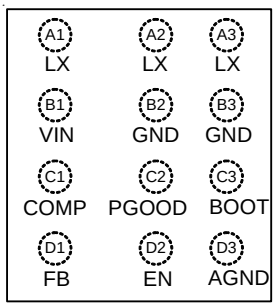
6A, 17V, 500kHz CSP Synchronous Step-Down Converter

General Description

The RT7271A is a high efficiency, synchronous step-down DC/DC converter for applications operating from 4.5V to 17V and requiring up to 6A maximum load. The current mode architecture of RT7271A allows the transient response to be optimized. Cycle-by-cycle current limit provides protection against shorted output and soft-start eliminates input current surge during start-up. Fault conditions also include output under voltage protection, output over voltage protection, and thermal shutdown. The low current shutdown mode provides output disconnect, enabling easy power management in battery powered systems.

Pin Configurations

(TOP VIEW)



WL-CSP-12B 1.65x1.95 (BSC)

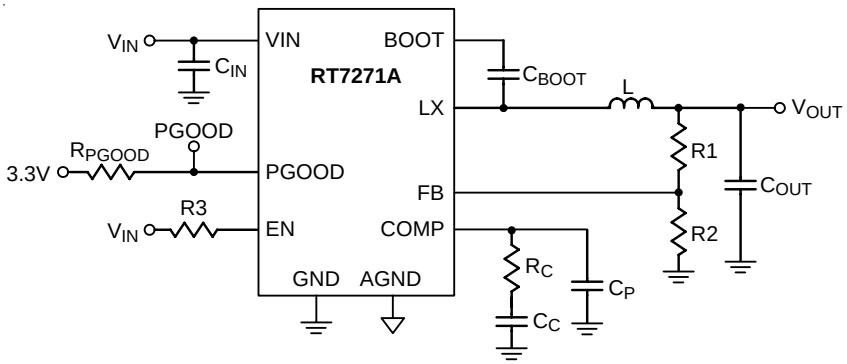
Features

- **4.5V to 17V Input Voltage Range**
- **6A Output Current**
- **Current Mode Control**
- **0.6V ± 1% Voltage Reference Over Temperature**
- **Latch Off when Short Circuit**
- **Monotonic Start-Up in Pre-biased Output**
- **500kHz Switching Frequency**
- **Low On-Resistance**
  - **45mΩ of High Side MOSFET**
  - **25mΩ of Low Side MOSFET**
- **Cycle-by-Cycle Current Limit**
- **Power Good Monitor for UVP & OVP**
- **Input Under Voltage Lockout**
- **Thermal Shutdown**
- **RoHS Compliant and Halogen Free**

Applications

- Industrial and Commercial Low Power Systems
- Computer Peripherals
- LCD Monitors and TVs
- Point of Load Regulation for High Performance DSPs, FPGAs and ASICs
- Green Electronics/Appliances

Simplified Application Circuit



Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Ordering Information

RT7271A □

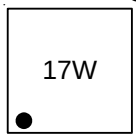
Package Type
WSC : WL-CSP-12B 1.65x1.95 (BSC)

