DESCRIPTION
The MP9488 is a 7.5V to 450V, wide input, 300mA, step-down converter. The MP9488 is typically used in buck topology, but it can also support buck boost, boost, and flyback topology applications, even if the power supply range is very wide.

The MP9488 employs peak-current and variable-off-time control modes to regulate the output voltage. It integrates a high-voltage start-up circuit and one 500V MOSFET. The very simple structure helps achieve low cost and high input voltage. In light-load condition, the MP9488 peak current and switching frequency decrease as the load decreases, achieving high efficiency. This makes the MP9488 ideal for scooters, E-bikes, and other civil applications.

Full protection features include thermal shutdown, VCC under-voltage lockout (UVLO), overload protection (OLP), short-circuit protection (SCP), and open-loop protection.

The MP9488 is available in a SOIC-8 package.

FEATURES
- 7.5V to 450V Wide Input Range
- Integrated 500V MOSFET
- >500mA Switching Current Limit
- Peak-Current and Variable Off-Time Control
- Low VCC Operating Current
- Frequency Foldback
- Limited Maximum Frequency
- Peak Current Compression in Light Load
- Internal High-Voltage Current Source
- Thermal Shutdown (Auto-Restart)
- VCC Under-Voltage Lockout (UVLO) with Hysteresis
- Timer-Based Overload Protection (OLP)
- Short-Circuit Protection (SCP)
- Open-Loop Protection

APPLICATIONS
- Scooter and E-Bike Control Power Supplies
- Solar Energy Systems
- Automotive System Power
- Industrial Power Supplies

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TYPICAL APPLICATION

[Diagram of typical application]

[Graph showing efficiency vs. output current]
MP9488 – 450V, 300MA, WIDE INPUT, STEP-DOWN REGULATOR

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number*</th>
<th>Package</th>
<th>Top Marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP9488GS</td>
<td>SOIC-8</td>
<td>See Below</td>
</tr>
</tbody>
</table>

* For Tape & Reel, add suffix –Z (e.g. MP9488GS–Z)

TOP MARKING

MP9488
LLLLLLLLL
MPSYWW

MP9488: Part number
LLLLLLLL: Lot number
MPS: MPS prefix
Y: Year code
WW: Week code

PACKAGE REFERENCE

ABSOLUTE MAXIMUM RATINGS (1)

- VIN to SW: -0.3V to 500V
- All other pins to SW: -0.3V to 6.5V
- Continuous power dissipation: \( T_A = +25^\circ C \) (2)
- Junction temperature: \(-150^\circ C \) to \( +125^\circ C \)
- Lead temperature: \( +260^\circ C \)
- Storage temperature: \(-65^\circ C \) to \(+150^\circ C \)

Recommended Operating Conditions (3)

- Supply VIN to SW: 7.5V to 450V
- Operating VCC range: 4.45V to 4.6V (4)
- Operating junction temp. \( (T_J) \): \(-40^\circ C \) to \(+125^\circ C \)

Thermal Resistance (5)

\( \theta_{JA} \quad \theta_{JC} \)

SOIC-8: \( 96 \ldots 45 \ldots^\circ C/W \)

NOTES:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature \( T_J \), \( (MAX) \), the junction-to-ambient thermal resistance \( \theta_{JA} \), and the ambient temperature \( T_A \). The maximum allowable continuous power dissipation at any ambient temperature is calculated by \( P_D (MAX) = (T_J (MAX) - T_A) / \theta_{JA} \). Exceeding the maximum allowable power dissipation produces an excessive die temperature, causing the regulator to go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.

4) See the Start-Up and Under-Voltage Lockout section on page 10 for more detail.

