, $$m 5˙@]h�\]i a ˙=cbž˙- J ˙=bdi h˙Jc˙hU[Y˙6UhhYfm˙@]bYUf˙7\Uf[Yf˙< A ($)) 5˙GYf]Yg˙

General Description

HM4055A is a complete constant-current/constant voltage linear charger for single cell lithium-ion batteries. Furthermore the HM4055A is specifically designed to work within USB power specifications.

No external sense resistor is needed and no blocking diode is required due to the internal PMOSFET architecture .Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature .The charge voltage is fixed at 4.2V,and the charge current can be programmed externally with a single resistor. The HM4055A automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.

When the input supply (wall adapter or USB supply) is removed the HM4055A automatically enters a low current state dropping the battery drain current to less than 2µA.The HM4055A can be put into shutdown mode reducing the supply current to 55µA.

Other features include charge current monitor, undervoltage lockout, automatic recharge and a status.

Features

- Maximum operating voltage 9V, improve system reliability
- Protection of battery cell reverse connection
- No MOSFET sense resistor or blocking diode required
- Complete Linear Charger in ThinSOT Package for Single Cell Lithium-Ion Batteries
- Constant-Current/Constant-Voltage operation with thermal regulation to maximize Rate Without risk of overheating.
- Preset 4.2V 、4.34V charge voltage with ±1% accuracy
- Automatic Recharge
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- C/10 charge termination
- 55µA supply current in shutdown
- 2.9V trickle current charge threshold
- Soft-Start limits inrush current
- Charge Status Output Pin

Typical Application

- Cellular Telephones, PDAs, MP3 Players
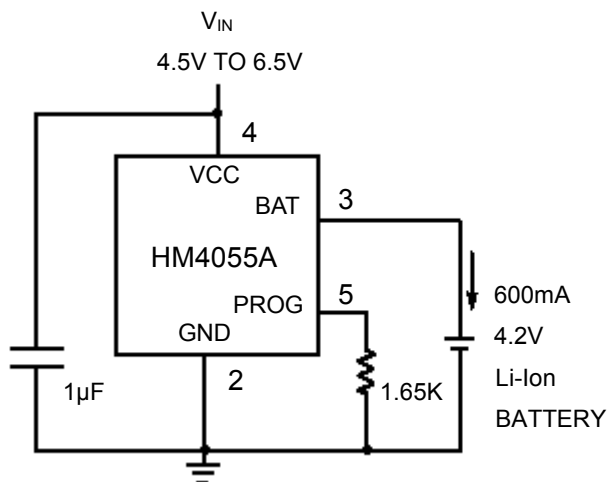- Charging Docks and Cradles
- Bluetooth Applications

Package
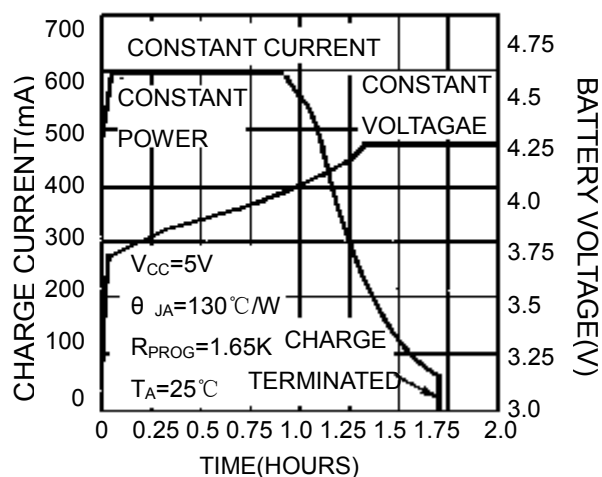
- 5 - pin SOT23-5
- 6 - pin DFN2*2-6

Typical Application circuit

Mainly used in Cellular telephones, MP3, MP4 players, digital still cameras, electronic dictionary, GPS, portable devices and vary chargers.
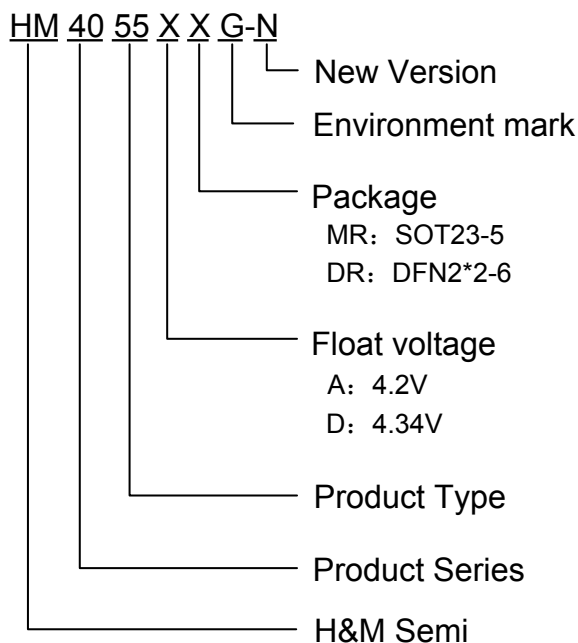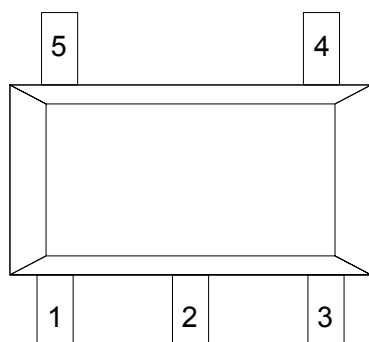
600mA Single Cell Li-Ion Charger

