



AF4156B

1A High Input Voltage Linear Charger

➤ Description

The AF4156B is a fully integrated, cost-effective 1A high input voltage single-cell Li-Ion battery linear charger. The AF4156B uses a CC&CV charge mode required by Li-Ion battery.

The AF4156B accepts an input voltage up to 30V. The AF4156B 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 AF4156B 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 AF4156B will charge at a trickle current, 10% of constant current.

The indication pins CHRG and STDBY, allow simple interface to a microprocessor or LEDs. When no adapter is attached or when disabled, the AF4156B draws less than 1μA leakage current from the battery.

➤ Applications

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

➤ Features

- 30V Maximum Input Voltage
- 30V Maximum BAT Voltage With VIN Floating
- 6.75V Input Over Voltage Protection
- 2.94V Trickle Charge Threshold.
- VIN Power Adaptive
- Programmable Charge Const
- Battery 0V Charge Function
- Battery Reverse Connection Protection
- <20μA Battery Reverse Current
- Built-in Current Limiter
- Integrated Power MOSFET and Sense Resistor
- Thermal Regulation Of Charge Current
- Enable Function
- Charge Indication

➤ Device Information

AF 4156 B L/T/H N/E

① ② ③ ④ ⑤

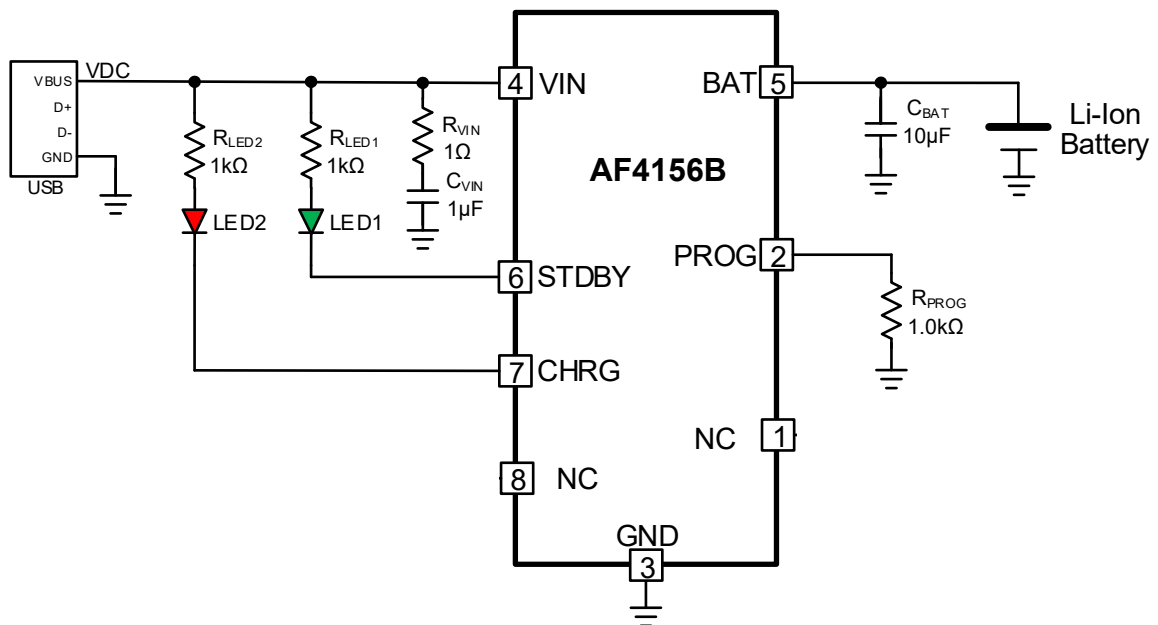
①	Standard
②	Product Name
③	B : without NTC and EN pins
④	L : Charge Float Voltage 4.05V T : Charge Float Voltage 4.20V H : Charge Float Voltage 4.35V
⑤	N : DFN3×3-8L Package E : ESOP-8L Package



