Burst Triple Mode PWM Flyback Controller

General Description

The R7731 is a high performance, low cost, low start-up 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.

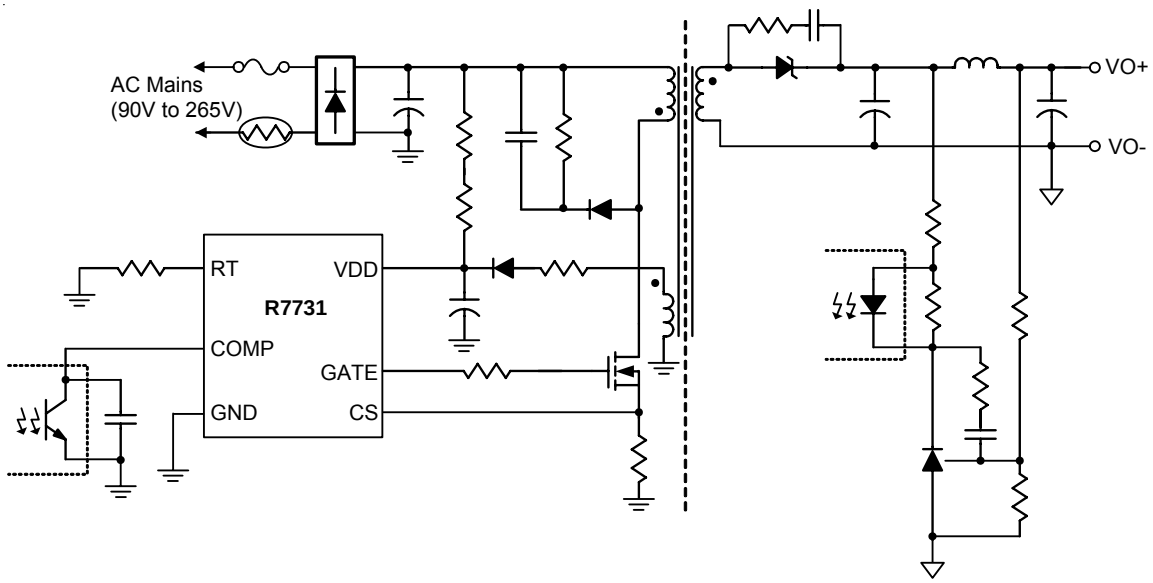
Features

- **Very Low Start-Up Current (<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 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 Halogen 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

R7731□□

- Package Type
  - E : SOT-23-6
  - N : DIP-8
- Lead Plating System
  - G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

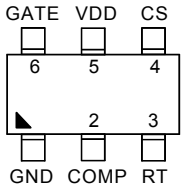
- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

Marking Information

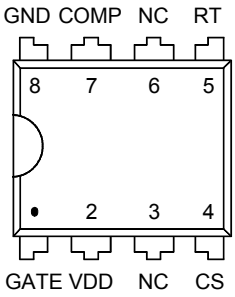
For marking information, contact our sales representative directly or through a Richtek distributor located in your area.

Pin Configurations

(TOP VIEW)

