EN is low, the I_{EN} is enabled as I_{EN_L} . When EN rises above the threshold and turns hysteresis current I_{EN_SYS} on, the total current is I_{EN_H} .



The EN threshold can be set via the below equations

$$R_1 = \frac{V_{ENL}(V_{IN_START} - V_{ENH}) - V_{ENH}(V_{IN_STOP} - V_{ENL})}{V_{ENH} \cdot I_{ENH} - V_{ENL} \cdot I_{ENL}} \quad (1)$$

$$R_2 = \frac{V_{ENH}}{I_{ENL} + \frac{V_{IN_START} - V_{ENH}}{R_1}} \quad (2)$$

36-V Input, 1-A Synchronous Step-Down Voltage Regulator**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 the internal reference ramps above the FB voltage.

Over Current Protection

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

Output Undervoltage Hiccup Protection

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

To support large output capacitance as large as 1 mF, the device has an extended soft start transition timer. Upon power up, the device gets into soft-start and prevents the device from output under voltage hiccup protection mode until soft start transition time t_{ss_done} is over.

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 above 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 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.

Application Information

As an easy-to-use step-down voltage regulator, also known as a buck regulator, the TPP36108x usually covers a higher input voltage to the desired output voltage set by the VFB resistor divider. The maximum output current is 1 A. The below section depicts a simplified design flow of circuitry for the TPP36108x.

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.

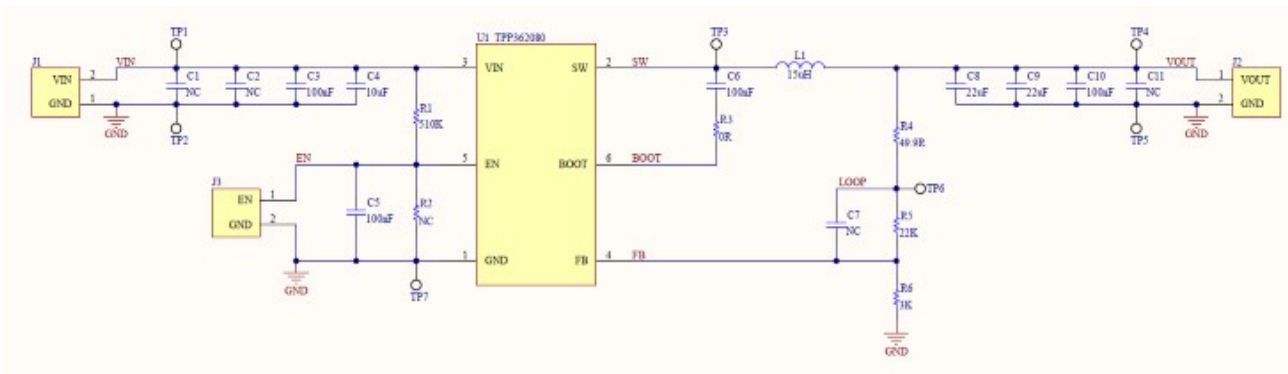


Figure 25. Typical Application Circuit

Component Selection

EVM: $F_{sw} = 500 \text{ kHz}$, $MODE = \text{Pulse-Skip}$, $I_{OUT} = 1 \text{ A}$, $t_{SS} = 2 \text{ ms}$, $V_{OUT} = 5 \text{ V}$						
Designator	Value	Quantity	Part No.	Package	Manufacturer	Description
U1	TPP361080	1	TPP361080-T6TR	SOT23-6	3PEAK	Buck Converter, 36 V, 1 A, 500 kHz, PFM
C1	NC	0				
C2	NC	0				
C3	100 nF	1	GGD21BR71H10 4KA02	0805	muRata	Capacitor, 100 nF, 50VDC, X7R, $\pm 15\%$
C4	10 μF	1	GCM32EC71H10 6MA03L	1210	muRata	Capacitor, 10 μF , 50VDC, X7S, $\pm 22\%$
R1	510 K	1	ARG03FTC5103	0603	Viking	Resistor, 510 K, $\pm 1\%$, 0.1 W
C5	NC	0				

