CL3651

1.5 MHz, 1.2A, High Efficiency Step-Down DC/DC Converter

General Description

CL3651 is a high-efficiency DC to DC step down switching regulator, capable of delivering up to 1.2A output current. The CL3651 operates in a wide range input voltage from 2.7V to 5.5V making the IC ideal for low voltage power conversions. Running at a fixed frequency of 1.5MHz allows the use of small inductance value and low DCR inductors, thereby achieving higher efficiency.

Features

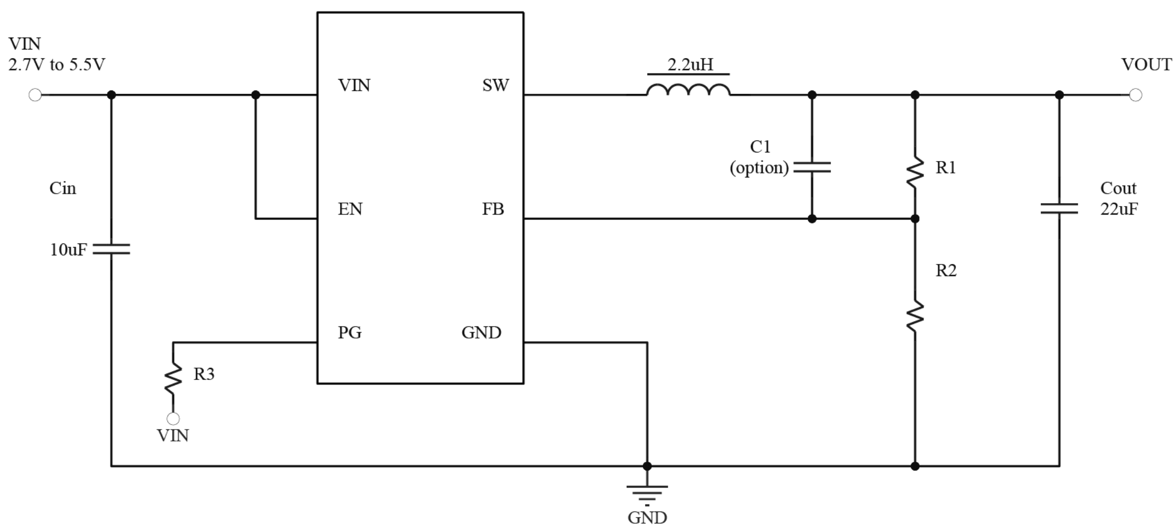
- ◆Up to 1.2A Max Output Current
- ◆2.7V to 5.5V Input Voltage Range
- ◆Fixed 1.5MHz Switching Frequency
- ◆Short circuit protect: Latch off
- ◆Light Load Operation
- ◆100% Duty Operation
- ◆Internal Compensation
- ◆RoHS Compliant and Halogen Free

Applications

- ◆USB ports/Hubs
- ◆Hot Swaps
- ◆Cell phones
- ◆Tablet PC
- ◆Set Top Boxes

CL3651 is offered in SOT-23-6L to package

Typical Application



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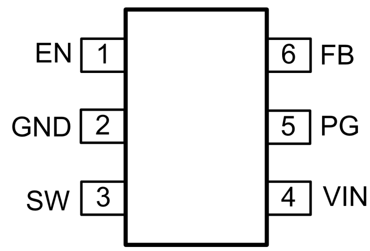
Pin Definition

SOT23-6L



PACKAGE	MARKING	MARKING DESCRIPTION
LEFT	CL3651	Chip Type Number
	C	Working Frequency
	A	High efficiency without light load
	YY	Year Number
	WW	Week Number

Pin Description

Pin Num	Pin Name
	SOT23-6
1	EN
2	GND
3	SW
4	VIN
5	PG
6	FB

Name	Description
EN	Turns on/turns off control input
GND	Power ground pin
SW	Inductor pin. Connect this pin to the switching node of inductor
VIN	Power input pin
PG	Power good indicator
FB	Output feedback pin

