Constant Voltage and Constant Current Controller for Adaptors and Battery Chargers

IK3051

Description

IK3051 is a highly integrated solution for SMPS applications requiring constant voltage and constant current mode.

IK3051 integrates one voltage reference, two operational amplifiers (with ORed outputs – common collectors), and a current sensing circuit.

The voltage reference combined with one operational amplifier makes it an ideal voltage controller, and the other low voltage reference combined with the other operational amplifier makes it an ideal current limiter for output low side current sensing.

The current threshold is fixed and precise.

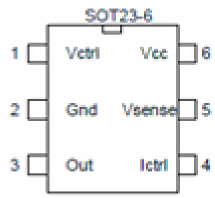
The only external components are:

- A resistor bridge to be connected to the output of the power supply (adapter, battery charger) to set the voltage regulation by dividing the desired output voltage to match the internal voltage reference value.
- A sense resistor having a value and allowable dissipation power which need to be chosen according to the internal voltage threshold.
- Optional compensation components (R and C).

IK3051, is ideal for smallest package available, is ideal for space shrinked applications such as adapters and battery chargers.

SOT23-6
(Plastic Package)

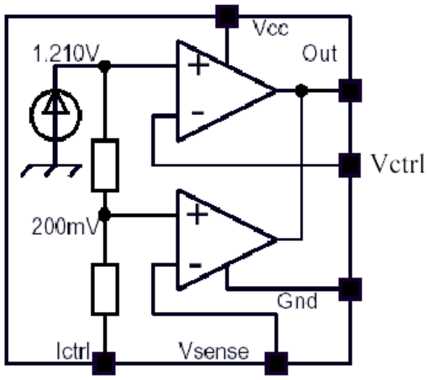
PIN CONNECTION (top view)



Features

- CONSTANT VOLTAGE AND CONSTANT CURRENT CONTROL
- LOW VOLTAGE OPERATION
- PRECISION INTERNAL COMPONENT COUNT
- CURRENT SINK OUTPUT STAGE
- EASY COMPENSATION
- LOW AC MAINS VOLTAGE REJECTION

INTERNAL SCHEMATIC



ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping
IK3051S2T	T_A = 0° to 85° C for all packages	Plastic SOT23-6	Tape& Reel

Pin Definitions and Functions

SOT23-6 Pin out

Name	Pin#	Type	Function
Vcc	6	Power Supply	Positive Power Supply Line
GND	2	Power Supply	Ground Line. 0V Reference For All Voltages
Vctrl	1	Analog Input	Input Pin of the Voltage Control Loop
Ictrl	4	Analog Input	Input Pin of the Current Control Loop
Out	3	Current Sink Output	Output Pin. Sinking Current Only
Vsense	5	Analog Input	Input Pin of the Current Control Loop

Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
Vcc	DC Supply Voltage	14	V
Vi	Input Voltage	-0.3 to Vcc	V
Top	Operating Free Air Temperature Range	0 to 85	^oC
Tj	Maximum Junction Temperature	150	^oC

Operation Conditions

Symbol	Parameter	Value	Unit
Vcc	DC Supply Conditions	2.5 to 12	V

Electrical Characteristics

Tamb = 25°C and Vcc = +5V (unless otherwise specified)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
Total Current Consumption						
Icc	Total Supply Current – not taking the output sinking current into account	Tamb 0 < Tamb < 85℃		1.1 1.2	2	mA
Voltage Control Loop						
Gmv	Transconduction Gain (Vctrl). Sink Current Only [1)]	Tamb 0 < Tamb < 85℃	1	3.5 2.5		mA/mV
Vref	Voltage Control Loop Reference [2)]	Tamb 0 < Tamb < 85℃	1.198 1.186	1.21	1.222 1.234	V
Iibv	Input Bias Current (Vctrl)	Tamb 0 < Tamb < 85℃		50 100		nA
Current Control Loop						
Gmi	Transconduction Gain (Ictrl). Sink Current Only [3)]	Tamb 0 < Tamb < 85℃	1.5	7		mA/mV
Vsense	Current Control Loop Reference [4)]	Iout = 2.5 mA Tamb 0 < Tamb < 85℃	196 192	200	204 208	mV
Iibi	Current out of pin Ictrl at -200mV	Tamb 0 < Tamb < 85℃		25 50		μA
Output Stage						
Vol	Low output voltage at 10 mA sinking current	Tamb 0 < Tamb < 85℃		200		mV
Ios	Output Short Circuit Current. Output to Vcc. Sink Current Only	Tamb 0 < Tamb < 85℃		27 35	50	mA

