# MPQ8626

## 带可调限流功能的 16V、6A 高效率同步降压变换器

## 描述

MPQ8626 是一款全集成高频同步降压变换器。它提供了非常紧凑的解决方案，在宽输入范围内可实现高达 6A 的输出电流，具有极好的负载和线性调整率。MPQ8626 在宽输出电流负载范围内可高效工作。

MPQ8626 采用具有内部补偿功能的恒定导通时间（COT）控制模式，可提供快速瞬态响应，并使环路更易稳定。

通过工作模式配置，MPQ8626 的工作频率可被方便地设置为 600kHz、1100kHz 或 2000kHz，且无论输入和输出电压如何，工作频率都可保持恒定。

输出电压上电斜坡由内部 1.5ms 定时器控制，可通过在 TRK/REF 上添加一个电容来提高斜坡率。漏级开路结构的电源正常输出指示（PGOOD）引脚，可指示输出电压是否在正常范围内。当输入电源无法供电给 MPQ8626 时，PGOOD 具有一个外部上拉电压，并钳位在 0.7V 左右。

全方位保护功能包括过流保护（OCP）、过压保护（OVP）、欠压保护（UVP）和过温保护（OTP）。

MPQ8626 最大限度地减少了现有标准外部元器件的使用，采用 QFN-14（2mmx3mm）封装。

## 特性

- 宽输入电压范围：
  - 2.85V 至 16V，外部 3.3V VCC 偏置
  - 4V 至 16V，内部 VCC 偏置或外部 3.3V VCC 偏置
- 6A 输出电流
- 可编程精确电流限电平
- 低导通阻抗集成功率 MOSFET
- 专有开关损耗降低技术
- 用于超速瞬态响应的自适应恒定导通时间（COT）控制
- 采用 Zero ESR 输出电容可稳定工作
- 0°C 至 +70°C 结温范围内的参考电压精确度为 0.5%
- -40°C 至 +125°C 结温范围内的参考电压精确度为 1%
- 可选强制连续导通模式（FCCM）或跳频工作模式
- 极好的负载调整率
- 输出电压追踪功能
- 输出电压放电
- 断电期间 PGOOD 低电平有源钳位
- 可编程软启动时间最小为 1ms（最大）
- 预偏置启动
- 可选开关频率：600kHz、1100kHz 和 2000kHz
- 非锁定过流保护（OCP）、过压保护（OVP）、欠压保护（UVP）、过温保护（OTP）和欠压锁定保护（UVLO）
- 输出电压可调范围为 0.6V 至 0.9 x VIN，最大可达 6V
- 采用 QFN-14（2mmx3mm）封装

## 应用

- 电信和网络系统
- 服务器、云计算和存储
- 基站
- 通用负载点（PoL）应用
- 12V 配电系统
- 高端 TV
- 游戏机和图形卡

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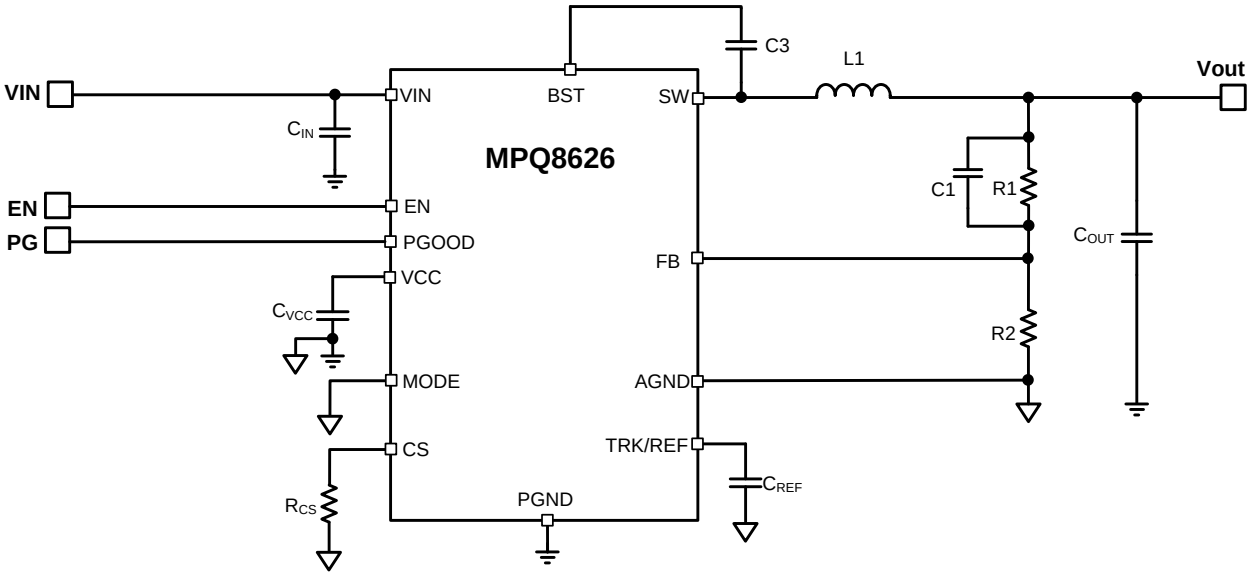
## 典型应用电路





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## ORDERING INFORMATION

| Part Number* | Package | Top Marking |
|---|---|---|
| MPQ8626GD | QFN-14 (2mmx3mm) | *See Below* |

* For Tape & Reel, add suffix –Z (e.g. MPQ8626GD–Z)

## TOP MARKING

AWR

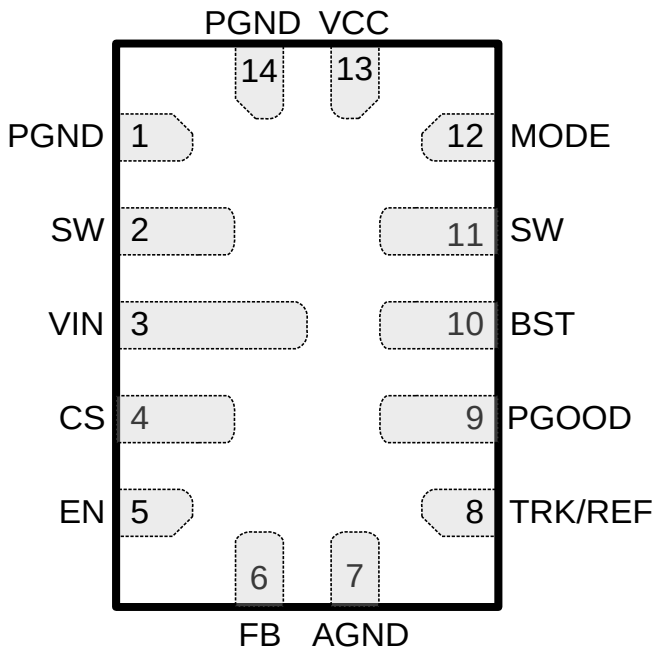
YWW

LLL

AWR: Product code of MPQ8626GD
Y: Year code
WW: Week code
LLL: Lot number

## PACKAGE REFERENCE

**TOP VIEW**




**QFN-14 (2mmx3mm)**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## ABSOLUTE MAXIMUM RATINGS (1)

Supply voltage (VIN) ..... 18V
$V_{SW}$ (DC) ..... -0.3V to VIN + 0.3V
$V_{SW}$ (25ns) (2) ..... -3V to 25V
$V_{SW}$ (25ns) ..... -5V to 25V
$V_{BST}$ ..... $V_{SW}$ + 4V
VCC, EN ..... -0.3V to 4.5V
All other pins ..... -0.3V to 4.3V
Junction temperature ..... 170°C
Lead temperature ..... 260°C
Storage temperature ..... -65°C to +170°C

## *Recommended Operating Conditions* (3)

Supply voltage (VIN) ..... 4V to 16V
$V_{IN(DC)}$ - $V_{SW(DC)}$ (4) ..... -0.3V to VIN + 0.3V
$V_{SW(DC)}$ (5) ..... -0.3V to VIN + 0.3V
Output voltage ($V_{OUT}$) ..... 0.6V to 6V
External VCC bias ($V_{CC_EXT}$) ..... 3.12V to 3.6V
Maximum output current ($I_{OUT_MAX}$) ..... 6A
Maximum output current limit ($I_{OC_MAX}$) ..... 8A
Maximum peak inductor current ($I_{L_PEAK}$) ..... 10A
EN voltage ($V_{EN}$) ..... 3.6V
Operating junction temp. ($T_J$). .. -40°C to +125°C

## *Thermal Resistance* (6) $\theta_{JB}$ $\theta_{JC_TOP}$

| | | | |
|---|---|---|---|
| QNF-14 (2mmx3mm) ..... | 6.8 ..... | 17.4 ... | °C/W |

**NOTES:**

1) Exceeding these ratings may damage the device.
2) Measured by using a differential oscilloscope probe.
3) The device is not guaranteed to function outside of its operating conditions.
4) The voltage rating can be in the range of -5V to 24V for a period of 25ns or less with a maximum repetition rate of 2MHz when the input voltage is 16V.
5) The voltage rating can be in the range of -3V to 24V for a period of 25ns or less with a maximum repetition rate of 2MHz when the input voltage is 16V.
6) $\theta_{JB}$ is the thermal resistance from the junction to the board around the PGND soldering point.
   $\theta_{JC_TOP}$ is the thermal resistance from the junction to the top of the package.


