

## Synchronous-Rectified Buck MOSFET Drivers

### General Description

The RT9600 is a high frequency, dual MOSFET driver specifically designed to drive two power N-Channel MOSFETs in a synchronous-rectified buck converter topology. This driver combined with the RT9237/RT9241 series of Multi-Phase Buck PWM controller form a complete core-voltage regulator solution for advanced microprocessors.

The RT9600 drives both the lower/upper gate in a synchronous-rectifier bridge with 12V. Independent driving of upper gate through PVCC pin is achievable. This drive-voltage flexibility provides the advantage of optimizing applications involving trade-offs between switching losses and conduction losses.

The output drivers in the RT9600 can efficiently switch power MOSFETs at frequency up to 500kHz. Switching frequency above 500kHz has to take into account the thermal dissipation of SOP-8 package. RT9600 is capable of driving a 3000pF load with a 30ns rise time. RT9600 implements bootstrapping on the upper gate with only an external capacitor required. This reduces implementation complexity and allows the use of higher performance, cost effective, N-Channel MOSFETs. Adaptive shoot-through protection is integrated to prevent both MOSFETs from conducting simultaneously.

### Ordering Information

RT9600□ □

- Package Type  
S : SOP-8
- Operating Temperature Range  
C : Commercial Standard  
P : Pb Free with Commercial Standard

Note :

RichTek Pb-free 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.

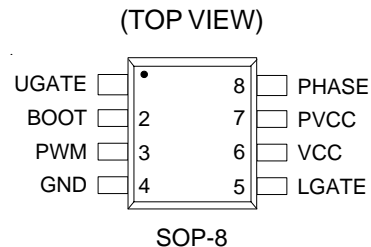
### Features

- Drives Two N-Channel MOSFETs
- Adaptive Shoot-Through Protection
- Internal Bootstrap Device
- Supports High Switching Frequency
  - Fast Output Rise Time
- Small SOP-8 Package
- Dual Gate-Drive Voltages for Optimal Efficiency
- Tri-State Input for Bridge Shutdown
- Supply Under Voltage Protection
- RoHS Compliant and 100% Lead (Pb)-Free

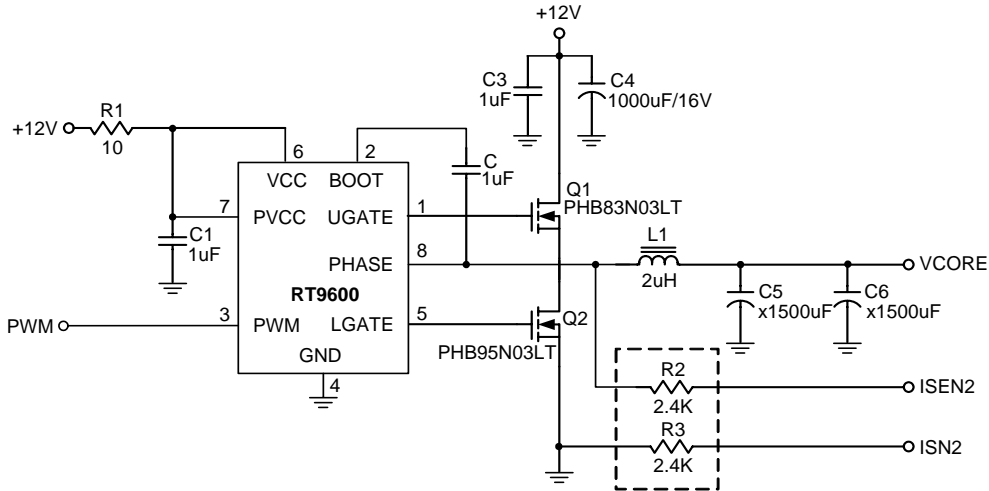
### Applications

- Core Voltage Supplies for Intel Pentium® 4, AMD® Athlon™ Microprocessors
- High Frequency Low Profile DC-DC Converters
- High Current Low Voltage DC-DC Converters

