

# Burst Triple-Mode PWM Flyback Controller

## General Description

The R7731 is a high-performance, low cost, low startup current, current mode PWM controller with burst triple-mode to support green mode power saving operation. The R7731 integrates functions of Soft Start, Under Voltage Lockout (UVLO), Leading Edge Blanking (LEB), Over Temperature Protection (OTP), 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 external power MOSFET from being damaged by supply over voltage, the R7731 output driver is clamped at 12V. Furthermore, R7731 features fruitful protections like OLP (Over Load Protection), OVP (Over Voltage Protection) to eliminate the external protection circuits and provide reliable operation. R7731 is available in SOT-23-6 and DIP-8 packages.

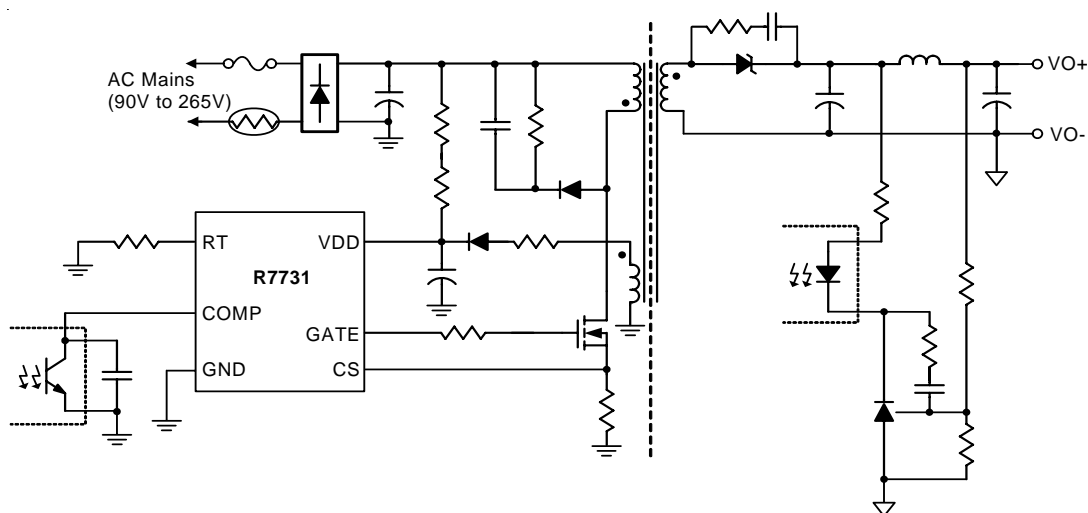
## Features

- Very Low Start-Up Current (<30uA)
- 10/14V UVLO
- Soft Start Function
- Current Mode Control
- Internal Leading-Edge Blanking
- Built-in Slope Compensation
- Burst Triple-Mode PWM for Green-Mode
- Cycle-by-Cycle Current Limiting
- Feedback Open Protection
- Output Over Voltage Protection
- Over Temperature Protection
- Over Load Protection
- Soft Driving for Reducing EMI
- High Noise Immunity
- Opto Coupler Short Protection
- RoHS Compliant and 100% Lead (Pb)-Free

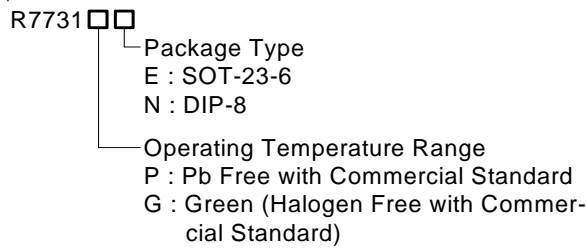
## Applications

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

## Typical Application Circuit



### Ordering Information



Note :

RichTek Pb-free and Green products are :

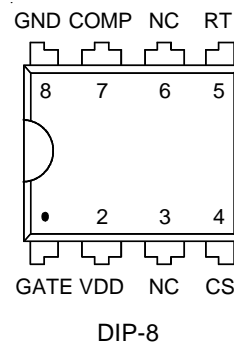
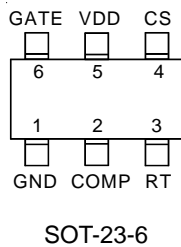
- ▶RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- ▶Suitable for use in SnPb or Pb-free soldering processes.
- ▶100% matte tin (Sn) plating.

