1A Standalone Linear Li-Ion Battery Charger

General Description

The FC4056 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Its ESOP8 package and low external component count make the FC4056 ideally suited for portable applications. Furthermore, the FC4056 is specifically designed to work within USB power specifications. No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The FC4056 automatically terminates the charge cycle when the charge current drops to 1C/10th the programmed value after the final float voltage is reached. When the input supply (wall adapter or USB supply) is removed, the FC4056 automatically enters a low current state, dropping the battery drain current to less than 1μA. Other features include charge current monitor, automatic recharge and a status pin to indicate charge termination and the presence of an input voltage.

Order Information

FC4056 □ □ □

- C: Pb-Free
- Package Type
  S : ESOP-8
- A :4.2V

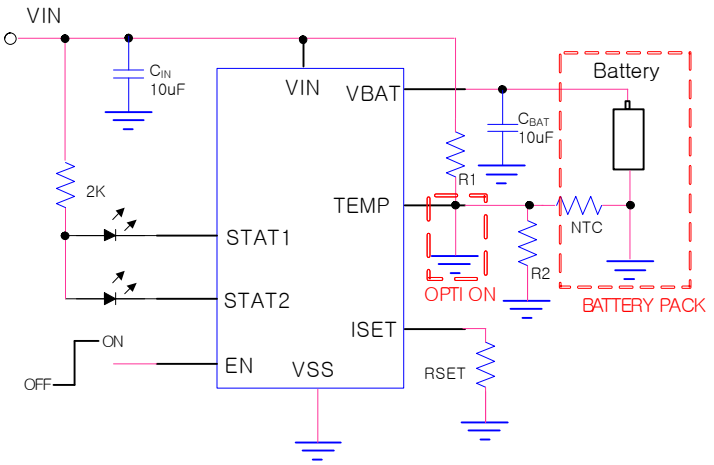
Applications

- Portable Media Players/MP3 players
- Cellular and Smart mobile phone
- PDA/DSC
- Bluetooth Applications

Features

- Protection of Reverse Connection of Battery
- Programmable Charge Current Up to 1000mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Constant-Current/Constant-Voltage Operation with Thermal Regulationto Maximize Charge Rate Without Risk of Overheating
- 1μA Supply Current in Shutdown
- Drainage Charge Current Thermal Regulation Status Outputs for LED or System Interface
- Indicates Charge and Full
- Optional Battery Temperature Monitoring Before and During Charge Automatic Sleep Mode for Low-Power
- Consumption Available in ESOP-8 Package
- RoHS Compliant and 100% Lead (Pb)-Free

Typical Application Circuit



Marking Information

Device	Marking	Package	Shipping
FC4056ASC	ASC4056 XXXX XXXXXX	ESOP-8	4K/REEL
The second and third lines are version number and quality information,defined by Manufacturer			

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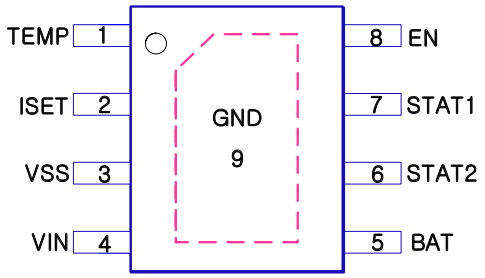
Functional Pin Description

