CL4056D
1A Li-ion Battery Linear Charger

Description

The CL4056D is a standalone linear Li-ion battery charger with ESOP8 package. With few external components, CL4056D is well suited for a wide range of portable applications. Charging current can be programmed by an external resistor. In standby mode, supply current will be reduced to around 35uA. When the input voltage is disconnected, CL4056D enters the sleep state, and the battery leakage current will drop below 1uA.

Other features include UVLO, automatic recharge, charge status indicators and thermal regulation.

Feature

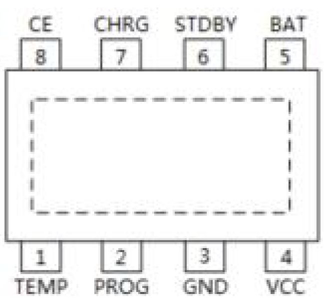
- ◆ Up to 1000mA Programmable Charge Current
- ◆ No External MOSFET, Sense Resistor, or Blocking Diode Required
- ◆ Standalone Linear Charger for Single Cell Li-ion Batteries
- ◆ Preset Charge Voltage with：4.2V-1% ~ 4.2V＋2%
- ◆ Automatic Recharge
- ◆ Charge Status Indicators for No Battery and Charge Failure Display
- ◆ C/10 Charge Termination
- ◆ 35uA Standby Supply Current
- ◆ 2.9V Trickle Charge Voltage
- ◆ Thermal Protection
- ◆ Soft-Start to Limit Inrush Current
- ◆ reverse protection

Application

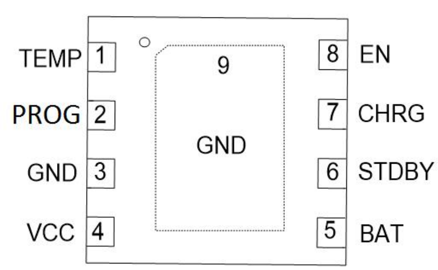
- ◆ Mobile Phone、PDA
- ◆ MP3、MP4
- ◆ Charger
- ◆ DSC
- ◆ Palmtop
- ◆ Bluetooth , GPS
- ◆ Portable Device

PackageType : ESOP8 / DFN2*2-8L

Pin Description

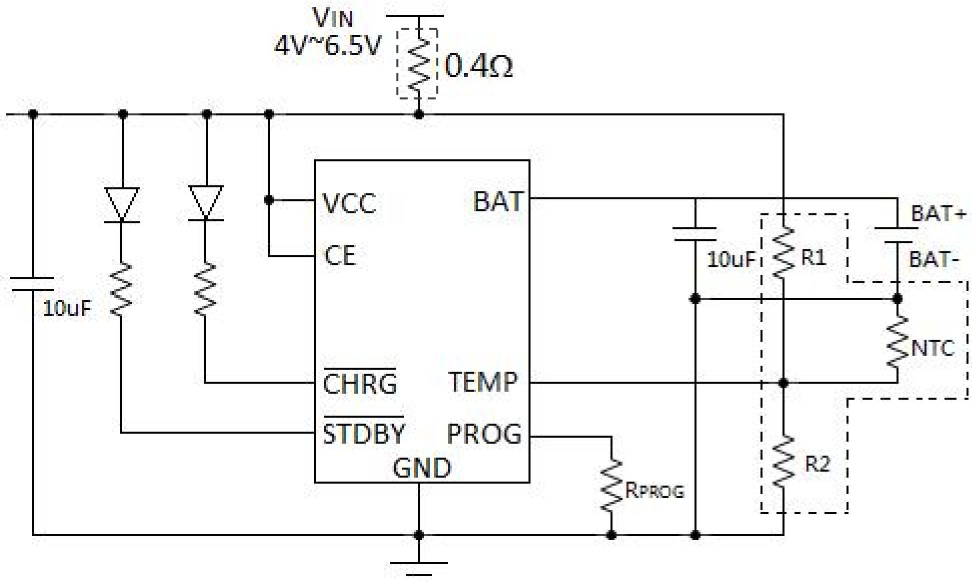


ESOP8



DFN2*2-8L

Typical Application Circuit



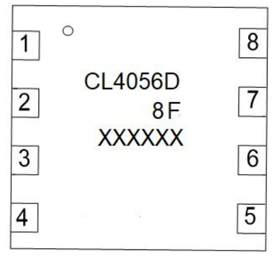
R1/R2/NTC resistors are optional. The TEMP pin can also be directly grounded without monitoring the battery temperature

