

**GENERAL DESCRIPTION**

The HM5054B is a highly integrated 5V 5-500mA Li-ion battery linear charging management device with super high  $\pm 0.75\%$  accuracy of full charge voltage and ultra-low 100nA of battery block current. The wide 5-500mA charge current range makes it suitable for many Li-battery supplied applications.

The HM5054B charges a battery in three phases: trickle charging, constant current, and constant voltage. Re-charging happens automatically when the battery voltage drops back to a threshold voltage. No external sense resistor is needed, and no blocking diode is required.

The HM5054B features UVLO, OVP, Current Limit, anti-polarity protection and thermal regulation functions.

The HM5054B is available in SOT23-5 package.

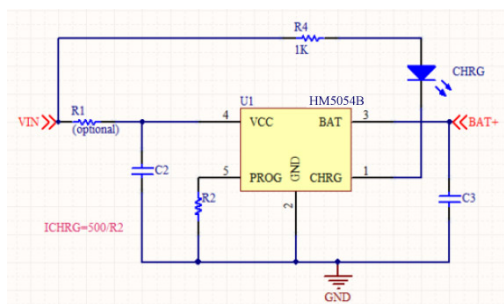
**FEATURES**

- Wide Operating Voltage: 3.8 to 6.5V
- Wide Range Charge Current: 5mA~ 500mA
- Ultra-low Block Current: 100nA typically
- Ultra-high Accuracy:  $\pm 0.75\%$  (4.1, 4.15, 4.2, 4.25, 4.3, 4.35, 4.4V available)
- Trickle Current: 20% (10%, 30%, 40% optional).
- UVLO, OVP, Current Limit and Thermal Regulation
- 0V Battery Charge supported
- Anti-Polarity protection (connecting a 220uF Capacitor to BAT pin if charge current over 100mA)
- SOT23-5 Package

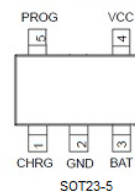
**APPLICATIONS**

- Wearable Devices
- Bluetooth Applications
- Portables
- Charging Docks and Cradles
- Other Li Battery powered devices

**TYPICAL APPLICATION CIRCUIT**



**PIN ASSIGNMENT**



**ORDER INFORMATION**

<p><b>FULL CODE</b> "....."</p>	<p>.....HM5054BXXAA                  XX: Float Voltage, 42=4.2V for example                  AAA: Package Type                  SMR= SOT23-5, 20% trickle current. Optional as follows:                  LMR= SOT23-5, 10% trickle current.                  MMR= SOT23-5, 30% trickle current.                  HMR= SOT23-5, 40% trickle current.</p>
<p><b>PACKAGE OPTION</b></p>	<p>TAPE &amp; REEL, 3000EA/REEL</p>

**PIN DESCRIPTION**

PIN No	SYMBOL	DESCRIPTION
1	CHRG	Open-Drain Charges Status Output.
2	GND	Ground
3	BAT	Charge Current Output. The positive side of battery.
4	VCC	Positive Input Supply Voltage.
5	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin.

**ABSOLUTE MAXIMUM RATINGS** (Note 1)

SYM	PARAMETER	VALUE	Units
V <sub>CC</sub>	Input Supply Voltage to GND, BAT pin floating	-0.3~ +9.5	V
V <sub>PROG</sub>	PROG & CE & TEMP Voltage	-0.3~+9.5	V
V <sub>BAT</sub>	BAT Voltage	-4.2~+9.5	V
V <sub>CC-BAT</sub>	Voltage between VCC and BAT pin	-0.3~ +9.5	V
V <sub>CHRG</sub>	CHRG pin Voltage	-0.3~+9.5	V
DSC	BAT Short-Circuit Duration	Continuous	
I <sub>BAT</sub>	BAT Pin Current	650	mA
I <sub>PROG</sub>	PROG Pin Current	120	μA
PD	Maximum Power Dissipation	600	mW
P <sub>TR1</sub>	Package Thermal Resistance, SOT23-5, θ <sub>JA</sub>	200	°C /W
P <sub>TR2</sub>	Package Thermal Resistance, SOT23-5, θ <sub>JC</sub>	130	°C /W
T <sub>j</sub>	Maximum Junction Temperature	150	°C
T <sub>s</sub>	Storage Temperature Range	-65 to 125	°C
T <sub>Lead</sub>	Lead Temperature, soldering	260°C, 10s	