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## ELECTRICAL CHARACTERISTICS

**$V_{IN}$ = 12V, $T_J$ = -40°C to 125°C, unless otherwise noted.**

| Parameters | Symbol | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **$V_{IN}$ Supply Current** | | | | | | |
| Supply current (shutdown) | $I_{IN}$ | $V_{EN}$ = 0V | | 0 | 10 | μA |
| Supply current (quiescent) | $I_{IN}$ | $V_{EN}$ = 2V, $V_{FB}$ = 0.7V | | 650 | 850 | μA |
| **MOSFET** | | | | | | |
| Switch leakage | $SW_{LKG_HS}$ | $V_{EN}$ = 0V, $V_{SW}$ = 0V | | 0 | 10 | μA |
| | $SW_{LKG_LS}$ | $V_{EN}$ = 0V, $V_{SW}$ = 12V | | 0 | 30 | |
| HS on-state resistance | $R_{DS_ON_HS}$ | $V_{EN}$ = 2V @ 25°C | | 22.6 | | mΩ |
| LS on-state resistance | $R_{DS_ON_HS}$ | $V_{EN}$ = 2V @ 25°C | | 8.1 | | mΩ |
| **Current Limit** | | | | | | |
| Current limit threshold | $V_{LIM}$ | | 1.15 | 1.2 | 1.25 | V |
| $I_{CS}$ to $I_{OUT}$ ratio | $I_{CS}/I_{OUT}$ | $I_{OUT}$ ≥ 2A | 36 | 40 | 44 | μA/A |
| Low-side negative current limit | $I_{LIM_NEG_10}$ | | | -8 | | A |
| Negative current limit time-out (7) | $t_{NCL_Timer}$ | | | 80 | | ns |
| **Timer** | | | | | | |
| Switching frequency (8) | $f_{SW}$ | | 530 | 660 | 790 | kHz |
| | | | 935 | 1100 | 1265 | kHz |
| | | | 1870 | 2200 | 2530 | kHz |
| Minimum on time (7) | $T_{ON_MIN}$ | | | | 50 | ns |
| Minimum off time (7) | $T_{OFF_MIN}$ | $V_{FB}$ = 1000mV | | | 180 | ns |
| **Over-Voltage (OVP) and Under-Voltage Protection (UVP)** | | | | | | |
| OVP threshold | $V_{OVP}$ | | 113% | 116% | 119% | $V_{REF}$ |
| UVP threshold | $V_{UVP}$ | | 77% | 80% | 83% | $V_{REF}$ |
| **Feedback Voltage and Soft Start (SS)** | | | | | | |
| Feedback voltage | $V_{REF}$ | $T_J$ = -40°C to +125°C | 594 | 600 | 606 | mV |
| | | $T_J$ = 0°C to +70°C | 597 | 600 | 603 | mV |
| TRK/REF sourcing current | $I_{TRACK_Source}$ | $V_{TRK/REF}$ = 0V | | 15 | | μA |
| TRK/REF sinking current | $I_{TRACK_Sink}$ | $V_{TRK/REF}$ = 0.7V | | 6 | | μA |
| Soft-start time | $t_{SS}$ | $C_{TRACK}$ = 1nF | 1.6 | 2.2 | | ms |
| **Error Amplifier (EA)** | | | | | | |
| Error amplifier offset | $V_{OS}$ | | -3 | 0 | 3 | mV |
| Feedback current | $I_{FB}$ | $V_{FB}$ = REF | | 50 | 100 | nA |
| **Enable (EN)** | | | | | | |
| Enable input rising threshold | $VIH_{EN}$ | | 1.17 | 1.22 | 1.27 | V |
| Enable hysteresis | $V_{EN\text{-}HYS}$ | | | 200 | | mV |
| Enable input current | $I_{EN}$ | $V_{EN}$ = 2V | | 0 | | μA |
| Soft shutdown discharge MOSFET | $R_{ON_DISCH}$ | | | 80 | | Ω |
| **$V_{IN}$ UVLO** | | | | | | |
| $V_{IN}$ under-voltage lockout threshold rising | $VIN_{Vth\text{-}Rise}$ | VCC = 3.3V | 2.25 | 2.55 | 2.85 | V |
| $V_{IN}$ under-voltage lockout threshold falling | $VIN_{Vth\text{-}Fall}$ | | 1.7 | 2 | 2.3 | V |
| **VCC Regulator** | | | | | | |
| VCC under-voltage lockout threshold rising | $VCC_{Vth_Rise}$ | | 2.65 | 2.8 | 2.95 | V |
| VCC under-voltage lockout threshold falling | $VCC_{Vth_Fall}$ | | 2.35 | 2.5 | 2.65 | V |
| VCC output voltage | $V_{CC}$ | | 2.88 | 3.00 | 3.12 | V |
| VCC load regulation | | $I_{CC}$ = 25mA | | 0.5 | | % |


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## ELECTRICAL CHARACTERISTICS *(continued)*

**$V_{IN}$ = 12V, $T_J$ = -40°C to +125°C, unless otherwise noted.**

| Parameters | Symbol | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **Power Good (PGOOD)** | | | | | | |
| Power good high threshold | $PG_{Vth_Hi_Rise}$ | FB from low to high | 89.5% | 92.5% | 95.5% | $V_{REF}$ |
| Power good low threshold | $PG_{Vth_Lo_Rise}$ | FB from low to high | 113% | 116% | 119% | $V_{REF}$ |
| | $PG_{Vth_Lo_Fall}$ | FB from high to low | 77% | 80% | 83% | $V_{REF}$ |
| Power good low-to-high delay | $PG_{Td}$ | $T_J$ = 25°C | 0.7 | 1 | 1.3 | ms |
| Power good sink current capability | $V_{PG}$ | $I_{PG}$ = 10mA | | | 0.4 | V |
| Power good leakage current | $I_{PG_LEAK}$ | $V_{PG}$ = 3V | | | 3 | µA |
| Power good low-level output voltage | $V_{OL_100}$ | $V_{IN}$ = 0V, pull PGOOD up to 3.3V through a 100kΩ resistor | | 650 | 850 | mV |
| | $V_{OL_10}$ | $V_{IN}$ = 0V, pull PGOOD up to 3.3V through a 10kΩ resistor | | 800 | 1000 | |
| **Thermal Protection (OTP)** | | | | | | |
| OTP shutdown (7) | $T_{SD}$ | | 150 | 160 | | °C |
| OTP shutdown hysteresis (7) | $T_{SD_Hys}$ | | | 20 | | °C |

**NOTES:**

7) Specified by design and characterization, not tested in production.

8) Specified by design.


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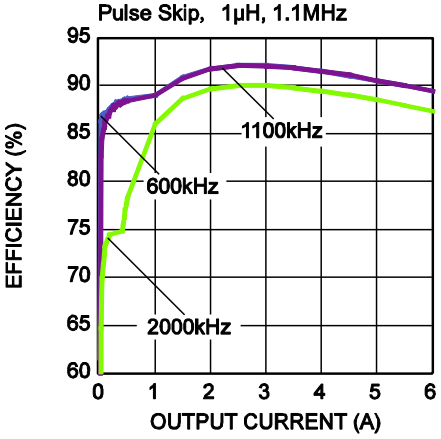
## TYPICAL PERFORMANCE CHARACTERISTICS

$V_{IN}$ = 12V, $V_{OUT}$ = 1.8V, L = 1µH, $T_A$ = +25°C, unless otherwise noted.