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



17 : Product Code

W : Date Code

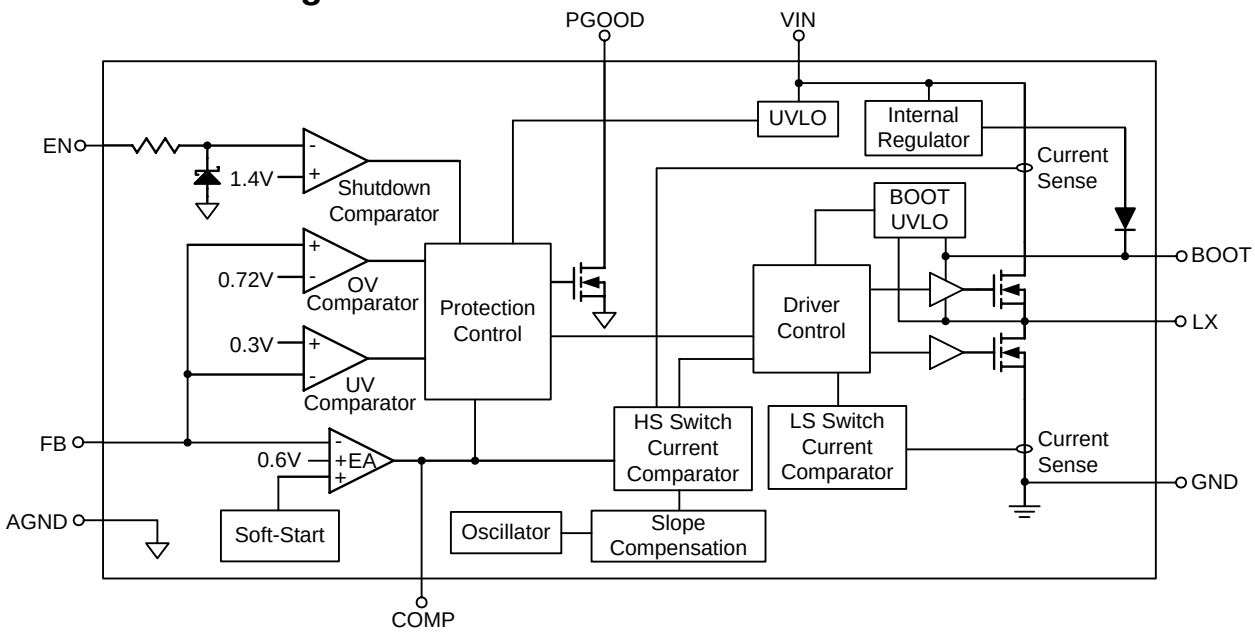
Functional Pin Description

Pin No.	Pin Name	Pin Function
A1, A2, A3	LX	Switch Node. Connect this pin to the external inductor.
B1	VIN	Power Input. Connect two 10μF or larger ceramic capacitors to this pin.
B2, B3	GND	Power Ground.
C1	COMP	Compensation Node. Connect external compensation elements to this pin to stabilize the control loop.
C2	PGOOD	Power Good Indicator Output. Asserts low if output voltage is low due to OTP, UVP, UVLO, OVP, EN shutdown or during soft-start.
C3	BOOT	Bootstrap Supply for the High Side MOSFET. Connect a capacitor between this pin and LX pin.
D1	FB	Feedback Voltage Input. This pin receives the feedback voltage from a resistive divider connected across the output.
D2	EN	Enable Control Input. Connecting this pin to ground forces the device into shutdown mode. Pulling this pin over 1.4V enables the device.
D3	AGND	Analog Ground.

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Function Block Diagram



Operation

The RT7271A is a constant frequency, current mode synchronous step-down converter. In normal operation, the high side N-MOSFET is turned on when the driver control is set by the oscillator and is turned off when the current comparator resets the driver control. While the high side N-MOSFET is turned off, the low side N-MOSFET is turned on to conduct the inductor current until next cycle begins.

Error Amplifier

The error amplifier adjusts its output voltage by comparing the feedback signal (V_{FB}) with the internal 0.6V reference. When the load current increases, it causes a drop in the feedback voltage relative to the reference, the error amplifier's output voltage then rises to allow higher inductor current to match the load current.

Oscillator

The internal oscillator runs at fixed frequency 500kHz.

Internal Regulator

The regulator provides low voltage power to supply the internal control circuits and the bootstrap power for high side gate driver.

Enable

The converter is turned on when the EN pin is higher than 1.4V. When the EN pin is lower than 1.15V, the converter will enter shutdown mode.

Soft-Start (SS)

An internal current source charges an internal capacitor to build a soft-start ramp voltage. The FB voltage will track the internal ramp voltage during soft-start interval. The typical soft-start time is 1.5ms.

UV Comparator

If the feedback voltage (V_{FB}) is lower than 0.3V, the UV Comparator will go high to turn off the high side MOSFET. The output under voltage protection is designed to operate in latch mode. When the UV condition is removed, the controller can be reset by EN pin or VIN pin.

Thermal Shutdown

The over temperature protection function will shut down the switching operation when the junction temperature exceeds 160°C. Once the junction temperature cools down by the hysteresis, the converter will automatically resume switching.

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, VIN ---------- –0.3V to 20V
- LX Pin Switch Voltage, V_{LX} ---------- –0.3V to (VIN + 0.3V)
- Boot Voltage, V_{BOOT} ---------- (V_{LX} – 0.3V) to (V_{LX} + 6V)
- EN Voltage, V_{EN} ---------- –0.3V to 3.6V
- Other Pins ---------- –0.3V to 6V
- Power Dissipation, P_D @ T_A = 25°C
  WL-CSP-12B 1.65x1.95 (BSC) ---------- 1.88W
- Package Thermal Resistance (Note 2)
  WL-CSP-12B 1.65x1.95 (BSC), θ_{JA} ---------- 53°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 Model) ---------- 2kV

Recommended Operating Conditions (Note 4)

- Supply Input Voltage, VIN ---------- 4.5V to 17V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{IN} = 12V, T_A = 25°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Shutdown Current		I_{SHDN}	V_{EN} = 0V	--	4	15	μA
VIN UVLO Threshold		V_{IN_TH}	V_{IN} Rising	--	4	4.5	V
VIN UVLO Hysteresis		V_{IN_HYS}		--	250	--	mV
Enable Threshold		V_{ENR}	Rising	--	1.4	1.5	V
Enable Threshold		V_{ENF}	Falling	1.15	1.25	--	V
Quiescent Current		I_Q	V_{FB} = 0.61V	--	0.9	1.2	mA
Feedback Reference Voltage		V_{REF}		0.594	0.6	0.606	V
Switch On-Resistance	High-Side	$R_{DS(ON)\_H}$		--	45	--	mΩ
	Low-Side	$R_{DS(ON)\_L}$		--	25	--	mΩ
Error Amplifier transconductance		gm	–2μ < I_{COMP} < 2μ, V_{COMP} = 1V	--	1600	--	μA/V
Error Amp Source/Sink			V_{COMP} = 1V, 100mV Input Overdrive	--	110	--	μA
COMP to Current Sense transconductance				--	16	--	A/V
High side Switch Peak Current Limit		I_{LIM_H}		8	12	--	A
Minimum On-Time		$T_{ON(MIN)}$		--	100	--	ns

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Thermal Shutdown	T_{SD}		--	160	--	°C
Thermal Shutdown Hysteresis	T_{SD_HYS}		--	10	--	°C
Switching Frequency	f_{SW}		425	500	575	kHz
OVP Threshold			--	120	--	%
Under Voltage Threshold	V_{UVP}		--	50	--	%
Soft-Start Time			--	1.5	--	ms
Power Good Threshold Rising			--	90	--	%
Power Good Threshold Falling			--	85	--	%
Power Good Output High Leakage Current		$V_{FB} = V_{REF}$, V_{PGOOD} = 5.5V	--	30	--	nA
Power Good Output Low		I_{PGOOD} = 2mA	--	--	0.3	V

Note 1. Stresses beyond those listed "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 may affect device reliability.

Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7.

