5V 1.25MHz Step-up 10-White LED Driver

GENERAL DESCRIPTION

The UCT4394 is a 5V step-up DC/DC converter designed for driving up to single 10-series or 9x3-series WLEDs from a single cell Lithium Ion battery.

The UCT4394 uses current mode, fixed frequency architecture to regulate the LED current, which is measured through an external current sense resistor. Its low 300mV feedback voltage reduces power loss and improves efficiency.

The UCT4394 is turned off if an over-voltage condition is present due to an open circuit condition.

The UCT4394 includes under-voltage lockout, current limiting and thermal overload protection preventing damage in the event of an output overload.

The UCT4394 is available in SOT23-5 and SOT23-6 packages

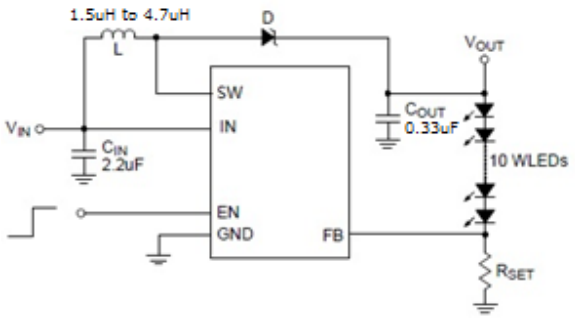
FEATURES

- Drives Up to 1x10 or 9x3 Series White LEDs
- Up to 90% Efficiency
- 1.25MHz Fixed Switching Frequency
- Low 300mV Feedback Voltage
- UVLO
- Open-circuit Protection
- Thermal Shutdown
- Internal 1.5A Current Limit
- SOT23-5 and SOT23-6 Packages

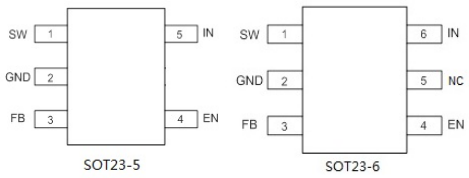
APPLICATIONS

- 5~7” LCD Panels
- Handheld Computers and PDAs
- Digital Cameras
- Small LCD Displays

TYPICAL APPLICATION CIRCUIT



PIN ASSIGNMENT



PIN DESCRIPTION

PIN NO		SYMBOL	DESCRIPTTION
SOT23-5	SOT23-6		
1	1	SW	Power Switch Output.
2	2	GND	Ground
3	3	FB	Feedback input.
4	4	EN	Chip Enable.
5	6	IN	Power Supply Input.
	5	NC	Not Connected.

ABSOLUTE MAXIMUM RATINGS (Note 1)

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	Input Voltage	-0.3～8	V
V_{SW}	Voltage at SW Pin	-0.5～40	V
V_{IO}	All Other I/O Pins	GND-0.3 to VDD+0.3	V
P_{DMAX}	Power Dissipation	0.4	W
P_{TR1}	Thermal Resistance，SOT23-5, Θ_{JA}	220	℃/W
T_J	Junction Temperature	-40~125	℃
Tstg	Storage Temperature	-55 to 150	℃
Tsolder	Package Lead Soldering Temperature	260℃, 10s	

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Recommended Operating Range indicates conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Range. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

RECOMMANDED OPERATING RANGE

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	VIN Supply Voltage	2.5 to 7	V
V_{SW}	Output Voltage	V_{IN} to 35	V
T_{OPT}	Operating Temperature	-40 to +85	℃

ELECTRICAL CHARACTERISTICS (Note 2, 3)