**Note1:** Absolute Maximum Ratings are threshold limit values that must not be exceeded even for an instant under any condition. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

**RECOMMENDED OPERATING RANGE**

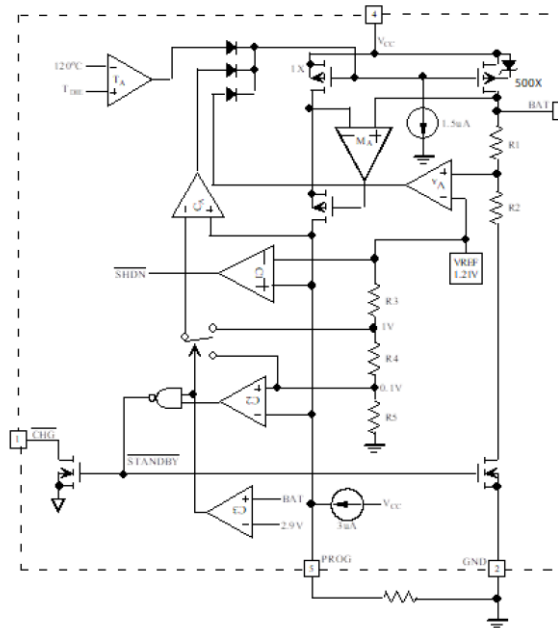
SYMBOL	PARAMETER	VALUE	Units
V <sub>CC</sub>	Input supply voltage	3.8 to VOVP	V
T <sub>j</sub>	Junction Temperature	-40 to +85	°C

**ELECTRICAL CHARACTERISTICS**

T<sub>A</sub>=25°C, V<sub>CC</sub>=5V, unless otherwise noted

SYMBOL	PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>CC</sub>	Input Supply Voltage		3.8		V <sub>OVP</sub>	V
V <sub>OVP</sub>	OVP Voltage			7.5		V
V <sub>UVLO</sub>	V <sub>CC</sub> UVLO Threshold	V <sub>CC</sub> from low to high		3.8		V
V <sub>UVHYS</sub>	V <sub>CC</sub> UVLO Hysteresis	V <sub>CC</sub> from high to low		300		mV
I <sub>CC</sub>	Input Supply Current	Charge Mode, R <sub>PROG</sub> =10K		250		uA
		Standby Mode, Charge Terminated		120		μA
		Shutdown Mode: R <sub>PROG</sub> Not Connected, V <sub>CC</sub> < V <sub>BAT</sub> , or V <sub>CC</sub> < V <sub>UVLO</sub>		110		μA
V <sub>BAT_ACC</sub>	Accuracy of VBAT			±0.5%	±0.75%	
V <sub>FLOAT</sub>	Regulated Output Voltage		4.1V to 4.4V at 50mV Step			
I <sub>CHRG</sub>	Charging Current	R <sub>PROG</sub> =10K, CC Mode	43	49	53	mA
I <sub>CHRG_MAX</sub>	Maximum Charging Current			650		mA
I <sub>CHRG_MIN</sub>	Minimum Charging Current			4		mA
I <sub>BAT</sub>	BAT pin Current	Standby Mode, V <sub>BAT</sub> =VFloat		0		μA
		Shutdown Mode(R <sub>PROG</sub> Not Connected)		0		μA
		Sleep Mode, V <sub>CC</sub> =0V		0.1	0.3	μA
I <sub>TRIK</sub> /I <sub>CHRG</sub>	Trickle Current Percentage	V <sub>BAT</sub> < V <sub>TRIK</sub>	Standard Version: 20%			
			10%, 30% or 40% optional			
V <sub>TRIK</sub>	Trickle Charge Threshold	V <sub>BAT</sub> Rising	2.8	2.9	3.0	V
V <sub>TRIKS</sub>	Trickle Charge Hysteresis	V <sub>BAT</sub> Falling		150		mV
V <sub>MSD</sub>	Manual Shutdown and Release Voltage	V <sub>PROG</sub> Rising		1.25		V
		V <sub>PROG</sub> Falling		1.15		V
V <sub>ASD</sub>	V <sub>CC</sub> -V <sub>BAT</sub> Lockout Threshold	V <sub>CC</sub> from Low to High		100		mV
		V <sub>CC</sub> from High to Low		60		mV
I <sub>TERM</sub> /I <sub>CHRG</sub>	Termination Current Percentage			10%		
V <sub>PROG</sub>	PROG Pin Voltage	CC Mode	0.9	1.0	1.1	V
I <sub>CHRG</sub>	CHRG Pin Leakage Current	V <sub>CHRG</sub> =5V			1	μA
V <sub>CHRG</sub>	CHRG Pin Low Voltage	I <sub>CHRG</sub> =2mA		0.15		V
V <sub>RECHRG</sub>	Recharge Battery Threshold			4.05		V
T <sub>REG</sub>	Thermal Regulation Start			120		°C
t <sub>SS</sub>	Soft-Start time	I <sub>BAT</sub> =0 to I <sub>CHRG</sub>		100		μs
T <sub>TRIK</sub>	Trickle Current Time	V <sub>BAT</sub> from low to up		450		μs
T <sub>RECHARGE</sub>	Recharge Filter Time	V <sub>BAT</sub> from High to Low		2		ms
T <sub>TERM</sub>	Termination Filter Time	I <sub>BAT</sub> falling below I <sub>CHRG</sub> /10		2		ms

