36V Withstand Input Voltage Battery Linear Charger ME4554H Series

General Description

ME4554H is a complete constant-current/ constant voltage linear charger for single cell lithium-ion batteries. The maximum charging current can reach 600mA. The internal thermal feedback circuit of the linear charger enables effective temperature control of the chip during the charging process, allowing for adjustment of the charging current to meet specific system heat dissipation requirements, particularly in cases with significant voltage differentials between input and output. No external sense resistor is needed and no blocking diode is required. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The ME4554H 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 ME4554H automatically enters a low current state dropping the battery drain current to less than 2uA. The ME4554H can be put into shutdown mode reducing the supply current to 100uA.

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

Features

- Maximum withstand input voltage 36V
- Programmable charging current up to: 600mA
- Protection of battery cell reverse connection
- Internal thermal feedback protection function, control system in a reasonable charging range
- No MOSFET sense resistor or blocking diode required
- Complete linear charge for single cell lithium-ion batteries
- Constant current and constant voltage switching
- 4.2V fixed charge regulation voltage with ±1% accuracy
- Automatic Recharge
- C/10 charge termination
- 100uA supply current in shutdown
- Over voltage protection: 6.5V
- 2.9V trickle current charge threshold
- Soft-start limits inrush current

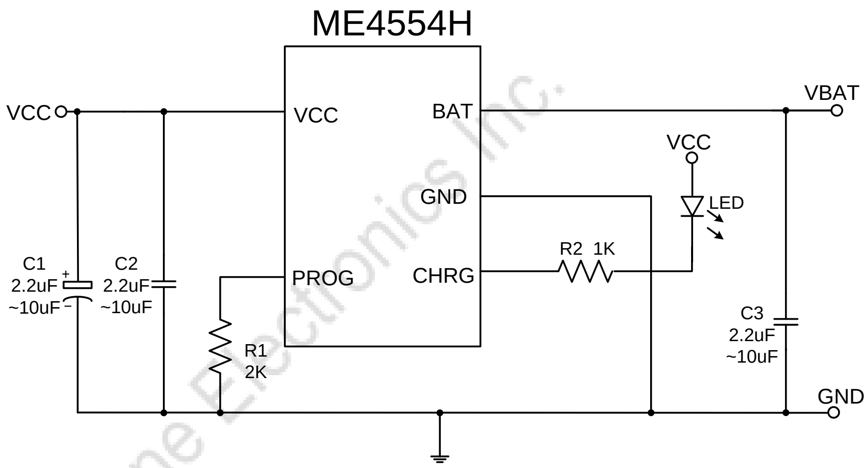
Applications

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

Package

- 5-pin SOT23-5

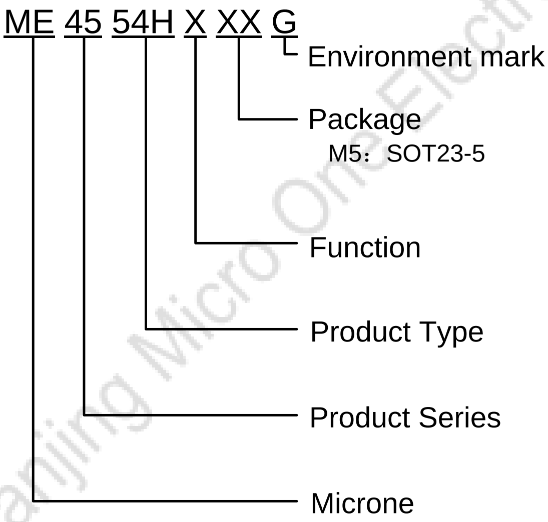
Typical Application Circuit



ME4554H Typical application circuit

Note: An electrolytic capacitor of 2.2uF~10uF the input is required if the input is required to withstand 36V power hot-plug applications.

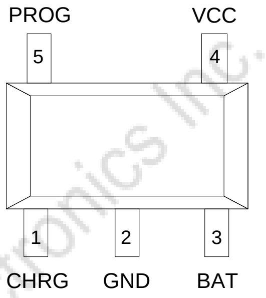
Selection Guide



Product Series	Product Description
ME4554HAM5G	V_{FLOAT} =4.2V; Charging current: 600mA; Package: SOT23-5

Note： If you need other voltage and package, please contact our sales staff.

