24V, 1A Monolithic Step-Up Switching Regulator

1 Features

- 4A Current Limited Integrated Switch
- 1.4V to 6.5V Supply Voltage Range,3.3V to24V Vout Max
- Integrated 80mΩ N-channe MOSFET switches
- Fixed 650KHz Switching Frequency
- Internal Soft-Start limits the inrush current at turn-on
- Internal compensation to save external components
- Output Over-Voltage Protection
- Over-Temperature Protection
- Peak Current-Mode Control
- Pulse skip mode at light load to improve light load efficiency
- SOT23-6 Package

2 Applications

- Chargers
- Handheld Devices
- Portable Products

3 Description

The PL33011 is a high efficiency, current-mode control Boost DC to DC regulator with an integrated 80mΩR_{DS}(ON) N-channel MOSFET. The fixed 650KHz switching frequency and internal compensation reduce external component count and save the PCB space.

The build-in internal soft start circuitry minimizes the inrush current at start-up.PL33011 also features a light load pulse skipping mode, which allows for a power loss reduction from the input power supply to the system at light loading. A cycle-by-cycle current limit protects the IC at over loading condition.

4 Typical Application Schematic

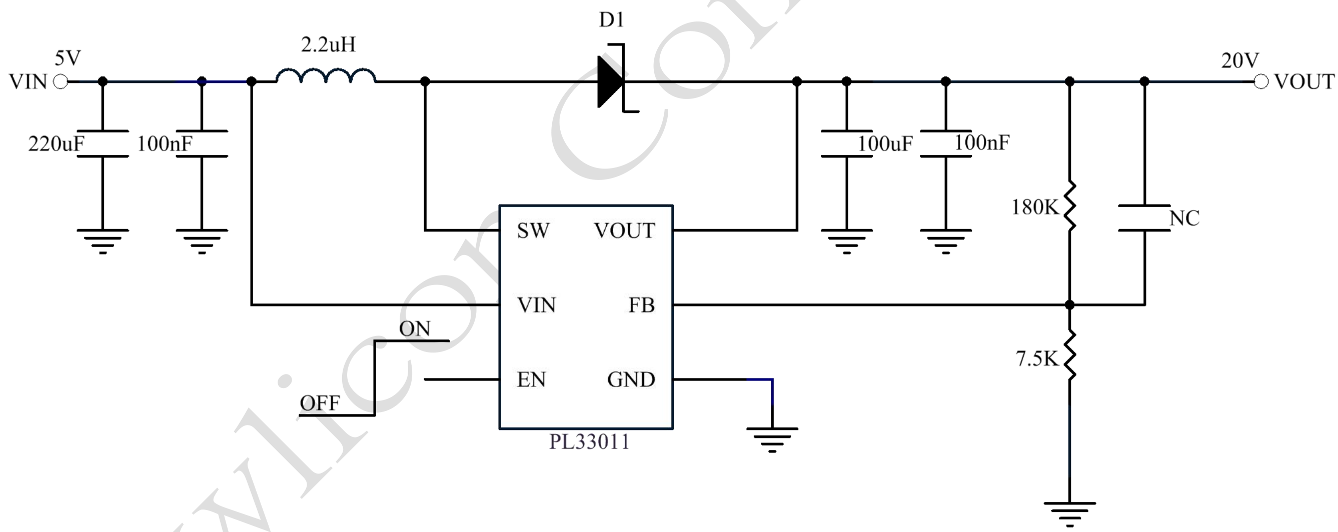


Fig. 1 Schematic

5 Pin Configuration and Functions

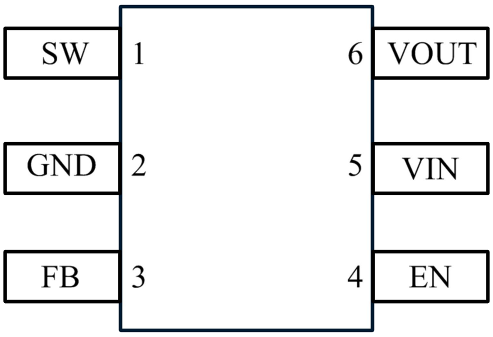


Fig. 2 PL33011 SOT23-6 Package

PL33011 Pin-Functions (SOT23-6 Package)