**SIMPLIFIED BLOCK DIAGRAM**



**OPERATION DESCRIPTION**

The HM5054B is a highly integrated 5V 5-500mA Li-ion battery linear charging management device with super high  $\pm 0.75\%$  accuracy of full charge voltage and ultra-low 100nA of battery block current. The wide 5-500mA charge current range makes it suitable for many Li-battery supplied applications.

The HM5054B charges a battery in three phases: trickle

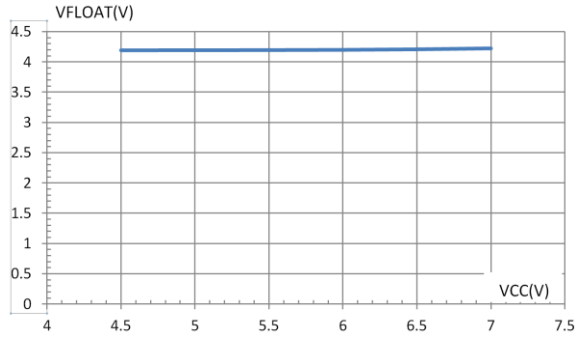
charging, constant current, and constant voltage. Re-charging happens automatically when the battery voltage drops back to a threshold voltage. No external sense resistor is needed, and no blocking diode is required.

The HM5054B features UVLO, OVP, Current Limit, anti-battery protection and thermal regulation functions.

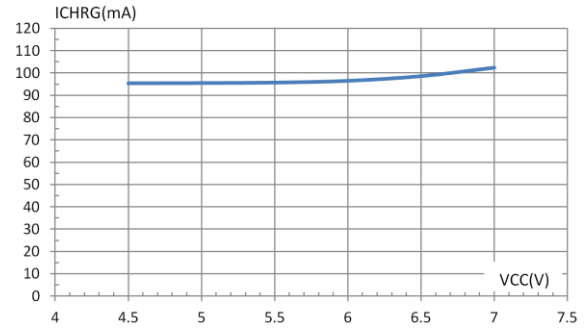
**TYPICAL OPERATING CHARACTERISTICS**

VCC=5V, VBAT=3.6V, TA=25°C, unless otherwise specified.

