# Enhanced Burst Triple-Mode PWM Controller with Integrated Power MOSFET for Flyback Converts

## General Description

The R7914 series consists of a high voltage power MOSFET and a high-performance, low cost, low start-up current and current mode PWM controller with burst triple-mode to support green mode power saving operation. The R7914 integrates functions of soft start, Under Voltage LockOut (UVLO), Leading Edge Blanking (LEB), Over Temperature Protection (OTP) and internal slope compensation. It provides the users a superior AC/DC power application of higher efficiency, low external component counts and lower cost solution.

To protect the internal power MOSFET from being damaged by supply over voltage, the R7914 driver is clamped at 12V. Furthermore, R7914 features fruitful protections like Over Load Protection (OLP) and Over Voltage Protection (OVP) to eliminate the external protection circuits and provide reliable operation. R7914 is available in DIP-8 package.

## Ordering Information

R7914 □□

- Package Type
  N : DIP-8
- Operating Temperature Range
  G : Green (Halogen Free with Commercial Standard)

Note :

Richpower Green products are :

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

## Marking Information

For marking information, contact our sales representative directly or through a Richpower distributor located in your area, otherwise visit our website for detail.

## Features

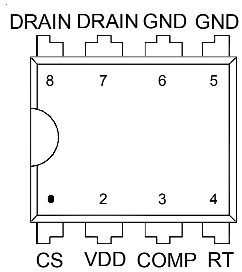
- **Integrated 650V Power MOSFET**
- **Very Low Start-up Current (<30μA)**
- **10/14V UVLO**
- **Soft Start Function**
- **Current Mode Control**
- **Jittering Switching Frequency**
- **Internal Leading Edge Blanking**
- **Built-in Slope Compensation**
- **Burst Triple-Mode PWM for Green-Mode**
- **Cycle-by-Cycle Current Limit**
- **Feedback Open Protection**
- **Over Voltage Protection**
- **Output Temperature Protection**
- **Over Load Protection**
- **Soft Driving for Reducing EMI**
- **High Noise Immunity**
- **Opto-Coupler Short Protection**
- **RoHS Compliant and Halogen Free**

## Applications

- Adaptor
- ATX Standby Power
- Set-Top Box (STB)
- DVD and CD(R)
- TV/Monitor Standby Power
- PC Peripherals

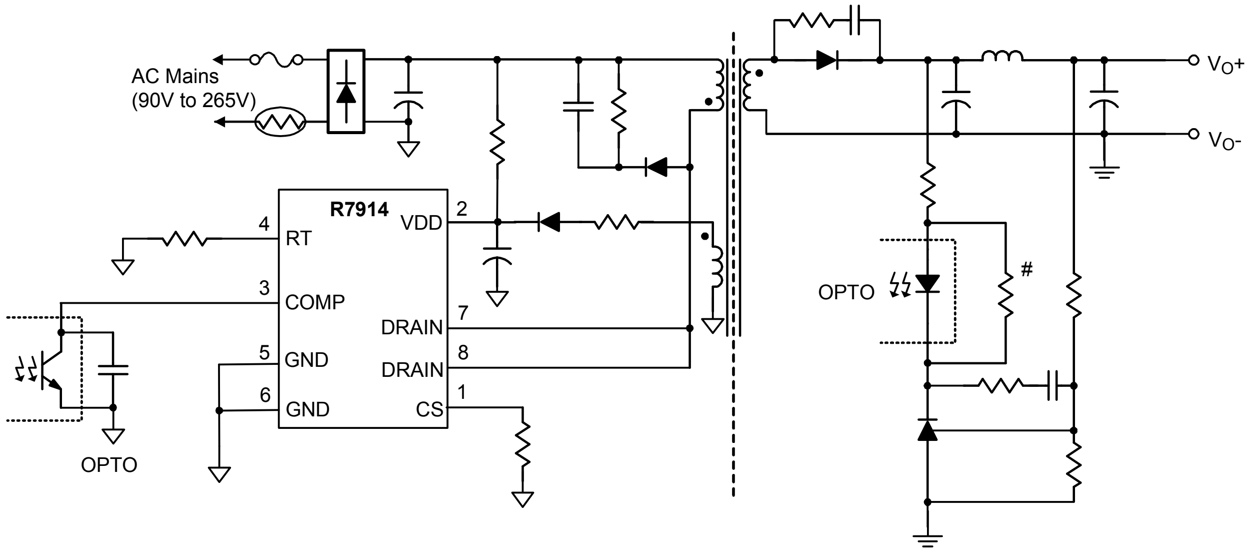
## Pin Configurations

(TOP VIEW)