V_{IN}
4.5V TO 6.5V

4 VCC

HM4055A

BAT 3

PROG 5

GND

2

1μF

1.65K

600mA
4.2V
Li-Ion
BATTERY

Typical charge cycle（750mAh batter）

CONSTANT CURRENT

CONSTANT POWER

CONSTANT VOLTAGAE

V_{CC}=5V
θ_{JA}=130℃/W
R_{PROG}=1.65K
T_A=25℃

CHARGE TERMINATED

CHARGE CURRENT(mA): 0, 100, 200, 300, 400, 500, 600, 700

BATTERY VOLTAGE(V): 3.0, 3.25, 3.5, 3.75, 4.0, 4.25, 4.5, 4.75

TIME(HOURS): 0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0

Selection Guide

HM 40 55 X X G-N

New Version

Environment mark

Package
  MR：SOT23-5
  DR：DFN2*2-6

Float voltage
  A：4.2V
  D：4.34V

Product Type

Product Series

H&M Semi

product series	product description
HM4055AMR	V_{FLOAT} =4.2V；Package：SOT23-5
HM4055ADR	V_{FLOAT} =4.2V；Package：DFN2*2-6
HM4055DDR	V_{FLOAT} =4.34V；Package：DFN2*2-6

NOTE:　If you need other voltage and package, please contact our sales staff。
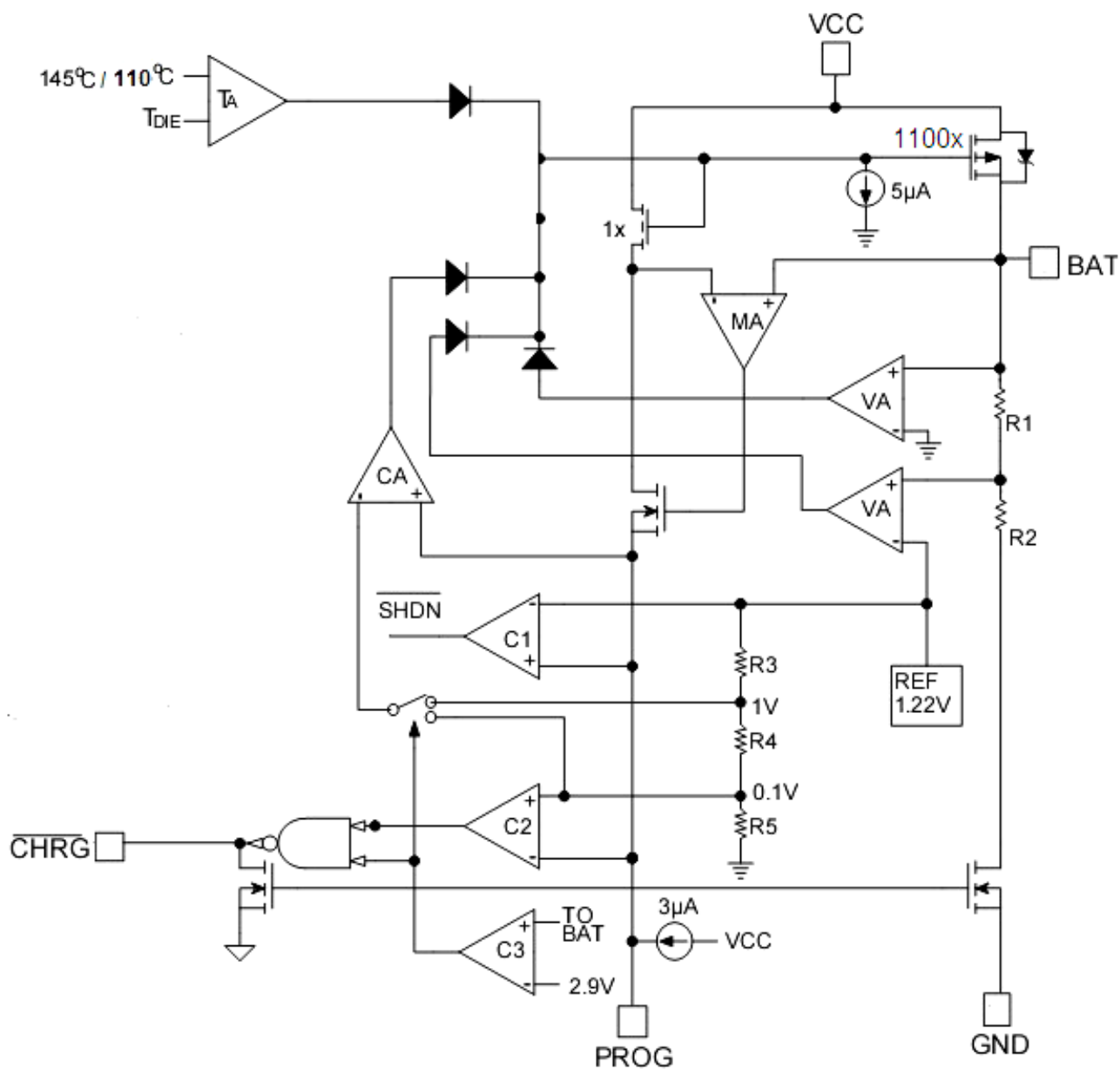
Pin Configuration& Pin Assignment

SOT23-5   DFN2*2-6

Pin Assignment

Pin Num. (SOT23-5)	Pin Num. (DFN2*2-6)	Symbol	Function
1	3	CHRG	**Open-Drain charge status output** When the battery is being charged, the $\overline{CHRG}$ pin is pulled low by an internal switch, otherwise, $\overline{CHRG}$ pin is in high impedance state.
2	2	GND	**Ground**
3	1	BAT	**Battery connection Pin** Connect the positive terminal of the battery to this pin. Dropping BAT pin's current to less than 2μA when IC in disable mode or in sleep mode. BAT pin provides charge current to the battery and provides regulation voltage of 4.2V/4.34V.
4	6	VCC	**Positive input supply voltage** Provides power to the internal circuit. When V_{CC} drops to within 80mV of the BAT pin voltage, the HM4055 enters low power sleep mode, dropping I_{BAT} to less than 2μA.
5	4	PROG	**Constant Charge Current Setting and Charge Current Monitor Pin** The charge current is programmed by connecting a resistor R_{PROG} from this pin to GND. When in precharge mode, the PROG pin's voltage is regulated to 0.1V. When charging in constant-current mode this pin's voltage is regulated to 1V. In all modes during charging, the voltage on this pin can be used to measure the charge current using the following formula: $$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} * 1100$$
	5	NC	

Block Diagram

Absolute Maximum Ratings

Parameter		Rating	Unit
Input supply voltage : V_{CC}		-0.3～10	V
PROG pin voltage		-0.3～VCC+0.3	V
BAT pin voltage		-0.3～10	V
$\overline{CHRG}$ pin voltage		-0.3～10	V
BAT pin current		800	mA
PROG pin current		1200	μA
Maximum junction temperature		145	℃
Operating ambient temperature :T_{opa}		-40～85	℃
Storage temperature :T_{str}		-55～150	℃
Soldering temperature and time		+260（Recommended 10S）	℃
Package thermal impedance $θ_{JA}$	SOT23-5	210	℃/W
	DFN2*2-6	95	℃/W
Maximum Power Dissipation:Pd	SOT23-5	0.6	W
	DFN2*2-6	1.32	W

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage.