Pin Assignment

ESOP8L

Exposed PAD-Must connect to Ground

DFN2*2-8L



Name	ESOP8 (CL4056D)	DFN2*2-8 (CL4056D8F)	Description
TEMP	1	1	Temp detect
PROG	2	2	CC charge current setting & monitor
GND	3	3	Ground
VCC	4	4	Supply Voltage
BAT	5	5	Battery voltage
STDBY	6	6	Stand by indicate
CHRG	7	7	Charge indicate
CE	8	8	Enable control

Marking Information

Part Number	Package	Marking	Description
CL4056D	ESOP8L	P/N XXXXXX	Line 1：P/N Line 2：DFN Type： 8D：DFN2*2 8F：DFN3*3 Line 3： Year/Week/Version/Lot/factory
CL4056D8F	DFN2*2-8L		

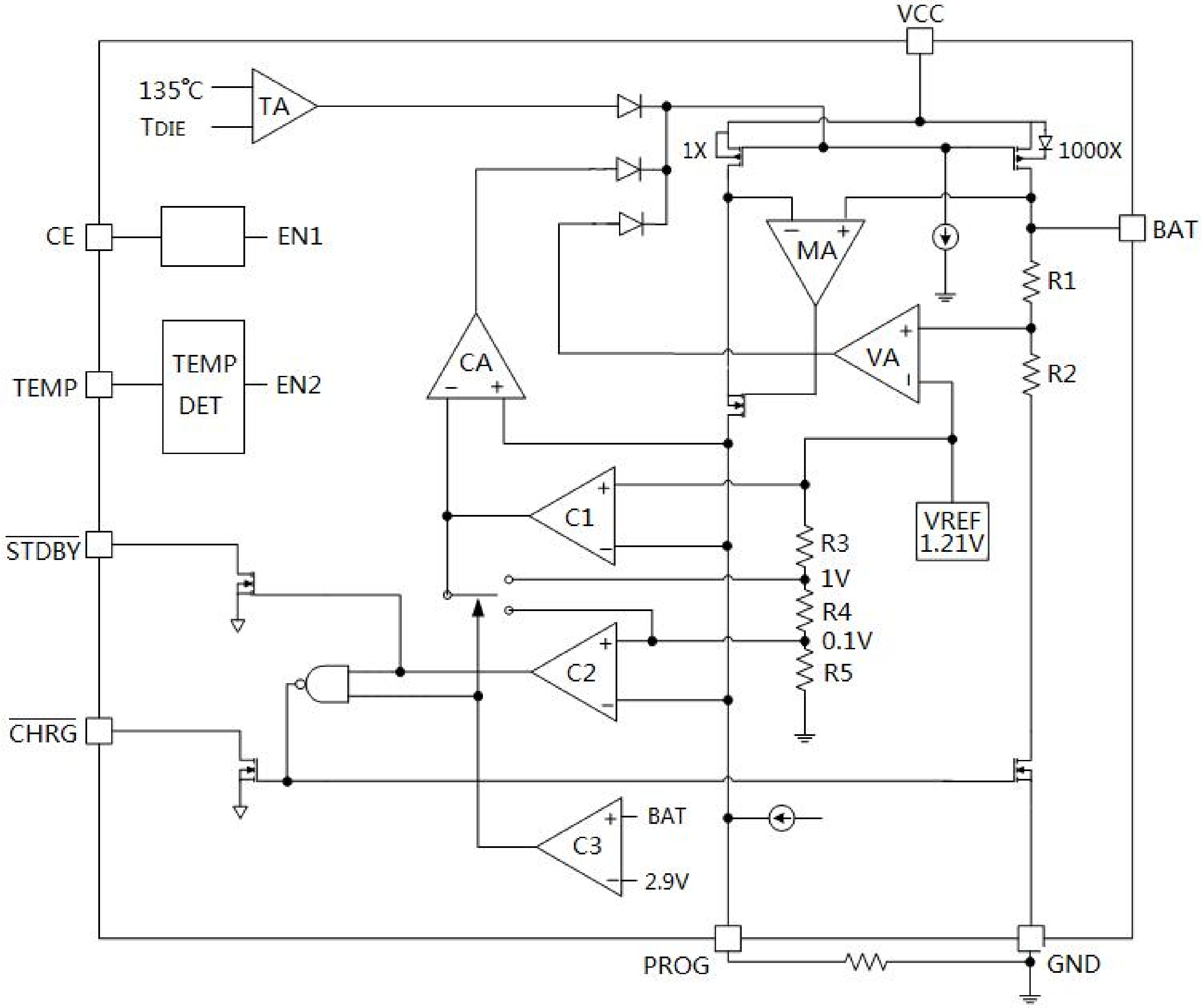
Absolute Maximum Ratings

Parameter	Range	Unit
Supply Voltage	-0.3 to 6.5	V
PROG, BAT, CE, TEMP voltage	-0.3 to 6.5	V
CHRG pin voltage	-0.3 to 8	V
STDBY pin voltage	-0.3 to 8	V
BAT Pin Current	1	A
PROG Pin Current	2	mA
Allowable Power Dissipation	1500	mW
Operating Temperature	-40 ~ 85	°C
Storage Temperature	-65 to 125	°C

ESD/Latch-up

Parameter	Range
HBM	4000V
MM	400 V
Latch-up	400mA

BLOCK DIAGRAM



DC Electrical Characteristics (V_{cc}=5V, T_A= 25°C, unless otherwise noted)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
VCC	Supply Voltage		4.2		6.5	V
ICC	Supply Current	Charge mode(RPROG=12K) (1)		240	500	uA
		Stand-by mode（Charge Termination）		50	100	uA