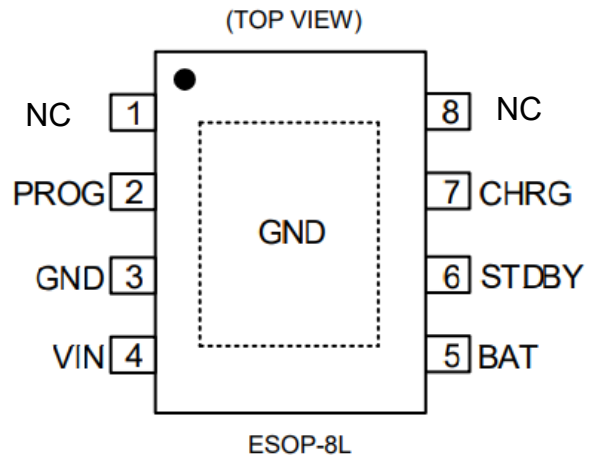
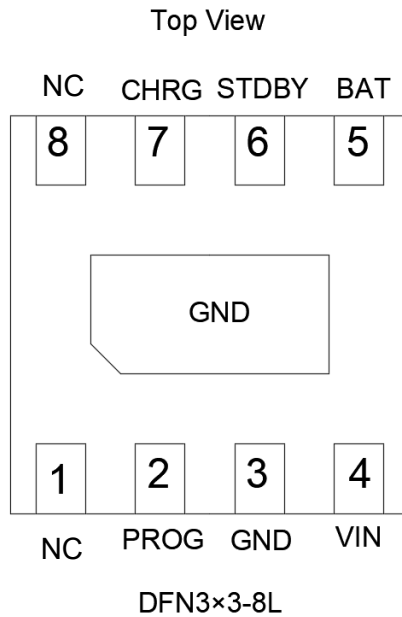
➤ Marking Information

Device	Ordering Number	Float Voltage	Marking	Package	Quantity	Packing
AF4156B Series	AF4156BLN	4.05V	4156BLN	DNF3×3-8L	5000pcs	Tape and Reel
	AF4156BTN	4.20V	4156BTN			
	AF4156BHN	4.35V	4156BHN			
	AF4156BLE	4.05V	4156BLE	ESOP-8L	4000pcs	
	AF4156BTE	4.20V	4156BTE			
	AF4156BHE	4.35V	4156BHE			

