

## 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 (TPP361060/2)
  - 1 MHz (TPP361064/5)
  - 2.2 MHz (TPP361061/3)
- Low 2-μA Shutdown, 70-μA Quiescent Current
- Internal Light Load Power-Save Mode for High Efficiency at Light Load (TPP361060/1/4)
- Forced-PWM Mode for Low Output Ripple (TPP361062/3/5)
- 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

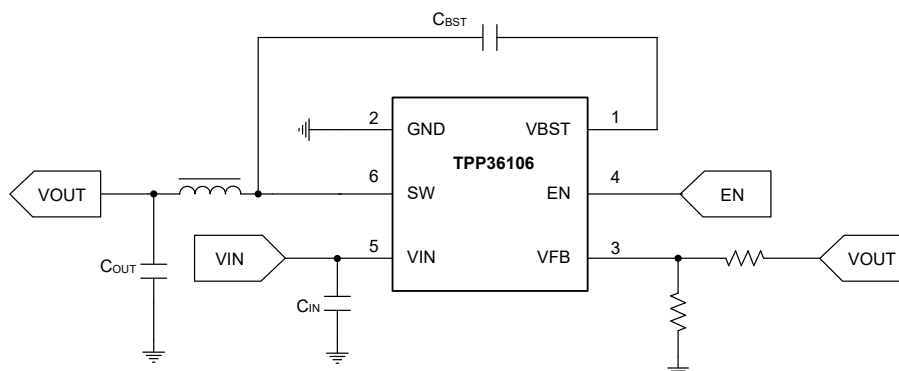
The TPP36106x series is a simple, easy-to-use, 1-A output, synchronous, step-down, and switch-mode converter with internal power MOSFETs.

The TPP36106x integrates low- $R_{DS(ON)}$  power transistors in the TSOT23-6 package with internal soft-start, compensation, and protection features. The TPP36106x offers a very compact solution to achieve 1-A continuous output current over a wide input supply range, with excellent load and line regulation.

The TPP36106x has different versions of switching frequency at 500-kHz, 1-MHz, and 2.2-MHz, and also supports light load PSM mode 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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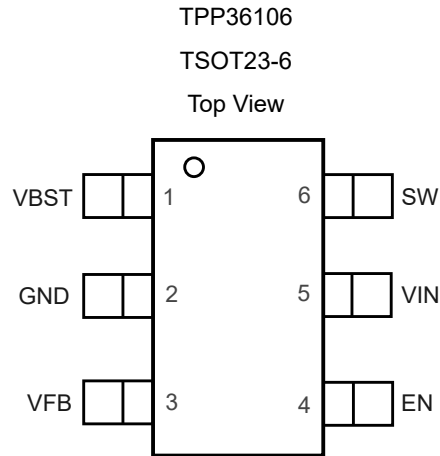
## Product Family Table

| Orderable Part Number | Frequency | Low Output Current Mode |
|-----------------------|-----------|-------------------------|
| TPP361060-T6TR        | 500 kHz   | Pulse-Skip Mode         |
| TPP361061-T6TR        | 2.2 MHz   | Pulse-Skip Mode         |
| TPP361062-T6TR        | 500 kHz   | Forced PWM Mode         |
| TPP361063-T6TR        | 2.2 MHz   | Forced PWM Mode         |
| TPP361064-T6TR        | 1 MHz     | Pulse-Skip Mode         |
| TPP361065-T6TR        | 1 MHz     | Forced PWM Mode         |

## Revision History

| Date       | Revision | Notes                                                            |
|------------|----------|------------------------------------------------------------------|
| 2023-02-13 | Rev A.0  | Initial release                                                  |
| 2023-05-12 | Rev A.1  | Updated electrical table, description, and typical applications. |
| 2024-04-01 | Rev A.2  | Updated recommended operating conditions and maximum duty cycle. |
| 2024-08-28 | Rev A.3  | Updated family table.                                            |

## Pin Configuration and Functions



**Table 1. Pin Functions: TPP36106**

| Pin | Name | I/O | Description                                                                                                                  |
|-----|------|-----|------------------------------------------------------------------------------------------------------------------------------|
| 1   | VBST | O   | High-side MOSFET gate supply pin. Connect 0.1- $\mu$ F between VBST and SW pins.                                             |
| 2   | GND  | G   | Ground pin. Power and controller circuit ground. Use star connection to GND pin with good contact.                           |
| 3   | VFB  | O   | Voltage feedback pin. Connect to output voltage with a feedback resistor divider.                                            |
| 4   | EN   | I   | Enable input. Active high. Internally weak pulled up.                                                                        |
| 5   | VIN  | I   | Supply input pin. Connect decoupling 2 $\times$ 10- $\mu$ F and 1 $\times$ 0.1- $\mu$ F capacitors between VIN and GND pins. |
| 6   | SW   | O   | Switching node, connect to inductor, boot capacitor.                                                                         |

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

### Specifications

#### Absolute Maximum Ratings <sup>(1)</sup>

| Symbol           | Parameter                           | Min  | Max                   | Unit |
|------------------|-------------------------------------|------|-----------------------|------|
| V <sub>IN</sub>  | Supply Voltage                      | -0.3 | 42                    | V    |
| SW               | Switching Node Voltage              | -0.3 | V <sub>IN</sub> + 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 | 5.5                   | V    |
| FB               | Feedback Voltage                    | -0.3 | 5.5                   | V    |
| EN               | Enable Input                        | -0.3 | 42                    | V    |
| T <sub>J</sub>   | Maximum Junction Temperature        |      | 150                   | °C   |
| T <sub>A</sub>   | Operating Temperature Range         | -40  | 125                   | °C   |
| T <sub>STG</sub> | Storage Temperature Range           | -65  | 150                   | °C   |
| T <sub>L</sub>   | 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

| Symbol | Parameter                | Condition                             | Minimum Level | Unit |
|--------|--------------------------|---------------------------------------|---------------|------|
| HBM    | Human Body Model ESD     | ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup> | 2             | kV   |
| CDM    | Charged Device Model ESD | ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup> | 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 | Max             | Unit |
|-----------------|--------------------------------|-----|-----------------|------|
| V <sub>IN</sub> | 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 Input Voltage Range       | 0   | 5.5             | V    |
| SW              | SW Input Voltage Range         | 0   | V <sub>IN</sub> | V    |
| T <sub>J</sub>  | Operating Junction Temperature | -40 | 150             | °C   |

**Thermal Information**

| Package Type | $\theta_{JA}$ | $\theta_{JC}$ | Unit |
|--------------|---------------|---------------|------|
| TSOT23-6     | 100           | 67            | °C/W |

