DATA SHEET

SUNPLUS

SPFD9698A

High-Efficiency Step-Up Current Regulator for LEDs B/L System

NOV. 01, 2004

Version 1.1

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HIGH-EFFICIENCY STEP-UP CURRENT REGULATOR FOR LEDs B/L system

1. GENERAL DESCRIPTION

The SPDF9698A is a high efficient boost converter to driver white or color LEDs. The device is ideal for LED backlit displays in PDAs and digital cameras, and can also be used for larger displays like those in laptop computers. The LED current is set with the external sense resistor and is directly regulated by the feedback pin (FB).

The required sense resistor is typically 10 ohms, not an expensive fractional-ohm value. The brightness of LEDs can be controlled by an analog signal applied to the adjust pin (ADJ). This analog signal can be applied from other chips or from reference voltage itself, as described in the application circuits. For larger light output, multiple LED banks can be connected in parallel.

2. FEATURES

- Up to 90% Efficiency
- Lossless, Adjustable LED Brightness
- Space-Saving 10-Pin MSOP Package

3. APPLICATIONS

- Battery-Powered Backlight Applications
- Backlight for LCD Panels
- Handy Terminals
- PDAs

4. BLOCK DIAGRAM

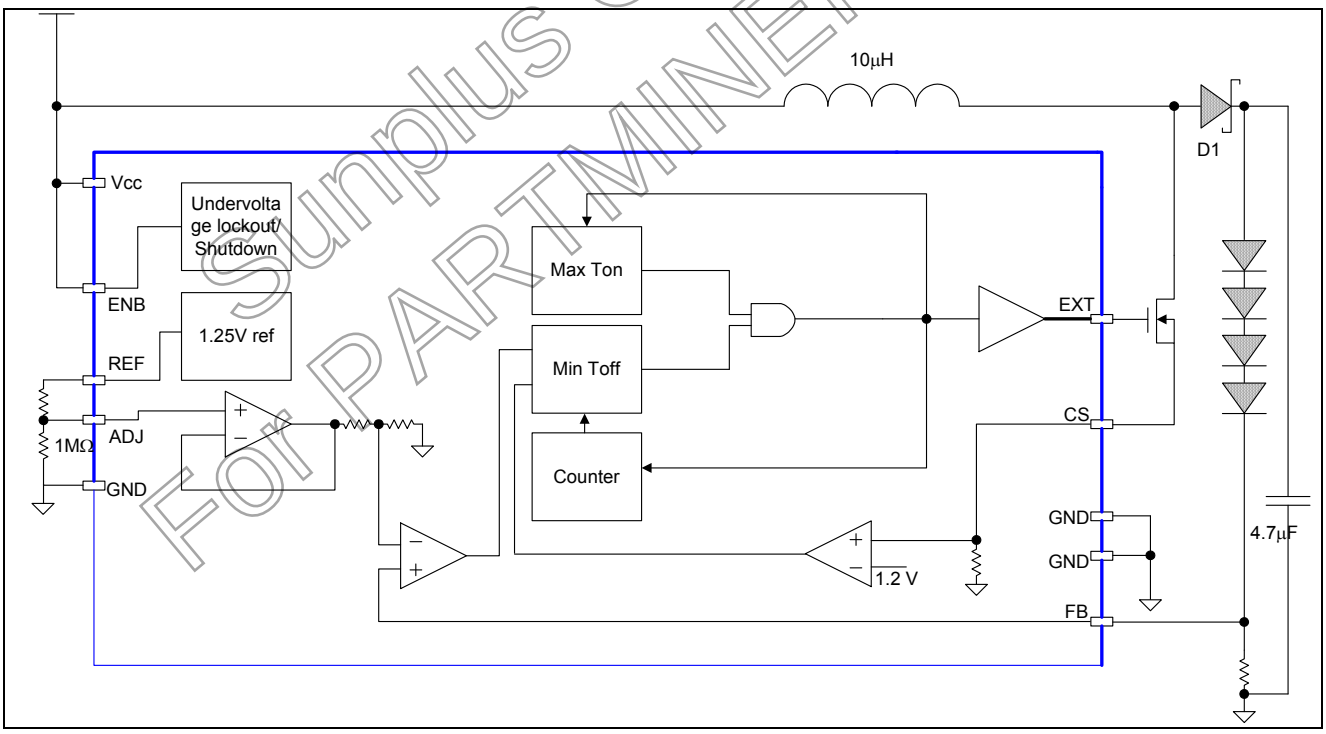


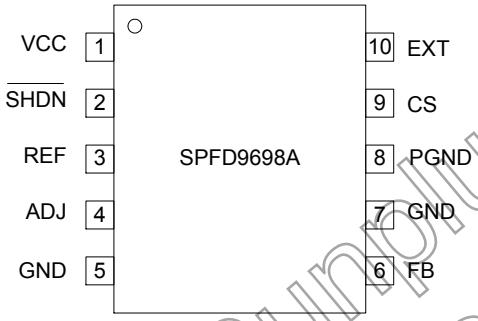
Figure 1: Functional Diagram with typical application

5. SIGNAL DESCRIPTIONS

Mnemonic	PIN No.	Function
VCC	1	IC Supply Voltage Input. Power for internal circuitry. Input range is 2.7V to 5.5V.
ENB	2	Active-Low for disable (shutdown). In shutdown, the MOSFET turns off, but a current path still exists between the input and output. The minimum forward voltage of the LED array must exceed the maximum VCC to ensure that the LEDs are off in shutdown.
REF	3	1.25V Reference Output. Capable of sourcing 100μA for external loads. This pin is internally compensated. Do not connect any bypass capacitors at REF.
ADJ	4	Adjust Input. Allows dynamic adjustment the LEDs current. FB regulates to 300mV when ADJ = REF.
GND	5, 7	Ground
FB	6	Feedback Input. Connect to the external LED current-sense feedback resistor.
PGND	8	Power Ground
CS	9	FET Current-Sense Input
EXT	10	Gate Driver Output

5.1. PIN Map

Top View