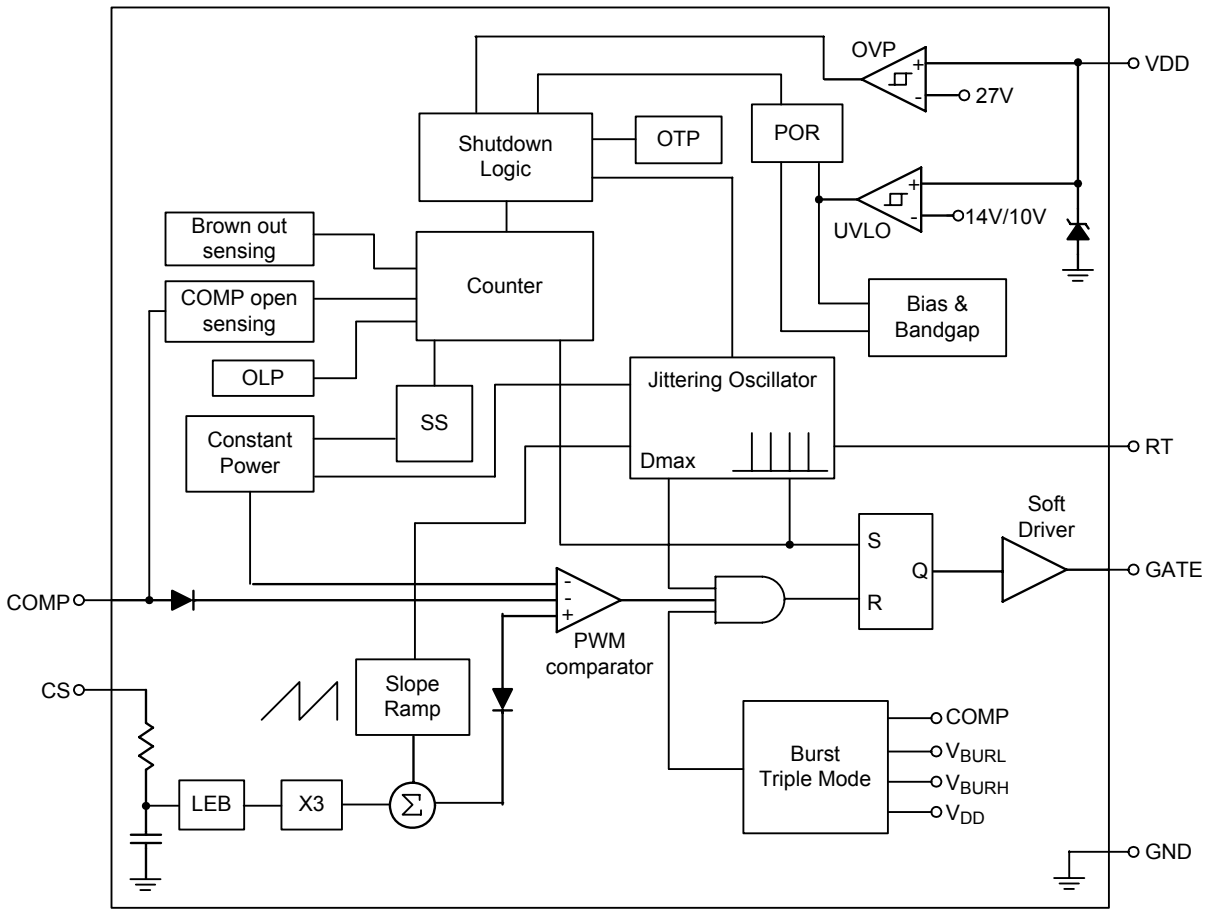


SOT-23-6



DIP-8

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°C
  SOT-23-6 ---------- 0.4W
  DIP-8 ---------- 0.714W
- Package Thermal Resistance (Note 2)
- SOT-23-6, θ_{JA} ---------- 250°C/W
- DIP-8, θ_{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 3)
  HBM (Human Body Mode) ---------- 4kV
  MM (Machine Mode) ---------- 250V

Recommended Operating Conditions (Note 4)

- 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 = 100kΩ, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
V_{DD} 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_{DD_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}	V_{DD} = 15V, R_T = 100kΩ, 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
Oscillator Section (RT pin)						
Normal PWM Frequency	f_{OSC}	R_T = 100kΩ	60	65	70	kHz
Frequency Jittering Range			--	±4	--	%
Maximum Duty Cycle	D_{MAX}		70	75	80	%

To be continued

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Frequency Variation Versus VDD Deviation	f_{DV}	V_{VDD} = 12V to 25V	--	--	2	%
Frequency Variation Versus Temperature Deviation	f_{DV}	T_A = –30°C to 105°C (Note 5)	--	--	5	%
COMP Input Section						
Open Loop Voltage	$V_{COMP-OP}$	COMP pin Open	5	5.5	6	V
COMP Open Loop Protection Delay Cycles	T_{OLP}	R_T = 100kΩ	--	29	--	ms
Short Circuit COMP Current	I_{ZERO}	V_{COMP} = 0V	--	1.2	2.2	mA
Current Sense Section						
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
GATE Section						
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	--	--	°C
OTP Hysteresis	T_{OTP_hys}		--	30	--	°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.

