500mA Fully Integrated Linear Charger for 1Cell Li-ion Battery with VINDPM

1 Descriptions

The SC70561x is a highly integrated linear charger for 1cell Li-ion battery applications. It supports up to 500mA charging current and provides battery charge management functions including trickle charge, constant current charge, constant voltage charge, charge termination and charging status indication.

No external sense resistor is needed, and no blocking diode is required. Furthermore, the SC70561x is specifically designed to work with in USB power specifications. Its low external component count makes the SC70561x ideally suited for portable applications. Thermal feedback regulates the charge current to limit their temperature during high power operation or high ambient temperature. The charge current and termination current can be programmed independently with external resistor. The SC70561x automatically terminates the charge cycle when the charge current drops to the programmed value after the final float voltage is reached. When the input supply (wall adapter or USB supply) is removed, the SC70561x automatically enters a low power sleep mode, dropping the battery drain current to less than 0.25μA. The SC70561x can be put into shutdown mode, also reducing the supply current to 0.25μA. Other features include battery pack temperature monitor, under voltage lockout, battery reserve insert protection , automatic recharge and two status pins to indicate charging and charge termination.

The SC70561x also supports input voltage limit (VINDPM). When input source is over-loaded, the input voltage falls below the input voltage limit (VINDPM). The device then reduces the charge current until the input voltage rises above the input voltage limit.

SC70561x is available in DFN 2X2-8 Package.

2 Features

- 26.5V Maximum Input Voltage Rating with Vin Over-Voltage Protection
- Integrated Linear Charger for Single-Cell Battery directly from USB or AC Adapter
- TC to CC Threshold: 2.5V,2.9V
- ±0.8% Accuracy VBAT Target Voltage: 4.2V,4.35V
- Independent Charge Current and Termination Current
- 5mA Termination Current
- 4.45V Fixed Input Voltage Limit(VINDPM)
- Charging Management: Trickle Charge/Constant Current Charge/Constant Voltage Charge/Charge Termination/Auto Recharge
- Battery Reserve Insert Protection
- ISET Short Protection
- Input Under Voltage and Over Voltage Protection
- Thermal Regulation and Thermal Shutdown
- Soft-Start Limits Inrush Current
- Chip Enable Control

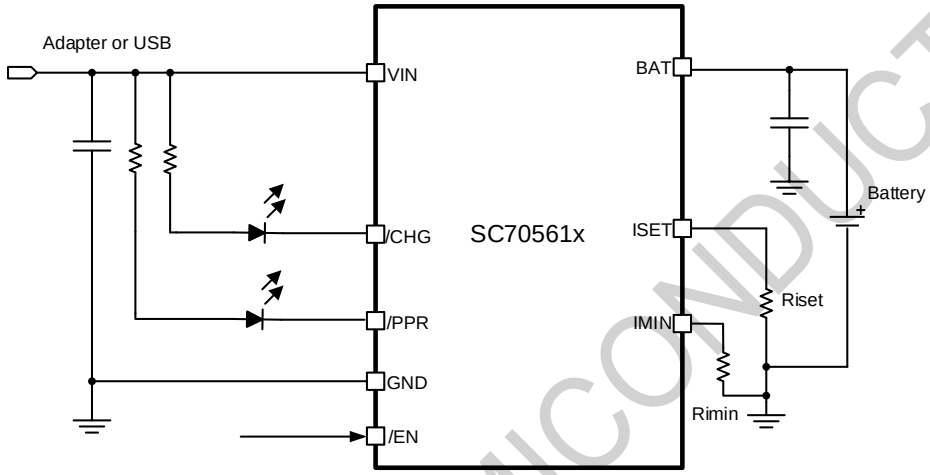
3 Applications

- IOT Gadgets
- Bluetooth Application
- Wearable Devices
- Wireless Remote

4 Device Information

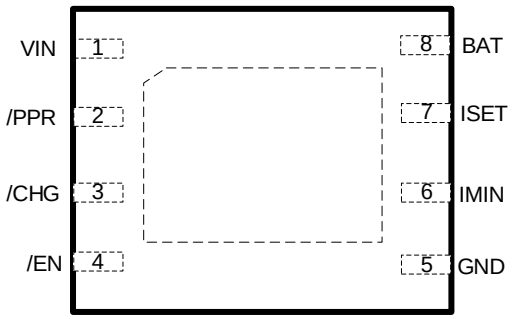
ORDER NUMBER	PARAMETER V_{BAT_TC}	PARAMETER V_{BAT_REG}	PACKAGE	BODY SIZE
SC70561ADDFR	2.9V	4.2V	DFN2X2-8	2mm x 2mm x 0.75mm
SC70561BDDFR	2.9V	4.35V	DFN2X2-8	2mm x 2mm x 0.75mm
SC70561CDDFR	2.5V	4.2V	DFN2X2-8	2mm x 2mm x 0.75mm
SC70561DDDFR	2.5V	4.35V	DFN2X2-8	2mm x 2mm x 0.75mm