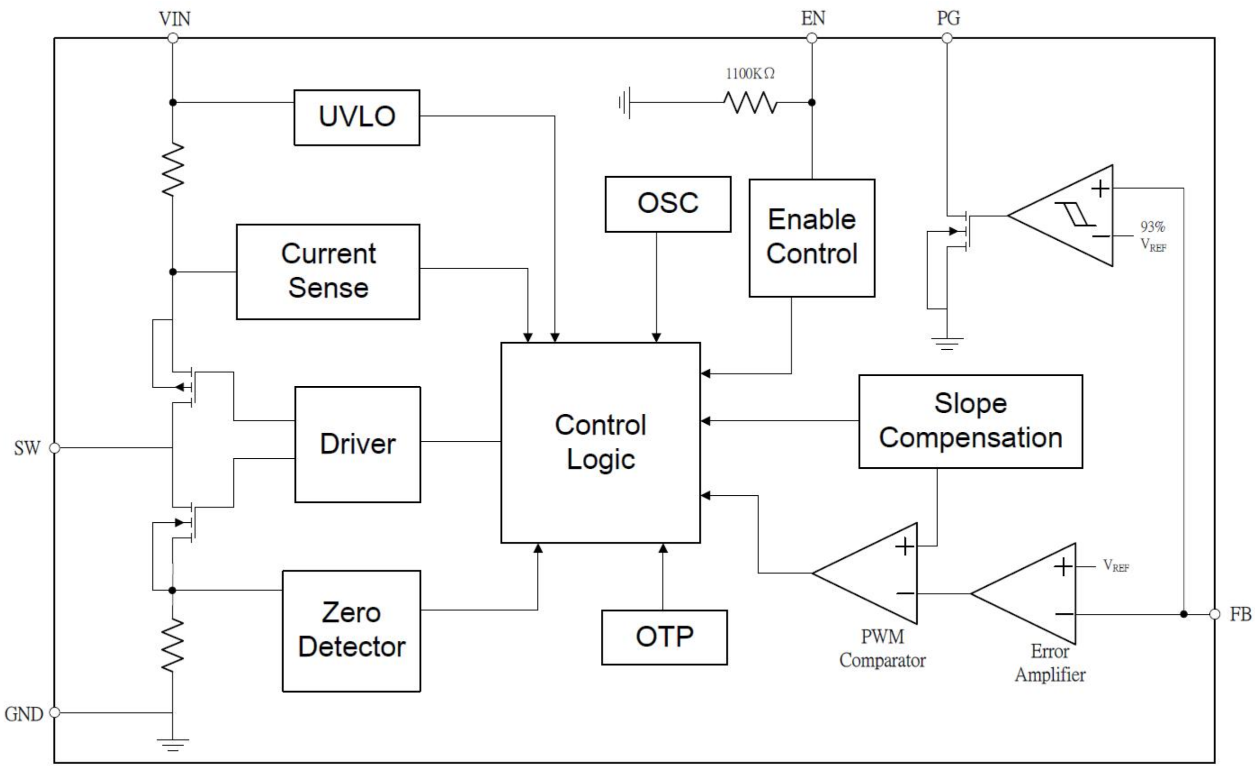
ESD AND LATCH-UP GRADE

Human body modelESDlevel	2000V
Machine mode ESDlevel	200 V

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	RATING	UNITS
INPUT VOLTAGE	V_{IN}	6.5	V
SW（DC） VOLTAGE	$V_{SW（DC）}$	Vss-0.3 ~ Vout+0.3	V
SW（AC，less than 10nS） VOLTAGE	$V_{SW（AC）}$	Vss-0.3 ~ Vout+6.5	V
FB VOLTAGE	V_{FB}	Vss-0.3 ~ Vout+6.5	V
OPERATING TEMP.	T_J	-40 ~ +150	
STORAGE TEMP.	T_{stg}	-55 ~ +150	℃
LEAD TEMP.	T_{solder}	260℃, 10s	