### Marking Information

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

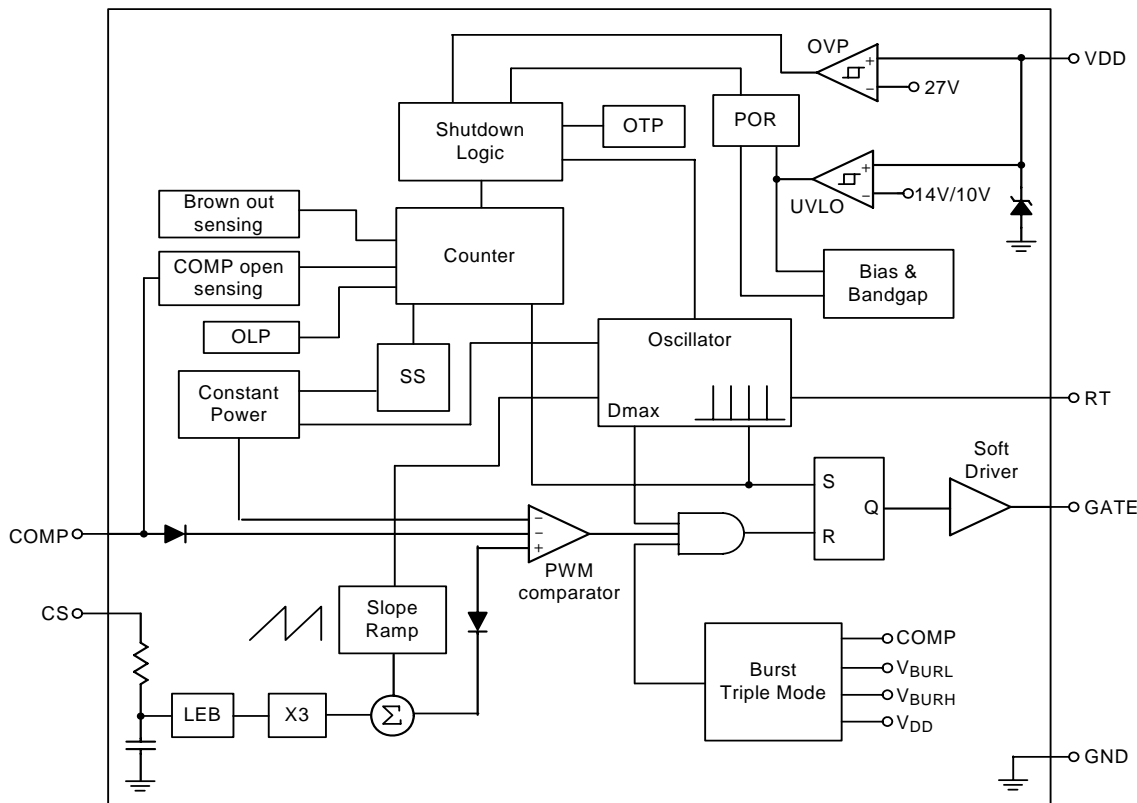
### Pin Configurations

(TOP VIEW)



**Note :** There is no pin1 indicator on top mark for SOT-23-6 type, and pin 1 will be lower left pin when reading top mark from left to right.

Function Block Diagram



Functional Pin Description

| Pin No.  |      | Pin Name | Pin Function   |
|----------|------|----------|--|
| SOT-23-6 | DIP8 |          |  |
| 1        | 8    | GND      | Ground.  |
| 2        | 7    | COMP     | Comparator Input Pin. By connecting a photo-coupler to this pin, the peak current set point is adjusted accordingly to the output power requirement. |
| 3        | 5    | RT       | Set the switching frequency by connecting a resistor to GND.   |
| 4        | 4    | CS       | Primary Current Sense Pin.   |
| 5        | 2    | VDD      | IC Power Supply Pin.   |
| 6        | 1    | GATE     | Gate driver output to drive the external MOSFET.   |
| --       | 3, 6 | NC       | No Internal Connection.  |

**Absolute Maximum Ratings** (Note 1)

- Supply Input Voltage,  $V_{DD}$  ----- 30V
- GATE Pin ----- 20V
- FB, RT, COMP, CS Pin ----- 6.5V
- $I_{DD}$  ----- 10mA
- Power Dissipation,  $P_D$  @  $T_A = 25^\circ C$ 
  - SOT-23-6 ----- 0.4W
  - DIP-8 ----- 0.714W
- Package Thermal Resistance (Note 4)
  - SOT-23-6,  $\theta_{JA}$  ----- 250°C/W
  - DIP-8,  $\theta_{JA}$  ----- 140°C/W
- Junction Temperature ----- 150°C
- Lead Temperature (Soldering, 10 sec.) ----- 260°C
- Storage Temperature Range ----- -65°C to 150°C
- ESD Susceptibility (Note 2)
  - HBM (Human Body Mode) ----- 3kV
  - MM (Machine Mode) ----- 250V

**Recommended Operating Conditions** (Note 3)

- Supply Input Voltage,  $V_{DD}$  ----- 12V to 25V
- Operating Frequency ----- 50k to 130kHz
- Junction Temperature Range ----- -40°C to 125°C
- Ambient Temperature Range ----- -40°C to 85°C