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

### Electrical Characteristics

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

| Parameter                         |                                                 | Conditions                                                                    | Min  | Typ   | Max  | Unit             |
|-----------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------|------|-------|------|------------------|
| <b>Power Supply</b>               |                                                 |                                                                               |      |       |      |                  |
| $V_{IN}$                          | Supply Voltage Range                            |                                                                               | 4.5  |       | 36   | V                |
| $I_Q$                             | Operating Supply Current                        | Non-switching, $EN = 5\text{ V}$ ,<br>$V_{FB} = 1\text{ V}$                   |      | 70    |      | $\mu\text{A}$    |
| $I_{QSD}$                         | Shut-Down Supply Current                        | $EN = \text{GND}$                                                             |      | 2     |      | $\mu\text{A}$    |
| $V_{UVLO\_rising}$                | UVLO Rising Threshold                           |                                                                               | 3.9  | 4.3   | 4.5  | V                |
| $V_{UVLO\_falling}$               | UVLO Falling Threshold                          |                                                                               | 3.7  | 3.9   | 4.1  | V                |
| <b>Enable</b>                     |                                                 |                                                                               |      |       |      |                  |
| $V_{ENH}$                         | EN Input Rising Threshold                       |                                                                               | 1.15 | 1.28  | 1.35 | V                |
| $V_{ENL}$                         | EN Input Falling Threshold                      |                                                                               | 1    | 1.17  | 1.2  | V                |
| $I_{EN\_L}$                       | EN current, $EN = L^{(1)}$                      | $V_{EN} = 0.9\text{ V}$                                                       | 0.65 | 1.04  | 1.5  | $\mu\text{A}$    |
| $I_{EN\_H}$                       | EN current, $EN = H$                            | $V_{EN} = 1.5\text{ V}$                                                       | 3.6  | 4.3   | 5.2  | $\mu\text{A}$    |
| $I_{EN\_HYS}$                     | EN hysteresis current                           | $V_{EN} = 1.5\text{ V}$                                                       |      | 3.3   |      | $\mu\text{A}$    |
| <b>Feedback and Power Stage</b>   |                                                 |                                                                               |      |       |      |                  |
| $V_{FB}$                          | $V_{FB}$ 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                      | $I_{SW} = 1\text{ A}$                                                         |      | 116.2 |      | $\text{m}\Omega$ |
| $f_{SW}$                          | Switching Frequency                             | TPP361060/2                                                                   | 390  | 500   | 590  | kHz              |
|                                   |                                                 | TPP361061/3                                                                   | 1.76 | 2.2   | 2.64 | MHz              |
|                                   |                                                 | TPP361064/5                                                                   | 0.8  | 1     | 1.2  | MHz              |
| $D_{MAX}$                         | Maximum duty cycle                              |                                                                               |      | 93    |      | %                |
| $t_{SS}$                          | Soft-Start Time                                 |                                                                               |      | 2     |      | ms               |
| $t_{SS\_done}$                    | Soft Start Transition Time                      |                                                                               | 14   | 18    | 24   | ms               |
| $I_{skip}$                        | Pulse-Skip Mode Peak Inductor Current Threshold | $V_{IN} = 12\text{ V}$ , $V_{OUT} = 5\text{ V}$ , $L = 15\text{ }\mu\text{H}$ |      | 300   |      | mA               |
| <b>Current Limit</b>              |                                                 |                                                                               |      |       |      |                  |
| $I_{Limit\_HS}$                   | High-side Current Limit                         | Inductor peak current                                                         | 1.2  | 1.5   | 1.8  | A                |
| $I_{Limit\_LS}$                   | Low-side Current Limit                          | Inductor valley current                                                       | 0.9  | 1.2   | 1.5  | A                |
| $I_{Limit\_LS\_neg}$              | Negative Low-side Current Limit                 |                                                                               |      | 0.9   |      | A                |
| <b>Diagnostics and Protection</b> |                                                 |                                                                               |      |       |      |                  |
| $V_{FB\_UVP\_rising}$             | FB Hiccup Protection Rising Ratio               |                                                                               |      | 40    |      | %                |
| $V_{FB\_UVP\_falling}$            | FB Hiccup Protection Falling Ratio              |                                                                               |      | 33    |      | %                |
| $V_{FB\_OVP\_rising}$             | FB Over-Voltage Protection Rising Ratio         |                                                                               |      | 108   |      | %                |

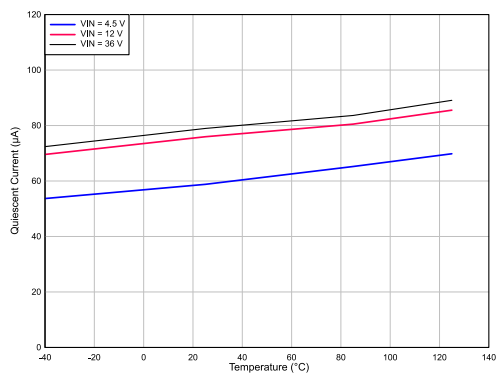
**36-V Input, 1-A Synchronous Step-Down Voltage Regulator**

| Parameter                   |                                          | Conditions | Min | Typ | Max | Unit   |
|-----------------------------|------------------------------------------|------------|-----|-----|-----|--------|
| V <sub>FB_OVP_falling</sub> | FB Over-Voltage Protection Falling Ratio |            |     | 107 |     | %      |
| t <sub>HIC_wait</sub>       | Hiccup Protection Wait Time              |            |     | 128 |     | Cycles |
| t <sub>HIC_restart</sub>    | Hiccup Protection Restart Time           |            |     | 60  |     | ms     |
| <b>Thermal Shut-Down</b>    |                                          |            |     |     |     |        |
| T <sub>SD</sub>             | Thermal Shut-Down Temperature            |            |     | 160 |     | °C     |
| T <sub>SD_hys</sub>         | Thermal Hysteresis                       |            |     | 10  |     | °C     |

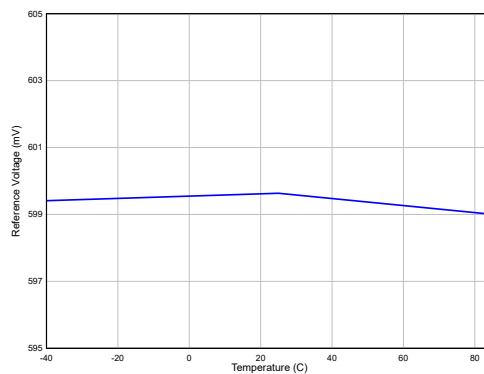
(1) Guaranteed by design.