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

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

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Typical Application Circuit

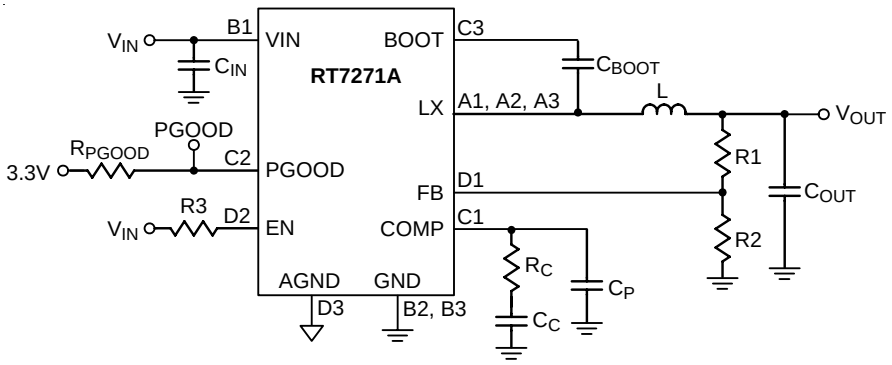


Table 1. Recommended Component Selection

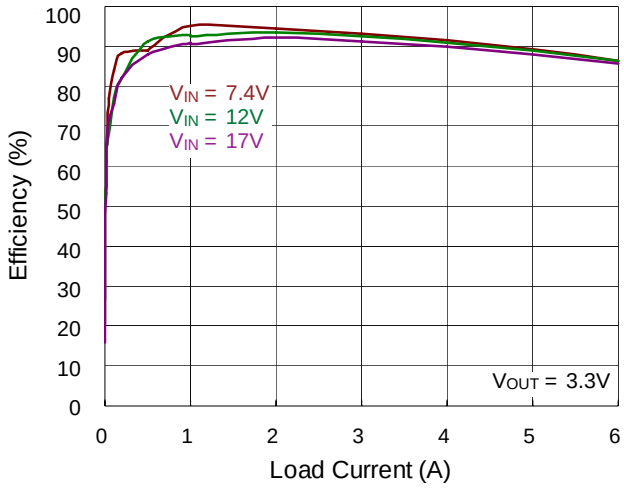
V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)	R_C (kΩ)	C_C (nF)	C_P (pF)	L (μH)	C_{OUT} (μF)
5	73.2	10	8.2	6.8	150	3.3	66
3.3	45.3	10	6.8	3.9	150	3.3	66
2.5	31.6	10	7.5	4.7	150	1.5	66
1.8	20	10	6.2	3.9	150	1.5	66
1.5	15	10	5.6	3.9	150	1.5	66
1.05	7.5	10	3	3.3	150	1.0	66

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

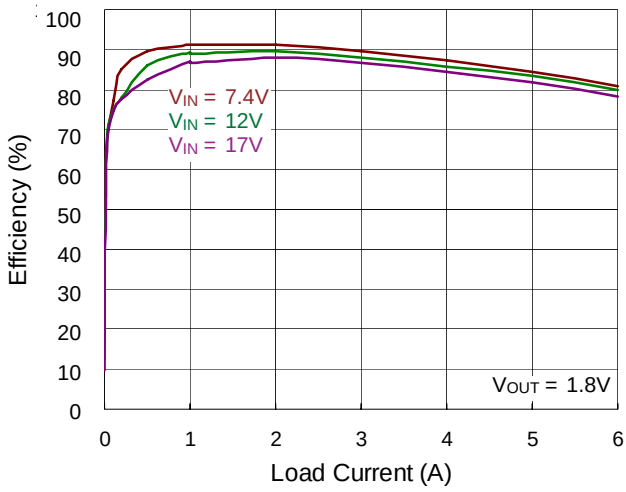
Free Datasheet http://www.datasheet4u.com/