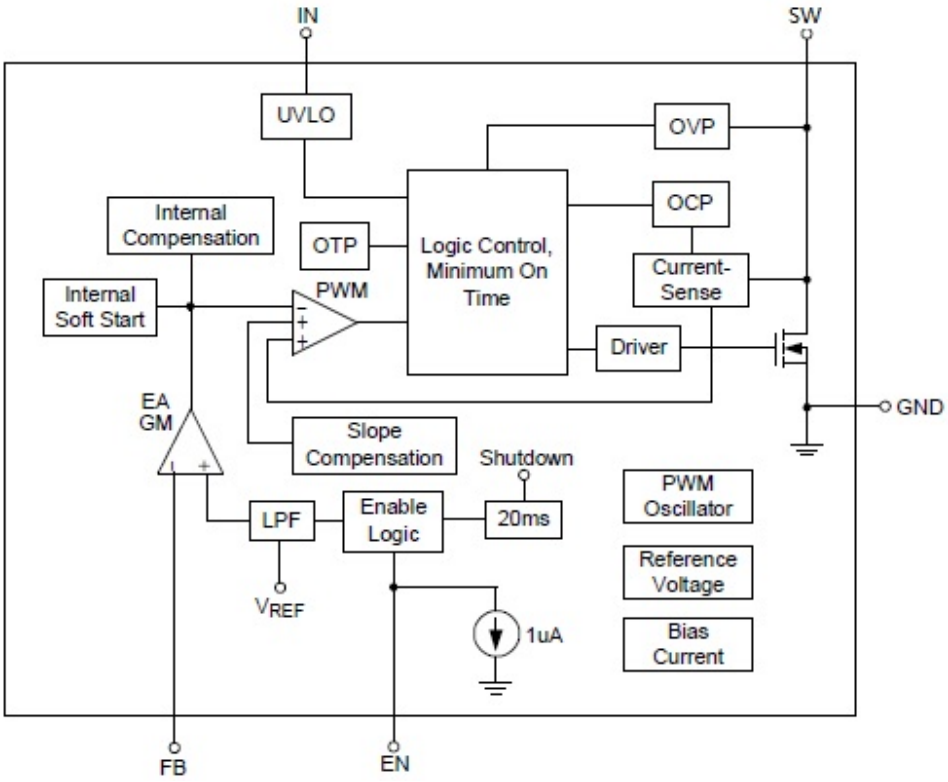
The following specifications apply for V_{IN}= V_{EN} =3.6V T_A=25 °C, unless specified otherwise.

SYMBOL	ITEMS	CONDITIONS	MIN	TYP	MAX	UNIT
V_{IN}	Input Voltage		2.5		7	V
V_{FB}	FB Pin Voltage		291	300	309	mV
I_{FB}	FB Pin Input Bias Current			0.05	1	μA
I_{SHDN}	Shutdown Current	V_{SW-ON} =0V		0.1	1	μA
I_Q	Quiescent Current	V_{FB}=0.4V		400	500	μA
F_{SW}	Switching Frequency		0.9	1.25	1.6	MHz
D_{MAX}	Maximum Duty Cycle	V_{FB}=0V	92	95		%
F_{DIM}	Dimming frequency		0.1		200	KHz
V_{EN_H}	EN Minimum High Level		1.5			V
V_{EN_L}	EN Maximum Low Level				0.4	V
I_{EN}	EN Input Bias Current	V_{SW-ON} =0V, 5V		0.1	1	μA
R_{ON}	SW On Resistance			0.6		Ω
I_{LIMIT}	SW Current Limit			1.5		A
I_{LEAK}	SW Leakage Current	V_{SW}＝5V		0.1	1	μA
V_{OV}	Open Circuit Shutdown Threshold	V_{OV} Rising		35		V
T_{SS}	Soft Start Time	V_{IN} Power On		800		μS

Note 2: Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the recommended operating Range. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 3: Typicals are measured at 25˚C and represent the parametric norm.