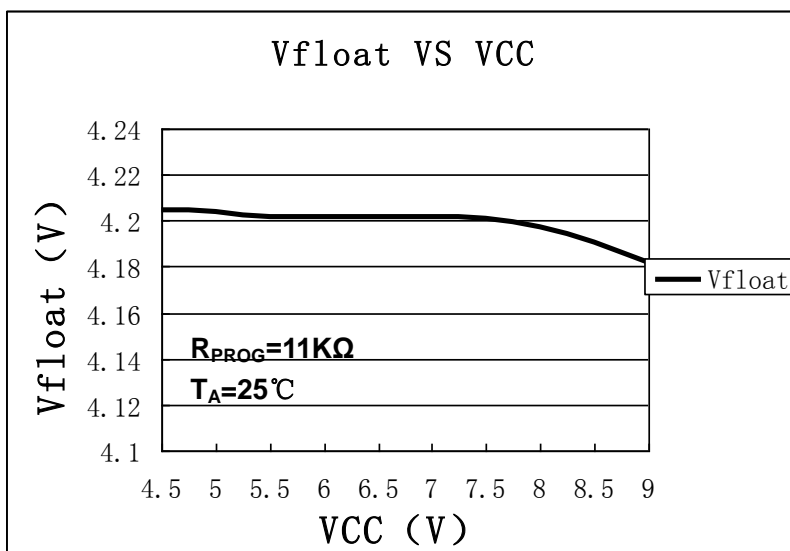These values must therefore not be exceeded under any conditions.
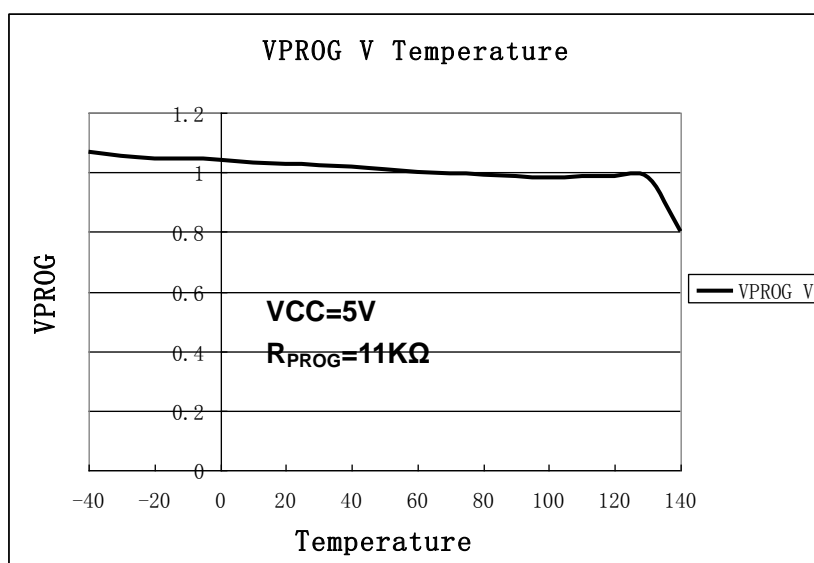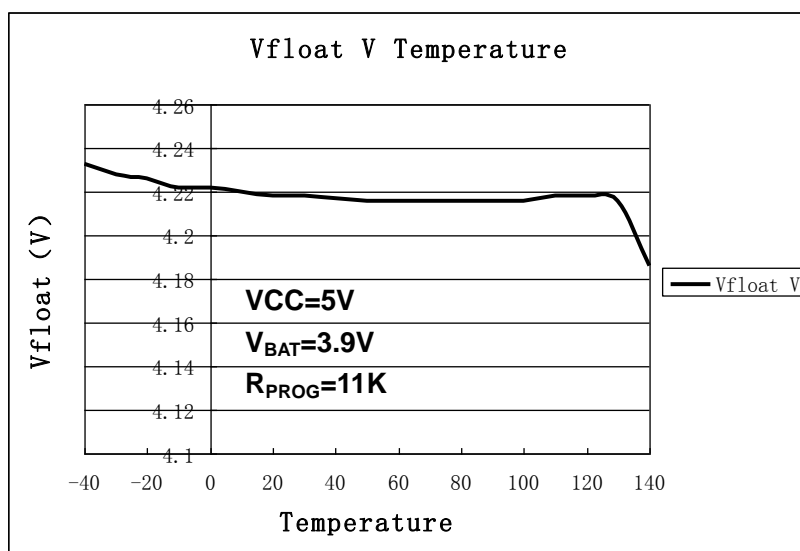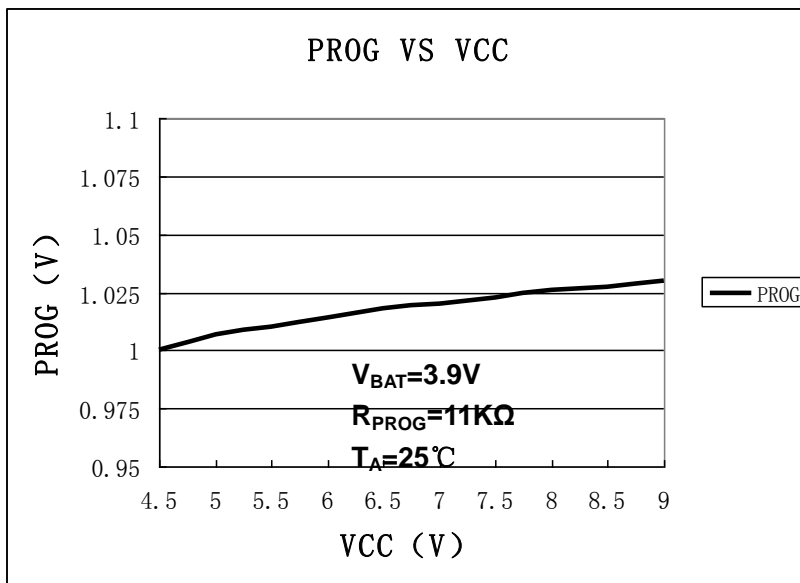
Electrical Characteristics

