AF4073

1A High Input Voltage Linear Charger

➢ Description

The AF4073 is a fully integrated, cost-effective 1A high input voltage single-cell Li-Ion battery linear charger. The AF4073 uses a CC&CV charge mode required by Li-Ion battery.

The AF4073 accepts an input voltage up to 30V. The AF4073 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 AF4073 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 AF4073 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 AF4073 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
- Integrated Power MOSFET and Sense Resistor
- Thermal Regulation Of Charge Current
- Enable Function
- Charge Indication

➢ Device Information

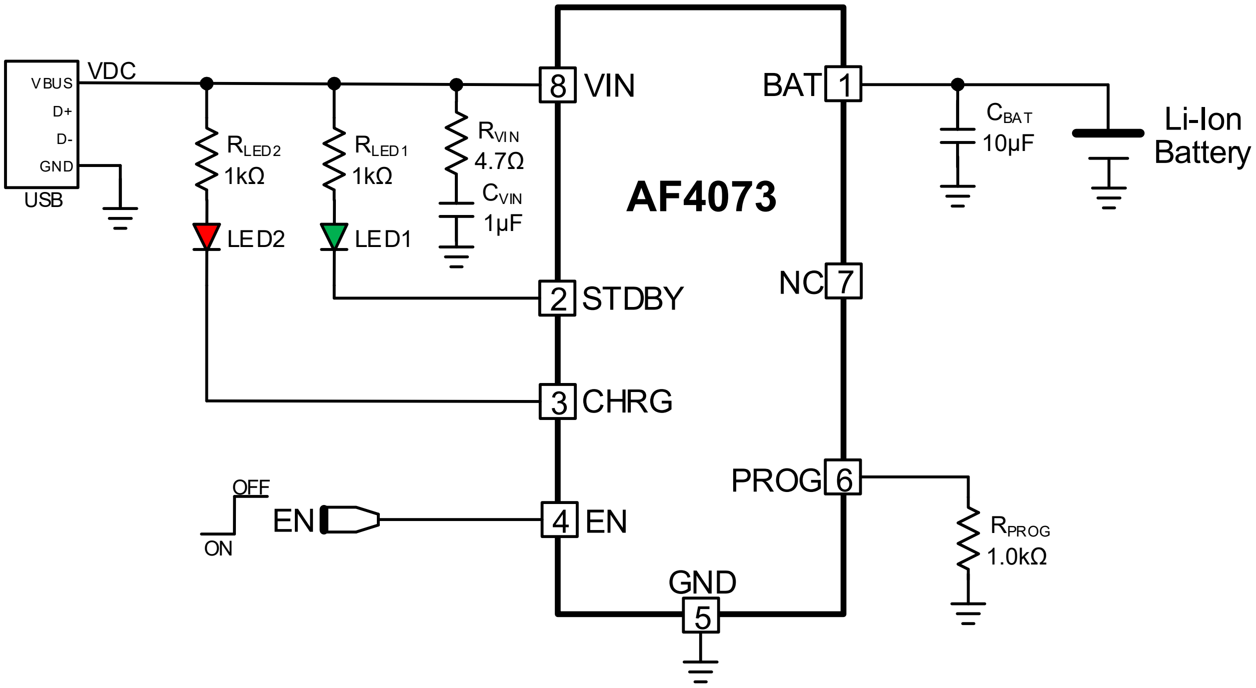
AF 4073 L/T/H N
① ② ③ ④

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	N : DFN3×3-8L Package

➢ Marking Information

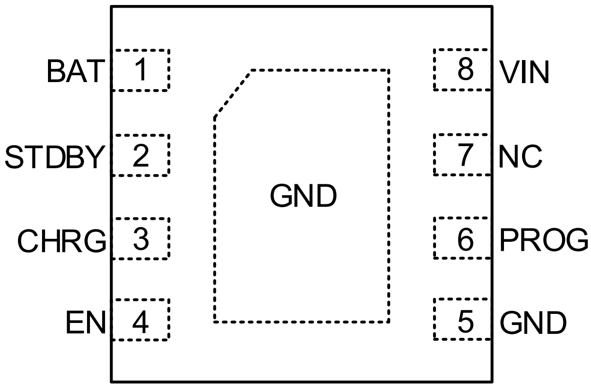
Device	Ordering Number	Float Voltage	Marking	Package	Quantity	Packing
AF4073 Series	AF4073LN	4.05V	4073LN	DNF3×3-8L	5000pcs	Tape and Reel
	AF4073TN	4.20V	4073TN			
	AF4073HN	4.35V	4073HN			