Package Type	Pin Configurations
ESOP-8	

Pin Description

PIN	PIN Number	DESCRIPTION
1	TEMP	Temperature sense input,Connecting TEMP pin to NTC termistor's output in Lithium-ion battery pack.If TEMP pins voltage is below 30% or above 60% of supply voltage VCC,this means that batterys temperature is too low or too high, charging is suspended. The temperature sense function can be disabled by grounding the TEMP pin.
2	ISET	Charge Current Program and Charge Current Monitor Pin. The charge current is programmed by connecting a 1% resistor, R_{ISET} , to ground. When charging in constant-current mode, this pin servos to 1V. In all modes, the voltage on this pin can be used to measure the charge current using the following formula: $I_{BAT}=960/R_{ISET}$
3	VSS	VSS is the connection to system ground.
4	VIN	VIN is the input power source. Connect to a wall adapter.
5	BAT	BAT is the connection to the battery.
6	STAT2	Open-Drain Charge Status Output. When the battery is charging, the STAT pin could be pulled High by an external pull high resistor. When the charge cycle is completed, the pin is pulled Low by an internal N-channel MOSFET.
7	STAT1	Open-Drain Charge Status Output. When the battery is charging, the STAT pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed,the pin could be pulled High by an external pull high resistor.
8	EN	Chip enable pin. Charging when the pin is connected to a high voltage. Discharge when the pin pull low.

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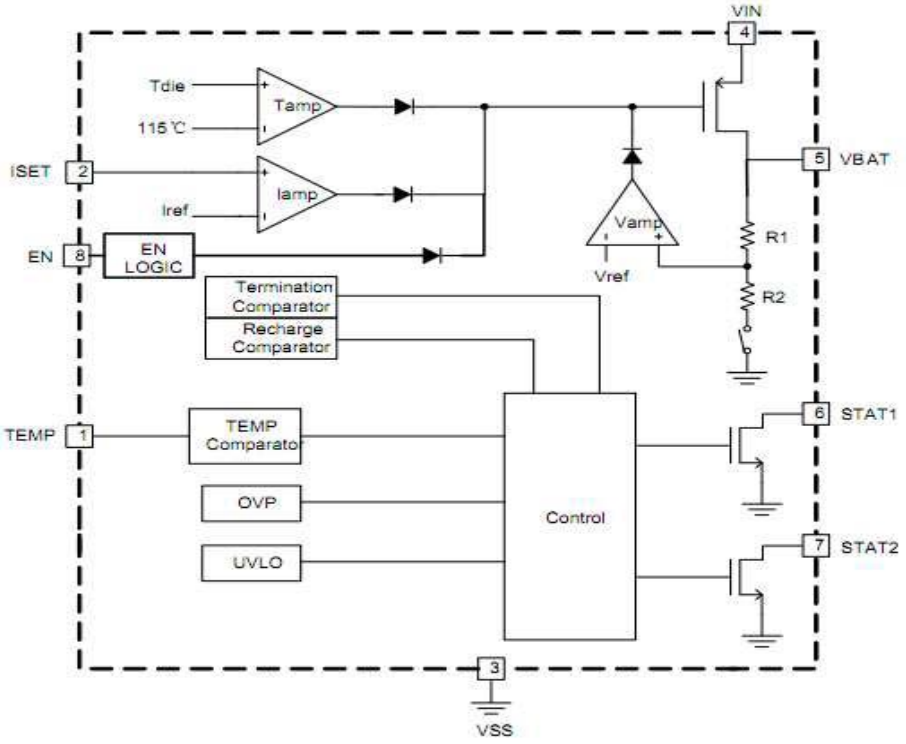
Function Block Diagram



Absolute Maximum Ratings Note 1

- Input to GND(VIN) ---------- -0.3V to7V
- BAT to GND ---------- -5V to 6V
- VIN to BAT ---------- 7V
- Other Pin to GND ---------- -0.3V to 7V
- BAT Short- circuit Duration ---------- Continuous
- Storage Temperature ---------- -45℃ to 165℃
- Operating Junction Temperature Range (TJ) ---------- -20℃ to 85°C
- Maximum Soldering Temperature (at leads, 10 sec) ---------- 260°C

Note 1. Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Information

- Maximum Power Dissipation (PD,TA=25°C) ---------- 2W
- Thermal Resistance (JA) ---------- -50℃/W

