AF4054H

600mA High Input Voltage Linear Charger

➢ Description

The AF4054H is a fully integrated, cost-effective 600mA high input voltage single-cell Li-Ion battery linear charger. The AF4054H uses a CC&CV charge mode required by Li-Ion battery.

The AF4054H accepts an input voltage up to 30V. The AF4054H is disabled when the input voltage exceeds the OVP threshold to prevent excessive power dissipation. The 30V rating eliminates the over voltage protection IC required in a low input voltage charger.

The AF4054H preset 4.05V/4.20V/4.35V charging float voltage, The charging constant current can be programmable by the external resistors. When the battery voltage is below 2.94V, the AF4054H will charge at a trickle current, 20% of constant current.

The indication pins CHRG, allow simple interface to a microprocessor or LED. When no adapter is attached, the AF4054H draws less than 1μA leakage current from the battery.

➢ Applications

- Mobile Phones ,PDAs, Power Bank
- Bluetooth™ Applications
- Portable Instruments

➢ Features

- 30V Maximum Input Voltage
- 20V Maximum BAT Voltage With VIN Floating
- Supports up to 600mA Charge Current
- 6.75V Input Over Voltage Protection
- 2.94V Trickle Charge Threshold.
- Programmable Charge Constant Current
- Battery 0V Charge Function
- Battery Reverse Connection Protection
- <50μA Battery Reverse Current
- Integrated Power MOSFET and Sense Resistor
- Thermal Regulation Of Charge Current
- Charge Indication

➢ Device Information

AF 4054H L/T/H S5

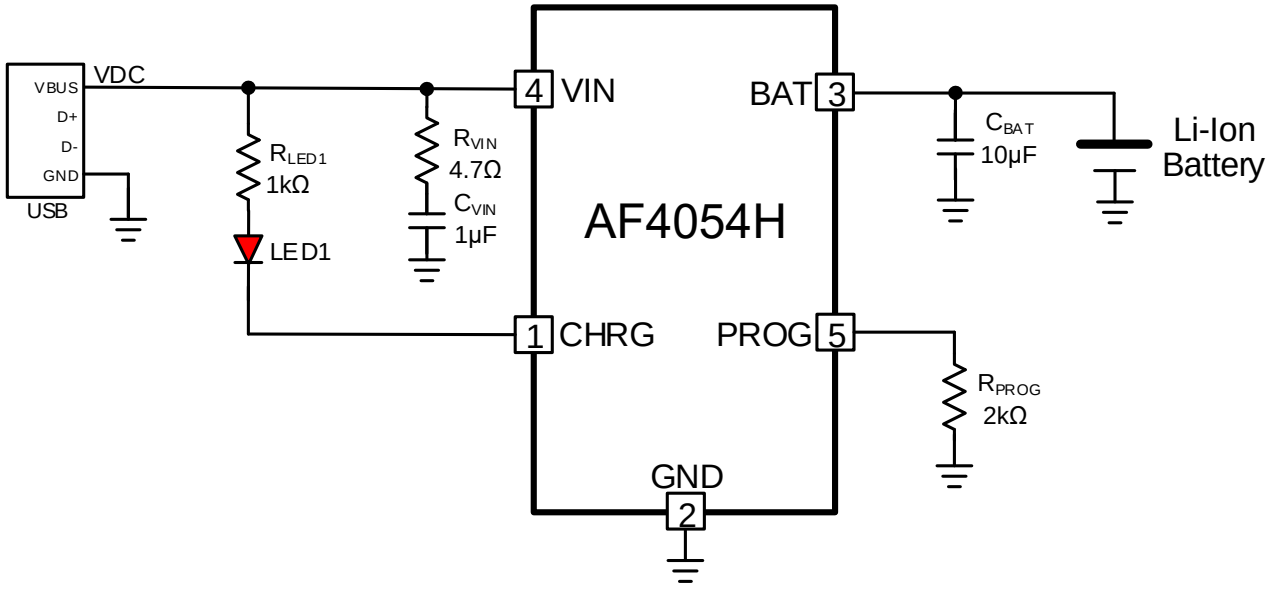
① ② ③ ④

①	Standard
②	Product Name
③	L: Charge Float Voltage 4.05V T: Charge Float Voltage 4.20V H: Charge Float Voltage 4.35V
④	S5: SOT23-5L Package