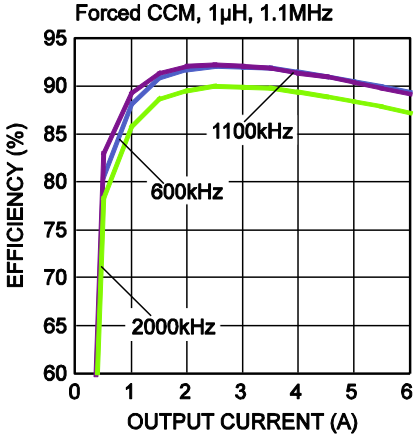
**Efficiency (12$V_{IN}$ to 1.8$V_{OUT}$)**

Pulse Skip, 1µH, 1.1MHz

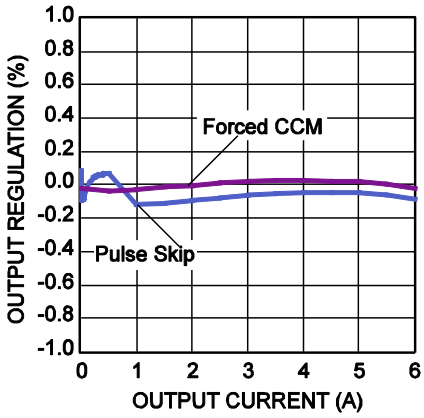



**Efficiency (12$V_{IN}$ to 1.8$V_{OUT}$)**

Forced CCM, 1µH, 1.1MHz

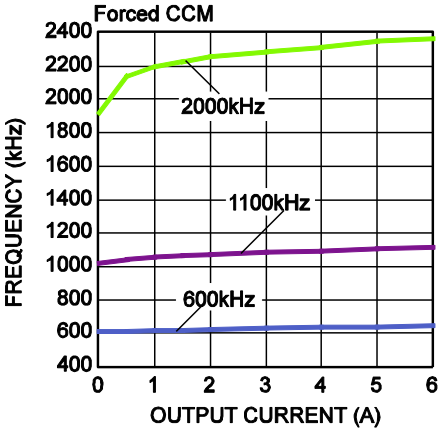



**Load Regulation**



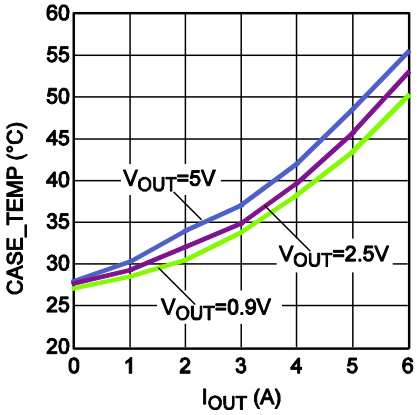

**Switching Frequency vs. Output Current**

Forced CCM



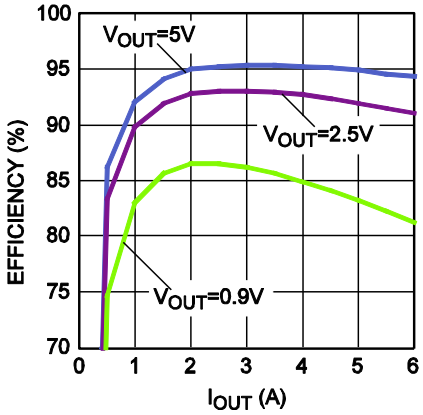

**Thermal Results**

1.1MHz, No air-flow



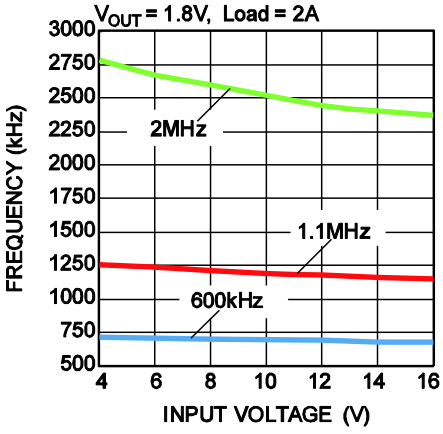

**Efficiency**

1.1MHz



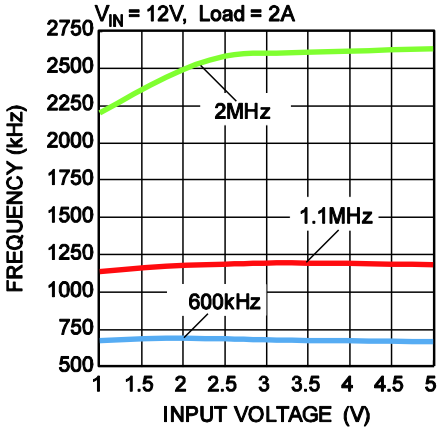

**Switching Frequency vs. Input Voltage**

$V_{OUT}$ = 1.8V, Load = 2A




**Switching Frequency vs. Output Voltage**

$V_{IN}$ = 12V, Load = 2A





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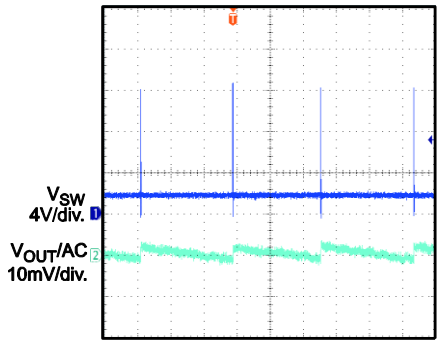
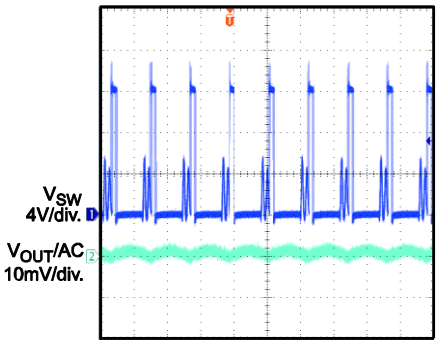
## TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

**$V_{IN}$ = 12V, $V_{OUT}$ = 1.8V, L = 1µH, $T_A$ = +25°C, unless otherwise noted.**

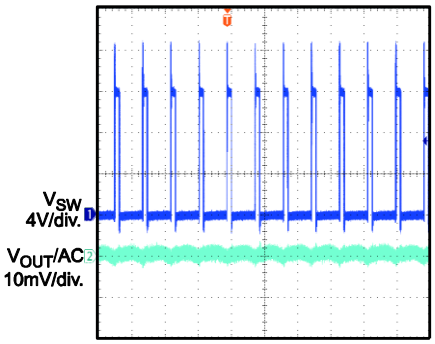
**Steady State**
$I_{OUT}$= 0A, Pulse Skip