Symbol	Parameter	Condition		Min	Typ.	Max	Unit
V_{CC}	Input supply voltage	●		4.0	5.0	9.0	V
I_{CC} -I_{BAT}	static current	●Charge mode, R_{PROG}=2.2KΩ		-	150	500	μA
		●Standby mode(charge end)		-	55	100	μA
		●Shutdown mode （R_{PROG} not connected, V_{CC}<V_{BAT}, or V_{CC}<V_{UV}）		-	55	100	μA
V_{FLOAL}	Regulated output voltage	0℃≤T_A≤85℃	HM4055A-N	4.158	4.20	4.25	V
			HM4055D-N	4.3	4.34	4.38	
I_{BAT}	BAT pin current (The condition of current mode is V_{BAT}=3.9V)	●R_{PROG}=2.2KΩ, current mode		425	500	575	mA
		●Standby mode: V_{BAT}=4.2V /4.34V		-6	-2.5	0	μA
		Shutdown mode, R_{PROG} not connected		-	±1	±2	μA
		Sleep mode, V_{CC}=0V		-	-1	-2	μA
I_{TRIKL}	Trickle charge current	●V_{BAT}<V_{TRIKL}, R_{PROG}=10KΩ		10	19	36	mA
V_{TRIKL}	Trickle charge threshold voltage	R_{PROG}=2.2KΩ, V_{BAT} rising		2.7	2.85	3.0	V
V_{TRHYS}	Trickle voltage hysteresis voltage	R_{PROG}=2.2KΩ		350	400	450	mV

V_{UV}	V_{CC} under voltage lockout threshold	● V_{CC} from low to high	3.5	3.7	3.9	V
V_{UVHYS}	V_{CC} under voltage lockout hysteresis	●	150	200	300	mV
V_{ASD}	V_{CC}-V_{BAT} lockout threshold voltage	V_{CC} from low to high	100	140	180	mV
		V_{CC} from high to low	50	80	110	
I_{TERM}	termination current threshold	●R_{PROG}=2.2KΩ	60	70	80	mA
V_{PROG}	PROG pin voltage	●R_{PROG}=2.2KΩ, current mode	0.9	1.0	1.1	V
V_{CHRG}	$\overline{CHRG}$ Pin output low voltage	$I_{\overline{CHRG}}$ =5mA	-	0.3	0.6	V
ΔV_{RECHRG}	Recharge battery threshold voltage	V_{FLOAT} -V_{RECHRG}	60	150	240	mV
T_{LIM}	Thermal protection temperature		-	145	-	℃
R_{ON}	The resistance of power FET ”ON”（between V_{CC} and BAT）		-	650	-	mΩ
t_{SS}	Soft-start time	I_{BAT}=0 to I_{BAT}=1100V/R_{PROG}	-	20	-	µS
$t_{RECHARGE}$	Recharge comparator filter time	V_{BAT} from low to high	0.8	1.8	4	mS
t_{TERM}	Termination comparator filter time	I_{BAT} below I_{CHG}/10	0.8	1.8	4	mS
I_{PROG}	PROG pin pull-up current		-	2.0	-	µA

Note: The ● denotes specifications which apply over the full operating temperature rang, otherwise specifications are at T_A=25℃，V_{CC}=5V，unless otherwise specified.

Typical performance characteristics

Vfloat VS VCC

R_{PROG}=11KΩ
T_A=25℃

PROG VS VCC

PROG (V)

VCC (V)

V_{BAT}=3.9V
R_{PROG}=11KΩ
T_A=25℃

PROG

Vfloat V Temperature

Vfloat (V)

Temperature

VCC=5V
V_{BAT}=3.9V
R_{PROG}=11K

Vfloat V

VPROG V Temperature

VPROG
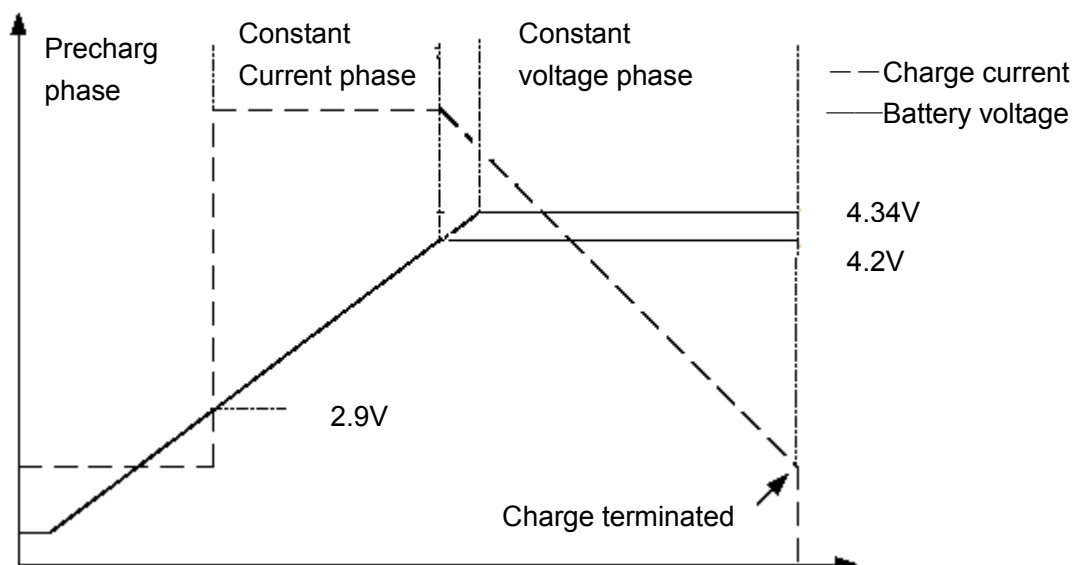
Temperature

VCC=5V
R_{PROG}=11KΩ

VPROG V

Description of the Principle

The HM4055 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Constant-current/constant-voltage to charger batter by internal MOSFET .It can deliver up to 800mA of charge current .No blocking diode or external current sense resistor is required. HM4055 include one Open-Drain charge status Pin: Charge status indicator $\overline{CHRG}$

The internal thermal regulation circuit reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 145℃. This feature protects the HM4055 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 HM4055 or the external components. Another benefit of adopting thermal regulation is that charge current can be set according to typical, not worst-case, ambient temperatures for a given application with the assurance that the charger will automatically reduce the current in worst-case conditions.