Pin		Description
Number	Name	
1	SW	Power Switching pin. Connect this pin to the switching node of inductor.
2	GND	Ground.
3	FB	Feedback Input. FB senses the output voltage. FB is a sensitive node. Keep FB away from SW pin.
4	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator; low to turn it off. EN pin is pulled to VIN internally by a larger resistor.
5	VIN	Input pin. Decouple this pin to the GND pin with a 0.1μF ceramic capacitor.
6	VOUT	Connect this pin to the output voltage.

6 Device Marking Information

Part Number	Order Information	Package	Package Qty	Top Marking
PL33011	**PL33011ISO06**	**SOT23-6**	**3000**	**D7YMD**

PL33011: Part Number
RAAYMD: RAA: LOT NO.; YMD: Package Date

7 Specifications

7.1 Absolute Maximum Ratings(Note1)

	PARAMETER	MIN	MAX	Unit
Input Voltages	V_{IN} to GND	-0.3	8	V
	V_{EN} to GND	-0.3	8	
	V_{FB} to GND	-0.3	8	
	V_{OUT} to GND	-0.3	30	
	V_{SW} to GND	-0.3	30	

7.2 Handling Ratings

PARAMETER	DEFINITION	MIN	MAX	UNIT
T_{ST}	Storage Temperature Range	-65	150	°C
T_J	Junction Temperature		+150	°C
T_L	Lead Temperature		+260	°C
V_{ESD}	HBM Human body model		2	kV
	CDM Charger device model		500	V

7.3 Recommended Operating Conditions (Note 2)

	PARAMETER	MIN	MAX	Unit
Input Voltages	V_{IN} to GND	1.4	6.5	V
Output Voltages	V_{OUT}		24	V
Output Current	I_{OUT}		1	A
Temperature	Operating junction temperature range, T_J	-40	+85	°C

7.4 Thermal Information (Note 3)

Symbol	Description	SOT23-6	Unit
θ_{JA}	Junction to ambient thermal resistance	56	°C/W
θ_{JC}	Junction to case thermal resistance	45	

Notes:
1) Exceeding these ratings may damage the device.
2) The device function is not guaranteed outside of the recommended operating conditions.
3) Measured on approximately 1” square of 1 oz copper.

7.5 Electrical Characteristics (Typical at Vin = 5V, T_J=25°C, unless otherwise noted.)

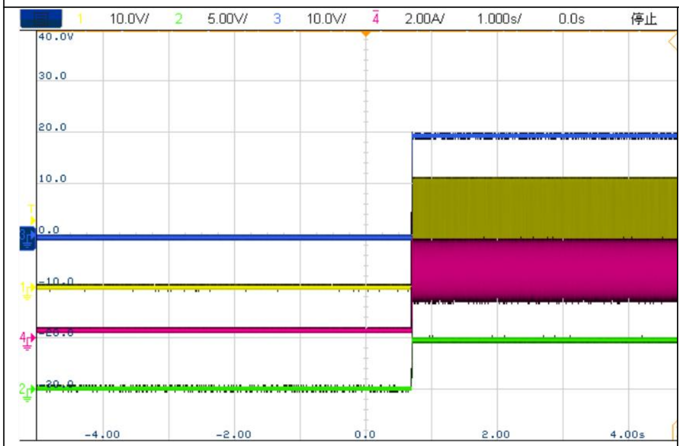
SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
SUPPLY VOLTAGE (VIN)						
VIN	Input Voltage Range		1.4		6.5	V
$VIN_{\_UVLO}$	VIN UVLO Rising Threshold			1.4		V
I_Q	Quiescent Current	No Load, FB = 0.8V		400		uA
I_{SHDN}	Shutdown Current	No Load, EN = 0V		2		uA
Enable and Reference Control						
V_{EN_UV}	Operation Threshold			1.2		V
R_{EN}	EN Internal Pull-Up Resistor			5		MΩ
MOSFET						
$R_{DS(ON)}$	Low Side Main FET R_{ON}			80		mΩ
CONTROL LOOP						
F_{oscb}	Boost oscillator frequency		550	650	750	kHz
D_{max}	Maximum Duty Cycle(Note 4)			88		%
T_{on}	Minimum On Time(Note 4)			100		nS
V_{FB}	Feedback Reference Voltage		0.75	0.8	0.85	V
PROTECTION						
I_{LIMIT}	Main FET Current Limit	Minimum Duty Cycle		4.5		A
$VOUT_{\_OVP}$	Output Over-voltage Threshold			1.1*FB		V
Th_{sd}	Thermal Shutdown(Note 4)			160		°C
Th_{sdhys}	Thermal Shutdown Hysteresis(Note 4)			50		°C

