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Low Voltage 1MHz Switching Frequency

3W High Power White LED Driver

CE9401 Series

■ INTRODUCTION:

The CE9401 is designed for single-cell or dual-cell or triangle-cell alkaline, NiMH, or NiCd or single-cell LiFePO4 lithium-ion battery powered application. It is a high efficiency boost converter with a low 95mV feedback voltage. A switching frequency of 1.0MHz minimizes solution footprint by allowing the use of tiny low profile inductors and ceramic capacitors. The current mode PWM design is internally compensated, and the device has a 0.9V start-up voltage with operation down to 0.65V. The CE9401 is rated over the -40°C to +85°C temperature range.

■ FEATURES:

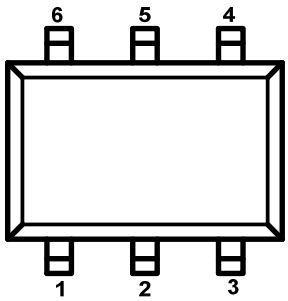
- V_{IN} Operation Range: 0.65V to V_{OUT} -0.2V
- Up to 90% Efficiency
- Low Start-Up Voltage: 0.9V (I_{LED}=270mA)
- Low Hold Voltage: 0.75V(I_{LED}=200mA)
- 1.0MHz Fixed Switching Frequency
- PWM/PFM Auto Switching Maintains High Efficiency
- Over-Thermal and Over-Current Protection
- Low Shutdown Current: <1.0μA
- -40°C to +85°C Temperature Range
- Pb-free, space-saving SOT-23-6L package

■ APPLICATIONS：

- Cellular and Smart Phones Flash
- White LED Torch
- Digital Still and Video Cameras Flash
- Camcorder Torch Lamp

■ PIN CONFIGURATION:

SOT-23-6L
Top View



■ ORDER INFORMATION:

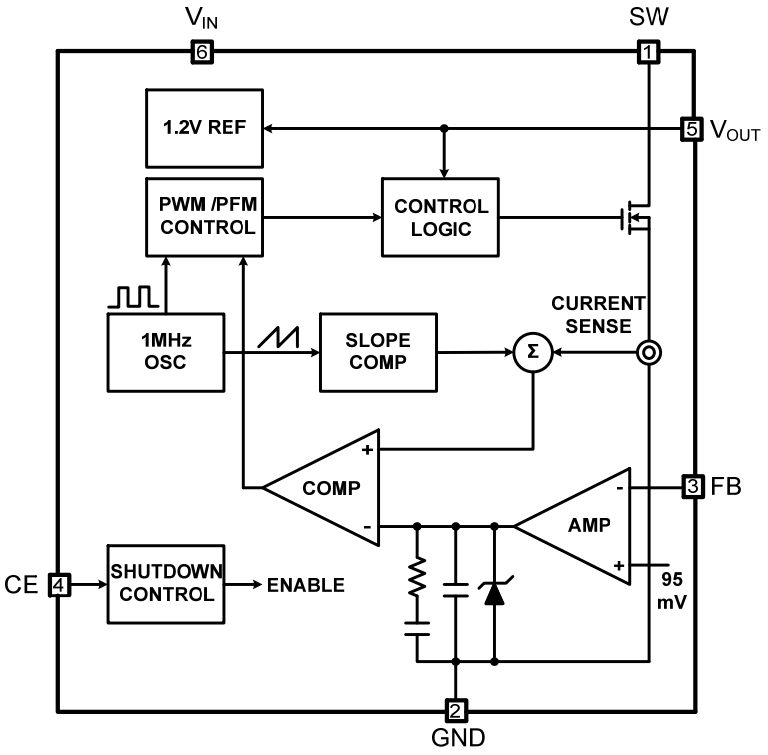
CE9401①②

DESIGNATOR	SYMBOL	DESCRIPTION
①	A	Standard
②	E	Package：SOT-23-6L

Tabel1. Pin Description

PIN NUMBER	PIN NAME	FUNCTION
1	SW	Switch Pin. Connect inductor between SW and VIN
2	GND	Signal and Power Ground
3	FB	Feedback Input
4	CE	Chip Enable. High Active
5	VOUT	Output Pin
6	VIN	Battery Input

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATINGS

(Unless otherwise specified, Ta=25°C)