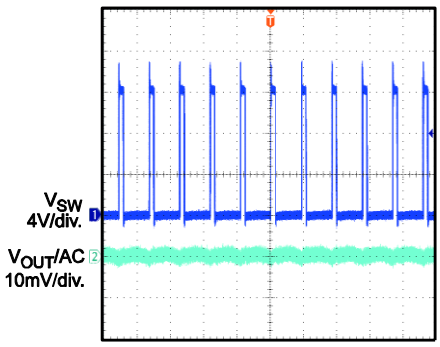

**Steady State**
$I_{OUT}$ = 0.5A, Pulse Skip



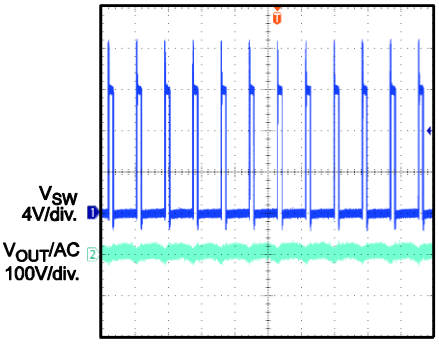

**Steady State**
$I_{OUT}$ = 6A, Pulse Skip



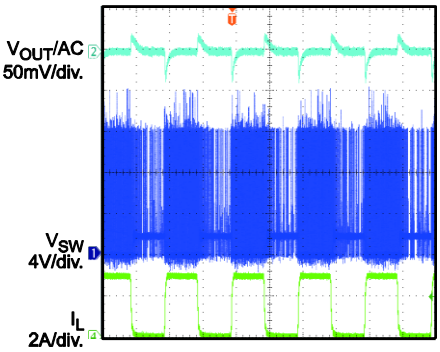

**Steady State**
$I_{OUT}$ = 0A, Forced CCM



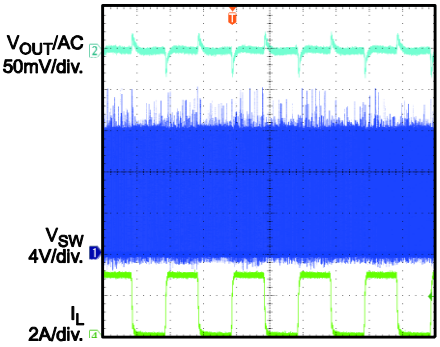

**Steady State**
$I_{OUT}$ = 6A, Forced CCM



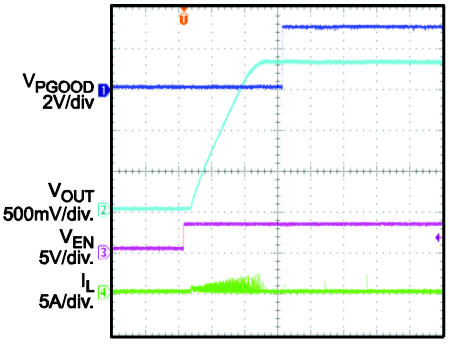

**Load Transient**
$I_{OUT}$ = 0A-3A, Pulse Skip



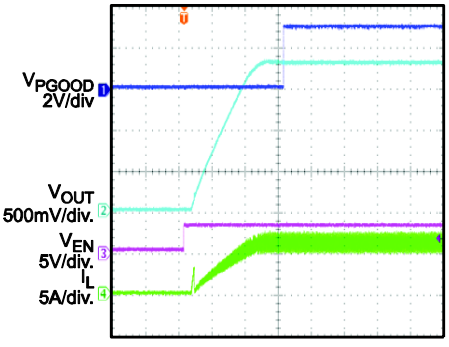

**Load Transient**
$I_{OUT}$ = 0A-3A, Forced CCM




**Power-Up through EN**
$I_{OUT}$= 0A, Pulse Skip




**Power-Up through EN**
$I_{OUT}$= 6A, Pulse Skip





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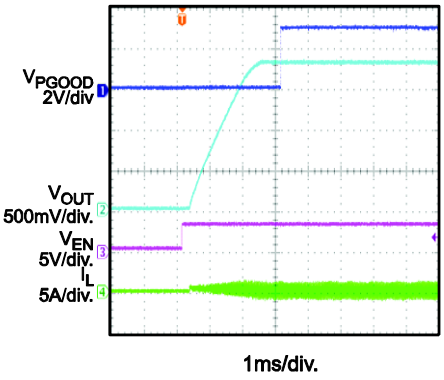
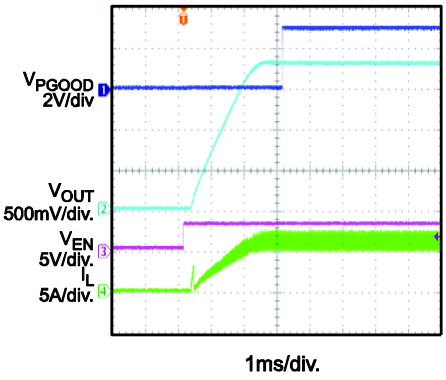
## TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

**$V_{IN}$ = 12V, $V_{OUT}$ = 1.8V, L = 1µH, $T_A$ = +25°C, unless otherwise noted.**

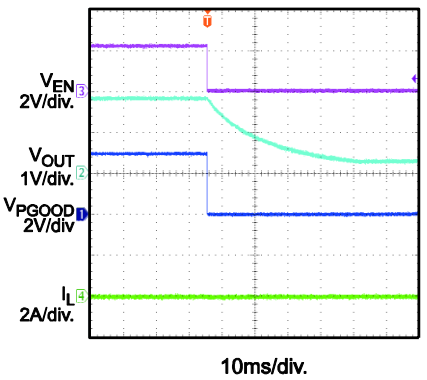
**Power-Up through EN**
$I_{OUT}$ = 0A, Forced CCM



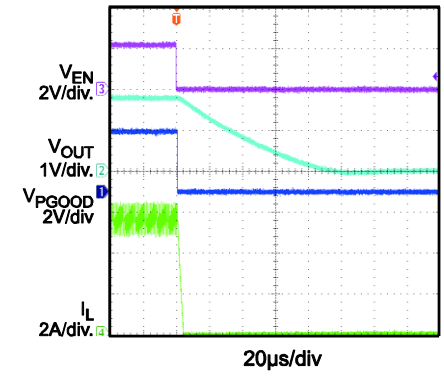

**Power-Up through EN**
$I_{OUT}$ = 6A, Forced CCM



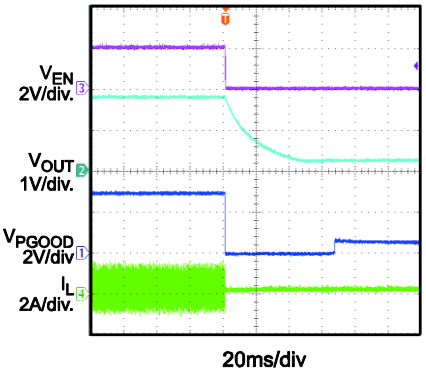

**Power-Down through EN**
$I_{OUT}$ = 0A, Pulse Skip



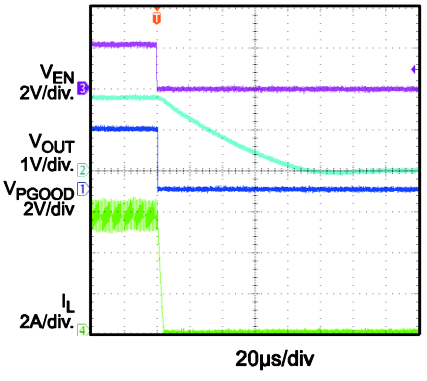

**Power-Down through EN**
$I_{OUT}$ = 6A, Pulse Skip



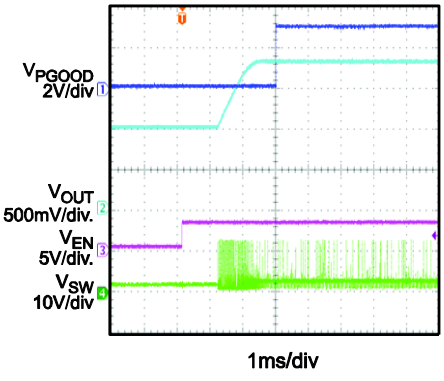

**Power-Down through EN**
$I_{OUT}$ = 0A, Forced CCM



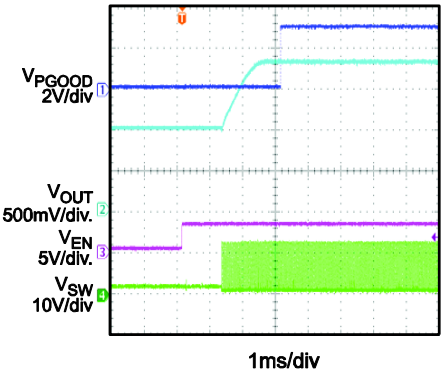

**Power-Down through EN**
$I_{OUT}$ = 6A, Forced CCM



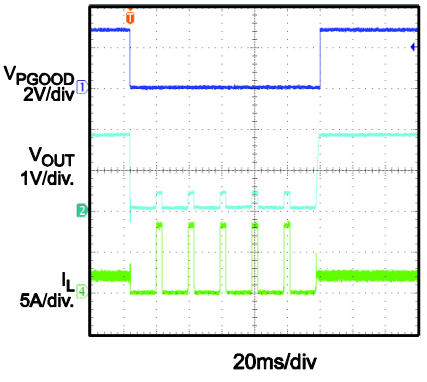

**Pre-Bias Start-Up**
Pulse Skip




**Pre-Bias Start-Up**
Forced CCM




**Over-Current Protection**





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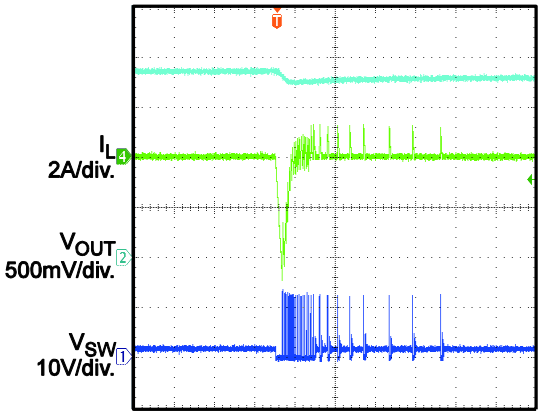
## TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