SIMPLIFIED BLOCK DIAGRAM



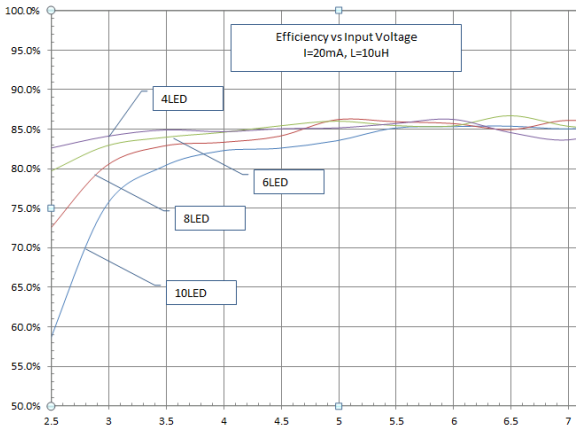
OPERATION DESCRIPTIONS

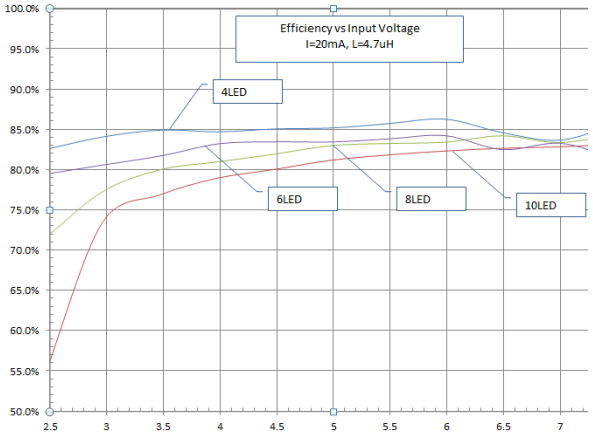
The UCT4394 uses a constant-frequency current-mode boost converter architecture to control the LED current by regulating the feedback voltage. Please refer to the functional block diagram above for an explanation of UCT4394 operation. The beginning of each cycle turns on the Power MOSFET. A slope compensation ramp is added to the output of the current sense amplifier and the result is fed into the positive input of the comparator. When this voltage goes above the output voltage of the error amplifier, the Power MOSFET is turned off. The voltage at the output of the g_M block amplifies the difference between the reference voltage and the feedback voltage, so that FB voltage can be regulated to the reference voltage.

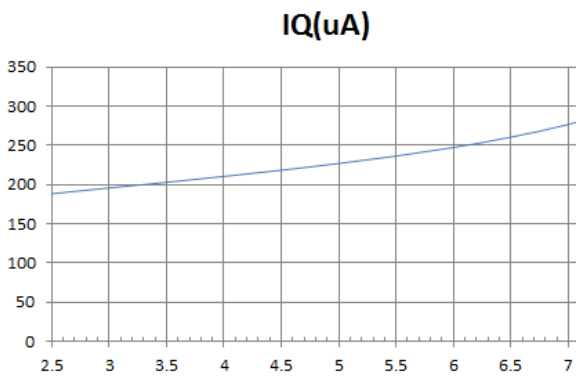
The UCT4394 has built-in soft-start to limit the inrush current during startup and to limit the amount of overshoot on the output. Protection features in the UCT4394 include over-voltage protection (OVP), cycle-by-cycle current limit protection and thermal shutdown. OVP protects in the event where an LED fails open, which forces the feedback voltage to zero. This causes the boost converter to operate in maximum duty cycle mode, ramping up the output voltage. Switching will stop when the output reaches the OVP threshold. The OVP feature protects the IC from damaging itself or external components by exceeding the voltage rating on SW pins.