1. If the voltage on Vctrl (the negative input of the amplifier) is higher than the positive amplifier input (Vref=1.210V), and it is increased by 1mV, the sinking current at the output OUT will be increased by 3.5mA.
2. The internal Voltage Reference is set at 1.210V (bandgap reference). The voltage control loop precision takes into account the cumulative effects of the internal voltage reference deviation as well as the input offset voltage of the trans-conductance operational amplifier. The internal Voltage Reference is fixed by bandgap, and trimmed to 1% accuracy at room temperature.
3. When the positive input at Ictrl is lower than -200mV, and the voltage is decreased by 1mV, the sinking current at the output OUT will be increased by 7mA.
4. The internal current sense threshold is set to -200mV. The current control loop precision takes into account the cumulative effects of the internal voltage reference deviation as well as the input offset voltage of the trans-conduction operational amplifier.

PRINCIPLE OF OPERATION AND APPLICATION HINTS

1. Voltage and Current Control

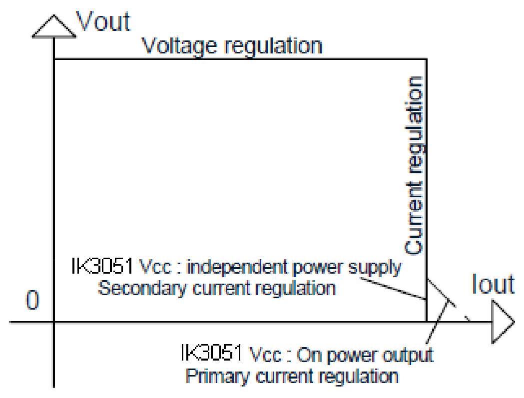
1.1. Voltage Control

The voltage loop is controlled via a first transconductance operational amplifier, the resistor bridge R1, R2, and the optocoupler which is directly connected to the output.
The relation between the values of R1 and R2 should be chosen as written in Equation 1.
R1 = R2 x Vref / (Vout - Vref)   Eq1
Where Vout is the desired output voltage.
To avoid the discharge of the load, the resistor bridge R1, R2 should be highly resistive. For this type of application, a total value of 100KΩ (or more) would be appropriate for the resistors R1 and R2.
As an example, with R2 = 100KΩ, Vout = 4.10V, Vref = 1.210V, then R1 = 41.9KΩ.
Note that if the low drop diode should be inserted between the load and the voltage regulation resistor bridge to avoid current flowing from the load through the resistor bridge, this drop should be taken into account in the above calculations by replacing Vout by (Vout + Vdrop).

1.2. Current Control

The current loop is controlled via the second trans-conductance operational amplifier, the sense resistor Rsense, and the optocoupler.
The control equation verifies:
Rsense x Ilim = Vsense   eq2
Rsense = Vsense / Ilim   eq2'
where Ilim is the desired limited current, and Vsense is the threshold voltage for the current control loop.
As an example, with Ilim = 1A, Vsense = -200mV, then Rsense = 200mΩ.
Note that the Rsense resistor should be chosen taking into account the maximum dissipation (Plim) through it during full load operation.
Plim = Vsense x Ilim.   eq3
As an example, with Ilim = 1A, and Vsense = 200mV, Plim = 200mW.
Therefore, for most adapter and battery charger applications, a quarter-watt, or half-watt resistor to make the current sensing function is sufficient.
Vsense threshold is achieved internally by a resistor bridge tied to the Vref voltage reference. Its middle point is tied to the positive input of the current control operational amplifier, and its foot is to be connected to lower potential point of the sense resistor as shown on the following figure. The resistors of this bridge are matched to provide the best precision possible.
The current sinking outputs of the two trans-conductance operational amplifiers are common (to the output of the IC). This makes an ORing function which ensures that whenever the current or the voltage reaches too high values, the optocoupler is activated.
The relation between the controlled current and the controlled output voltage can be described with a square characteristic as shown in the following V/I output-power graph.