Pin Configuration

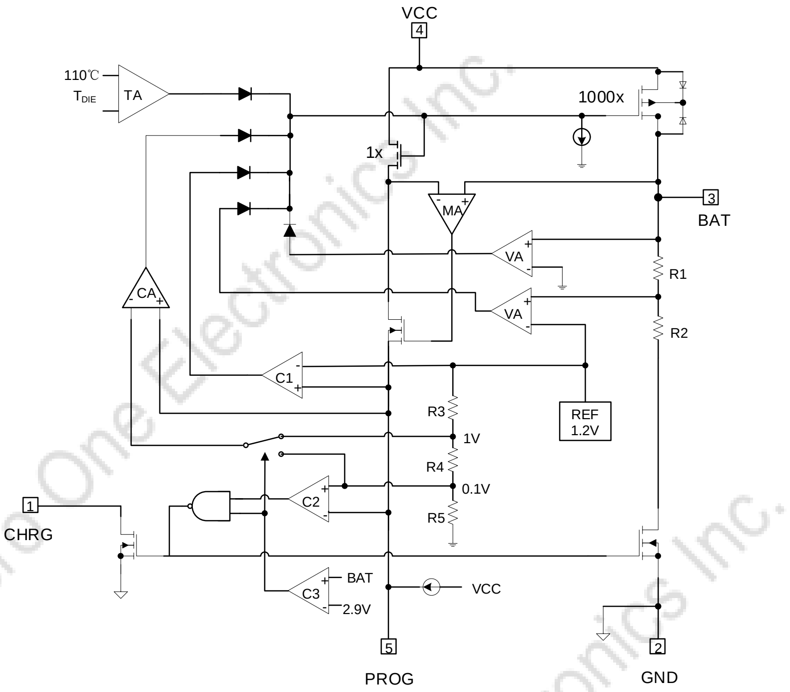


SOT23-5

Pin Assignment

Pin No.	Symbol	Function
1	CHRG	Open-drain charge status output When the battery is being charged, the CHRG pin is pulled low by an internal switch, otherwise, CHRG pin is in high impedance state.
2	GND	Ground
3	BAT	Battery connection pin Connect the positive terminal of the battery to this pin. BAT pin provides charge current to the battery and provides regulation voltage of 4.2V.
4	V_{CC}	Positive input supply voltage Provides power to the internal circuit. When V_{CC} drops to within 50mV of the BAT pin voltage, the ME4554H enters low power sleep mode, dropping I_{BAT} to less than 1μA.
5	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.

Functional Block Diagram



Absolute Maximum Ratings

Parameter		Ratings	Unit
Input supply voltage: V_{CC}		-0.3~36	V
PROG pin voltage		-0.3~6	V
BAT pin voltage		-0.3~12	V
CHRG pin voltage		-0.3~36	V
BAT pin current		600	mA
PROG pin current		600	μA
Junction temperature T_J		-40~150	℃
Operating ambient temperature T_A		-40~85	℃
Storage temperature T_{stg}		-55~150	℃
Soldering temperature and time		+260（10s）	℃
Package thermal impedance θ_{JA}	SOT23-5	210	℃/W
Power dissipation P_D	SOT23-5	0.6	W