➤ Typical Application



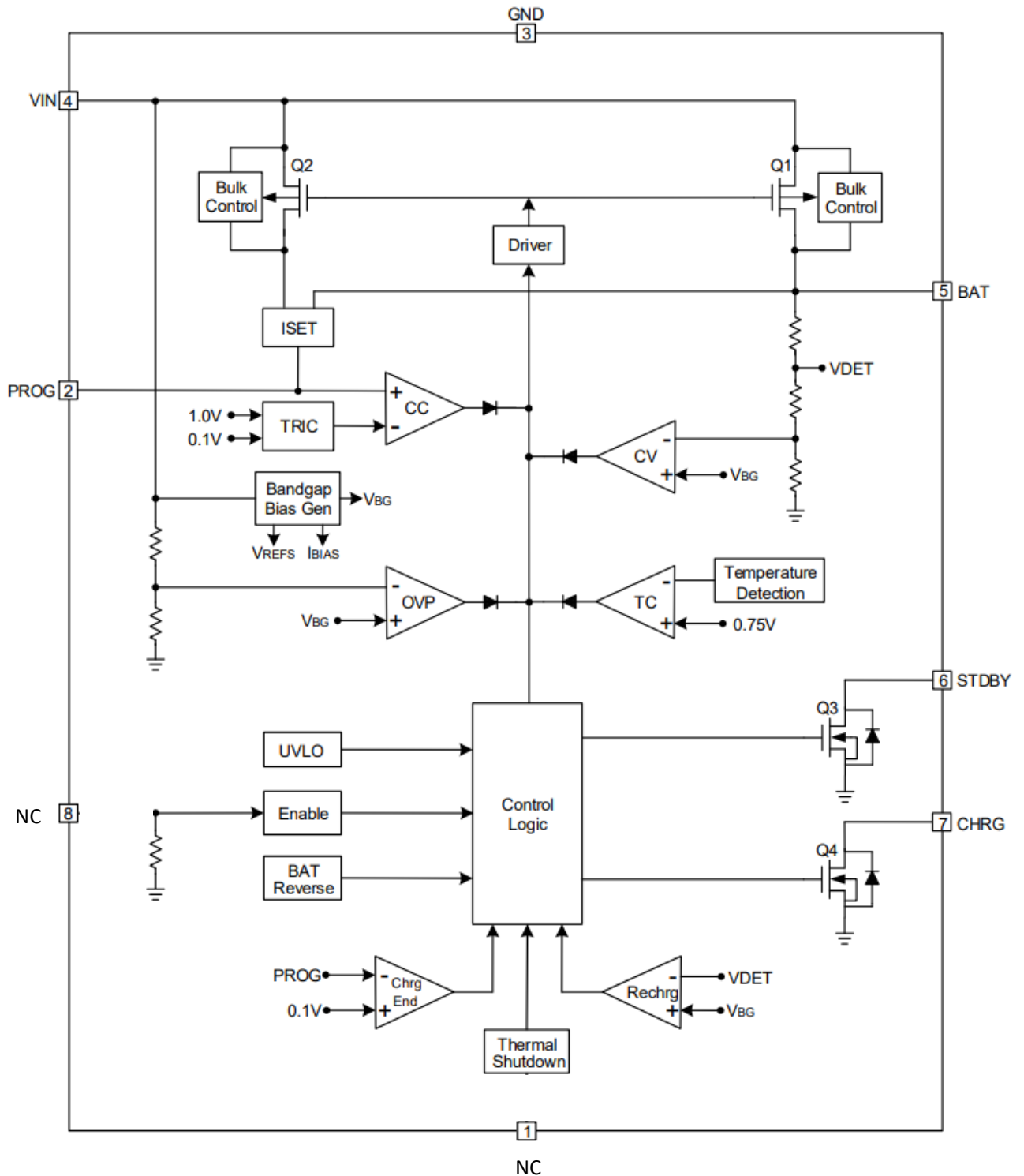
PIN Configuration



Pin Description

Pin Name	Pin No.	Pin Function
NC	1	No internal connections.
PROG	2	The charge constant current threshold programming terminal. Connecting a resistor to GND to set the charge constant current threshold.
GND	3	The ground terminal.
VIN	4	The Input Power terminal. Connected to external DC supply. Bypass VIN to GND with a ceramic capacitor (1μF Min.).
BAT	5	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.
STDBY	6	The open-drain charge indication output. This pin outputs a logic high impedance when a charge cycle starts and turns to low when the charge cycle is completed.
CHRG	7	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.
NC	8	No internal connections.
Thermal Pad	-	The thermal pad is electrically connected to GND internally. The thermal pad must be connected to the same potential as the GND pin on the PCB.

➤ Block Diagram





➤ Operation

Overview

The AF4156B is a fully integrated, cost-effective 1A high input voltage single-cell Li-Ion battery linear charger. The AF4156B uses a CC&CV charge mode required by Li-Ion battery.

The AF4156B accepts an input voltage up to 30V. The AF4156B 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 AF4156B 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 AF4156B will charge at a trickle current, 10% of constant current.

The indication pins CHRG and STDBY of AF4156B, allow simple interface to a microprocessor or LEDs. When no adapter is attached or when disabled, BAT pin of AF4156B draws less than 1μA leakage current from the battery.

UVLO

The AF4156B resets when the input voltage at VIN pin exceeds the UVLO threshold. The AF4156B 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 AF4156B in standby mode if VIN falls below the battery voltage.

VIN-BAT Lockout

The AF4156B 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 AF4156B 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 AF4156B 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 AF4156B 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:

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

The AF4156B will not charge the battery if the input voltage is not in the power good range.

Charge Cycle

The AF4156B 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 AF4156B enters the trickle charge mode. In this mode, the charge trickle current is about 10% of constant current until the battery voltage is raised to a safe level for constant current charging.

The AF4156B 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 AF4156B enters constant voltage mode and the charge current begins to decrease until the cutoff current is reached. Then the charge cycle of the AF4156B ends.