### Pin Configurations



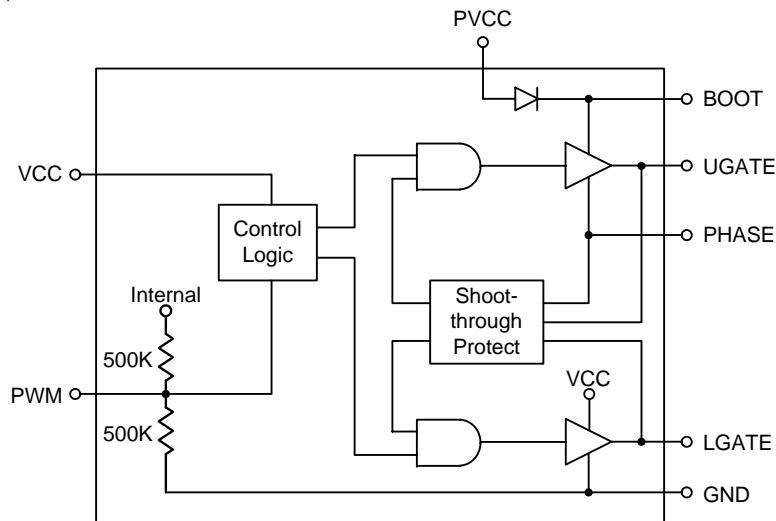
Typical Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	UGATE	Upper Gate Drive Output. Connect to gate of high-side power N-Channel MOSFET
2	BOOT	Floating bootstrap supply pin for upper gate drive.
3	PWM	Input PWM signal for controlling the driver.
4	GND	Ground
5	LGATE	Lower gate drive output. Connect to gate of low-side power N-Channel MOSFET.
6	VCC	+12V Supply Voltage
7	PVCC	Upper Gate Drive Supply Bias. Typical +12V
8	PHASE	Connect this pin to the source of the high-side MOSFET and the drain of the low-side MOSFET

Function Block Diagram



**Absolute Maximum Ratings**

- Supply Voltage,  $V_{CC}$  ----- 15V
- Supply Voltage,  $PV_{CC}$  -----  $V_{CC} + 0.3V$
- BOOT Voltage ( $V_{boot}$ - $V_{phase}$ ) ----- 15V
- PWM Input Voltage ----- GND - 0.3V to 7V
- PHASE to GND
  - DC ----- -5V to 15V
  - < 200ns ----- -10V to 30V
- BOOT to PHASE ----- 15V
- BOOT to GND
  - DC ----- -0.3V to  $V_{CC}+15V$
  - < 200ns ----- -0.3V to 42V
- UGATE -----  $V_{PHASE} - 0.3V$  to  $V_{BOOT} + 0.3V$
- LGATE ----- GND - 0.3V to  $V_{PVCC} + 0.3V$
- Power Dissipation,  $P_D$  @  $T_A = 25^\circ C$ 
  - SOP-8 ----- 0.625W
- Package Thermal Resistance
  - SOP-8,  $\theta_{JA}$  -----  $160^\circ C/W$
- Ambient Temperature Range -----  $0^\circ C$  to  $70^\circ C$
- Junction Temperature -----  $0^\circ C$  to  $125^\circ C$
- Storage Temperature Range -----  $-40^\circ C$  to  $150^\circ C$
- Lead Temperature (Soldering, 10 sec.) -----  $260^\circ C$
- EDS Level
  - HBM (Human Body Mode) ----- 2kV
  - MM (Machine Mode) ----- 200V

**Electrical Characteristics**

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
<b><math>V_{CC}</math> Supply Current</b>						
Bias Supply Current	$I_{VCC}$	$f_{PWM} = 250kHz$ , $V_{PVCC} = 12V$ , $C_{boot} = 0.1\mu F$ , $R_{phase} = 20\Omega$	--	5.2	6	mA
Power Supply Current	$I_{PVCC}$	$f_{PWM} = 500kHz$ , $V_{PVCC} = 12V$ , $C_{boot} = 0.1\mu F$ , $R_{phase} = 20\Omega$	--	3.7	5	mA
<b>Power-On Reset</b>						
$V_{CC}$ Rising Threshold			9.1	9.6	10	V
$V_{CC}$ Falling Threshold			7.5	8.1	8.5	V
<b>Output</b>						
Upper Drive Source	$R_{UGATE}$	$V_{VCC} = 12V$ , $V_{PVCC} = 12V$	--	1.5	--	$\Omega$
Upper Drive Sink	$R_{UGATE}$	$V_{VCC} = 12V$ , $V_{PVCC} = 12V$	--	1.45	2	$\Omega$
Lower Drive Source	$R_{LGATE}$	$V_{VCC} = 12V$ , $V_{PVCC} = 12V$	--	1.6	--	$\Omega$
Lower Drive Sink	$R_{LGATE}$	$V_{VCC} = V_{PVCC} = 12V$	--	0.75	1	$\Omega$

*To be continued*

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
<b>PWM Input</b>						
Maximum Input Current		$V_{PWM} = 0$ or $5V$	--	60	--	$\mu A$
PWM Floating Voltage		$V_{CC} = 12V$	--	1.9	--	V
PWM Rising Threshold			--	3.7	--	V
PWM Falling Threshold			--	1.1	--	V
UGATE Rise Time		$V_{PVCC} = V_{VCC} = 12V, 3nF$ load	--	30	--	ns
LGATE Rise Time		$V_{PVCC} = V_{VCC} = 12V, 3nF$ load	--	30	--	ns
UGATE Fall Time		$V_{PVCC} = V_{VCC} = 12V, 3nF$ load	--	40	--	ns
LGATE Fall Time		$V_{PVCC} = V_{VCC} = 12V, 3nF$ load	--	30	--	ns
UGATE Turn-Off Propagation		$V_{PVCC} = V_{VCC} = 12V, 3nF$ load	--	60	--	ns
LGATE Turn-Off Propagation		$V_{PVCC} = V_{VCC} = 12V, 3nF$ load	--	45	--	ns
Shutdown Window			1.1	--	3.7	V