**Electrical Characteristics**

( $V_{DD} = 15V$ ,  $R_T = 100k\Omega$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

| Parameter                                     | Symbol          | Conditions  | Min  | Typ     | Max  | Unit    |
|---|-----------------|---|------|---------|------|---------|
| <b><math>V_{DD}</math> Section</b>            |                 |   |      |         |      |         |
| $V_{DD}$ 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                    | $V_{DD\_hys}$   |   | 3    | 4       | 5    | V       |
| Start-up Current                              | $I_{DD-ST}$     | $V_{DD} = V_{TH\_ON} - 0.1V$  | --   | 20      | 30   | $\mu A$ |
| Operating Current                             | $I_{DD-OP}$     | $V_{DD} = 15V$ , $R_T = 100k\Omega$ ,<br>GATE = Open, $V_{COMP} = 2.5V$ | --   | 1.1     | 2.2  | mA      |
| $V_{DD}$ Hold-up Mode Hysteresis Ending Level | $V_{DD\_hys}$   | $V_{COMP} < 1.6V$   | --   | 11.5    | --   | V       |
| $V_{DD}$ Hold-up Mode Entry Level             | $V_{DD\_Low}$   | $V_{COMP} < 1.6V$   | --   | 11      | --   | V       |
| $V_{DD}$ Clamp Voltage                        | $V_{DD\_Clamp}$ |   | --   | 29      | --   | V       |
| <b>Oscillator Section (RT pin)</b>            |                 |   |      |         |      |         |
| Normal PWM Frequency                          | $f_{OSC}$       | $R_T = 100k\Omega$  | 60   | 65      | 70   | kHz     |
| Frequency Jittering Range                     |                 |   | --   | $\pm 4$ | --   | %       |
| Maximum Duty Cycle                            | $D_{MAX}$       |   | 70   | 75      | 80   | %       |

To be continued

| Parameter  | Symbol         | Conditions                                      | Min  | Typ | Max  | Unit        |
|--|----------------|---|------|-----|------|-------------|
| Frequency Variation Versus VDD Deviation         | $f_{DV}$       | $V_{DD} = 12V$ to $25V$                         | --   | --  | 2    | %           |
| Frequency Variation Versus Temperature Deviation | $f_{DV}$       | $T_A = -30^{\circ}C$ to $105^{\circ}C$ (Note 5) | --   | --  | 5    | %           |
| <b>COMP Input Section</b>                        |                |   |      |     |      |             |
| Open Loop Voltage                                | $V_{COMP-OP}$  | COMP pin Open                                   | 5    | 5.5 | 6    | V           |
| COMP Open-loop Protection Delay cycles           | $T_{OLP}$      | $R_T = 100k\Omega$                              | --   | 29  | --   | ms          |
| Short Circuit COMP Current                       | $I_{ZERO}$     | $V_{COMP} = 0V$                                 | --   | 1.2 | 2.2  | mA          |
| <b>Current-Sense Section</b>                     |                |   |      |     |      |             |
| Peak Current Limitation                          | $V_{CSTH}$     |   | 0.65 | 0.7 | 0.75 | V           |
| Leading Edge Blanking Time                       | $T_{LEB}$      |   | --   | 420 | 520  | ns          |
| Propagation Delay Time                           | $T_{PD}$       |   | --   | 100 | --   | ns          |
| <b>GATE Section</b>                              |                |   |      |     |      |             |
| Rising Time                                      | $T_R$          | $V_{DD} = 15V, C_L = 1nF$                       | --   | 250 | 350  | ns          |
| Falling Time                                     | $T_F$          | $V_{DD} = 15V, C_L = 1nF$                       | --   | 150 | 250  | ns          |
| Gate Output Clamping Voltage                     | $V_{clamp}$    | $V_{DD} = 22V$                                  | --   | 12  | --   | V           |
| Over Temperature Protection                      | $T_{OTP}$      |   | --   | 140 | --   | $^{\circ}C$ |
| OTP Hysteresis                                   | $T_{OTP\_hys}$ |   | --   | 30  | --   | $^{\circ}C$ |