5 Typical Application Circuit



6 Terminal Configuration and Functions

TOP VIEW (DFN2X2-8)



TERMINAL		I/O	DESCRIPTION
NUMBER	NAME		
1	VIN	I	Charger Input Supply. Needs to be bypassed with a MLCC capacitor.
2	/PPR	O	Open-Drain Power Presence Indication. The open-drain MOSFET turns on when the input voltage is above the POR threshold but below the OVP threshold (also exit Sleep Mode) and off otherwise. This pin is independent on the /EN pin input.
3	/CHG	O	Open-Drain Charge Indication. This pin outputs a logic low when a charge cycle starts and turns to high impedance when the EOC condition is qualified. When the charger is disabled, the /CHG pin outputs high impedance.
4	/EN	I	Chip enable pin. A low input will put the device in the normal operating mode. Pulling the /EN pin to high level will put the SC70561x into disable mode. /EN pin has an internal 200kΩ pull down resistor.
5	GND	I/O	Ground Pin.
6	IMIN	I	EOC Current Programming Pin. Connect a resistor(R_{IMIN}) between this pin and the GND pin to set the EOC current. The EOC current can be programmed by the following equation: $I_{TERM}=10mA*(R_{IMIN}/R_{ISET})$ Where R_{IMIN} is the resistor between the IMIN pin to GND, R_{ISET} is the resistor between the ISET pin to GND. Suggested I_{TERM} range is $0.05*I_{CC}$ to $0.2*I_{CC}$.
7	ISET	I	Program the charge current and Shutdown. This pin set to 1V in constant-current charge mode. The charge current is programmed by connecting a 1% resistor (R_{ISET}), between ISET, to GND pin. The charge current can be calculated using the following formula: $I_{CC}=1000/ R_{ISET}$ Where R_{ISET} is the resistor between the ISET pin to GND. The ISET pin can also be used to switch the charger to shutdown mode by disconnecting the program resistor from ground.
8	BAT	O	Charger current output pin. Bypass BAT to GND with a MLCC capacitor.

7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

		MIN	MAX	Unit
Voltage range at terminals(2)	VIN	-0.3	26.5	V
	BAT	-8	8	V
	ISET, IMIN, /PPR, /CHG, /EN	-0.3	6	V
T_J	Operating junction range	-40	150	°C
T_{stg}	Storage temperature range	-65	150	°C

(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 under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to network ground terminal.

7.2 Handling Ratings

PARAMETER	DEFINITION		MIN	MAX	UNIT
ESD(1)	Human body model (HBM) ESD stress voltage(2)	All pins	-2	2	kV
	Charged device model (CDM) ESD stress voltage(3)		-1	1	kV

(1) Electrostatic discharge (ESD) to measure device sensitivity and immunity to damage caused by assembly line electrostatic discharges into the device.

(2) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(3) Level listed above is the passing level per EIA-JEDEC JESD22-C101. JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

		MIN	TYP	MAX	UNIT
V_{IN}	Input voltage range(USB Input)	4.5	5	6	V
I_{BAT_CHG}	MAX BAT charge constant current		500		mA
V_{BAT_REG}	VBAT regulation voltage(SC70561A, SC70561C)		4.2		V
	VBAT regulation voltage(SC70561B, SC70561D)		4.35		V
V_{BAT_TC}	Trickle charge to constant current charge threshold(SC70561A, SC70561B)		2.9		V
	Trickle charge to constant current charge threshold(SC70561C, SC70561D)		2.5		V
T_A	Operating ambient temperature	-40		85	°C
T_J	Operating junction temperature	-40		125	°C

7.4 Thermal Information

(4) THERMAL RESISTANCE(1)			Unit
θ_{JA}	Junction to ambient thermal resistance	118	°C/W
θ_{JC}	Junction to case resistance	25	°C/W

Measured on JESD51-7, 4-layer PCB.