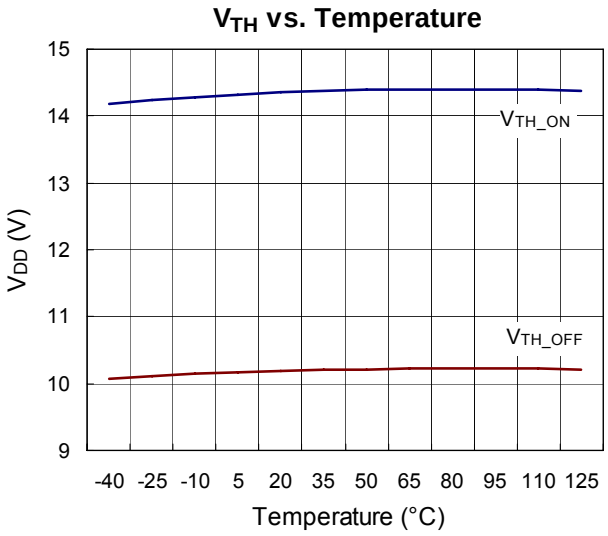
Note 2. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

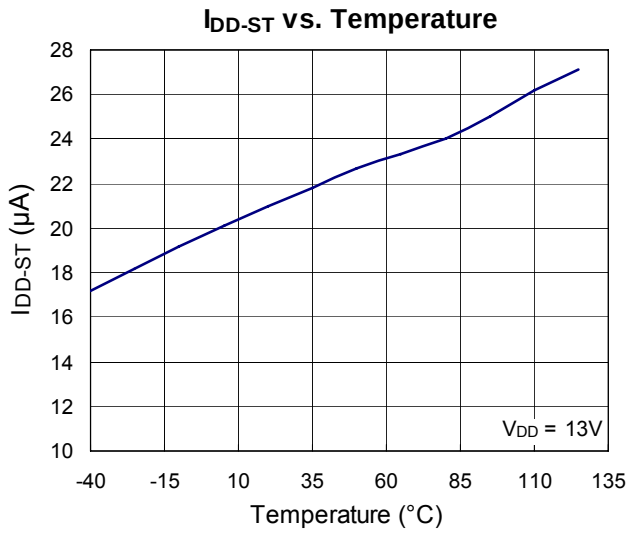
Note 3. Devices are ESD sensitive. Handling precaution is recommended.

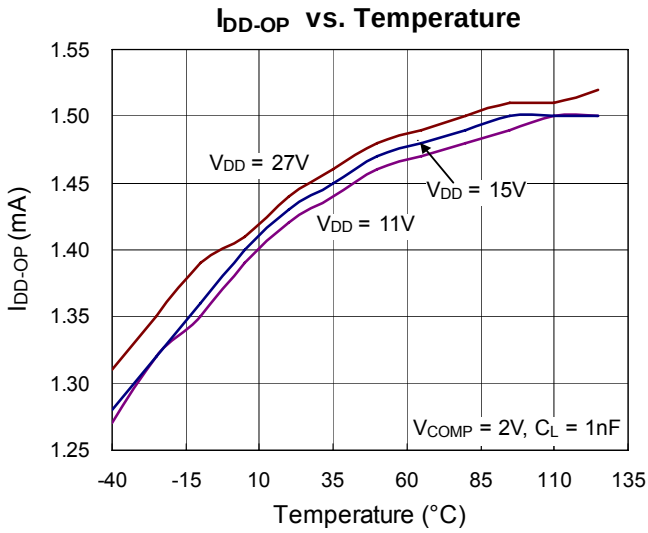
Note 4. The device is not guaranteed to function outside its operating conditions.