➢ Typical Application



PIN Configuration

(Top View)

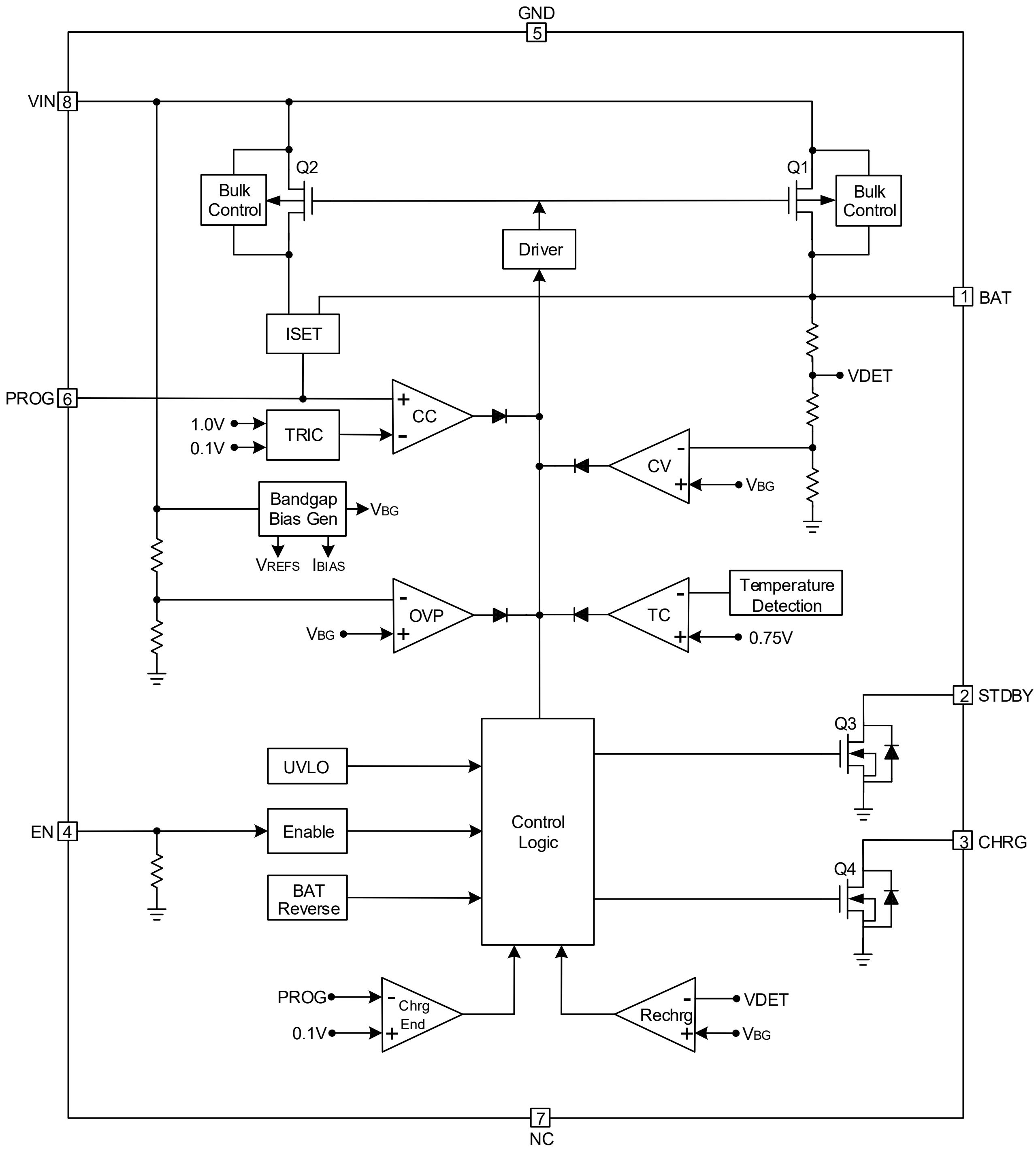


DFN3X3-8L

Pin Description

Pin Name	Pin No.	Pin Function
BAT	1	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	2	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	3	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.
EN	4	The chip enables the input pin, and a low level is effective. When EN is at a high level, the chip is turned off. The EN pin has a built-in pull-down resistor; when the EN function is not used, the EN pin can be left floating.
GND	5	The ground terminal.
PROG	6	The charge constant current threshold programming terminal. Connecting a resistor to GND to set the charge constant current threshold.
NC	7	No internal connections.
VIN	8	The Input Power terminal. Connected to external DC supply. Bypass VIN to GND with a ceramic capacitor (1μF Min.).
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

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The AF4073 accepts an input voltage up to 30V. The AF4073 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 AF4073 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 AF4073 will charge at a trickle current, 10% of constant current.

The indication pins CHRG and STDBY of AF4073, allow simple interface to a microprocessor or LEDs. When no adapter is attached or when disabled, BAT pin of AF4073 draws less than 1μA leakage current from the battery.

UVLO

The AF4073 resets when the input voltage at VIN pin exceeds the UVLO threshold. The AF4073 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 AF4073 in standby mode if VIN falls below the battery voltage.

VIN-BAT Lockout

The AF4073 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 AF4073 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 AF4073 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 AF4073 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 AF4073 will not charge the battery if the input voltage is not in the power good range.

Charge Cycle

The AF4073 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 AF4073 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 AF4073 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 AF4073 enters constant voltage mode and the charge current begins to decrease until the cutoff current is reached. Then the charge cycle of the AF4073 ends.

Auto Recharge