Figure 1 : Output voltage versus output current



2. Compensation

The voltage-control trans-conductance operational amplifier can be fully compensated. Both of its output and negative input are directly accessible for external compensation components.
An example of a suitable compensation network is shown in Fig.2. It consists of a capacitor Cvc1=2.2nF and a resistor Rcv1=470KΩ in series, connected in parallel with another capacitor Cvc2=22pF.

The current-control trans-conductance operational amplifier can be fully compensated. Both of its output and negative input are directly accessible for external compensation components.
An example of a suitable compensation network is shown in Fig.2. It consists of a capacitor Cic1=2.2nF and a resistor Ric1=22KΩ in series.

When the Vcc voltage reaches 12V it could be interesting to limit the current coming through the output in the aim to reduce the dissipation of the device and increase the stability performances of the whole application.
An example of a suitable Rout value could be 330Ω in series with the opto-coupler in case Vcc=12V.

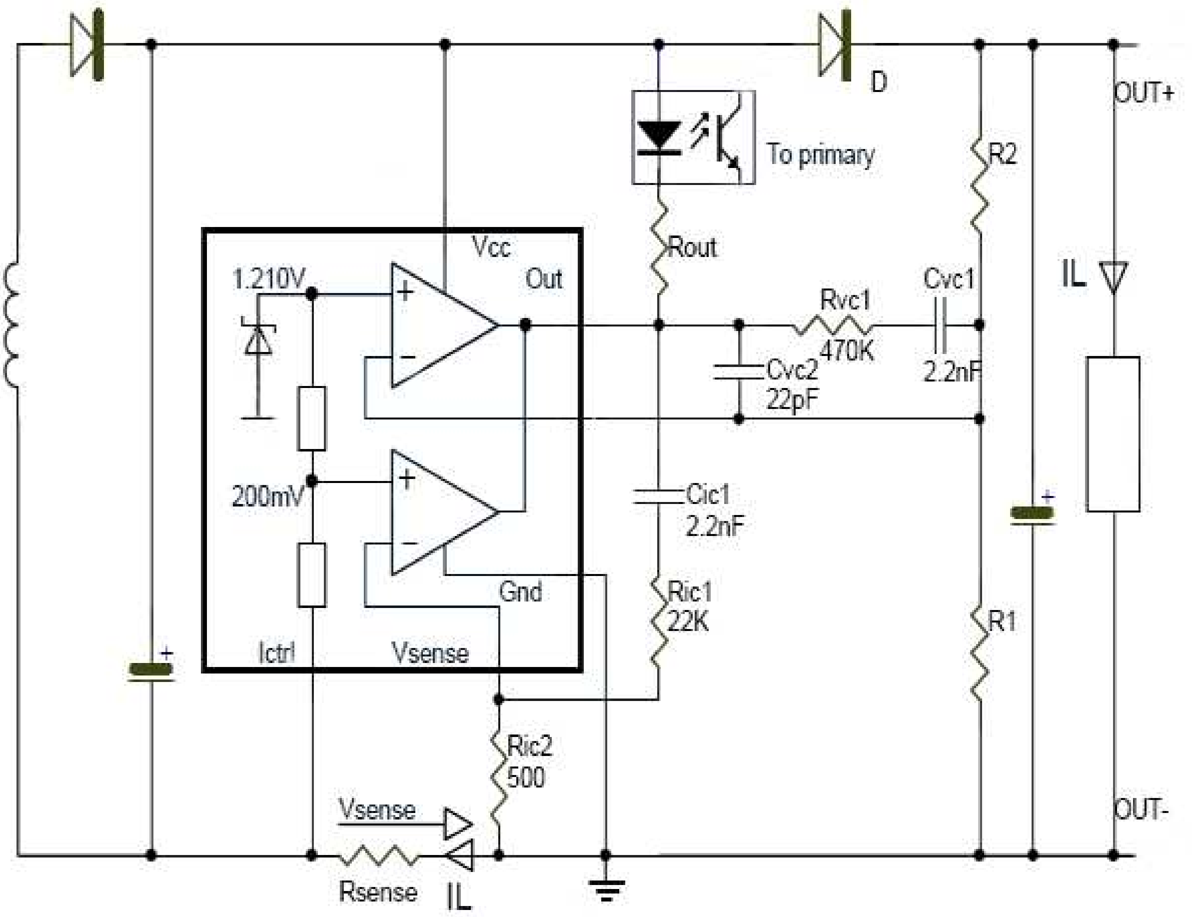
3. Start Up and Short Circuit Conditions

Under start-up or short-circuit conditions the IK3051 is not provided with a high enough supply voltage. This is due to the fact that the chip has its

power supply line in common with the power supply line of the system.
Therefore, the current limitation can only be ensured by the primary PWM module, which should be chosen accordingly.
If the primary current limitation is considered not to be precise enough for the application, then a sufficient supply for the IK3051 has to be ensured under any condition. It would then be necessary to add some circuitry to supply the chip with a separate power line. This can be achieved in numerous ways, including an additional winding on the transformer.