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

## Typical Performance Characteristics

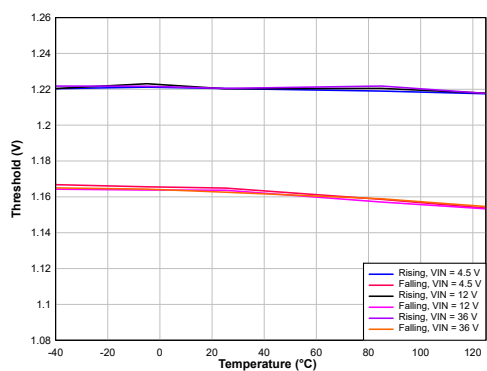


**Figure 1. Quiescent Current vs. Supply Voltage**

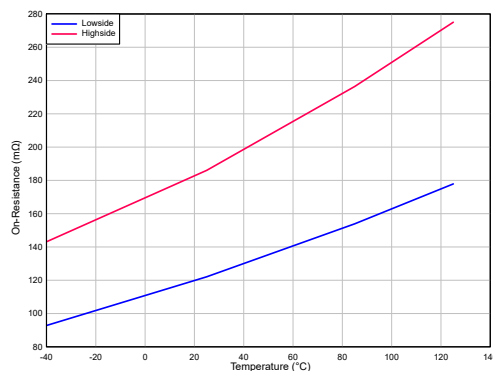


**Figure 2. Reference Voltage vs. Temperature**

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

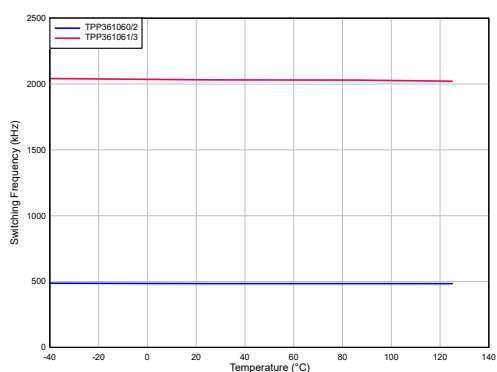


**Figure 3. EN Threshold vs. Junction Temperature**

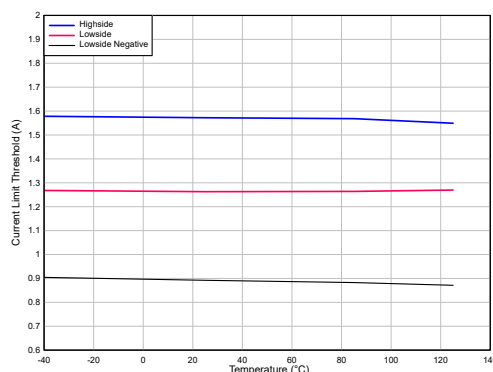


**Figure 4. On-Resistance vs Temperature**

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

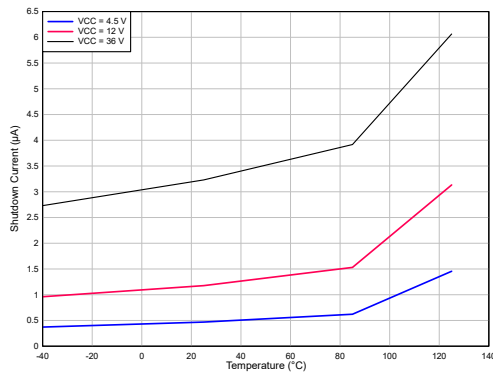


**Figure 5. Switching Frequency vs. Temperature**

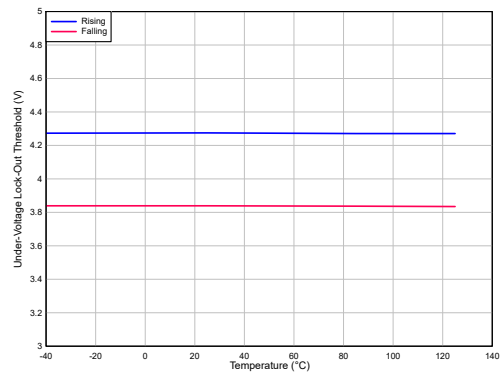


**Figure 6. Current Limit vs. Temperature**

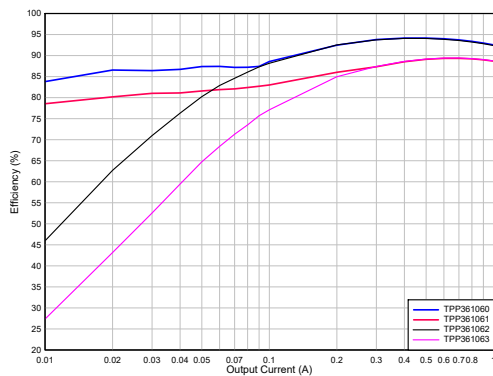
# 36-V Input, 1-A Synchronous Step-Down Voltage Regulator



**Figure 7. Shutdown Current vs Junction Temperature**

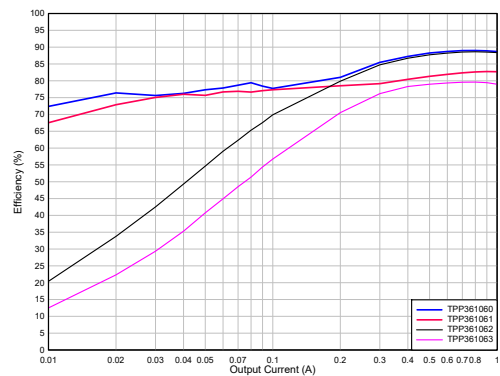


**Figure 8. UVLO Threshold vs Temperature**



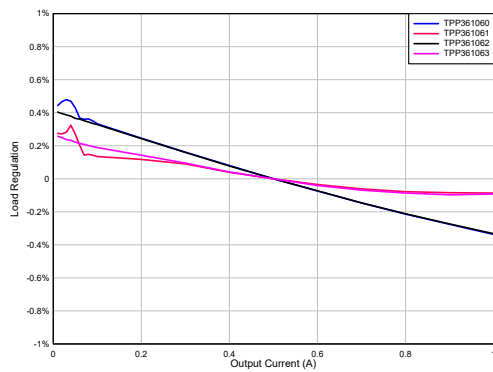
**Figure 9. Efficiency vs. Output Current**

$V_{IN} = 12\text{ V}$ ,  $V_{OUT} = 5\text{ V}$ ,  $L = 2.2\text{ }\mu\text{H}$



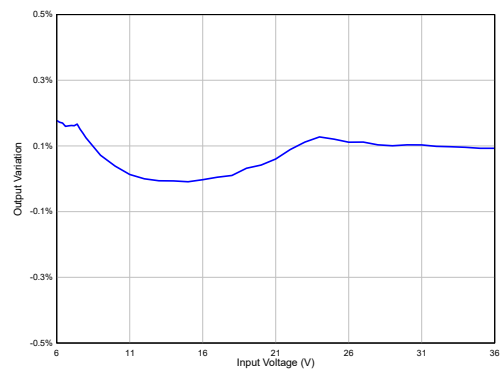
**Figure 10. Efficiency vs. Output Current**

$V_{IN} = 36\text{ V}$ ,  $V_{OUT} = 5\text{ V}$ ,  $L = 2.2\text{ }\mu\text{H}$



**Figure 11. Load Regulation**

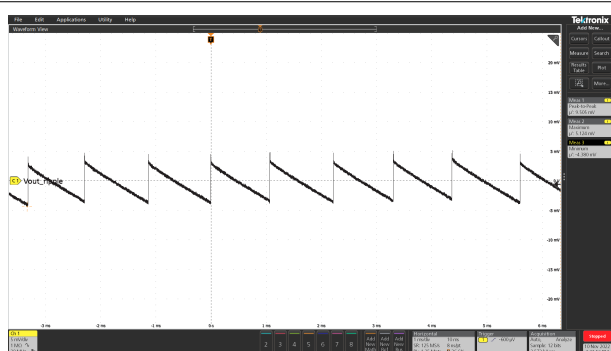
$V_{OUT} = 5\text{ V}$



**Figure 12. Line Regulation**

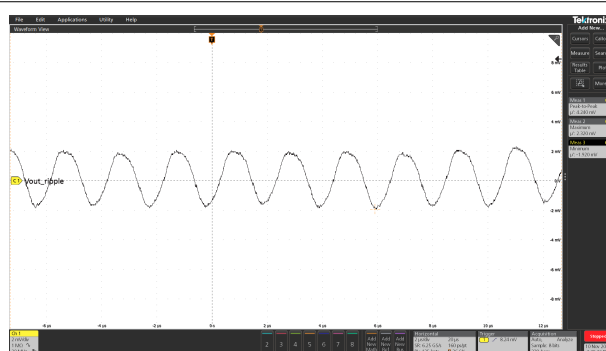
$V_{OUT} = 5\text{ V}$

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



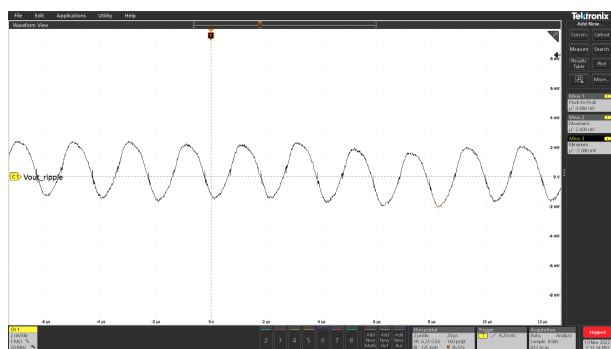
**Figure 13. Pulse Skip Mode Output Voltage Ripple**