DIP-8

## Typical Application Circuit

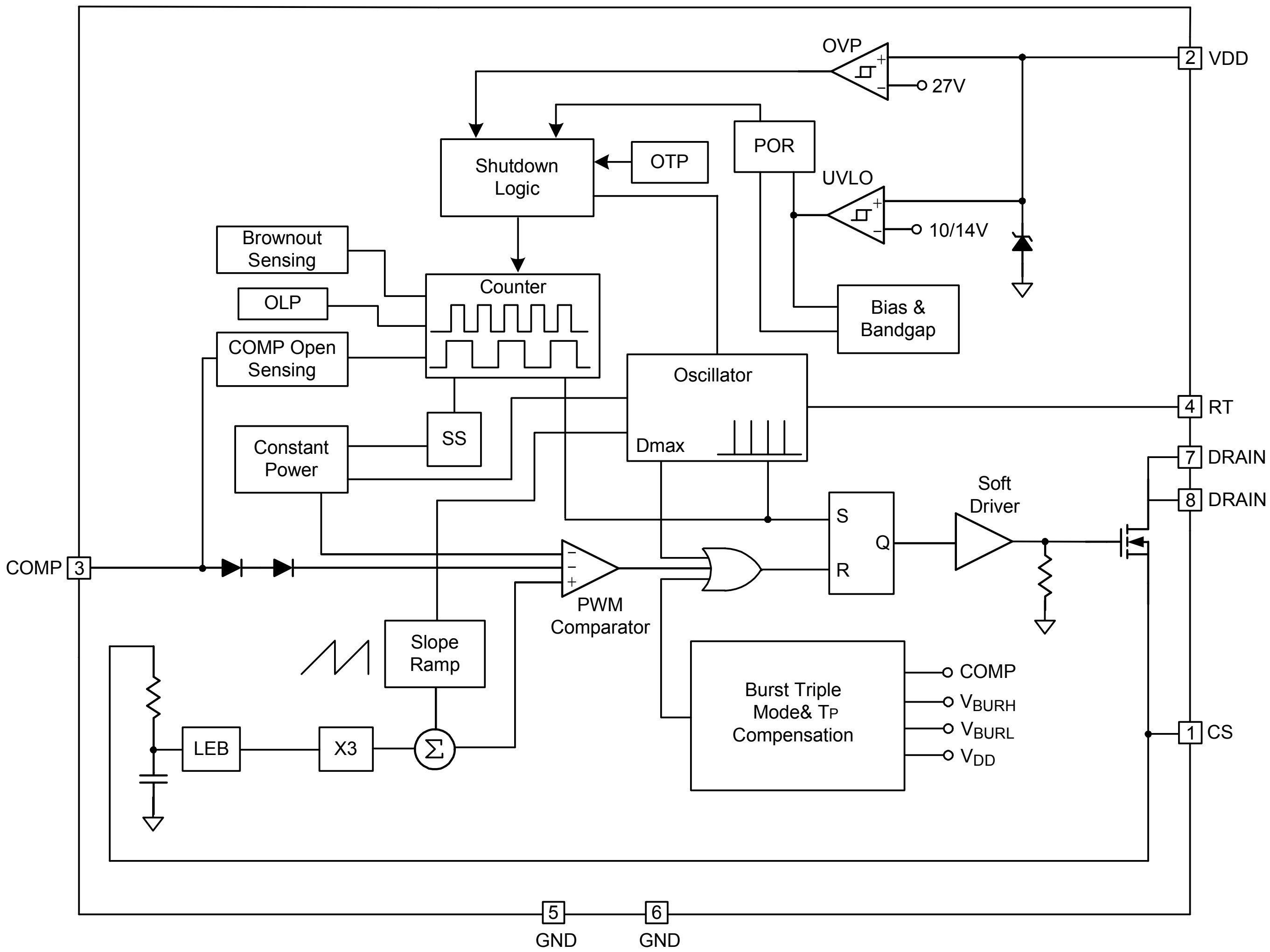



# See Application Information

## Pin Description

| Pin No. | Pin Name | Pin Description |
|---|---|---|
| 1 | CS | Current sensing pin. |
| 2 | VDD | Power supply pin. |
| 3 | COMP | Voltage feedback pin. By connecting an opto-couple to close control loop and achieve the regulation. |
| 4 | RT | Set the switching frequency by connecting a resistor to GND. |
| 5 | GND | Ground. |
| 6 | GND | Ground. |
| 7 | DRAIN | MOSFET Drain. |
| 8 | DRAIN | MOSFET Drain. |