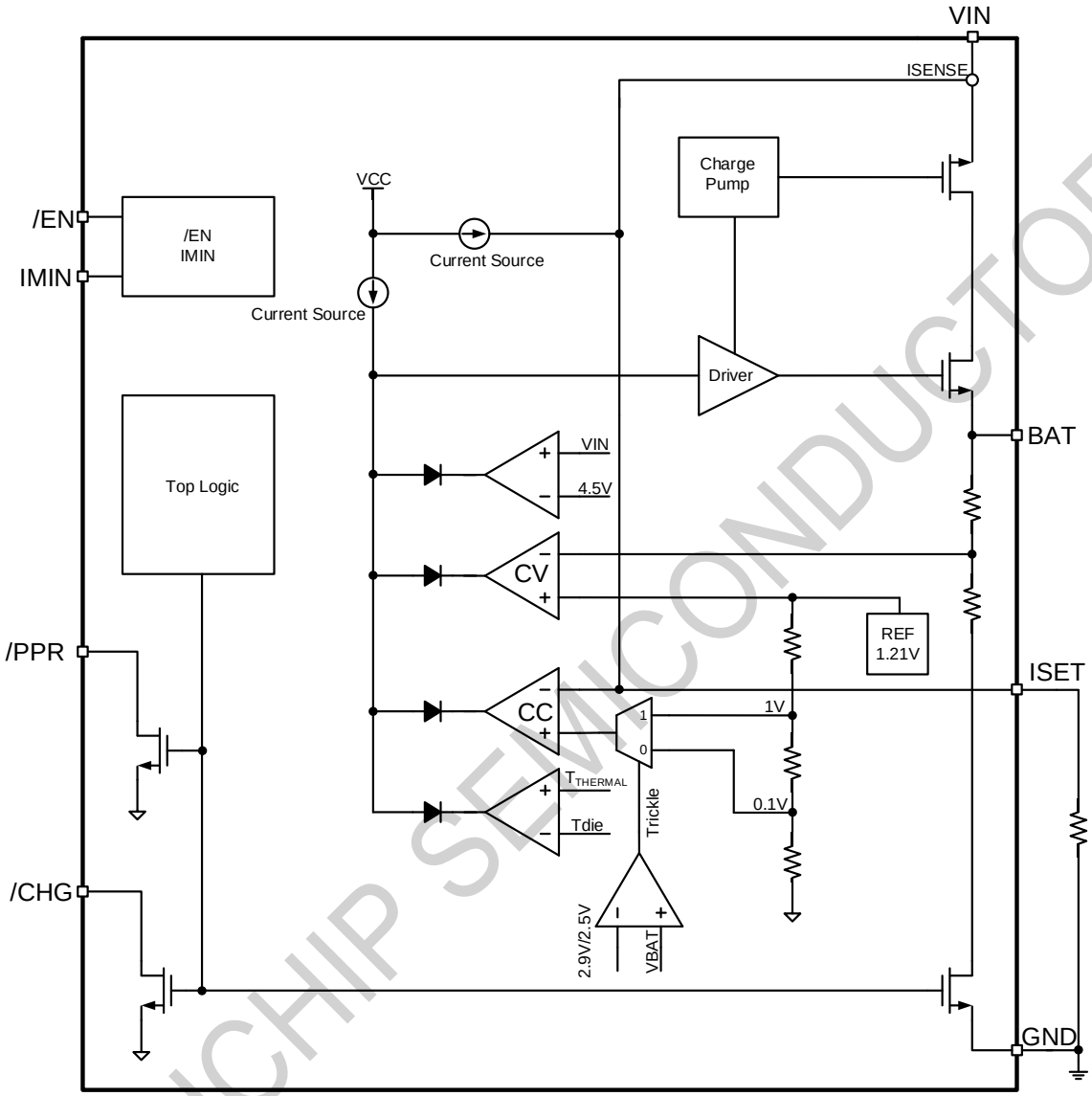
7.5 Electrical Characteristics

T_A= 25°C and V_{IN} = 5V, V_{BAT} = 3.5V unless otherwise noted.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY VOLTAGE and Battery Protection						
V_{IN}	Operating input voltage		4.5	5	6	V
V_{IN_UVLO}	V_{IN} under-voltage lockout threshold	Rising edge	3.55	3.8	4.1	V
		Hysteresis		500		mV
V_{IN_OVP}	V_{IN} over-voltage protection threshold	Rising edge	6.5	6.7	7	V
		Hysteresis		200		mV
V_{SLEEP}	V_{IN} - V_{BAT} under-voltage lockout threshold	Rising edge		100		mV
		Hysteresis		70		mV
I_{IN}	V_{IN} Supply current	Standby Mode (After EOC)		100		μA
		Shutdown Mode (ISET Floating, /EN Low, VIN<V_{BAT}, V_{IN}<V_{IN_UVLO})		40		μA
I_{BAT}	BAT Pin current	Standby Mode (After EOC), V_{BAT} =4.2V		2		μA
		Shutdown Mode (ISET Floating, /EN Low, VIN<V_{BAT}, V_{IN}<V_{IN_UVLO})		250	350	nA
		Sleep Mode (V_{IN}=0V)		250	350	nA
Power						
R_{ON}	RDSON resistance of MOSFET			600		mΩ
Battery Charger Management						
V_{BAT}	BAT regulated voltage	SC70561A SC70561C	4.167	4.2	4.234	V
		SC70561B SC70561D	4.316	4.35	4.385	V
I_{CC}	Constant charge current	R_{ISET}=20kΩ, CC Mode	44	50	56	mA
		R_{ISET}=10kΩ, CC Mode	94	100	106	mA
		R_{ISET}=5kΩ, CC Mode	188	200	212	mA
		R_{ISET}=2kΩ, CC Mode	470	500	530	mA

I_{TC}	Trickle change current			0.1*I_{CC}		
I_{TERM}	Charge termination current	I_{TERM}=5mA	2.5	5	7.5	mA
T_{TERM_DGL}	Termination deglitch time			1		s
V_{BAT_TC}	Trickle charge to constant current charge threshold	VBAT rising (SC70561A,SC70561B)		2.9		V
		VBAT rising (SC70561C,SC70561D)		2.5		V
		Hysteresis		130		mV
V_{RECH}	Battery auto-recharge voltage	V_{BAT_REG}-V_{BAT}		120		mV