ESD Susceptibility

- HBM(Human Body Mode) ---------- 2KV
- MM(Machine Mode) ---------- 200V

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Electrical Characteristics

(TA = 25°C. VIN = 5V, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input supply voltage:VCC	Vcc	-	4.25	-	5.5	V
VIN Supply Current	Icc	Charge mode,Riset=10K	-	200	2000	μA
		Standby mode	-	20	30	μA
		Shutdown mode1(Riset not connected,Vcc<Vbat or Vcc<Vuv)	-	50	100	μA
		Shutdown mode1（CE=0）		20		μA
BAT Charging Voltage	Vfloat	0℃≤TA≤85℃,IBAT=40mA	4.16	4.2	4.25	V
BAT Pin Output Current	Ibat	Riset=10k,Current mode	86	96	106	mA
		Riset=1k,Current mode	882	960	1038	mA
		Standby mode,Vbat=4.2V	0	-2.5	-6	μA
		Shutdown mode	-	-	1	μA
		Sleep mode,Vcc=0V	-	-	0.1	μA
Trickle Charge current	Itrikl	Vbat<Vtrikl,Rprog=2k	76	96	116	mA
Trickle Charge Threshold Voltage	Vtrikl	Riset=10K, Vbat Rising	2.8	2.9	3.0	V
Trickle Charge Hysteresis Voltage	Vtrhys	Riset=10k	60	80	120	mV
VIN Under Voltage Lockout Threshold	Vuv	From Vcc low to high	3.7	3.8	3.93	V
VIN Under Voltage Lockout Hysteresis	Vuvhys	-	150	200	300	mV
Manual Shutdowm Threshold Voltage	Vmsd	Iset pin rising	1.15	1.21	1.30	V
		Iset pin falling	0.9	1.0	1.1	V
Vcc-Vbat Lockout Threshold Voltage	Vasd	Vcc from low to high	70	100	140	mV
		Vcc from high to low	5	30	50	mV
C/10 Termination Current Threshold	Iterm	Riset=10k	8	10	12	mA
		Riset=2k	40	50	65	mA
ISET Pin Voltage	V iset	Riset=10k, Current mode	0.93	1.0	1.07	V
STAT1 Threshold Voltage	Vstat1	Istat1=5mA	-	0.35	0.6	V
STAT2 Threshold Voltage	Vstat2	Istat2=5mA	-	0.35	0.6	V
Recharge Battery Threshold Voltage	Δ Vrecg	VFLOAT - VRECHRG	-	150	200	mV

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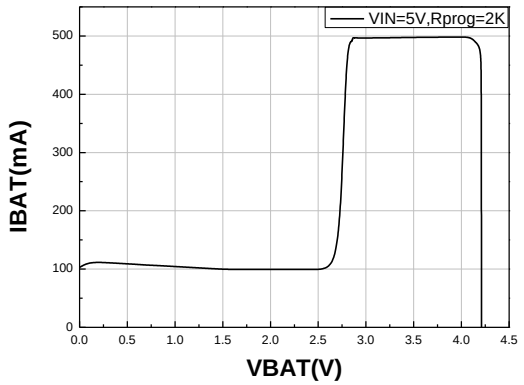
Typical performance characteristics