## Block Diagram



## Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, $V_{DD}$ ---------- –0.3V to 30V
- DRAIN Pin ---------- 650V
- RT, COMP, CS Pin ---------- –0.3V to 6.5V
- $I_{DD}$ ---------- 10mA
- Power Dissipation, $P_D$ @ $T_A$ = 25°C
  DIP-8 ---------- 1.053W
- Package Thermal Resistance (Junction to Ambient $\theta_{JA}$ )
  DIP-8, $\theta_{JA}$ (Note 2) ---------- 95°C/W
- Junction Temperature ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Mode) ---------- 3kV
  MM (Machine Mode) ---------- 250V

## Recommended Operating Conditions (Note 4)

- Supply Input Voltage, $V_{DD}$ ---------- 12V to 23V
- Operating Frequency ---------- 50k to 130kHz
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

## Electrical Characteristics

($V_{DD}$ = 15V, $T_A$ = 25°C, unless otherwise specified)

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **VDD Section** | | | | | | |
| $V_{DD}$ Over Voltage Protection Level | $V_{OVP}$ | | 25.5 | 27 | 28.5 | V |
| On Threshold Voltage | $V_{TH\_ON}$ | | 13 | 14 | 15 | V |
| $V_{DD}$ On/Off Hysteresis | $V_{TH\_HYS}$ | | 3 | 4 | 5 | V |
| Start-up Current | $I_{DD\_ST}$ | $V_{DD} < V_{TH\_ON} - 0.1V$ | -- | 20 | 30 | μA |
| Operating Current | $I_{DD\_OP}$ | $R_T$ = 100kΩ, $V_{DD}$ = 15V, $V_{COMP}$ = 2.5V | -- | 1.6 | 2.7 | mA |
| VDD Holdup Mode Ending Point | $V_{DD\_HIGH}$ | $V_{COMP}$ < 1.6V | -- | 11.5 | -- | V |
| VDD Holdup Mode Entry Point | $V_{DD\_LOW}$ | $V_{COMP}$ < 1.6V | -- | 11 | -- | V |
| $V_{DD}$ Zener Clamp Voltage | $V_Z$ | | -- | 29 | -- | V |

*To be continued*

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Oscillator Section (RT pin)** | | | | | | |
| Normal PWM Frequency | $f_{OSC}$ | $R_T$ = 100kΩ | 60 | 65 | 70 | kHz |
| Maximum Duty Cycle | $DCY_{MAX}$ | | 70 | 75 | 80 | % |
| PWM Frequency Jitter Range | Δf | | – | ±6 | -- | % |
| PWM Frequency Jitter Period | $T_{JIT}$ | $R_T$ = 100kΩ | – | 4 | -- | ms |
| Frequency Variation Versus $V_{DD}$ Deviation | $f_{DV}$ | $V_{DD}$ = 12V to 25V | – | – | 2 | % |
| Frequency Variation Versus Temperature Deviation | $f_{DT}$ | $T_A$ = –30°C to 105°C (Note 5) | – | – | 5 | % |
| **COMP Input Section** | | | | | | |
| Open Loop Voltage | $V_{COMP\_OP}$ | COMP pin open | 5.2 | 5.6 | 6 | V |
| COMP Open-loop Protection Delay Time | $T_{OLP}$ | $R_T$ = 100kΩ | – | 60 | -- | ms |
| Short Circuit COMP Current | $I_{ZERO}$ | $V_{COMP}$ = 0V | – | 1.2 | 2.2 | mA |
| **Current-Sense Section** | | | | | | |
| Peak Current Limitation | $V_{CSTH}$ | | 0.8 | 0.85 | 0.9 | V |
| Leading Edge Blanking Time | $T_{LEB}$ | (Note 6) | – | 420 | 520 | ns |
| **MOS Section** | | | | | | |
| Drain-Source Breakdown Voltage | $BV_{DSS}$ | $V_{GS}$ = 0V, $I_D$ = 1mA | 650 | – | -- | V |
| Drain-Source Leakage Current | $I_{DSS}$ | $V_{DS}$ = 600V, $V_{GS}$ = 0V | – | – | 10 | μA |
| Drain-Source On-Resistance | $R_{DS\_ON}$ | $V_{GS}$ = 10V, $I_D$ = 1.6A | – | – | 4.4 | Ω |

**Note 1.** Stresses beyond those listed under " Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**Note 2.** Without copper clad.