T_{RECH_DGL}	Battery auto-recharge deglitch time			0.5		s
V_{I_SET}	I_{SET} PIN voltage	CC Mode		1		V
I_{I_SET}	I_{SET} PIN pull up current			3		μA
T_{SS}	Soft start time	I_{BAT} from 0A to I_{CC}		100		μs
V_{STAT_LOW}	/CHG or /PPR output Low voltage				0.6	V
VINDPM						
V_{INDPM}	Input Voltage limit			4.45		V
Thermal Protection						
T_{J_SD}	Thermal shutdown temperature			150		°C
	Thermal shutdown hysteresis			20		°C
T_{J_REG}	Thermal regulation temperature			120		°C
Logic I/O Pin						
V_{IL}	/EN Low logic voltage threshold				0.4	V
V_{IH}	/EN High logic voltage threshold		1.3			V

8 Functional Block Diagram



9 Feature Description

9.1 Operation

The SC70561x is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 500mA of charge current with a final float voltage accuracy of ±0.8%. The SC70561x includes an internal power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required.

9.2 Input OVP and UVLO

The SC70561x has an input over-voltage protection (VIN_OVP) and an input UVLO threshold. Once the input voltage is out of its normal range, the charger is turned off immediately.

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VIN rises above the under voltage lockout threshold. The UVLO circuit has a built-in hysteresis of 500mV.

9.3 Battery Charge Management

The SC70561x provides charge management functions for 1 cell Li-ion battery. The typical charge profile is shown in Figure 1.

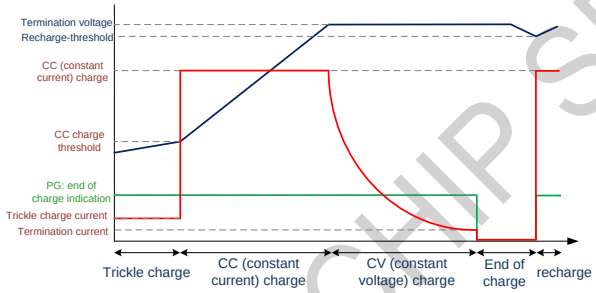


Figure 1 Typical Charge Profile

9.3.1 Trickle Charge

When VBAT is lower than 2.8V(SC70561A,SC70561B)/ 2.4V(SC70561C,SC70561D), the SC70561x charges the battery cells in trickle charge mode(TC). The trickle charge current is 1/10 of setting I_{CC} Current.