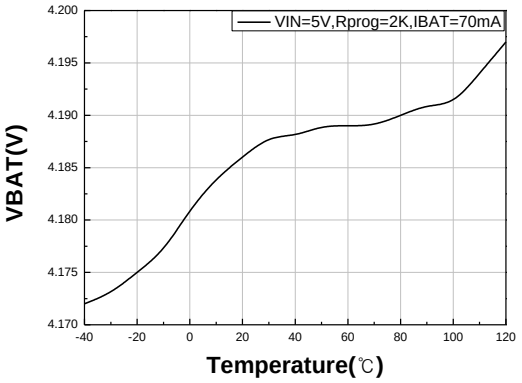
1、BAT Voltage vs. BAT Current

Test conditions: Vin=5V, Rpog=2K



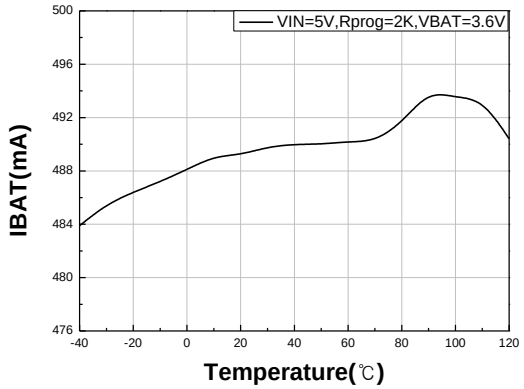
2、BAT Voltage vs. Temperature

Test conditions: VIN=5V, Ibat=70mA, Rprog=2K



3、BAT Current vs. Temperature

Test conditions: Vin=5V, Rpog=2K, Vbat=3.6V



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Application Information

The FC4056 is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 1000mA of charge current (using a good thermal BC layout) with a final float voltage accuracy of ±1% (4.2V). The FC4056 includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus, the basic charger circuit requiresonly two external components. Furthermore, the FC4056 is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the VIN pin rises above the UVLO threshold level and a 1% ISET ram resistor is connected from the ISET pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 3V, the charger enters trickle charge mode. In this mode, the FC4056 supplies approximately1/10 of the ISET rammed value current to bring the battery voltage up to a safe level for full current charging.

When the BAT pin voltage rises above 3V, the charger enters constant-current mode, where the ISETrammed charge current is supplied to the battery. When the BAT pin approaches the final float voltage, the FC4056 enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the ISET rammed value, the charge cycle ends.

ISET ramming Charge Current

The charge current is ISETrammed using a single resistor from the ISET pin to ground. The battery charge current is 1000 times the current out of the ISET pin. The ISET ram resistor and the charge current are calculated using the following equations:

R_{SET}=960V/I_{BAT}, I_{BAT}= 960V/R_{SET}

The charge curent out of the BAT pin can be determined at any time by monitoring the ISET pin voltage using the following equation:

I_{BAT}= V_{SET} x 960R_{SET}(4056)

Automatic Recharge

Once the charge cycle is terminated, the FC4056 continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time. A charge cycle restarts when the battery voltage falls below 4.0V (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. CHRG output enters a strong pull-down state during recharge cycles.

Charge Status Indicator (STAT)

The charge status output has two different states: strong pull-down (~5mA) and high impedance. The strong pull-down state indicates that the FC4056 is in a charge cycle. High impedance indicates thathe charge cyclecomplete or the FC4056 is in undervoltage lockout mode: either V_{IN} is less than 150mV above the BAT pin voltage or insufficient voltage is applied to the VIN pin. A microprocessor can be used to distinguish between these two states.

Function	STAT 1(pin7)	STAT 2(pin6)
Charging	Low	High
Charge END	High	Low

Thermal Limiting

An internal thermal feedback loop reduces the I_{SET} rammed charge current if the die temperature attempts to rise above a preset value of approximately 125°C. This feature protects the FC4056 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 FC4056 .

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.

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Power Dissipation

The conditions that cause the FC4056 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:

$$P_D=(VIN-V_{BAT})\cdot I_{BAT}$$

where PD is the power dissipated,VIN is the input supply voltage, VBAT is the battery voltage and IBAT is the charge current. The approximate ambient temperature at whichet thermal feedback begins to protect the IC is:

$$T_A=125℃-P_D\theta_{JA}$$

$$T_A=125℃-(VIN-V_{BAT})\cdot I_{BAT}\cdot\theta_{JA}$$

.

Normal Charge Cycle

The values of R1 and R2 in the application circuit can be determined according to the assumed temperature monitor range and thermistor' s values. The follows is an example: Asssume temperature monitor range is TL~TH, the thermistor in battery has negative temperature coefficient (NTC, RTL is thermistors resistance at TL, RTH is the resistance at TH, resistance at TH, then at temperature TL,voltage at TEMP pin is: the

$$V_{TEMPH}=\frac{R_2//R_{TH}}{R_1+R_2//R_{TH}}\times Vin$$

At temperature TH, the voltage at TEMP pin is:

