AF4056H

1.2A High Input Voltage Linear Charger

➢ Description

The AF4056H is a fully integrated, cost-effective linear charger IC for single-cell lithium batteries, supporting a 1.2 A charging current with high-voltage input capability. It adopts a constant current and constant voltage (CC&CV) charging mode, making it particularly suitable for single-cell lithium battery charging applications.

The AF4056H accepts an input voltage of up to 33 V. When the input voltage exceeds the chip's input over-voltage protection threshold, the AF4056H immediately ceases charging to prevent excessive power dissipation on the chip. The 33 V high-voltage tolerance of the AF4056H eliminates the need for an external over-voltage protection IC that is typically required in conventional chargers with low input voltage tolerance.

The AF4056H offers preset full-charge float voltage options of 4.05 V, 4.20 V, or 4.35 V, and the charging current can be set using an external resistor. When the battery voltage drops below 2.92 V, the AF4056H operates in trickle charge mode, during which the charging current is 20% of the constant current value.

The AF4056H features charge status indication. The CHRG and STDBY pins can be used for simple signal interaction with an MCU or to drive LED indicators for charge status display. When no input adapter is connected or the adapter is disabled, the AF4056H operates in a low-current standby state, in which the standby current at the BAT pin is less than 1 μA.

➢ Features

- Maximum VIN input withstand voltage: 33 V
- BAT pin maximum withstand voltage when VIN pin is floating: 20 V
- Supports charging current up to 1.2 A
- Float voltage accuracy: ±1%
- Input over- voltage protection threshold: 6.75 V
- Trickle charge threshold: 2.92 V
- Integrated charging power MOSFET and current sense resistor
- Charging current settable by external resistor
- Ultra- low BAT self- consumption current
- 0 V battery charging function
- Battery reverse connection protection
- Battery reverse connection protection current: <20 μA
- NTC protection function
- Automatic thermal regulation of charging current
- Chip enable function
- Charge status indication function

➢ Applications

- Bluetooth headsets, e-cigarettes, chargers
- Lithium battery- based electronic devices
- Portable electronic devices

➢ Device Information

AF 4056H L/T/H E8

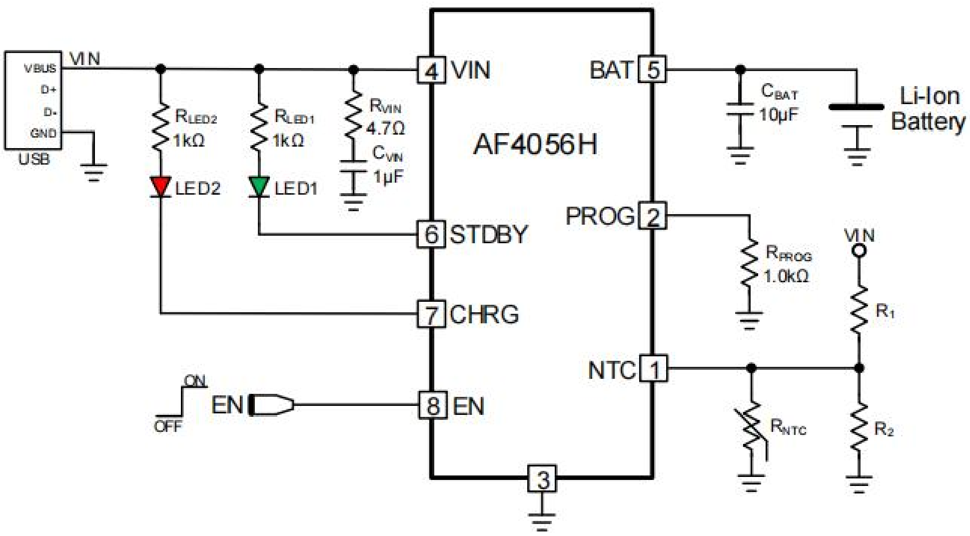
① ② ③ ④

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	E8: ESOP-8L Package

➢ Marking Information

Device	Ordering Number	Float Voltage	Marking	Package	Quantity	Packing
AF4056H Series	AF4056HLE8	4.05V	**4056H XXXX**	ESOP-8L	4000pcs	Tape and Reel
	AF4056HTE8	4.20V				
	AF4056HHE8	4.35V				
Marking Description: XXXX is the internal traceability code.						

