DATA SHEET

SUNPLUS

SPFD9848A

White LED Step-Up Converter

JAN. 14, 2005

Version 1.3

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WHITE LED STEP-UP CONVERTER

1. GENERAL DESCRIPTION

The SPFD9848A is a fixed frequency PWM converter to drive white LEDs with a constant current to provide backlight in cell phones, PDAs, and other hand-held devices. Because it directly regulates output current, the step-up converter topology allows series connection of the white LEDs so that the LED currents are identical for uniform brightness.

SPFD9848A is a PWM converter with an internal, highvoltage, low RDSON N-channel MOSFET switch for high efficiency. battery life. A control pin is used for both shutdown and brightness adjusted for LEDs. The switching frequency of PWM is around 1MHz which allows using small input and output capacitors and a small inductor while minimizing ripple on the input supply/battery. Softstart function is included to eliminate inrush current during startup.

2. FEATURES

- Constant Current Regulation for Uniform Illumination
- Up to 87% Efficiency
- Dimming control
- Internal High-Voltage MOSFET Switch
- Small External Components
- 2.6V to 5.5V Input Range
- 13V Maximum Output with Overvoltage Protection
- Optimized for Low Input Ripple
- Soft-Start function includes
- 0.3μA Shutdown Current

3. APPLICATIONS

- PDAs
- Cellular phones
- Digital cameras
- White LED Display Backlighting

4. BLOCK DIAGRAM

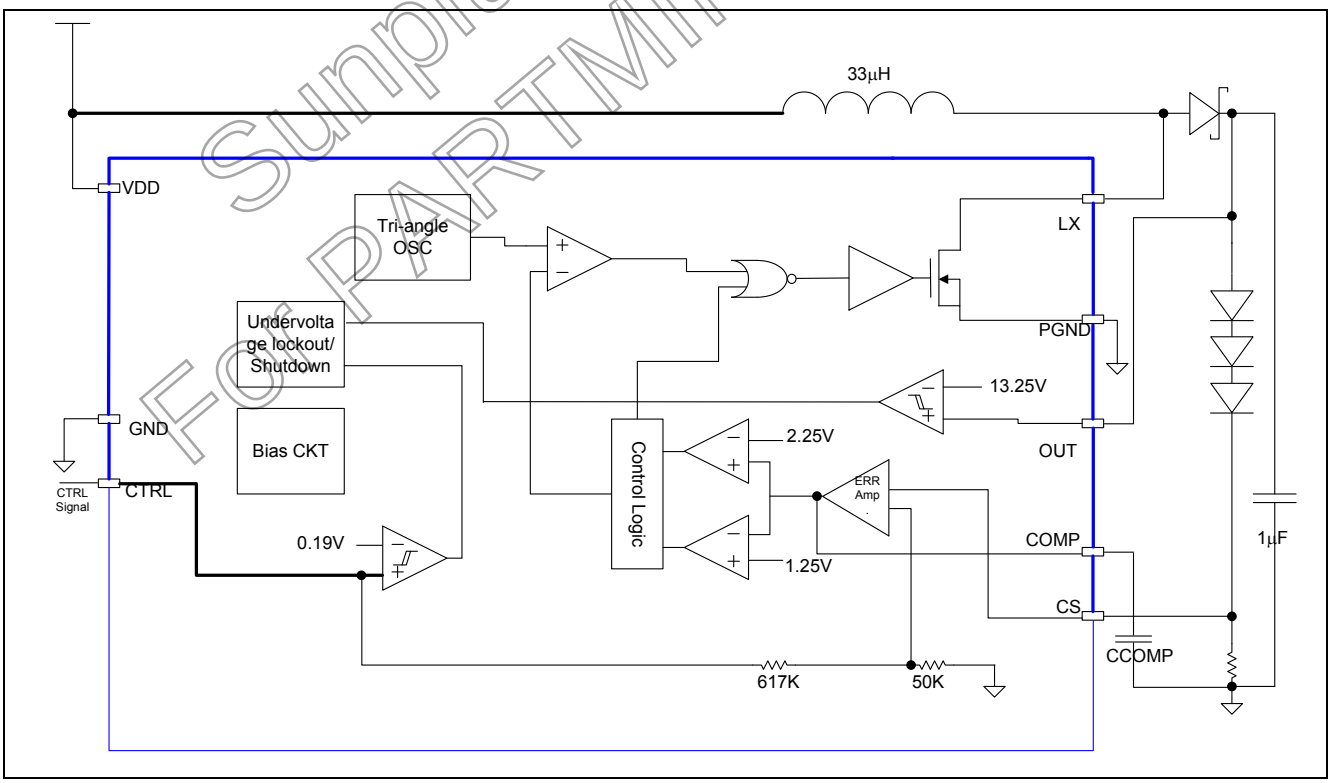


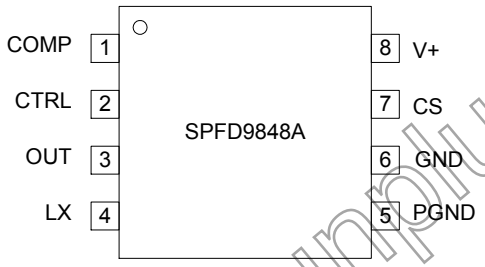
Figure 1: Functional Diagram with typical application

5. SIGNAL DESCRIPTIONS

Mnemonic	PIN No.	Function
COMP	1	Compensation Pin for Error Amplifier. Soft-start is programmed through this pin. The capacitance value is usually between 0.15uF and 1uF. V_{COMP} passively discharges to GND when in shutdown.
CTRL	2	A control pin for control Input. LED brightness and IC shutdown. The voltage on CTRL between 250mV and 5.5V adjust the brightness of LEDs. The voltage on CTRL less than 100mV shutdown the IC.
OUT	3	Output voltage Sense. When V_{OUT} is greater than 13.25V, the internal N-channel MOSFET is turned off and V_{COMP} decays to GND. When VOUT drops below 12.25V, the IC will re-enter soft-start.
LX	4	Inductor Connection. Drain of the internal N-channel MOSFET.
PGND	5	Power Ground. Source of the internal N-channel MOSFET.
GND	6	Ground