Block Dingram:SOT23-6L



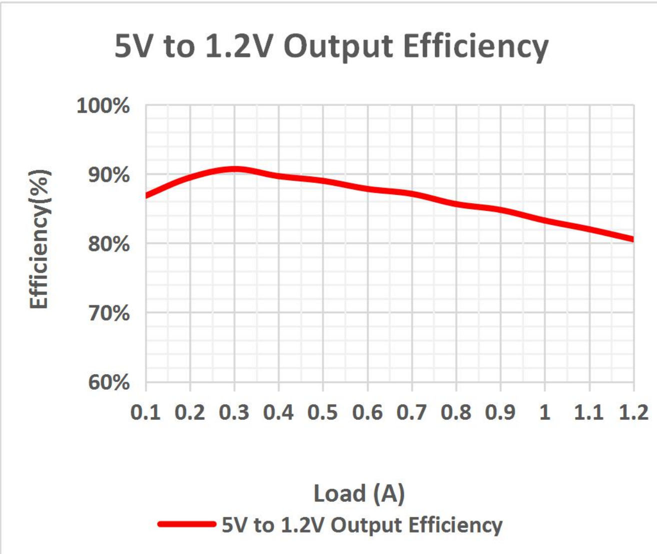
Electrical Characteristics

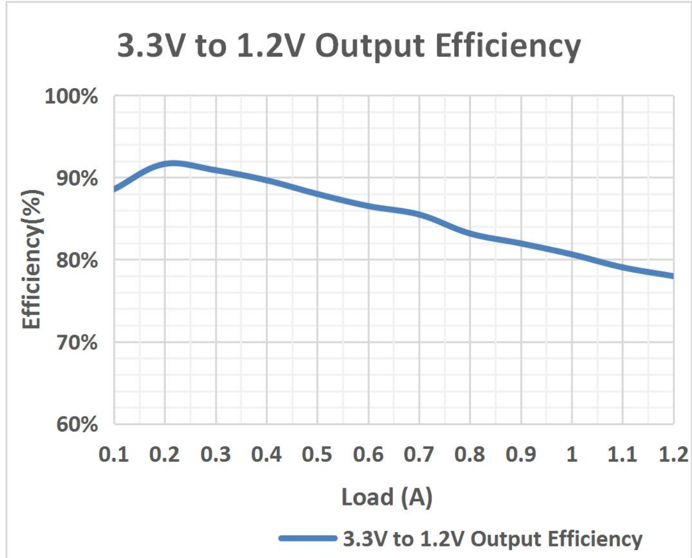
(V_{IN}=5V, T_A = 25℃T unless otherwise specified)

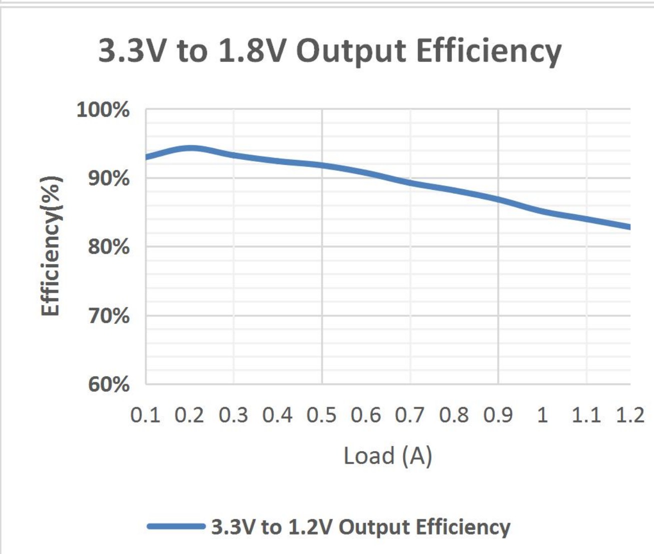
Parameters	Condition	Min	Typ	Max	Units
Input Voltage		2.7		5.5	V
UVLO Threshold			2.5		V
UVLO Hysteresis			0.15		V
Quiescent Current	VFB =0.7V		40		μA
Shutdown Supply Current	VEN=0V			1	μA
Reference Voltage	VIN=2.7 to 5.5V	0.591	0.6	0.609	V
Reference Current			0.01		μA
Maximum Duty		100			%
Switching Frequency			1.5		MHz
Internal Soft-Start Time			1		ms
High Side MOSFET On-Resistance			150		mΩ
Low Side MOSFET On-Resistance			130		mΩ
High Side MOSFET Current Limit			2.4		A
High Side MOSFET Leakage Current	VIN=5V, VFB=0.7V			10	μA
EN Pin Pull-Low Resistance			1100		KΩ
EN Pin Input Low Voltage				0.4	V
EN Pin Input High Voltage		1.5			V
Power Good Rising Threshold			93		%
Power Good Falling Threshold			88		%
Output Discharge Switch On Resistance	V_{EN}=0V		60		Ω
Thermal Shutdown Temperature			160		°C