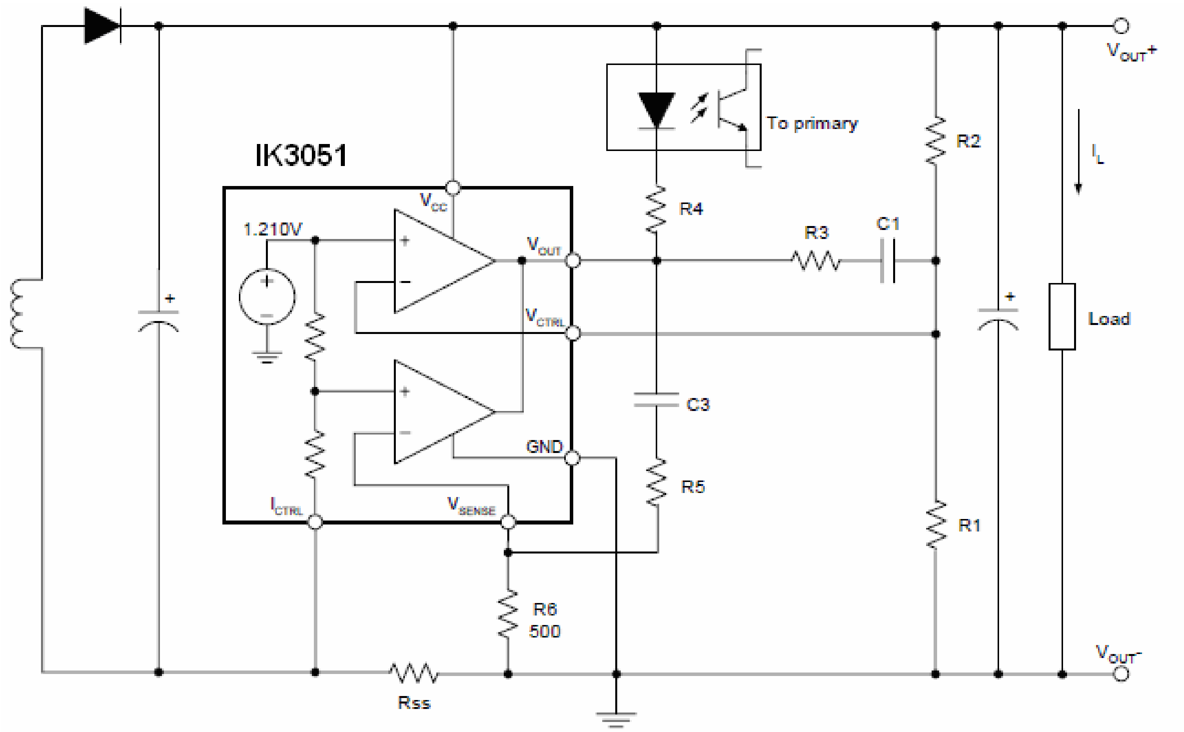
The following schematic shows how to realize a low-cost power supply for the IK3051 (with no additional windings).
Please pay attention to the fact that in the particular case presented here, this low-cost power supply can reach voltages as high as twice the voltage of the regulated line. Since the Absolute Maximum Rating of the IK3051 supply voltage is 14 V, this low-cost auxiliary power supply can only be used in applications where the regulated line voltage does not exceed 7 V.

Figure 2 : Typical Adapter or Battery Charger Application Using IK3051



In the above application schematic, the IK3051 is used on the secondary side of a flyback adapter (or battery charger) to provide an accurate control of voltage and current. The above feedback loop is made with an optocoupler.