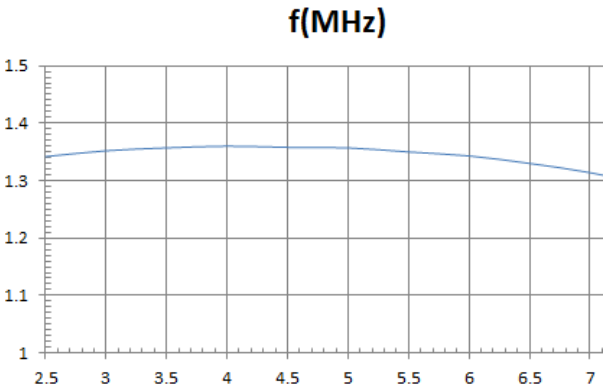
TYPICAL OPERATING CHARACTERISTICS

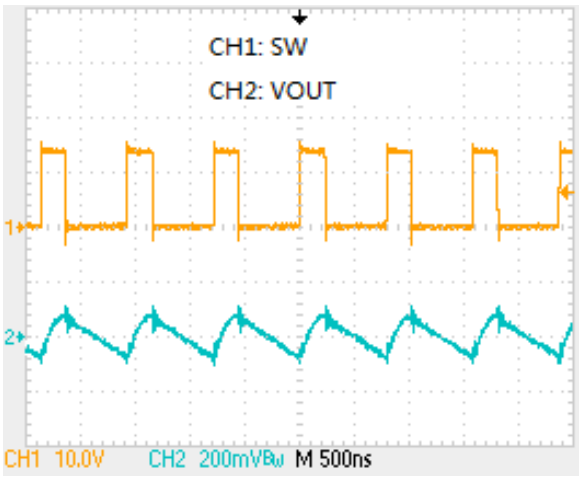
Tested under TA=25°C, unless otherwise specified