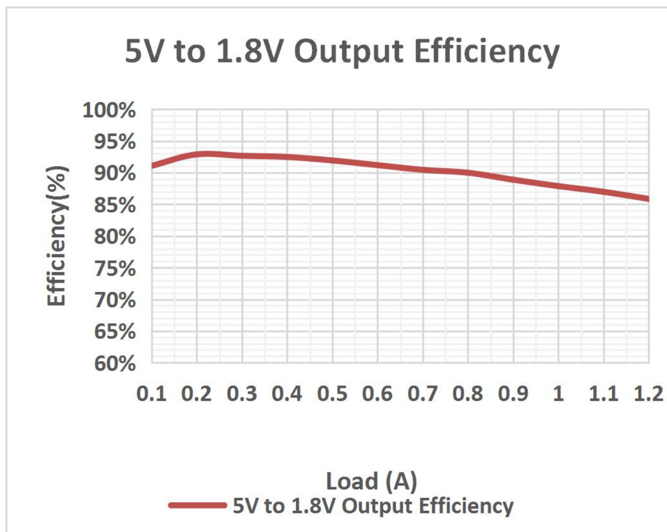
Application Performance Curves

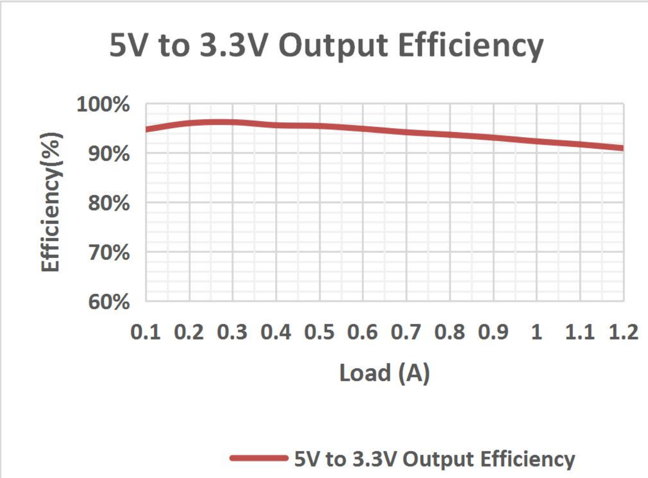
VIN = 5 V, VOUT = 1.2 V, L = 2.2 μH, TA = 25 °C, unless otherwise noted.