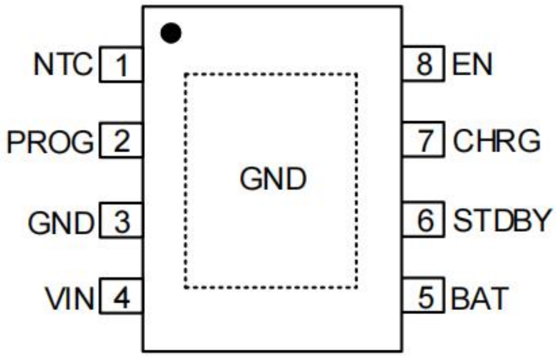
➢ Typical Application



Note: R1, R2, and RNTC are the setting resistors for the NTC protection temperature threshold. Their resistance values can be configured according to specific application requirements. When the NTC function is not used, the NTC pin shall be connected to ground.

PIN Configuration

(Top View)

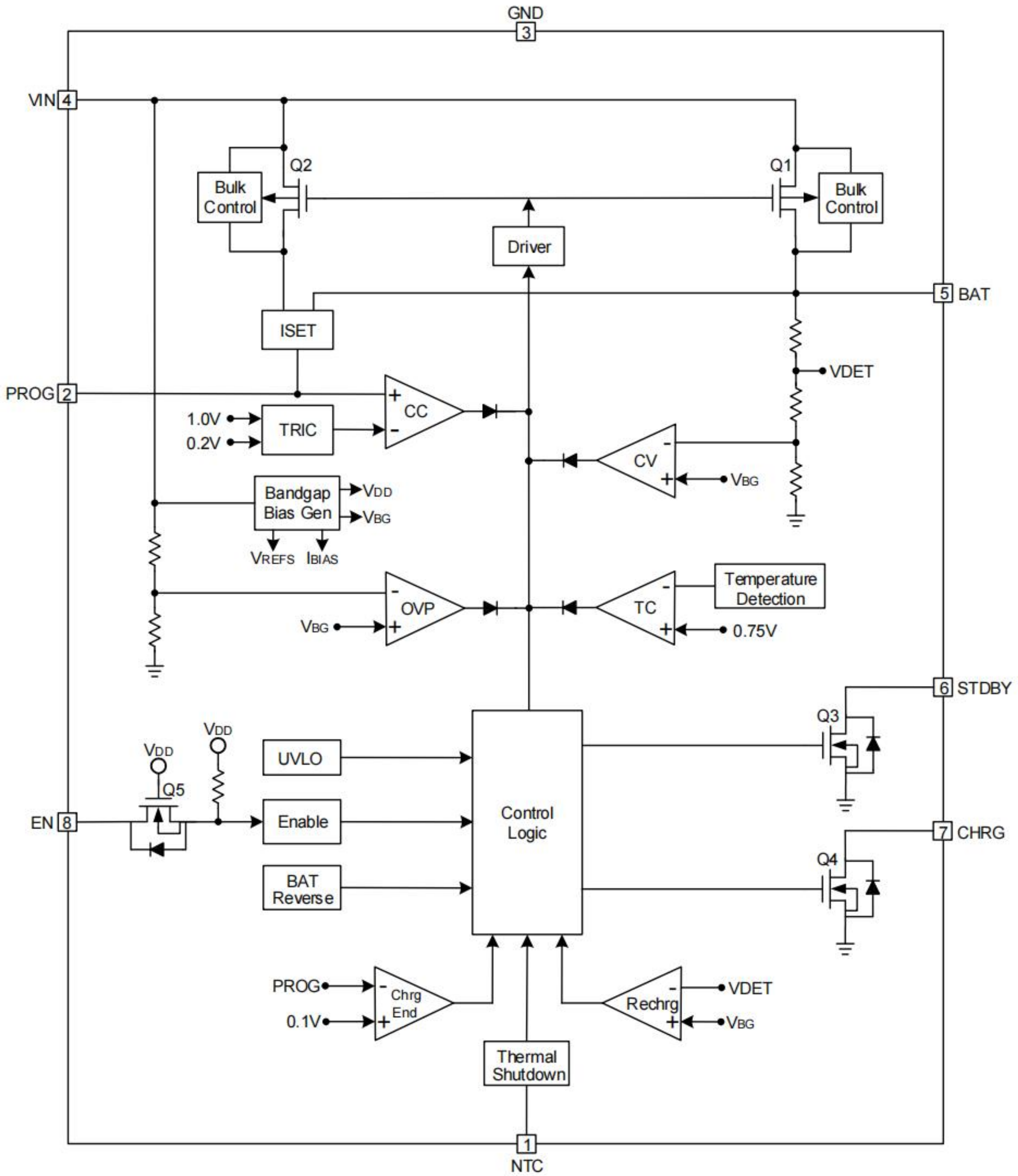


ESOP-8L

Pin Description

Pin Name	Pin No.	Pin Function
NTC	1	The battery temperature detection pin is connected to an NTC resistor that is tied to ground. When the NTC function is not in use, the NTC pin is grounded.
PROG	2	Constant-current charge current setting pin. The charging current is set by connecting an external resistor from this pin to ground.
GND	3	Chip ground.
VIN	4	Power input pin. Connect to a DC input power source. A ceramic chip capacitor of 1 μF or greater must be connected between the VIN pin and GND for filtering.
BAT	5	Charge output pin. Connect to the positive terminal of the lithium battery. It is recommended to connect an X5R ceramic chip capacitor of 10 μF or greater between the BAT pin and GND to filter the BAT voltage and maintain system stability.
STDBY	6	Charge completion indicator pin. Open-drain output; capable of driving an LED indicator. During charging, the output is in a high-impedance state, and the LED remains off. When charging is complete, the output goes low, and the LED turns on.
CHRG	7	Charging process indicator pin. Open-drain output; capable of driving an LED indicator. During charging, the output is low, and the LED turns on. When charging is complete, the output becomes high-impedance, and the LED turns off.
EN	8	Chip enable input pin. Active high. When EN is low, the chip is shut down. The EN pin has an internal pull-up resistor connected to the internal power supply; when the EN pin is left floating, it defaults to a high level.
Thermal Pad	-	Thermal pad. Connect to the chip ground. It must be well soldered to the PCB ground plane.

➢ Block Diagram



➢ Operation

Functional Description

The AF4056H is a fully integrated, cost-effective 1.2A high-voltage input linear charger for single-cell lithium-ion batteries. The AF4056H adopts a constant-current constant-voltage charging profile, making it particularly suitable for single-cell Li-ion battery charging applications.