36-V Input, 1-A Synchronous Step-Down Voltage Regulator

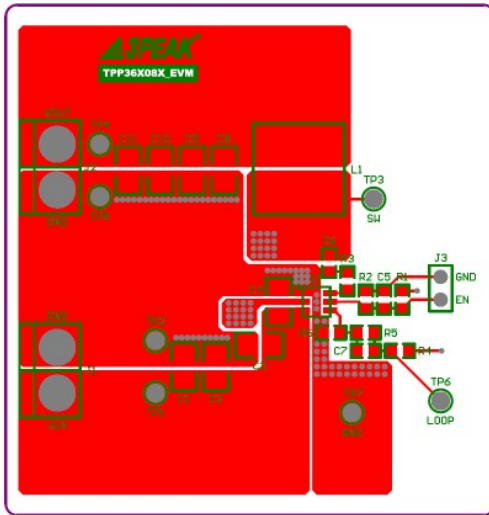
EVM: $F_{sw} = 500$ kHz, MODE = Pulse-Skip, $I_{out} = 1$ A, $t_{ss} = 2$ ms, $V_{out} = 5$ V						
Designator	Value	Quantity	Part No.	Package	Manufacturer	Description
R2	100 K	1	ARG03FTC1003	0603	Viking	Resistor, 100 K, $\pm 1\%$, 0.1 W
C6	100 nF	1	GRM188R71C104KA01D	0603	muRata	Capacitor, 100 nF, 16VDC, X7R, $\pm 15\%$
C7	NC	0				
R3	0 R	1	ERJ-3GEY0R00V	0603	Panasonic	Resistor, 0 Ω , 5%, 0.1 W
L1	15 μ H	1	7447714150	10mm \times 5mm \times 10mm	Wurth Elektronik eiSos	Inductor, 15 μ H, 3.5 A, 36ohm, $\pm 20\%$
C8	22 μ F	1	GRM32ER71E226ME15L	1210	muRata	Capacitor, 22 μ F, 25VDC, X7R, $\pm 15\%$
C9	22 μ F	1	GRM32ER71E226ME15L	1210	muRata	Capacitor, 22 μ F, 25VDC, X7R, $\pm 15\%$
C10	100 nF	1	GGD21BR71H104KA02	0805	muRata	Capacitor, 100 nF, 50VDC, X7R, $\pm 15\%$
C11	NC	0				
R4	49.9 R	1	ARG03FTC49R9	0603	Viking	Resistor, 49.9 Ω , $\pm 1\%$, 0.1 W
R5	22 K	1	ARG03FTC2202	0603	Viking	Resistor, 22 K, $\pm 1\%$, 0.1 W
R6	3 K	1	ARG03FTC3001	0603	Viking	Resistor, 3 K, $\pm 1\%$, 0.1 W

Layout

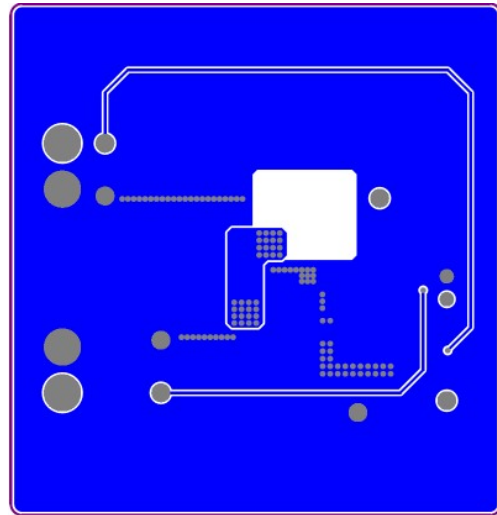
Layout Guideline

- Both input capacitors and output capacitors must be placed to the device pins as close as possible.
- It is recommended to bypass the input pin to ground with a 0.1 μF bypass capacitor.
- It is recommended to use wide and thick copper to minimize $I \times R$ drop and heat dissipation.
- Exposed pad must be connected to the PCB ground plane directly, the copper area must be as large as possible.