CS	7	Current-Sense pin. Connect a resistor from this pin to GND to set the LED bias current. This pin regulates to 7.5% of V_{CTRL}.
VDD	8	Supply Voltage Input. The IC is powered from this pin. Input range is 2.6V to 5.5V. Undervoltage lockout function includes.

5.1. PIN Map

Top View



6. FUNCTIONAL DESCRIPTIONS

The SPFD9848A uses a constant frequency to regulate the LEDs current. Operation can be understood by referring to the block diagram in Figure 1. It operates as a boost DC-DC converter that controls output current rather than voltage. The 1MHz internal oscillator allows for a small inductor and small input and output capacitors while minimizing input and output ripple.

The brightness of the LEDs is adjusted through a voltage level on CTRL pin. When the level falls below 0.1V, the chip goes into shut-down mode and consumes less than 0.3μA of current for VDD is equal to 3.0V. A programmable soft-start gradually illuminates the LEDs, reducing the inrush current during startup.

6.1. Soft-Start

The soft-start function works by charging CCOMP gradually with a constant 12μA current. When VCOMP is above 1.25V, the internal MOSFET begins switching, but at a reduced duty cycle. When VCOMP is above 2.25V, the duty cycle will be at its maximum.

6.2. Shutdown

When voltage on CTRL is less than 100mV SPFD9848A goes into shutdown. In shutdown, supply current is reduced to 0.3μA CCOMP is passively discharged during shutdown, allowing the device to function a soft-start whenever the device is enabled.

When in shutdown, the internal N-channel FET does not switch, which leaves a current path between the input and the LEDs through the boost inductor and Schottky diode. The minimum forward voltage of the LED array must exceed the maximum VDD to ensure that the LEDs remain off in shutdown.

6.3. Overvoltage Protection

When the voltage on OUT is above 13.25V. SPFD9848A will shutdown to stop the internal MOSFET switching and causes VCOMP to decay to GND. The device comes out of shutdown and reinitiates a soft-start when VOUT is below 12.25V.

7. DESIGN PROCEDURE

7.1. Adjusting LED Current

The brightness of LEDs are controlled by the voltage level on CTRL pin. This voltage can be either DC or a PWM signal. The voltage level on CTRL determines the current through LEDs and the value can be calculated by:

$$ILED = \frac{V_{CTRL}}{13.33 \times R_{SENSE}}$$

The voltage level on CTRL for adjusting LEDs current is from 250mV to 5.5V.