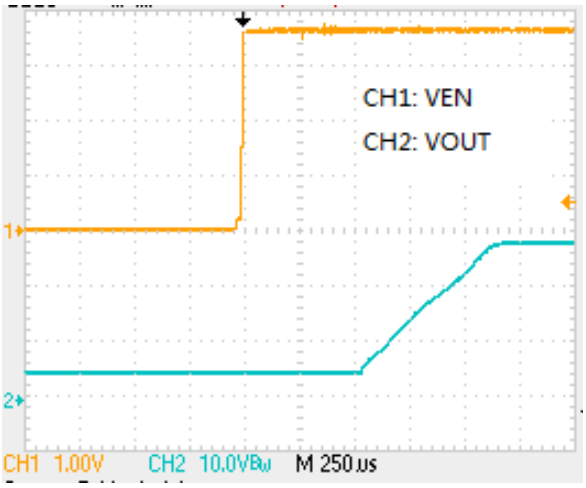


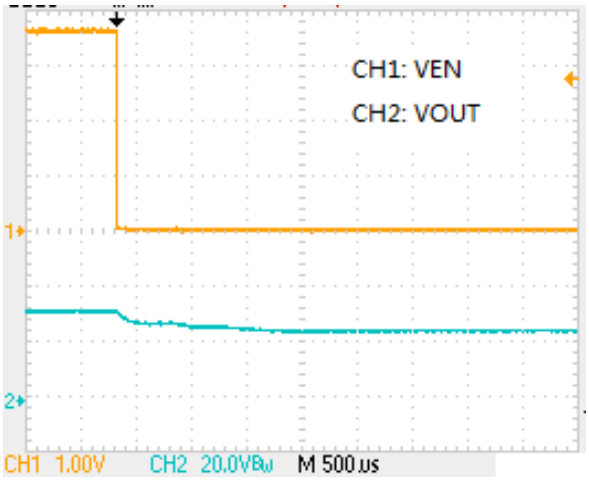


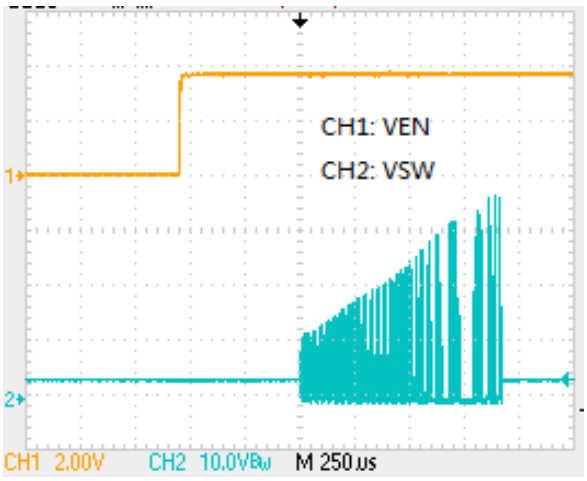


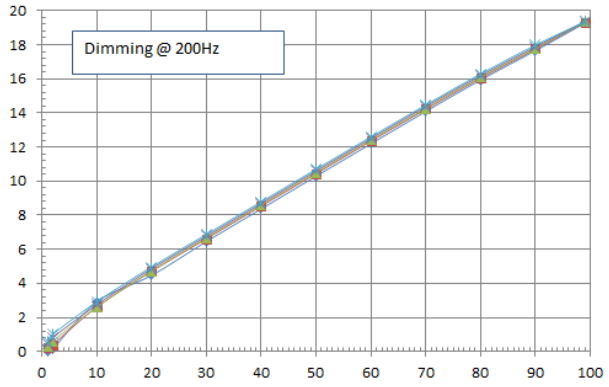


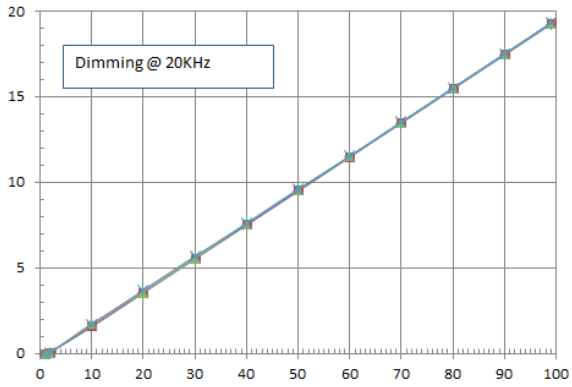












APPLICATION INFORMATION

- **Inductor Selection**

A 1.5 ~4.7 µ H inductor is recommended for 10/8/6-Series LED applications and 3seriesx9 LED applications. Small size and better efficiency are the major concerns for portable devices, such as the UCT4394 used for mobile phone. If high efficiency is a critical requirement, a low DCR inductor should be selected. The inductor's saturation current rating should also exceed the peak input current, especially for high load current application.

Application	Part Number	L (µ H)	DCR (Ω)	Saturation Current(A)	Dimensions (mm)	Manufacturer
6-series	LQH3NPN100NM0	1.5	0.26	0.55	3.0 x 3.0 x 1.4	Murata
6-series	CDR7D43MNNP- 220N	4.7	0.085	2.85	7.6 x 7.6 x 4.5	Sumida
6-series	744043220	4.7	0.185	0.7	4.8 x 4.8 x 2.8	Wurth Elektronik
10- series	LQH55DN220M03L	4.7	0.19	1.2	5.7 x 5.0 x 4.7	Murata

- **Capacitor Selection**

Small size ceramic capacitors are ideal for UCT4394 application. A 4.7uF input capacitor and a 0.47uF output capacitor are suggested for 10/8/6-Series LED applications. For high output current applications, larger value output capacitors like 2.2uF is recommended to minimize output ripple. For better voltage filtering, ceramic capacitors with low ESR are recommended. X5R and X7R types are suitable because of their wider voltage and temperature ranges.

- **Diode Selection**

Using a schottky diode is recommended in UCT4394 applications because of its low forward voltage drop and fast reverse recovery time. The current rating of the schottky diode should exceed the peak current of the boost converter. The voltage rating should also exceed the target output voltage.