Note:
4) Guaranteed by design, not tested in production.

8 Typical Characteristics

Vin = 5V, Vout = 12V

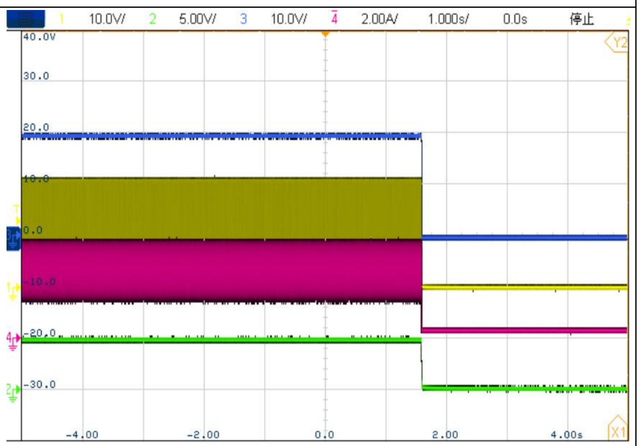
Fig. 3 Efficiency



Vin = 5V, Vo = 20V

Ch1: SW Ch2:VIN Ch3:VOUT Ch4:IL

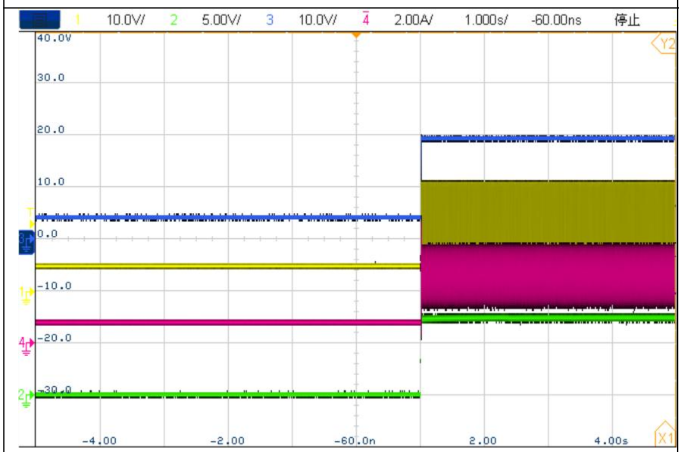
Fig. 4 Startup waveform VIN, Iout = 0.5A