Typical Operating Characteristics

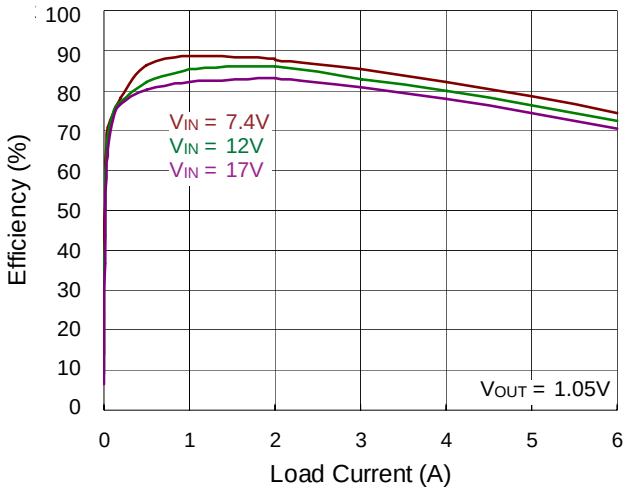
Efficiency vs. Load Current



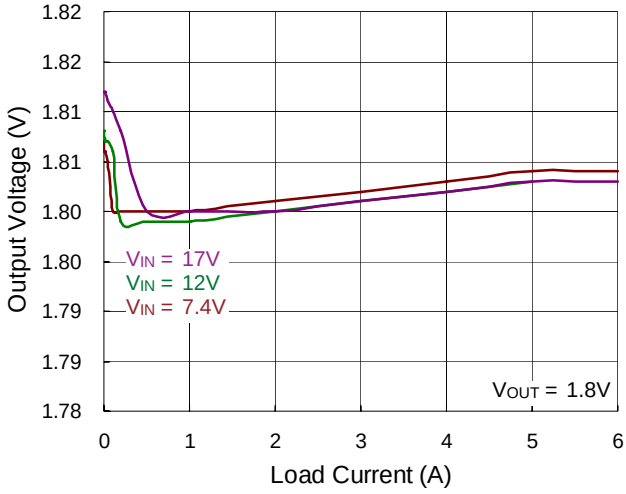
Efficiency vs. Load Current



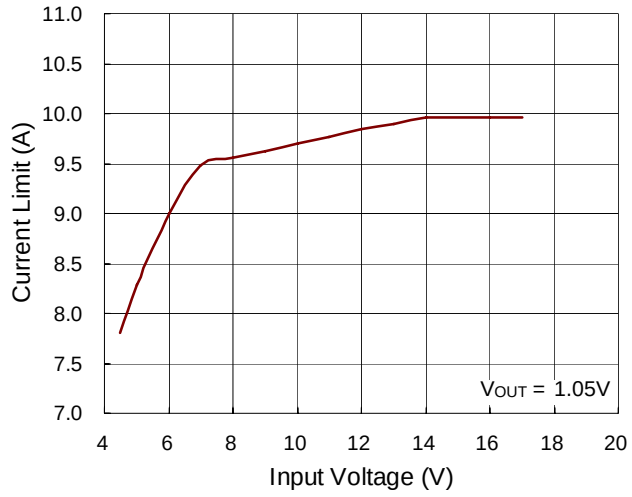
Efficiency vs. Load Current



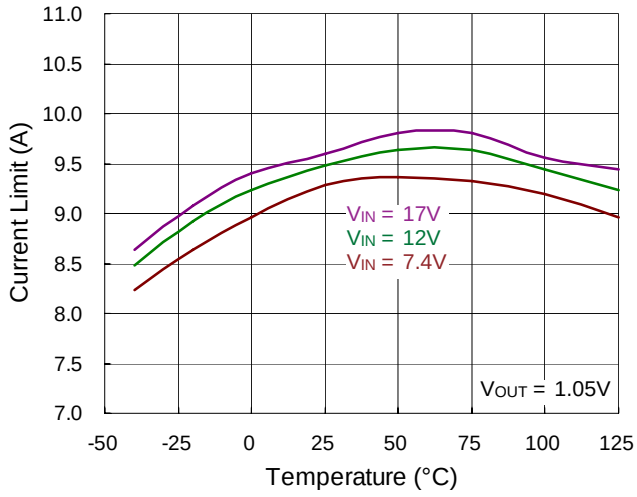
Output Voltage vs. Load Current



Current Limit vs. Input Voltage



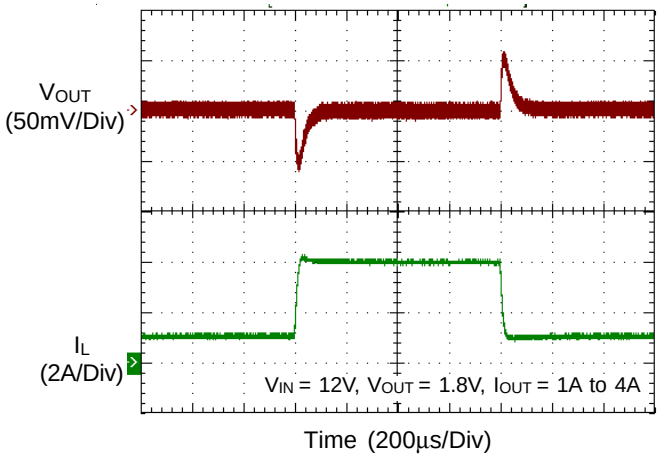
Current Limit vs. Temperature



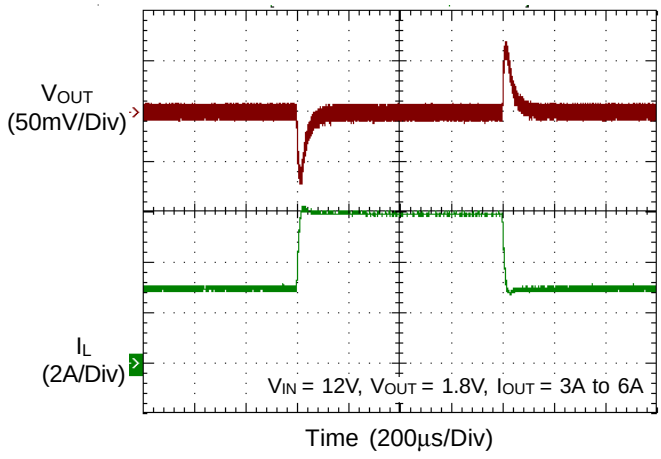
Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