Note：

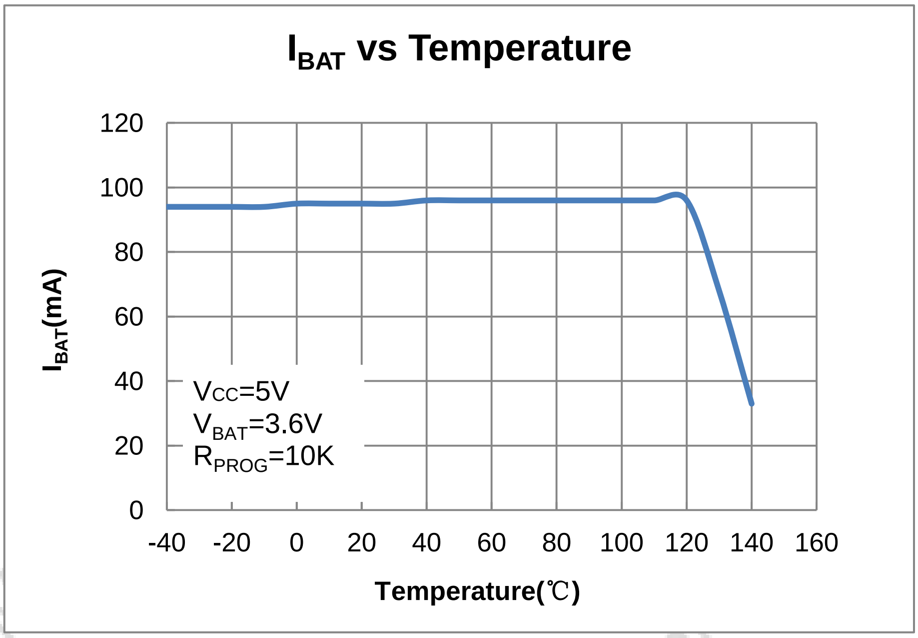
1. The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.
2. The maximum allowable power dissipation is a function of the maximum junction temperature TJ (MAX), the junction-to- ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D(MAX)}=(T_{J(MAX)}-T_A)/\theta_{JA}$.
3. Chip is soldered to 400mm^2 (20mm*20mm) copper (top side solder mask) on 1oz.2 layers FR-4 PCB（for reference only）. The θ_{JA} values given in this table are for comparison with other packages only and cannot be used for design purposes. They do not represent the performance achieved in real-world applications.