The AF4056H can accept an input voltage up to 33 V. When the input voltage exceeds the chip's input overvoltage protection threshold, the AF4056H immediately stops charging to prevent excessive power dissipation in the chip. The 33 V high-voltage tolerance of the AF4056H eliminates the need for an additional overvoltage protection chip that is typically required in conventional chargers with low input-voltage tolerance.

The AF4056H offers selectable preset float voltages of 4.05 V, 4.20 V, or 4.35 V. The charging current can be set via an external resistor. When the battery voltage is below 2.92 V, the AF4056H operates in trickle-charge mode, with the trickle current set to 20 % of the constant current value.

The AF4056H provides charge status indication functions. The CHRG and STDBY pins can be used for simple signal exchange with an MCU or to drive LEDs for charge status indication. When no input adapter is connected or the adapter is disabled, the AF4056H operates in a low-current standby state, with the standby current at the BAT pin less than 1 μA.

UVLO

When the input voltage at the VIN pin exceeds the UVLO threshold, the AF4056H resets and begins operation. When the VIN input voltage falls below the chip's UVLO threshold (V_{UVLO}–V_{UVLO_HYS}), the AF4056H remains in standby mode. Additionally, to prevent abnormal reverse current through the internal charging power MOSFET Q1, the UVLO circuit keeps the AF4056H in standby mode if the VIN voltage drops below the battery voltage.

VIN-BAT Lockout

The AF4056H features a VIN-BAT lockout function. Unless the VIN voltage exceeds the BAT voltage by a preset offset voltage V_{OS}, the AF4056H is locked and does not enable operation. This function ensures that the AF4056H stays off when the charger input power is disconnected. Without this feature, after the input power is removed, the chip's input might not be de-energized to enter the low-current standby mode, because the operating current could leak from the BAT terminal to the VIN terminal through the charging power MOSFET Q1, continuing to supply the UVLO and other blocks.