7.2. Capacitor Selection

Low ESR (equivalent series resistance) capacitors is recommended to be used at the output. The exact values of input and output capacitors are not critical. The typical value for the input capacitor is 3.3μF and the typical value for the output capacitor is 1μF. The larger values help reduce output ripple at the expense of size and higher cost.

The requirements of the input capacitor depend on the type of the input voltage source. However, in many applications, the same capacitor type and value are used for both the input and output capacitors. The capacitance value of CCOMP is between 0.15μF and 1μF, and is not critical.

7.3. Inductor Selection

The value of the inductor depends on the maximum output current to the LEDs. The typical value 33μH.

7.4. Schottky Diode Selection

Schottky diodes with low forward voltage and fast switching speed are recommended for most applications. Ensure that the diode's average and peak current ratings exceed the average output current and peak inductor current, respectively.

In addition, the diode's reverse breakdown voltage must exceed VOUT. For output voltages exceeding 16V, high-speed silicon rectifiers may be required for their higher breakdown voltages.

8. APPLICATIONS INFORMATION

8.1. Connecting Four or Six LEDs

The SPFD9848A can typically drive one leg of 3LEDs (Figure 2). Other configurations are also valid (Ex. One leg of 2LEDs, or two legs of 3LEDs), but not shown here. For the efficiency, please refer to the typical operating characteristics.

8.2. PC Board Layout

As with all switching regulators, careful attention must be paid to the PCB layout and component placement.

To maximize efficiency, minimize trace lengths between the IC and CS, the inductor, diode, input capacitor, and output capacitor. To prevent radiation and high frequency resonance problems, minimize the length and area of all traces connected to the drain of the internal NMOS (LX). And always use a ground plane under the PCB to minimize interplane coupling. Keep noisy traces such as the inductor's traces away from CS. VDD's bypass capacitor should be placed as close to the IC as possible. Keep traces short, direct, and wide. Keep noisy traces, such as the inductor's traces, away from CS.

9. ELECTRICAL SPECIFICATIONS

9.1. Absolute Maximum Ratings

VDD to GND	-0.3V to +6.0V
PGND to GND	-0.3V to +0.3V
LX, OUT to GND	-0.3V to +14V
LX to OUT	-14V to +0.3V
CTRL to GND	-0.3V to +6.0V or (V+ + 2V)
COMP, CS to GND	-0.3V to (V+ + 0.3V)
LX Current	0.45ARMS
Continuous Power Dissipation (TA = +70°C)	777mW
Operating Temperature Range	-40 °C to +85°C
Junction Temperature	+150 °C
Storage Temperature Range	-60 °C to +150°C
Lead Temperature	(Note 1)

Note1: This device is constructed using a unique set of packaging techniques that impose a limit on the thermal profile the device can be exposed to during board-level solder attach and rework. Maxim recommends the use of the solder profiles recommended in the industry-standard specification, JEDEC 020A, paragraph 7.6, Table 3 for IR/VPR and convection reflow processes. Preheating, per this standard, is required. Hand or wave soldering is not recommended.

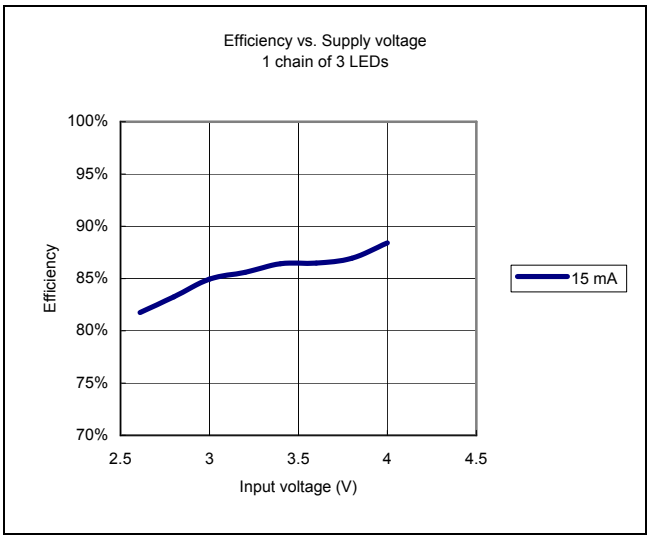
Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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