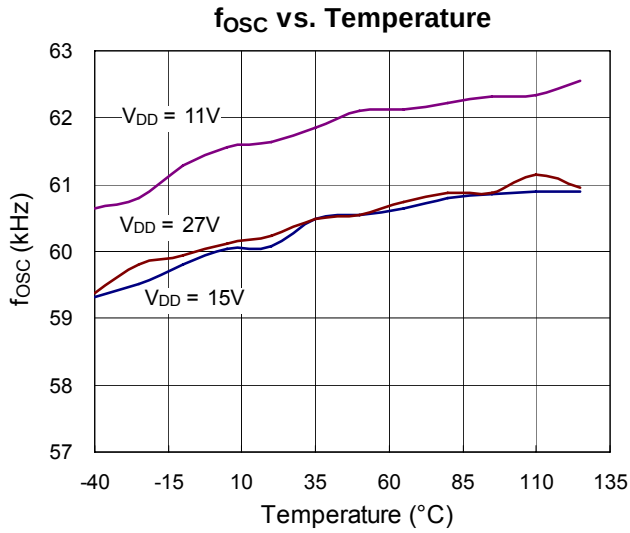
Note 5. Guaranteed by design.

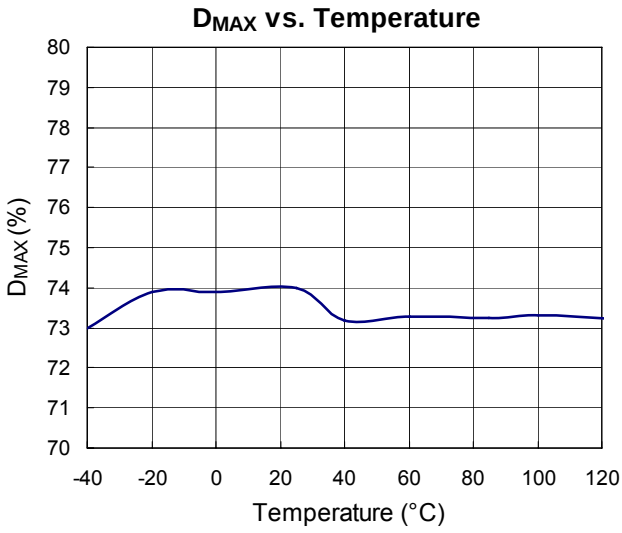
Typical Operating Characteristics

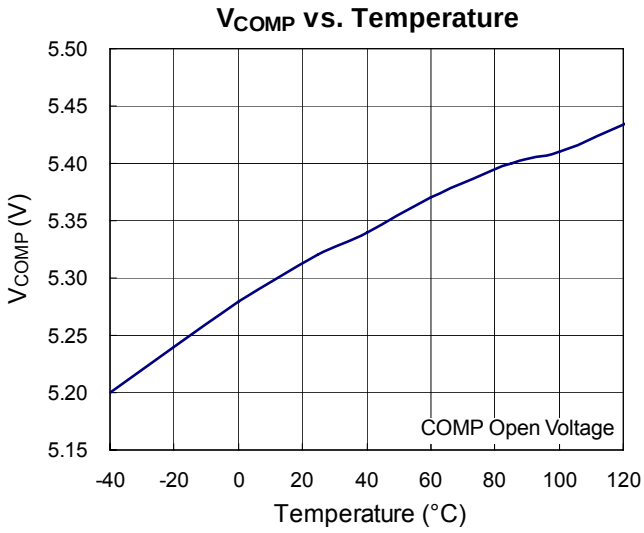




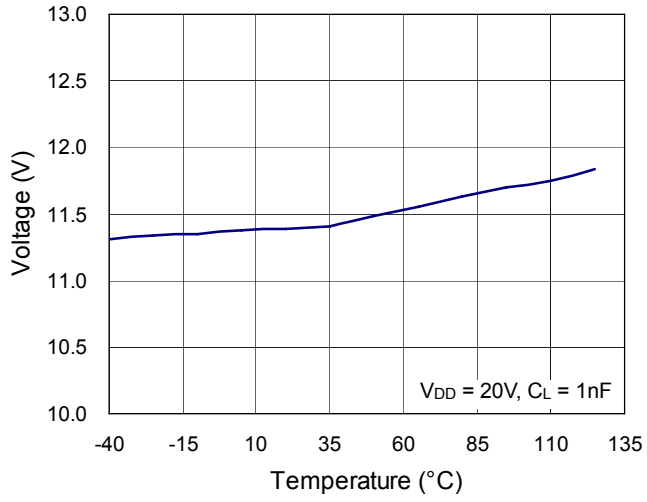




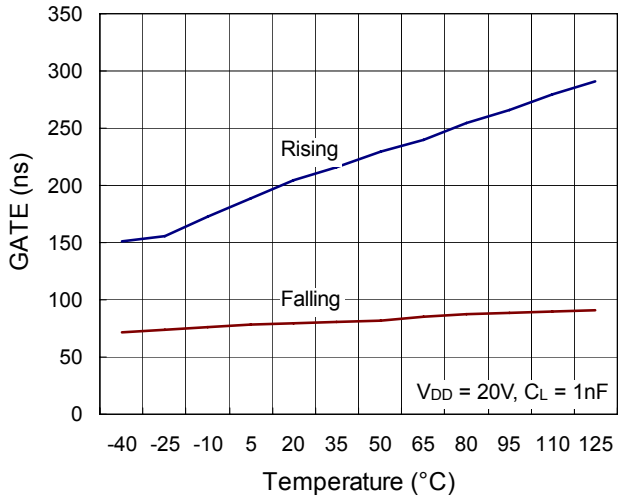




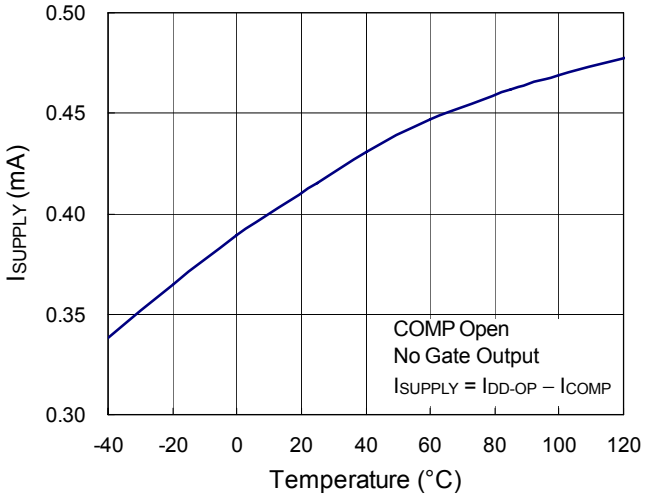
Clamp Voltage vs. Temperature



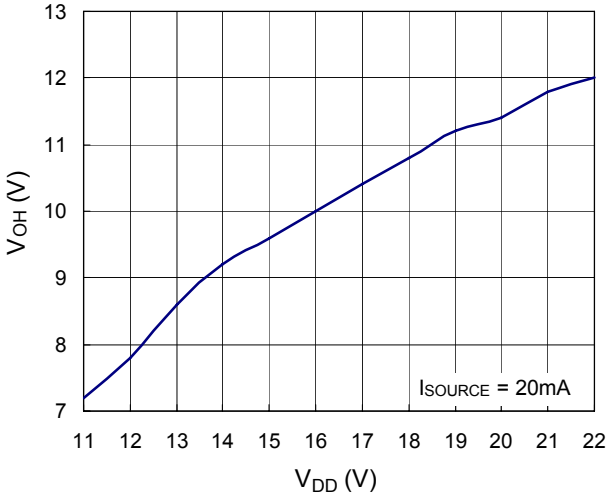