The charge cycle begins when the voltage at the V_{CC} pin rises above the UVLO level, a current set resistor is connected from the PROG pin to ground. The $\overline{CHRG}$ pin outputs a logic low to indicate that the charge cycle is on going. At the beginning of the charge cycle, if the battery voltage is below 2.9V, the charge is in precharge mode to bring the cell voltage up to a safe level for charging. The charger goes into the fast charge constant-current mode once the voltage on the BAT pin rises above 2.9 V. In constant current mode, the charge current is set by R_{PROG}. When the battery approaches the regulation voltage 4.2V, the charge current begins to decrease as the HM4055 enters the constant-voltage mode. When the current drops to charge termination threshold, the charge cycle is terminated, and $\overline{CHRG}$ pin assumes a high impedance state to indicate that the charge cycle is terminated . The charge termination threshold is 10% of the current in constant current mode. To restart the charge cycle, remove the input voltage and reapply it . The charge cycle can also be automatically restarted if the BAT pin voltage falls below the recharge threshold. The on-chip reference voltage, error amplifier and the resistor divider provide regulation voltage with 1% accuracy which can meet the requirement of lithium-ion and lithium polymer batteries. When the input voltage is not present, or input voltage is below V_{BAT}, the charger goes into a sleep mode, dropping battery drain current to less than 2μA. This greatly reduces the current drain on the battery and increases the standby time. The charging profile is shown in the following figure:

Programming charge current

The charge current is programmed using a single resistor from the PROG pin to ground. The program resistor and the charge current are calculated using the following equations.:

$$R_{PROG} = \frac{1100}{I_{BAT}} \text{ (error } \pm 10\% \text{)}$$

In application, according the charge current to determine R_{PROG}, the relation between R_{PROG} and charge current can reference the following chart:

$K = \dfrac{1100}{R_{PROG} \times I_{BAT}}$	I_{BAT} (mA)	R_{PROG} (KΩ)
0.9	30	40
0.75	60	24
0.8	114	12
0.9	305	4
1	650	1.7
1.1	1000	1

Note:

a. K is the coefficient of variation, It generally is 1, but due to the vary operating environment, K is varied in the range: 0.8~1.4

b. The up form is just for reference, it will varied $\pm 10\%$ according to the heat dissipation of the using PCB board;

c. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient.

Charge termination

A charge cycle is terminated when the charge current falls to 1/10th the programmed value after the final float voltage is reached. This condition is detected by using an internal filtered comparator to monitor the PROG pin. When the PROG pin voltage falls below 100mV for longer than t_{TEMP} (typically 1.8mS), Charging is terminated. The charge current is latched off and the HM4055-N enters standby mode, where the input supply current drops to 55μA

(Note:C/10 termination is disabled in trickle charging and thermal limiting modes).

When charging, transient loads on the BAT pin can cause the PROG pin to fall below 100mV for short periods of time before the DC charge current has dropped to $1/10^{th}$ the programmed value. The 1.8mS filter time (t_{TEMP}) on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination. Once the average charge current drops below $1/10^{th}$ the programmed value, the HM4055 terminated the charge cycle and ceases to provide any current through the BAT pin. In this state all loads on the BAT pin must be supplied by the battery.

The HM4055 constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.02V recharge threshold (V_{RECHRG}),another charge cycle begins and current is once again supplied to the battery. To manually restart a charge cycle when in standby mode, the input voltage must be removed and reapplied or the charger must be shut down and restarted using the PROG pin. Figure 1 shows the state diagram of a typical charge cycle.

Charge Status Indicator (CHRG)

HM4055 has one open-drain status indicator output $\overline{CHRG}$. $\overline{CHRG}$ is pull-down when the HM4055 in a charge cycle. In other status $\overline{CHRG}$ in high impedance.

Represent in failure state, when the charger with no battery: LED don't light. If battery is not connected to charger, $\overline{CHRG}$ pin outputs a PWM level to indicate no battery. If BAT pin connects a 10μF capacitor, the frequency of $\overline{CHRG}$ flicker about 1-4S, If not use status indicator should set status indicator output connected to GND.

Thermal limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 110℃ . The feature protects the HM4055 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 HM4055. The charge current can be set according to typical (not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions.

Under Voltage lockout (UVLO)

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the under voltage lockout threshold . If the UVLO comparator is tripped, the charger will not come out of shutdown mode until VCC rises 140mV above the battery voltage.

Manual terminate

At any time of the cycle of charging will put the HM4055 into disable mode to remove RPROG（PROG pin is float）. This made the battery drain current to less than 2μA and reducing the supply current to 55μA. To restart the charge cycle, connect a programming resistor.

If HM4055 in the under voltage Lockout mode, the $\overline{CHRG}$ is in high impedance state, or VCC is above BAT pin 140mV, or VCC is too low.