Input OverVoltage Protection

The VIN pin of the AF4056H can accept an input voltage up to 33 V. However, when the VIN input voltage exceeds the chip's OVP threshold, the charging function is disabled. This prevents the AF4056H from continuing to operate when an unqualified or faulty adapter is connected, and also prevents excessive power dissipation on the chip. If the VIN input voltage rises above the OVP threshold V_{OVP}, the internal charging power MOSFET Q1 is turned off after the comparator propagation delay T_{PD_OVP}. At that point, charging of the Li-ion battery stops, and the CHRG pin outputs a logic high level. When the VIN input voltage falls below V_{OVP}–V_{OVP_HYS}, the internal charging power MOSFET Q1 is turned on again, and the AF4056H resumes charging the Li-ion battery.

VIN Power Good Range

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

- $V_{VIN} > V_{UVLO}$
- $V_{VIN} - V_{BAT} > V_{OS}$
- $V_{VIN} < V_{OVP}$.

The AF4056H will not charge the battery if the input voltage is not in the power good range.

Charge Cycle

When the VIN input voltage rises above the UVLO threshold, the AF4056H begins a new charging cycle. If the battery voltage is below 2.92 V at this moment, the AF4056H enters trickle-charge mode. In trickle-charge mode, the trickle charging current is approximately 20 % of the constant-current charging current, and this continues until the battery voltage rises to the safe threshold for constant-current charging.

When the battery voltage rises above 2.92 V, the AF4056H enters constant-current (CC) charging mode. In CC mode, an external resistor connected to the PROG pin sets the constant-current charging current. When the battery voltage approaches the final float voltage, the AF4056H enters constant-voltage (CV) charging mode. At this point, the charging current begins to decrease gradually. When the charging current reaches the charge termination current threshold, the AF4056H ends the charging process.

Auto Recharge

After a charging cycle is completed, the AF4056H continuously monitors the lithium-ion battery voltage. The AF4056H automatically initiates a recharge cycle only when the battery voltage drops below $V_{FLOAT} - \Delta V_{RCH}$. This ensures that the battery remains at or near a fully charged state while avoiding the need for periodic charging cycle restarts.

Manual Shutdown

The AF4056H features a manual shutdown function. At any time during a charging cycle, removing the R_{PROG} resistor leaves the PROG pin open-circuit. The 0.2 μA pull-up current at the PROG pin then gradually pulls the PROG voltage high. When the PROG voltage reaches the manual shutdown threshold voltage V_{MSD}, the AF4056H immediately stops charging and enters manual shutdown mode. In this mode, the AF4056H draws a BAT standby current of less than 1 μA, the CHRG and STDBY pins are in a high-impedance state as open-drain outputs, and the LED indicators turn off. Reconnecting the R_{PROG} resistor from the PROG pin to ground restores the AF4056H to a normal charging cycle.

CHRG and STDBY Indicators

CHRG is an open-drain output pin (NMOS) for charge status indication, with a pull-down capability of up to 5 mA. When the AF4056H is charging, the CHRG open-drain output is low. When the AF4056H enters constant-voltage mode and reaches the charge termination current, the CHRG output becomes high-impedance after charging ends. At that time, the CHRG pin can withstand an input voltage of up to 33 V.

STDBY is an open-drain output pin (NMOS) for charge completion status indication, with a pull-down capability of up to 5 mA. When the AF4056H is charging, the STDBY open-drain output is high-impedance.

During charging, the STDBY pin can withstand an input voltage of up to 33 V. When the AF4056H enters constant- voltage mode and reaches the charge termination current, the STDBY output becomes low after charging ends.

The CHRG and STDBY signals of the AF4056H can be connected to the GPIO interface of an MCU or used to drive LEDs for charge status indication. When driving LEDs with the CHRG and STDBY signals, the status summary is as follows:

Charging Status	CHRG LED	STDBY LED
Charging in progress	On	Off
Charge complete	Off	On
VDD undervoltage, VDD- BAT lockout, NTC protection, battery reverse connection, PROG pin open, EN disabled	Off	Off
10 μF capacitor connected to BAT terminal, no battery present	Blinking	On

EN Enable

The AF4056H features an EN enable control function, which can be used to enable or disable the chip’s charging function. When the EN pin is driven low, the internal charging power MOSFET Q1 is turned off, and the AF4056H stops charging. When the EN pin is driven high, the AF4056H begins charging. The EN pin integrates an internal 300 kΩ pull- up resistor connected to the internal power supply. When the EN enable control function is not used, the EN pin may be left floating. Additionally, when the EN pin is low, both the CHRG and STDBY status indicator pins are in a high- impedance state (open- drain output).