		Shunt-down mode(Vcc< VBAT , Vcc< VUVLO RPROG not connect)		35	70	uA
VFLOAT	CV Output (Float) Voltage	0°C≤T≤85°C	4.158	4.2	4.284	V
IBAT	BAT Pin Current	CC MODE，RPROG=2.4K	465	500	535	mA
		CC MODE，RPROG=1.2K	930	1000	1070	mA
		Stand-by mode，VBAT=4.2V	0	-2.5	-6	uA
		Shunt-down mode		1	2	uA
		BAT Reverse，VBAT=-4V		0.7		mA
		Sleep mode，VCC=0V		0	1	uA
ITRIKL	Trickle Charge Current	VBAT＜VTRIKL, RPROG=2.4K	40	50	60	mA
		VBAT＜VTRIKL, RPROG=1.2K	80	100	120	mA
VTRIKL	Trickle Charge Threshold Voltage	VBAT Rising	2.8	2.9	3.0	V
VTRHYS	Trickle Charge Hysteresis Voltage	VBAT Falling	60	80	100	mV
VUVLO	VCC Under Voltage Lockout Threshold	VCC Rising	3.7	3.8	3.93	V
VUVHYS	VCC Under Voltage Lockout Threshold Hysteresis	VCC Falling	150	200	300	mV
VMSD	Manual shutdown threshold voltage	PROG Rising	1.15	1.21	1.30	V
		PROG Falling	0.9	1.0	1.1	V
VASD	VCC-VBAT Lockout Threshold	VCC Rising	70	100	140	mV
		VCC Falling	5	30	50	mV
ITERM	C/10Termination Comparator Filter Time（2）	RPROG=1.2K	0.085	0.10	0.115	mA/mA
		RPROG=2.4K	0.085	0.10	0.115	mA/mA
VPROG	PROG Pin Voltage	CC MODE，RPROG=1.2K	0.93	1.0	1.07	V
VCHRG	CHRG Pin Output Low Voltage	ICHRG=5mA		0.35	0.6	V
VSTDBY	STDBY Pin Output Low	ISTDBY=5mA		0.35	0.6	V
VTEMP_H	TEMP pin high threshold voltage			80	83	%VCC
VTEMP_L	TEMP pin low threshold voltage		42	45		%VCC