After the termination of the charge cycle, the AF4073 always monitors the battery voltage. When the battery voltage falls below VFLOAT-ΔVRCH, the AF4073 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 AF4073 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 AF4073 is in a charge cycle. When the AF4073 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 AF4073 is completed. When the AF4073 enters the constant voltage mode and the charge cutoff current is reached, the STDBY pin will become low level. When the AF4073 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.

EN Enable

The AF4073 has an EN enable control function, which can be used to enable or disable the chip's charging function. When the EN pin is input with a high level, the internal charging power transistor Q1 of the AF4073 is turned off, and the AF4073 stops charging. When the EN pin is input with a low level, the AF4073 will begin charging. The EN pin of the AF4073 is integrated with a 200kΩ pull-down resistor, so when the EN enable control function is not used, the EN pin can be left floating. Additionally, when the EN pin is input with a high level, both the STDBY and CHRG status indication pins are in a high-impedance state with open-drain output.

Automatic Temperature Regulation

If the internal junction temperature of the AF4073 chip exceeds TJRG, the AF4073 will begin thermal regulation by automatically reducing the charging current. This prevents the junction temperature of the chip from rising further, ensuring the safe operation of the device. This automatic thermal regulation function can protect the AF4073 from the effects of excessive temperatures. Therefore, in practical applications, the system's charging current can be set according to typical ambient temperatures to ensure that the AF4073 automatically reduces the charging current under high-temperature conditions.

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 AF4073 will face a high voltage that is more than 5V. So that the BAT pin needs a high voltage rating. The BAT pin of AF4073 can accept an input voltage up to 30V with VIN input floating. This feature protects the AF4073 from excessive BAT voltage.

Battery Reverse Protection

The AF4073 has a battery reverse protection, it will protect the AF4073 from damage when battery reverse connection happening at steps for installing the battery cell. The battery reverse current is less than 20μA 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
- EN, PROG (with respect to GND) -- -0.3V to 6V
- BAT Pin Source Current--- 1.0A
- CHRG, STDBY Pins Source Current--- 5mA
- Package Thermal Resistance

  DFN3×3-8L, θJA-- 65℃/W

  DFN3×3-8L, θJC-- 15℃/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

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
- BAT Output Current Range -- 0.05A to 1.0A
- Operating Temperature Range-- -40℃ to +85℃