GATE (Rising/Falling) vs. Temperature



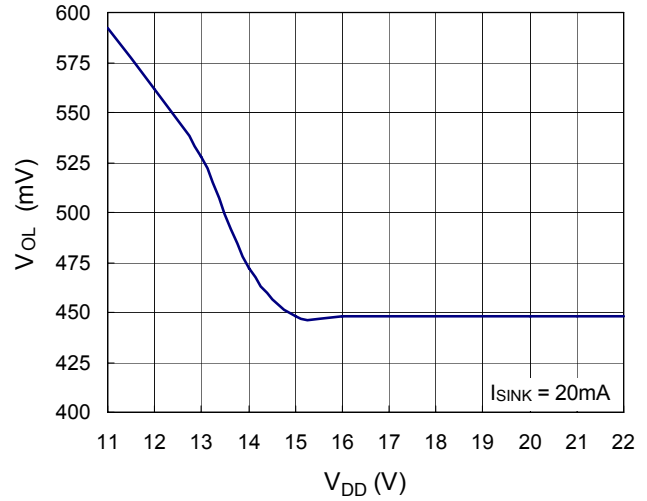
I_{SUPPLY} vs. Temperature



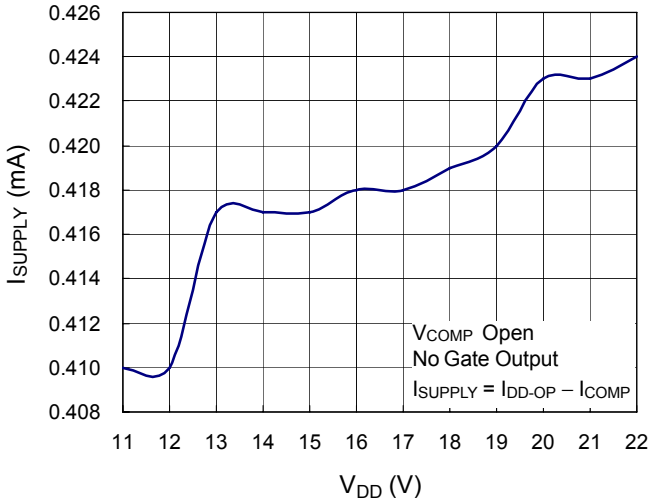
V_{OH} vs. V_{DD}



V_{OL} vs. V_{DD}



I_{SUPPLY} vs. V_{DD}



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.

Jittering Oscillator

For batter EMI performance, R7731 will operate the system with ±4% 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.