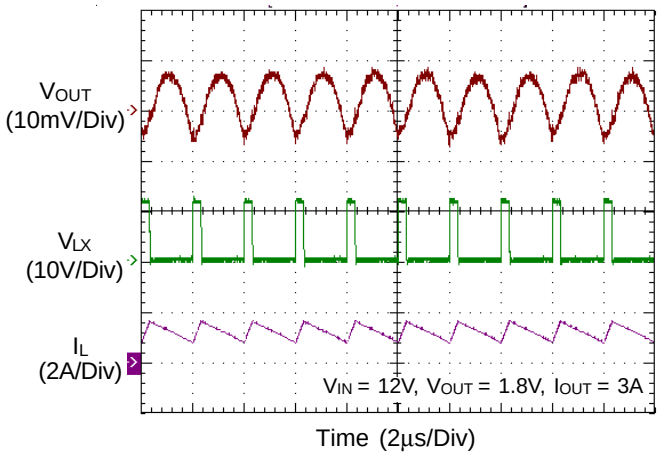
Load Transient Response



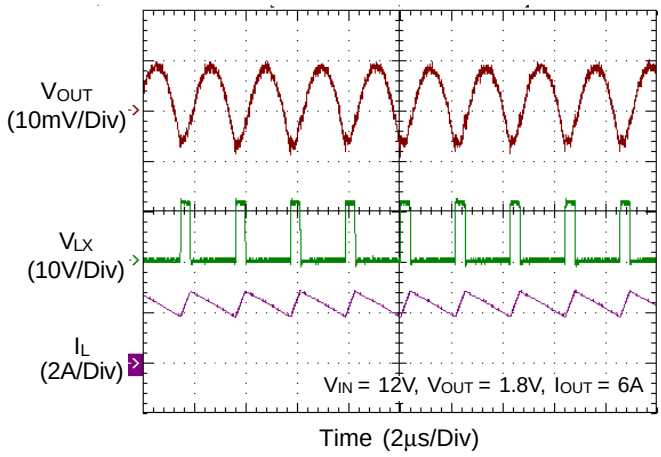
Load Transient Response



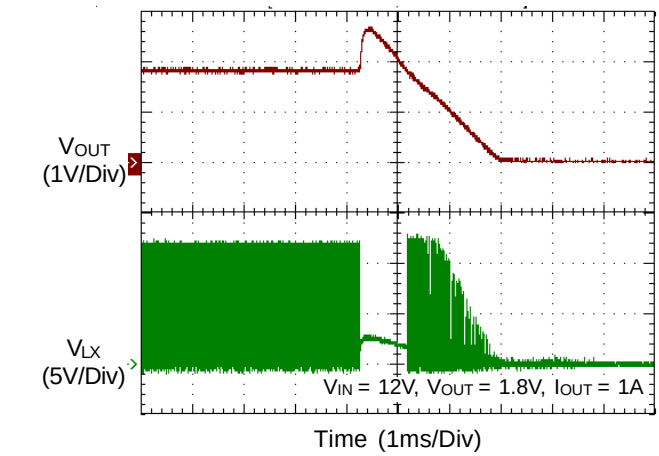
Output Voltage Ripple



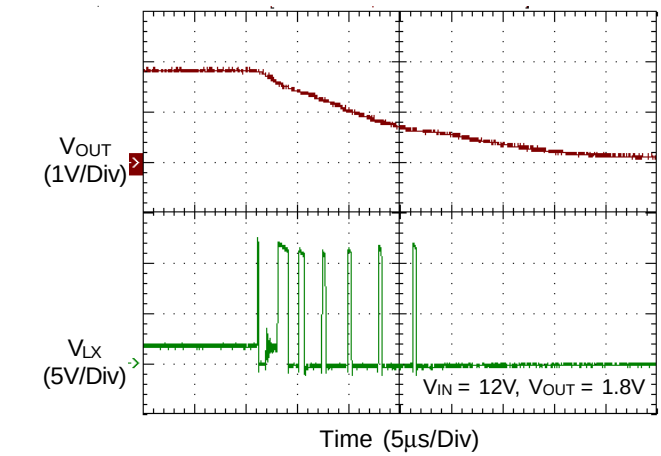
Output Voltage Ripple



Over Voltage Protection



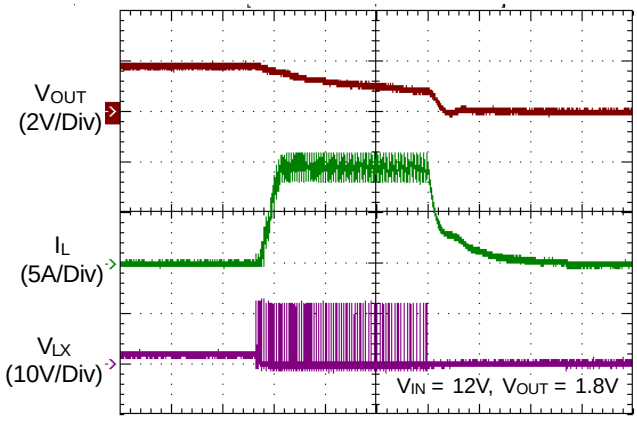
Under Voltage Protection



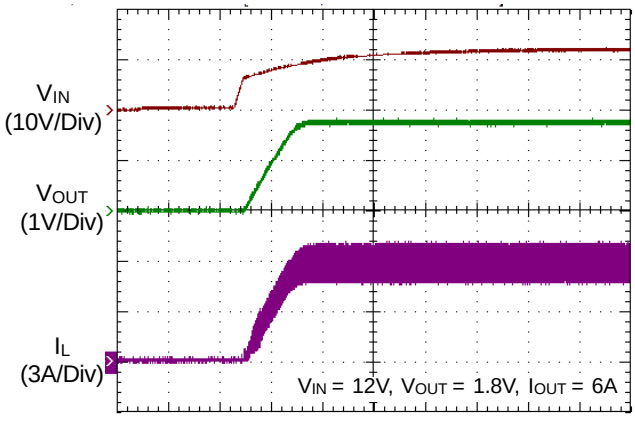
Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