5) Measured on JESD51-7, 4-layer PCB.
### ELECTRICAL CHARACTERISTICS

VCC = 5V, TA = 25°C, unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
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<tbody>
<tr>
<td><strong>Start-Up Current Source (VIN)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Internal regulator supply current</td>
<td>I_{regulator}</td>
<td>VCC = 4V, VIN = 100V</td>
<td>2.5</td>
<td>3.5</td>
<td>5.5</td>
<td>mA</td>
</tr>
<tr>
<td>Leakage current from VIN</td>
<td>I_{Leak}</td>
<td>VCC = 5V, VIN = 400V</td>
<td>10</td>
<td>25</td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Break-down voltage between VIN and SW</td>
<td>V_{(BR)DSS}</td>
<td></td>
<td>500</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td><strong>Supply Voltage Management (VCC)</strong></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>VCC increasing level at which the internal regulator stops</td>
<td>VCC^{OFF}</td>
<td></td>
<td>4.5</td>
<td>4.6</td>
<td>4.9</td>
<td>V</td>
</tr>
<tr>
<td>VCC decreasing level at which the internal regulator turns on</td>
<td>VCC^{ON}</td>
<td></td>
<td>4.3</td>
<td>4.45</td>
<td>4.7</td>
<td>V</td>
</tr>
<tr>
<td>VCC regulator on and off hysteresis</td>
<td></td>
<td></td>
<td>230</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>VCC decreasing level at which the IC stops working</td>
<td>VCC^{stop}</td>
<td></td>
<td>3.2</td>
<td>3.35</td>
<td>3.5</td>
<td>V</td>
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<tr>
<td>VCC decreasing level at which the protection phase ends</td>
<td>VCC^{pro}</td>
<td></td>
<td>2.05</td>
<td>2.35</td>
<td>2.65</td>
<td>V</td>
</tr>
<tr>
<td>Internal IC consumption</td>
<td>I_{CC}</td>
<td>VCC = 4.6V, FS = 45kHz, duty = 40%</td>
<td>500</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>Internal IC consumption (no switch)</td>
<td>I_{CC}</td>
<td>VCC = 4.6V</td>
<td>165</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>VCC discharge current during protection</td>
<td></td>
<td>VCC = 5V</td>
<td>16</td>
<td></td>
<td></td>
<td>μA</td>
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<tr>
<td><strong>Internal MOSFET (VIN)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break-down voltage</td>
<td>V_{BRDSS}</td>
<td></td>
<td>500</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>On-state resistance</td>
<td>R_{on}</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td>Ω</td>
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<tr>
<td><strong>Internal Current Sense</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak current limit</td>
<td>I_{Limit}</td>
<td></td>
<td>500</td>
<td>640</td>
<td>780</td>
<td>mA</td>
</tr>
<tr>
<td>Leading edge blanking</td>
<td>T_{LEB1}</td>
<td></td>
<td>400</td>
<td></td>
<td></td>
<td>ns</td>
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<tr>
<td>SCP point</td>
<td>I_{SCP}</td>
<td></td>
<td>900</td>
<td>1200</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Leading edge blanking for SCP (6)</td>
<td>T_{LEB2}</td>
<td></td>
<td>180</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td><strong>Feedback Input (FB)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum off time</td>
<td>T_{minoff}</td>
<td></td>
<td>10.6</td>
<td>13.1</td>
<td>15.6</td>
<td>μs</td>
</tr>
<tr>
<td>Feedback threshold to turn on the primary MOSFET</td>
<td>V_{FB}</td>
<td></td>
<td>2.45</td>
<td>2.55</td>
<td>2.65</td>
<td>V</td>
</tr>
<tr>
<td>Feedback threshold to trigger OLP</td>
<td>V_{FB,OLP}</td>
<td></td>
<td>1.6</td>
<td>1.7</td>
<td>1.8</td>
<td>V</td>
</tr>
<tr>
<td>Overload protection delay time</td>
<td>T_{OLP}</td>
<td>FS = 37kHz</td>
<td>150</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>Open-loop detection</td>
<td>V_{OLD}</td>
<td></td>
<td>60</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td><strong>Thermal Shutdown</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shutdown threshold (6)</td>
<td></td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

**NOTE:**

6) Guaranteed by characterization.
TYPICAL CHARACTERISTICS

- **Break-Down Voltage vs. Temperature**
- **On-State Resistance vs. Temperature**
- **Feedback Threshold vs. Temperature**
- **VCC Increasing Level at Which the Internal Regulator Stops vs. Temperature**
- **VCC Decreasing Level at Which the Internal Regulator Turns On vs. Temperature**
- **VCC Decreasing Level at Which the Protection Phase Ends vs. Temperature**
- **Minimum Off Time vs. Temperature**
- **Peak Current Limit vs. Temperature**
- **SCP Point vs. Temperature**
TYPICAL PERFORMANCE CHARACTERISTICS
VIN = 60V, VOUT = 15V, IOUT = 300mA, L = 1.2mH, COUT = 100µF, TA = +25°C, unless otherwise noted.