PARAMETER		SYMBOL	RATINGS	UNITS
Input Voltage		V_{IN}	V_{SS}-0.3~V_{SS}+7	V
CE,SW,FB/V_{OUT} Voltage			V_{SS}-0.3~V_{IN}+0.3	V
Peak SW Sink and Source Current		I_{SWMAX}	3000	mA
Power Dissipation	SOT-23-6L	P_d	400	mW
Operating Temperature		T_{opr}	-40~+85	℃
Junction Temperature		T_j	125	℃
Storage Temperature		T_{stg}	-40~+125	℃
Soldering Temperature & Time		T_{solder}	260℃, 10s	

■ ELECTRICAL CHARACTERISTICS

CE9401 (V_{IN}= 2.4V, I_{LED}=700mA, Ta=25℃, Test Circuit Figure1, unless otherwise specified)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Feedback Voltage	V_{FB}		90	95	100	mV
Minimum Start-Up Voltage	V_{START}	V_{IN}:0V→3V, I_{LED} =270mA		0.9		V
Minimum Hold Voltage	V_{HOLD}	V_{IN}:3V→0V, I_{LED} =200mA		0.75		V
Minimum Operating Voltage	V_{IN}			0.65		V
Quiescent Current	I_{CC}	Measured On V_{OUT},V_{FB}=130mV, V_{OUT}=3.4V, I_{LED}=0		130	300	μA
Max Duty Cycle		V_{FB} = GND	80	87		%
Oscillator Frequency	f_{osc}			1.0		MHz
NMOS Current Limit	I_{PK}			3.0		A
Switch On Resistance		V_{OUT} = 3.4V,I_{LED} = 700mA		0.1		Ω
NMOS Switch Leakage		V_{CE}=0,V_{SW}=5.0V		±0.01	±1	μA
CE "High" Voltage(1)	$V_{CE"H"}$	V_{IN}=1.8V	1.0		V_{IN}	V
CE "Low" Voltage(2)	$V_{CE"L"}$	V_{IN}=1.8V			0.4	V
CE Leakage Current	I_{CE}	V_{CE}=5.0V		±0.1	±1	μA
Over Thermal Shutdown				140		℃
Over Thermal Hysteresis				20		℃

NOTE :

1. High Voltage：Forcing CE above 1.0V enables the part.
2. Low Voltage：Forcing CE below 0.4V shuts down the device. In shutdown, all functions are disabled drawing <1μA supply current. Do not leave CE floating.

■ TYPICAL APPLICATION CIRCUITS

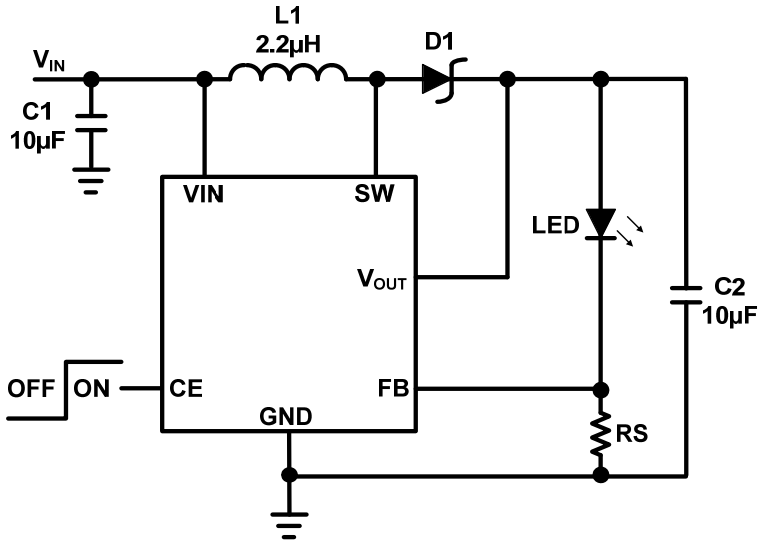
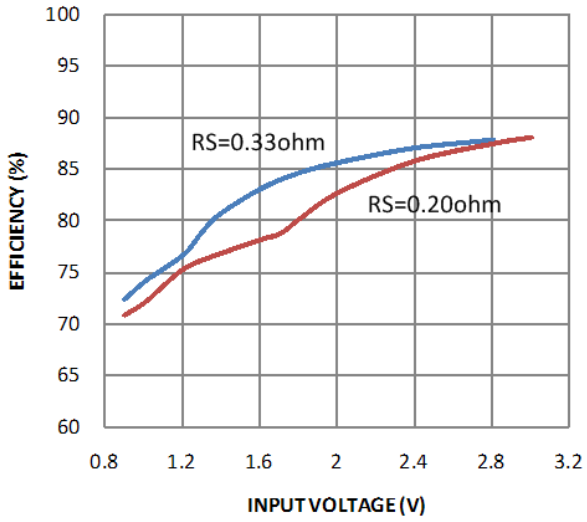