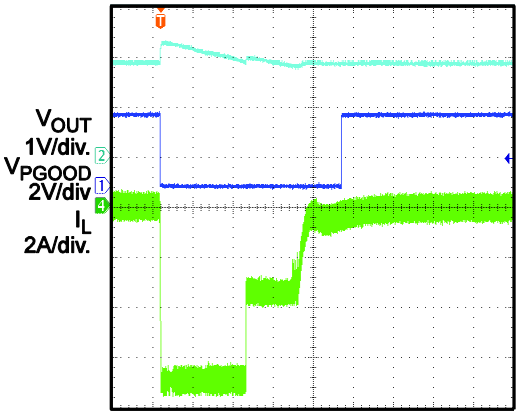
**$V_{IN}$ = 12V, $V_{OUT}$ = 1.8V, L = 1µH, $T_A$ = +25°C, unless otherwise noted.**

### OSM Operation

Pulse Skip Mode




### Over-Voltage Protection





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## PIN FUNCTIONS

| PIN # | Name | Description |
|---|---|---|
| 1, 14 | PGND | **System ground.** PGND is the reference ground of the regulated output voltage. PGND requires careful consideration during PCB layout. Connect PGND using wide PCB traces. |
| 2, 11 | SW | **Switch output.** Connect SW to the inductor and bootstrap capacitor. SW is driven up to VIN by the high-side switch during the on-time of the PWM duty cycle. The inductor current drives SW low during the off-time. Connect SW using wide PCB traces. |
| 3 | VIN | **Input voltage.** VIN supplies power to the internal MOSFET and regulator. Input capacitors are needed to decouple the input rail. Connect VIN using wide PCB traces. |
| 4 | CS | **Current limit.** Connect a resistor from CS to ground to set the current limit trip point. See Table 2 for additional details. |
| 5 | EN | **Enable.** EN is an input signal that turns the regulator on or off. Drive EN high to turn on the regulator; drive EN low to turn off the regulator. Connect EN to VIN through a pull-up resistor or a resistive voltage divider for automatic start-up. Do not float EN. |
| 6 | FB | **Feedback.** An external resistor divider from the output to AGND tapped to FB sets the output voltage. It is recommended to place the resistor divider as close to FB as possible. Vias should be avoided on the FB traces. |
| 7 | AGND | **Analog ground.** Select AGND as the control circuit reference point. |
| 8 | TRK/REF | **External tracking voltage input.** The output voltage tracks this input signal. Decouple TRK/REF with a ceramic capacitor placed as close to it as possible. Ceramic capacitors with X7R or X5R grade dielectrics are recommended for their stable temperature characteristics. The capacitance of this capacitor determines the soft-start time. See Equation 2 and 3 for additional details. |
| 9 | PGOOD | **Power good output.** PGOOD is an open-drain signal. A pull-up resistor connected to a DC voltage is required to indicate a logic high signal if the output voltage is within regulation. There is a delay of about 1ms from the time FB is greater than or equal to 92.5% and PGOOD pulling high. |
| 10 | BST | **Bootstrap.** Connect a capacitor between SW and BS to form a floating supply across the high-side switch driver. |
| 12 | MODE | **Operation mode selection.** Program MODE to select CCM, pulse-skip mode, or the operating switching frequency. See Table 1 for additional details. |
| 13 | VCC | **Internal 3V LDO output.** The driver and control circuits are powered from VCC. Decouple VCC with a minimum 1µF ceramic capacitor as close to it as possible. Ceramic capacitors with X7R or X5R grade dielectrics are recommended for their stable temperature characteristics. |


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## BLOCK DIAGRAM

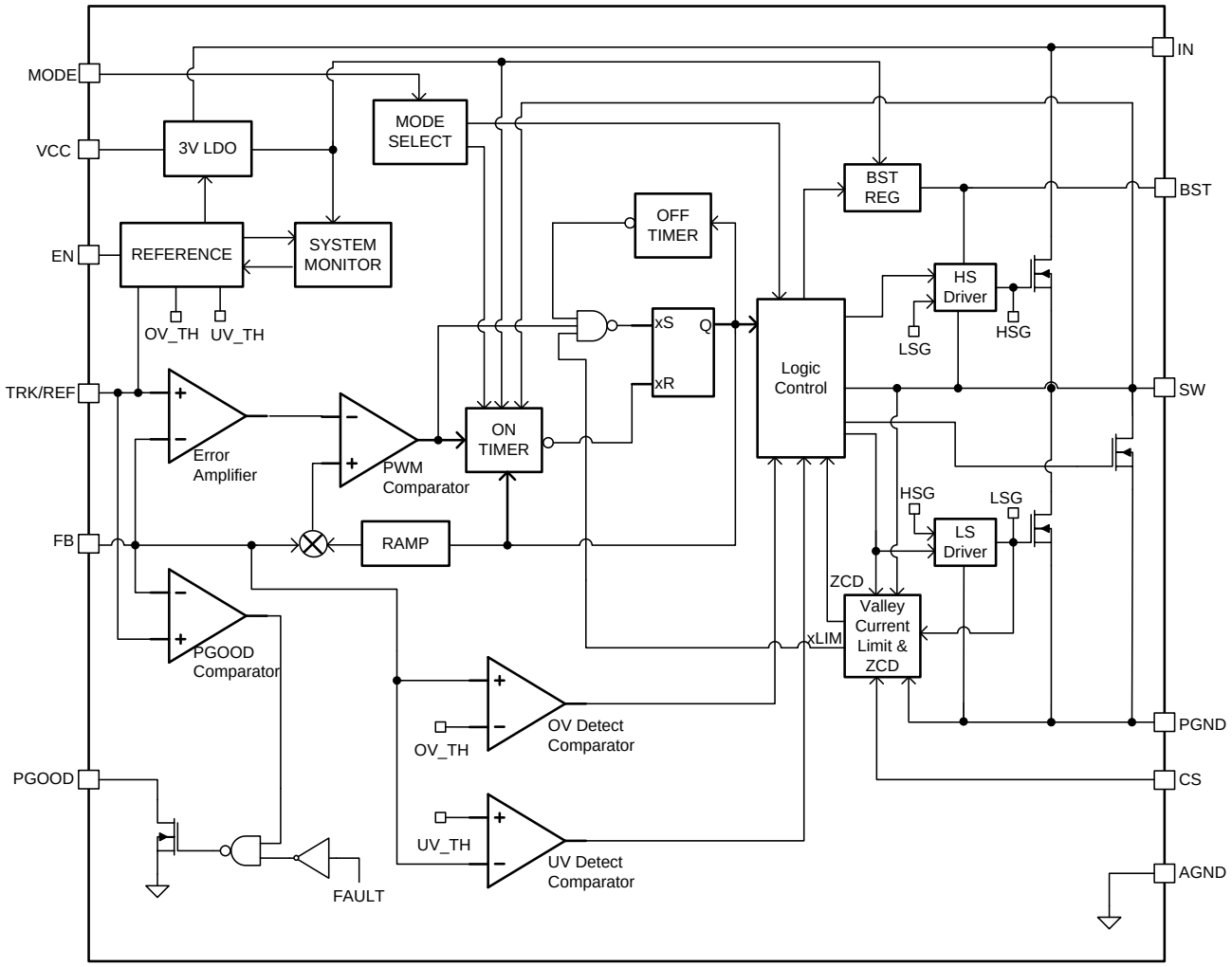


**Figure 1: Functional Block Diagram**


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# OPERATION

## Constant-On-Time (COT) Control

The MPQ8626 employs constant-on-time (COT) control to achieve fast load transient response. Figure 2 shows the details of the control stage of the MPQ8626.

The operational amplifier (AMP) corrects any error voltage between FB and REF. The MPQ8626 can use AMP to provide excellent load regulation over the entire load range, whether it is operating in forced continuous conduction mode (CCM) or pulse-skip mode.

The MPQ8626 has internal ramp compensation to support low ESR MLCC output capacitor solutions. The adaptive internal ramp is optimized so that the MPQ8626 is stable in the entire operating input/output voltage range with a proper design of the output L/C filter.

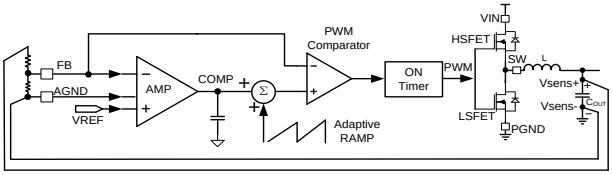


**Figure 2: COT Control**

## Pulse-Width Modulation (PWM) Operation

Figure 3 shows how the pulse-width modulation (PWM) signal is generated. AMP corrects any error between FB and REF and generates a fairly smooth DC voltage (COMP). The internal ramp is superimposed onto COMP. The superimposed COMP is compared with the FB signal. Whenever FB drops below the superimposed COMP, the integrated high-side MOSFET (HS-FET) is turned on and remains on for a fixed turn-on time. The fixed on time is determined by the input voltage, output voltage, and selected switching frequency. After the on period elapses, the HS-FET turns off. The HS-FET turns on again when FB drops below the superimposed COMP. By repeating this operation, the MPQ8626 regulates the output voltage. The integrated low-side MOSFET (LS-FET) turns on when the HS-FET is in its off state to minimize conduction loss.