**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.

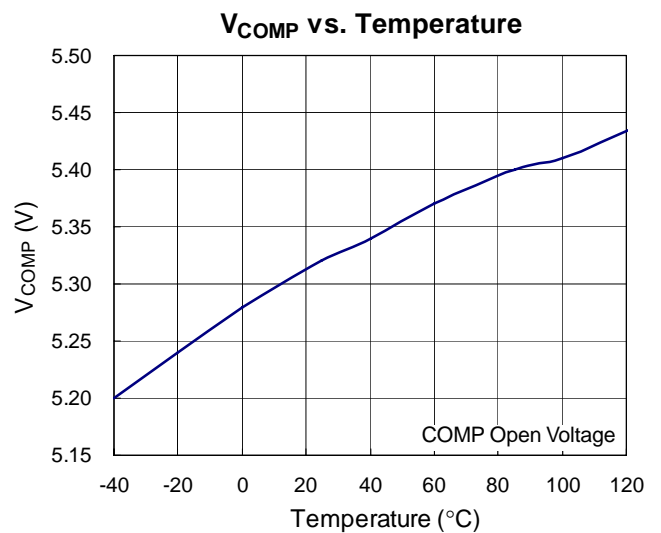
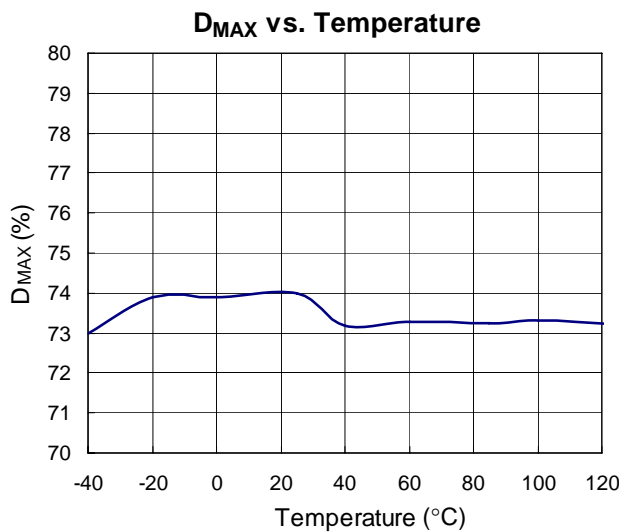
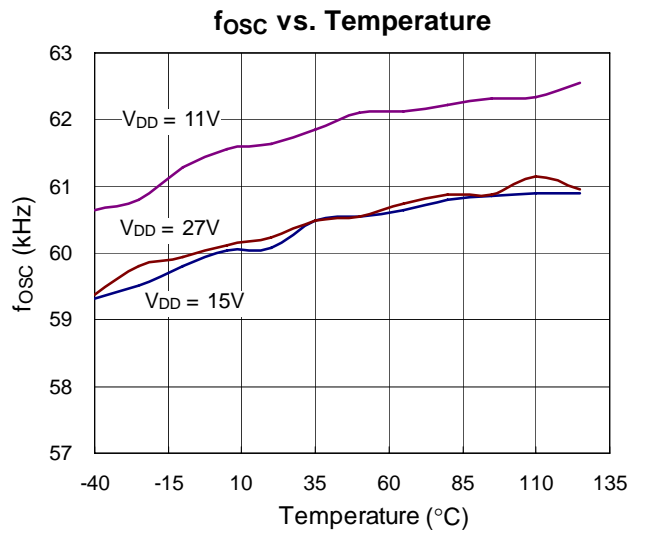
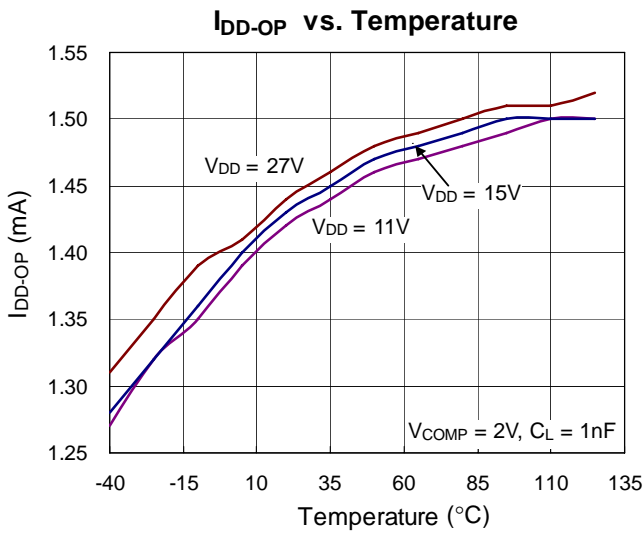
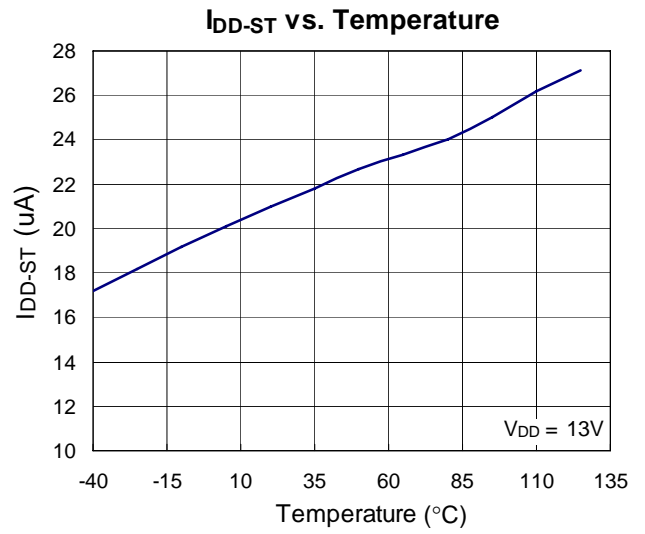
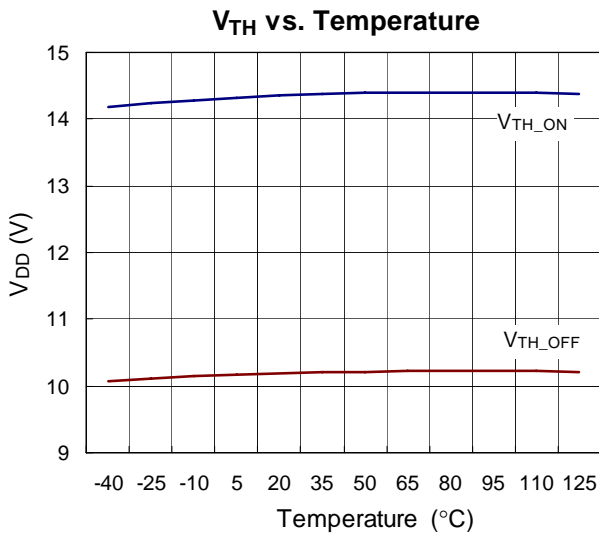
**Note 2.** Devices are ESD sensitive. Handling precaution recommended. The human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.