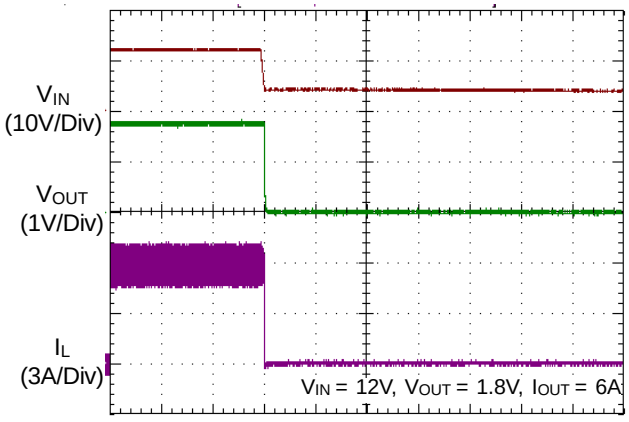
Over Current Protection



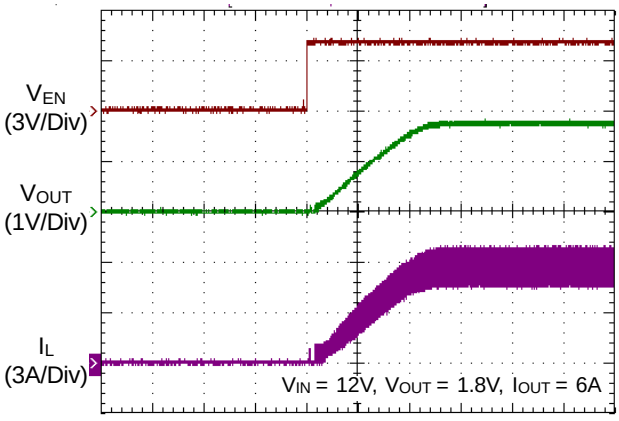
Power On from VIN



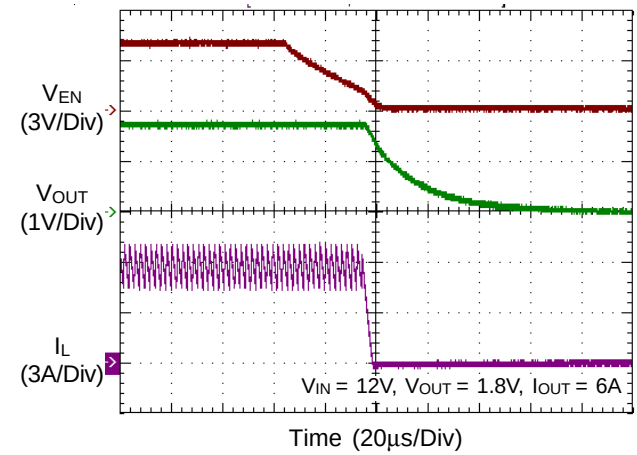
Power Off from VIN



Power On from EN



Power Off from EN



Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Application Information

The RT7271A is a single-phase Buck converter. It provides single feedback loop, current mode control with fast transient response. An internal 0.6V reference allows the output voltage to be precisely regulated for low output voltage applications. A fixed switching frequency (500kHz) oscillator and internal compensation are integrated to minimize external component count. Protection features include over current protection, under voltage protection, over voltage protection and over temperature protection.

Output Voltage Setting

Connect a resistive voltage divider at the FB between V_{OUT} and GND to adjust the output voltage. The output voltage is set according to the following equation :

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R_{FB1}}{R_{FB2}}\right)$$

where V_{REF} is 0.6V (typ.).

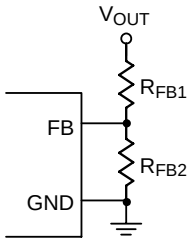


Figure 1. Setting V_{OUT} with a Voltage Divider

Chip Enable and Disable

The EN pin allows for power sequencing between the controller bias voltage and another voltage rail. The RT7271A remains in shutdown if the EN pin is lower than 1.25V. When the EN pin rises above the V_{EN} threshold, the RT7271A begins a new initialization and soft-start cycle.

Internal Soft-Start

The RT7271A provides an internal soft-start function to prevent large inrush current and output voltage overshoot when the converter starts up. The soft-start (SS) automatically begins once the chip is enabled. During soft-start, the internal soft-start capacitor becomes charged and generates a linear ramping up voltage across the capacitor. This voltage clamps the voltage at the FB pin, causing PWM pulse width to increase slowly and in turn reduce the output surge current. The internal 0.6V reference takes over the loop control once the internal ramping up voltage becomes higher than 0.6V.

UVLO Protection

The RT7271A provides input Under Voltage Lockout Protection (UVLO). If the input voltage exceeds the UVLO rising threshold voltage (4V typ.), the converter resets and prepares the PWM for operation. If the input voltage falls below the UVLO falling threshold voltage during normal operation, the device will stop switching. The UVLO rising and falling threshold voltage has a hysteresis to prevent noise-caused reset.

Inductor Selection

The switching frequency (on-time) and operating point (% ripple or LIR) determine the inductor value as shown below:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{f_{SW} \times LIR \times I_{LOAD(MAX)} \times V_{IN}}$$

where LIR is the ratio of the peak-to-peak ripple current to the average inductor current.

Find a low loss inductor having the lowest possible DC resistance that fits in the allotted dimensions. Ferrite cores are often the best choice, although powdered iron is inexpensive and can work well at 200kHz. The core must be large enough and will not saturate at the peak inductor current (I_{PEAK}) :

$$I_{PEAK} = I_{LOAD(MAX)} + \left(\frac{LIR}{2} \times I_{LOAD(MAX)}\right)$$

The calculation above serves as a general reference. To further improve transient response, the output inductor can be further reduced. This relation should be considered along with the selection of the output capacitor.

Input Capacitor Selection

High quality ceramic input decoupling capacitor, such as X5R or X7R, with values greater than 20μF are recommended for the input capacitor. The X5R and X7R ceramic capacitors are usually selected for power regulator capacitors because the dielectric material has less capacitance variation and more temperature stability.