Auto Recharge

After the termination of the charge cycle, the AF4156B always monitors the battery voltage. When the battery voltage falls below $V_{FLOAT} - \Delta V_{RCH}$, the AF4156B 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.

VIN Power Adaptive

The AF4156B integrates the VIN power adaptive function. When VIN voltage decreases to 4.50V, the adaptive circuit will start, automatically reduce the constant charge current until VIN is no longer reduced. With this function, the large current charging systems can use the USB or low-power adapter, solar power battery as the power source, avoiding the power reset or restart problems.

CHRG Indication

The CHRG is an open-drain output capable of sinking at most 5mA current when the AF4156B is in a charge cycle. When the AF4156B 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.

STDBY Indication

The STDBY is an open-drain output capable of sinking at most 5mA current when the charge cycle of the AF4156B is completed. When the AF4156B enters the constant voltage mode and the charge cutoff current is reached, the STDBY pin will become low level. When the AF4156B is in charge cycle, the STDBY pin will become high impedance, then the STDBY pin can accept an input voltage up to 30V. The STDBY signal is interfaced either with a microprocessor GPIO or an LED for indication.



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 AF4156B will face a high voltage that is more than 5V. So that the BAT pin needs a high voltage rating. The BAT pin of AF4156B can accept an input voltage up to 30V with VIN input floating. This feature protects the AF4156B from excessive BAT voltage.

Battery Reverse Protection

The AF4156B has a battery reverse protection, it will protect the AF4156B from damage when battery reverse connection happening at steps for installing the battery cell. The battery reverse current is less than 20 μ A 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 30V
● CHRG, STDBY (with respect to GND) -----	-0.3V to 30V
● PROG (with respect to GND) -----	-0.3V to 6V
● BAT Pin Source Current-----	1.1A
● CHRG, STDBY Pins Source Current-----	5mA
● Package Thermal Resistance	
DFN3×3-8L/ESOP-8L, θ_{JA} -----	58°C/W
DFN3×3-8L/ESOP-8L, θ_{JC} -----	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: 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 1.0A
● 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, $T_A=25^{\circ}\text{C}$, $V_{IN}=5\text{V}$)**

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, V _{VIN} Rising, Check CHRG		120		mV
VIN-BAT Lockout Hysteresis	V _{OS_HYS}	V _{BAT} =4.2V, V _{VIN} Falling, Check CHRG		40		mV
VIN Operating Current	I _{OP}	R _{PROG} =1.0K Ω , BAT floating		150		μA
BAT Standby Current	I _{BAT_STY1}	V _{BAT} =4.2V, V _{VIN} =0V or floating			1	μA
BAT Standby Current	I _{BAT_STY2}	V _{BAT} =4.2V, V _{VIN} =5V, Charge ends		3.5		μA
BAT Reverse Current	I _{BAT_REV}	V _{BAT} =-4.2V, V _{VIN} floating		20		μA
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
VIN Adaptive Start Voltage	V _{ADPT_ST}	V _{VIN} from 5V to 4V		4.50		V
VIN Adaptive 10%*ICC Voltage	V _{ADPT_END}	V _{VIN} from 5V to 4V		4.15		V
BAT Charge Float Voltage	V _{FLOAT_L}	R _{PROG} =1.0K Ω , I _{BAT} =110mA, Order Number: AF4156BLE8	4.010	4.05	4.091	V
	V _{FLOAT_T}	R _{PROG} =1.0K Ω , I _{BAT} =110mA, Order Number: AF4156BTE8	4.158	4.20	4.242	V
	V _{FLOAT_H}	R _{PROG} =1.0K Ω , I _{BAT} =110mA, Order Number: AF4156BHE8	4.307	4.35	4.393	V
Programmed Charge Current	I _{CHRG}	V _{VIN} = 5V, V _{BAT} =3.7V	50		1030	mA
PROG Pin Output Voltage	V _{PROG}	V _{VIN} = 5V, V _{BAT} =3.7V, R _{PROG} =1.0K Ω		1		V