ΔVRECHG	Battery Recharge Threshold Voltage	VFLOAT-VRECHG		100	200	mV
TRECHG	Recharge Comparator Filter Time	VBAT High to Low	0.8	1.8	4	ms
TTERM	C/10Termination Comparator Filter Time	IBAT Falling below ITERM	0.63	1.4	3	ms
IPROG	PROG Pin Pull-up Current			2.0		uA
VCE_H	CE High		1.3			V
VCE_L	CE low				0.7	V

Notes（1）： At this time it is charging，ICC=IVCC-IBAT

（2）： C/10 termination current threshold refers to the ratio of termination current to constant current charging current

Function Description

CL4056D is a linear charger specially designed for lithium-ion batteries, which uses the power MOSFET inside the chip to charge the battery with constant current/constant voltage. The charging current can be programmed by an external resistor, and the maximum charging current can reach 1000mA. CL4056D has two open-drain output status indication output terminals, charging status indication terminal CHRG and battery charging completion indication output terminal STDBY. The power tube circuit inside the chip automatically reduces the charging current when the junction temperature of the chip exceeds 135°C. This function allows users to maximize the use of chip charging without worrying about chip overheating and damage to the chip or external components.

When the input voltage is greater than the UVLO detection threshold and the chip enable input terminal CE is connected to high level, CL4056D starts to charge the battery. If the battery voltage is lower than 2.9V, the charger precharges the battery with a small current. When the battery voltage exceeds 2.9V, the charger adopts constant current mode to charge the battery, and the charging current is determined by the resistance between the PROG terminal and the GND terminal. When the battery voltage is close to 4.2V, the charging current gradually decreases, and CL4056D enters the constant voltage charging mode. The charging cycle ends when the charging current decreases to the end-of-charge threshold.

The end-of-charge threshold is 1/10 of the constant-current charge current. When the battery voltage drops below the recharge threshold, a new charge cycle is automatically started. The high-precision voltage reference source, error amplifier and resistor divider network inside the chip ensure that the accuracy of the modulation voltage at the BAT terminal is within 1%, which meets the requirements of lithium-ion and lithium-polymer batteries. When the input voltage drops or the input voltage is lower than the battery voltage, the charger enters shutdown mode, and the current consumed by the battery terminal is less than 2uA, thereby increasing the standby time.

If the enable input terminal CE is connected to a low level, the charger stops charging.

●charging current

The relationship between RPROG and charging current can be determined by referring to the following table:：

$$R_{PROG} = \frac{1200}{I_{BAT}}$$

RPROG(K)	IBAT(mA)
1.2	1000
2.4	500
3.0	400
4.0	300
6.0	200
12.0	100

●charge termination

When the charge current drops to 1/10 of the set value after reaching the final float voltage, the charge cycle is terminated. This condition is detected by monitoring the PROG terminal with an internal filtered comparator. When the PROG terminal voltage drops below 100mV for more than 1.8ms, charging is terminated and CL4056D enters standby mode, at which time the input power current drops to about 50uA.

When charging, the transient load on the BAT terminal will cause the PROG terminal voltage to drop below 100mV briefly between the DC charging current drops to 1/10 of the set value, and the 1.8ms delay time of the comparator ensures this property transient loads will not cause premature termination of the charge cycle. Once the average charge current drops below 1/10 of the set value, the CL4056D centralizes the charge cycle and stops supplying any current through the BAT terminal. In this state, all loads on the BAT terminal must be powered by the battery.