- **LED Current Setting**

LED current is determined by the feedback resistor (R1 in Figure 1 and Figure 2 above). The feedback voltage is internally set at 300mV. The LED current is programmed according to the formula I=300mV/R1. For accurate LED current settings, precision 1% resistors are recommended. The formula and table for R1 selection are shown below:

$R1 = 300mV/I_{LED}$

- **LED Dimming Control**

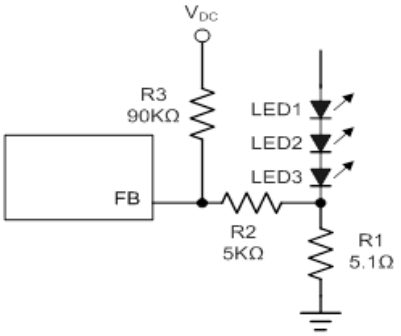
Below there are five different LED dimming control methods described:

1. Using a PWM Signal to EN Pin

With the PWM signal applied to the EN pin, the UCT4394 is correspondingly turned ON or OFF by the PWM signal. The LEDs alternate between zero and full programmed current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle PWM signal will turn off the UCT4394 and corresponds to zero LED current. A 100% duty cycle PWM signal turns on the LEDs continuously at full current. The typical frequency range of the PWM signal is 100Hz to 200KHz.The magnitude of the PWM signal should be higher than the minimum EN voltage HIGH specification. The UCT4394 has an internal RC filter which creates a DC average of the PWM duty cycle. The -3dB cutoff frequency of the low pass filter is 360Hz. PWM control signals with low frequencies will not be filtered which means a PWM ripple can pass to the output; however, the average output current is continuously proportional to the PWM control signal regardless of the ripple amplitude. For systems which are sensitive to audible noise, it is recommended to use PWM frequencies greater than 5KHz.

2. Using a DC Voltage

For some applications, the preferred method of brightness control is a variable DC voltage to adjust the LED current. As the DC voltage increases, the voltage drop on R2 increases and the voltage drop on R1 decreases. Thus, the LED current decreases. The selection of R2 and R3 should make the current from the variable DC source much smaller than the LED current and much larger than the FB pin leakage current.



- **LED Minimum Dimming Current Setting**

LED dimming current can be programmed to very low levels by applying a PWM dimming duty ratio. However, due to the internal offset of the LED driver control loop, the LED current's absolute accuracy decreases with lower PWM dimming duty ratio. It is recommended to set the minimum LED dimming PWM duty ratio to at least 15% for reasonable accuracy and device-to-device matching.

- **Power Sequence**

In order to assure the normal soft start function for suppressing the inrush current the input voltage should be ready before EN pulls high.

- **Soft-Start**

The function of soft-start is made for suppressing the inrush current to an acceptable value at the beginning of power on. The UCT4394 provides a built-in soft-start function by clamping the output voltage of error amplifier so that the duty cycle of the PWM will be increased gradually in the soft-start period.

- **Current Limiting**

The current flow through inductor as charging period is detected by a current sensing circuit. As the value comes across the current limiting threshold, the N-MOSFET will be turned off so that the inductor will be forced to leave charging stage and enter discharging stage. Therefore, the inductor current will not increase over the current limiting threshold.

- **Thermal Considerations**

For continuous operation, do not exceed absolute maximum operation junction temperature. The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surroundings airflow and temperature difference between junction to ambient. For the recommended operating conditions specification of UCT4394, the maximum junction temperature of the die is 125℃. The junction to ambient thermal resistance θ_{JA} is layout dependent. The junction to ambient thermal resistance for SOT23-5 package is 220℃/W on the standard JEDEC51-3 single layer thermal test board.

- **OVP/UVLO/OTP**

The Over Voltage Protection is detected by a junction breakdown detecting circuit. Once VOUT goes over the detecting voltage, SW pin stops switching and the power N-MOSFET will be turned off. Then, the VOUT will be clamped to be near VOVP. As the output voltage is higher than a specified value or input voltage is lower than a specified value, the chip will enter protection mode to prevent abnormal function. As the die temperature is higher than 160℃, the chip also will enter protection mode. The power MOSFET will be turned off during protection mode to prevent abnormal operation.