CH1: V<sub>OUT</sub> Ripple  
V<sub>IN</sub> = 12 V, V<sub>OUT</sub> = 5 V, I<sub>OUT</sub> = 0 A



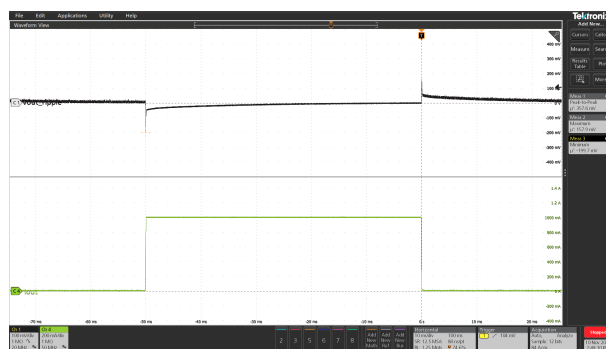
**Figure 14. Pulse Skip Mode Output Voltage Ripple**

CH1: V<sub>OUT</sub> Ripple  
V<sub>IN</sub> = 12 V, V<sub>OUT</sub> = 5 V, I<sub>OUT</sub> = 100 mA



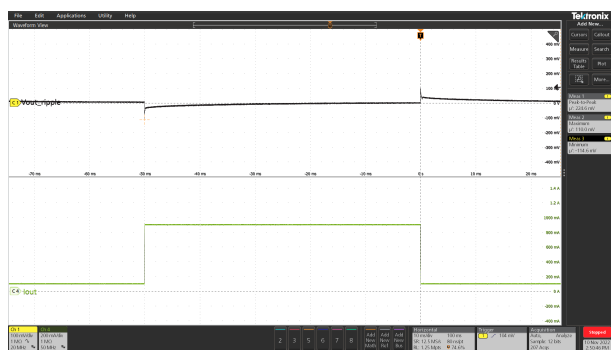
**Figure 15. Output Voltage Ripple**

CH1: V<sub>OUT</sub> Ripple  
V<sub>IN</sub> = 12 V, V<sub>OUT</sub> = 5 V, I<sub>OUT</sub> = 1 A



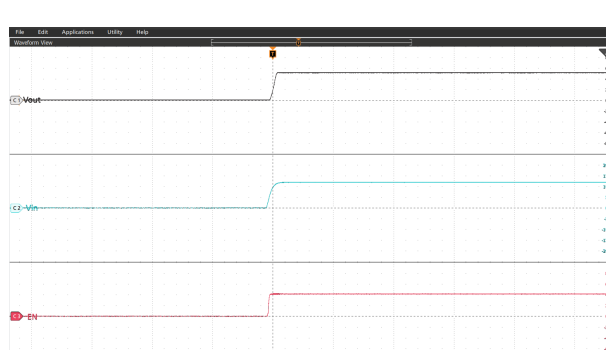
**Figure 16. Load Transient**

CH1: V<sub>OUT</sub> Ripple, CH4: Load Current  
V<sub>IN</sub> = 12 V, V<sub>OUT</sub> = 5 V, I<sub>OUT</sub> = 0 A to 1 A to 0 A



**Figure 17. Load Transient**

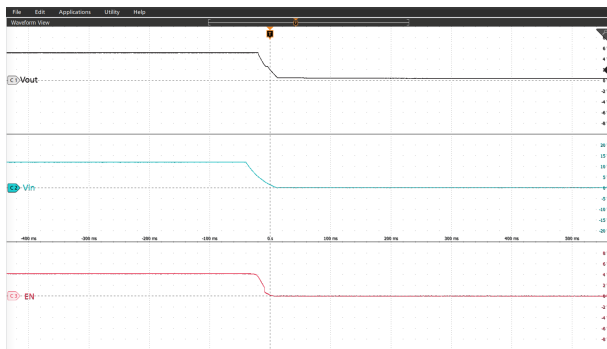
CH1: V<sub>OUT</sub> Ripple, CH4: Load Current  
V<sub>IN</sub> = 12 V, V<sub>OUT</sub> = 5 V, I<sub>OUT</sub> = 0.1 A to 0.9 A to 0.1 A



**Figure 18. Start-Up by VIN**

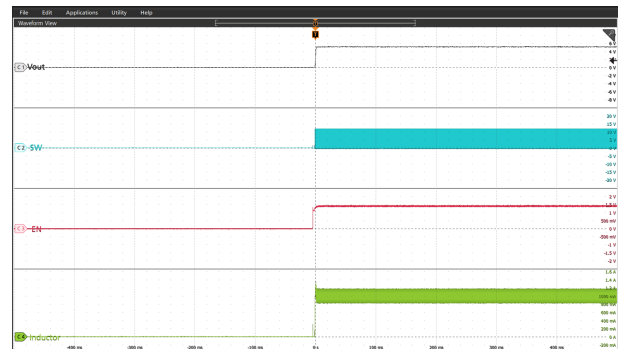
CH1: V<sub>OUT</sub>, CH2: V<sub>IN</sub>, CH3: V<sub>EN</sub>

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



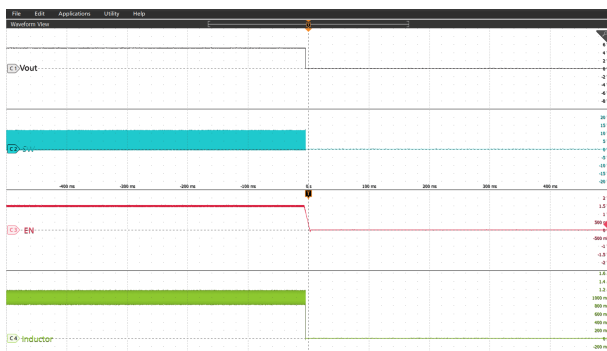
**Figure 19. Power-Down by VIN**

CH1: V<sub>OUT</sub>, CH2: V<sub>IN</sub>, CH3: V<sub>EN</sub>



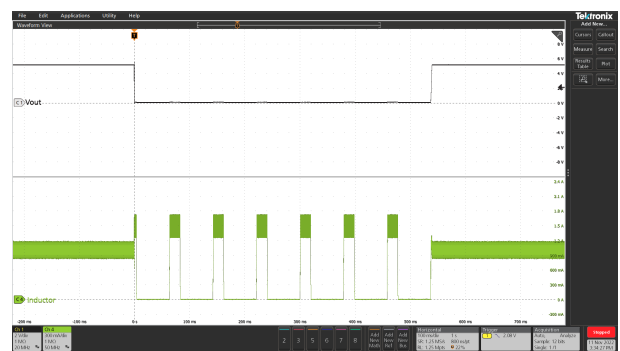
**Figure 20. Start-Up by EN**

CH1: V<sub>OUT</sub>, CH2: SW, CH3: V<sub>EN</sub>, CH4: I<sub>L</sub>



**Figure 21. Power-Down by EN**

CH1: V<sub>OUT</sub>, CH2: SW, CH3: V<sub>EN</sub>, CH4: I<sub>L</sub>



**Figure 22. Hiccup Protection**

CH1: V<sub>OUT</sub>, CH4: I<sub>L</sub>

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

### Detailed Description

#### Overview

The TPP36106x 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 |
|----------------|-----------|-------------------------|
| TPP361060-T6TR | 500 kHz   | Pulse-Skip Mode         |
| TPP361061-T6TR | 2.2 MHz   | Pulse-Skip Mode         |
| TPP361062-T6TR | 500 kHz   | Forced-PWM Mode         |
| TPP361063-T6TR | 2.2 MHz   | Forced-PWM Mode         |
| TPP361064-T6TR | 1 MHz     | Pulse-Skip Mode         |
| TPP361065-T6TR | 1 MHz     | Forced-PWM Mode         |