●charging status indicator

CL4056D has two open-drain status indication outputs CHRG and STDBY. When the charger is in the charging state, CHRG is pulled to a low level, and in other states CHRG is in a high-impedance state; when the battery is charged, STDBY is pulled to a low level, and in other states STDBY is in a high-impedance state.

When the battery is not connected to the charger, CHRG flashes to indicate that there is no battery installed.

STATUS	CHRG	STDBY
Charging	on	Off
finished charging	off	on
Undervoltage, battery temperature is too high, too low Waiting for fault status, or no battery access (TEMP use)	off	off
Connect 1uF capacitor to BAT terminal, no battery	flashing（Freq 20Hz）	on

●Thermal

An internal thermal feedback loop reduces the programmed charge current if the die temperature rises above 135℃. This feature prevents the CL4056D from overheating and allows the user to increase the upper limit of a given board's power handling capability while reducing the risk of damaging the CL4056D.

●Battery temperature detection

In order to prevent damage to the battery caused by high or low temperature, CL4056D integrates a battery temperature monitoring circuit inside. Battery temperature monitoring is realized by measuring the voltage of the TEMP pin, which is realized by an NTC thermistor inside the battery and a resistor divider network, as shown in the typical application diagram. If the voltage of the TEMP pin is less than 45% of the input voltage or greater than 80% of the input voltage, it means that the battery temperature is too low or too high, and the charging is suspended.

If the TEMP pin is directly connected to GND, the battery temperature detection function is canceled, and other charging functions are normal.

The values of R1 and R2 should be determined according to the temperature monitoring range of the battery and the resistance value of the thermistor. The examples are as follows:

Assume that the set battery temperature range is TL～TH, (where TL<TH); the battery uses a negative temperature coefficient thermistor (NTC), RTL is its resistance at the temperature TL, and RTH is its resistance at the temperature TL. The resistance value at the temperature TH, then RTL>RTH, then, at the temperature TL, the voltage at the first pin TEMP is:

$$V_{TEMPL} = \frac{R2 \| R_{TL}}{R1 + R2 \| R_{TL}} \times VIN$$

At the temperature TH, the voltage at the first pin TEMP is:

$$V_{TEMPH} = \frac{R2 \| R_{TH}}{R1 + R2 \| R_{TH}} \times VIN$$

$$V_{TEMPL} = V_{HIGH} = K_2 \times V_{CC} (K_2 = 0.8)$$

$$V_{TEMPH} = V_{LOW} = K_1 \times V_{CC} (K_1 = 0.45)$$

$$R1 = \frac{R_{TL} R_{TH} (K_2 - K_1)}{(R_{TL} - R_{TH}) K_1 K_2}$$

$$R2 = \frac{R_{TL} R_{TH} (K_2 - K_1)}{R_{TL}(K_1 - K_1 K_2) - R_{TH}(K_2 - K_1 K_2)}$$

Similarly, if the inside of the battery is a thermistor with a positive temperature coefficient (PTC), then >, we can calculate:

$$R1 = \frac{R_{TL} R_{TH} (K_2 - K_1)}{(R_{TH} - R_{TL}) K_1 K_2}$$

$$R2 = \frac{R_{TL} R_{TH} (K_2 - K_1)}{R_{TH}(K_1 - K_1 K_2) - R_{TL}(K_2 - K_1 K_2)}$$

It can be seen from the above derivation that the temperature range to be set has nothing to do with the power supply voltage VCC, and is only related to R1, R2, RTH, and RTL;among them, RTH and RTL can be checked by referring to the relevant battery manual or through experiments get.