6. FUNCTIONAL DESCRIPTIONS

The SPFD9698A's operates like a standard boost DC/DC converter that controls output current rather than voltage. This gives an accurate regulated LED current independent of the input voltage and number of LEDs connected. In the standard configuration, a feedback resistor, RFB, sets the current through the primary chain of LEDs. Additional chains of matching LEDs can be added with an equivalent resistor. In matched LED arrays, the secondary chain currents closely track the primary chain. An optional zener diode can be added to prevent overvoltage in the event that one of the LEDs in the primary chain becomes an open circuit. The LED brightness can be adjusted dynamically by a voltage input at ADJ.

6.1. Shutdown

In shutdown mode, the supply current of SPFD9698A is reduced below 1μA. EXT goes low in shutdown, turning off the external N-channel FET. There exists a current path between the input and the LEDs through the boost inductor and catch diode. The minimum forward voltage of the LED array must higher than the maximum VCC to prevent that the LEDs turn on in shutdown. Typical shutdown timing characteristics are shown in the Typical Operating Characteristics.

6.2. Soft-Start

The SPFD9698A includes a soft-start function that prevents the high inrush current during start-up. It does this by extending the external FET driver (EXT) minimum off-time during start-up. During the first 512 switching cycles, the minimum off-time is 5.75μs. It is then allowed to drop to 2.3μs for the next 1500 switching cycles. After that time, the minimum off-time falls to the 1.15μs value used during normal operation. (See Shutdown/Soft-Start Timing in the Typical Operating Characteristics section.)

6.3. Design Procedure

6.3.1. Adjusting LED current

LED current can be set proportional to the voltage at the ADJ pin (see Normalized Output Current vs. ADJ Voltage in the Typical Operating Characteristics section). Figure 3

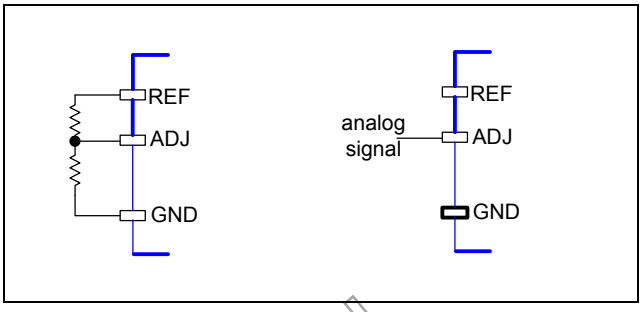


Figure3. Adjusting LED Current

shows the standard method of setting the ADJ voltage. Use the following equation to determine ILED:

$$I_{LED} = \frac{V_{ADJ}}{4.2 * R_{FB}}$$

where VADJ is the voltage at ADJ.