**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

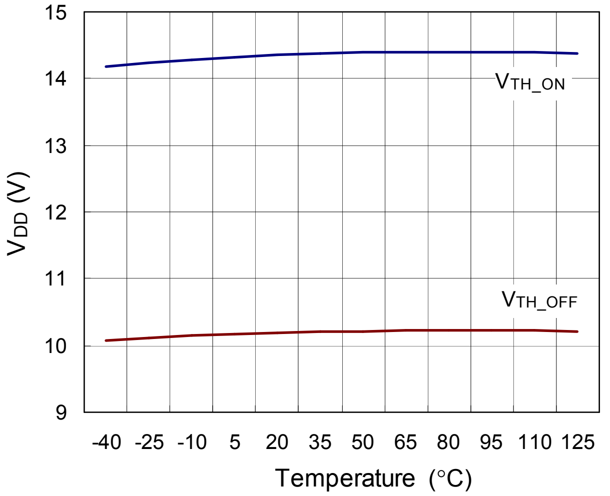
**Note 4.** The device is not guaranteed to function outside its operating conditions.

**Note 5.** Guaranteed by design.

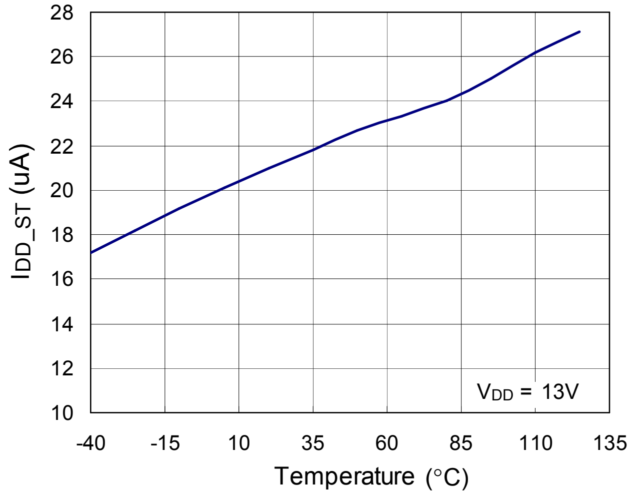
**Note 6.** Leading edge blanking time is guaranteed by design.