**Efficiency**

**Load Regulation**

**Line Regulation**

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**Case Temperature Rise**

---

VIN = 60V
VIN = 300V
TYPICAL PERFORMANCE CHARACTERISTICS (continued)
VIN = 60V, VOUT = 15V, IOUT = 300mA, L = 1.2mH, COUT = 100µF, TA = +25°C, unless otherwise noted.

Steady State

Power On

Power Off

SCP Entry

SCP Steady State

SCP Recovery
TYPICAL PERFORMANCE CHARACTERISTICS (continued)
VIN = 60V, VOUT = 15V, IOUT = 300mA, L = 1.2mH, COUT = 100µF, TA = +25°C, unless otherwise noted.

Loop Opened

Loop Closed

Load Transient

IOUT = 0→0.3A
## PIN FUNCTIONS

<table>
<thead>
<tr>
<th>Pin#</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCC</td>
<td>Power supply of all control circuits.</td>
</tr>
<tr>
<td>2</td>
<td>FB</td>
<td>Feedback of the regulator.</td>
</tr>
<tr>
<td>3, 4</td>
<td>SW</td>
<td>Source of the internal power MOSFET. SW is the ground reference for VCC and FB.</td>
</tr>
<tr>
<td>5, 6, 8</td>
<td>NC</td>
<td>Not connected.</td>
</tr>
<tr>
<td>7</td>
<td>VIN</td>
<td>Drain of the internal power MOSFET. VIN is the input of the high-voltage current source.</td>
</tr>
</tbody>
</table>
BLOCK DIAGRAM

Figure 1: Functional Block Diagram
OPERATION
The MP9488 is a green-mode operation regulator. When the load decreases, the peak current and the switching frequency both decrease as well, resulting in excellent efficiency performance at light load and better average efficiency. The regulator is designed to operate with a minimum number of external components.

Start-Up and Under Voltage Lockout (UVLO)
The internal high-voltage regulator self-supplies the IC from VIN. The IC begins switching, and the internal high-voltage regulator turns off once the voltage on VCC reaches VCC_OFF (typically 4.6V). The internal high-voltage regulator turns on to charge the external VCC capacitor when the VCC voltage decreases below VCC_ON (typically 4.45V). VCC is self-regulated to a suitable value.

Due to the on/off discharge logic on VCC, a small capacitor is needed to maintain the voltage. It is also recommended to supply VCC from an external power such as V_OUT to decrease regulator power loss. In this case, if the external power voltage is higher than 4.8V, which is the threshold of the VCC internal clamping circuit (typically 4.8V, the clamp voltage is about 0.2V higher than VCC_OFF), the regulator’s current should be limited below 2mA.

When the voltage on VCC drops below VCC_stop (typically 3.35V), the IC stops working.

When a fault condition occurs (such as OLP, SCP, or OTP), the IC stops working, and an internal current source (around 16µA) discharges the VCC capacitor. Before VCC drops below VCC_pro (typically 2.35V), the internal high-voltage regulator does not start to charge the VCC capacitor again. When the fault condition occurs, the restart time can be calculated by Equation (1):

\[ t_{\text{restart}} = C_{\text{VCC}} \times \frac{V_{\text{CC}} - 2.35\text{V}}{16\mu\text{A}} + C_{\text{VCC}} \times \frac{4.6\text{V} - 2.35\text{V}}{3.5\text{mA}} \]  

(1)

Figure 2 shows the typical waveform with a VCC recharge after one fault occurs.

Constant Voltage Operation
The operation of MP9488 resembles a constant on-time (COT) control.