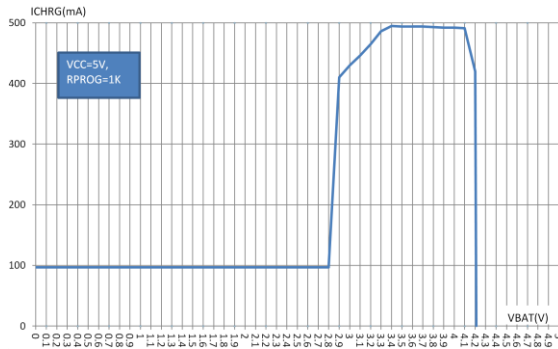
1. VFLOAT vs VCC



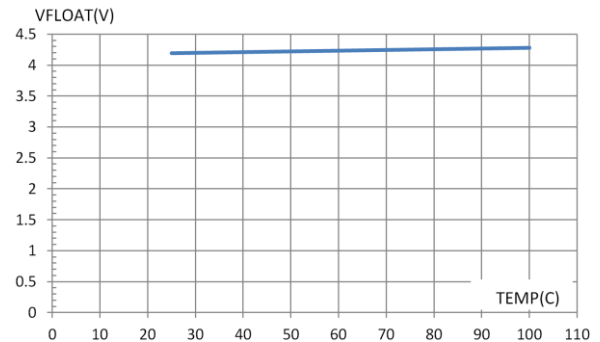
2. ICHRG vs VCC



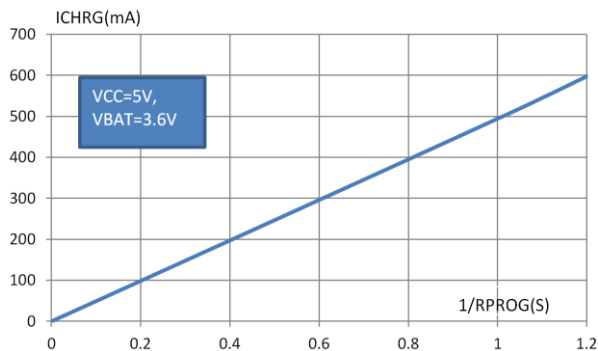
3. ICHRG vs VBAT



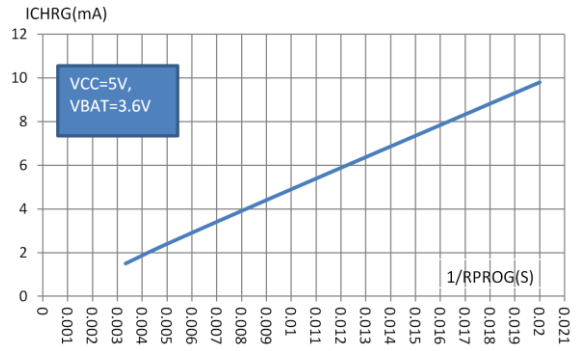
4. VFLOAT vs TEMP



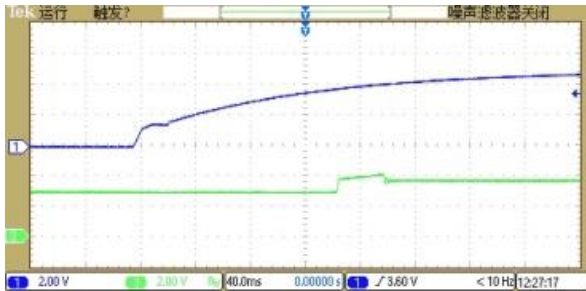
5. ICHRG vs 1/RPROG



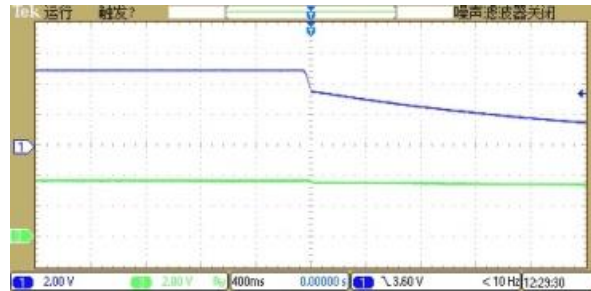
6. ICHRG vs 1/PROG(scaled)



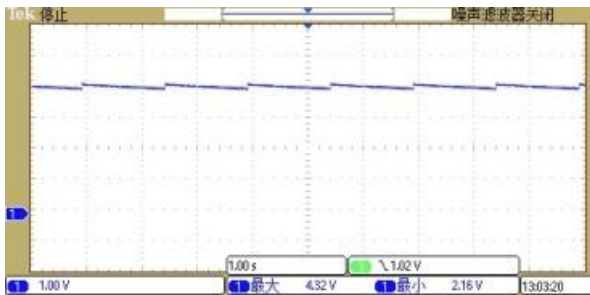
7. Power On



8. Power Off



9. No Battery Output



10. No Battery Output rush



## APPLICATION INFORMATION

### Set the Charging Current

The charging current is programmed using 1% precision resistor from PROG pin to ground. The charging current and the programming resistor are calculated using the following equations:

$$R_{PROG} = 1000V / I_{CHRG}$$

$$I_{CHRG} = 1000V / R_{PROG}$$

For 100mA application,  $R_{PROG}$  is 10K  $\Omega$ .

### PROG short to GND and Current Limit

As seen in last section,  $I_{CHRG} = 1000V / R_{PROG}$ , consider the extreme case that PROG PIN is short to ground, the charge current is theoretically  $\infty$ , which can surely damage the device. The HM5054B has current limit feature to limit the maximum value to typically 650mA, which is safe enough for operating.