Auto restart

Once charge is been terminated, HM4055 immediately use a 1.8ms filter time （ $t_{RECHARGE}$ ） on the

termination comparator to constant monitor the voltage on BAT pin. If this voltage drops below the 4.02V recharge threshold (about between 80% and 90% of V_{CC}), another charge cycle begins. This ensured the battery maintained (or approach) to a charge full status and avoid the requirement of restarting the periodic charging cycle. In the recharge cycle,$\overline{CHRG}$ pin enters a pulled down status.
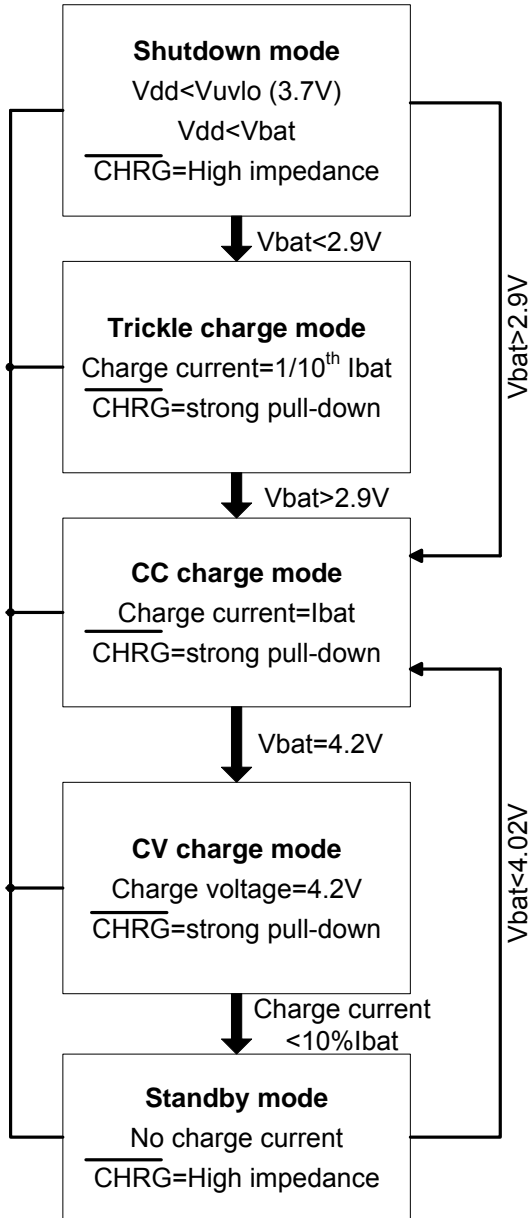
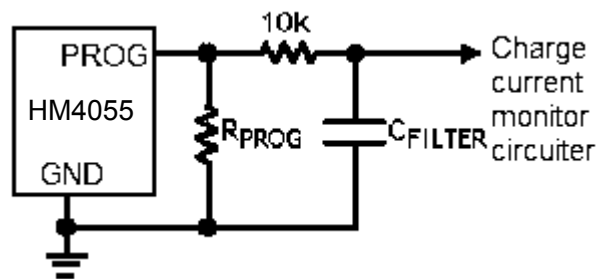

Fig.1 State diagram of a typical charge cycle

Fig.2 Isolating with capacitive load on PROG Pin

Stability Considerations

In constant-current mode, the PROG pin is in the feedback loop, not the battery. 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 program resistor values as high as 20KΩ. However, additional capacitance on this node reduces the maximum allowed program resistor. Therefore, if I_{PROG} pin is loaded with a capacitance C, the following equation should be used to calculate the maximum resistance value for R_{PROG}:

$$R_{PROG} \leq \frac{1}{2\pi \cdot 10^5 \cdot C_{PROG}}$$

As user, may think charge current is important, not instantaneous current. For example, to run a low current mode switch power which parallel connected with battery, the average current from BAT pin usually importance to instantaneous current. In this case, In order to measure average charge current or isolate capacitive load from I_{PROG} pin, a simple RC filter can be used on PROG pin as shown in Figure 2. In order to ensure the stability add a 10KΩ resistor between PROG pin and filter capacitor.

Power dissipation

The conditions that cause the HM4055 to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET-this is calculated to be approximately:

$$P_D = (V_{CC} - V_{BAT}) \times I_{BAT}$$

The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 110°C - P_D \theta_{JA}; \qquad T_A = 110°C - (V_{CC} - V_{BAT}) \times I_{BAT} \times \theta_{JA}$$

For example: The HM4055 with 5V supply voltage through programmable provides full limiting current 800mA to a charge lithium-ion battery with 3.75V voltage. If θ_{JA} is 150℃/W (reference to PCB layout considerations), When HM4055 begins to decrease the charge current, the ambient temperature about:

$$T_A = 110°C - (5V - 3.75V) \times (800mA) \times 150°C / W$$

$$T_A = 110°C - 0.5W \times 150°C / W = 110°C - 75°C \qquad T_A = 35°C$$

HM4055 can work in the condition of the temperature is above 35℃, but the charge current will pull down to below 800mA. In a fixed ambient temperature, the charge current is calculated to be approximately :

$$I_{BAT} = \frac{110°C - T_A}{(VCC - V_{BAT}) * \theta_{JA}}$$

Just as Description of the Principle part talks about so, the current on PROG pin will reduce in proportion to the reduced charge current through thermal feedback. In HM4055 design applications don't need to considerate the worst case of thermal condition, this point is importance, because if the junction temperature up to 110℃ ,IC will auto reduce the power dissipation.

Thermal considerations

Because of the small size of the thin SOT23-5 package, it is important to use a good thermal PC board layout to maximize the available charge current. The thermal path for the heat generated by the IC is from the die to the copper lead frame, through the package leads, (especially the ground lead) to the PC board copper. The PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

Add thermal regulation current

It will effective to decrease the power dissipation through reduce the voltage of both ends of the inner MOSFET.

In the thermal regulation, this action of transporting current to battery will raise. One of the measure is through an external component(as a resistor or diode) to consume some power dissipation.

For example: The HM4055 with 5V supply voltage through programmable provides full limiting current 800mA to a charge lithium-ion battery with 3.75V voltage. If θ_{JA} is 105℃/W, so that at 25℃ ambient temperature, the charge current is calculated to be approximately :

$$I_{BAT} = \frac{110℃ - 25℃}{(Vs - I_{BAT} * Rcc - V_{BAT}) * \theta_{JA}}$$

In order to increase the thermal regulation charge current, can decrease the power dissipation of the IC through reducing the voltage (as show fig.3) of both two ends of the resistor which connecting in series with a 5V AC adapter. With square equation to calculate I_{BAT} :

$$I_{BAT} = \frac{(Vs - V_{BAT}) - \sqrt{(Vs - V_{BAT})^2 - \dfrac{4Rcc(110℃ - T_A)}{\Theta_{JA}}}}{2Rcc}$$

If R_{CC}=0.25Ω, V_S=5V, V_{BAT}=3.75V, T_A=25℃ and θ_{JA} =105℃/W, we can calculate the thermal regulation charge current: I_{BAT}＝764mA. It means that in this structure it can output 800mA full limiting charge current at more high ambient temperature environment.