### Application Information

The RT9600 is designed to drive both high side and low side N-channel MOSFET through externally input PWM control signal. It has power on protection function which held UGATE and LGATE low before  $V_{CC}$  up across the rising threshold voltage. After the initialization, the PWM signal takes the control. The rising PWM signal first forces the LGATE signal turns low then UGATE signal is allowed to go high just after a non-overlapping time to avoid shoot-through current. The falling of PWM signal first forces UGATE to go low. When UGATE and PHASE signal reach a predetermined low level, LGATE signal is allowed to turn high. The non-overlapping function is also presented between UG and LG signal transient.

The PWM signal is recognized as high if above rising threshold and as low if below falling threshold. Any signal level in this window is considered as tri-state, which causes turn-off of both high side and low-side MOSFET. When PWM input is floating (not connected), internal divider will pull the PWM to 1.9V to give the controller a recognizable level. The maximum sink/source capability of internal PWM reference is  $60\mu A$ .

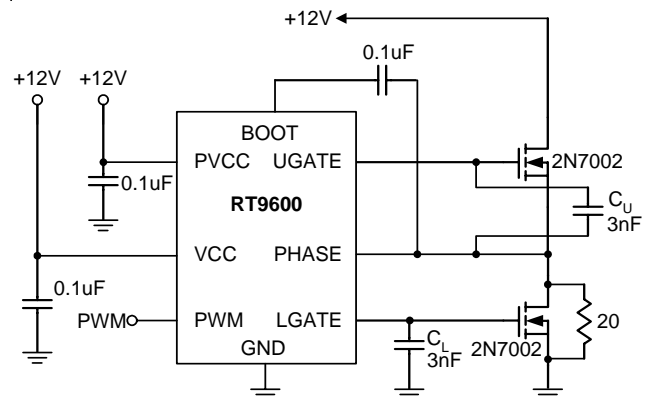
The PVCC pin provides flexibility of high side MOSFET gate drive voltage. If 8V, for example, is applied to PVCC, then high side MOSFET gate drive is 8V-1.5V (approximately, internal diode plus series resistance voltage drop).

The RT9600 typically operates at frequency of 200~250kHz. A 1N4148 diode connecting PVCC and BOOT is recommended for higher operating frequency.

### Test Conditions

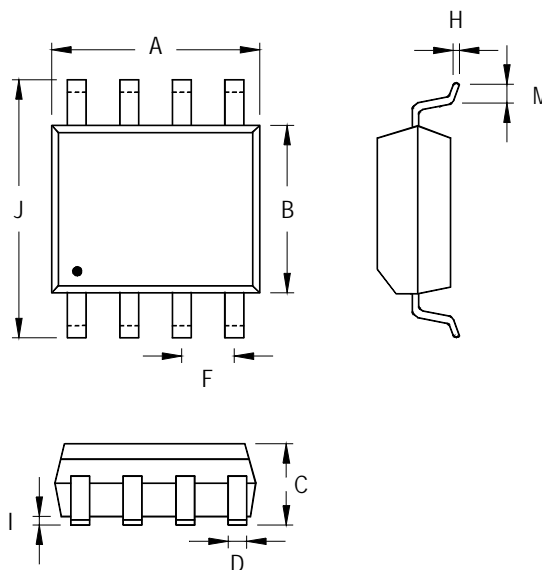
The  $C_U$  and  $C_L$  capacitors in the test circuit are high side and low side low capacitors. The  $20\Omega$  resistor between PHASE and ground is implemented as the load of the buck converter.

For output resistance, typical voltage/current measurements are made to calculate the  $R_{DS(ON)}$ . It should be noted that source of both high side and low side drivers are both current controlled current sources, the output resistance is acquired by interpolation.



Test Circuit

**Outline Dimension**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.801	5.004	0.189	0.197
B	3.810	3.988	0.150	0.157
C	1.346	1.753	0.053	0.069
D	0.330	0.508	0.013	0.020
F	1.194	1.346	0.047	0.053
H	0.178	0.254	0.007	0.010
I	0.102	0.254	0.004	0.010
J	5.791	6.198	0.228	0.244
M	0.406	1.270	0.016	0.050

**8-Lead SOP Plastic Package**

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