Typical Application

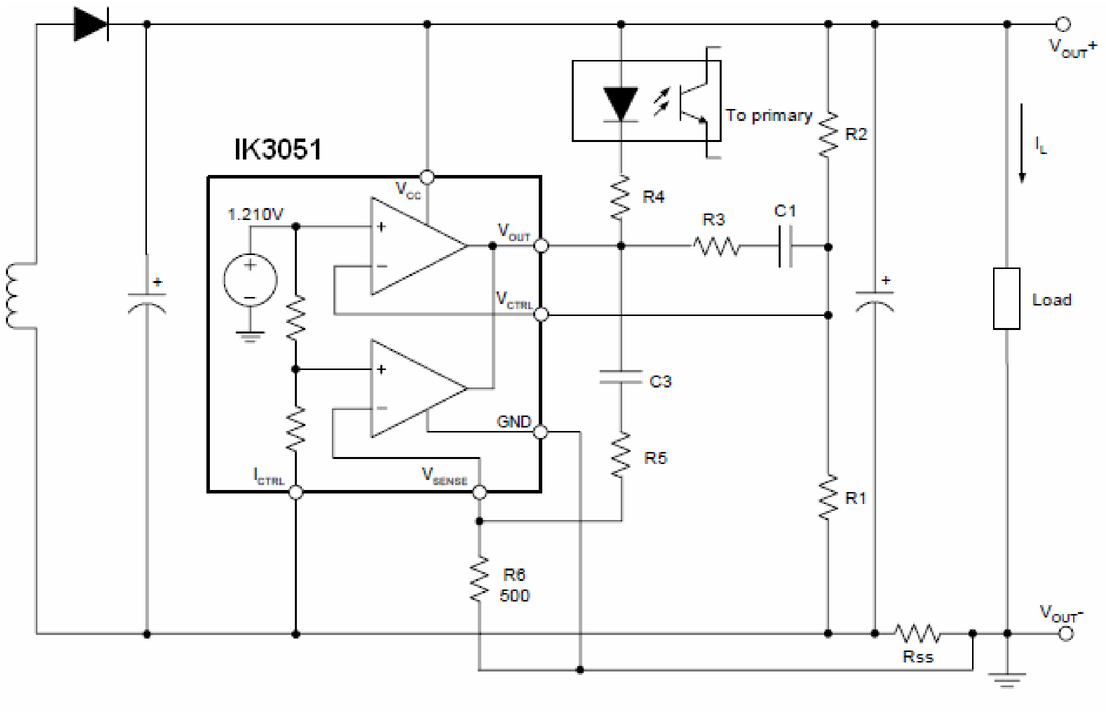


$$V_{OUT} = V_{REF} \times \frac{R1 + R2}{R1} \quad \text{(V)}$$

$$CurrentLimit = \frac{V_{SENSE}}{R_{SS}} \quad \text{(A)}$$

Figure 3

Typical Application (continue)