## Typical Operating Characteristics

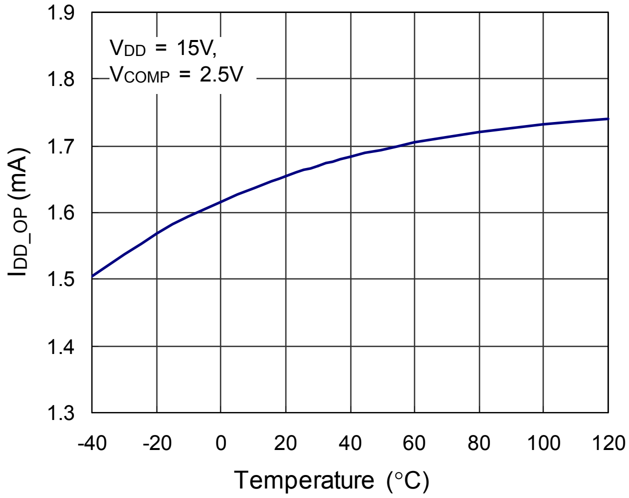
**$V_{TH}$ vs. Temperature**



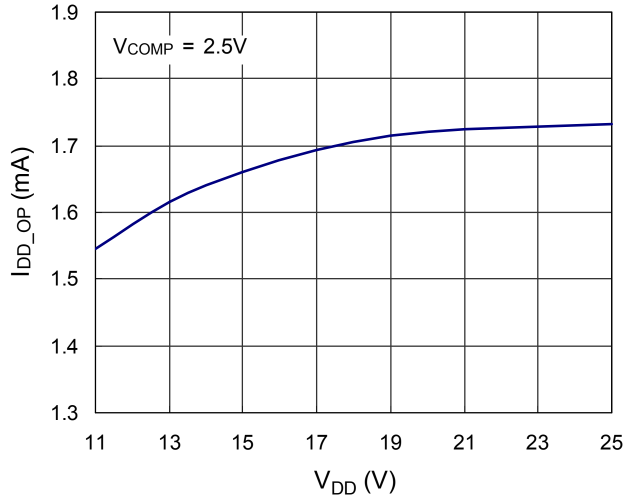

**$I_{DD\_ST}$ vs. Temperature**



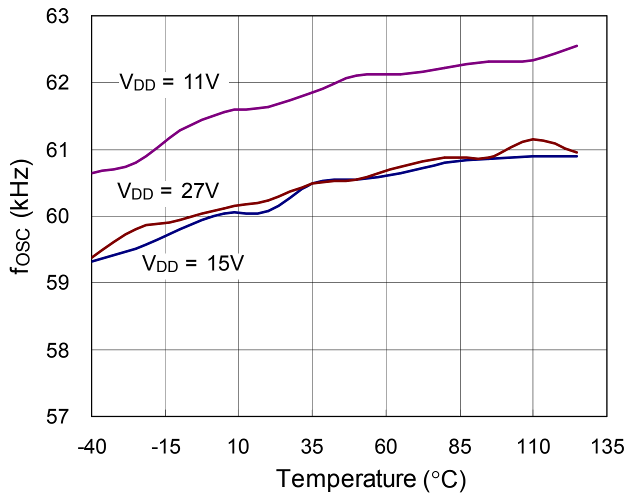

**$I_{DD\_OP}$ vs. Temperature**



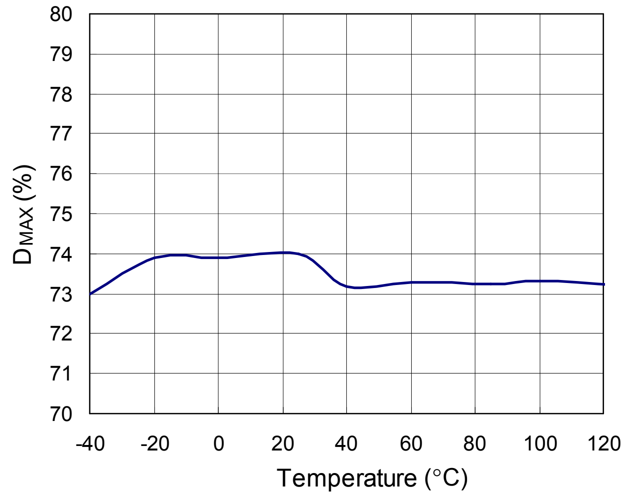

**$I_{DD\_OP}$ vs. $V_{DD}$**

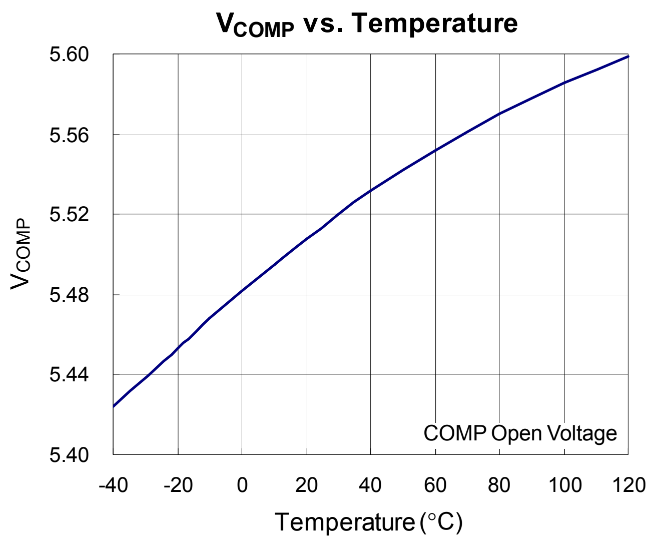



**$f_{OSC}$ vs. Temperature**

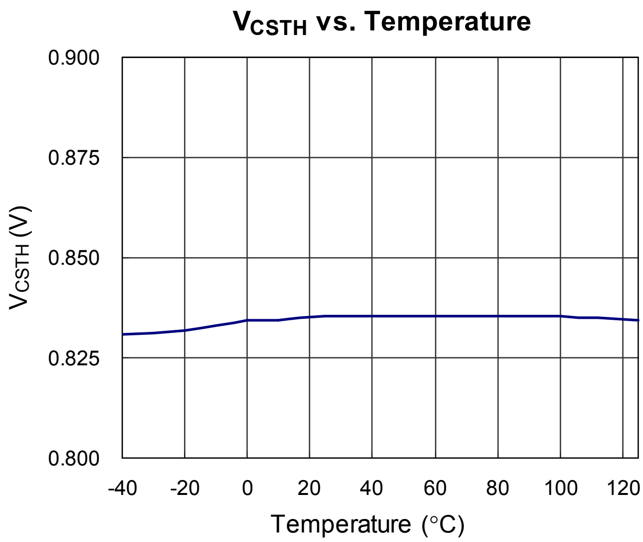



**$D_{MAX}$ vs. Temperature**





$V_{COMP}$ vs. Temperature
5.60
5.56
5.52
5.48
5.44
5.40
$V_{COMP}$
COMP Open Voltage
-40
-20
0
20
40
60
80
100
120
Temperature (°C)

$V_{CSTH}$ vs. Temperature
0.900
0.875
0.850
0.825
0.800
$V_{CSTH}$ (V)
-40
-20
0
20
40
60
80
100
120
Temperature (°C)

## Application Information

**Burst Triple-Mode**

To fulfill green mode requirement, there are 3 operation modes in R7914. Please refer to Figure 1 for details.