### Charge Termination and Recharge

A charging process is terminated while:

- (1)  $V_{BAT}$  rises to  $V_{FLOAT}$
- (2) Charge current drops to  $I_{TERM}$ , which is typically 1/10 of the set charge current
- (3) Stay in this condition for a period longer than  $T_{TERM}$ , which is normally 2ms.

The second condition is easy to be neglected. In some cases, the load is connected only to the batter and keeps operating during the charging. This leads to a load current on the BAT PIN. If the load current is larger than  $I_{ITEM}$ , then charge termination .fails. A way to this problem is to let the charging power source powers the load whenever a source is connected in, and let batter powers the load only when the charge source is not connected. However, it is not suitable for all cases.

Once a charging process is terminated, recharge process happens only at  $V_{BAT}$  drops back to  $V_{RECHARGE}$ , typically 4.05V.

### Full Charge Voltage and Power Reset

The full charge voltage is theoretically  $V_{FLOAT}$ ,

however, this value can hardly be reached due to the battery internal resistance. This parasitic resistor attributes a voltage drop of charge current X resistance during charging and disappears after charge process terminates. This explains why the battery voltage is always below the target even just after a charge process ends up.

A charge process always starts when a Power Reset occurs, no matter whether the battery is fully charged before the Power Reset. This is due to the battery can't be really fully charged for the reason of internal resistance.

### Charge status indicator

The HM5054B has the CHRG status indicator output. By connecting an LED and a resistor between the CHRG pin and any suitable power supply, the Battery Charging status is indicated as following table.

Status	CHRG pin LED
Charging	Lighting
Full	Dark
No battery on BAT pin	Blink
BAT short to ground	Lighting
OVP, UVLO or Other faults	Dark

The blinking frequency under no battery condition depends on the equivalent capacitor value between the BAT pin and ground.

### Anti-polarity Protection

Anti-polarity protection is incorporated to protect itself from any damage when the battery polarity is wrong. The protection is reliable under following condition:

- (1) Charge current not more than 100mA, otherwise add a 220uF capacitor to the BAT node.
- (2)  $VCC + V_{BAT} < 9V$ .

For the applications that charge current is higher than 100mA, the anti-polarity protection may fail.

### Manual Termination

Several ways can manually terminate a charge process.

#### 1. Float the PROG PIN

Let the PROG PIN be floating can be considered as connecting a  $\infty$  resistor to the PIN, which gives a zero charge current according to the formula given in the first section.

#### 2. Force a high voltage to the PROG PIN

Force a voltage higher than the  $V_{MSD}$  threshold leads to a termination. Charge process resumes while the VPROG drops back, or the power source is released.

#### 3. Force $V_{BAT}$ to higher than $V_{FLOAT}$

This is only for discussion and cannot be happen for a normal battery charging applications.

#### 4. Force the charge power source the a lower voltage

This is also not for normal applications. Whenever the power supply voltage drops down to less than  $V_{BAT}+V_{ASD}$ , the charge process terminates. It resumes charging again when VCC rise back to normal condition.

### Zero-V Battery Charging and BAT short to GND

The HM5054B treats 0V Battery as normal and delivers trickle charging current since  $V_{BAT}<V_{TRICKLE}$ , thus is able to charge a 0V Battery. Meanwhile, it is safe enough if a BAT PIN short to ground really happens, even during the charging process.

#### Block Current

A block current flows from the battery connected with the BAT pin to the VCC PIN while there is no power supply available on the PIN. The HM5054B has extremely low block current, which is typically only 100nA.

### Under-Voltage Lockout (UVLO)

The HM5054B shuts itself down when the input voltage is below the UVLO threshold,  $V_{UVLO}$ , and automatically resumes operating while the input voltage rises back to the operating range.

### Over-Voltage Protection (OVP)

The device shuts down itself while encountering input voltage higher than the  $V_{OVP}$  threshold,  $V_{OVP}$ , and automatically resumes operating while the input voltage drops back to normal condition. By this means the device can avoid from any damage caused by the input overstress.

### Thermal Regulation

An internal thermal feedback loop reduces the set charge current if the device temperature attempts to rise above the temperature threshold  $T_{REG}$ . This feature protects the HM5054B from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board without risk of damaging the HM5054B.