6.3.2. Inductor selection

An inductor with low DC resistance is preferred (in the neighborhood of 100mΩ) to minimize losses. A typical inductance value for L is 10μH; however, values from 3.3μH to 100μH can also be used. Higher inductor values will reduce the SPFD9698A's switching frequency.

The SPFD9698A limits peak inductor current to 1.25A.

6.3.3. Capacitor selection

The exact value of output capacitance is not critical. However, to choose a suitable value range depending on the loading of LED is required. Typical values for the output capacitor are 0.1μF to 10μF. 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.

Low ESR (equivalent series resistance) capacitors are recommended to be used at the output to minimize the output ripple and high performance capacitors are helpful for efficiency.

6.3.4. Transistor selection

The SPFD9698A can source up to 200mA of gate current. An N-channel MOSFET (NMOS) with a relatively low threshold voltage, low gate charge and low turn on resistance is required to optimize overall circuit performance. The external NMOS's maximum drain-to-source voltage (VDS(MAX)) must exceed the output voltage.

6.3.5. Diode (D1) 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 40V, high-speed silicon rectifiers may be required for their higher breakdown voltages.

6.3.6. Zener diode

For applications requiring open-circuit protection if one of the LEDs in the primary chain opens, add a zener diode as shown in the application circuit. The zener diode protects the MOSFET and output capacitor if the current feedback signal is lost. The zener voltage should exceed the maximum forward voltage of the LED network by at least 2V.

6.4. Applications Information

6.4.1. 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 to 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 external NMOS and always use a ground plane under the PCB to minimize interplane coupling. Keep noisy traces such as the inductor's traces away from FB. VCC's bypass capacitor should be placed as close to the IC as possible.

7. ELECTRICAL SPECIFICATIONS

7.1. Absolute Maximum Ratings

VCC, SHDN to GND	-0.3V to +6V
EXT, FB, CS, ADJ, REF to GND	-0.3V to (VCC + 0.3V)
GND to PGND	±0.3V
Continuous Power Dissipation (T_A = +70°C)	
10-Pin MSOP (derate 5.6mW/°C above +70°C)	444mW
Operating Temperature Range	-40°C to +85°C
Junction Temperature	+150°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature Range (soldering, 10s)	+300°C

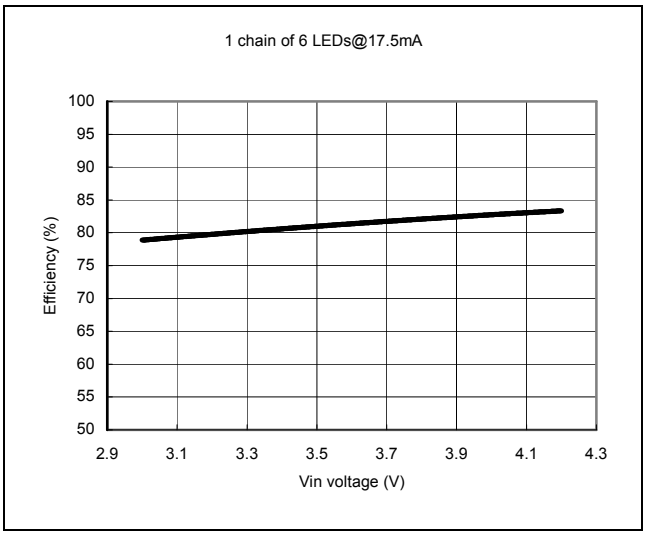
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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