When the feedback voltage drops below the reference voltage (2.55V, which indicates an insufficient output voltage), the integrated MOSFET is turned on, indicating a new switching cycle. The on period is determined by the peak-current limit with about 10µs of maximum on time. After the on period elapses, the integrated MOSFET is turned off. The freewheeling diode (D1) and D2 are turned on due to the inductor current. The voltage of the sampling capacitor (C3) is then charged to equal to the output voltage, and SW is pulled to GND. The voltage across the sampling capacitor (C3) changes along with the output voltage and holds the output voltage when the internal MOSFET turns on. The MP9488 senses this voltage to regulate V_OUT. The detailed operation of continuous conduction mode (CCM) is shown in Figure 3.
By monitoring the sampling capacitor, the output voltage can be regulated. The output voltage can be determined with Equation (2):

$$V_{OUT} = 2.55V \times \frac{R1 + R2}{R2}$$  \hspace{1cm} (2)

In the actual circuit, the sampled voltage may differ from the real output voltage due to the layout and different characteristics of D1 and D2, especially at light load, where D1 may not conduct at all. As a result, a dummy load is necessary to keep $V_{OUT}$ in good regulation in no-load condition.

**Frequency Foldback**

At light-load or no-load conditions, the output drops very slowly. This makes the MOSFET off time increase, so the frequency decreases as the load decreases. Therefore, the MP9488 can maintain a high efficiency in light-load condition by reducing the switching frequency automatically.

The switching frequency in CCM condition can be calculated with Equation (3):

$$f_s = \frac{(V_{IN} - V_{OUT}) \cdot V_{OUT}}{2L(I_{PEAK} - I_{OUT}) \cdot V_{IN}}$$  \hspace{1cm} (3)

At the same time, the peak-current limit starts to decrease from 640mA as the off time increases. In standby mode, the frequency and the peak current are both at a minimum, so a smaller dummy load is sufficient. As a result, a peak-current compression function helps save no-load consumption. The peak-current limit can be calculated by Equation (4):

$$I_{PEAK} = 640mA - (3mA/\mu s) \times (T_{OFF} - 13.1\mu s)$$  \hspace{1cm} (4)

Where $T_{OFF}$ is the off time of the power module.

**Minimum Off Time Limitation**

A minimum off time limitation is implemented in the MP9488. During normal operation, the minimum off time limit is about 13.1\mu s. During the start-up period, the minimum off time limit is shortened gradually from 52.4\mu s to 26.2\mu s to 13.1\mu s (see Figure 4). Each minimum off time lasts for 128 switching cycles. This soft-start function ensures a safe start-up.

---

**Figure 4: t\text{minoff} at Start-Up**

**EA Compensation**

To achieve a better load regulation, the MP9488 employs an error amplifier (EA) compensation function (see Figure 5). After a 6\mu s delay from the MOSFET turning off, the MP9488 samples the feedback voltage. With EA compensation, the reference voltage (2.55V) can be regulated with the load. This can achieve a better regulation of the power module.

**Figure 5: EA and Ramp Compensation**

**Ramp Compensation**

To maintain a precise output voltage, an internal ramp compensation circuit is added. An exponential voltage sinking source is added to pull down the reference voltage of the feedback comparator (see Figure 5). The ramp compensation is related to the load conditions. In full-load condition, the compensation is about 3mV/\mu s. When the load decreases, the compensation increases exponentially.

**Overload Protection (OLP)**

As the load increases, the peak current and the switching frequency both increase. When the switching frequency and peak current reach the maximum, the output voltage decreases if the load continues to increase, so the FB voltage drops below the OLP point.
By continuously monitoring the FB voltage, when the FB voltage drops below 1.7V (which is considered to be an error flag), the timer begins counting. If the error flag is removed, the timer resets. If the timer ends when it has counted to 150ms (F_S = 37kHz), OLP occurs. This timer duration prevents a trigger of the OLP function when the power supply is at a start-up or load transition phase. The power supply should start up in less than 150ms (F_S = 37kHz). Different switching frequencies (f_S) lead to different OLP delay times, as shown in Equation (5):

$$ T_{\text{Delay}} \approx 150\text{ms} \times \frac{37\text{kHz}}{f_S} $$  \hspace{1cm} (5)

After OLP is triggered, the MP9488 restarts after VCC discharges to 2.35V.