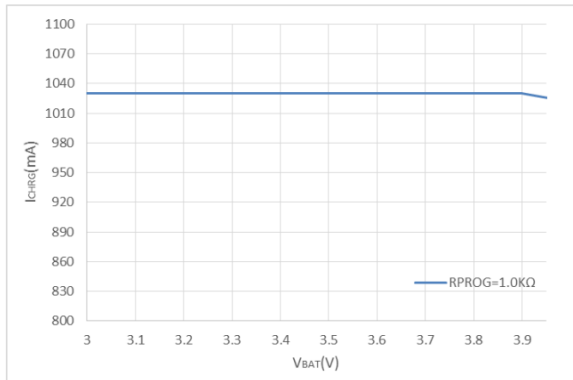
AF4156B

Charge Constant Current	I _{CC}			1010		mA
Charge Trickle Current	I _{TRIC}			101		mA
BAT 0V Charge Current	I _{TRIC_0V}			102		mA
Charge Cutoff Current	I _{OFF}	V _{VIN} = 5V, R _{PROG} =1.0KΩ		101		mA
Charge Full Delay Time	T _{D_FULL}	V _{VIN} = 5V, R _{PROG} =1.0KΩ		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		2.94		V
Trickle Charge Hysteresis Voltage	V _{TRIC_HYS}	V _{VIN} = 5V, BAT Falling		120		mV
CHRG Output Logic Low	V _{L_CHRG}	Sink 5mA		0.5		V
CHRG Off-State Leakage Current	I _{LK_CHRG}	V _{CHRG} = 30V		5		uA
STDBY Output Logic Low	V _{L_STDBY}	Sink 5mA		0.5		V
STDBY Off-State Leakage Current	I _{LK_STDBY}	V _{STDBY} = 30V		5		uA
Thermal Regulation Threshold	T _{JRG}			135		°C
10% Charge Current Temperature	T _{JRC_10%}			150		°C

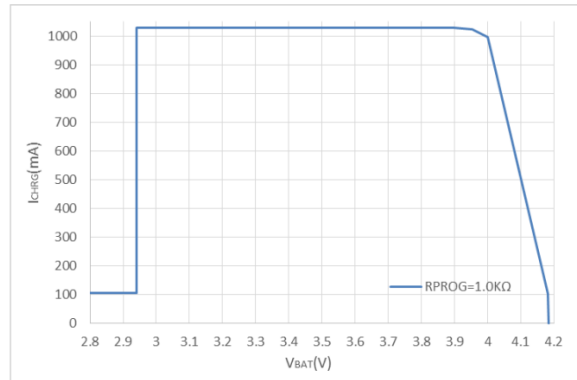
Note 4: Not tested in production. Specified by design.



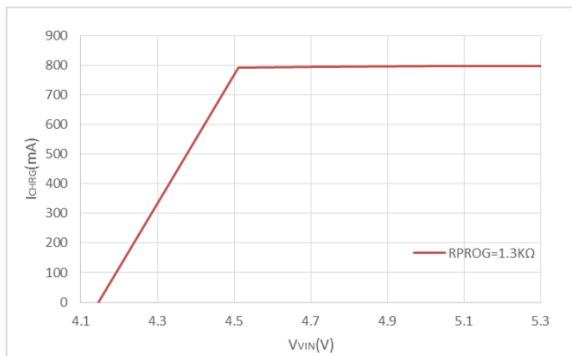
➤ **Typical Characteristics (Unless otherwise specified, $T_A=25^{\circ}\text{C}$, $V_{IN}=5\text{V}$)**