- **PWM Mode :** For most of load condition, the circuit will run at traditional PWM current mode.

  #It's highly recommended to add a resistor in parallel with the photo-coupler. To provide sufficient bias current to make TL-431 regulate properly, 1.2kΩ resistor is suggested.

- **Burst Mode :** During light load, switching loss will dominate the power efficiency calculation. This mode is to cut switching loss. As shown in Figure 1, when the output load gets light, feedback signal drops and touches $V_{BURL}$. Clock signal will be blanked and system ceases to switching. After $V_{OUT}$ drops and feedback signal goes back to $V_{BURH}$, switching will be resumed. Burst mode so far is widely used in low power application because it's simple, reliable and will not have any patent infringement issue.

- **VDD Holdup Mode :** When the $V_{DD}$ drops down to $V_{DD}$ turn off threshold voltage, the system will be shut down. During shutdown period, controller does nothing to any load change and might cause $V_{OUT}$ down. To avoid this, when VDD drops to a setting threshold, 11V, the hysteresis comparator will bypass PWM and burst mode loop and force switching at a very low level to supply energy to VDD pin. VDD holdup mode was also improved to hold up $V_{DD}$ by less switching cycles. This mode is very useful in reducing start-up resistor loss while still getting start-up time in spec.. It's not likely for $V_{DD}$ to touch UVLO turn off threshold during any light load condition. This will also makes bias winding design easier.

Furthermore, VDD holdup mode is only designed to prevent $V_{DD}$ from touching turn off threshold voltage under light load or load transient moment. Relative to burst mode, switching loss will increase on the system at VDD holdup mode, so it is highly recommended that the system should avoid operating at this mode during light load or no load condition, normally.

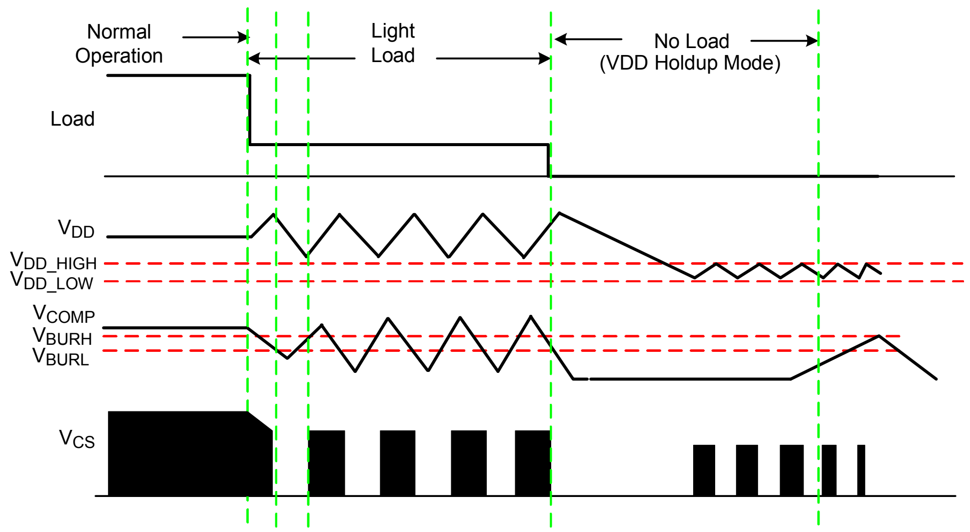



Figure 1. Burst Triple-Mode

### UVLO

Under Voltage LockOut (UVLO) block is to ensure $V_{DD}$ has reached proper operation voltage before we enable the whole IC blocks. To provide better temperature coefficient and precise UVLO threshold voltage, the reference voltage of hysteresis voltage (10V / 14V) is from band-gap block directly. By this way, R7914 can operate more reliable in different environments.

### Jittering Oscillator

For better EMI performance, R7914 will operate the system with ±6% frequency deviation around setting frequency.

To guarantee precise frequency, it is trimmed to 5% tolerance. It also generates slope compensation saw-tooth, 75% maximum duty cycle pulse and overload protection slope. By adjusting resistor of RT pin according to the following formula :

$$f_{OSC}\,(kHz) = \frac{6500}{R_T\,(k\Omega)}$$

It can typically operate between 50kHz to 130kHz. Note that RT pin can't be short or open otherwise oscillator will not operate. R7914 series features frequency jittering function. Its jittering depth is 6% with about 4ms envelope frequency at 65kHz.