A dead short occurs between VIN and PGND if both the HS-FET and the LS-FET are turned on at the same time. This is called a shoot-through. To avoid shoot-through, a dead time (DT) is generated internally between the HS-FET off and the LS-FET on period or the LS-FET off and the HS-FET on period.

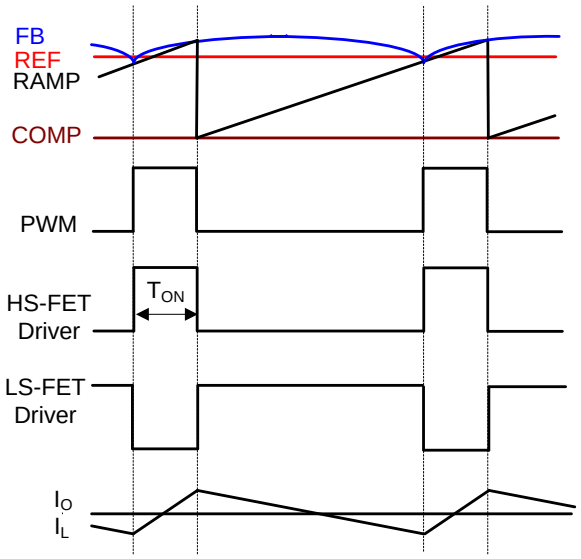


**Figure 3: Heavy-Load Operation (PWM)**

## Continuous Conduction Mode (CCM) Operation

Continuous conduction mode (CCM) occurs when the output current is high and the inductor current is always above zero amps (see Figure 3). The MPQ8626 can also be configured to operate in forced CCM operation when the output current is low. See the MODE Selection section on page 14 for details.

In CCM operation, the switching frequency is fairly constant (PWM mode), so the output ripple remains almost constant throughout the entire load range.

## Pulse-Skip Operation (PSM)

At light-load condition, the MPQ8626 can be configured to work in pulse-skip mode (PSM) to optimize efficiency. When the load decreases, the inductor current decreases as well. Once the inductor current reaches zero, the MPQ8626 transitions from CCM to PSM if the MPQ8626 is configured in this way. See the MODE Selection section on page 14 for details.


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Figure 4 shows PSM operation at light-load condition. When FB drops below the superimposed COMP, the HS-FET turns on for a fixed interval. When the HS-FET turns off, the LS-FET turns on until the inductor current reaches zero. In PSM operation, FB does not reach the superimposed COMP when the inductor current approaches zero. The LS-FET driver turns into tri-state (Hi-Z) when the inductor current reaches zero. A current modulator takes over the control of the LS-FET and limits the inductor current to less than -1mA. Therefore, the output capacitors discharge slowly to PGND through the LS-FET. In light-load condition, the HS-FET is not turned on as frequently in PSM as it is in forced CCM. As a result, the efficiency in PSM is improved greatly compared to that in forced CCM operation.

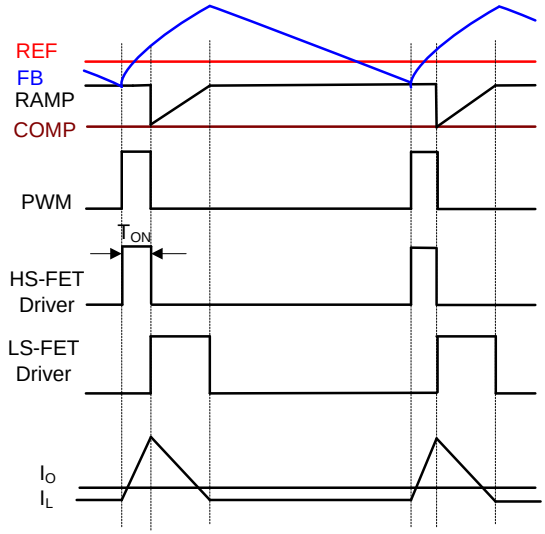


**Figure 4: Pulse Skip in Light Load**

As the output current increases from light-load condition, the current modulator regulation time period becomes shorter. The HS-FET is turned on more frequently, and the switching frequency increases accordingly. The output current reaches critical levels when the current modulator time is zero. The critical level of the output current can be determined with Equation (1):

$$I_{OUT} = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{2 \times L \times F_{SW} \times V_{IN}} \quad (1)$$

Where $F_{SW}$ is the switching frequency.

The MPQ8626 enters PWM mode once the output current exceeds the critical level. Afterward, the switching frequency remains fairly constant over the output current range.

The MPQ8626 can be configured to operate in forced CCM, even in light-load condition (see Table 1).

## MODE Selection

The MPQ8626 provides both forced CCM operation and pulse-skip operation in light-load condition. The MPQ8626 has three options for switching frequency: 600kHz, 1100kHz, and 2000kHz. Selecting the operation mode under light-load condition and the switching frequency is done by choosing the resistance value of the resistor connected between MODE and AGND or VCC (see Table 1).

**Table 1: MODE Selection**

| MODE | Light-Load Mode | Switching Frequency |
|---|---|---|
| AGND | Forced CCM | 1100kHz |
| 30.1kΩ (±20%) to AGND | Forced CCM | 2000kHz |
| 60.4kΩ (±20%) to AGND | Forced CCM | 600kHz |
| 121kΩ (±20%) to AGND | Pulse skip | 600kHz |
| 243kΩ (±20%) to AGND | Pulse skip | 2000kHz |
| VCC | Pulse skip | 1100kHz |

## Soft Start (SS)

The minimum soft-start time is limited to 1ms. This can be increased by choosing the capacitance between TRK/REF and AGND. A minimum value of 3.3nF for this capacitor is always required to stabilize the reference voltage.

The capacitance of this capacitor can be determined with Equation (2) and Equation (3):

$$C_{REF}(nF) = 3.3 \sim 33 \quad (t_{SS} = 2.2ms) \quad (2)$$

$$C_{REF}(nF) = \frac{t_{ss}(ms) \times 10\mu A}{0.6V} \quad (t_{SS} > 2.2ms) \quad (3)$$


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### Output Voltage Tracking and Reference

The MPQ8626 provides an analog input pin (TRK/REF) to track another power supply or accept an external reference voltage ($V_{REF}$). When an external voltage signal is connected to TRK/REF, it acts as a reference for the MPQ8626 output voltage. The FB voltage ($V_{FB}$) follows this external voltage signal exactly, and the soft-start settings are ignored. The TRK/REF input signal can be in the range of 0.3V to 1.4V. During the initial start-up, the TRK/REF must reach 600mV or above first to ensure proper operation. Afterward, TRK/REF can be set to any value between 0.3V and 1.4V.

### Pre-Bias Start-Up

The MPQ8626 has been designed for monotonic start-up into pre-biased loads. If the output is pre-biased to a certain voltage during start-up, the IC disables switching for both the HS-FET and LS-FET until the voltage on the TRK/REF capacitor exceeds the sensed output $V_{FB}$. Before the TRK/REF voltage reaches the pre-biased FB level, if the BST voltage (from BST to SW) is lower than 2.3V, the LS-FET is turned on to allow the BST voltage to be charged through VCC. The LS-FET is turned on for very narrow pulses, so the drop in the pre-biased level is negligible.

### Output Voltage Discharge

When the MPQ8626 is disabled through EN, the output voltage discharge mode is enabled. This causes both the HS-FET and the LS-FET to latch off. A discharge MOSFET connected between SW and PGND is turned on to discharge the output voltage. The typical switch on resistance of this MOSFET is about 80Ω. Once $V_{FB}$ drops below 10% * REF, the discharge MOSFET turns off.

### Current Sense and Over-Current Protection (OCP)

The MPQ8626 features an on-die current sense and a programmable positive current limit threshold. The current limit is active when the MPQ8626 is enabled. During the LS-FET on state, the SW current (inductor current) is sensed and mirrored to CS with the ratio of $G_{CS}$. By using a resistor ($R_{CS}$) from CS to AGND, the CS voltage ($V_{CS}$) is proportional to the SW current cycle-by-cycle. The HS-FET is only allowed to turn on when $V_{CS}$ is below the internal over-current protection (OCP) voltage threshold ($V_{OCP}$) during the LS-FET on state to limit the SW valley current cycle-by-cycle.