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 V_{CS} is about 0.3V lower than competitor. Again, this will provide more reliable operation and possibility to use smaller current rating power MOSFET.

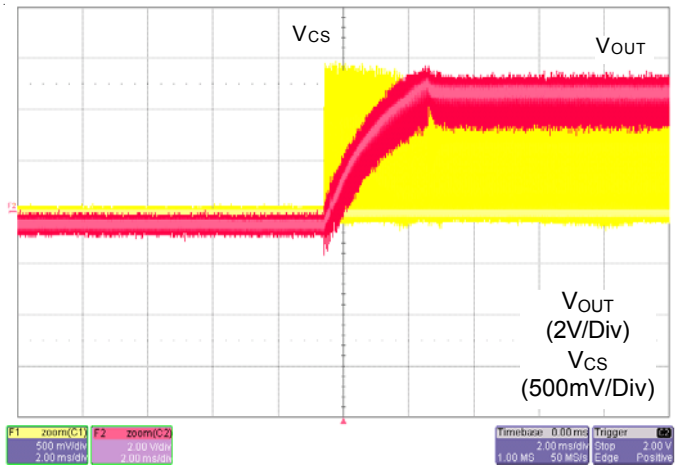


Figure 1. Competitor

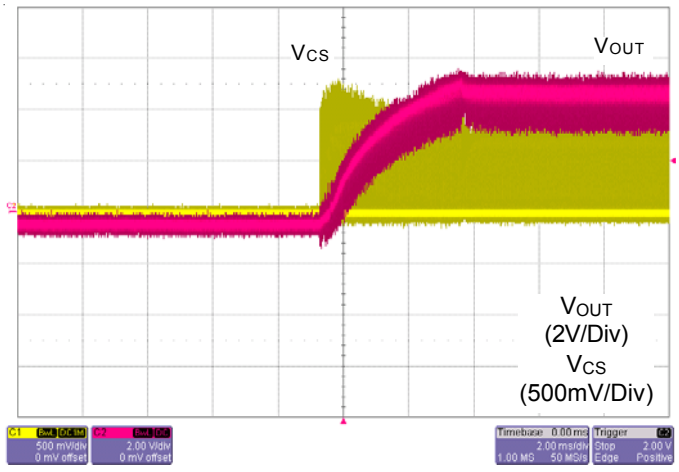


Figure 2. R7731

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.