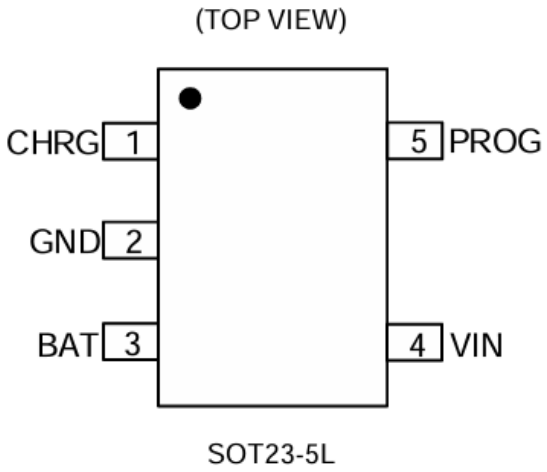
➢ Marking Information

Device	Ordering Number	Float Voltage	Marking	Package	Quantity	Packing
AF4054H	AF4054HLS5	4.05V	AF4054H	SOT23-5L	3000pcs	Tape and Reel
	AF4054HTS5	4.20V				
	AF4054HHS5	4.35V				

➢ Typical Application



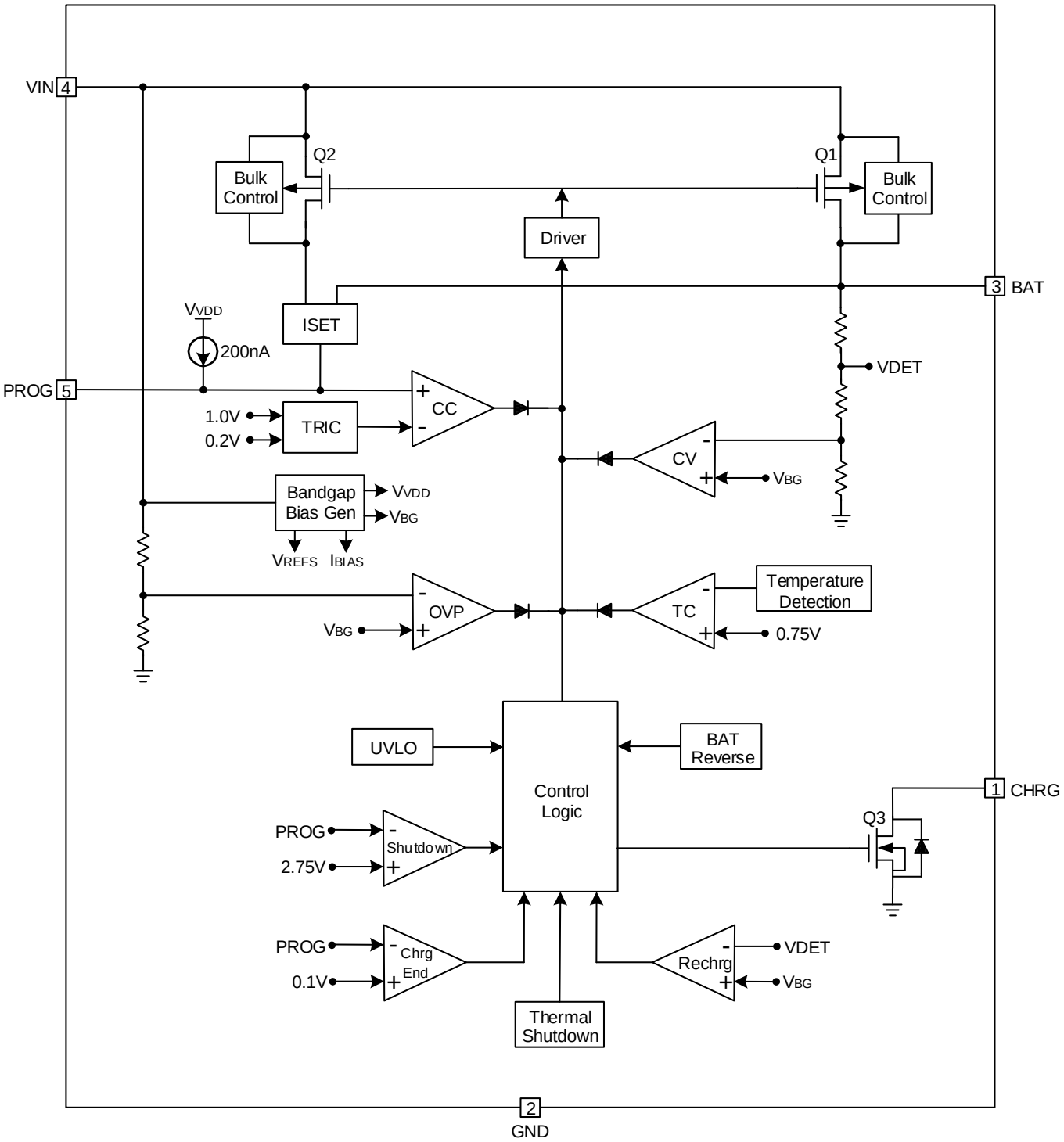
➢ PIN Configuration



➢ Pin Description

Pin Name	Pin No.	Pin Function
CHRG	1	The open-drain charge indication output. This pin outputs a logic low when a charge cycle starts and turns to high impedance when the charge cycle is disable.
GND	2	The ground terminal.
BAT	3	The output terminal of the charging system. Connect this pin to the battery. Bypass BAT to GND with a ceramic capacitor. A 10μF or larger X5R ceramic capacitor is recommended for decoupling and stability purposes.
VIN	4	The Input Power terminal. Connected to external DC supply. Bypass VIN to GND with a ceramic capacitor (1μF Min.).
PROG	5	The charge constant current threshold programming terminal. Connecting a resistor to GND to set the charge constant current threshold.

➢ Block Diagram



➢ Operation

Overview

The AF4054H is a fully integrated, cost-effective 600mA high input voltage single-cell Li-Ion battery linear charger. The AF4054H uses a CC&CV charge mode required by Li-Ion battery.

The AF4054H accepts an input voltage up to 30V. The AF4054H is disabled when the input voltage exceeds the OVP threshold to prevent excessive power dissipation. The 30V rating eliminates the over voltage protection IC required in a low input voltage charger.

The AF4054H preset 4.05V/4.20V/4.35V charging float voltage. The charging constant current can be programmable by the external resistors. When the battery voltage is below 2.94V, the AF4054H will charge at a trickle current, 20% of constant current.