Generally, the current limit threshold setting is calculated from $R_{CS}$ with Equation (4):

$$R_{CS}(\Omega) = \frac{V_{OCP}}{G_{CS} \times (I_{LIM} - \frac{(V_{IN} - V_O) \times V_O}{V_{IN}} \times \frac{1}{2 \times L \times f_s})} \quad (4)$$

Where $V_{OCP}$ is 1.2V, $G_{CS}$ is 40μA/A, and $I_{LIM}$ is the desired output current limit.

There is some offset for the low current limit threshold setting. Refer to Table 2 for a more accurate setting.

**Table 2: Threshold Setting**

| $L_{LIM_DC}$ (A) | $R_{CS}$ (KΩ) |
|---|---|
| 8 | 3.83 |
| 7.5 | 4.02 |
| 7 | 4.32 |
| 6.5 | 4.64 |
| 6 | 4.87 |
| 5.5 | 5.49 |
| 5 | 5.9 |
| 4.5 | 6.49 |
| 4 | 7.15 |

The OCP HICCUP is active 3ms after the MPQ8626 is enabled, Once OCP HICCUP is active, if the MPQ8626 detects over-current condition for consecutive 31 cycles, or if the FB drops below under-voltage protection (UVP) threshold, it enters HICCUP mode. In HICCUP mode, the MPQ8626 latches off the HSFET immediately, and latches off LSFET after ZCD is detected. Meanwhile, the TRK/REF capacitor is also discharged. After about 14ms, the MPQ8626 will try to soft start automatically. If the over-current condition still holds after 3ms of running, the MPQ8626 repeats this operation cycle until the over-current condition disappears, and the output voltage rises smoothly back to the regulation level.

### Negative Inductor Current Limit

When the LS-FET detects a -8A current, the MPQ8626 turns off the LS-FET and turns on the HS-FET for 100ns to limit the negative current.

### Output Sinking Mode (OSM)

The MPQ8626 employs output sinking mode (OSM) to regulate the output voltage to the


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targeted value. When $V_{FB}$ is higher than 105% * REF but below the over-voltage protection (OVP) threshold, OSM is triggered. During OSM, the LS-FET remains on until it reaches the -4A negative current limit. The LS-FET is then turned off, the HS-FET is turned on momentarily for 100ns, and then the LS-FET is turned on again. The MPQ8626 repeats this operation until $V_{FB}$ drops below 102% * REF. The MPQ8626 exits OSM after 15 consecutive cycles of forced CCM.

### Over-Voltage Protection (OVP)

The MPQ8626 monitors the output voltage by connecting FB to the tap of the output voltage feedback resistor divider to detect an over-voltage condition. This provides hiccup OVP.

If $V_{FB}$ exceeds 116% of $V_{REF}$, OVP is triggered. PG is pulled low until the over-voltage (OV) condition is cleared. The LS-FET is turned on until it reaches the low-side negative current limit of -8A (NOCP). The LS-FET is then turned off momentarily for 100ns, and the HS-FET is turned on. After 100ns, the LS-FET is turned on again. The MPQ8626 continues this operation to discharge the over-voltage condition on the output. The device exits OVP discharge mode when $V_{FB}$ drops below 105% * REF. PGOOD is pulled high again a 1ms delay.

### Over-Temperature Protection (OTP)

The MPQ8626 has over-temperature protection (OTP). The MPQ8626 monitors the junction temperature internally. If the junction temperature exceeds the threshold value (typically 160°C), the converter shuts off. There is a hysteresis of about 20°C. Once the junction temperature drops to around 140°C, a new SS is initiated.

### Output Voltage Setting and Remote Output Voltage Sensing

First, choose a value for R1. Then R2 can be determined with Equation (5):

$$R_2(k\Omega) = \frac{V_{REF}}{V_O - V_{REF}} \times R_1(k\Omega) \quad (5)$$

Where $V_{REF}$ is 600mV.

To optimize the load transient response, a feed-forward capacitor ($C_{FF}$) is recommended to be added in parallel to R1. R1 and $C_{FF}$ add an extra zero to the system, which improves loop response. R1 and $C_{FF}$ are selected so that the zero formed by R1 and $C_{FF}$ is located around 20 ~ 60kHz. $f_Z$ can be determined with Equation (6):

$$f_Z = \frac{1}{2\pi \times R1 \times C_{FF}} \quad (6)$$

### Power Good (PGOOD)

The MPQ8626 has a power good (PGOOD) output. PGOOD is the open drain of a MOSFET. Connect PGOOD to VCC or another external voltage source less than 3.6V through a pull-up resistor (typically 10kΩ). After applying the input voltage, the MOSFET turns on, so PGOOD is pulled to GND before TRK/REF is ready. After $V_{FB}$ reaches 92.5% of $V_{REF}$, PGOOD is pulled high after a 0.8ms delay.

When $V_{FB}$ drops to 80% of $V_{REF}$ or exceeds 116% of the nominal $V_{REF}$, PGOOD is latched low. PGOOD can be pulled high again only after a new SS.

If the input supply fails to power the MPQ8626, PGOOD is clamped low, even though PGOOD is tied to an external DC source through a pull-up resistor. The relationship between the PGOOD voltage and the pull-up current is shown in Figure 5.

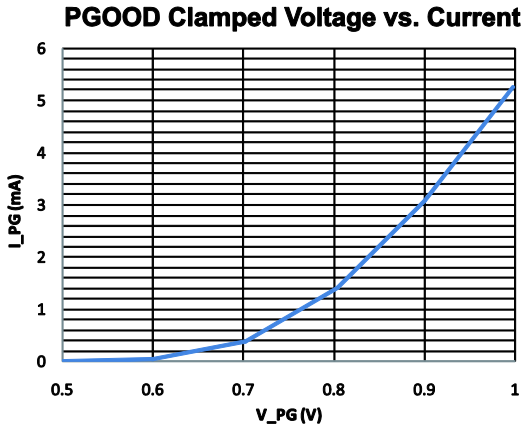


**Figure 5: PGOOD Clamped Voltage vs. Pull-Up Current**

### Enable (EN) Configuration

The MPQ8626 turns on when EN goes high and turns off when EN goes low. EN cannot be left floating for proper operation. EN can be driven by an analog or digital control logic signal to enable or disable the MPQ8626.


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The MPQ8626 provides accurate EN thresholds, so a resistor divider (R3/R4 in Figure 2) from VIN to AGND can be used to program the input voltage at which the MPQ8626 is enabled. This is highly recommended for applications where there is no dedicated EN control logic signal to avoid possible under-voltage lockout (UVLO) bouncing during power-up and power-down. The resistor divider values can be determined with Equation (7):

$$V_{IN_START}(V) = VIH_{EN} \times \frac{R_{UP} + R_{DOWN}}{R_{DOWN}} \quad (7)$$

Where $VIH_{EN}$ is 1.22V, typically.

$R_{UP}$ and $R_{DOWN}$ should be chosen so that $V_{EN}$ does not exceed 3.6V when VIN reaches the maximum value.

EN can also be connected to VIN directly through a pull-up resistor ($R_{UP}$). $R_{UP}$ should be chosen so that the maximum current going to EN is 50μA. $R_{UP}$ can be calculated with Equation (8):

$$R_{UP}(k\Omega) = \frac{VIN_{MAX}(V)}{0.05(mA)} \quad (8)$$


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# APPLICATION INFORMATION

### Input Capacitor

The input current to the step-down converter is discontinuous and therefore requires a capacitor to supply AC current to the step-down converter while maintaining the DC input voltage. Use ceramic capacitors for the best performance. During layout, place the input capacitors as close to VIN as possible.

The capacitance can vary significantly with the temperature. Capacitors with X5R and X7R ceramic dielectrics are recommended because they are fairly stable over a wide temperature range. The capacitors must have a ripple current rating that exceeds the converter's maximum input ripple current. Estimate the input ripple current with Equation (9):

$$I_{CIN} = I_{OUT} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times (1 - \frac{V_{OUT}}{V_{IN}})} \quad (9)$$

The worst-case condition occurs at VIN = $2V_{OUT}$, shown in Equation (10):

$$I_{CIN} = \frac{I_{OUT}}{2} \quad (10)$$

For simplification, choose an input capacitor with an RMS current rating that exceeds half the maximum load current.

The input capacitance value determines the converter input voltage ripple. Select a capacitor value that meets any input voltage ripple requirement.