Vin = 5V, Vo = 20V

Ch1: SW Ch2:VIN Ch3:VOUT Ch4:IL

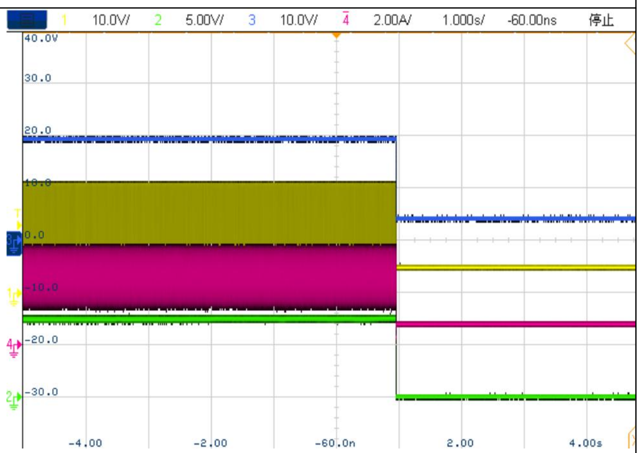
Fig. 5 Shutdown waveform VIN, Iout = 0.5A



Vin = 5V, Vout = 20V

Ch1: SW Ch2:VIN Ch3:VOUT Ch4:IL

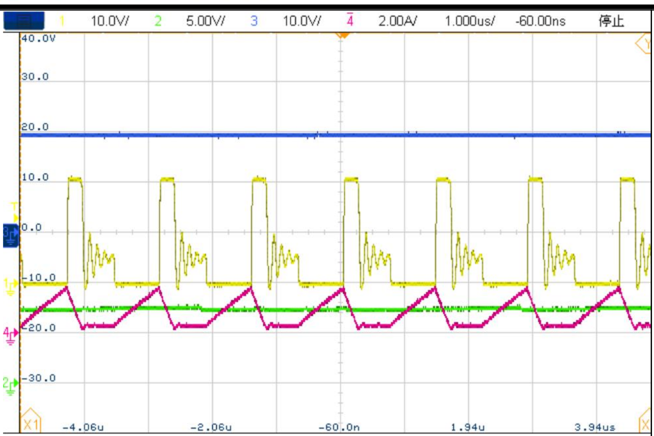
Fig. 6 Startup waveform EN, Iout = 0.5A



Vin = 5V, Vout = 20V

Ch1: SW Ch2:VIN Ch3:VOUT Ch4:IL

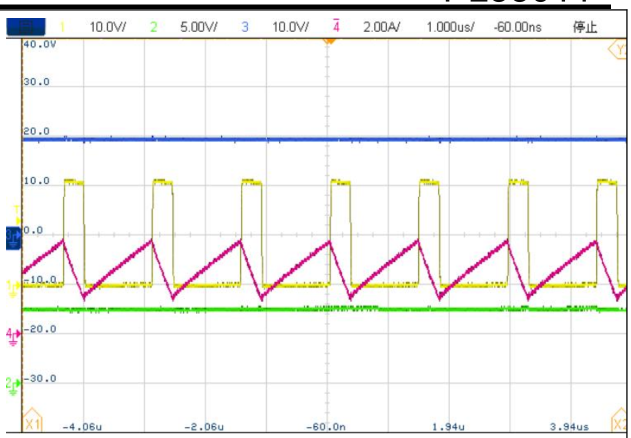
Fig. 7 Shutdown waveform, Iout = 0.5A



Vin = 5V, Vout = 20V

Ch1: SW Ch2:VIN Ch3:VOUT Ch4:IL

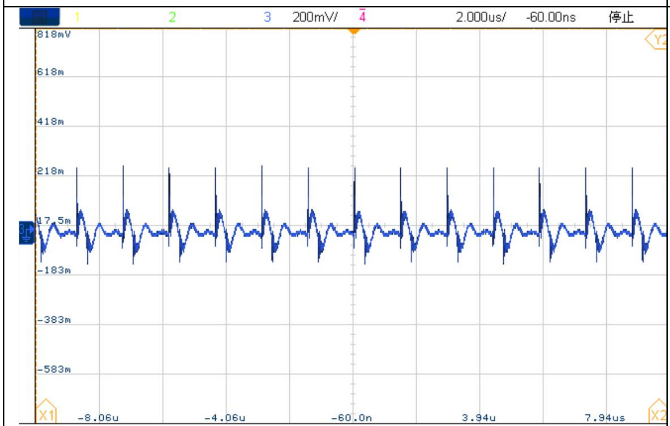
Fig. 8 Steady state waveform, Iout = 0.1A