The indication pins CHRG of AF4054H, allow simple interface to a microprocessor or LED. When no adapter is attached, BAT pin of AF4054H draws less than 1μA leakage current from the battery.

UVLO

The AF4054H resets when the input voltage at VIN pin exceeds the UVLO threshold. The AF4054H remains in standby mode when the input voltage is below the UVLO threshold (VUVLO-VUVLO_HYS). Furthermore, to protect the reverse current in the internal Power MOS Q1, the UVLO circuit keeps the AF4054H in standby mode if VIN falls below the battery voltage.

VIN-BAT Lockout

The AF4054H will not be enabled unless the VIN voltage is higher than the BAT voltage by an offset voltage VOS. The purpose of this function is to ensure that the AF4054H is turned off when the input power is removed from the charger. Without this function, it is possible that the charger will fail to power down when the input is removed and the current can leak through the Power MOS Q1 to continue biasing the UVLO and other blocks.

Input Over-Voltage Protection

The AF4054H accepts an input voltage at VIN pin up to 30V. But the charging function is disable when the input voltage exceeds the OVP threshold to protect against unqualified or faulty AC adapters.

If the input voltage is increased above VOVP, the internal Power MOS Q1 is turned off after the propagation delay TPD_OVP, removing power from the charging circuitry connected to BAT pin. The CHRG output is then indicated a logic high signal. When the input voltage drops below VOVP-VOVP_HYS, the internal Power MOS Q1 is turned back on. The AF4054H is enable to charge the battery again.