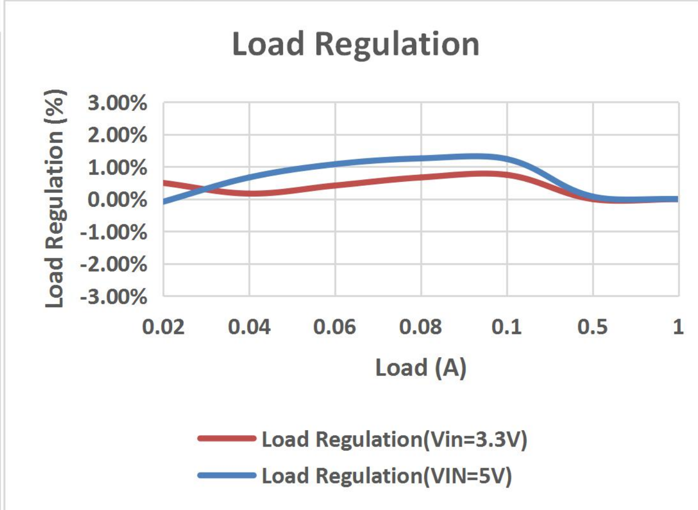


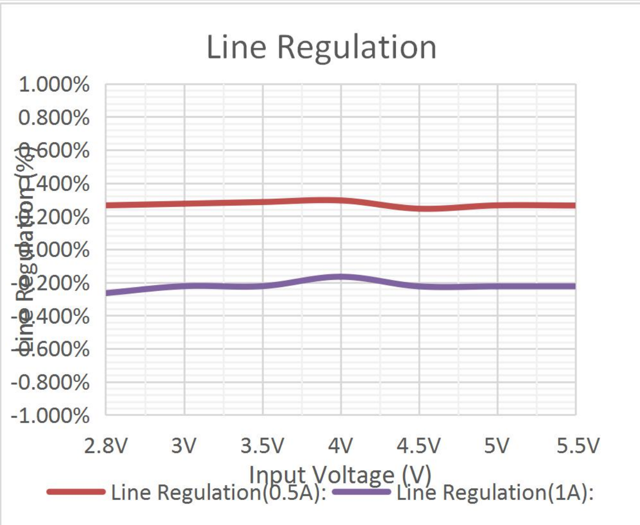







5V to 3.3V Output Efficiency
Efficiency(%)
100%
90%
80%
70%
60%
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
Load (A)
5V to 3.3V Output Efficiency


Load Regulation
Load Regulation (%)
3.00%
2.00%
1.00%
0.00%
-1.00%
-2.00%
-3.00%
0.02 0.04 0.06 0.08 0.1 0.5 1
Load (A)
Load Regulation(Vin=3.3V)
Load Regulation(VIN=5V)


Line Regulation
Line Regulation(%)
1.000%
0.800%
0.600%
0.400%
0.200%
0.000%
-0.200%
-0.400%
-0.600%
-0.800%
-1.000%
2.8V 3V 3.5V 4V 4.5V 5V 5.5V
Input Voltage (V)
Line Regulation(0.5A):
Line Regulation(1A):

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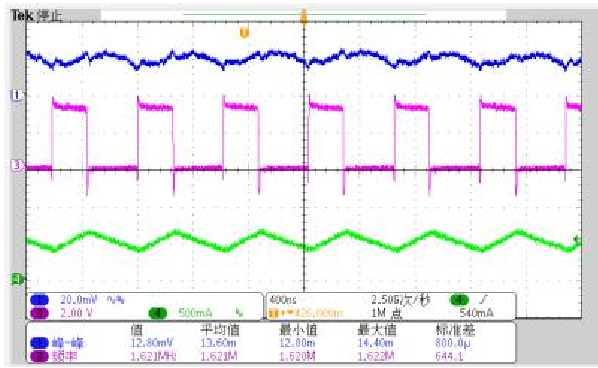
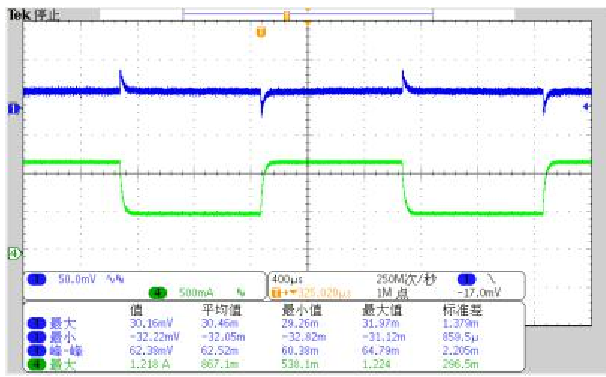
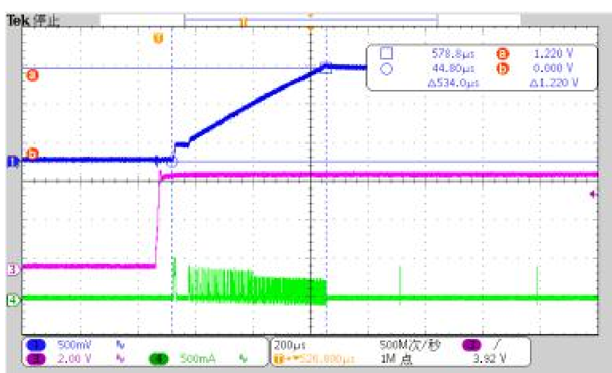
Working waveform