**Short-Circuit Protection (SCP)**

The MP9488 monitors the peak current and shuts down when the peak current rises above 900mA, featuring a short-circuit protection (SCP). Once the fault disappears, the power supply resumes operation after VCC discharges to 2.35V.

**Open-Loop Detection**

If the FB voltage is lower than 60mV in a condition (i.e.: R1 is not soldered well), the IC stops working and a restart cycle begins after VCC discharges to 2.35V. During the start-up, open loop detection is blanked for 128 switching cycles.

**Leading Edge Blanking (LEB)**

To avoid a premature termination of the switching pulse due to the parasitic capacitance, an internal leading edge blanking (LEB) unit is employed between the current sense resistor inside the IC and the current comparator input. During the blanking time, the current comparator is disabled and cannot turn off the MOSFET (see Figure 6).

![Leading Edge Blanking](image)

**Thermal Shutdown**

To protect against any lethal thermal damage, the MP9488 shuts down the switching cycle when the inner temperature exceeds 150°C. During thermal shutdown, VCC is discharged to 2.35V and recharged by the internal high-voltage regulator.
APPLICATION INFORMATION

Topology Options
The MP9488 can be used in common topologies, such as buck, buck boost, boost, and flyback (see Table 1).

Table 1: Common Topologies Using the MP9488

<table>
<thead>
<tr>
<th>Topology</th>
<th>Circuit Schematic</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Side Buck</td>
<td><img src="image" alt="Circuit Diagram" /></td>
<td>1. No isolation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Positive output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Low cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Direct feedback</td>
</tr>
<tr>
<td>High-Side Buck Boost</td>
<td><img src="image" alt="Circuit Diagram" /></td>
<td>1. No isolation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Negative output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Low cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Direct feedback</td>
</tr>
<tr>
<td>Boost</td>
<td><img src="image" alt="Circuit Diagram" /></td>
<td>1. No isolation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Positive output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Low cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Direct feedback</td>
</tr>
<tr>
<td>Flyback</td>
<td><img src="image" alt="Circuit Diagram" /></td>
<td>1. Isolation</td>
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<tr>
<td></td>
<td></td>
<td>2. Positive output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Low cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Indirect feedback</td>
</tr>
</tbody>
</table>
BUCK OPERATION

Input Capacitor
The input capacitor is used to supply DC input voltage to the converter. Because the input voltage is usually high, an aluminum electrolytic capacitor is recommended.

By ignoring the current ripple, the RMS current through the input capacitor can be approximated with Equation (6):

\[ I_{IN_{-AC}} = I_{OUT} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times x(1 - \frac{V_{OUT}}{V_{IN}})} \]  

(6)

Then the total peak-to-peak ripple on VIN can be estimated with Equation (7):

\[ \Delta V_{IN} = \frac{I_{OUT} \times V_{OUT}}{F_{SW} \times C_{IN} \times V_{IN}} \times (1 - \frac{V_{OUT}}{V_{IN}}) + I_{OUT} \times ESR \]  

(7)

Inductor
The MP9488 has a minimum off time limit that decides the maximum power it can output. The maximum power increases as the inductor increases. Using a smaller inductor leads to a lower load capability. The maximum power in CCM condition can be obtained with Equation (8):

\[ P_{omax} = V_o (I_{peak} - \frac{V_o t_{minoff}}{2L}) \]  

(8)

To consider the parameter error of the converter (such as peak current limit, minimum off time, etc.), calculate the minimum value (P_{min}) of the maximum power. The principle of choosing the inductor is that P_{min} should be higher than the rated power.

For CCM operation, if the input voltage is too high, the selection of L should make the frequency of the converter lower than 40kHz to reduce turn-on switching loss caused by the reverse-recovery of the freewheeling diode.

Freewheeling Diode
The diode should have a maximum reverse voltage rating greater than the maximum input voltage. The current rating of the diode is determined by the output current.

The reverse recovery of the freewheeling diode can affect the efficiency and the circuit operation. For CCM operation, an ultra-fast diode with Trr < 35ns (i.e.: STTH2R06, STTH1R06, or UGC10JH) can be used. For DCM operation, use a diode with Trr < 75ns.