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Voltage rating and current rating are the key parameters when selecting an input capacitor. Generally, selecting an input capacitor with voltage rating 1.5 times greater than the maximum input voltage is a conservatively safe design.

The input capacitor is used to supply the input RMS current, which can be approximately calculated using the following equation :

$$I_{IN\_RMS} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

The next step is selecting a proper capacitor for RMS current rating. A good design uses more than one capacitor with low equivalent series resistance (ESR) in parallel to form a capacitor bank.

The input capacitance value determines the input ripple voltage of the regulator. The input voltage ripple can be approximately calculated using the following equation :

$$\Delta V_{IN} = \frac{I_{OUT(MAX)} \times V_{OUT}}{C_{IN} \times f_{SW} \times V_{IN}}$$

For example, if I_{OUT_MAX} = 6A, C_{IN} = 22µF, f_{SW} = 500kHz, V_{IN} = 12V and V_{OUT} = 1.05V, the input voltage ripple will be 47.7mV.

Output Capacitor Selection

The output capacitor and the inductor form a low pass filter in the Buck topology. In steady state condition, the ripple current flowing into/out of the capacitor results in ripple voltage. The output voltage ripple (V_{P-P}) can be calculated by the following equation :

$$V_{P\_P} = LIR \times I_{LOAD(MAX)} \times \left(ESR + \frac{1}{8 \times C_{OUT} \times f_{SW}}\right)$$

When load transient occurs, the output capacitor supplies the load current before the controller can respond. Therefore, the ESR will dominate the output voltage sag during load transient. The output voltage undershoot (V_{SAG}) can be calculated by the following equation :

$$V_{SAG} = \Delta I_{LOAD} \times ESR$$

For a given output voltage sag specification, the ESR value can be determined.

Another parameter that has influence on the output voltage sag is the equivalent series inductance (ESL). The rapid change in load current results in di/dt during transient. Therefore, the ESL contributes to part of the voltage sag. Using a capacitor with low ESL can obtain better transient performance. Generally, using several capacitors connected in parallel can have better transient performance than using a single capacitor for the same total ESR.

Unlike the electrolytic capacitor, the ceramic capacitor has relatively low ESR and can reduce the voltage deviation during load transient. However, the ceramic capacitor can only provide low capacitance value. Therefore, use a mixed combination of electrolytic capacitor and ceramic capacitor to obtain better transient performance.

Power Good Output (PGOOD)

PGOOD is an open-drain output and requires a pull-up resistor. PGOOD is actively held low in soft-start, standby, and shutdown. It is released when the output voltage rises above 90% of nominal regulation point. The PGOOD signal goes low if the output is turned off or VOUT under 85% of setting.

Under Voltage Protection (UVP)

The output voltage can be continuously monitored for under voltage protection. Both high side and low side gate drivers will be forced to low if the output is less than 50% of its set voltage threshold. The UVP will be ignored for at least 1.5ms (typ.) after start up or a rising edge on the EN threshold. Remove the UVP fault latch by reseting the EN pin and V_{IN} to restart the controller.

Over Voltage Protection (OVP)

The RT7271A is latched once OVP is triggered and can only be released by toggling EN threshold or cycling V_{IN}. There is a 20µs delay built into the over voltage protection circuit to prevent false transition.

Over Current Protection (OCP)

The RT7271A provides over current protection by detecting high side MOSFET peak inductor current. If the sensed peak inductor current is over the current limit threshold (12A typ.), the OCP will be triggered. When OCP is tripped, the RT7271A will keep the over current threshold level until the over current condition is removed.

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Thermal Shutdown (OTP)

The device implements an internal thermal shutdown function when the junction temperature exceeds 160°C. The thermal shutdown forces the device to stop switching when the junction temperature exceeds the thermal shutdown threshold. Once the die temperature decreases below the hysteresis of 10°C, the device reinstates the power up sequence.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications of the RT7271A, the maximum junction temperature is 125°C and T_A is the ambient temperature. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For WL-CSP-12B 1.65x1.95 (BSC), the thermal resistance, θ_{JA}, is 53°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formulas :

$P_{D(MAX)}$ = (125°C – 25°C) / (53°C/W) = 1.88W for WL-CSP-12B 1.65x1.95 (BSC) package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curve in Figure 2 allow the designer to see the effect of rising ambient temperature on the maximum power dissipation.

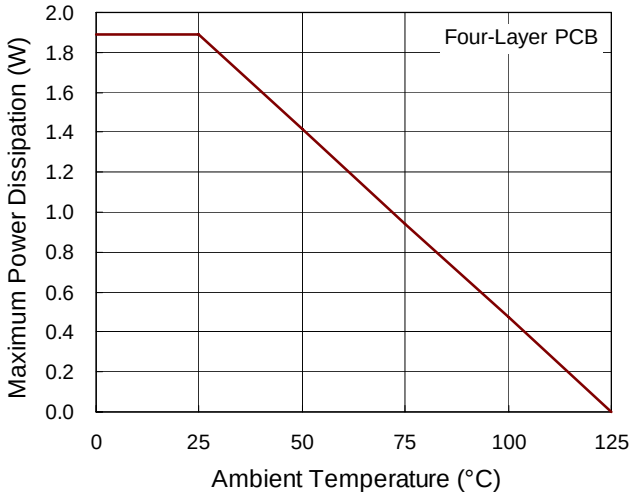


Figure 2. Derating Curve of Maximum Power Dissipation

Layout Considerations

Layout is very important in high frequency switching converter design. The PCB can radiate excessive noise and contribute to converter instability with improper layout. Certain points must be considered before starting a layout using the RT7271A.