Estimate the input voltage ripple with Equation (11):

$$\Delta V_{IN} = \frac{I_{OUT}}{F_{SW} \times C_{IN}} \times \frac{V_{OUT}}{V_{IN}} \times (1 - \frac{V_{OUT}}{V_{IN}}) \quad (11)$$

The worst-case condition occurs at VIN = $2V_{OUT}$, shown in Equation (12):

$$\Delta V_{IN} = \frac{1}{4} \times \frac{I_{OUT}}{F_{SW} \times C_{IN}} \quad (12)$$

### Output Capacitor

The output capacitor maintains the DC output voltage. Use ceramic capacitors or POSCAPs. Estimate the output voltage ripple with Equation (13):

$$\Delta V_{OUT} = \frac{V_{OUT}}{F_{SW} \times L} \times (1 - \frac{V_{OUT}}{V_{IN}}) \times (R_{ESR} + \frac{1}{8 \times F_{SW} \times C_{OUT}}) \quad (13)$$

When using ceramic capacitors, the capacitance dominates the impedance at the switching frequency. The capacitance also dominates the output voltage ripple. For simplification, estimate the output voltage ripple with Equation (14):

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times F_{SW}^{2} \times L \times C_{OUT}} \times (1 - \frac{V_{OUT}}{V_{IN}}) \quad (14)$$

The ESR dominates the switching frequency impedance for POSCAPs. For simplification, the output ripple can be approximated with Equation (15):

$$\Delta V_{OUT} = \frac{V_{OUT}}{F_{SW} \times L} \times (1 - \frac{V_{OUT}}{V_{IN}}) \times R_{ESR} \quad (15)$$

### Inductor

The inductor supplies a constant current to the output load while being driven by the switching input voltage. A larger value inductor results in less ripple current and lower output ripple voltage, but also has a larger physical size, a higher series resistance, and a lower saturation current. Generally, select an inductor value that allows the inductor peak-to-peak ripple current to be 30% to 40% of the maximum switch current limit. Also design for a peak inductor current that is below the maximum switch current limit. Calculate the inductance value with Equation (16):

$$L = \frac{V_{OUT}}{F_{SW} \times \Delta I_{L}} \times (1 - \frac{V_{OUT}}{V_{IN}}) \quad (16)$$

Where $\Delta I_L$ is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum inductor peak current. The peak inductor current can be calculated with Equation (17):

$$I_{LP} = I_{OUT} + \frac{V_{OUT}}{2 \times F_{SW} \times L} \times (1 - \frac{V_{OUT}}{V_{IN}}) \quad (17)$$


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## PCB Layout Guidelines

Efficient PCB layout is critical for stable operation. For the best performance, refer to Figure 7 and follow the guidelines below.

1. Place the input MLCC capacitors as close to VIN and PGND as possible.
2. Place the major MLCC capacitors on the same layer as the MPQ8626.
3. Maximize the VIN and PGND copper plane to minimize parasitic impedance.
4. Place as many PGND vias as possible as close to PGND as possible to minimize both parasitic impedance and thermal resistance.
5. Place the VCC decoupling capacitor close to the device.
6. Connect AGND and PGND at the point of the VCC capacitor's ground connection.
7. Place the BST capacitor as close to BST and SW as possible.
8. Use traces with a width of 20mil or wider to route the path.
9. Use a 0.1μF to 1μF bootstrap capacitor.
10. Place the REF capacitor close to TRK/REF to AGND.

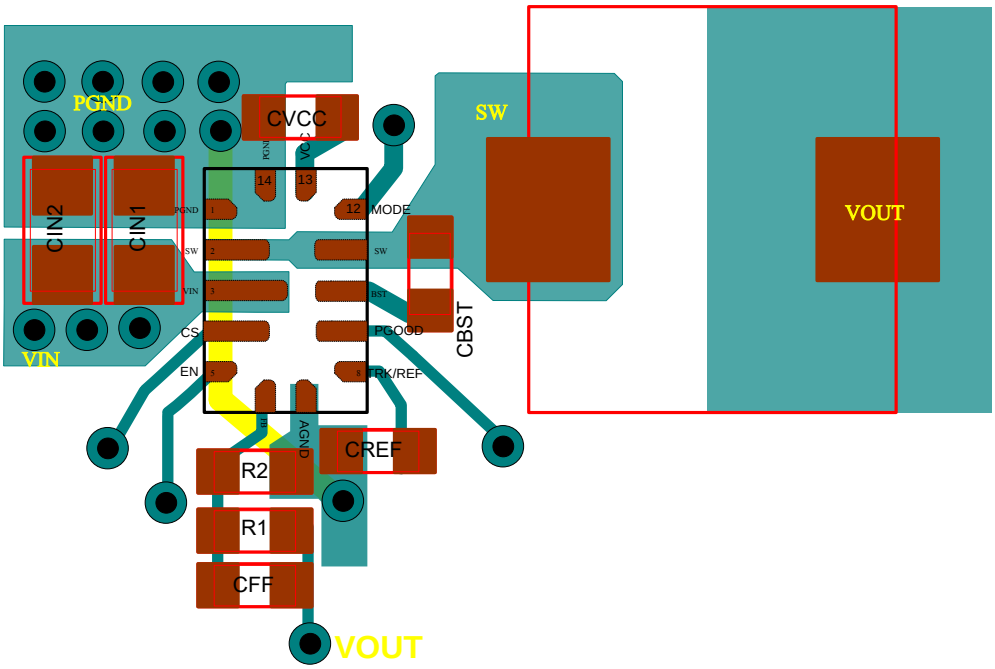


**Figure 7: Example of PCB Layout (Placement & Top Layer PCB)**

**NOTE:** Via size is 20/10mils.


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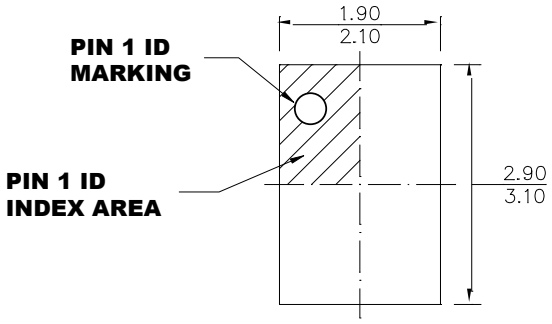
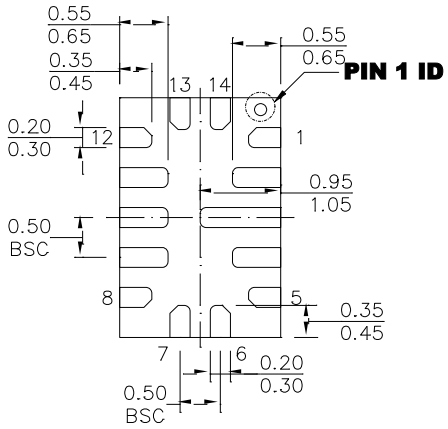
# PACKAGE INFORMATION

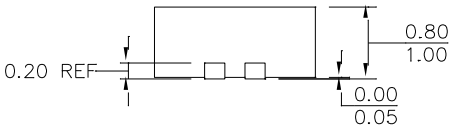
## QFN-14 (2mmx3mm)



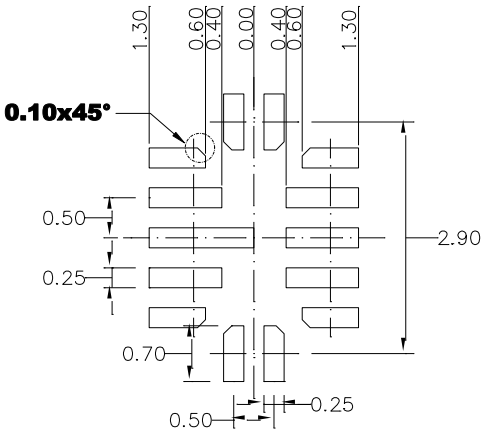

**TOP VIEW**




**BOTTOM VIEW**




**SIDE VIEW**




**RECOMMENDED LAND PATTERN**

## NOTE:

**1) LAND PATTERNS OF PIN1,5,8 AND PIN12 HAVE THE SAME SHAPE.**
**2) LAND PATTERNS OF PIN2,4,9,10 AND PIN11 HAVE THE SAME SHAPE.**
**3) ALL DIMENSIONS ARE IN MILLIMETERS.**
**3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETERS MAX.**
**4) JEDEC REFERENCE IS MO-220.**
**5) DRAWING IS NOT TO SCALE.**

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