#### Functional Block Diagram

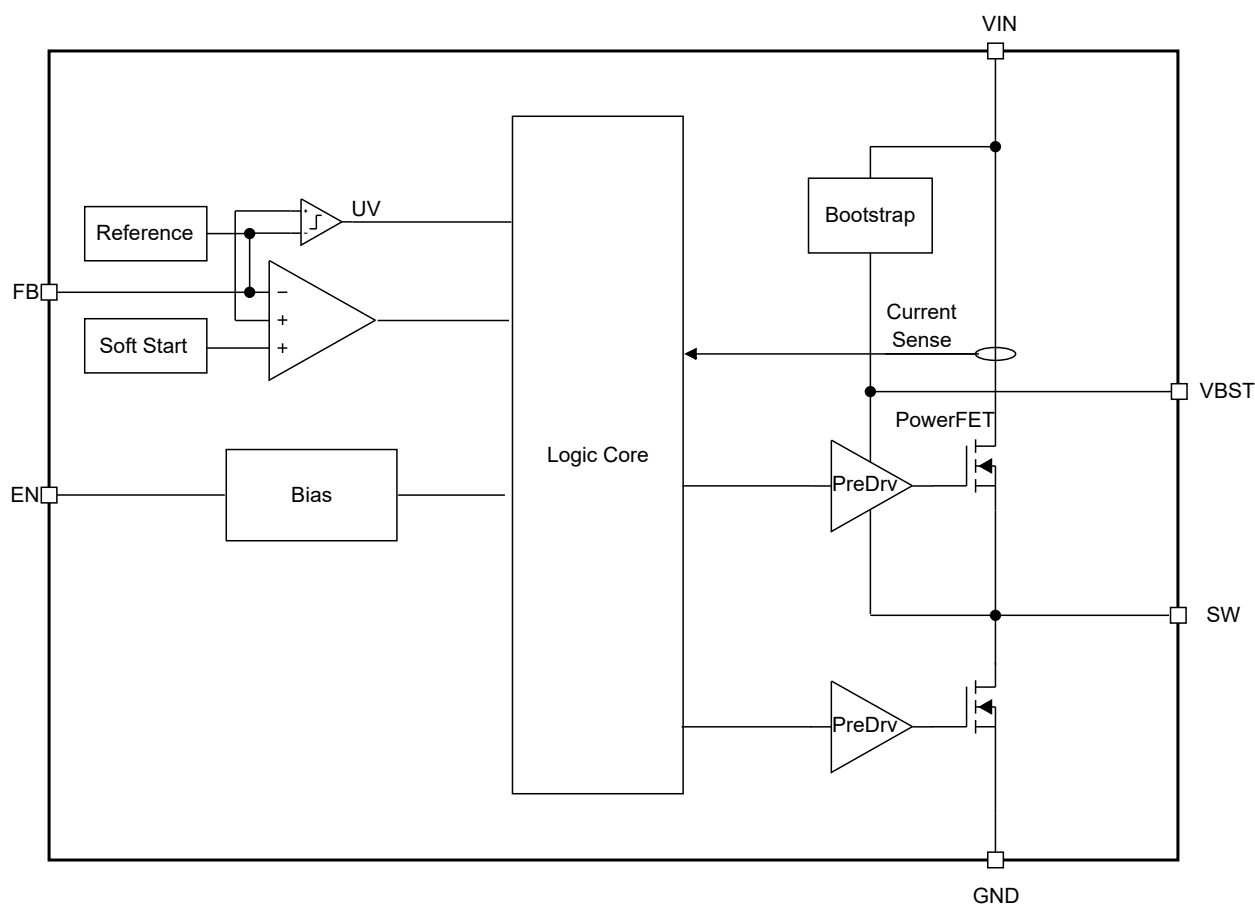


Figure 23. Functional Block Diagram

## Feature Description

### Current Mode Control

The TPP36106x 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

The TPP36106x supports both 500-kHz (TPP361060/TPP361062), 1-MHz (TPP361064/5), and 2.2-MHz switching frequency (TPP361061/TPP361063). 500-kHz has better efficiency due to less switching loss, 2.2-MHz supports high-frequency inductors with small form factor and 1-MHz is a good balance in between. 3PEAK recommends evaluating thermal performance in 1-MHz and 2.2-MHz scenarios, especially at high-temperature conditions.

### Pulse-Skip Mode

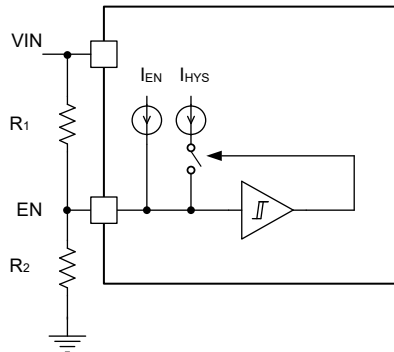
To improve light-load efficiency, the TPP361060/1/4 will automatically enter improved light-load mode when the inductor ripple valley current reaches zero. The controller keeps the on-time of the high-side switch the same. With a light load, the decay of voltage takes a longer time and lowers the switching frequency accordingly.

### Forced-PWM Mode

The TPP361062/3/5 has Forced-PWM mode to support low-noise applications. When the 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.

### 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  $I_{EN\_H}$ .



**Figure 24. EN Block Diagram**

The EN threshold can be set via the equations below:

$$R_1 = \frac{V_{ENL}(V_{IN\_START} - V_{ENH}) - V_{ENH}(V_{IN\_STOP} - V_{ENL})}{V_{ENH} \cdot I_{ENH} - V_{ENL} \cdot I_{ENL}} \quad (1)$$

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

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

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**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 the FB voltage.

**Over Current Protection**

The device has a cycle-by-cycle current limit. During the OFF state, once the over current is detected at the 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 a negative current and can block reverse current when the reverse inductor current is higher than the 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.