**Note 3.** The device is not guaranteed to function outside its operating conditions.

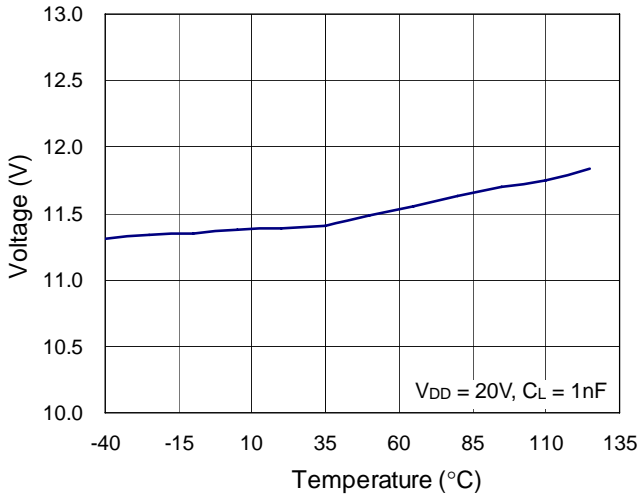
**Note 4.**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^{\circ}C$  on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

**Note 5.** Guaranteed by design.

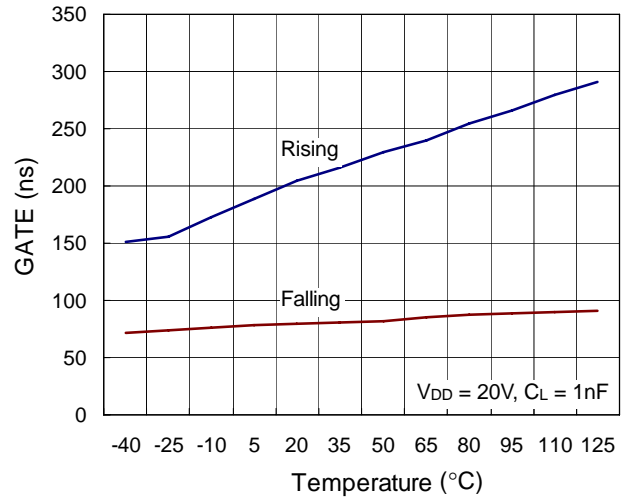
Typical Operating Characteristics



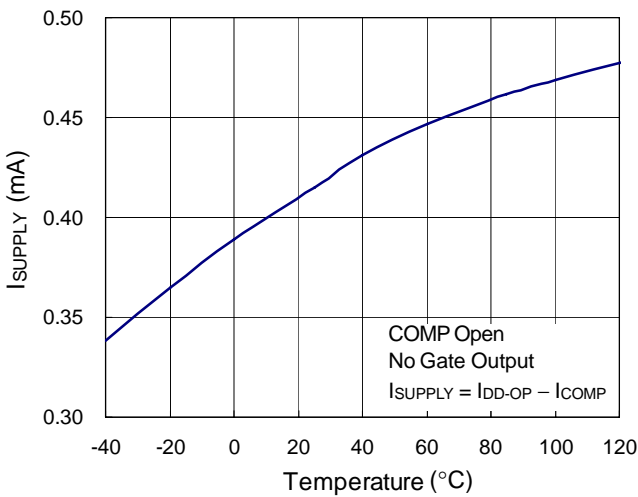
Clamp Voltage vs. Temperature



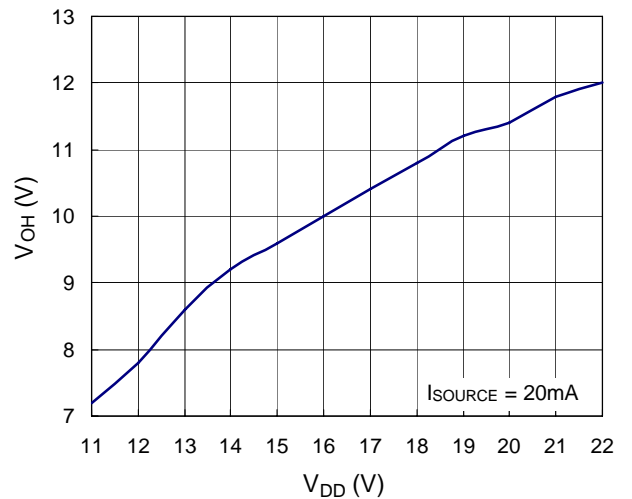
GATE (Rising/Falling) vs. Temperature



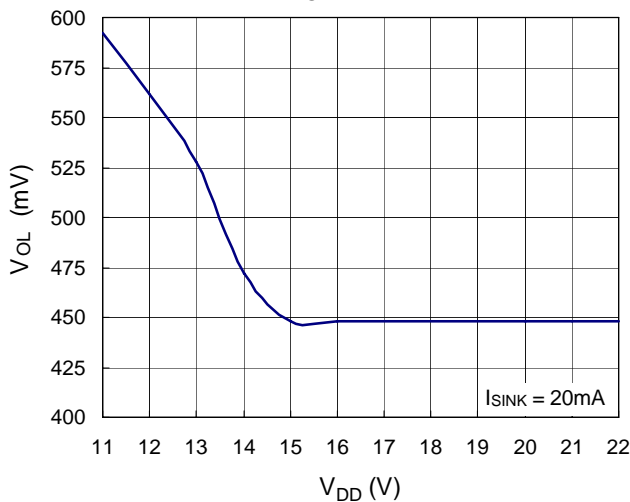
ISUPPLY vs. Temperature



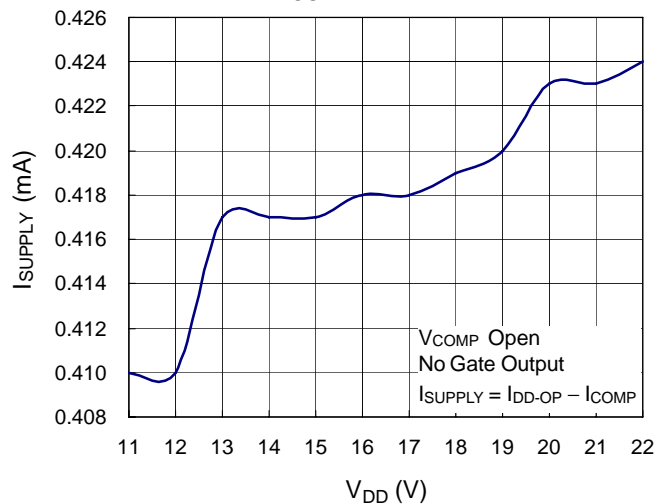
VOH vs. VDD



VOL vs. VDD



ISUPPLY vs. VDD



## Application Information

### UVLO

Under voltage lockout (UVLO) block is to ensure VDD 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, R7731 can operate more reliable in different environments.

### Oscillator

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 :

$$f_{OSC} \text{ (kHz)} = \frac{6500}{RT \text{ (k}\Omega)}$$

It can typically operate between 50kHz to 130kHz. Note that RT pin can't be short or open otherwise oscillator will not operate.

### Built-in Slope Compensation

To reduce component count, 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.

### Leading Edge Blanking (LEB)

MOSFET Coss, 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. R7731 provides built-in 420ns LEB to guarantee proper operation in diverse design.

### Noise Immunity

Current mode controller is very sensitive to noise. R7731 takes the advantages of RICHTEK 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.

### Soft Start

During initial power on, especially at high line, current spike is kind of unlimited by current limit. Therefore, besides cycle-by-cycle current limiting, R7731 still provides soft start function. It effectively suppresses the start up current spike. As shown in the Figure 1 and Figure 2, the start up Vcs is about 0.3V lower than competitor. Again, this will provide more reliable operation and possibility to use smaller current rating power MOSFET.