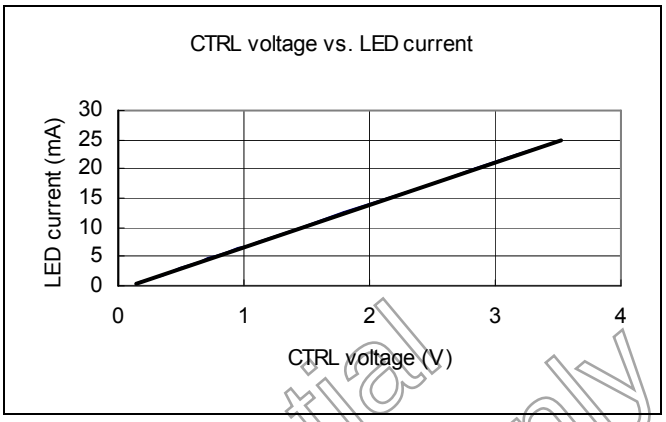
9.2. DC Characteristics

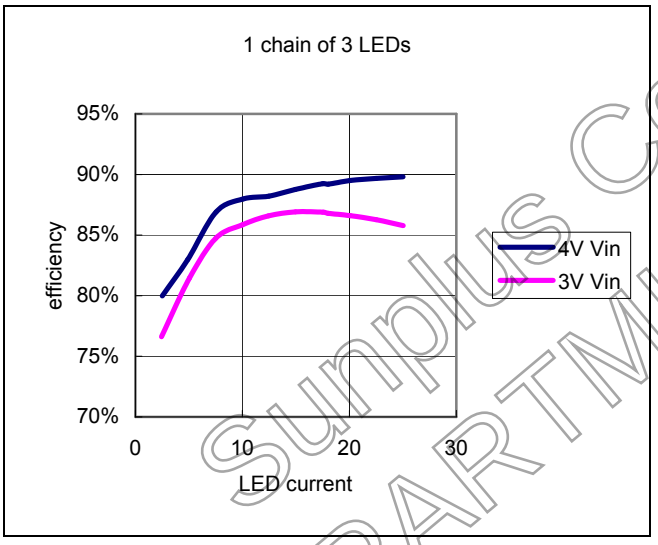
(VDD = 3.0V, VOUT = 11V, L = 33µH, COUT = 1µF, CCOMP = 0.22µF, RSENSE = 10Ω, VCTRL = 1V, Typical values are at T = +25°C.)

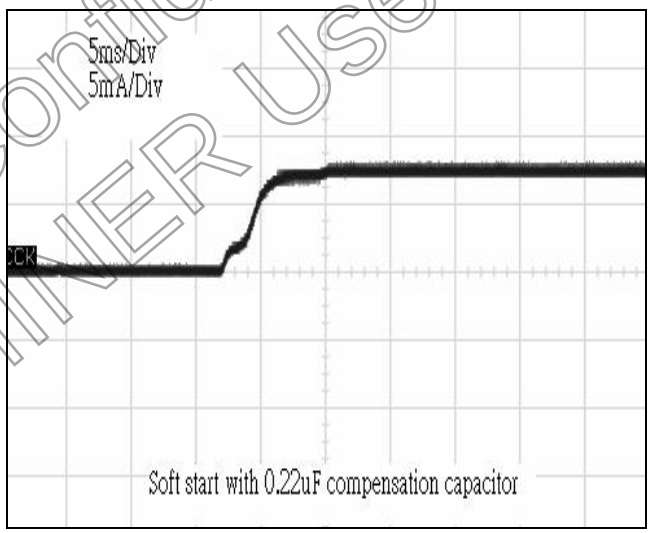
Parameter	Conditions		Min.	Typ.	Max.	Units
Supply Voltage			2.6	-	5.5	V
Undervoltage Lockout Threshold	V+ rising, 40mV hysteresis typical		2.1	2.35	2.6	
Quiescent Current	Not switching, VCTRL = VCS = V+		-	0.25	0.40	mA
	Switching, VCTRL = V+, VCS = GND		-	1.0	2.0	
Shutdown Supply Current	VCTRL = GND		-	0.5	1.0	µA
Overvoltage Threshold	V+ rising, 1V hysteresis typical		12.15	13.5	15.0	V
OUT Input Bias Current	VOUT = 13V	VCTRL > 0.25V	10	20	30	µA
		VCTRL = GND	-	0.01	1.0	
Output Voltage Range			V+ - V_{DIODE}	-	12.5	V
ERROR AMPLIFIER						
CTRL to CS Regulation	VCTRL = 2.0V, V+ = 2.6V to 5.5V		90	100	110	mV/V
CS Input Bias Current	VCS = VCTRL /13.33		-	0.01	1.0	µA
CTRL Input Resistance			546	780	1014	KΩ
CTRL Threshold	Hysteresis = 25mV typical		100	170	240	mV
CS Line Regulation	V+ = 2.6V to 5.5V, VCTRL = 3.0V		-	0.05	-	%/V
COMP Pin Resistance to Ground	Device in shutdown or overvoltage		10	20	50	KΩ
OSCILLATOR						
Operating Frequency			0.8	1.0	1.2	MHz
Maximum Duty Cycle	VCTRL = V+, VCS = GND		85	90	97	%
N-CHANNEL SWITCH						
LX On-Resistance	ILX = 100mA		-	1.4	2.2	Ω