Vin = 5V, Vout = 20V

Ch1: SW Ch2:VIN Ch3:VOUT Ch4:IL

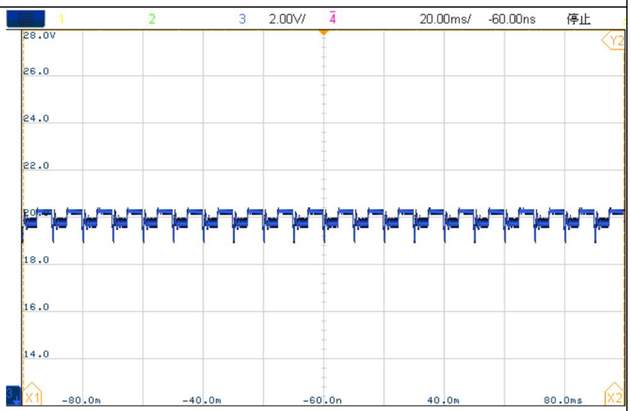
Fig. 9 Steady state waveform, Iout = 0.5A



Vin = 5V, Vout = 20V

Ch3:VOUT

Fig. 10 Ripple wave，Iout = 0.5A



Vin = 5V, Vout = 20V

Ch3:VOUT

Iout = 0A-0.3A,3A/uS ,Duty50%

Fig. 11 Load translent,

9 Detailed Description

9.1 Overview

The PL33011 is a 24V, 1A Current Limited Integrated Switch, step-up (boost) converter. To improve performance during line and load transients, the device implements a constant frequency, current mode control which reduces output capacitance and simplifies external frequency compensation design.

9.2 Functional Block Diagram

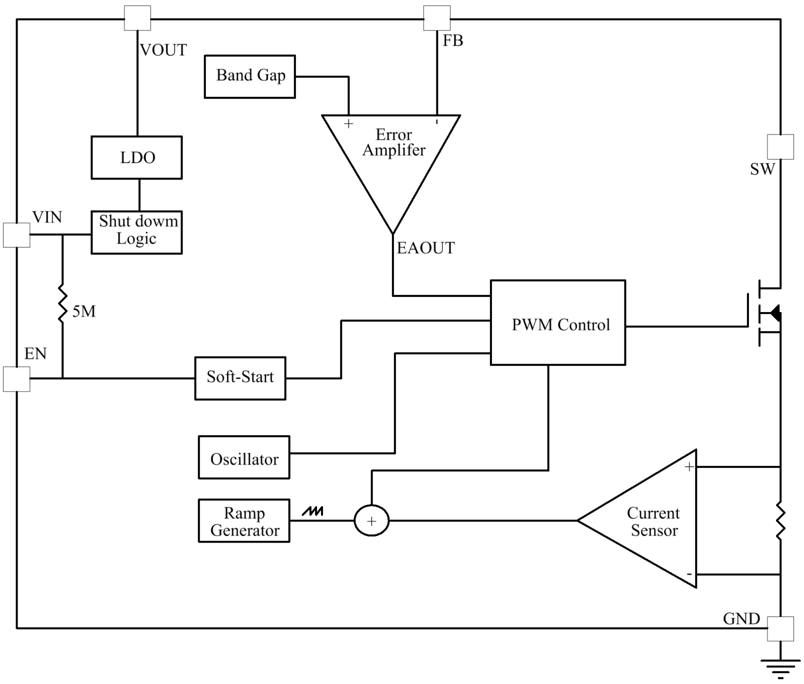


Fig.12 PL33011 Diagram

9.3 Peak Current Mode Control

The PL33011 employs peak current mode control. The output voltage is sensed by an internal feedback resistor string on VOUT pin and fed to an internal error amplifier. The output of error amplifier will compare with high side current sense signal by an internal PWM comparator. When the second signal is higher than the first one, the PWM comparator will generate a turn-off signal to turn off high side switch. The output voltage of error amplifier will increase or decrease proportionally with the output load current. PL33011 has a cycle-by-cycle peak current limit feature inside to help maintain load current in a safe region.