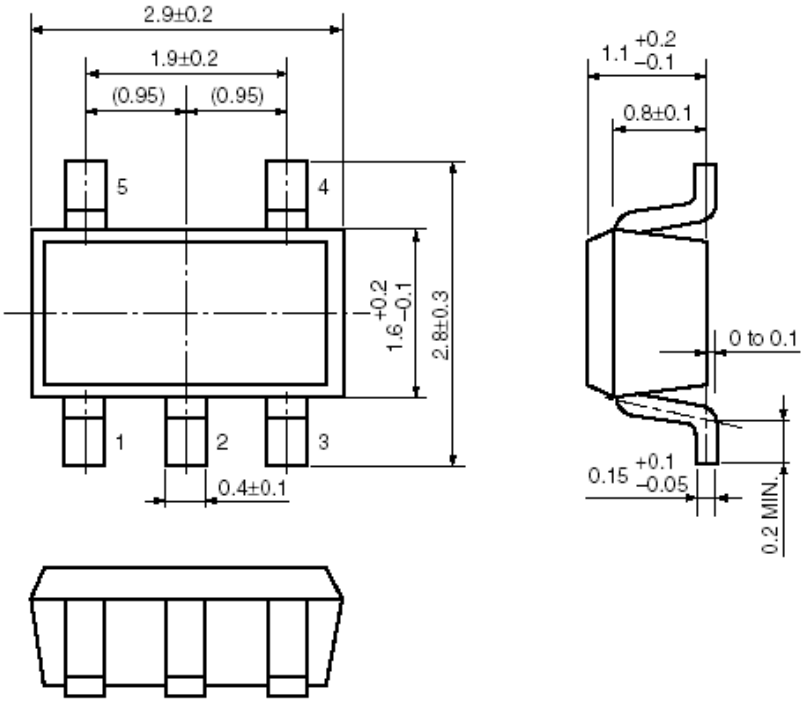
- **Layout Considerations**

PCB layout is very important for high frequency switching regulators in order to keep the loop stable and minimize noise. For best performance of the UCT4394, the following guidelines must be strictly followed.

- Input and Output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
- The GND pin should be connected to a strong ground plane for heat sinking and noise protection.
- Keep the main current traces as possible as short and wide.
- The SW node is with high frequency voltage swing. It should be kept in a smallest area.
- Place the feedback components (on FB pin) as close as possible to the IC and keep away from the noisy devices.

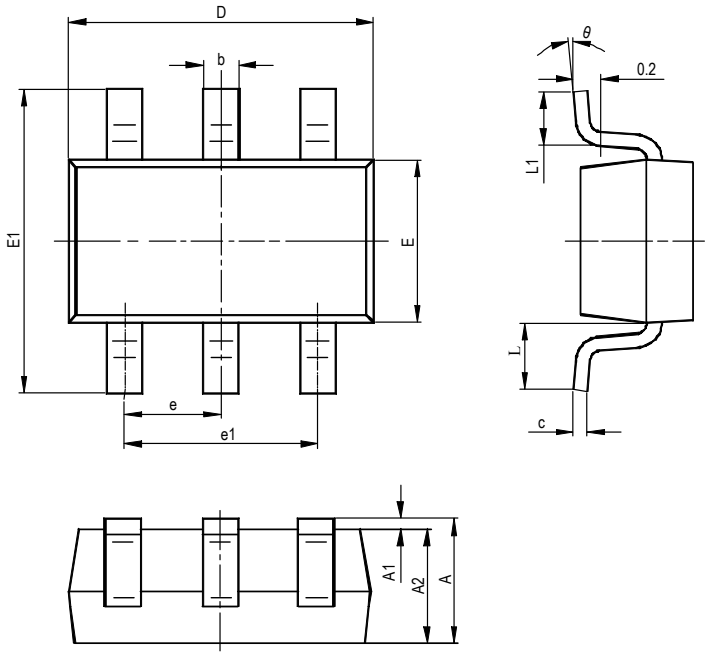
PACKAGE OUTLINE

SOT23-5



PACKAGE OUTLINE

SOT23-6



SYMBOL	MILLIMETERS		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	0.400	0.012	0.016
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	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°