VIN Power Good Range

As described above, the power good range is defined by the following three conditions:

- VVIN > VUVLO
- VVIN - VBAT > VOS
- VVIN < VOVP.

The AF4054H will not charge the battery if the input voltage is not in the power good range.

Charge Cycle

The AF4054H starts a charge cycle once the voltage at VIN pin rises above the UVLO threshold level. If the battery voltage is below 2.94V, the AF4054H enters the trickle charge mode. In this mode, the charge trickle current is about 20% of constant current until the battery voltage is raised to a safe level for constant current charging.

The AF4054H enters constant current charge mode once the battery voltage rises above 2.94V, where the PROG pin programmed charge constant current is supplied to the battery. When the battery approaches the final battery float voltage, the AF4054H enters constant voltage mode and the charge current begins to decrease until the cutoff current is reached. Then the charge cycle of the AF4054H ends.

Auto Recharge

After the termination of the charge cycle, the AF4054H always monitors the battery voltage. When the battery voltage falls below VFLOAT-ΔVRCH, the AF4054H starts a recharge action. This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations.

CHRG Indication

The CHRG is an open-drain output capable of sinking at most 5mA current when the AF4054H is in a charge cycle. When the AF4054H enters the constant voltage mode and the charge cutoff current is reached, the CHRG pin will become high impedance. Then the CHRG pin can accept an input voltage up to 30V. The CHRG signal is interfaced either with a microprocessor GPIO or a LED for indication.

Thermal Regulation

If the junction temperature of the AF4054H exceeds T_{JRG}, the AF4054H starts to reduce the charge current. So that it will prevent the junction temperature from further increase and ensure device safe operation. This feature protects the AF4054H from excessive temperature. The charge current can be programmed according to a typical ambient temperature with the assurance that the AF4054H will automatically reduce the current in high temperature conditions.

Manual shutdown

AF4054H has a manual shutdown function. At any point in a charge cycle, the PROG pin is left open by removing the RPROG resistor, at which point the 200nA pull-up current of the PROG pin gradually increases the PROG voltage. When the PROG voltage reaches the manual shutdown threshold voltage VMSD, the AF4054H will immediately stop charging and enter the manual shutdown mode. At this time, the AF4054H BAT standby current is less than 1μA, the CHRG pin is open-drain to output a high-impedance state, and the LED indicator is off. Reconnecting the RPRAG resistor to ground at the PROG pin will allow the AF4054H to return to normal charge cycles.

BAT Maximum Rating

The BAT pin is the output terminal of the charging system. In some applications, at steps for installing the battery cell, maybe the BAT pin of AF4054H will face a high voltage that is more than 5V. So that the BAT pin needs a high voltage rating. The BAT pin of AF4054H can accept an input voltage up to 20V with VIN input floating. This feature protects the AF4054H from excessive BAT voltage.

Battery Reverse Protection

The AF4054H has a battery reverse protection, it will protect the AF4054H from damage when battery reverse connection happening at steps for installing the battery cell. The battery reverse current is less than 50μA when the battery is reverse connection.

➢ Absolute Maximum Ratings (Note 1)

- VIN (with respect to GND)---------- -0.3V to 30V
- BAT (with respect to GND, VIN floating) ---------- -5V to 20V
- CHRG (with respect to GND) ---------- -0.3V to 30V
- PROG (with respect to GND) ---------- -0.3V to 6V
- BAT Pin Source Current---------- 700mA
- CHRG Pin Source Current---------- 5mA
- Package Thermal Resistance
  SOT23-5L, θJA---------- 200℃/W
  SOT23-5L, θJC---------- 32℃/W
- Junction Temperature Range---------- -40℃ to +150℃
- Storage Temperature Range---------- -65℃ to +150℃
- Lead Temperature (Soldering, 10 sec.) ---------- +260℃
- ESD Susceptibility (Note 2)
  HBM (Human Body Model) ---------- ±2000V
  MM (Mechanical Electrostatic Model) ---------- ±200V

Note 1: Stresses exceeding the absolute maximum ratings may damage the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Note 2: Devices are ESD sensitive. This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. Handling precaution is recommended. ESD damage can range from subtle performance degradation to complete device failure.