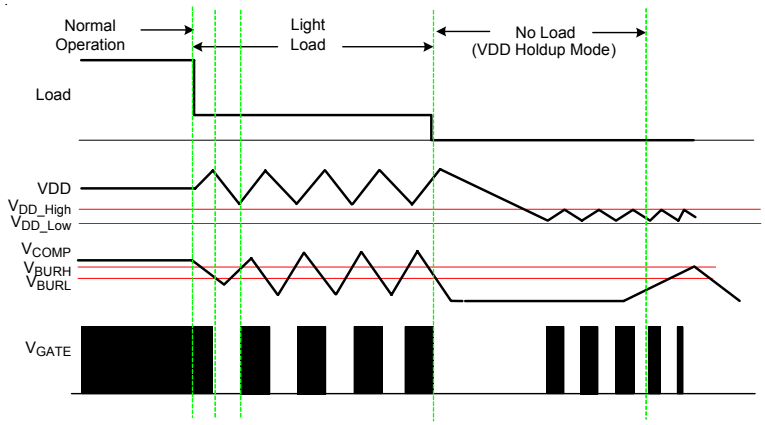


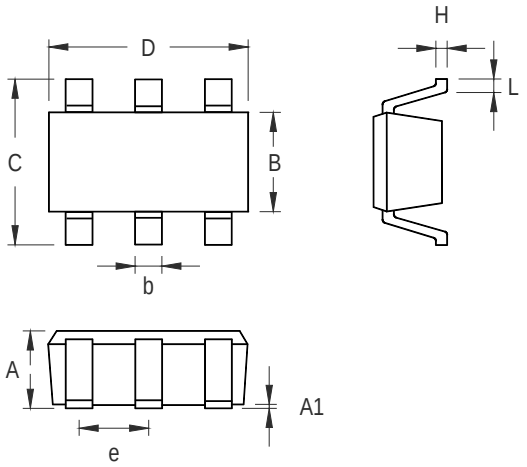
Figure 3. Burst Triple Mode

Protection

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

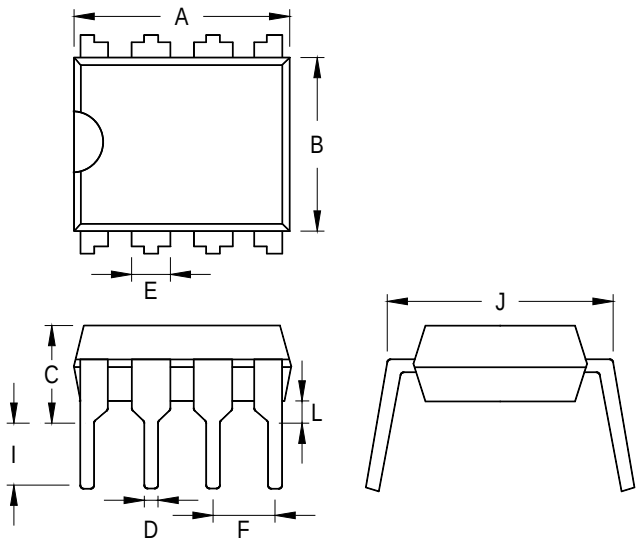
- **Cycle-by-Cycle Current Limiting :** This is a basic but very useful function and it can be implemented easily in current mode controller.
- **Overload Protection :** Long time cycle-by-cycle current limiting will lead to system thermal stress. To further protect system, system will be shutdown after about 2048 clock cycles. It′ s about 30ms delay in 67kHz operation. After shutdown, system will resume and behave as hiccup. By proper 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.
- **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 OTP function will protect the controller itself from suffering thermal stress and permanent damage. It stops the system from switching until the temperature is under threshold level. Meanwhile, if VDD reaches VDD turn off threshold voltage, system will hiccup till over temperature condition is gone.

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

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