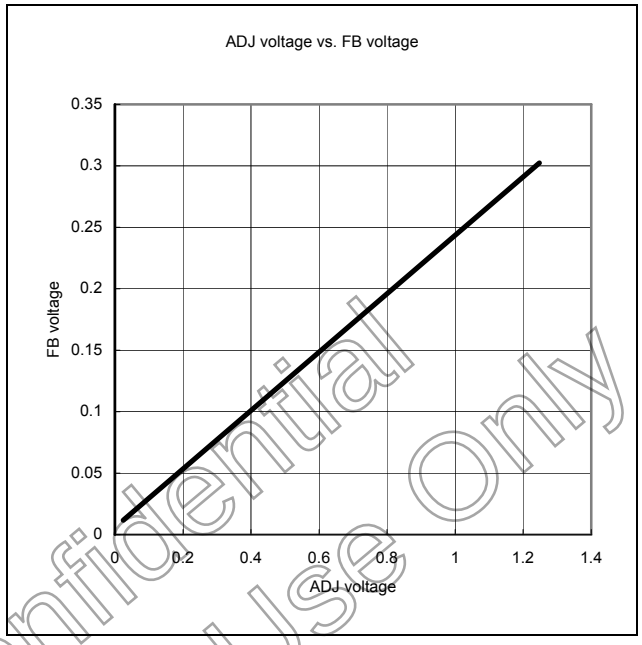
7.2. DC Characteristics

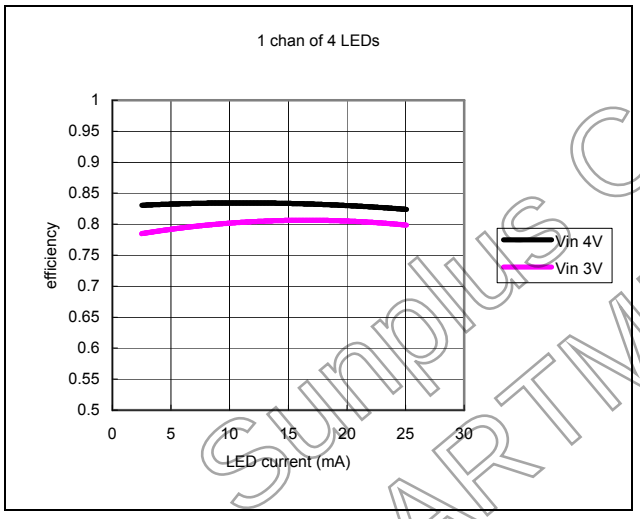
(VCC = +3.3V, T_A = 0°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Supply Voltage	VCC		2.7	-	5.5	V
Quiescent Supply Current	I_{CC}	V_{FB} = 0.3V	-	240	400	µA
Undervoltage Lockout		Rising edge	2.20	2.4	2.65	V
Undervoltage Hysteresis			-	40	-	mV
FB Regulation Voltage	V_{FB}	ADJ = REF	290	310	330	mV
CS Trip Current		FB = GND	0.8	1.25	2.5	A
Minimum Off Time	$T_{OFF(MIN)}$	FB = GND, ADJ = REF	0.92	1.15	1.38	µs
Maximum On Time	$T_{ON(MAX)}$	FB = GND, ADJ = REF, CS = GND	14	18	22	µs
FB Input Bias Current	I_{FB}	V_{FB} = 300mV	-15	-	15	nA
ADJ Input Bias Current	I_{ADJ}	ADJ = REF	-15	-	15	nA
Shutdown Supply Current		$\overline{SHDN}$ = GND	-	0.04	1.0	µA
REF Output Voltage	V_{REF}	I_{REF} = 0	1.20	1.25	1.30	V
REF Load Regulation	$\triangle V_{REF}$	I_{REF} = 0 to 100µA	-	-2.0	-15	mV
REF Short-Circuit Current		REF = GND	-	0.16	0.25	mA
REF Power-Supply Rejection Ratio	PSRR	VCC = 2.7V to 5.5V	-	+2.5	+5.0	mV/V
EXT Driver Sink/Source Current		VCC = 5V, EXT = 2V	-	0.2	-	A
$\overline{SHDN}$ Input High Voltage	V_{IH}	VCC = 2.7V to 5.5V	0.8*VCC	-	-	V
$\overline{SHDN}$ Input Low Voltage	V_{IL}	VCC = 2.7V to 5.5V	-	-	0.2*VCC	V
$\overline{SHDN}$ Input Bias Current	$I\overline{SHDN}$	VCC = 2.7V to 5.5V	-1.0	-	1.0	µA