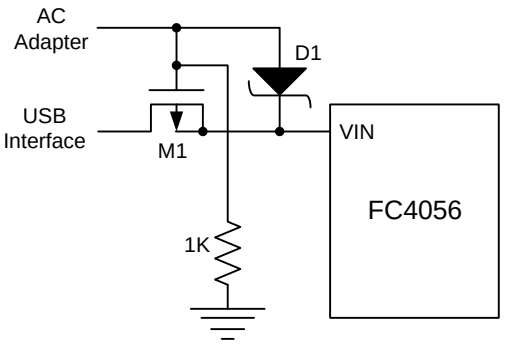
$$V_{TEMPL}=\frac{R_2//R_{TL}}{R_1+R_2//R_{TL}}\times Vin$$

We know VTEMPL=VHIGH=K2×VCC (K2=0.6);
VTEMPH=VLOW=K1×VCC(K1=0.3) Then we can have:

$$R1=\frac{R_{TL}R_{TH}(K2-K1)}{(R_{TL}-R_{TH})K1K2}$$

$$R2=\frac{R_{TL}R_{TH}(K2-K1)}{R_{TL}(K1-K1K2)-R_{TH}(K2-K1K2)}$$

Suitable for the application of USB power and the charge of wall adapter



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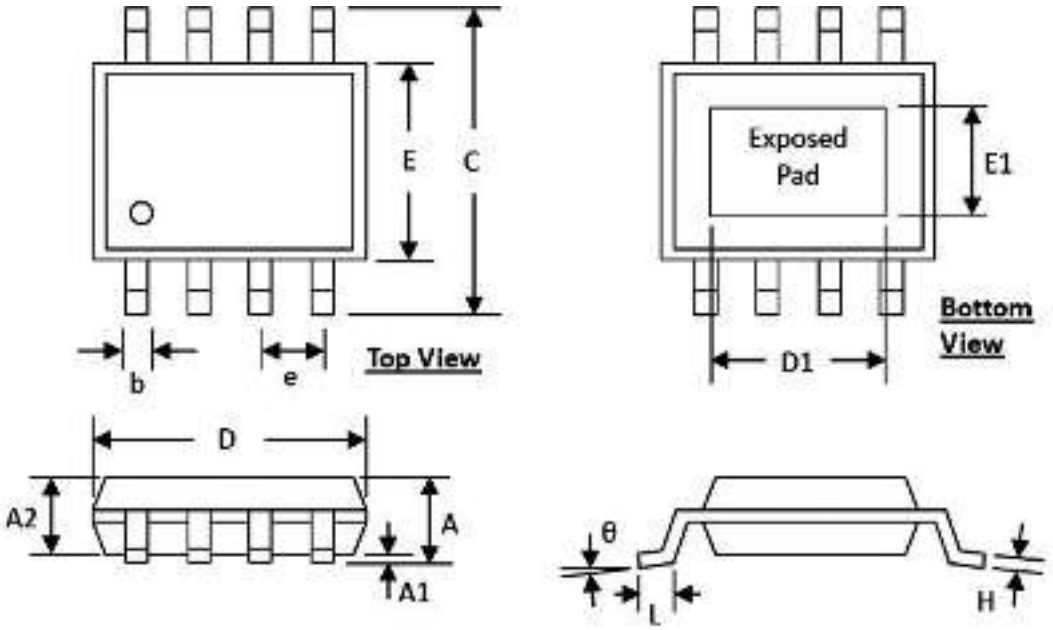
Packaging Information



SYMBOLS	DIMENSION (MM)		DIMENSION (INCH)	
	MIN	MAX	MIN	MAX
A	1.30	1.70	0.051	0.067
A1	0.00	0.15	0.000	0.006
A2	1.25	1.52	0.049	0.060
b	0.33	0.51	0.013	0.020
C	5.80	6.20	0.228	0.244
D	4.80	5.00	0.189	0.197
D1	3.15	3.45	0.124	0.136
E	3.80	4.00	0.150	0.157
E1	2.26	2.56	0.089	0.101
e	1.27 BSC		0.050 BSC	
H	0.19	0.25	0.0075	0.0098
L	0.41	1.27	0.016	0.050
θ	0°	8°	0°	8°