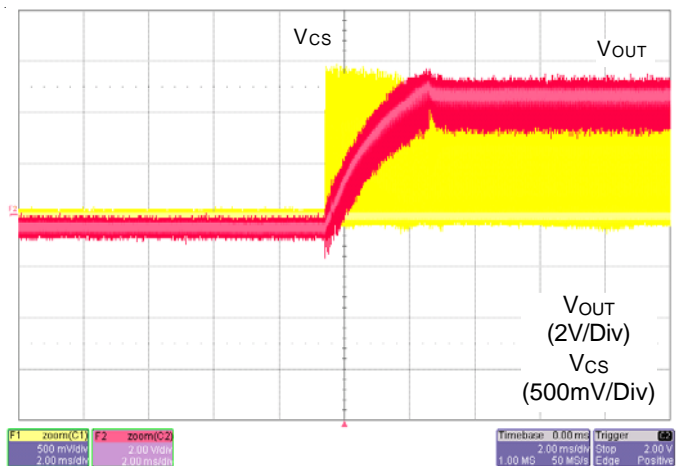


Figure 1. Competitor

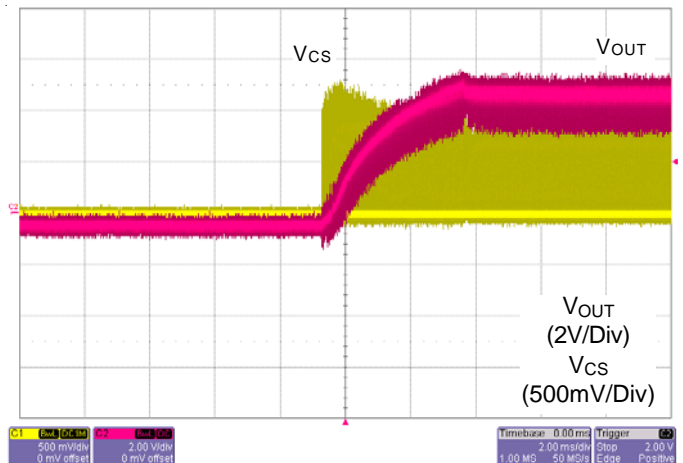


Figure 2. R7731

### Gate Driver

A totem pole gate driver is fine tuned to meet both EMI and efficiency requirement in low power application. An internal pull low circuit is activated after pretty low VDD to prevent external MOSFET from accidentally turning on during UVLO.



**Burst Triple-Mode**

To fulfill green mode requirement, there are 3 operation modes in R7731. Please also refer to Figure. 3 for details.

- **PWM Mode** : For most of load condition, the circuit will run at traditional PWM current mode.
- **Burst Mode** : During light load, switching loss will dominate the power efficiency calculation. This mode is to cut switching loss. As shown in Figure 3, 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 VDD drops down to VDD turn off threshold voltage, the system will be shutdown. 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.