Automatic Thermal Regulation

If the junction temperature inside the AF4056H chip exceeds T_{JRG}, the AF4056H initiates thermal regulation and automatically reduces the charging current. This prevents further increase of the chip’s junction temperature, thereby ensuring safe device operation. This automatic thermal regulation feature protects the AF4056H from excessive temperatures. Therefore, in practical applications, the system charging current can be set according to typical ambient temperature, ensuring that the AF4056H automatically reduces the charging current under high- temperature conditions.

Battery NTC Protection

The AF4056H can monitor the temperature of the lithium- ion battery by placing an NTC thermistor next to the battery. The NTC resistor is connected between the NTC pin and GND. When the battery temperature falls outside the normal operating range, the internal charging power MOSFET Q1 is immediately turned off. The battery NTC protection temperature threshold of the AF4056H can be set using resistors R_{NTC}, R1, and R2. The NTC pin voltage and corresponding response of the AF4056H are shown as follows:

NTC Pin Voltage	Lithium Battery Temperature	AF4056H Response
$V_{NTC} \geq 80\% V_{VIN}$	Temperature too low	Charging stops; enters standby mode
$45\% V_{VIN} < V_{NTC} < 80\% V_{VIN}$	Temperature within normal range	Normal charging
$5\% V_{VIN} < V_{NTC} \leq 45\% V_{VIN}$	Temperature too high	Charging stops; enters standby mode
$V_{NTC} \leq 5\% V_{VIN}$		Normal charging (NTC protection function is overridden)

In practical applications of the AF4056H, the temperature range for the chip's NTC protection can be adjusted by modifying the resistor network composed of R_{NTC}, R1, and R2. When the NTC function is not required, the NTC pin can be connected to ground.

BAT Maximum Rating

The BAT pin is the output terminal of the charging system and is connected to the positive terminal of the lithium-ion battery. During battery installation in practical applications, the BAT pin may be subjected to high voltages exceeding 5 V. Therefore, the BAT pin must have a sufficiently high voltage rating. When the VIN input pin is left floating, the BAT pin of the AF4056H can withstand an input voltage of up to 20 V. This protects the AF4056H's BAT pin from damage caused by excessive voltage spikes during battery installation.

Battery Reverse Connection Protection

The AF4056H features battery reverse connection protection. If the battery is connected in reverse during installation, the reverse-connection protection function of the AF4056H protects both the AF4056H and the lithium-ion battery from damage. Under this condition, the AF4056H stops charging, and both the CHRG and STDBY status indicator pins are in a high-impedance state (open-drain output). When the battery is reversed, the maximum reverse leakage current at the BAT pin of the AF4056H is less than 20 μA. After the reversed battery is correctly connected, the AF4056H automatically begins a charging cycle.

If the reversed battery is removed, the capacitor at the AF4056H output BAT pin may still hold a negative voltage. Under this condition, the CHRG indicator does not light up immediately as normal. The AF4056H will display the normal no-battery indicator status only after the negative voltage on the BAT capacitor becomes positive.

Absolute Maximum Ratings (Note 1)

- VIN (with respect to GND)--- -0.3V to 33V
- BAT (with respect to GND, VIN floating) --- -5V to 20V
- CHRG, STDBY (with respect to GND) -- -0.3V to 33V
- EN, PROG (with respect to GND) --- -0.3V to 6V
- BAT Pin Source Current--- 1.25A
- CHRG, STDBY Pins Source Current-- 5mA
- Package Thermal Resistance

  ESOP-8L, θJA-- 58°C/W

  ESOP-8L, θJC-- 10°C/W
- Junction Temperature Range-- -40°C to +150°C
- Storage Temperature Range--- -65°C to +150°C
- Lead Temperature (Soldering, 10 sec.) --- +260°C
- ESD Susceptibility (Note 2)

  HBM (Human Body Model) --- ±2000V

Note 1: Conditions exceeding the absolute maximum ratings may cause damage to the chip. Operation of the chip at absolute maximum ratings or under any other conditions beyond the recommended operating conditions is not advised. Continuous operation of the chip under absolute maximum rating conditions may adversely affect its lifetime and reliability.