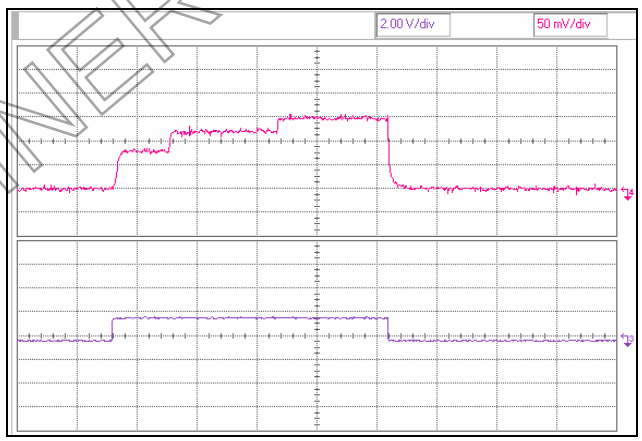
7.3. Typical Operating Characteristics

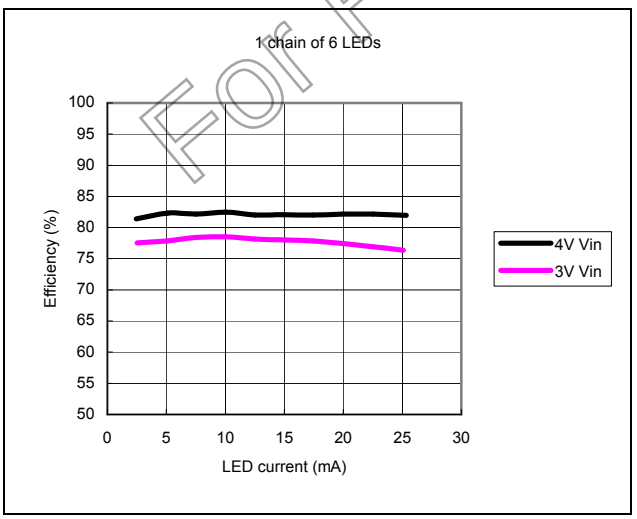




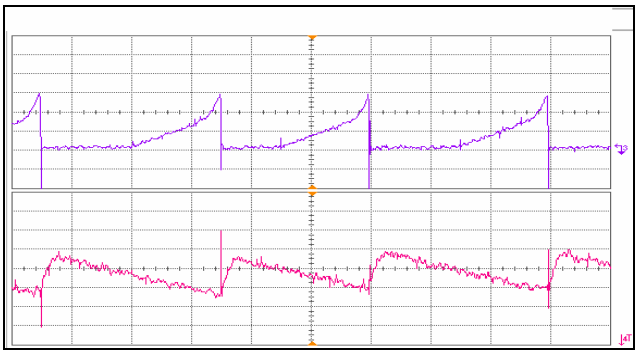


7.3.1. Shuntdown/Soft-start (5ms/Div)





7.3.2. LED and inductor current waveform (5us/Div)



8. APPLICATION CIRCUITS

8.1. Typical Operating Characteristics

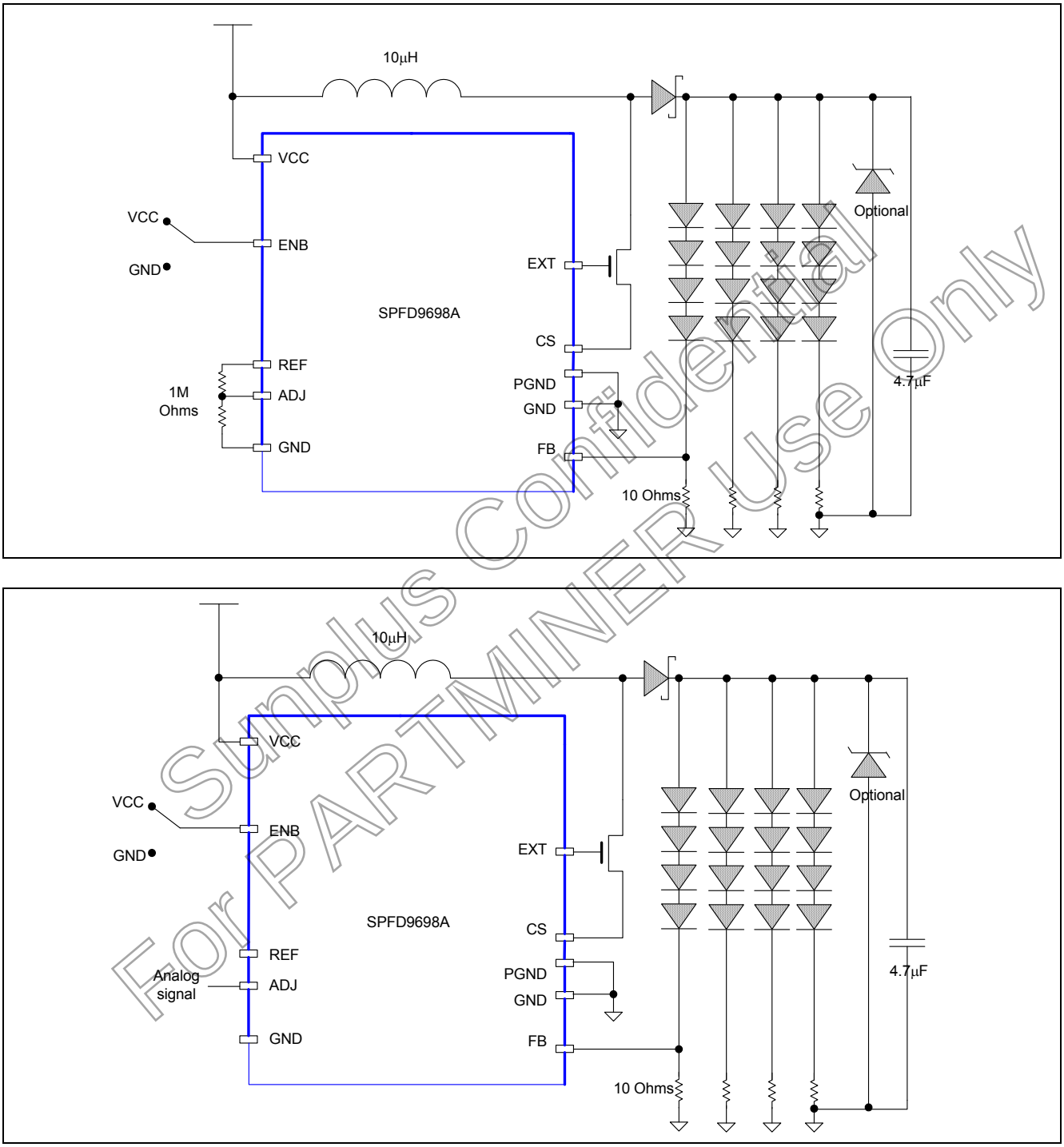


Figure 2: Typical Operating Circuit

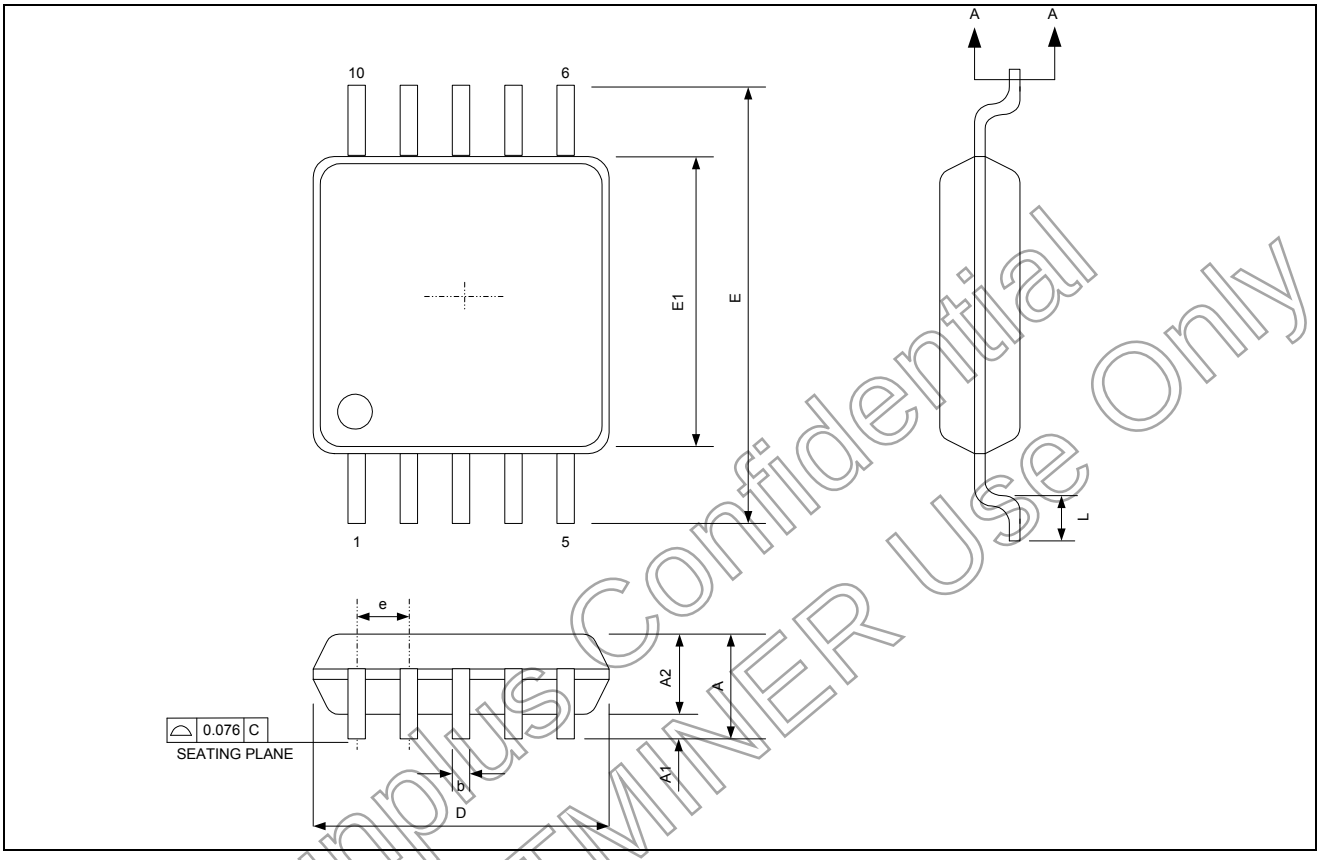
Related Key Parts