➢ Recommended Operating Conditions (Note 3)

- VIN Voltage Range---------- -0.3V to 6V
- Output Current Range ---------- 0.05A to 0.6A
- Operating Temperature Range---------- -40℃ to +85℃

Note 3: The device is not guaranteed to function outside its operating conditions.

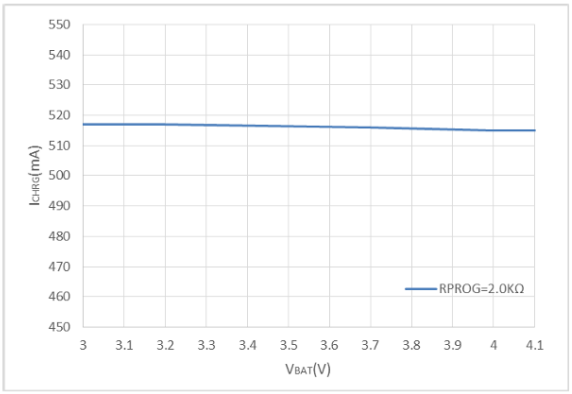
➢ Electronics Characteristics (Unless otherwise specified, T_A=25°C, V_{IN}=5V)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
V_{IN} Under Voltage Lockout	V_{UVLO}	V_{VIN} rising from 0V to 5V		3.95		V
Hysteresis on UVLO	V_{UVLO_HYS}	V_{VIN} falling from 5V to 0V		200		mV
Input Voltage Operation Range	V_{VIN}		3.5	5	30	V
VIN-BAT Lockout Threshold	V_{OS}	V_{BAT}=4.2V,VIN Rising, Check CHRG		120		mV
VIN-BAT Lockout Hysteresis	V_{OS_HYS}	V_{BAT}=4.2V,VIN Falling, Check CHRG		50		mV
VIN Operating Current	I_{OP}	EN=L, R_{PROG}=2.0KΩ, BAT floating		140		uA
VIN Standby Current In Manual Shutdown Mode	I_{MSD}	V_{VIN} = 5V, V_{BAT}=3.7V, R_{PROG} floating		115		uA
BAT Standby Current	I_{BAT_STY}	V_{BAT}=4.2V, V_{VIN}=0V or floating		0	1	uA
BAT Standby Current At The End Of Charging	I_{BAT_END}	V_{BAT}=4.2V, V_{VIN}=5V, Charge ends		3.5		uA
BAT Standby Current In Manual Shutdown Mode	I_{BAT_MSD}	V_{VIN} = 5V, V_{BAT}=3.7V, R_{PROG} floating		0	1	uA
BAT Reverse Current	I_{BAT_REV}	V_{BAT}=-4.2V, V_{VIN} floating		48		uA
VIN OVP Threshold	V_{OVP}	V_{VIN} from 5V to 10V		6.75		V
VIN OVP threshold Hysteresis	V_{OVP_HYS}	V_{VIN} from 10V to 5V		200		mV
VIN OVP Propagation Delay	T_{PD_OVP}	V_{VIN} from 5V to 10V (Note 4)		500		ns
BAT Charge Float Voltage	V_{FLOAT_L}	R_{PROG}=2.0KΩ,I_{BAT}=55mA, Order Number: AF4054HLS5	4.010	4.05	4.091	V
	V_{FLOAT_T}	R_{PROG}=2.0KΩ,I_{BAT}=55mA, Order Number: AF4054HTS5	4.158	4.20	4.242	V
	V_{FLOAT_H}	R_{PROG}=2.0KΩ,I_{BAT}=55mA, Order Number: AF4054HHS5	4.307	4.35	4.393	V
Programmed Charge	I_{CHRG}	V_{VIN} = 5V, V_{BAT}=3.7V	50		600	mA