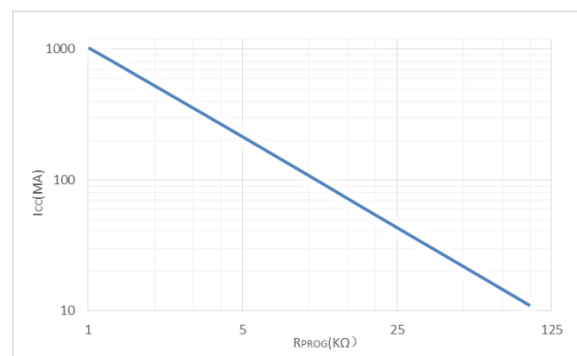
Charge Current Vs. BAT Voltage



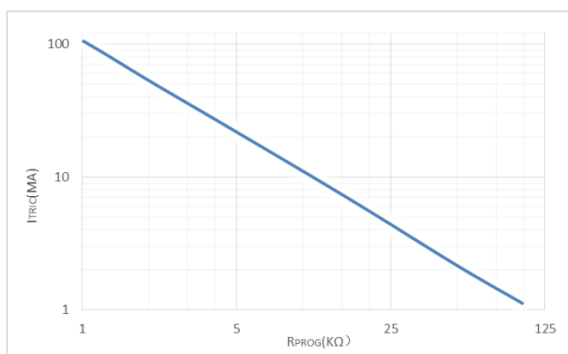
Charge Current Vs. BAT Voltage



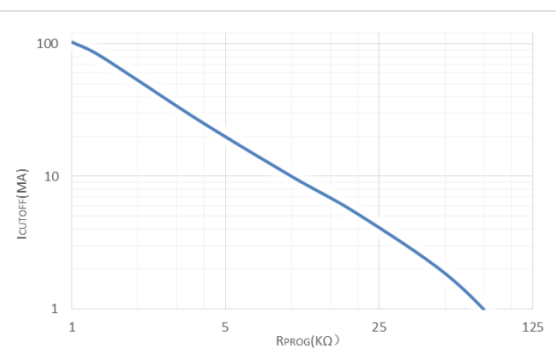
Charge Constant Current Vs. VIN Voltage



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 1Ω 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 1A is recommend and apply the above equation to select a RPROG resistor value from 1.0kΩ to 20kΩ respectively. The resistor RPROG should be located very close to the PROG pin.

Selection of RLED1, RLED2 Resistors

The STDBY and CHRGE signals can interfaced with two LEDs for indication. The resistors RLED1 and RLED2 are used to set the LED current. Choosing RLED1 and RLED2 in the range of 500Ω to 4kΩ is a good compromise. If the RLED1 and RLED2 is selected with 1kΩ, the current of green LED1 is 2mA and the current of red LED2 is 2.9mA typically.

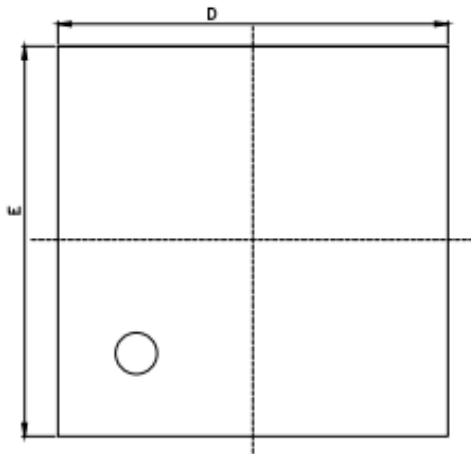
PCB Layout Guidelines

The AF4156B 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.

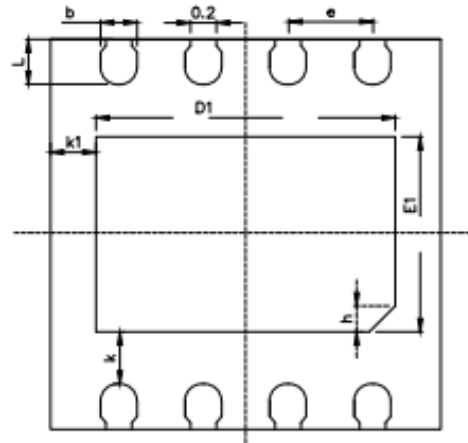
- Connected all ground together with one uninterrupted ground plane, which include power ground and analog ground.
- The input capacitor CVIN and output capacitor CBAT should be placed as close as possible to the AF4156B. Other components like RPROG should also be located close to the device.
- Minimize the power trace length and avoid using vias for the input and output capacitors connection.
- The AF4156B uses DFN3×3-8L/ESOP-8L package with a thermal pad. For good thermal performance, the thermal pad should be thermally coupled with the PCB ground plane. In most applications, this will require a copper pad directly under the AF4156B. This copper pad should be connected to the ground plane with an array of thermal vias. Each thermal via is recommended to have 0.3mm diameter and 1mm distance from other thermal vias.