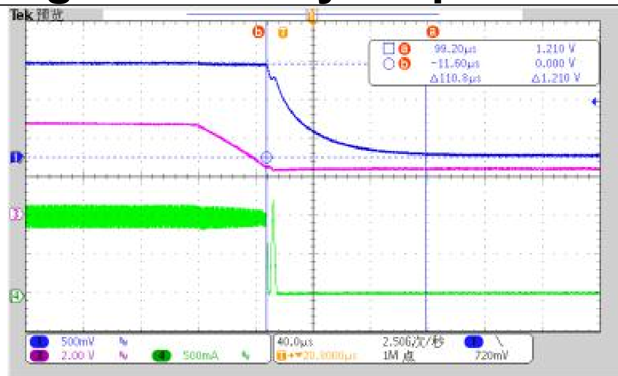
3.3V->1.2V, Iload=,500mA（Steady State Waveform）



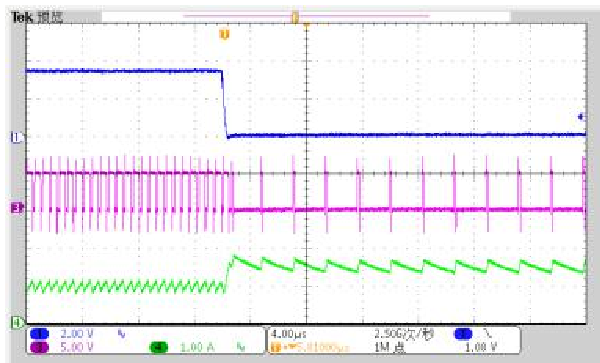
Vin=3.3V, 0.5A to 1.2A transient waveform（Transient Response）



Cin=1cm to Vin pin, Iload=0A power on（VIN Power ）



Cin=1cm to Vin pin, Iload=3A power off（VIN Power ）



Iload=3A short

Function Description

CL3651 high efficiency switching regulator is a small, simple, DC-to-DC step-down converter capable of delivering up to 1.2A of output current. The device operates in pulse-width modulation (PWM) at 1.5MHz from 2.7V to 5.5V input voltage and provides an output voltage from 0.6V to VIN, making the IC ideal for on-board post-regulation applications. An internal synchronous rectifier improves efficiency and eliminates the typical Schottky free-wheeling diode. Using the on resistance of the internal high-side MOSFET to sense switching currents eliminates current-sense resistors, further improving efficiency and reducing cost.

●Loop Operation

The IC uses a PWM current-mode control scheme. An open-loop comparator compares the integrated voltage-feedback signal against the sum of the amplified current-sense signal and the slope compensation ramp. At each rising edge of the internal clock, the internal high-side MOSFET turns on until the PWM comparator terminates the on cycle. During this on-time, current ramps up through the inductor, sourcing current to the output and storing energy in the inductor. The current mode feedback system regulates the peak inductor current as a function of the output voltage error signal. During the off cycle, the internal high-side P-channel MOSFET turns off, and the internal low-side N-channel MOSFET turns on. The inductor releases the stored energy as its current ramps down.

●Current Sense

An internal current-sense amplifier senses the current through the high-side MOSFET during on time and produces a proportional current signal which is used to sum the slope compensation signal. The summed signal then is compared with the error amplifier output by the PWM comparator to terminate the on cycle.

●Current Limit

There is a cycle-by-cycle current limit on the high-side MOSFET. When the current flowing out of SW exceeds this limit, the high-side MOSFET turns off and the synchronous rectifier turns on.

●Soft-start

The IC has an internal soft-start circuit to reduce supply inrush current during startup conditions. When the device exits under-voltage lockout (UVLO), shutdown mode, or restarts following a thermal-overload event, the soft-start circuit slowly ramps up the output voltage.