### Built-in Slope Compensation

To reduce component counts, slope compensation is implemented by internal built-in saw-tooth. Since it's built-in, it's compromised between loop gain and sub-harmonic reduction. In general design, it can cancel sub-harmonic to 90Vac.

### Soft Start

During initial power on, especially at high line, current spike is a kind of unlimited by current limit. Therefore, besides cycle-by-cycle current limiting, R7914 still provides soft start function. It effectively suppresses the start-up current spike. As shown in the Figure 2 and Figure 3, the start-up $V_{CS}$ is about 0.3V lower than competitor. The typical soft start duration is 4ms ($R_T$=100kΩ). Again, this will provide more reliable operation and possibility to use smaller current rating power MOSFET.

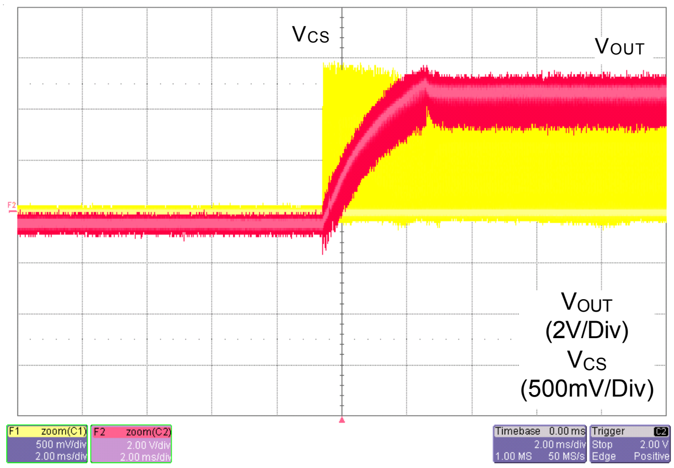



Figure 2. Competitor

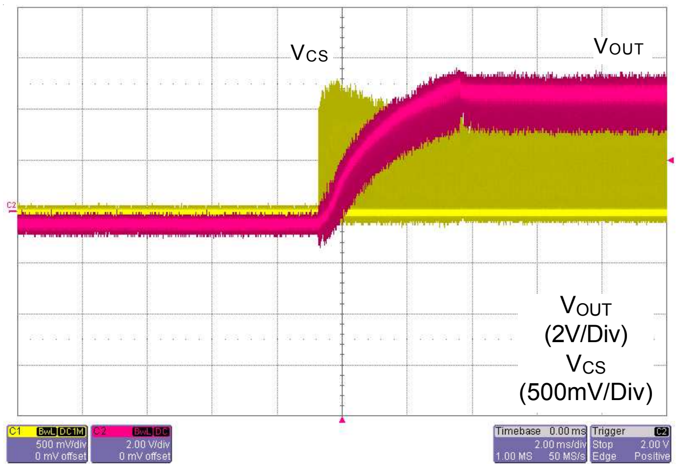



Figure 3. R7914

### Leading Edge Blanking (LEB)

MOSFET $C_{OSS}$ , secondary rectifier reverse recovery current and gate driver sourcing current comprise initial current spike. The spike will seriously disturb current mode operation especially at light load and high line. R7914 provides built-in 420ns LEB to guarantee proper operation in diverse design.

### Noise Immunity

Current mode controller is very sensitive to noise. R7914 takes the advantages of Richpower long term experience in designing high noise immunity current mode circuit and layout. Also, we amplify current sense signal to compare with feedback signal instead of dividing feedback signal. All the effort is to provide clean and reliable current mode operation.

**Protection**

R7914 provides fruitful protection functions that intend to protect system from being damaged. All the protection functions can be listed as below:

- **Cycle-by-Cycle Current Limit :** This is a basic but very useful function and it can be implemented easily in current mode controller.
- **Over Load Protection :** Long time cycle-by-cycle current limit will lead to system thermal stress. To further protect system, system will be shut down after about 60ms delay in 65kHz operation. After shutdown, system will resume and behave as hiccup. By proper start-up resistor design, thermal will be averaged to an acceptable level over the ON/OFF cycle of IC. This will last until fault is removed.
- **OVP :** Output voltage can be roughly sensed by $V_{DD}$ pin. If the sensed voltage reaches 27V threshold, system will be shut down after 20μs deglitch delay.
- **Feedback Open and Opto Short :** This will trigger OVP or 60ms delay protection in 65kHz operation. It depends on which one occurs first.

## PCB Layout Guide

A proper PCB layout can abate unknown noise interference and EMI issue in the switching power supply. Please refer to the guidelines when you want to design PCB layout for switching power supply:

**I.** The current path(1) from bulk capacitor, transformer, IC, Rcs return to bulk capacitor is a huge high frequency current loop. It must be as short as possible to decrease noise coupling and kept a space to other low voltage traces, such as IC control circuit paths, especially.