Layout Recommendations

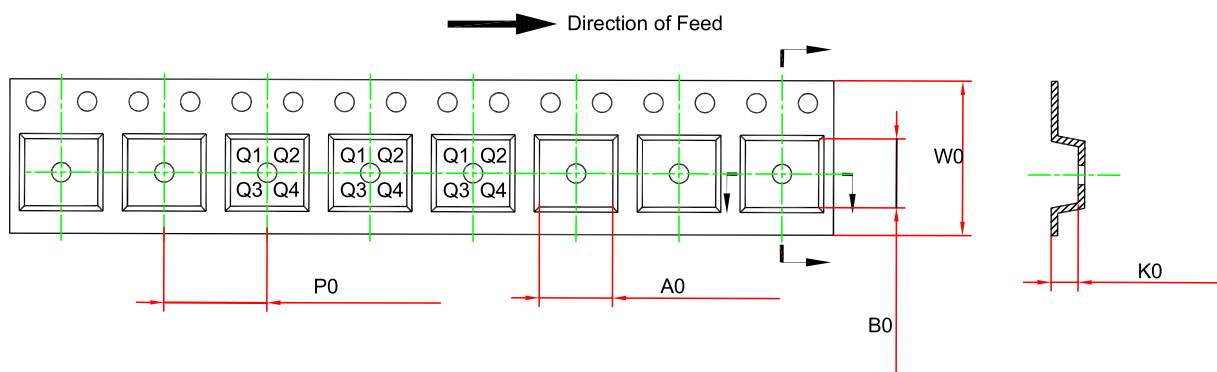
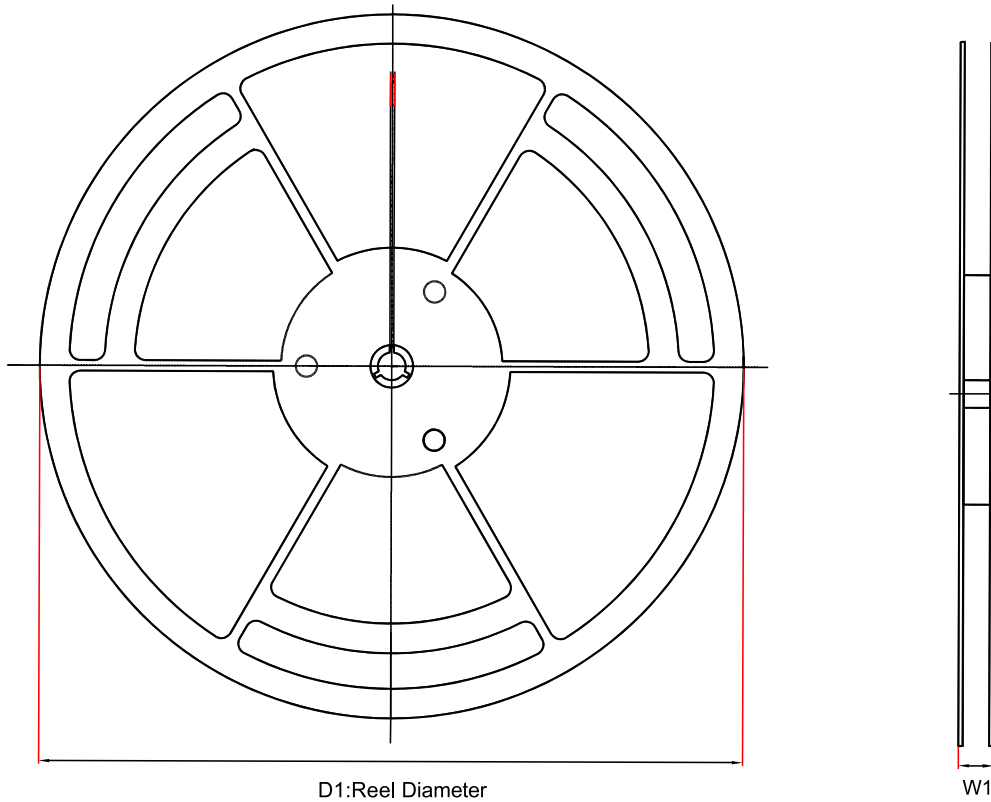