Note 2: The chip is an ESD-sensitive device. If proper ESD precautions are not taken, the entire integrated circuit may be damaged by electrostatic discharge. It is recommended that preventive measures be implemented in practical applications. ESD-induced damage to the chip may manifest as anything from slight performance degradation to complete device failure.

Recommended Operating Conditions (Note 3)

- VIN Voltage Range-- 4.5V to 6.5V
- BAT Output Current Range -- 0.05A to 1.2A
- Operating Temperature Range-- -40°C to +85°C

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		3.90		V
Hysteresis on UVLO	V_{UVLO_HYS}	V_{VIN} falling from 5V to 0V		200		mV
Input Voltage Operation Range	V_{VIN}		4.5	5	33	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		40		mV
VIN Operating Current	I_{OP}	EN=L, R_{PROG}=1.0KΩ, BAT floating		160		uA
VIN Standby Current	I_{VIN_STY}	EN=H, R_{PROG}=1.0KΩ, BAT floating		130		uA
BAT Standby Current	I_{BAT_STY1}	V_{BAT}=4.2V, V_{VIN}=0V or floating			1	uA
BAT Standby Current	I_{BAT_STY2}	V_{BAT}=4.2V, V_{VIN}=5V, Charge ends		3.5		uA
BAT Shutdown Current	I_{BAT_STOP}	V_{BAT} = 4.2 V, V_{VDD} = 5 V, PROG pin open			1	uA
BAT Reverse Current	I_{BAT_REV}	V_{BAT}=-4.2V, V_{VIN} floating		20		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		300		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}=1.0KΩ,I_{BAT}=110mA, Order Number: AF4056HLE8	4.010	4.05	4.091	V
	V_{FLOAT_T}	R_{PROG}=1.0KΩ,I_{BAT}=120mA, Order Number: AF4056HTE8	4.158	4.20	4.242	V
	V_{FLOAT_H}	R_{PROG}=1.0KΩ,I_{BAT}=120mA, Order Number: AF4056HHE8	4.307	4.35	4.393	V
Programmed Charge Current	I_{CHRG}	V_{VIN} = 5V, V_{BAT}=3.7V	50		1200	mA
PROG Pin Output Voltage	V_{PROG}	V_{VIN} = 5V, R_{PROG}=1.0KΩ		1		V
Charge Constant Current	I_{CC}			1100		mA
Charge Trickle Current	I_{TRIC}			220		mA
BAT 0V Charge Current	I_{TRIC_0V}			222		mA
Charge Cutoff Current	I_{OFF}			110		mA
Charge Full Delay Time	T_{D_FULL}			1.5		ms
BAT Recharge Threshold Voltage	ΔV_{RCH}	V_{VIN} = 5V, BAT Falling, V_{FLOAT}-V_{RCH}		160		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		2.92		V
Trickle Charge Hysteresis Voltage	V_{TRIC_HYS}	V_{VIN} = 5V, BAT Falling		120		mV
EN Logic High Threshold	V_{ENH}	V_{VIN} = 5V, Increasing EN voltage	1.4			V
EN Logic Low Threshold	V_{ENL}	V_{VIN} = 5V, decreasing EN voltage			0.4	V
EN Input Resistance to GND	R_{ENPD}	V_{EN} = 0V		300		KΩ
PROG pin pull-up current IPU_PROGIPU _PROG	I_{PU_PROG}	PROG pin open		0.2		μA
PROG manual shutdown threshold voltage VMSDVMSD	V_{MSD}	PROG pin voltage rising; indicated by CHRG pin		2.7		V
PROG manual shutdown threshold voltage hysteresis VMSD_HYS VMSD_HYS	V_{MSD_HYS}	PROG pin voltage falling; indicated by CHRG pin		100		mV
CHRG Output Logic Low	V_{L_CHRG}	Sink 3mA		0.5		V
CHRG Off-State Leakage Current	I_{LK_CHRG}	V_{CHRG} = 33V			100	nA
STDBY Output Logic Low	V_{L_STDBY}	Sink 5mA		0.5		V
STDBY Off-State Leakage Current	I_{LK_STDBY}	V_{STDBY} = 33V			100	nA
NTC pin high trip voltage	V_{NTCH}	NTC low- temperature protection		80		%VVIN
NTC pin low trip voltage	V_{NTCL}	NTC high- temperature protection		45		%VVIN
NTC pin voltage for disabling NTC protection	V_{NTC_SBY}	VNTC falling		5		%VVIN
Thermal Regulation Threshold	T_{JRG}			140		℃
10% Charge Current Temperature	$T_{JRC\_10\%}$			155		℃