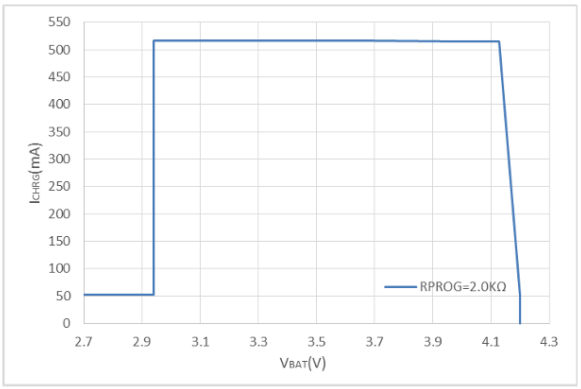
Current						
PROG Pin Output Voltage	V_{PROG}	V_{VIN} = 5V, R_{PROG}=2.0KΩ		1		V
Charge Constant Current	I_{CC}			505		mA
Charge Trickle Current	I_{TRIC}			101		mA
BAT 0V Charge Current	I_{TRIC_0V}			103		mA
Charge Cutoff Current	I_{OFF}			51		mA
Charge Full Delay Time	T_{D_FULL}	V_{VIN} = 5V, R_{PROG}=2.0KΩ		1.5		ms
BAT Recharge Threshold Voltage	ΔV_{RCH}	V_{VIN} = 5V, BAT Falling, V_{FLOAT}-V_{RCH}		120		mV
Recharge Delay Time	T_{D_RCH}	V_{VIN} = 5V, BAT Falling		1.5		ms
Trickle Charge Threshold Voltage	V_{TRIC}	V_{VIN} = 5V, BAT Rising		2.94		V
Trickle Charge Hysteresis Voltage	V_{TRIC_HYS}	V_{VIN} = 5V, BAT Falling		140		mV
PROG Manual Shutdown Threshold Voltage	V_{MSD}	PROG Rising		2.75		V
PROG Pull-Up Current	I_{PU_PROG}			200		nA
CHRG Output Logic Low	V_{L_CHRG}	Sink 5mA		0.5		V
CHRG Off-State Leakage Current	I_{LK_CHRG}	V_{CHRG} = 30V			100	nA
Thermal Regulation Threshold	T_{JRG}			140		℃
10% Charge Current Temperature	$T_{JRC\_10\%}$			150		℃

Note 4: Not tested in production. Specified by design.

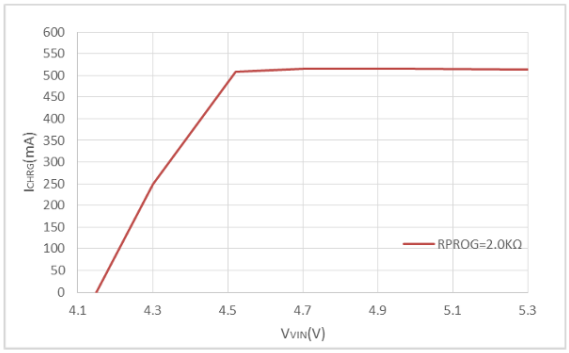
➢ Typical Characteristics (Unless otherwise specified, T_A=25°C, V_{IN}=5V)