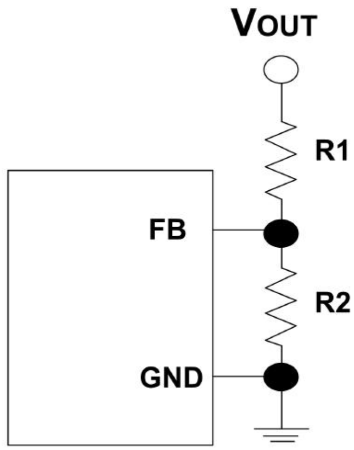
●UVLO and Thermal Shutdown

If VIN drops below 2.5V, the UVLO circuit inhibits switching. Once VIN rises above 2.7V, the UVLO clears, and the soft-start sequence activates. Thermal-overload protection limits total power dissipation in the device. When the junction temperature exceeds TJ= +160°C, a thermal sensor forces the device to shutdown, allowing the die to cool down. The thermal sensor turns the device on again after the junction temperature falls below 60°C. After a thermal-shutdown condition, the soft-start sequence begins.

Application Information

●Setting Output Voltages

The resistive voltage divider allows the FB pin to sense a fraction of the output voltage shown as below.



For adjustable voltage mode, the output voltage is set by an external resistive voltage divider according to the following equation:

$$V_{OUT} = V_{FB}\left(1 + \frac{R1}{R2}\right)$$

where V_{FB} is the feedback reference voltage (0.6V typ.).

●Inductor Selection

The peak-to-peak ripple is set to 30% of the output current. This places the peak current far enough from the minimum over current trip level to ensure reliable operation while providing enough current ripples for the current mode converter to operate stably. The inductance is determined as expressed in the following equation:

$$L \geq \frac{(V_{IN} - V_{OUT}) \times D}{\Delta I_L \times f_{SW}}$$

Where ΔI_L is the inductor peak-to-peak ripple current, D is the duty cycle determined by VOUT/VIN, f_{SW} is the switching frequency.

●Output Capacitor Selection

For most applications a nominal 22μF*2 capacitor is suitable. The output capacitor keeps output ripple small and ensures control-loop stability.

The output capacitor must also have low impedance at the switching frequency. Ceramic, polymer, and Tantalum capacitors are suitable, with ceramic exhibiting the lowest ESR and high-frequency impedance. Output ripple with a ceramic output capacitor is approximately as follows:

$$\Delta V_{OUT} \leq \Delta I_L\left[ESR + \frac{1}{8 f_{SW} C_{OUT}}\right]$$

●Input Capacitor Selection

The input capacitance, C_{IN}, is needed to filter the trapezoidal current at the source of the top MOSFET. To prevent large ripple current, a low ESR input capacitor sized for the maximum RMS current should be used. The RMS current is given by :