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

Application Information

Selection of Input Capacitor

In the typical application circuit of the AF4056H, the input capacitor CVIN plays a critical role in input voltage filtering and decoupling. Whenever a step-down change occurs in the input current, the parasitic inductance of the input cable induces an upward overshoot spike at the VIN input voltage. CVIN prevents this overshoot spike from reaching a level that could damage the device. It is recommended to use a ceramic chip capacitor of at least 1 μF at the VIN pin of the AF4056H, and this capacitor must be placed in close proximity to the VIN pin. Optionally, a resistor RVIN of approximately 4.7 Ω can be connected in series with CVIN to better absorb the voltage spikes generated at the VIN input port during live insertion/removal.

Selection of Output Capacitor

The output capacitor C_{BAT} in the AF4056H's typical application circuit is also important. The criterion for selecting the BAT capacitor is to maintain the stability of the charging system while providing effective filtering against any transient load currents. It is recommended to use a ceramic chip capacitor of at least 10 μF at the BAT pin, placed as close as possible to the BAT pin. In practical applications, the capacitance value connected to the BAT output terminal may further depend on specific application requirements.

Selection of RPROG Resistor

The constant-current charging current of the AF4056H can be set via an external resistor from the PROG pin to GND. The constant-current charging current is calculated using the formula shown below:

$$I_{CC} = 1100 \div R_{PROG}$$

where I_{CC} is the constant-current charging current in amperes (A), and R_{PROG} is the setting resistor for I_{CC} in ohms (Ω). The recommended constant-current charging current I_{CC} ranges from 50 mA to 1.2 A; accordingly, the corresponding setting resistor R_{PROG} calculated from the above formula ranges from 1.0 kΩ to 24 kΩ. In PCB layout, the resistor R_{PROG} should be placed in close proximity to the PROG pin.

Selection of R_{LED1}, R_{LED2} Resistors

The STDBY and CHRG signals of the AF4056H can be indicated by two LEDs. Resistors R_{LED1} and R_{LED2} are used to set the current through the two LED indicators, respectively. The typical value range for R_{LED1} and R_{LED2} is from 500 Ω to 4 kΩ. If both R_{LED1} and R_{LED2} are selected as 1 kΩ, the typical current through the green LED1 indicator is 2 mA, and that through the red LED2 indicator is 2.9 mA.

Selection of Resistors R_{NTC}, R, and R2

The AF4056H can monitor the temperature of a lithium battery by placing a negative temperature coefficient (NTC) thermistor near the battery. Suppose the set normal operating temperature range of the lithium battery is from TL to TH (where TL<TH); let R_{TL} be the resistance of the selected NTC thermistor at temperature TL, and R_{TH} be its resistance at temperature TH; then $R_{TL} > R_{TH}$. The resistance values of R_{TL} and R_{TH} can be obtained from the datasheet of the selected NTC thermistor.

Once the model and specifications of the NTC thermistor are determined, with the circuit connection as shown in the typical application diagram, the resistance values of the external resistors R_1 and R_2 can be calculated as follows:

At temperature TL, the voltage at the NTC pin, denoted as V_{NTC_TL}, satisfies the following relationship:

$$V_{NTC\_TL}=\frac{R_2//R_{TL}}{R_1+R_2//R_{TL}}\times V_{VDD}$$

At temperature TH, the voltage at the NTC pin, denoted as V_{NTC_TH} , satisfies the following relationship:

$$V_{NTC\_TH}=\frac{R_2//R_{TH}}{R_1+R_2//R_{TH}}\times V_{VDD}$$

From the electrical characteristics specification of the AF4056H, it can be known that:

$$V_{NTC\_TH}=V_{NTCL}=0.45\times V_{VDD}=K_1\times V_{VDD}\ (K_1=0.45)$$

$$V_{NTC\_TH}=V_{NTCL}=0.45\times V_{VDD}=K_1\times V_{VDD}\ (K_1=0.45)$$

Thus, one obtains:

$$R_1=\frac{R_{TL}R_{TH}(K_2-K_1)}{(R_{TL}-R_{TH})K_1K_2}$$

$$R_2=\frac{R_{TL}R_{TH}(K_2-K_1)}{R_{TL}(K_1-K_1K_2)-R_{TH}(K_2-K_1K_2)}$$

From the derivation of R_1 and R_2, it can be seen that the NTC temperature protection range is independent of the input supply voltage VIN of the chip, and is only related to R_1, R_2, R_{TH}, and R_{TL}. Among these, the resistance values of R_{TL} and R_{TH} can be obtained from the datasheet of the selected NTC thermistor. Substituting the values of K_1, K_2, R_{TH}, and R_{TL} into the expressions for R_1 and R_2 yields the resistance values of R_1 and R_2.

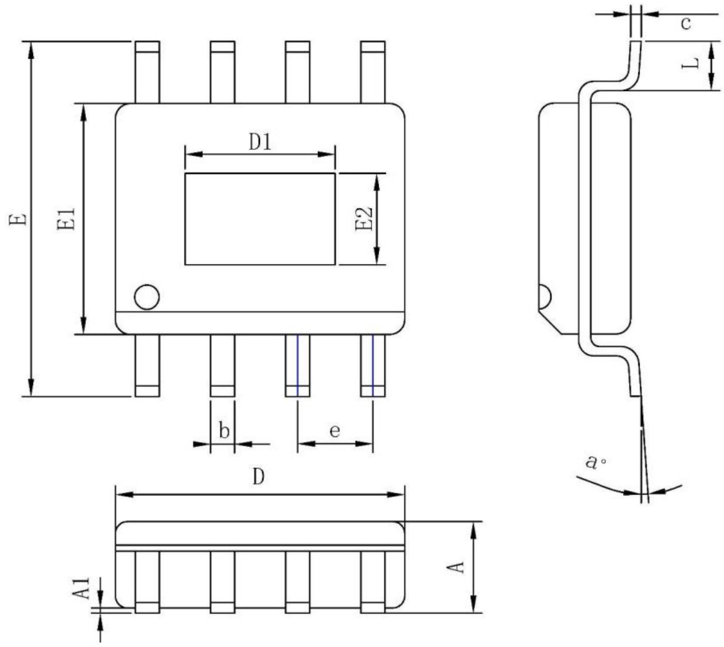
PCB Layout Guidelines

The AF4056H is a lithium battery charging IC capable of withstanding high input voltages, thereby protecting low-voltage circuitry from high-voltage stress. In practical application circuits, a high input voltage is applied to the charging system; therefore, it is essential to ensure that the creepage distances of the PCB traces in the application circuit comply with high-voltage design rules.

- The ground plane of the application circuit should be implemented as a copper pour, with the ground area made as large as possible. All analog ground and power ground traces should be tied together.
- The input capacitor CVIN and output capacitor CBAT should be placed as close as possible to the corresponding pins of the IC. The ground terminals of these capacitors should be connected directly to the large ground plane, rather than being routed through a narrow ground trace before reaching the IC ground and the large ground plane. Other components, such as RPROG, should also be placed in close proximity to the IC pins.
- PCB traces carrying high current should be as short and wide as possible. The PCB traces connecting the input capacitor CVIN and the output capacitor CBAT should avoid the use of vias.
- The AF4056H is offered in an ESOP-8L package with an exposed thermal pad. To achieve good thermal performance, a sufficiently large thermal pad must be placed under the IC on the PCB, ensuring good physical contact with the IC's heat sink during soldering. This thermal pad should be directly connected to the large copper ground plane, and a set of thermal vias should be placed within the thermal pad. The recommended diameter for each thermal via is 0.3 mm, with an adjacent via spacing of 1 mm.

➢ Package Information

ESOP-8L



Symbol	Dimensions(mm)		
	Min.	Nom.	Max.
A			1.75
A1	0		0.1
b	0.35		0.48
c	0.19		0.25
D	4.7	4.9	5
E	5.8	6	6.2
E1	3.7	3.9	4.1
e	1.27BSC		
L	0.4		0.8
aº	0º		8º
D1		3.151	
E2		2.283	

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