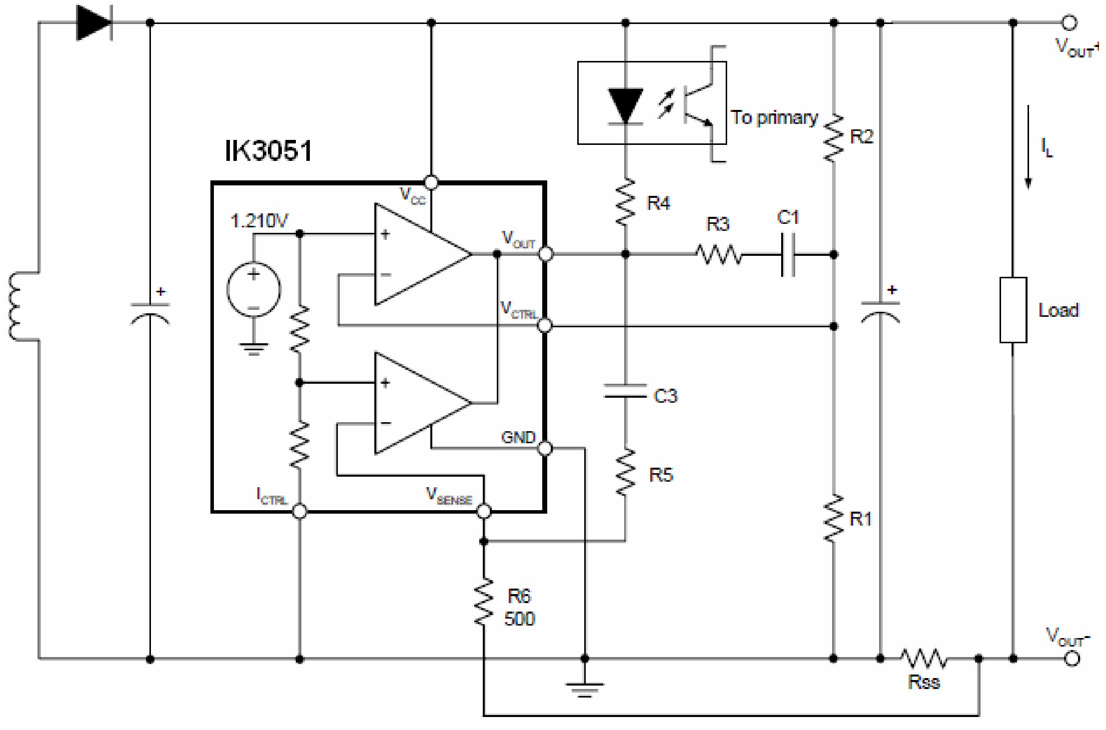


$$V_{OUT} = [V_{REF} + (I_L \times R_{SS})] \times \frac{R1 + R2}{R1} - (I_L \times R_{SS}) \quad \text{(V)}$$

$$CurrentLimit = \frac{V_{SENSE}}{R_{SS}} \quad \text{(A)}$$

Figure 4

Typical Application (continue)



$$V_{OUT} = V_{REF} \times \frac{R1 + R2}{R1} - (I_L \times R_{SS}) \quad \text{(V)}$$

$$CurrentLimit = \frac{V_{SENSE} \times V_{REF}}{(V_{SENSE} + V_{REF}) \times R_{SS}} \quad \text{(A)}$$