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 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

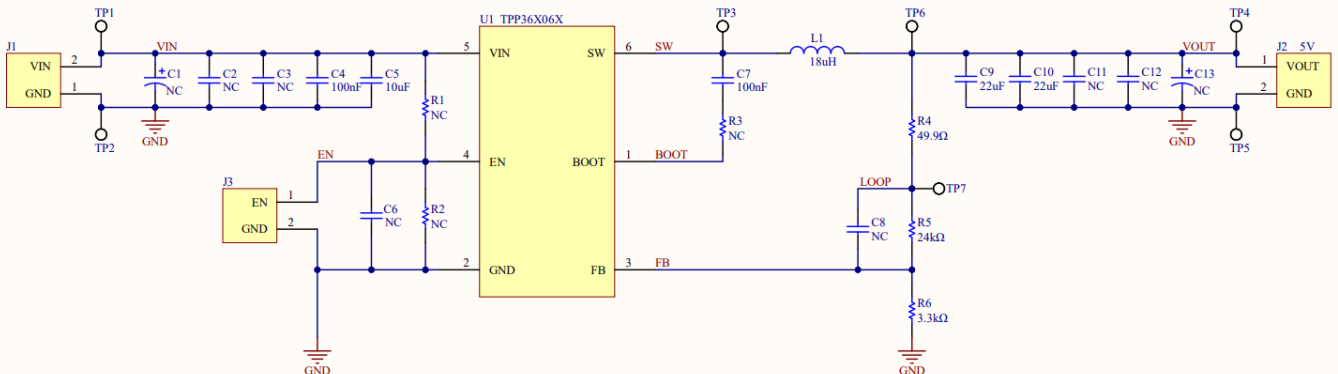
Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design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

## Application Information

As an easy-to-use, industrial pinout, step-down voltage regulator, also known as a buck regulator, the TPP36106x usually converts 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 TPP36106x.

## 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**

The following steps provide how to design a buck solution for the TPP361060 based on the above.

1. To establish the desired output voltage ( $V_{OUT}$ ), employ Equation 3 and proceed with the selection of the resistor divider ( $R_{HS}/R_{LS}$ ).

$$R_{HS} = R_{LS} \cdot \left( \frac{V_{OUT}}{0.6} - 1 \right) \quad (3)$$

2. For the selection of the output inductor ( $L_O$ ), determine the minimum value ( $L_{O\_MIN}$ ) by applying equations below.

$$I_{RIPPLE} = \frac{V_{OUT} \cdot (V_{IN\_MAX} - V_{OUT})}{V_{IN\_MAX} \cdot L_O \cdot f_{SW}} \quad (4)$$

$$L_{O\_MIN} = \frac{V_{OUT} \cdot (V_{IN\_MAX} - V_{OUT})}{V_{IN\_MAX} \cdot f_{SW} \cdot I_{OUT} \cdot r} \quad (5)$$

$$I_{LO\_RMS} = \sqrt{I_{OUT}^2 + \frac{I_{RIPPLE}^2}{12}} \quad (6)$$

$$I_{LO\_PEAK} = I_{OUT} + \frac{I_{RIPPLE}}{2} \quad (7)$$

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

Where  $V_{IN\_MAX}$  represents the maximum input voltage,  $r$  denotes the ratio between the inductor ripple current ( $I_{RIPPLE}$ ) and the maximum output current ( $I_{OUT}$ ),  $I_{LO\_RMS}$  signifies the RMS inductor current, and  $I_{LO\_PEAK}$  represents the peak inductor current. Typically, a value of 0.2-0.5 is chosen when utilizing low ESR output capacitors. For the TPP361060 with an  $f_{SW}$  of 500kHz, we recommend selecting an inductor with  $I_{OUT} = 1A$  and  $r=0.5$ , regardless of the operating conditions.

For example, when  $V_{IN\_MAX} = 36V$  and  $V_{OUT} = 5V$ , the minimum value of the output inductor ( $L_{(LO\_MIN)}$ ) is calculated to be approximately 17.2  $\mu H$ . In this case, a standard inductor with a rating of 18 $\mu H$ , a saturation current of 2.05 A, and a rated current of 1.5 A would be suitable.

### 3. Choose the Output Capacitor ( $C_{OUT}$ )

For the selection of the output capacitor ( $C_{OUT}$ ), the minimum value ( $C_{O\_MIN}$ ) is determined by employing equations below.

$$C_{O\_MIN} \geq \frac{2\Delta I_{OUT}}{f_{SW} \cdot \Delta V_{OUT}} \quad (8)$$

$$C_{O\_MIN} \geq L_O \cdot \frac{I_{OI}^2 - I_{Of}^2}{V_f^2 - V_i^2} \quad (9)$$

$$\Delta I_{OUT} = I_{OI} - I_{Of} \quad (10)$$

$$C_{O\_MIN} \geq \frac{I_{RIPPLE}}{8f_{SW} \cdot V_{O\_RIPPLE}} \quad (11)$$

$$R_{ESR} \leq \frac{V_{O\_RIPPLE}}{I_{RIPPLE}} \quad (12)$$

$$I_{CO\_RMS} \geq \frac{V_{OUT} \times (V_{IN\_MAX} - V_{OUT})}{\sqrt{12} \cdot V_{IN\_MAX} \cdot L_O \cdot f_{SW}} \quad (13)$$

Where  $\Delta I_{OUT}$  represents the change in output current,  $I_{OI}$  signifies the heavy load output current, and  $I_{Of}$  represents the light load output current during load transient.  $\Delta V_{OUT}$  denotes the allowable change in output voltage, while  $V_i$  represents the initial output voltage, and  $V_f$  represents the maximum allowable output voltage during the transient from light load to heavy load.  $V_{O\_RIPPLE}$  represents the maximum allowable value of output voltage ripple under maximum output current conditions.  $R_{ESR}$  indicates the equivalent series resistance of the output capacitor, and  $I_{CO\_RMS}$  represents the RMS current of the output capacitor.

As an example, let's consider  $V_{OUT} = 5V$ ,  $\Delta I_{OUT} = 0.75A - 0.25A = 0.5A$ ,  $V_{O\_RIPPLE} < 25mV$ , and  $\Delta V_{OUT} < 100mV$ . In this case, a minimum output capacitance of approximately 20  $\mu F$  with an ESR of less than 53 m $\Omega$  is calculated. Therefore, with capacitance derating in consideration, 2 \* 22  $\mu F$  ceramic capacitors rated at 25 V with an ESR of 5 m $\Omega$  will be used.

### 4. Choosing the Bootstrap Capacitor ( $C_{BST}$ )

To ensure proper operation of the TPP36106x device, a 0.1  $\mu F$  ceramic capacitor should be connected between the BOOT and SW pins. It is recommended to use a ceramic capacitor with X5R or superior grade dielectric and a voltage rating of 10 V or higher.

### 5. Choosing the Input Capacitor ( $C_{IN}$ )

To ensure proper operation of the TPP36106x device, it is necessary to connect a 10  $\mu F$  capacitor between the VIN and GND pins with a short PCB trace. It is recommended to use a ceramic capacitor with X5R or superior grade dielectric and a voltage rating of 50 V or higher. Additionally, it is common to include a 0.1  $\mu F$ , 50 V decoupling ceramic capacitor as an input capacitor.