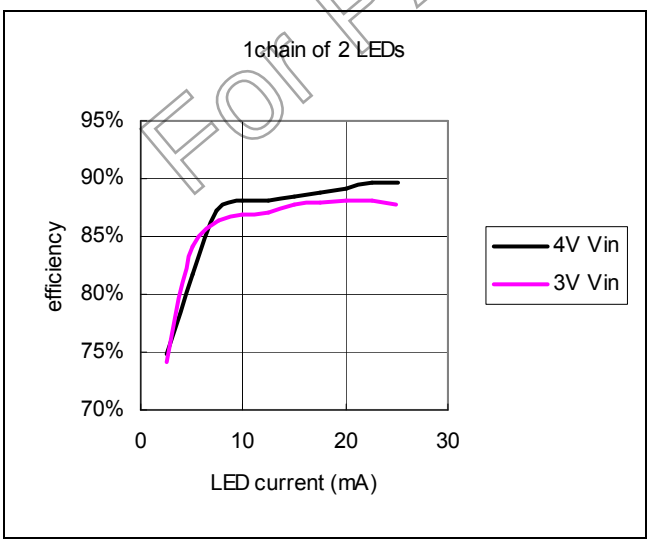
9.3. Typical Operating Characteristics

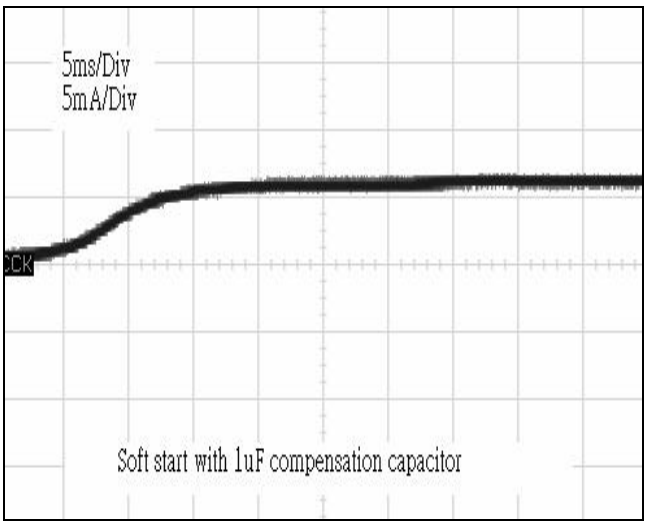












10. APPLICATION CIRCUITS

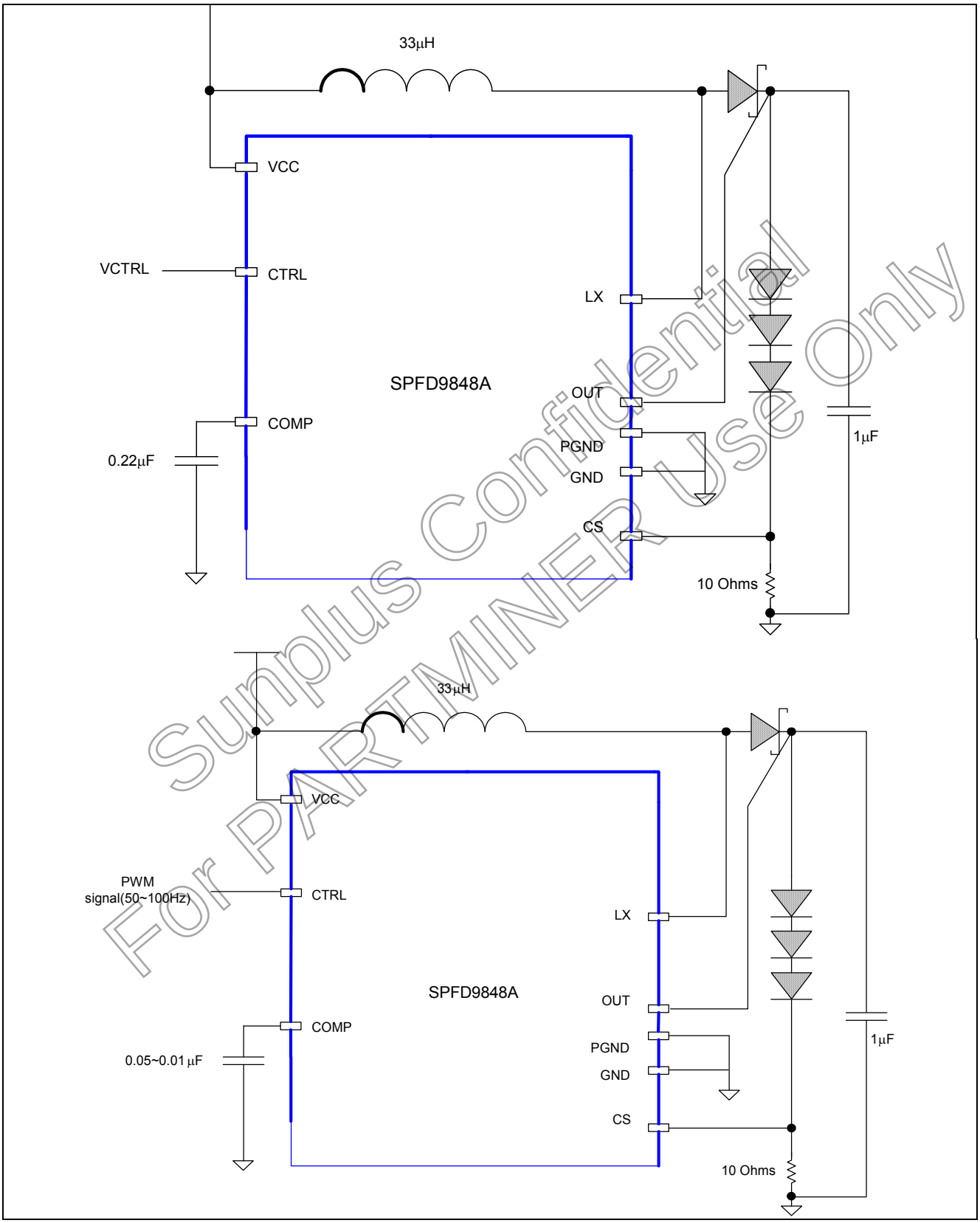


Figure 2: Typical application circuit