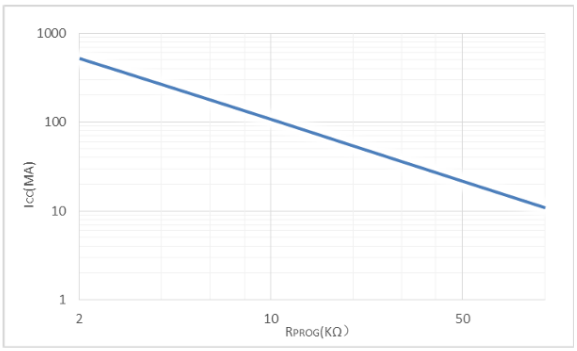
Charge Current Vs. BAT Voltage



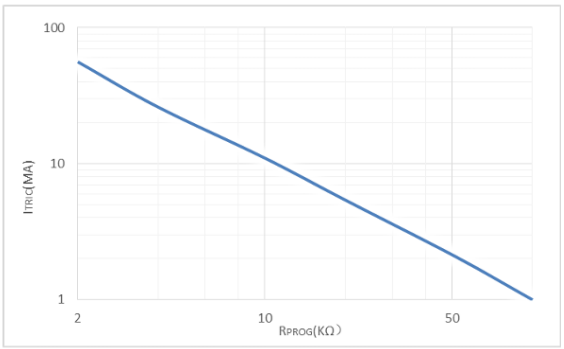
Charge Current Vs. BAT Voltage



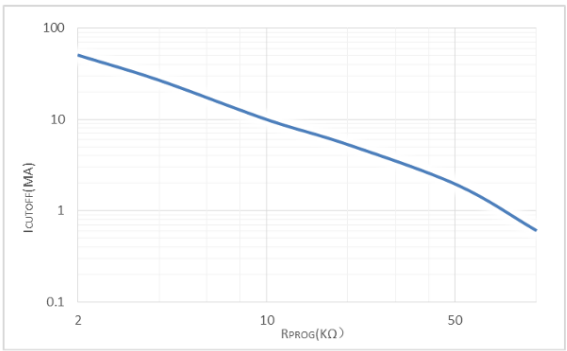
Charge Constant Current Vs. VIN Voltage



Charge Constant Current Vs. RPROG



Charge Trickle Current Vs. RPROG



Charge Cutoff Current Vs. RPROG

➢ Application Information

Selection of Input Capacitor

The input capacitor CVIN in typical application circuit is for decoupling and serves an important purpose. Whenever an input current step change downwards, the inductance of the input cable causes the input voltage to spike up. CVIN prevents the input voltage from over shooting to dangerous levels. It is recommended that a ceramic capacitor of at least 1μF be used at the input of the device. It must be located in close proximity to the VIN pin. It is optional to series a resistor RVIN of about 4.7Ω to CVIN to absorb the input voltage spike.

Selection of Output Capacitor

The output capacitor CBAT in typical application circuit is also important. The criterion for selecting the BAT capacitor is to maintain the stability of the charger as well as to bypass any transient load current. CBAT must be a ceramic capacitor of at least 10μF recommend, located close to the BAT pin. The actual capacitance connected to the output is dependent on the actual application requirement.

Selection of RPROG Resistor

The charge constant current threshold can be programmable by external resistor between PROG pin and GND. The threshold is calculated as the following equation:

$$I_{CC} = 1010 \div R_{PROG}$$

Where, ICC is charge constant current threshold, in A; RPROG is the ICC setting resistor, in Ω. Choosing a ICC between 50mA and 600mA is recommend and apply the above equation to select a RPROG resistor value from 1.68kΩ to 20kΩ respectively. The resistor RPROG should be located very close to the PROG pin.

Selection of R_{LED1} Resistors

The CHRG signal can interfaced with a LED for indication. The resistors RLED1 is used to set the LED current. Choosing RLED1 in the range of 500Ω to 4kΩ is a good compromise. If the RLED1 is selected with 1kΩ, the current of green LED1 is 2.8mA typically.