9.4 Pulse-Skipping Mode

The PL33011 integrates a pulse-skipping mode at the light load. When a light load condition occurs, the EAOUT voltage naturally decreases and reduces the peak current. When the EAOUT voltage further goes down with the load lowered and reaches the pre-set low threshold, the output of the error amplifier is clamped at this threshold and does not go down any more. If the load is further lowered, the output voltage of PL33011 exceeds the nominal voltage and the device skips the switching cycles. The pulse-skipping mode reduces the switching losses and improves efficiency at the light load condition by reducing the average switching frequency.

9.5 Open loop start

At the beginning of the start up, a 650k clock is generated to driver the power nmos,Both the clock and the drive circuit are powered by input voltage.As the output voltage increases to 2.8V,The clock turns off and switches to closed-loop operation,All the circuits are powered by output voltage.This ensures that the chip will work even when the input voltage is only 1V.

9.6 Slope Compensation

In order to avoid sub-harmonic oscillation at high duty cycle, PL33011 adds a slope compensation ramp to the sensed signal of current flowing through high side switch.

9.7 Error Amplifier

The error amplifier compares the FB voltage against the internal reference (V_{ref}) and outputs a current proportional to the difference between these two signals. This output current charges or discharges the internal compensation network to generate the error amplifier output voltage, which is used to control the power MOSFET current. The optimized internal compensation network minimizes the external component counts and simplifies the control-loop design.
The voltage reference system produces a ±2.5% initial accuracy voltage reference by scaling the output of a temperature stable bandgap circuit. The typical voltage reference is designed at 0.8 V.

9.8 Enable/UVLO

When EN is greater than 1.2V operating threshold, the control loop starts to work and regulate output to target voltage. When EN pin is below the standby threshold (0.9V typical), PL33011 stops working . EN is pulled high to VIN internally using a 1Meg resistor.

9.9 Over-Voltage Protection (OVP)

When the output voltage is higher than 28.5V,The power nmos is turned off and the chip stops working,after the output voltage is smaller than 27V，chip stops works again.

9.10 Thermal Shutdown

The internal thermal-shutdown circuitry forces the device to stop switching if the junction temperature exceeds 150°C typically. When the junction temperature drops below 100°C, IC will start to work again.

10 Application and Implementation

10.1 Inductor selection

The operating frequency and inductor selection are interrelated in that higher operating frequencies allow the use of smaller inductor and capacitor values. The inductor value has a direct effect on ripple current. The inductor current ripple ΔI_L is typically set to 20% to 40% of the maximum inductor current in the boost region at $V_{IN(MIN)}$.

For a given ripple, the inductance terms in continuous mode are as follows:

$$L > \frac{V_{IN(MIN)}^2 * (V_{OUT} - V_{IN(MIN)}) * 1000}{f * \Delta I_L * V_{OUT}^2} uH \quad (1)$$

where: f is operating frequency, kHz

$V_{IN(MIN)}$ is minimum input voltage, V

$V_{IN(MAX)}$ is maximum input voltage, V

V_{OUT} is output voltage, V

ΔI_L is maximum inductor ripple current, A, usually select 20~40% maximum output current.

For high efficiency, choose an inductor with low core loss, such as ferrite. Also, the inductor should have low DC resistance to reduce the I2R losses, and must be able to handle the peak inductor current without saturating. To minimize radiated noise, use a toroid, pot core or shielded bobbin inductor.