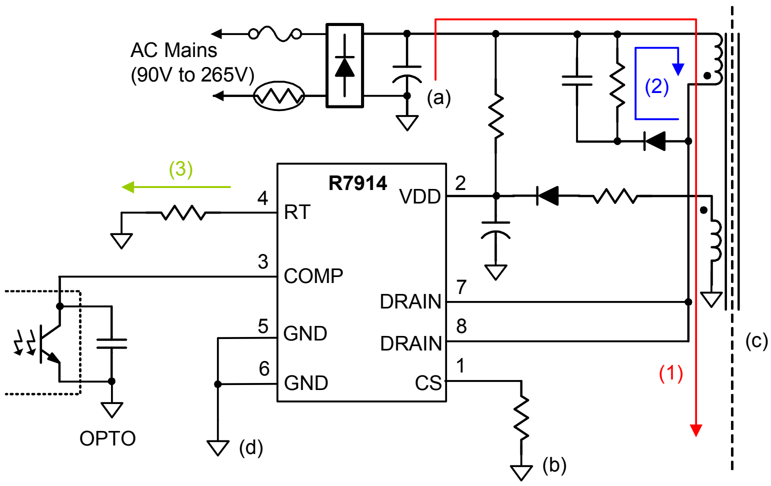
**II.** The path(2) from RCD snubber circuit to MOSFET is also a high switching loop. Keep it as small as possible.

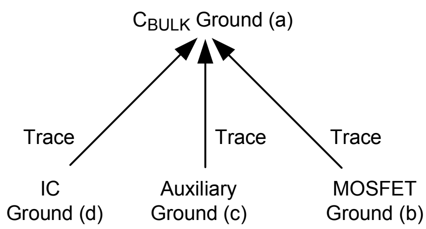
**III.** The path(3) from RT pin to IC ground(d) is a sensitive loop. It must be as short as possible and kept a space to transformer to reduce flux coupling.

**IV.** It is good for reducing noise, output ripple and EMI issue to separate ground traces of bulk capacitor(a), MOSFET(b), auxiliary winding(c) and IC control circuit (d). Finally, connect them together on bulk capacitor ground(a). The areas of these ground traces should be kept large.

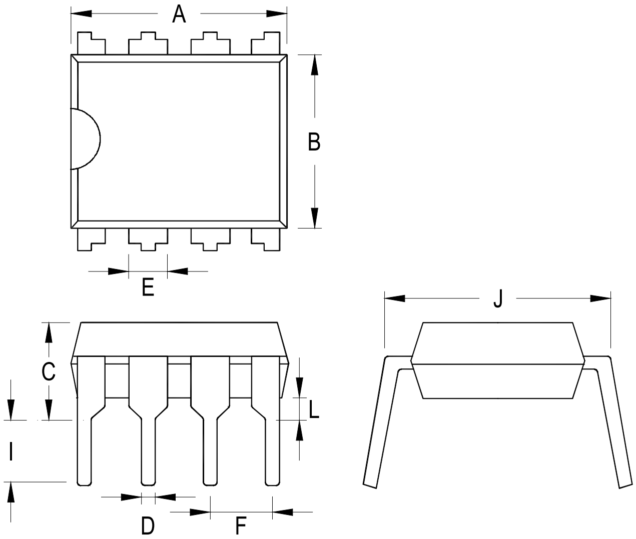
**V.** Placing bypass capacitor for abating noise on IC is highly recommended. The bypass capacitor should be placed as close to controller as possible.

**VI.** In order to minimize reflected trace inductance and EMI, it is minimize the area of the loop connecting the secondary winding, the output diode, and the output filter capacitor. In addition, apply sufficient copper area at the anode and cathode terminal of the diode for heatsinking. Apply a larger area at the quiet cathode terminal. A large anode area can increase high-frequency radiated EMI.



## Outline Dimension




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 9.068 | 9.627 | 0.357 | 0.379 |
| B | 6.198 | 6.604 | 0.244 | 0.260 |
| C | 3.556 | 4.318 | 0.140 | 0.170 |
| D | 0.356 | 0.559 | 0.014 | 0.022 |
| E | 1.397 | 1.651 | 0.055 | 0.065 |
| F | 2.337 | 2.743 | 0.092 | 0.108 |
| I | 3.048 | 3.556 | 0.120 | 0.140 |
| J | 7.366 | 8.255 | 0.290 | 0.325 |
| L | 0.381 | | 0.015 | |

**8-Lead DIP Plastic Package**

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