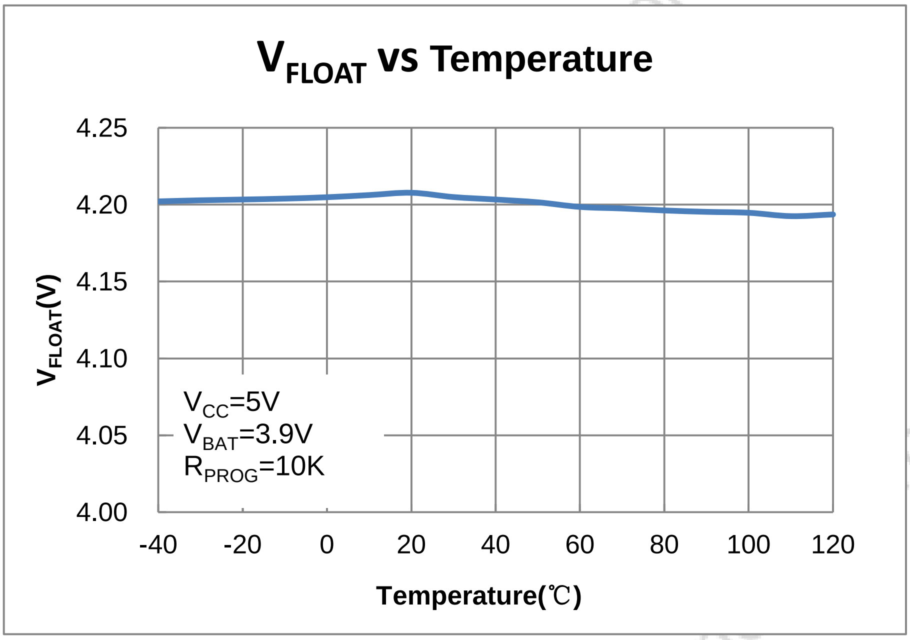
Electrical Characteristics

Test condition: T_A=25℃，V_{CC}=5V，unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Input supply voltage	V_{CC}		4.7	5.0	6.3	V
Input current	I_{CC}	Standby mode (charge end)	-	100	200	μA
		Shutdown mode （R_{PROG} not connected, V_{CC}<V_{BAT}, or V_{CC}<V_{UV}）	-	100	200	μA
Regulated output voltage	V_{FLOAL}	0℃≤T_A≤85℃	4.158	4.20	4.242	V
BAT pin current (The condition of current mode is V_{BAT}=3.9V)	I_{BAT}	R_{PROG}=2KΩ，current mode	440	500	560	mA
		Standby mode，V_{BAT}=4.3V	-	±2.4	±3	μA
		R_{PROG} not connected	-	±0.1	±1	μA
		Sleep mode，V_{CC}=0V	-	±0.1	±1	μA
Trickle charge current	I_{TRIKL}	V_{BAT}<V_{TRIKL}, R_{PROG}=2KΩ	-	65	-	mA
Trickle voltage threshold voltage	V_{TRIKL}	R_{PROG}=2KΩ, V_{BAT} rising	2.8	2.9	3.0	V
Trickle voltage hysteresis voltage	V_{TRHYS}	R_{PROG}=2KΩ	-	150	-	mV
V_{CC} under voltage lockout threshold	V_{UV}	V_{CC} from low to high	3.7	3.9	4.1	V
V_{CC} under voltage lockout hysteresis	V_{UVHYS}		-	120	-	mV
V_{CC} over voltage protection	V_{OVP}	V_{CC} from low to high	6.3	6.5	6.7	V
V_{CC}-V_{BAT} lockout threshold voltage	V_{ASD}	V_{CC} from low to high	-	140	-	mV
		V_{CC} from high to low	-	45	-	
Termination current threshold	I_{TERM}	R_{PROG}=2KΩ	-	65	-	mA
PROG pin voltage	V_{PROG}	R_{PROG}=2KΩ，current mode	0.9	1.0	1.1	V
CHRG pin output low voltage	V_{CHRG}	I_{CHRG}=5mA	-	0.5	0.6	V
Recharge battery threshold voltage	ΔV_{RECHRG}	V_{FLOAT} -V_{RECHRG}	50	130	200	mV

Typical Performance Characteristics





Note: The above sampling temperatures are chip surface temperature.

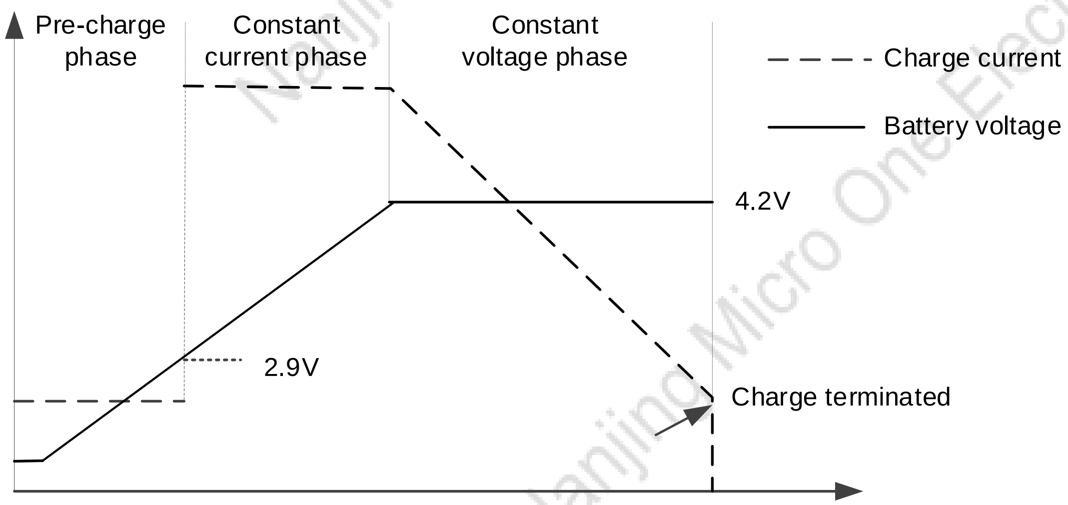
Description of the principle

The ME4554H 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 600mA of charge current. No blocking diode or external current sense resistor is required. ME4554H include one open-drain charge status pin: charge status indicator CHRG.

The internal thermal feedback circuit reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120℃ (V_{CC}=5V). This feature protects the ME4554H 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 ME4554H or the external components.

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 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 pre-charge 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 RPROG. When the battery approaches the regulation voltage 4.2V, the charge current begins to decrease as the ME4554H enters the constant-voltage mode. When the current drops to charge termination threshold, the charge cycle is terminated, and 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 VBAT, 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:



Charging current set

The charging current is set using a resistor connected to the PROG pin and the ground. The calculation formula of setting resistor and charging current is as follows:

$$R_{PROG}=1000/I_{BAT}$$

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 to 1/10 constant current charge, charging is terminated. The charge current is latched off and the ME4554H enters standby mode, where the input supply current drops to 100uA (Note: C/10 termination is disabled in trickle charging and thermal limiting modes).

The ME4554H constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.1V, recharge threshold (V_{RECHRG}), another charge cycle begins and current is once again supplied to the battery.