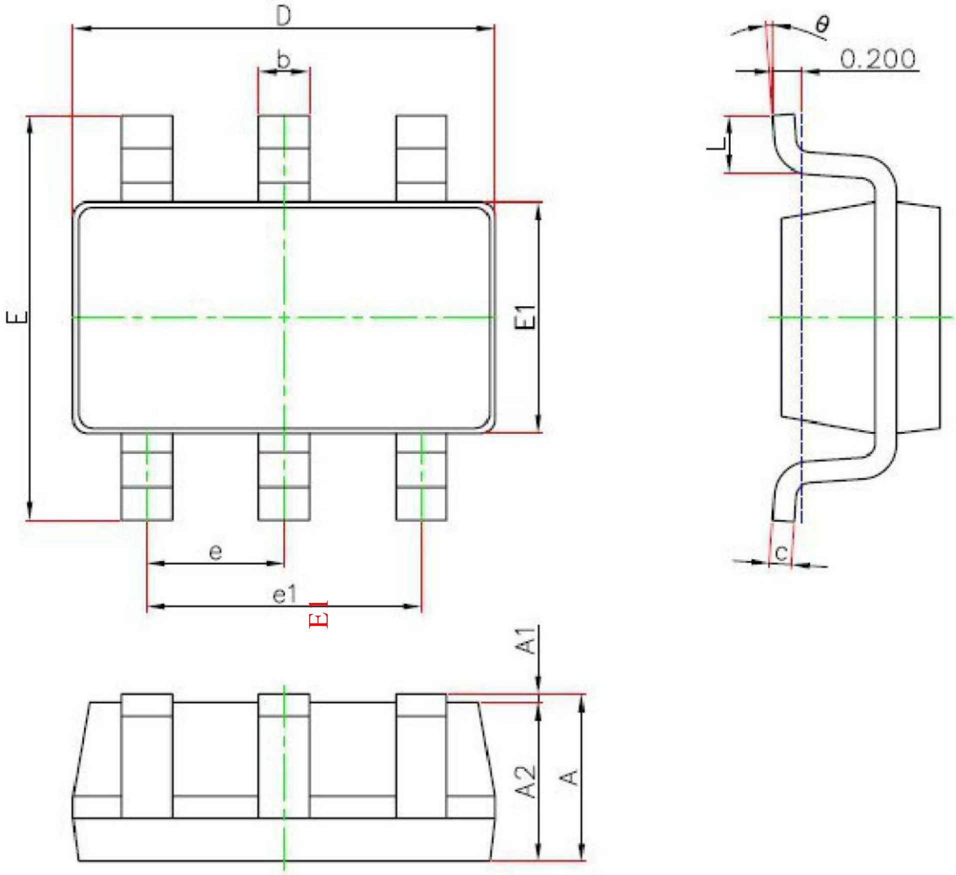
$$I_{RMS} = I_{OUT} \times \sqrt{D \times (1 - D)}$$

This formula has a maximum at ,$V_{IN} = 2V_{OUT}$, where $I_{RMS} = {I_{OUT}}/{2}$

●Power Good Function

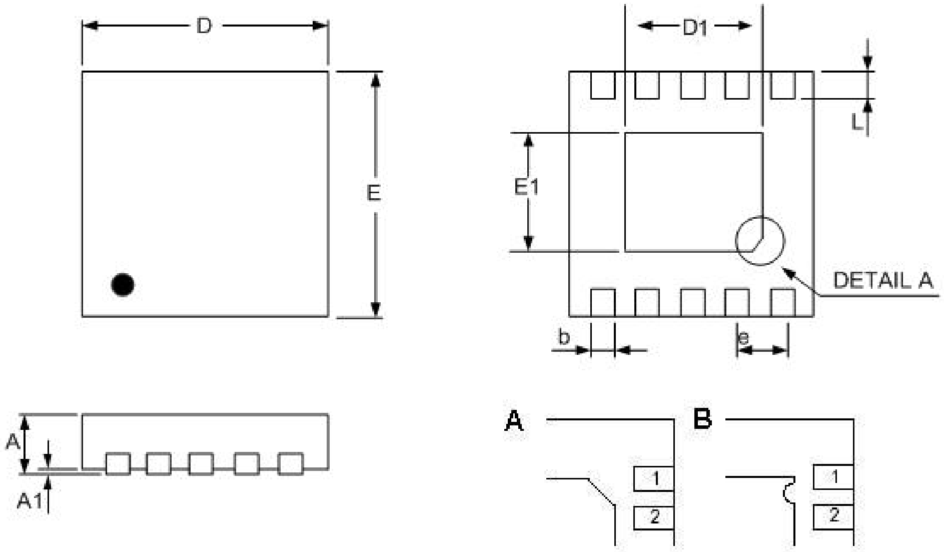
PG pin for CL3651 is an open drain input, when output voltage higher than 92% setting value, the state is high. If the output voltage is less than 88%, the state will change to low. Recommend the value of pull up resistor is from 50Kohm to 100Kohm to take better performance.

Package Mechanical Data ： SOT-23-6L



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
E1	1.500	1.700	0.059	0.067
E	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°

Package Mechanical Data ：



DETAIL A
Thermal Pad Option

SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
b	0.18	0.30	0.007	0.012
D	2.90	3.10	0.114	0.122
D1	2.10	2.60	0.083	0.102
E	2.90	3.10	0.114	0.122
E1	1.35	1.75	0.053	0.069
e	0.50		0.020	
L	0.30	0.50	0.012	0.020

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