10μH inductor	Taipei Multipower Electronics : SMI-4532-100	886-2-8667-2006
4.7μF capacitor	Taiyo Yuden : TMK325BJ475MN	www.t-yuden.com
NMOS	Fairchild Semiconductor : FDN337N (30V 2.2A) (SuperSOT-3)	www.fairchildsemi.com

9. PACKAGE/PAD LOCATIONS

9.1. Package Information

9.1.1. MSOP 10



Note: The SPFD9698A does not have an exposed pad.

Symbol	Dimension in mm		
	Min.	Typ.	Max.
A	-	-	1.10
A_1	0.05	-	0.15
A_2	0.81	0.86	0.91
b	0.17	-	0.27
D	2.90	3.00	3.10
e	0.50 BSC.		
E1	2.90	3.00	3.10
E	4.90 BSC		
L	0.445	0.55	0.648

9.2. Ordering Information

Product Number	Package Type
GPWL9698A - PK01	Package form - MSOP 10 (top side mark WL9698 with tube)
GPWL9698A - RK01	Package form - MSOP 10 (top side mark WL9698 with tape & reel)

10. DISCLAIMER

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11. REVISION HISTORY

Date	Revision #	Description	Page
NOV. 01, 2004	1.1	Correct package information	10
JUN. 09, 2003	1.0	Original	12