Top Layer



Bottom Layer

Tape and Reel Information



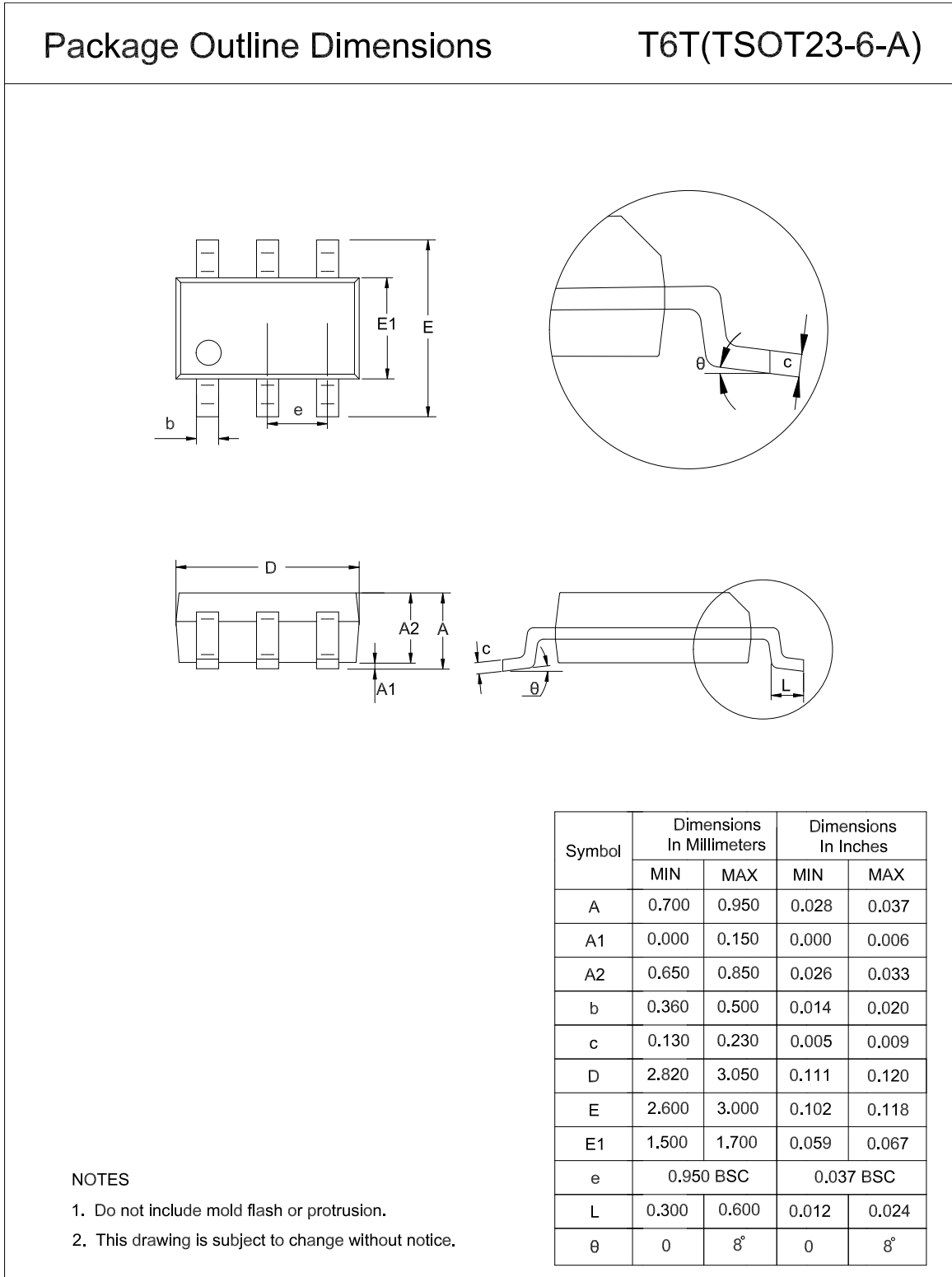
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPP361080-T6TR	TSOT23-6	180	12.3	3.2	3.05	1.1	4	8	Q3
TPP361081-T6TR	TSOT23-6	180	12.3	3.2	3.05	1.1	4	8	Q3
TPP361082-T6TR	TSOT23-6	180	12.3	3.2	3.05	1.1	4	8	Q3

36-V Input, 1-A Synchronous Step-Down Voltage Regulator

Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPP361083-T6TR	TSOT23-6	180	12.3	3.2	3.05	1.1	4	8	Q3
TPP361084-T6TR	TSOT23-6	180	12.3	3.2	3.05	1.1	4	8	Q3
TPP361085-T6TR	TSOT23-6	180	12.3	3.2	3.05	1.1	4	8	Q3

Package Outline Dimensions

TSOT23-6



Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPP361080-T6TR	-40 to 125°C	TSOT23-6	310	MSL3	Tape and Reel, 3000	Green
TPP361081-T6TR	-40 to 125°C	TSOT23-6	311	MSL3	Tape and Reel, 3000	Green
TPP361082-T6TR	-40 to 125°C	TSOT23-6	312	MSL3	Tape and Reel, 3000	Green
TPP361083-T6TR	-40 to 125°C	TSOT23-6	313	MSL3	Tape and Reel, 3000	Green
TPP361084-T6TR ⁽¹⁾	-40 to 125°C	TSOT23-6	314	MSL3	Tape and Reel, 3000	Green
TPP361085-T6TR ⁽¹⁾	-40 to 125°C	TSOT23-6	315	MSL3	Tape and Reel, 3000	Green

(1) Contact 3PEAK representatives for more information.

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

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