Figure1 Basic Application Circuit

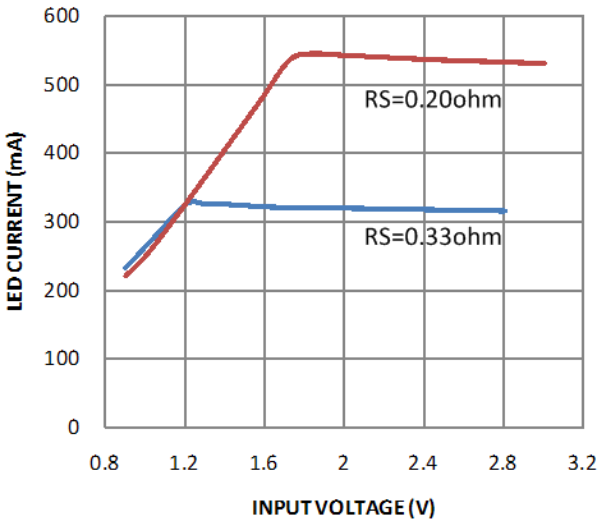
■ TYPICAL PERFORMANCE CHARACTERISTICS

(V_F=3.1V@550mA，Test Figure1 above unless otherwise specified)

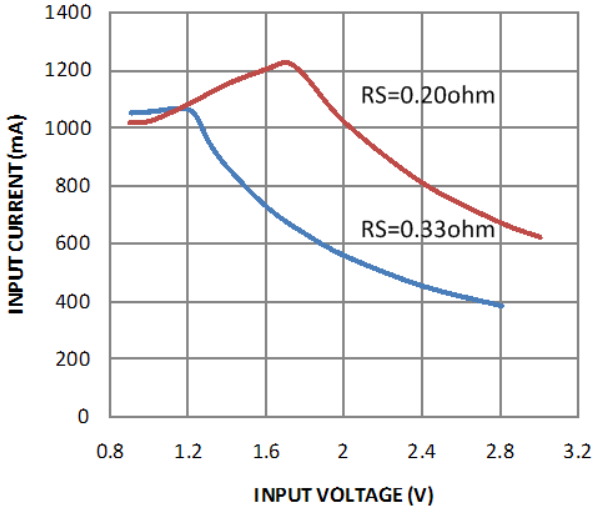
Efficiency vs Input Voltage



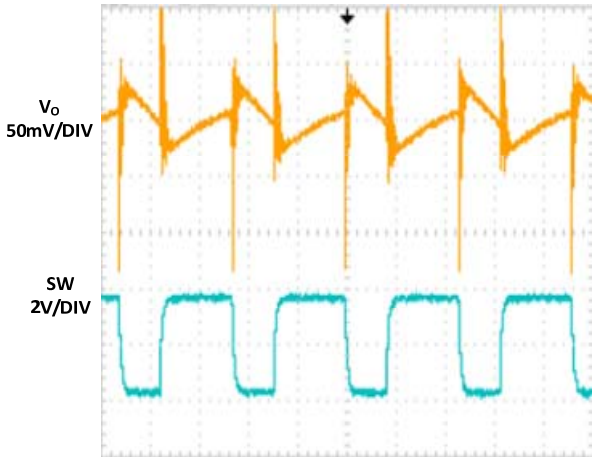
LED Current vs Input Voltage



INPUT CURRENT vs VOLTAGE



SWITCHING WAVEFORM



V_{IN}=2.4V,I_{LED}=550mA 500ns/DIV

■ OPERATION

The CE9401 3W High Power White LED Driver is targeted for single-cell or dual-cell or triangle-cell alkaline, NiMH, and NiCd and single-cell LiFePO4 lithium-ion battery applications. It has a 0.9V typical start-up voltage with operation after start-up to less than 0.65V.

The high 1.0MHz switching frequency of the CE9401 facilitates output filter component size reduction for improved power density and reduced overall footprint. It also provides greater bandwidth and improved transient response over other lower frequency step-up converters. With its low $R_{DS(ON)}$ and 95mV feedback Voltage, the devices attain up to 90% efficiency.

SLOPE COMPENSATION

Slope compensation provides stability in constant frequency architecture by preventing sub-harmonic oscillations at high duty cycles. It is accomplished internally by adding a compensating ramp to the inductor current signal at duty cycles in excess of 50%. This slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for excellent load and line response.