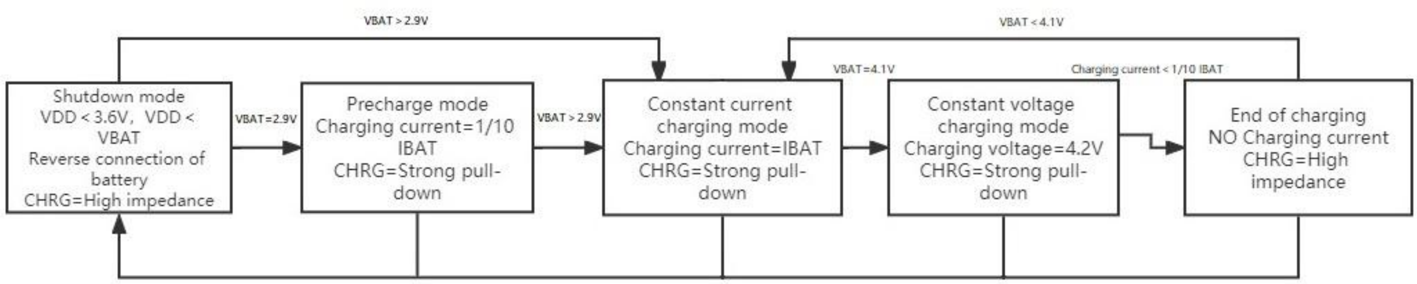
In practical applications, if you only care about the temperature characteristics of a certain end, such as overheating protection, then R2 can be used instead of R1. The derivation of R1 also becomes simple, and will not be repeated here.

●UVLO

CL4056D has an internal under-voltage lockout circuit to monitor the input voltage and keep the chip in shutdown mode before VCC rises to the under-voltage lockout threshold voltage. When the VCC voltage rises to 3.8V, the chip exits UVLO and starts to work normally. The UVLO hysteresis voltage is 200mV when VCC is falling.

●automatic charge cycle

When the battery voltage reaches the float voltage and the charge cycle is terminated, the CL4056D immediately monitors the BAT terminal voltage. When the BAT terminal voltage is lower than 4.1V, the charging cycle starts again. This ensures that the battery is maintained at a near-full state while eliminating the need for periodic charge cycle initiation.