- Make the traces of the main current paths as short and wide as possible.
- Put the input capacitor as close as possible to the device pins (V_{IN} and GND).
- LX node encounters high frequency voltage swings so it should be kept in a small area. Keep sensitive components away from the LX node to prevent stray capacitive noise pick-up.
- Ensure all feedback network connections are short and direct. Place the feedback network as close to the chip as possible.
- The GND pin should be connected to a strong ground plane for heat sinking and noise protection.
- An example of PCB layout guide is shown in Figure 3 for reference.

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

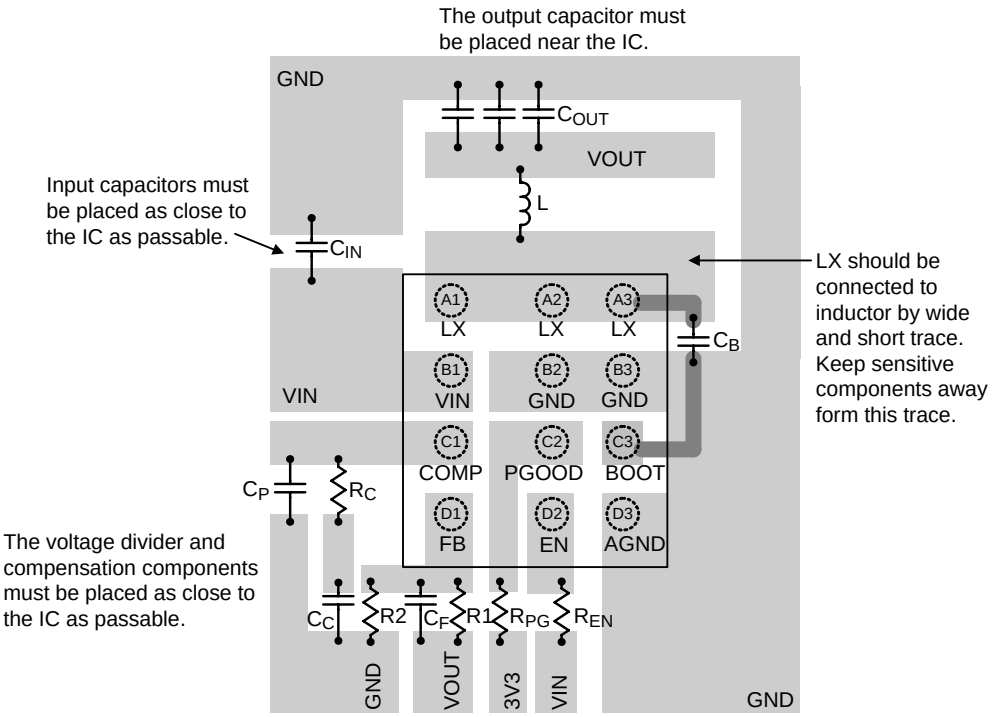
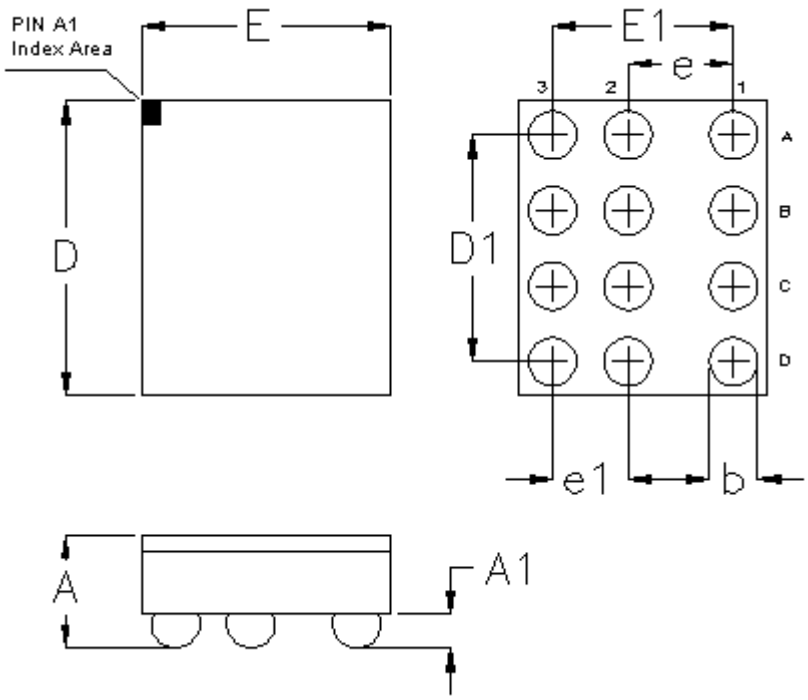


Figure 3. PCB Layout Guide

Copyright ©2013 Richtek Technology Corporation. All rights reserved. RICHTEK is a registered trademark of Richtek Technology Corporation.

Free Datasheet http://www.datasheet4u.com/

Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.200	0.260	0.008	0.010
b	0.290	0.350	0.011	0.014
D	1.900	2.000	0.075	0.079
D1	1.500		0.059	
E	1.600	1.700	0.063	0.067
E1	1.200		0.047	
e	0.700		0.028	
e1	0.500		0.020	

12B WL-CSP 1.65x1.95 Package (BSC)

Richtek Technology Corporation

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

Richtek products are sold by description only. Richtek reserves the right to change the circuitry and/or specifications without notice at any time. Customers should obtain the latest relevant information and data sheets before placing orders and should verify that such information is current and complete. Richtek cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Richtek product. Information furnished by Richtek is believed to be accurate and reliable. However, no responsibility is assumed by Richtek or its subsidiaries for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Richtek or its subsidiaries.

Free Datasheet http://www.datasheet4u.com/