➤ **Package Information**

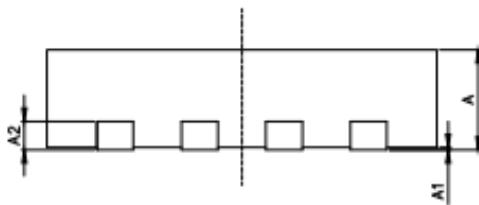
DNF3×3-8L



TOP VIEW

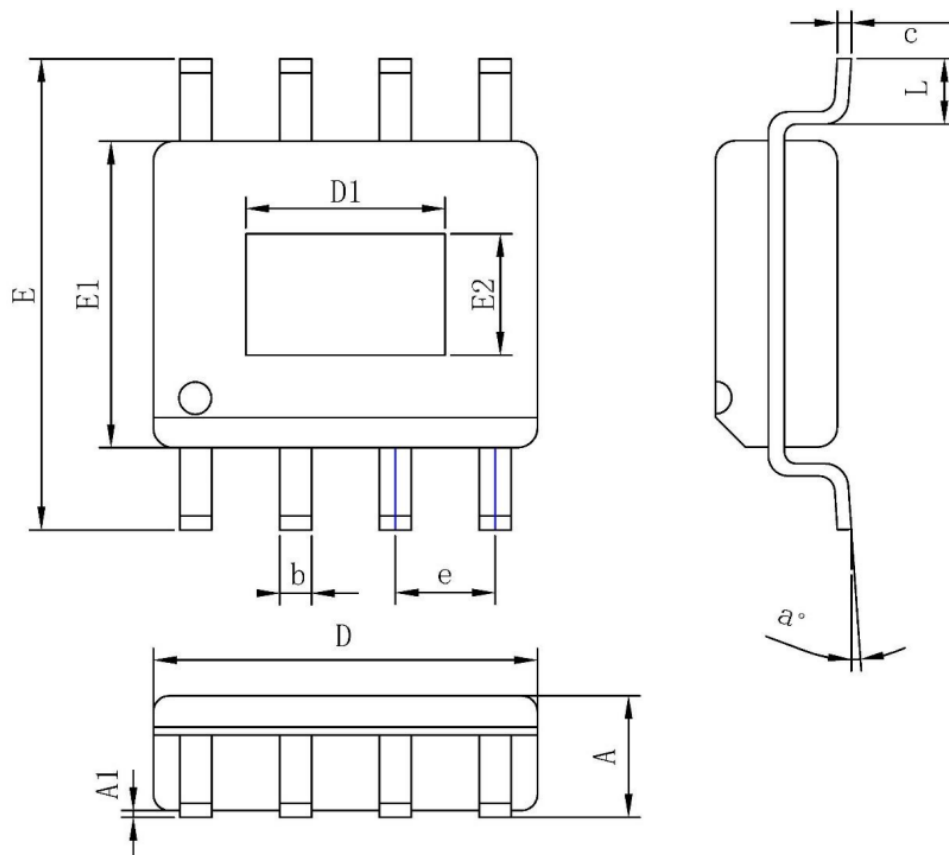


BOTTOM VIEW



SIDE VIEW

Symbol	Dimensions(mm)		
	Min.	Nom.	Max.
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.25	0.30	0.05
A2	0.203BSC		
D	2.90	3.00	3.10
E	2.90	3.00	3.10
E1	1.45	1.50	1.55
D1	2.25	2.30	2.35
e	0.65REF		
L	0.25	0.30	0.35
h	0.20REF		
K1	0.30	0.35	0.40
K	0.35	0.40	0.45

ESOP-8L


Symbol	Dimensions(mm)		
	Min.	Nom.	Max.
A	-	-	1.75
A1	0	-	0.10
b	0.35	-	0.48
c	0.19	-	0.25
D	4.70	4.90	5.00
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
L	0.40	-	0.80
a°	0°	-	8°
D1	-	3.151	-
E2	-	2.283	-



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