Although it can transport more energy and reduce the charge time in this application, but actually spread charge time, if HM4055 stay in under-voltage state, when V_{CC} becomes too low in voltage mode. Fig.4 shows how the voltage reduced with increase R_{CC} value in this circuit. This technique will act the best function when in order to maintain the minimize the dimension of the components and avoid voltage decreased to minimize R_{CC} .
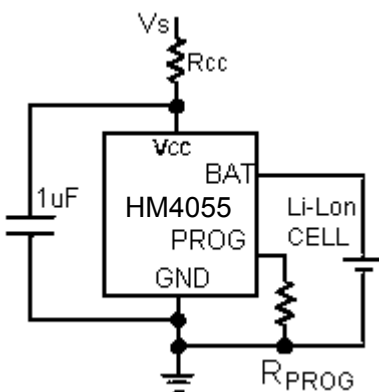

Fig.3:A circuit to maximum the thermal
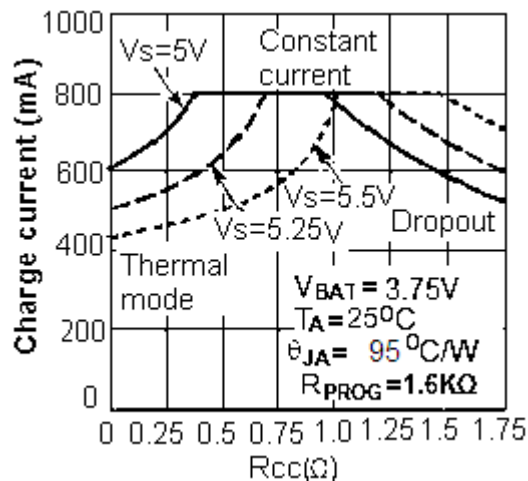   regulation charge current

Fig.4:The relationship curve between charge
    current with R_{CC}

VCC bypass capacitor

Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1.5Ω resistor in series with a ceramic capacitor will minimize start-up voltage

transients.

Charging Current Soft Start

HM4055 includes a soft start circuit which used to maximize to reduce the surge current in the begging of charge cycle. When restart a new charge cycle, the charging current ramps up from 0 to the full charging current within 20μs. In the start process it can maximize to reduce the action which caused by surge current load.

USB and Wall Adapter Power

HM4055 allows charging from a USB port, a wall adapter can also be used to charge Li-Ion/Li-polymer batteries. Figure 5 shows an example of how to combine wall adapter and USB power inputs. A P-channel MOSFET, M1, is used to prevent back conducting into the USB port when a wall adapter is present and Schottky diode, D1, is used to prevent USB power loss through the 1KΩ pull-down resistor.
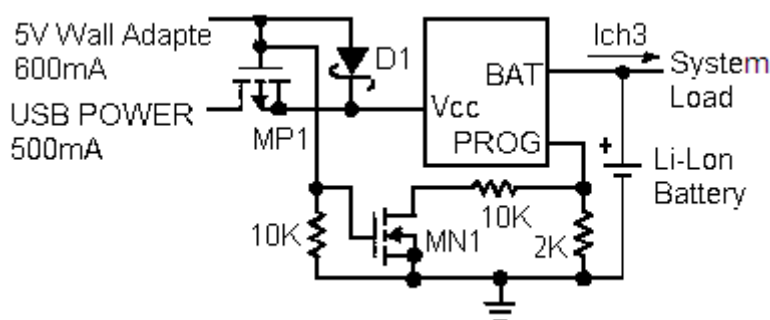

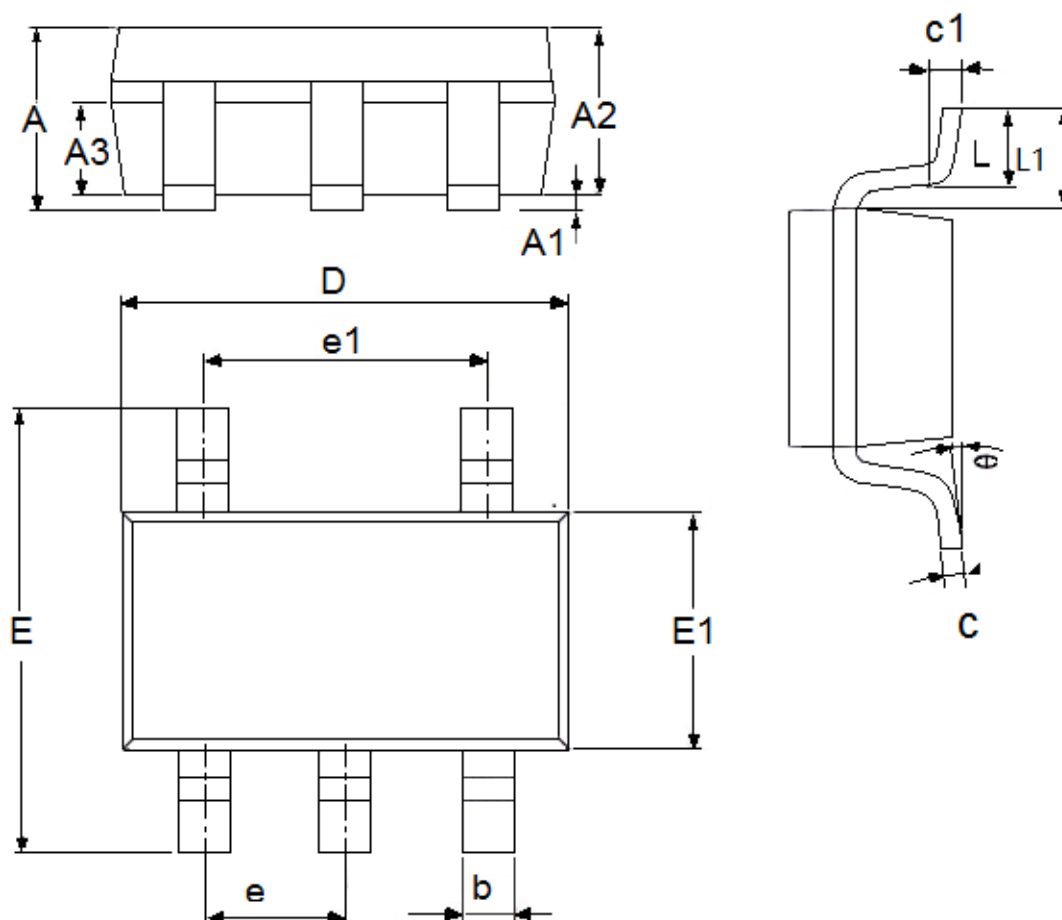**Fig.5:Combining Wall Adapter and USB Power**