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

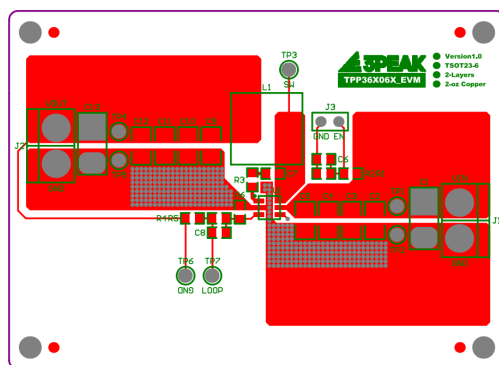
| EVM: $V_{OUT} = 5\text{ V}$ |               |                                             |           |           |                    |     |
|-----------------------------|---------------|---------------------------------------------|-----------|-----------|--------------------|-----|
| RefDes                      | Value         | Description                                 | Package   | MFR       | Part No.           | Qty |
| U1                          |               | Buck Converter, 36 V, 1 A, 500 kHz, PFM     | TSOT23-6  | 3PEAK     | TPP361060-T6TR     | 1   |
| C1                          | NC            |                                             |           |           |                    | 0   |
| C2                          | NC            |                                             |           |           |                    | 0   |
| C3                          | NC            |                                             |           |           |                    | 0   |
| C4                          | 100nF         | Capacitor, 100 nF, 50 V DC, X7R, $\pm 10\%$ | 0805      | YAGEO     | CC0805KRX7R9BB104  | 1   |
| R1                          | NC            |                                             |           |           |                    | 0   |
| C5                          | 10uF          | Capacitor, 10 uF, 50 V DC, X7R, $\pm 15\%$  | 1210      | muRata    | GXM32ER71H106KA10L | 1   |
| R2                          | NC            |                                             |           |           |                    | 0   |
| C6                          | NC            |                                             |           |           |                    | 0   |
| C7                          | 100nF         | Capacitor, 100 nF, 50 V DC, X7R, $\pm 10\%$ | 0805      | YAGEO     | CC0805KRX7R9BB104  | 0   |
| R3                          | 0R            | Resistor, 0 $\Omega$ , 5%, 0.1W             | 0603      | Panasonic | ERJ-3GEY0R00V      | 1   |
| L1                          | 18uH          | 18 uH, 5 ARat, 3.8 ASat, 34.4 mohm          | 10×4×10mm | Wurth     | 7447798181         | 1   |
| C8                          | NC            |                                             |           |           |                    | 0   |
| C9                          | 22uF          | Capacitor, 22 uF, 25 V DC, X7R, $\pm 15\%$  | 1210      | muRata    | GRM32ER71E226ME15L | 1   |
| C10                         | 22uF          | Capacitor, 22 uF, 25 V DC, X7R, $\pm 15\%$  | 1210      | muRata    | GRM32ER71E226ME15L | 1   |
| C11                         | NC            |                                             |           |           |                    | 0   |
| C12                         | NC            |                                             |           |           |                    | 0   |
| C13                         | NC            |                                             |           |           |                    | 0   |
| R4                          | 49.9 $\Omega$ | Resistor, 49.9 $\Omega$ , $\pm 1\%$ , 0.1 W | 0603      | Viking    | ARG03FTC49R9       | 1   |
| R5                          | 24K           | Resistor, 24 K, $\pm 1\%$ , 0.1 W           | 0603      | Viking    | ARG03FTC2402       | 1   |
| R6                          | 3.3K          | Resistor, 3.3 K, $\pm 1\%$ , 0.1 W          | 0603      | Viking    | ARG03FTC3301       | 1   |

## Layout

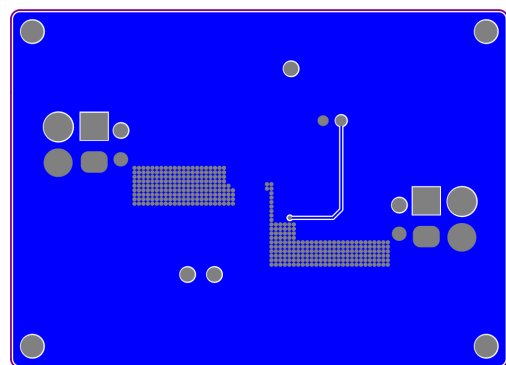
### Layout Guideline

- 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- $\mu$ F bypass capacitor.
- It is recommended to use wide and thick copper to minimize  $I \times R$  drop and heat dissipation.

### Layout Recommendations

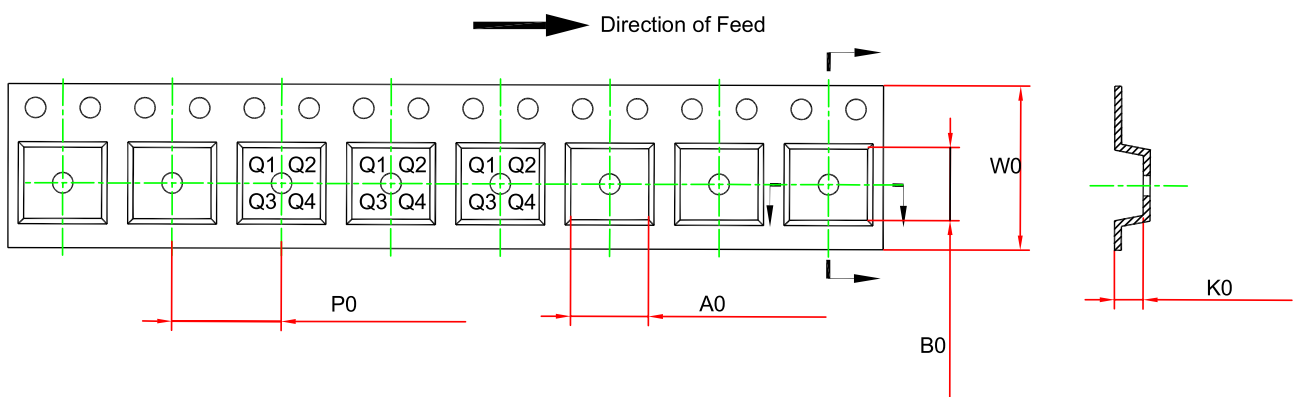
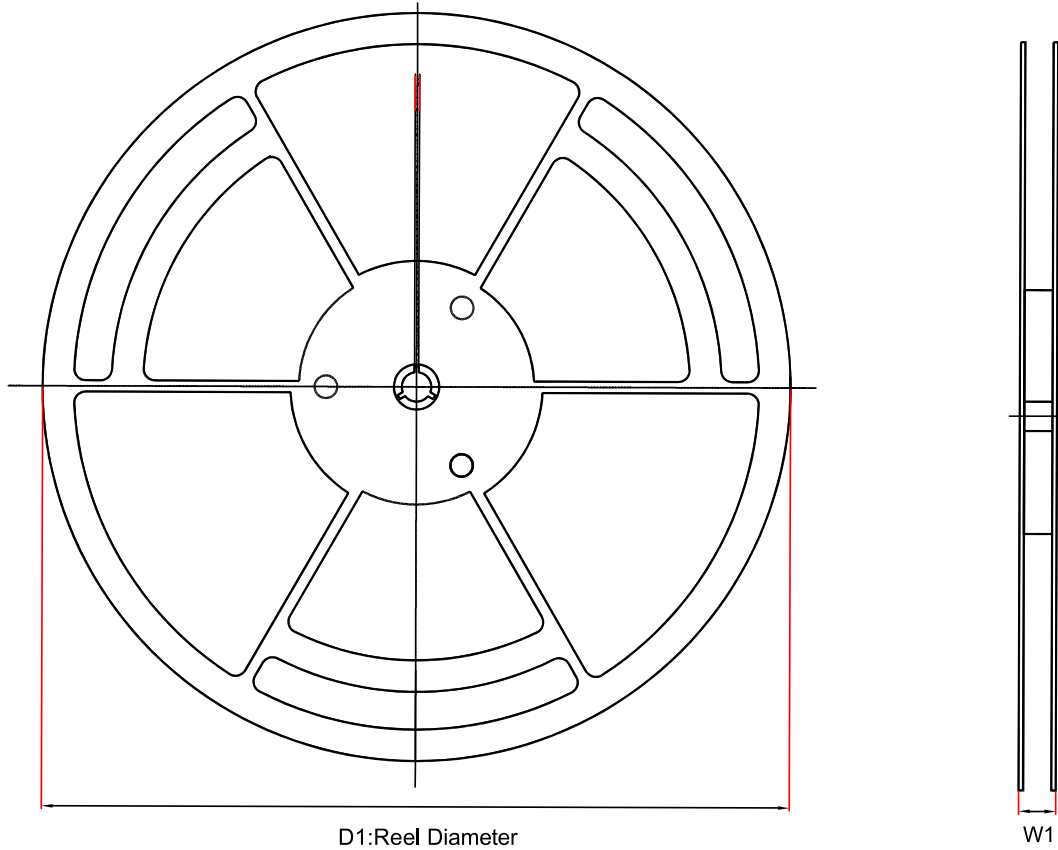