9.3.2 Constant Current Charge

When VBAT voltage is charged above 2.9V(SC70561A, SC70561B)/2.5V(SC70561C,SC70561D), the SC70561x enters into constant current charge (CC) mode. The constant current can be programmed via:

I_{CC}=1000/ R_{ISET}

Where R_{ISET} is the resistor between the ISET pin to GND.

9.3.3 Constant Voltage Charge

When the battery voltage rises to 4.2V(SC70561A, SC70561C)/4.35V(SC70561B,SC70561D), the charge mode changes from CC mode to CV mode. In CV mode, the battery voltage is regulated at V_{BAT_REG}. The charge current automatically drops.

9.3.4 Charge Termination Current

I_{TERM}=10mA*(R_{IMIN}/R_{ISET})

Where R_{ISET} is the resistor between the ISET pin to GND.R_{IMIN} is the resistor between the IMIN pin to GND.

9.3.5 Charge Termination/End of Charge

A charge cycle is terminated when the charge current falls to the charge termination current after the final float voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the ISET pin. When the ISET pin voltage falls below 100mV for longer than t_{TERM} (typically 1s), charging is terminated. The charge current is latched off and the SC70561x enters standby mode, where the input supply current drops to 100μA.In this state, all loads on the BAT pin must be supplied by the battery.

A new charge cycle starts when any of the following conditions are valid:

- The input power is recycled .
- Auto-recharge kicks in.
- Pull /EN High then to Low.
- Reconnecting the ISET resistor.

9.3.6 Auto Recharge

When the battery is fully charged and charging is terminated, the battery may be discharged due to system consumption or self-discharge. When the battery voltage is discharged below the recharge threshold and VIN is still in the operating range, the SC70561x begins another new charging cycle automatically without having to restart a charging cycle manually.

9.4 Charge Status indicator

Charge Status	/CHG	/PPR
Charging	Low	Low
Charge Termination	HI-Z	Low
V_{IN} UVLO, V_{IN} OVP, V_{IN} Sleep, V_{IN} Removed	HI-Z	HI-Z
Shutdown mode (/EN High or float ISET Pin)	HI-Z	Low

Table 1 /CHG and /PPR Status

9.5 Manual Shut Down

There are two methods to manual shut down the charger:

1. Pull /EN high.

2. Float the ISET pin by removing the resistor from ISET pin to GND.

Once one of above conditions occurs can put the charger into shutdown mode. The battery drain current reduced to be 250nA and supply current to be 40μA. Reconnecting the ISET resistor or pull /EN low will start a new charger cycle.

9.6 Thermal Regulation and Shut Down

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120°C. This feature protects the SC70561x 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 SC70561x . 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.

Once the die temperature reach to 150°C, the chip enters into shutdown mode, after the temperature back to 130°C, the chip recover normal mode.

9.7 VINDPM

The SC70561x also supports input voltage limit (typical 4.45V). When input source is over-loaded, the input voltage falls below the input voltage limit (VINDPM). The device then reduces the charge current until the input voltage rises above the input voltage limit.

9.8 ISET Short Protection

After Vin power up and /EN is low, SC70561x will have a ISET short detection. When the ISET short is detected, the charge current will be clamped and latched to about 850mA.

A new ISET short detection cycle starts when any of the following conditions are valid:

- The input power is recycled .
- Pull /EN high to low.

10 Application Information

10.1 Input Capacitor Selection

Typically, a 1μF X5R ceramic capacitor should be sufficient to suppress the power supply noise.