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

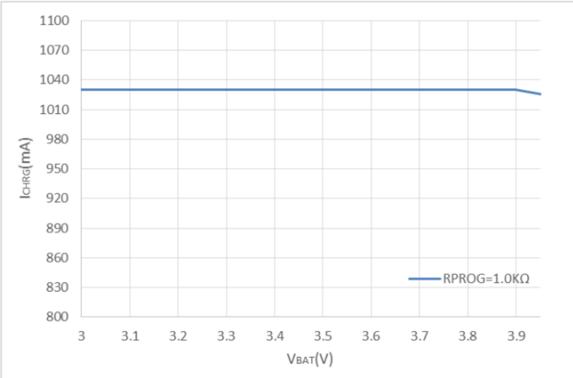
Electronics Characteristics (Unless otherwise specified, T_A=25°C, V_{IN}=5V)

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		40		mV
VIN Operating Current	I_{OP}	EN=L, R_{PROG}=1.0KΩ, BAT floating		150		uA
VIN Standby Current	I_{VIN_STY}	EN=H, R_{PROG}=1.0KΩ, BAT floating		110		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 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		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}=1.0KΩ,I_{BAT}=110mA, Order Number: AF4073LN	4.010	4.05	4.091	V
	V_{FLOAT_T}	R_{PROG}=1.0KΩ,I_{BAT}=110mA, Order Number: AF4073TN	4.158	4.20	4.242	V
	V_{FLOAT_H}	R_{PROG}=1.0KΩ,I_{BAT}=110mA, Order Number: AF4073HN	4.307	4.35	4.393	V
Programmed Charge Current	I_{CHRG}	V_{VIN} = 5V, V_{BAT}=3.7V	50		1010	mA

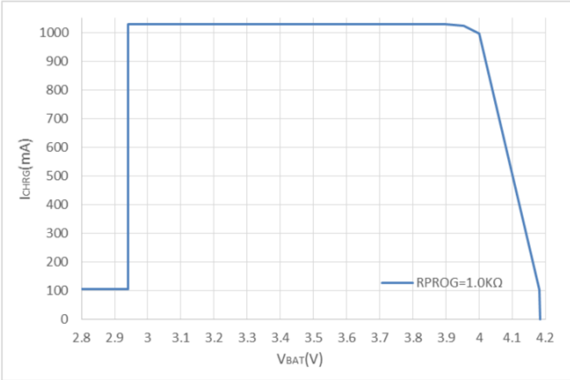
PROG Pin Output Voltage	V_{PROG}			1		V
Charge Constant Current	I_{CC}	V_{VIN} = 5V, V_{BAT}=3.7V, R_{PROG}=1.0KΩ		1010		mA
Charge Trickle Current	I_{TRIC}			101		mA
BAT 0V Charge Current	I_{TRIC_0V}			102		mA
Charge Cutoff Current	I_{OFF}	V_{VIN} = 5V, R_{PROG}=1.0KΩ		101		mA
Charge Full Delay Time	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
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} = 5V		200		KΩ
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		℃
10% Charge Current Temperature	$T_{JRC\_10\%}$			150		℃

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

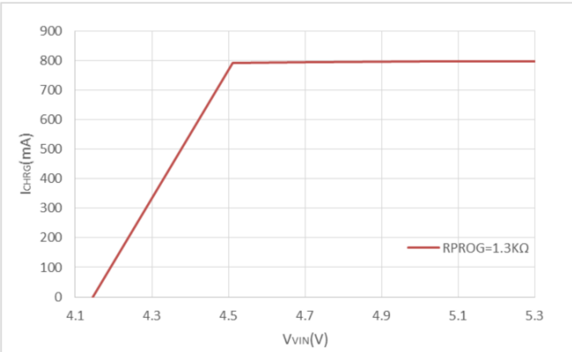
➢ Typical Characteristics (Unless otherwise specified, T_A=25°C, V_{IN}=5V)