10.2 C_{IN} and C_{OUT} Selection

The C_{OUT} must be capable of reducing the output voltage ripple because of the discontinuous output current. The effects of ESR (equivalent series resistance) and the bulk capacitance must be considered when choosing the right capacitor for a given output ripple voltage. The steady ripple due to charging and discharging the bulk capacitance is given by:

$$\Delta V_{(Cap)} = \frac{I_{OUT(MAX)} * (V_{OUT} - V_{IN(MIN)})}{C_{OUT} * V_{OUT} * f} V \quad (2)$$

where C_{OUT} is the output filter capacitor.

The steady ripple due to the voltage drop across the ESR is given by:

$$\Delta V_{(ESR)} = I_{OUT(MAX,BOOST)} * ESR \quad (3)$$

10.3 Output voltage setting

The PL33011 output voltage is set by an external feedback resistive divider carefully placed across the output capacitor. The 1% resistance accuracy of this resistor divider is preferred. The resultant feedback signal is compared with the internal precision 0.8V voltage reference by the error amplifier. The output voltage is given by the equation:

$$V_{OUT} = 0.8V * \left(1 + \frac{R_1}{R_2}\right) \quad (4)$$

Where R_1 is the upper resistor and R_2 is the lower resistor in the feedback network.

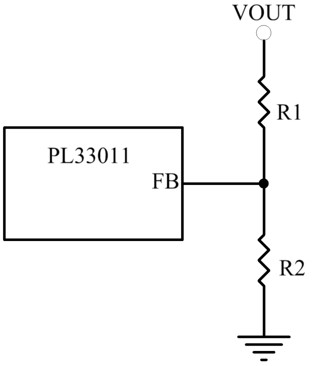
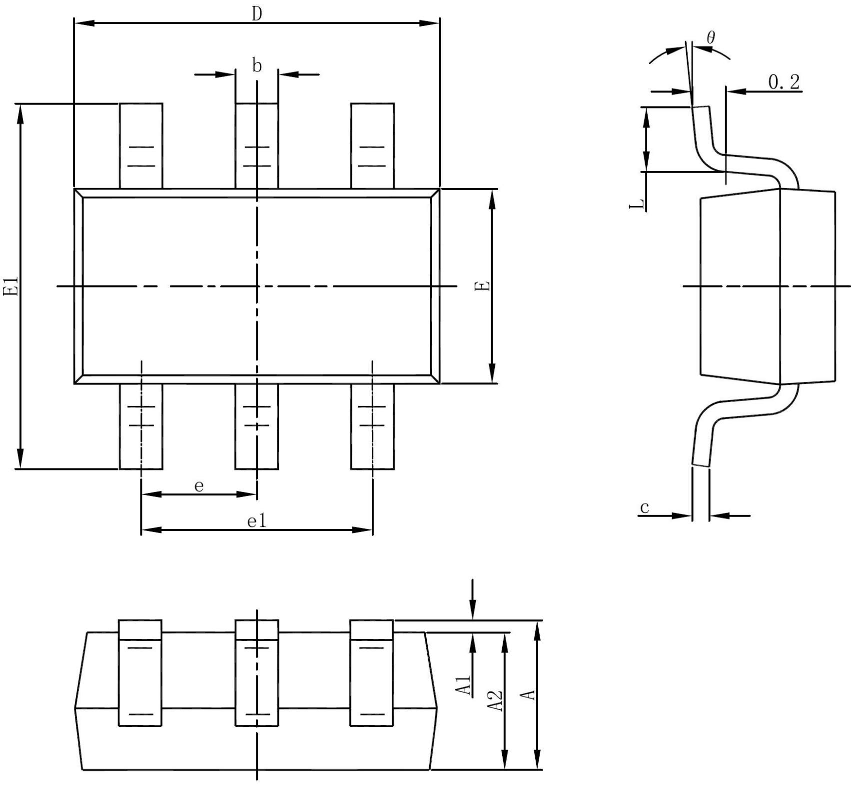


Figure 13. Output Voltage Programming

12 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°