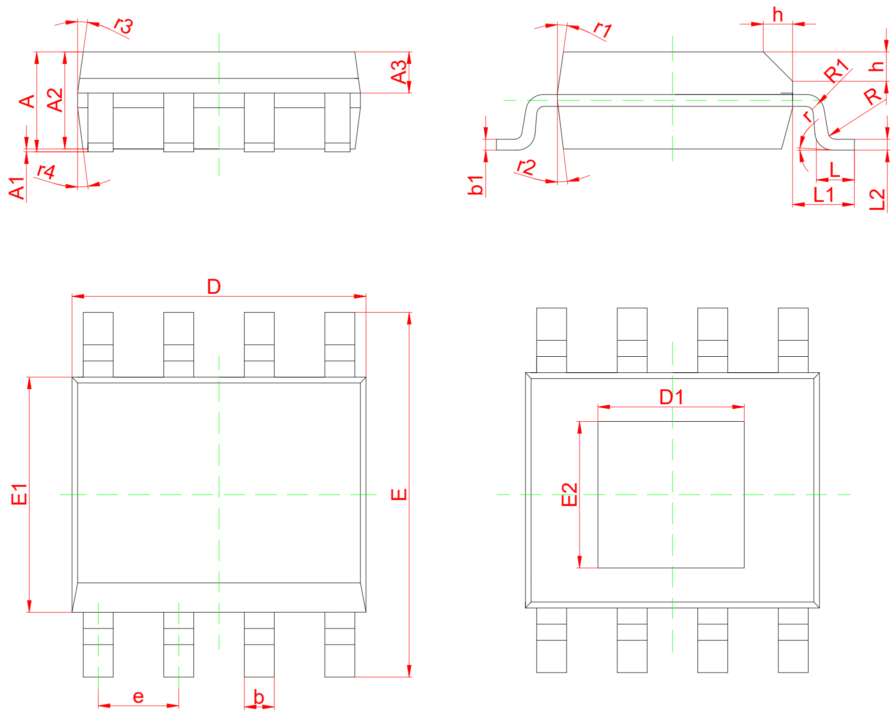


State diagram of a typical charging cycle

●Battery reverse polarity protection

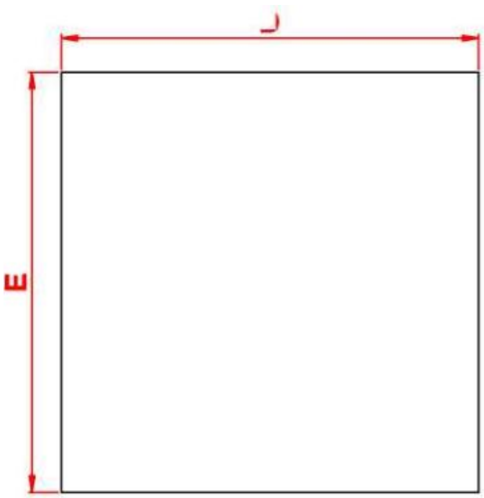
CL4056D has lithium battery reverse connection protection function. When the positive and negative poles of the battery are reversely connected to the voltage output BAT pin of CL4056D, CL4056D will stop and display a fault state without charging current. The charging indicator pin is in a high-impedance state, and the RLED is off. At this time, the leakage current of the reversely connected battery is less than 1mA. Connect the reversed battery correctly, and the CL4056D will automatically start the charging cycle.

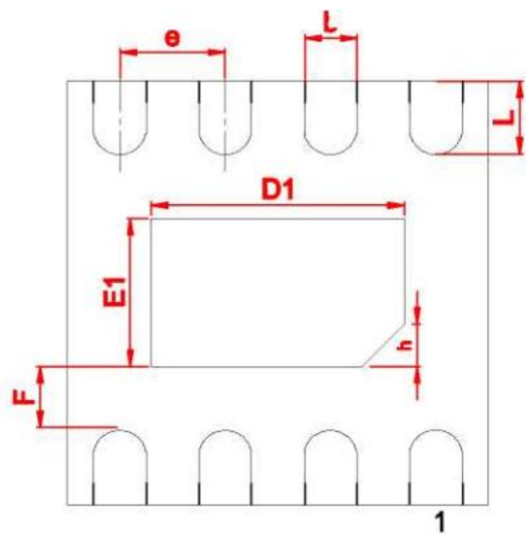
Package Outline：ESOP8

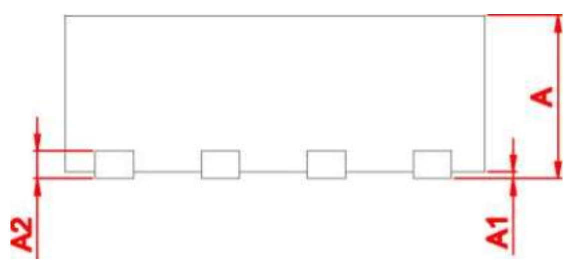


SYMBOL	MIN	NOM	MAX
A	1.35	1.55	1.70
A1	0	0.10	0.15
A2	1.25	1.40	1.65
A3	0.50	0.60	0.70
b	0.38	-	0.51
b1	0.37	0.42	0.47
D	4.80	4.90	5.00
D1	3.10	3.30	3.50
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
E2	2.20	2.40	2.60
e	1.17	1.27	1.37
L	0.45	0.60	0.80
L1		1.04REF	
L2		0.25BSC	
R	0.07	-	-
R1	0.07	-	-
h	0.30	0.40	0.50
r	0°	-	8°
r1	15°	17°	19°
r2	11°	13°	15°
r3	15°	17°	19°
r4	11°	13°	15°

Package Outline：DFN2*2-8







SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.700	0.750	0.800
*A1	0.000	0.020	0.050
* b	0.200	0.250	0.300
*A2	0.180	0.200	0.220
* D	1.900	2.000	2.100
* E	1.900	2.000	2.100
*D1	1.100	1.200	1.300
*E1	0.600	0.700	0.800
* e	0.450	0.500	0.550
* L	0.300	0.350	0.400
* F	0.250	0.300	0.350
h	R	IEF	0