Top Layer



Bottom Layer

## Tape and Reel Information



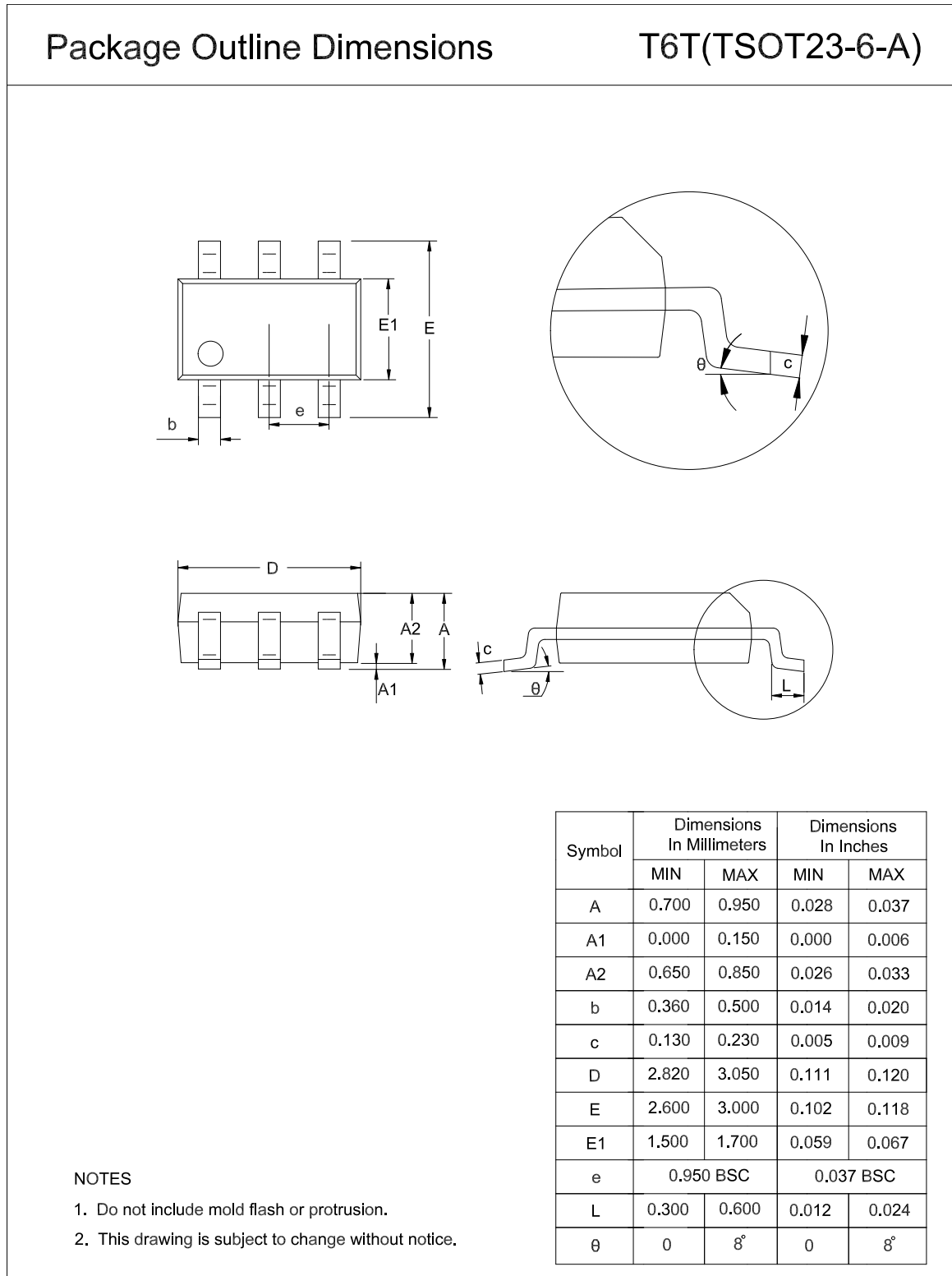
| Order Number   | Package  | D1 (mm) | W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | W0 (mm) | Pin1 Quadrant |
|----------------|----------|---------|---------|---------|---------|---------|---------|---------|---------------|
| TPP361060-T6TR | TSOT23-6 | 178     | 12.3    | 3.2     | 3.05    | 1.1     | 4.0     | 8.0     | Q3            |
| TPP361061-T6TR | TSOT23-6 | 178     | 12.3    | 3.2     | 3.05    | 1.1     | 4.0     | 8.0     | Q3            |

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

| Order Number   | Package  | D1<br>(mm) | W1<br>(mm) | A0<br>(mm) | B0<br>(mm) | K0<br>(mm) | P0<br>(mm) | W0<br>(mm) | Pin1<br>Quadrant |
|----------------|----------|------------|------------|------------|------------|------------|------------|------------|------------------|
| TPP361062-T6TR | TSOT23-6 | 178        | 12.3       | 3.2        | 3.05       | 1.1        | 4.0        | 8.0        | Q3               |
| TPP361063-T6TR | TSOT23-6 | 178        | 12.3       | 3.2        | 3.2        | 1.1        | 4.0        | 8.0        | Q3               |
| TPP361064-T6TR | TSOT23-6 | 178        | 12.3       | 3.2        | 3.05       | 1.1        | 4.0        | 8.0        | Q3               |
| TPP361065-T6TR | TSOT23-6 | 178        | 12.3       | 3.2        | 3.05       | 1.1        | 4.0        | 8.0        | Q3               |

## Package Outline Dimensions

TSOT23-6



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

| Order Number   | Operating Temperature Range | Package  | Marking Information | MSL  | Transport Media, Quantity | Eco Plan |
|----------------|-----------------------------|----------|---------------------|------|---------------------------|----------|
| TPP361060-T6TR | -40 to 125°C                | TSOT23-6 | 610                 | MSL1 | Tape and Reel, 3000       | Green    |
| TPP361061-T6TR | -40 to 125°C                | TSOT23-6 | 611                 | MSL1 | Tape and Reel, 3000       | Green    |
| TPP361062-T6TR | -40 to 125°C                | TSOT23-6 | 612                 | MSL1 | Tape and Reel, 3000       | Green    |
| TPP361063-T6TR | -40 to 125°C                | TSOT23-6 | 613                 | MSL1 | Tape and Reel, 3000       | Green    |
| TPP361064-T6TR | -40 to 125°C                | TSOT23-6 | 614                 | MSL1 | Tape and Reel, 3000       | Green    |
| TPP361065-T6TR | -40 to 125°C                | TSOT23-6 | 615                 | MSL1 | Tape and Reel, 3000       | Green    |

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

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