Figure 5

Typical Performance Characteristics

Figure 6: Vref vs Ambient Temperature

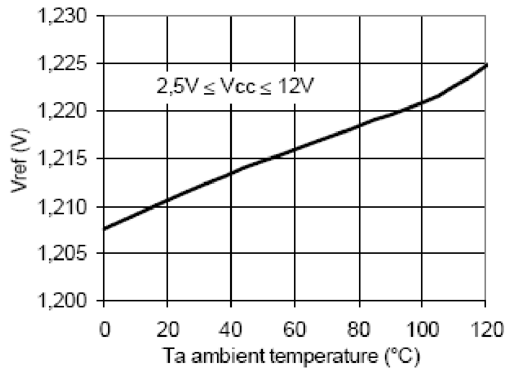


Figure 7: Vsense pin input bias current vs Ambient Temperature

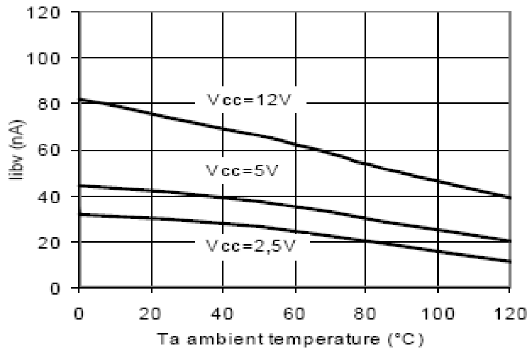


Figure 8: Output short circuit current vs Ambient Temperature

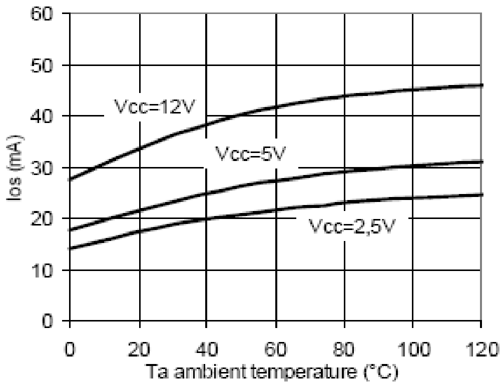


Figure 9: Vsense vs Ambient Temperature

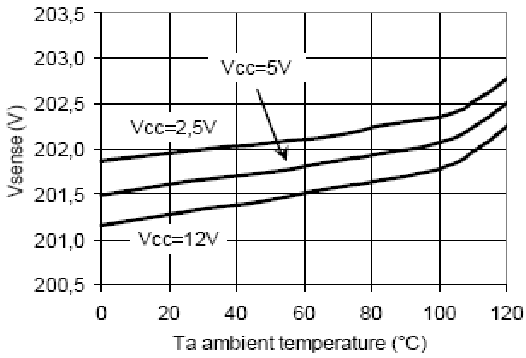


Figure 10: Ictrl pin input bias current vs Ambient Temperature

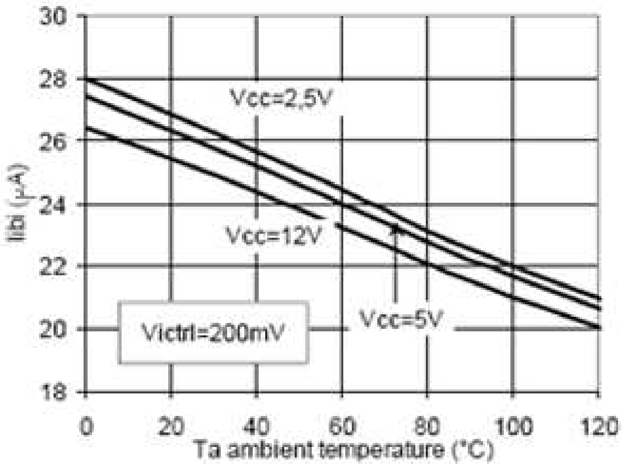
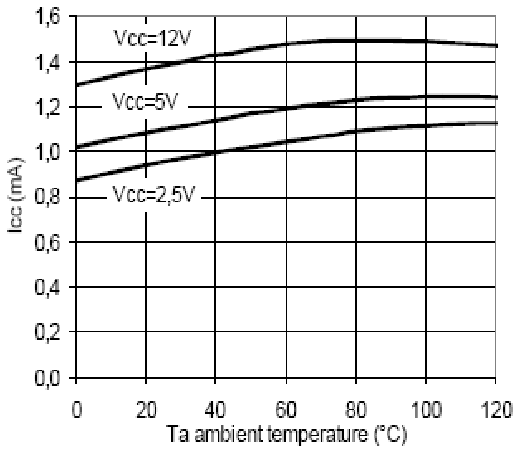
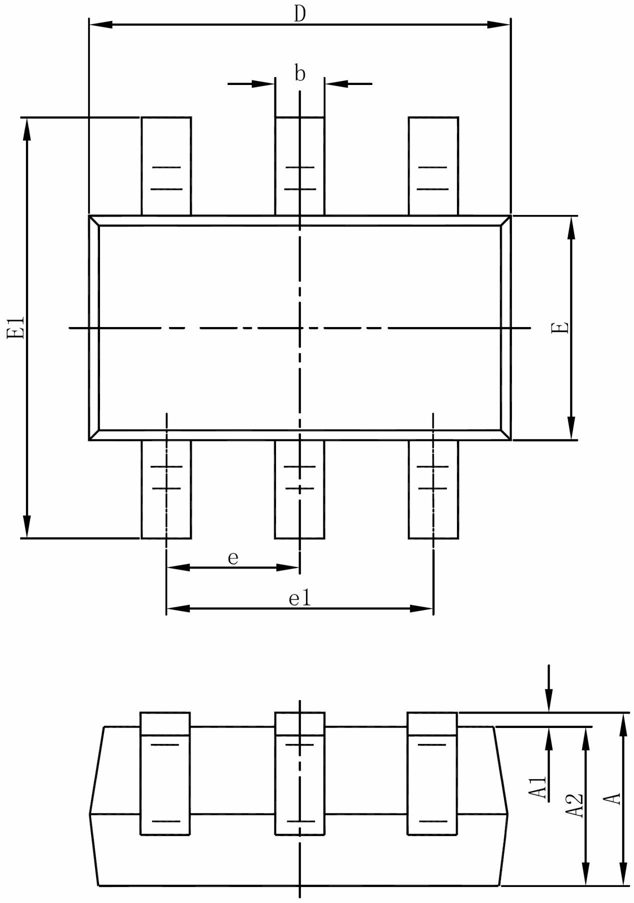


Figure 11: Supply current vs Ambient Temperature



PACKAGE DIMENSION

SOT-23-6



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	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.600REF		0.024REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°