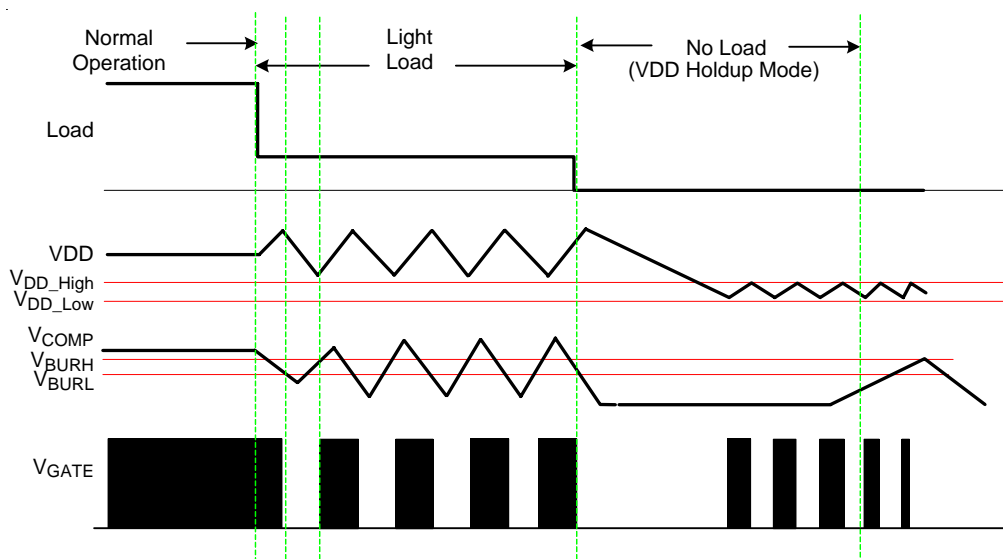


Figure 3. Burst Triple-Mode

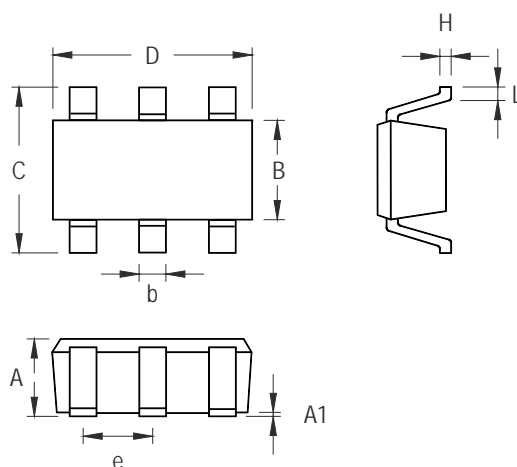
**Protection**

R7731 provides fruitful protection functions that intend to protect system from being damaged. All the protection function can be listed as below:

- **Cycle-by-Cycle Current Limiting** : This is a basic but very useful function and it can be implemented easily in current mode controller.
- **Overload Protection** : Long time cycle-by-cycle current limiting will lead to system thermal stress. To further protect system, system will be shutdown after about 2048 clock cycles. It's about 30ms delay in 67kHz operation. After shutdown, system will resume and behave as hiccup. By proper startup resistor design, thermal will be averaged to an acceptable level over the ON/OFF cycle of IC. This will last until fault is removed.

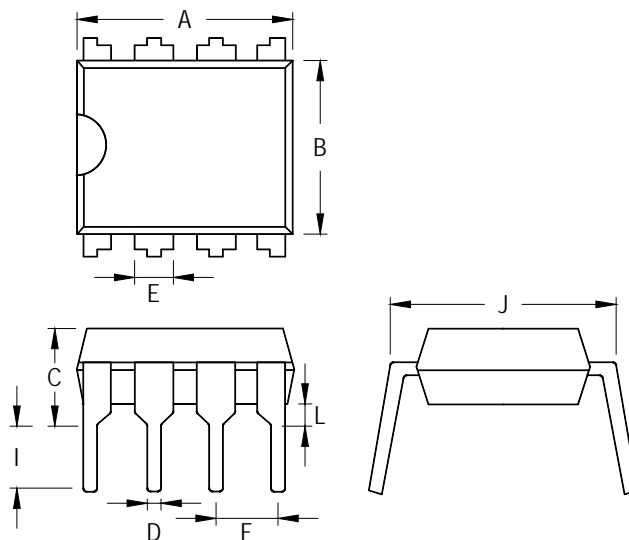
- **Brownout Protection** : During heavy load, this will trigger 30ms protection and shutdown the system. If it's in light load condition, system will be shutdown after VDD is running low and triggers UVLO.
- **OVP** : Output voltage can be roughly sensed by VDD pin. If the sensed voltage reaches 27V threshold, system will be shutdown after 20us deglitch delay.
- **Feedback Open and Opto Coupler Short** : This will trigger OVP or 30ms delay protection. It depends on which one occurs first.
- **OTP** : Internal 110/140°C hysteresis comparator will provide over temperature protection (OTP). OTP will not shutdown system. It stops the system from switching until the temperature is under 110°C. Meanwhile, if VDD touches VDD turn off threshold voltage, system will hiccup.

## Outline Dimension



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min                       | Max   | Min                  | Max   |
| A      | 0.889                     | 1.295 | 0.031                | 0.051 |
| A1     | 0.000                     | 0.152 | 0.000                | 0.006 |
| B      | 1.397                     | 1.803 | 0.055                | 0.071 |
| b      | 0.250                     | 0.560 | 0.010                | 0.022 |
| C      | 2.591                     | 2.997 | 0.102                | 0.118 |
| D      | 2.692                     | 3.099 | 0.106                | 0.122 |
| e      | 0.838                     | 1.041 | 0.033                | 0.041 |
| H      | 0.080                     | 0.254 | 0.003                | 0.010 |
| L      | 0.300                     | 0.610 | 0.012                | 0.024 |

SOT-23-6 Surface Mount Package



| 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**

**Richtek Technology Corporation**

Headquarter  
 5F, No. 20, Taiyuen Street, Chupei City  
 Hsinchu, Taiwan, R.O.C.  
 Tel: (8863)5526789 Fax: (8863)5526611

**Richtek Technology Corporation**

Taipei Office (Marketing)  
 8F, No. 137, Lane 235, Paochiao Road, Hsintien City  
 Taipei County, Taiwan, R.O.C.  
 Tel: (8862)89191466 Fax: (8862)89191465  
 Email: marketing@richtek.com