Charge status indicator

ME4554H has one open-drain status indicator output CHRG. CHRG is pull-down when the ME4554H in a charge cycle. In other status CHRG in high impedance.

If battery is not connected to charger, CHRG pin outputs a PWM level to indicate no battery. If BAT pin connects a 10μF capacitor, the frequency of CHRG flicker about 1~4 seconds. If not use status indicator should set status indicator output connected to GND.

Charger's status	Red LED CHRG
Charging	light
Battery in full state	dark
Under-voltage, over-voltage and other fault states	dark
BAT pin is connected to 10uF capacitor，no battery mode	Red LED flicker F=1~4s （At this time, reverse-battery, the light does not shine, this phenomenon is normal. Such a case, after the battery is properly connected to the indicator light back to flicker）

Thermal limit

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120℃. The feature protects the ME4554H 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 ME4554H. 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.

Undervoltage 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 100mV above the battery voltage.

Auto restart

Once charge is terminated, ME4554H immediately to constant monitor the voltage on BAT pin. If this voltage drops below the 4.1V, 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, CHRG pin enters a pulled down status.

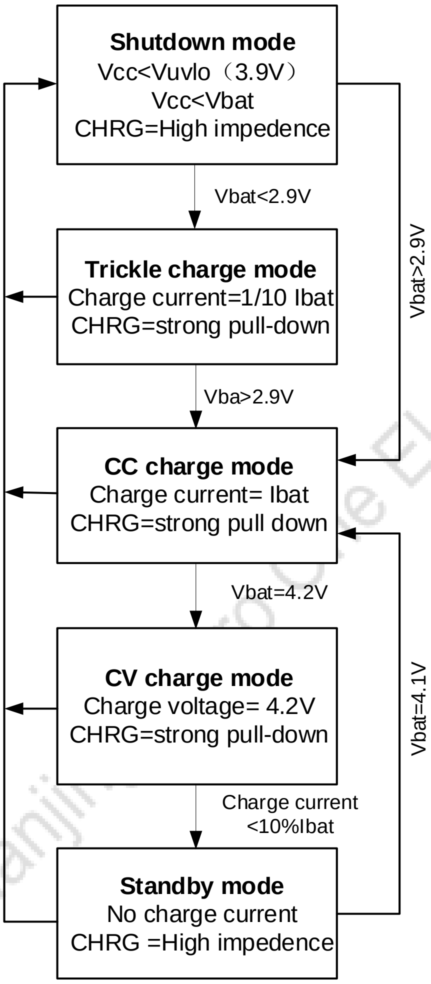


Fig1 State diagram of a typical charge cycle

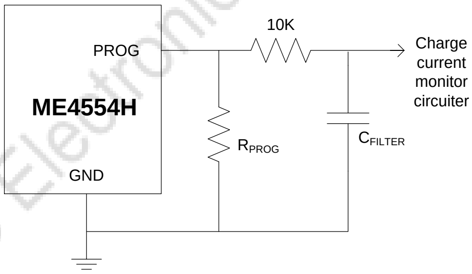


Fig2 Isolating with capacitive load on PROG pin

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. When the PROG pin has no additional capacitance, it reduces the maximum allowable resistance of the set resistor. The pole frequency on the PROG pin should be maintained at C_{PROG}, the following equation should be used to calculate the maximum resistance value for R_{PROG}:

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

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 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 ME4554H 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:

$$T_A=115-P_D\times\theta_{JA}$$

$$T_A=115-(V_{CC}-V_{BAT})\times I_{BAT}\times\theta_{JA}$$

In a fixed ambient temperature, the charge current is calculated to be approximately:

$$I_{BAT}=\frac{120-T_A}{(V_{CC}-V_{BAT})\times\theta_{JA}}$$

Just as description of the principle part talks about, the current on PROG pin will reduce in proportion to the reduced charge current through thermal feedback. In ME4554H design applications don't need to considerate the worst case of thermal condition, this point is importance, because if the junction temperature up to 120℃ ,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.

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

ME4554H 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

ME4554H allows charging from a USB port, a wall adapter can also be used to charge Li-Ion/Li-polymer batteries. Figure 3 shows an example of how to combine wall adapter and USB power inputs. AP-channel MOSFET(MP1) 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.

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.