CURRENT SENSING

A signal representing NMOS switch current is summed with the slope compensator. The summed signal is compared to the error amplifier output to provide a peak current control command for the PWM. Peak switch current is limited to approximately 3A independent of input or output voltage. The current signal is blanked for 40ns to enhance noise rejection.

PWM/PFM AUTO SWITCHING

The CE9401 offers PWM/PFM automatic switching operation. The PWM operation is shifted to the PFM operation automatically at light load so that it maintains high efficiency over a wide range of load currents.

■ APPLICATION INFORMATION

The basic CE9401 application circuits are shown in Figure 1.External component selection is driven by the load requirement and begins with the selection of L followed by C_{IN} and C_{OUT}.

OUTPUT AND INPUT CAPACITOR SELECTION

Surface mount X5R or X7R ceramic capacitors are suggested for both the output and the input. For the output capacitor (C2 in Figure 1) a 10μF, 10V, X5R ceramic capacitor is necessary for stability, transient response, and ripple performance.

The same 0805 sized capacitor is used for the input (C1 of Figure 1). If desired, a smaller, 0603 sized, 10μF, 6.3V, X5R ceramic capacitor can be substituted for the input capacitor (C1).

INDUCTOR SELECTION

The CE9401 is designed to operate with a 2.2μH inductor for all input/output voltage combinations. The inductor saturation current rating should be greater than the NMOS current limit specification listed in the Electrical Characteristics table. If necessary, the peak inductor current can exceed the saturation level by a small amount with no significant effect on performance.

Different core materials and shapes will

change the size/current and price/current relationship of an inductor. The choice of which style inductor to use often depends more on the price vs. size requirements and any radiated field/EMI requirements than on what the CE9401 requires to operate. Table 2 shows some typical surface mount inductors that work well in CE9401 applications.

Table 2.Representative Surface Mount Inductors

PART NUMBER	VALUE (μH)	MAX DCR (mΩ)	MAX DC CURRENT (A)	SIZE W×L×H (mm^3)
Sumida CDRH 3D16	2.2 3.3 4.7	75 110 162	1.20 1.10 0.90	3.8×3.8×1.8
Sumida CR43	2.2 3.3 4.7	71.2 86.2 108	1.75 1.44 1.15	4.5×4.0×3.5
Sumida CDRH 4D18	2.2 3.3 4.7	75 110 162	1.32 1.04 0.84	4.7×4.7×2.0

OUTPUT DIODE

Use a schottky diode such as an MBR0520L, PMEG2010EA, 1N5817 or equivalent with rated current over 3A. Do not use ordinary rectifier diodes, since the slow recovery times will compromise efficiency.

SETTING THE LED CURRENT

Figure1 shows the basic application circuit of the CE9401. The internal 95mV reference voltage is compared to the voltage at the FB pin to generate an error signal at the output of the error amplifier. It's recommended to use a 1% or better precision resistor for the better LED current accuracy. The external resistor sets the LED current according to the following equation:

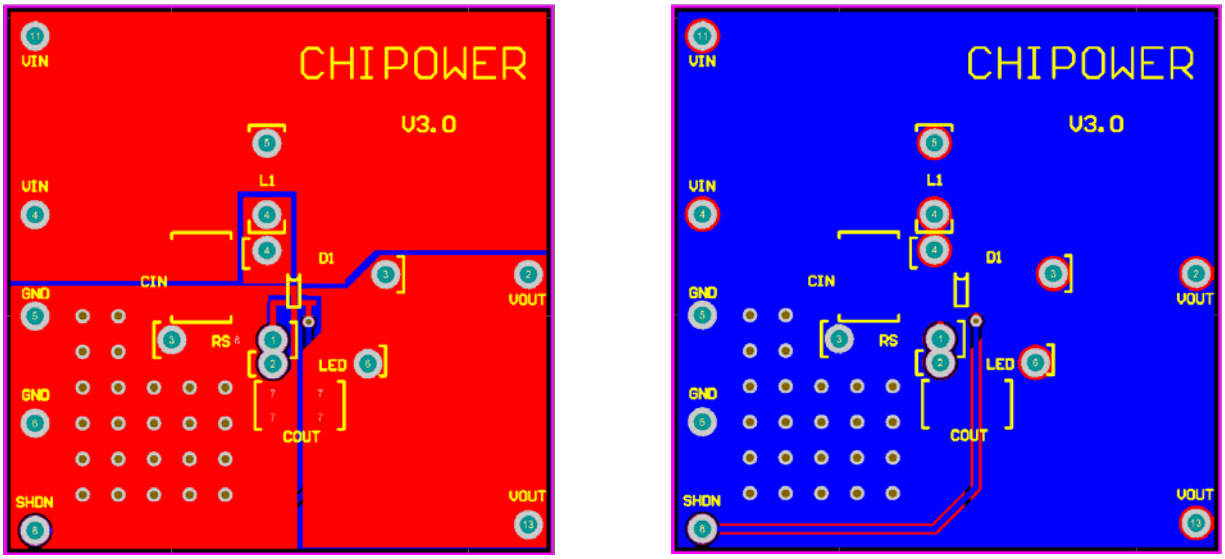
$$R_1 = {}^{95mV}/_{I_{LED}}$$

PCB LAYOUT GUIDANCE

When laying out the printed circuit board, the following suggestions should be taken to ensure proper operation of the CE9401. These items are also illustrated graphically in Figure 2.

The power traces, including the GND trace, the SW trace and the V_{IN} trace should be kept short, direct and wide to allow large current flow. Put enough multiply-layer pads when they need to change the trace layer. Keep the switching node, SW, away from the sensitive FB node.

1. The FB pin should directly connect to the feedback resistors. The divider LED/RS must be connected between the (+) plate of C_{OUT} and ground.
2. Connect the (+) plate of C_{IN} to the V_{IN} pin as closely as possible.
3. Keep the (-) plate of C_{IN} and C_{OUT} as close as possible.

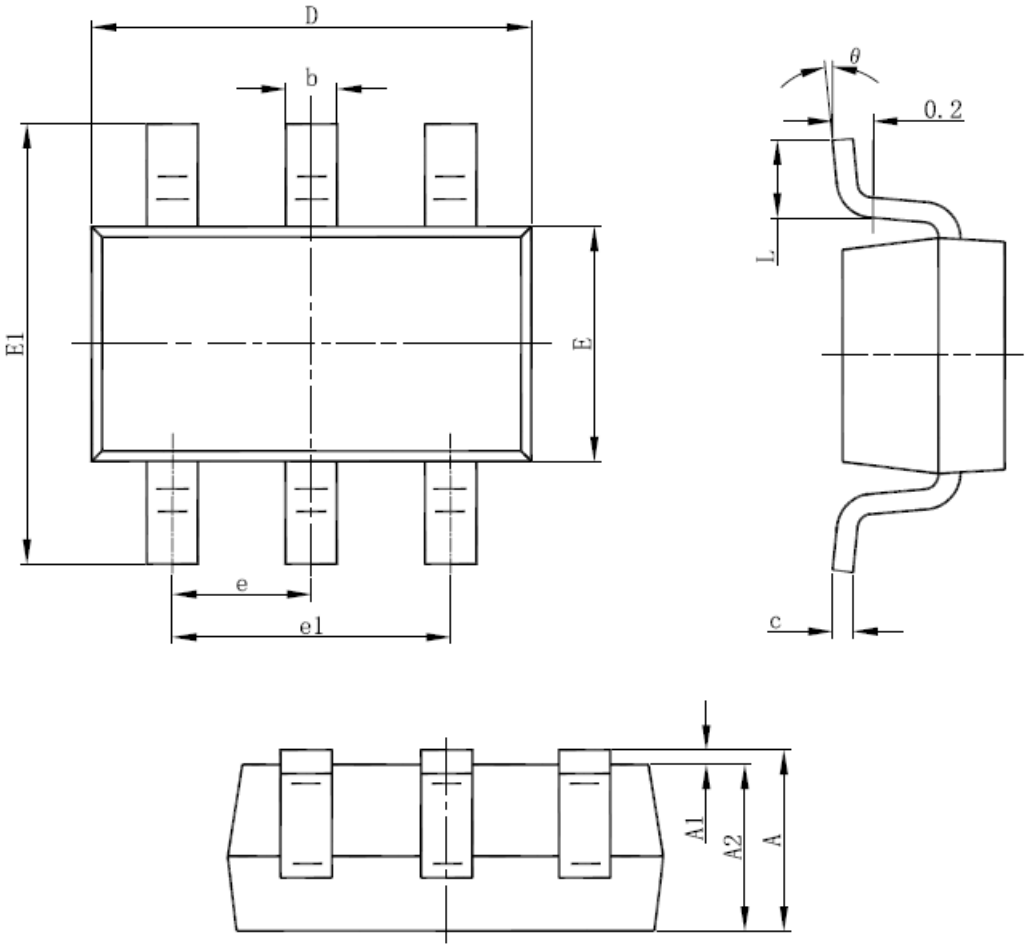


(A) Top View (B) Top View

Figure2 PCB Layout

■ PACKAGING INFORMATION

● SOT-23-6L Package Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°