10.2 Output Capacitor Selection

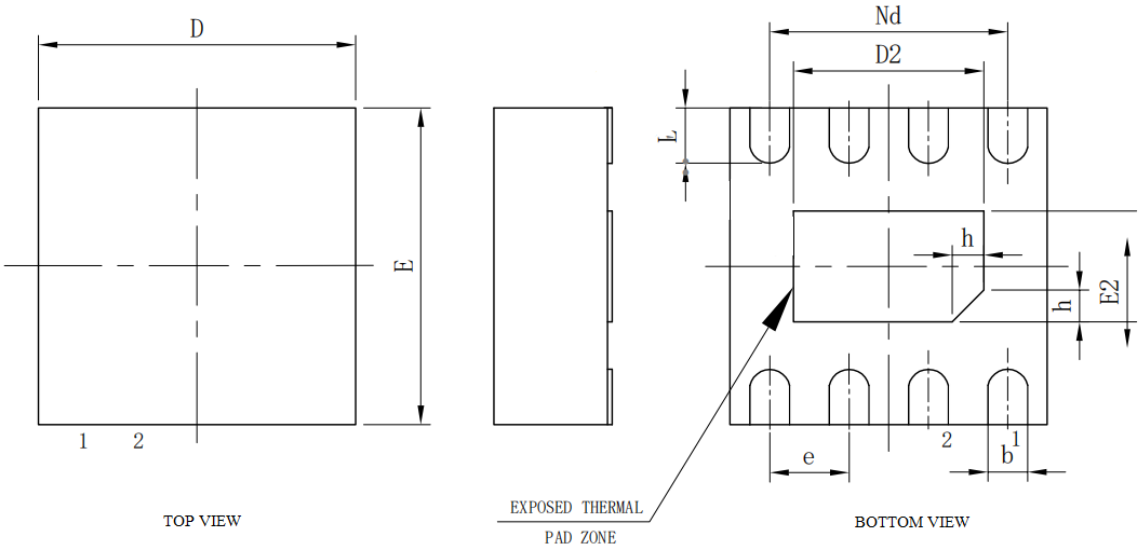
Typically, a 1μF X5R ceramic capacitor to maintain the stability of the charger as well as to bypass any transient load current.

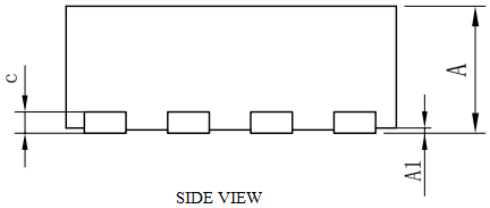
10.3 Layout Guideline

The SC70561x uses DFN package which has an exposed thermal pad at the bottom side of the package. The layout should connect as much as possible to copper on the exposed pad. Typically the component layer is more effective in dissipating heat. The thermal impedance can be further reduced by using other layers of copper connecting to the exposed pad through a thermal via array.

MECHANICAL DATA

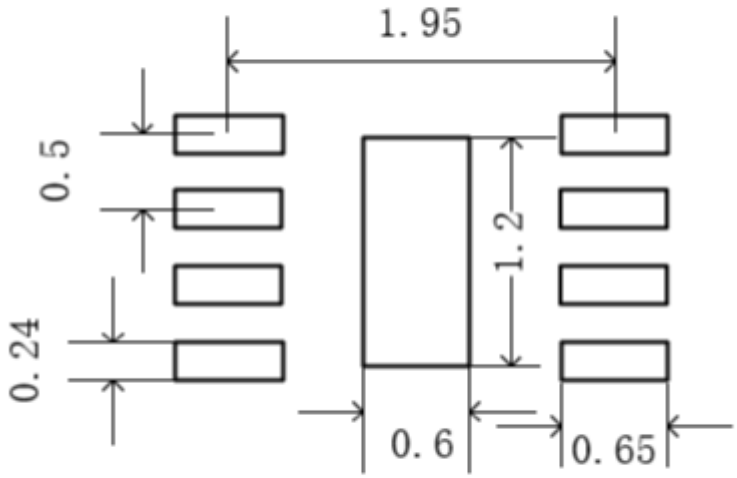
DFN -8 (2mm X 2mm)





SYMBOL	MILLIMETER			
	MIN	NOM	MAX	
A	0.70	0.75	0.80	
	0.80	0.85	0.90	②
	0.85	0.90	0.95	③
A1	—	0.02	0.05	
b	0.18	0.25	0.30	
c	0.18	0.20	0.25	
D	1.90	2.00	2.10	
D2	1.10	1.20	1.30	
e	0.50BSC			
Nd	1.50BSC			
E	1.90	2.00	2.10	
E2	0.60	0.70	0.80	
L	0.30	0.35	0.40	
h	0.15	0.20	0.25	
载体尺寸（mil）	63X39			

RECOMMENDED FOOTPRINT(Unit mm)



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