Temperature rising can be estimated by follows:

$$\begin{aligned} T_A &= 120^{\circ}\text{C} - PD \cdot \theta_{JA} \\ &= 120^{\circ}\text{C} - (V_{CC} - V_{BAT}) \cdot I_{BAT} \cdot \theta_{JA} \end{aligned}$$

Since  $I_{BAT}$  and  $\theta_{JA}$  are predetermined, the temperature rising depends only on  $V_{CC}-V_{BAT}$ , and reaches the maximum value at  $V_{BAT}$  going to the lowest value for the constant current condition, which is around 3V. For such reason, the charging current is lower than the set value at low VBAT in large charge current applications.

### Input Capacitors and Resistors

Input capacitor is always suggested to suppress any input voltage ripple.

Input resistor has two functions. The first is to better suppress the input glitch, together with the input capacitor, the second is to share the power consumption with the HM5054B, while the input voltage is high.

### Output Capacitors

With no battery present, an output capacitor of 1uF or higher is recommended to reduce ripple voltage.



### Stability Consideration

The constant-voltage mode feedback loop is stable without an output capacitor provided a battery is connected to the charger output. With no battery present, an output capacitor is recommended to reduce ripple voltage. In constant current mode, the PROG pin

is in the feedback loop, so the constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with the programming resistor value as high as 200K  $\Omega$ .

### ● Layout Considerations

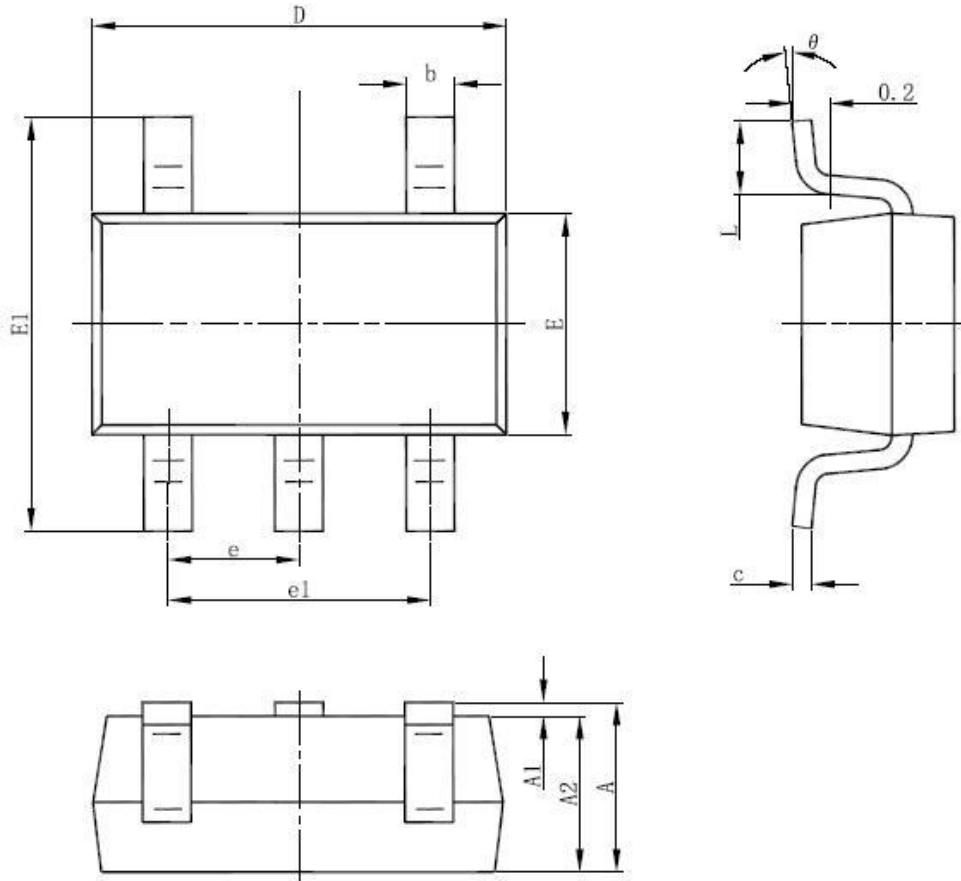
PCB layout is very important for better stability and thermal performance. For best performance of the AR4054E, the

following guidelines must be strictly followed.

- Besides the main current trace capacitors, a ceramic input capacitor must be placed close to the VCC pin 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.
- Keep the PROG pin connection short and away from the noisy devices.

PACKAGE OUTLINE

SOT23-5



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°