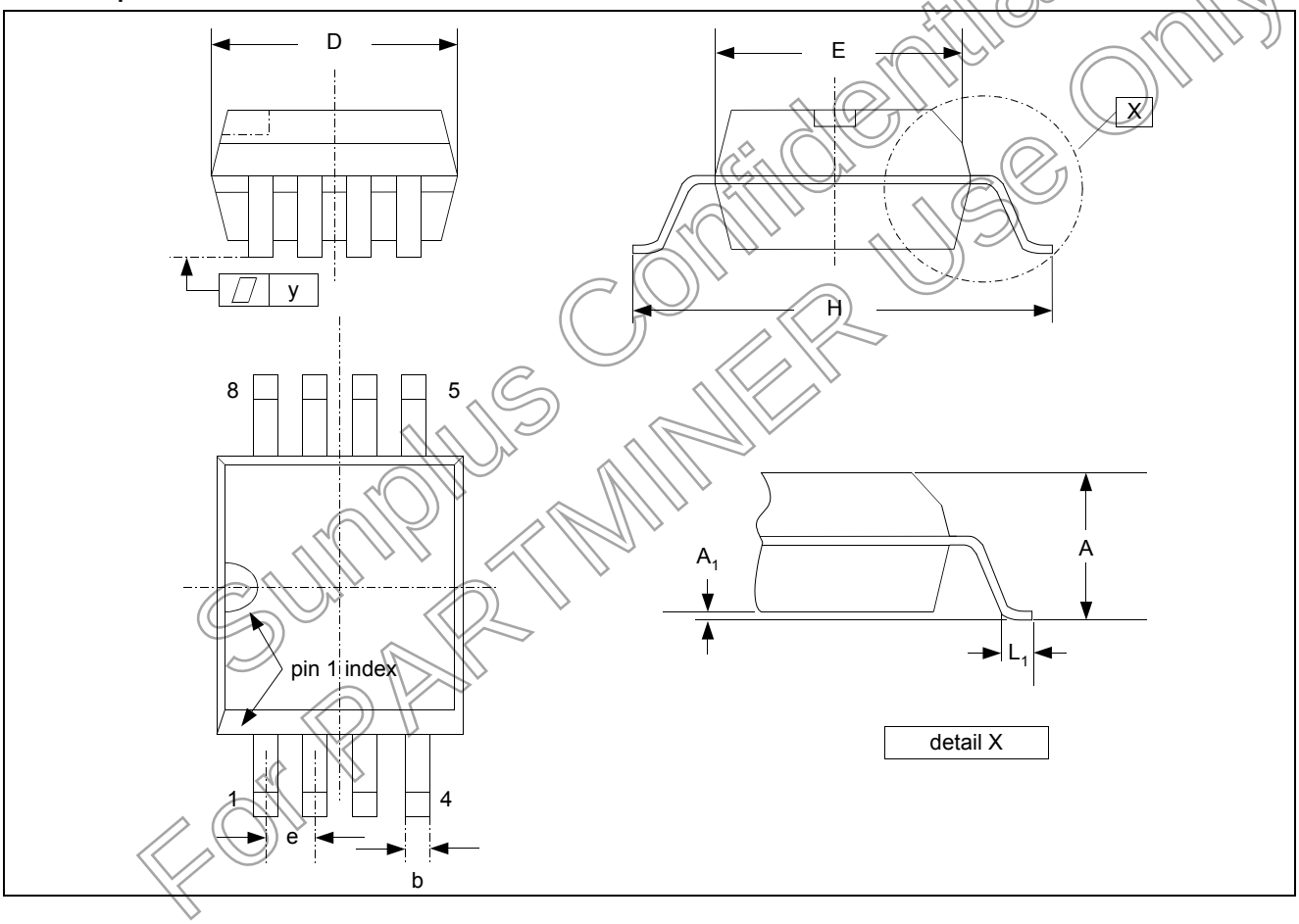
11. PACKAGE/PAD LOCATIONS

11.1. Ordering Information

Product Number	Package Type
SPFD9848A - PK02	Package form - MSOP 8 (top side mark WL9848 with tube)
SPFD9848A - RK02	Package form - MSOP 8 (top side mark WL9848 with tape & reel)
SPFD9848A - HV12	Package form - QFN 8 (top side mark WL9848) environmental protection material
SPFD9848A - EV12	Package form - QFN 8 (top side mark WL9848 with tape & reel) environmental protection material