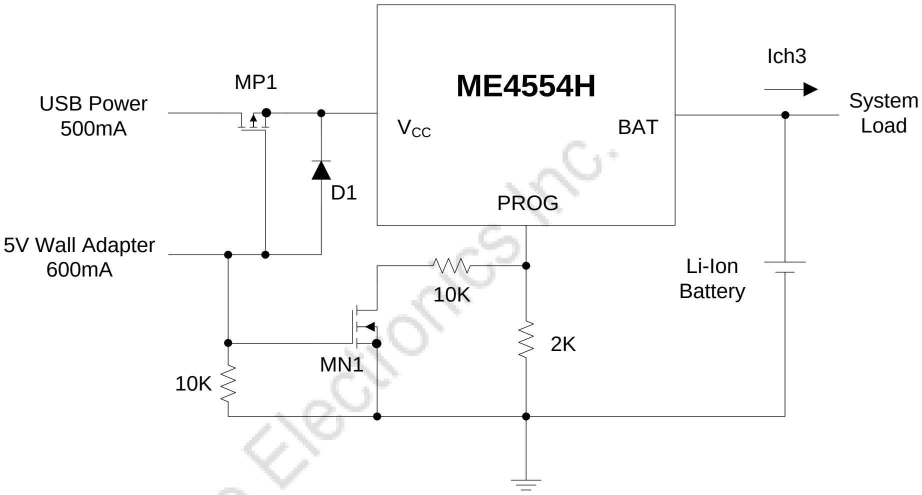


Fig3 Combing wall adapter and USB power

PCB Layout Considerations

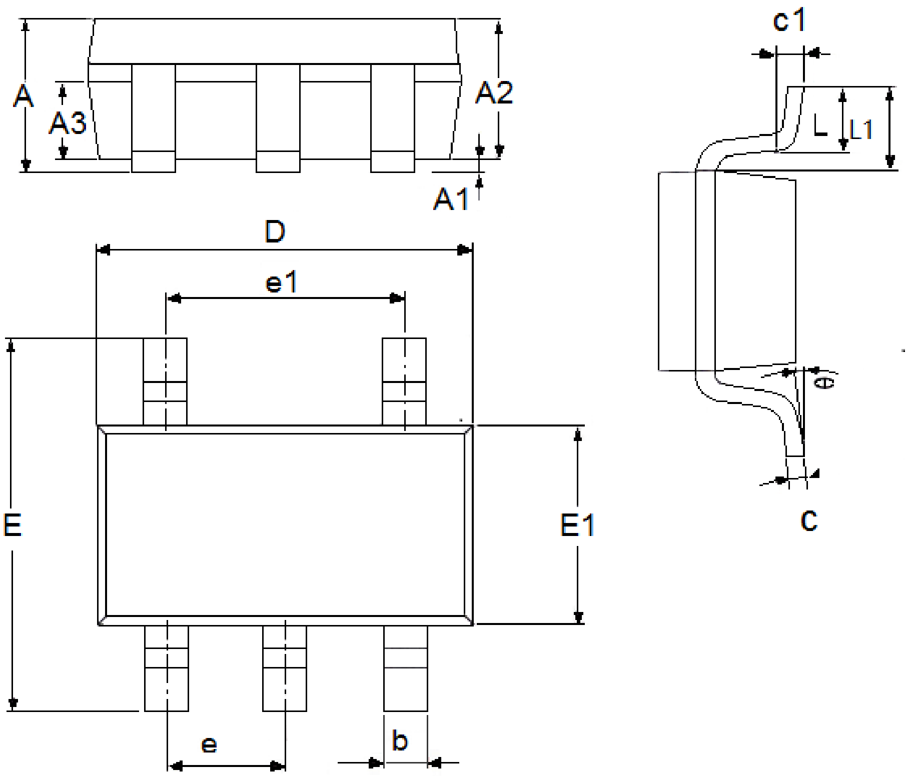
- R_{PROG} at PROG pin should be as close to ME4554H as possible, also the parasitic capacitance at PROG pin should be kept as small as possible.
- The capacitance at V_{CC} pin and BAT pin should be as close to ME4554H as possible.
- It is very important to use a good thermal PC board layout to maximize 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.

Package Quantity

Package	Minimum Packing QTY	Units	Small Box	Large Box
SOT23-5	3000	Tape & Reel	30K	120K

Package Information

- **Package Type：SOT23-5**



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