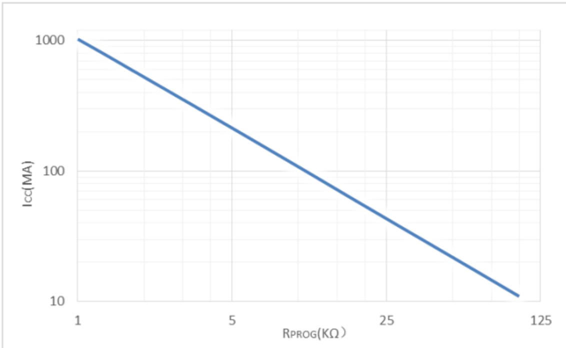
Charge Current Vs. BAT Voltage



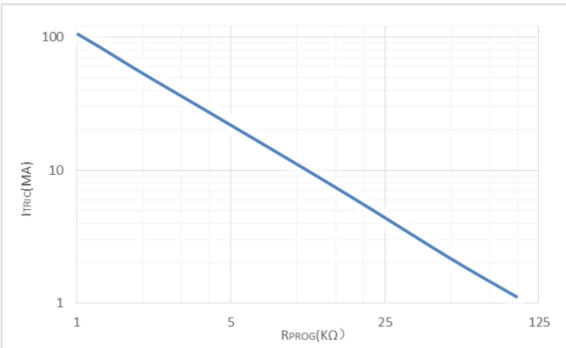
Charge Current Vs. BAT Voltage



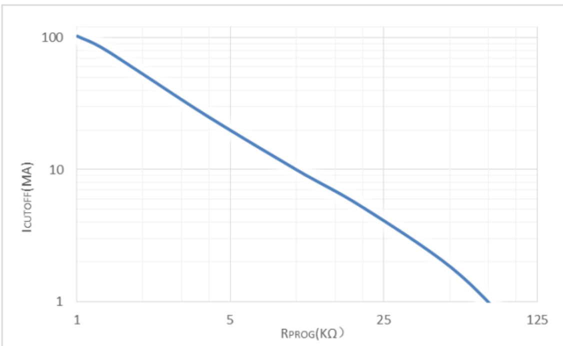
Charge Constant Current Vs. VIN Voltage



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 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 CHRG 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.

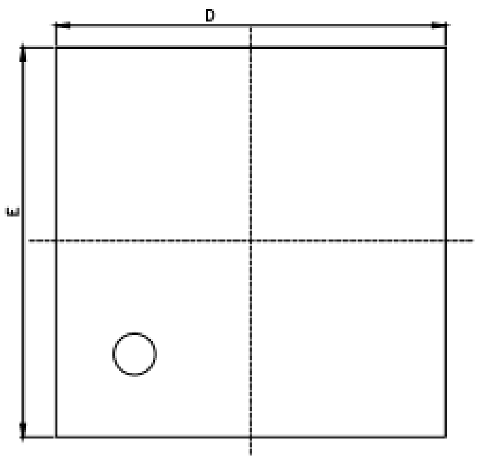
PCB Layout Guidelines

The AF4073 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.

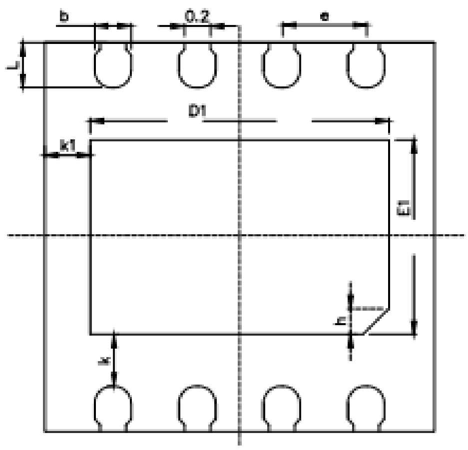
- Connected all ground together with one uninterrupted ground plane, which include power ground and analog ground.
- The input capacitor CVIN and output capacitor CBAT should be placed as close as possible to the AF4073. Other components like RPROG should also be located close to the device.
- Minimize the power trace length and avoid using vias for the input and output capacitors connection.
- The AF4073 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 AF4073. 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

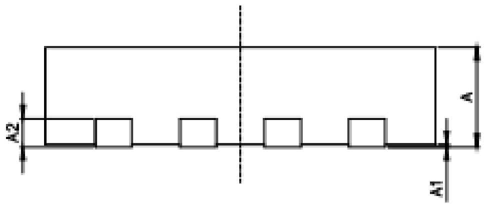
DNF3×3-8L



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

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