Sampling Diode
The diode is used to charge the sample-and-hold capacitor when the MOSFET is turned off so the MP9488 can obtain feedback information about the output.

To achieve good regulation, this diode should be the same as the freewheeling diode, theoretically. Otherwise, the sampling diode can conduct while the freewheeling diode is blocked. As a result, the sampled voltage is much different from the real output voltage. Considering cost, it is not practical to use a diode identical to the freewheeling diode. The minimum requirement is to use a diode with a minimum Trr. If the Trr is long, the sampled voltage may be lower than the real output voltage, especially at a low input condition.

Output Capacitor
An output capacitor is required to maintain the DC output voltage. The output voltage ripple in CCM condition can be estimated with Equation (9):

\[ V_{ripple} = \frac{\Delta i}{8f_s C_o} + \Delta i \cdot R_{ESR} \]  

(9)

Ceramic, tantalum, or low ESR electrolytic capacitors are used to reduce the output voltage ripple.

Feedback Resistors
The resistor divider determines the output voltage. Choose appropriate values for R1 and R2 to maintain V_FB at 2.55V. Avoid a large R2 value (typically 4kΩ to 10kΩ).

Place a large capacitor (valued at hundreds of pF) between FB and SW as close to the IC as possible to filter noise.
Feedback Sampling Capacitor

The feedback capacitor (C3) provides a sample-and-hold function. Small capacitors result in poor regulation at light loads, and large capacitors may result in instability. Roughly estimate an optimal capacitor value using Equation (10):

$$\frac{1}{2} \frac{V_o}{R_1 + R_2} \cdot C_3 \leq C_3 \leq \frac{V_o}{R_1 + R_2} \cdot C_o$$  \hspace{1cm} (10)

Choose the nearest appropriate value.

Dummy Load

A dummy load is required to maintain load regulation. This ensures sufficient inductor energy to charge the sample-and-hold capacitor to detect the output voltage. Normally, a 3~5mA dummy load is needed and can be adjusted based on the regulated voltage. Increasing the dummy load reduces the efficiency and no-load consumption. Use a Zener diode if no-load regulation is not a concern.

Auxiliary VCC Supply

If the output voltage is higher than the VCC voltage, an auxiliary VCC supply can be implemented by connecting a diode (D3) and a resistor (R3) between C3 and C4 to reduce overall power consumption (see Figure 7).

![Figure 7: Auxiliary VCC Supply Circuit](image)

PCB Layout Guidelines

Efficient PCB layout is critical for stable operation, good EMI, and good thermal performance. For best results, refer to Figure 8 and follow the guidelines below.

1) Minimize the loop area formed by the input capacitor, IC, freewheeling diode, inductor and output capacitor.
2) Route the FB trace far away from the VIN/VOUT traces.
3) Place the FB resistors (R1, R2) as close to FB as possible.
4) Place R2 close to SW.
5) Connect VIN and NC to a larger copper area to improve thermal performance.

Figure 8 shows an example of PCB layout, for which the circuit schematic can be found on page 1.

![Figure 8: Recommended Layout](image)
Design Example

Table 3 is a design example following the application guidelines for the specifications below.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>$V_{IN}$</td>
<td>48V - 400V</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>15V</td>
</tr>
<tr>
<td>$I_{OUT}$</td>
<td>300mA</td>
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</table>

The detailed application schematic is shown in Figure 9. The typical performance and circuit waveforms are shown in the Typical Performance Characteristics section. For more device applications, please refer to the related evaluation board datasheet.
Figure 9: Typical Application at 15V, 300mA
PACKAGE INFORMATION

MP9488 – 450V, 300MA, WIDE INPUT, STEP-DOWN REGULATOR

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NOTE:
1) CONTROL DIMENSION IS IN INCHES  DIMENSION IN BRACKET IS IN MILLIMETERS
2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH PROTRUSIONS OR GATE BURRS
3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
4) LEAD COPLANARITY(BOTTOM OF LEADS AFTER FORMING SHALL BE0.004” INCHES MAX
5) DRAWING CONFORMS TO JEDEC MS012, VARIATION AA
6) DRAWING IS NOT TO SCALE