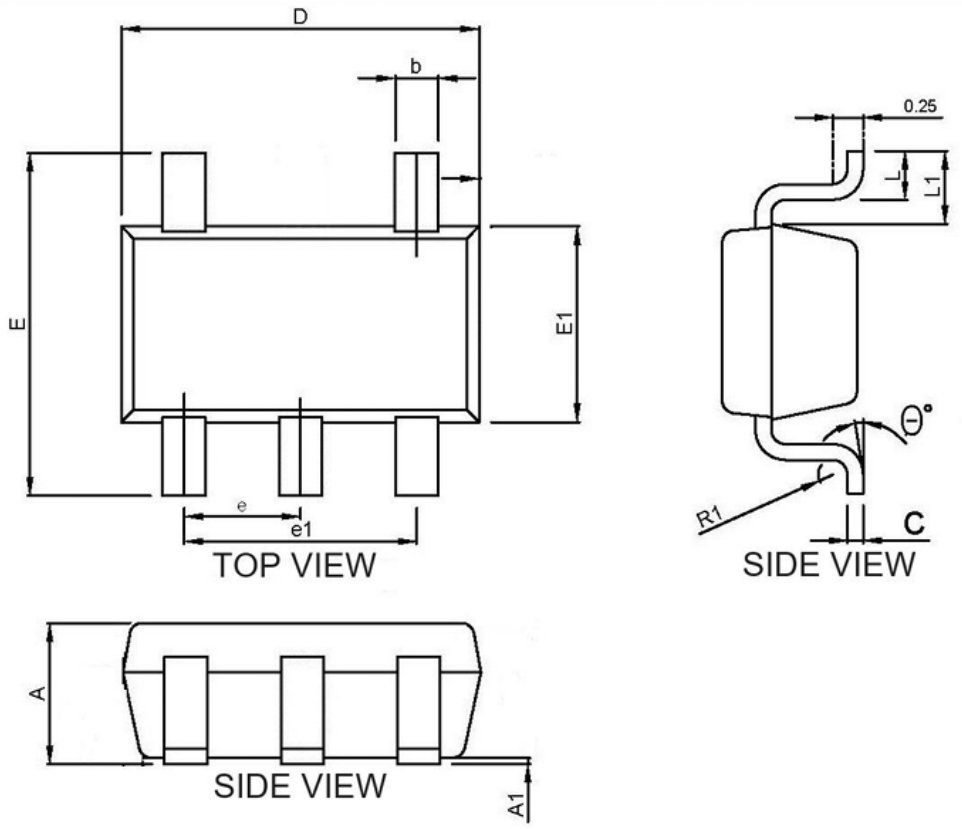
PCB Layout Guidelines

The AF4054H is a high input voltage charge device, it can protect the low voltage circuitry from hazardous voltages. Potentially, high voltages may be applied to this system. It has to be ensured that the edge-to-edge clearances of PCB traces satisfy the design rules for high voltages.

- Connected all ground together with one uninterrupted ground plane, which include power ground and analog ground.
- The input capacitor CVIN and output capacitor CBAT should be placed as close as possible to the AF4054H. Other components like RPROG should also be located close to the device.
- Minimize the power trace length and avoid using vias for the input and output capacitors connection.
- The AF4054H uses SOT23-5L package. For good thermal performance, the GND pin should be thermally coupled with the PCB ground plane.

➢ Package Information

SOT23-5L



Symbol	Dimensions(mm)		
	Min.	Nom.	Max.
A	-	-	1.35
A1	0.01	-	0.15
b	0.30	-	0.50
c	0.152 BSC		
D	2.80	2.90	3.00
E	2.70	-	3.00
E1	1.50	1.60	1.70
e	0.95 BSC		
L	0.30	0.45	0.60
L1	0.52	0.60	0.68
R1	0.12 REF		
Θ	0°	4°	8°
e1	1.90 BSC		

DISCLAIMER

SSCSEMI RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION OR DESIGN. SSCSEMI DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICIENCE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS.

THE GRAPHS PROVIDED IN THIS DOCUMENT ARE STATISTICAL SUMMARIES BASED ON A LIMITED NUMBER OF SAMPLES AND ARE PROVIDED FOR INFORMATIONAL PURPOSE ONLY. THE PERFORMANCE CHARACTERISTICS LISTED IN THEM ARE NOT TESTED OR GUARANTEED. IN SOME GRAPHS, THE DATA PRESENTED MAY BE OUTSIDE THE SPECIFIED OPERATING RANGE (E.G. OUTSIDE SPECIFIED POWER SUPPLY RANGE) AND THEREFORE OUTSIDE THE WARRANTED RANGE.

OUR PRODUCT SPECIFICATIONS ARE ONLY VALID IF OBTAINED THROUGH THE COMPANY'S OFFICIAL WEBSITE, CRM SYSTEM, OR OUR SALES PERSONNEL CHANNELS. IF CHANGES OR SPECIAL VERSIONS ARE INVOLVED, THEY MUST BE STAMPED WITH A QUALITY SEAL AND MARKED WITH A SPECIAL VERSION NUMBER TO BE VALID.