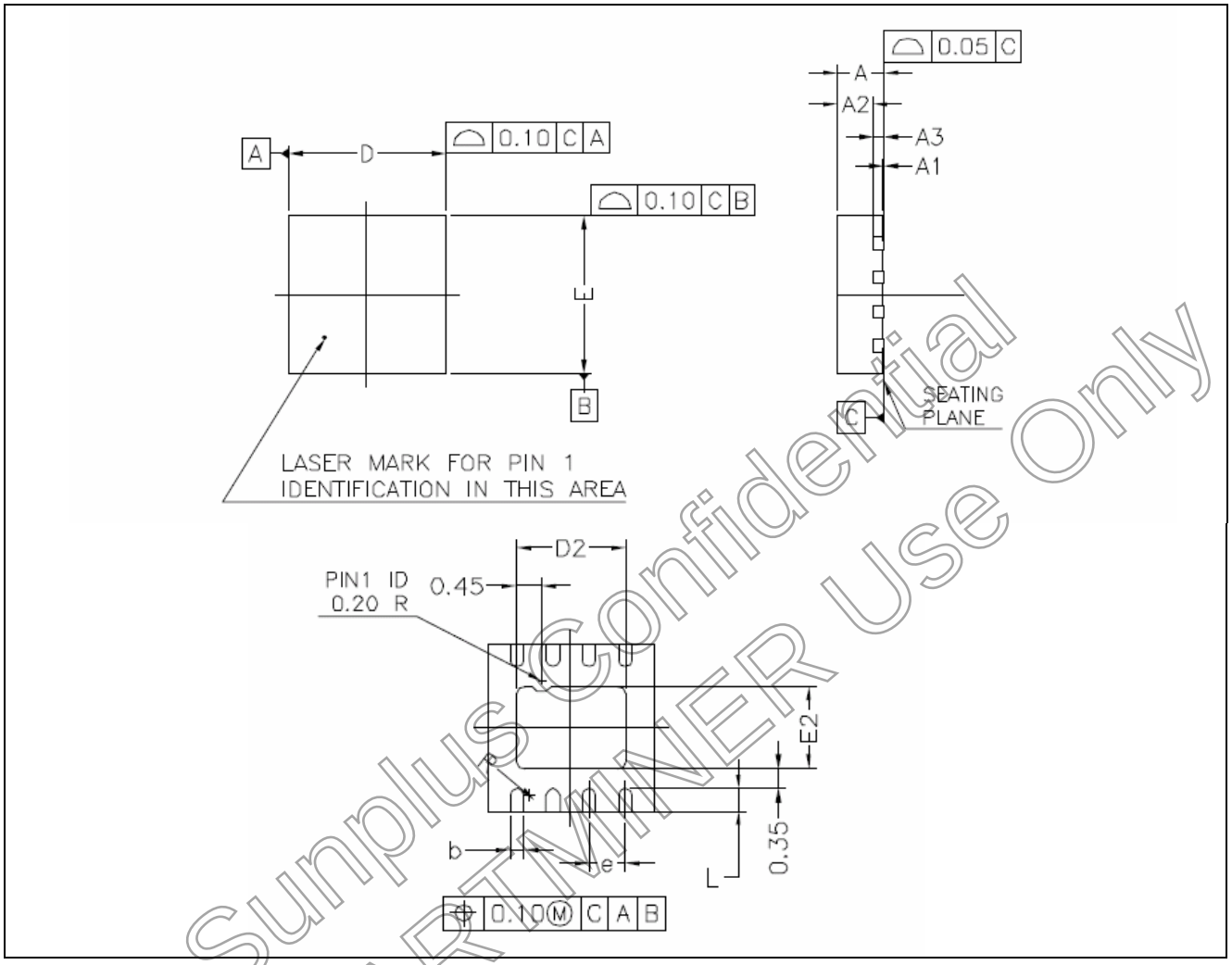
11.2. Package Information

11.2.1. 8-pin MSOP



Symbol	Dimension in Millimeter		
	Min.	Typ.	Max.
A	-	-	1.10
A_1	0.00	-	0.15
b	-	0.30	-
D	3.00 BSC		
E	3.00 BSC		
e	0.65 BSC		
H	4.90 BSC		
L_1	0.40	0.60	0.80
y	-	-	0.05

11.2.2. 8-pin QFN



Symbol	Dimension in Millimeter		
	Min.	Typ.	Max.
A	-	-	0.90
A_1	-	-	0.025
A_2	-	0.65	0.70
A_3	0.20 REF		
b	0.20	0.25	0.32
D	3.00 BSC.		
D_2	1.876	1.976	2.076
E	3.00 BSC.		
E_2	1.40	1.50	1.60
e	0.65 BSC.		
L	0.30	0.40	0.50
R	0.09	-	-
aaa	0.10		
bbb	0.10		
ccc	0.05		

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13. REVISION HISTORY

Date	Revision #	Description	Page
JAN. 14, 2005	1.3	Modify 11.1 Ordering Information	10
SEP. 07, 2004	1.2	Add an application circuit	9
JUL. 26, 2004	1.1	Add QFN-8 package information	11
DEC. 12, 2003	1.0	Original	12