Generally, AC adaptor is able to provide bigger much current than the value of specific current limiting which is 500mA for USB port. So can rise charge current to 600mA with using a N-MOSFET (MN1) and an additional set resistor value as high as 10KΩ.

Board Layout Considerations

● RPROG at PROG pin should be as close to HM4055 as possible, also the parasitic capacitance at PROG pin should be kept as small as possible.

● The capacitance at VCC pin and BAT pin should be as close to HM4055 as possible.

● It is very important to use a good thermal PC board layout to maximize charging current. The thermal path for the heat generated by the IC is from the die to the copper lead frame through the package lead (especially the ground lead) to the PC board copper, the PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feed through vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

● The ability to deliver maximum charge current under all conditions require that the exposed metal pad on the back side of the HM4055 package be soldered to the PC board ground. Failure to make the thermal contact between the exposed pad on the backside of the package and the copper board will result in larger thermal resistance.
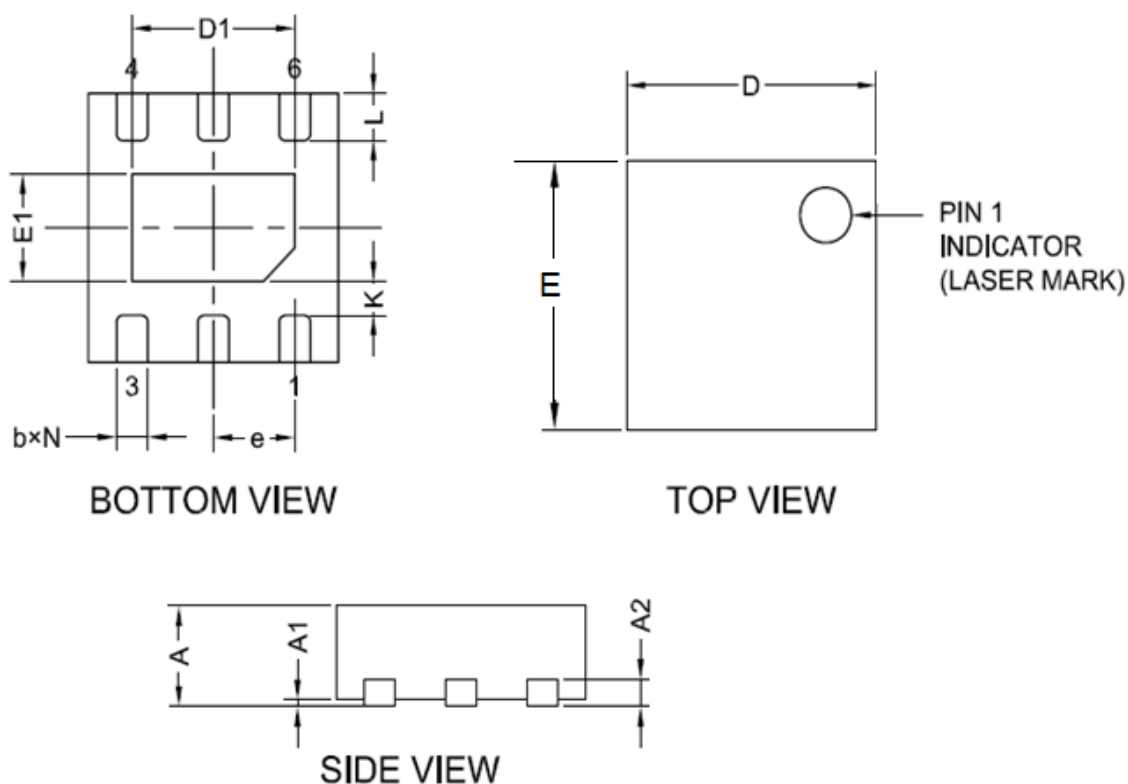
Package Information

- **Package Type：SOT23-5**

DIM	Millimeters		Inches	
	Min	**Max**	**Min**	**Max**
A	1.05	1.45	0.0413	0.0571
A1	0	0.15	0.0000	0.0059
A2	0.9	1.3	0.0354	0.0512
A3	0.6	0.7	0.0236	0.0276
b	0.25	0.5	0.0098	0.0197
c	0.1	0.23	0.0039	0.0091
D	2.82	3.05	0.1110	0.1201
e1	1.9(TYP)		0.0748(TYP)	
E	2.6	3.05	0.1024	0.1201
E1	1.5	1.75	0.0512	0.0689
e	0.95(TYP)		0.0374(TYP)	
L	0.25	0.6	0.0098	0.0236
L1	0.59(TYP)		0.0232(TYP)	
θ	0	8°	0.0000	8°
c1	0.2(TYP)		0.0079(TYP)	

- **Package Type：DFN2*2-6**

BOTTOM VIEW

TOP VIEW

SIDE VIEW

DIM	Millimeters		Inches	
	Min	Max	Min	Max
A	0.7	0.8	0.0276	0.0315
A1	0	0.05	0	0.002
A2	0.203(TYP)		0.008(TYP)	
b	0.2	0.35	0.0078	0.0138
D	1.9	2.1	0.0748	0.0827
E	1.9	2.1	0.0748	0.0827
E1	0.5	0.9	0.0197	0.0354
e	0.65(TYP)		0.0256(TYP)	
L	0.25	0.426	0.0098	0.0168
K	0.2	——	0.0079	——
D1	1	1.45	0.0393	0.0571