Li-Ion Linear Battery Charger with LDOs

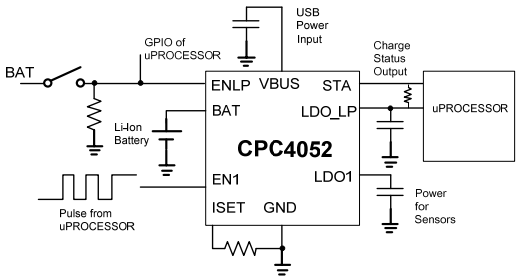
Features

- Charges single-cell Li-Ion batteries with CC/CV algorithm and charge termination
- charge current from 10mAto 600 mAadjustable by external resistor
- Auto-recharge function
- Charging timeout
- Charge status output
- Linear charger with OVP,OCP and OTP
- 3.3V always-on 2uA I_Q LDO
- Enable pulse configuration LDO output voltage
- ESD HBM ±?kV CDM ±?kV
- Package
  - TSOT23-6L
  - DFN1.5*1.58L
  - DFN2*28L
  - QFN2*212L

Applications

- Wristbands
- Smart watches and wearable devices
- Fitness and medical accessories
- Li-Ion battery rechargeable equipment
- Bluetooth beacon
- Ant+ device

Typical Application



Description

The CPC4053 is a highly integrated power management, embedding a linear battery charger, a low power LDO, 2 LDOs with configurable output voltage.Each LDO has an independent enable pin.

The CPC4050/1/2 reduces the channel of LDO and enable pins on the basis of the CPC4053.

The CPC405X uses a CC/CV algorithm to charge the battery.The constant charging current can beprogrammed using external resistor. The charger is automatically powered off when the VBUS pin is not connected to a valid power source.

The CPC405X provides a minimum of 2.25 square millimeters of package, to achieve a multi-channel power control and charging.

Device List

Device	Enable Signal	LDOs
CPC4050	None	1
CPC4051	EN1	2
CPC4052	ENLP,EN1	2
CPC4053	ENLP,EN1,EN2	3

Device Information

Part Number	Package	Size
CPC4050ST	TSOT23-6L	2.9mm∗1.6mm ∗1.1mm(H)
CPC4051DN	DFN1.5*1.5 8L	1.5mm∗1.5mm ∗0.45mm(H)
CPC4052DN	DFN 2*28L	2.0mm∗2.0mm ∗0.75mm(H)
CPC4053QN	QFN 2*2 12L	2.0mm∗2.0mm ∗0.75mm(H)

Pin Configuration

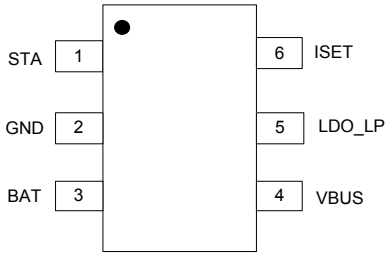


Figure 1　CPC4050TSOT23-6L Pin Assignment（Top View）

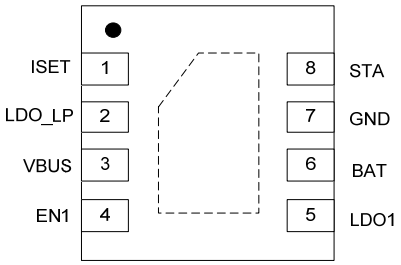


Figure 2 CPC4051 DFN1.5*1.5 8L Pin Assignment（Top View）

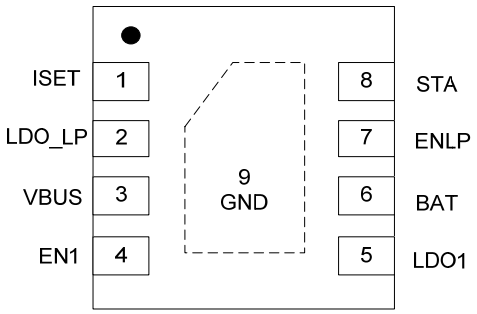


Figure 3 CPC4052 DFN2*2 8L Pin Assignment（Top View）

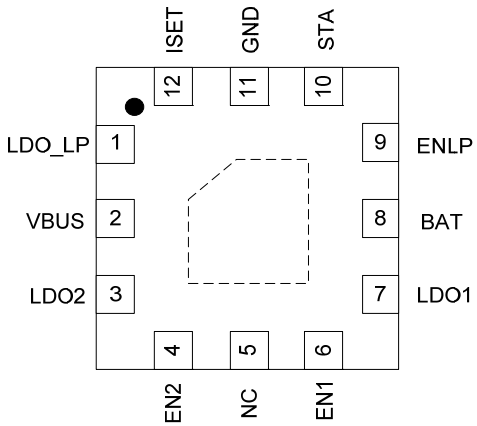


Figure 4 CPC4053 QFN 2*2 12L Pin Assignment（Top View）

Pin Description

CPC4050

Name	I/O	Description
ISET	I	Charge Current Program
GND	G	Ground
LDO_LP	O	3.3V output
BAT	P	Li-ion battery
VBUS	P	Power
STA	O	Open-Drain Charge Status Output, pull down when charging

CPC4051

Name	I/O	Description
ISET	I	Charge Current Program
EN1	I	Configuration pin of LDO1
GND	G	Ground
LDO_LP	O	3.3V output
LDO1	O	0.9~3.3V output
BAT	P	Li-ion battery
VBUS	P	Power
STA	O	Open-Drain Charge Status Output, pull down when charging

CPC4052

Name	I/O	Description
ISET	I	Charge Current Program
ENLP	I	Enable pin of LDO_LP
EN1	I	Configuration pin of LDO1
GND	G	Ground
LDO_LP	O	3.3V output
LDO1	O	0.9~3.3V output
BAT	P	Li-ion battery
VBUS	P	Power
STA	O	Open-Drain Charge Status Output, pull down when charging

CPC4053

Name	I/O	Description
ISET	I	Charge Current Program
ENLP	I	Enable pin of LDO_LP
EN1	I	Configuration pin of LDO1
EN2	I	Configuration pin of LDO2
GND	G	Ground
LDO_LP	O	3.3V output
LDO1	O	0.9~3.3V output
LDO2	O	0.9~3.3V output
BAT	P	Li-ion battery
VBUS	P	Power
STA	O	Open-Drain Charge Status Output, pull down when charging

Typical Applications

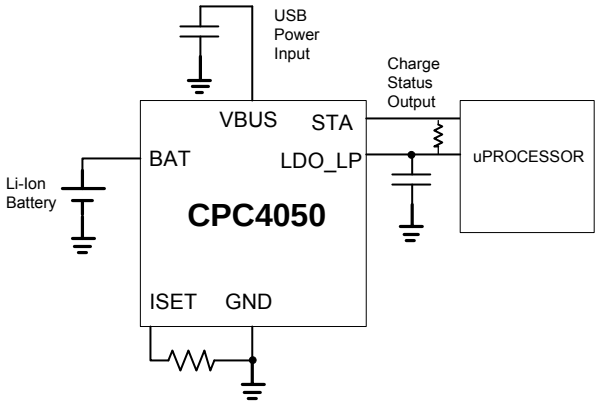


Figure 5 CPC4050 application

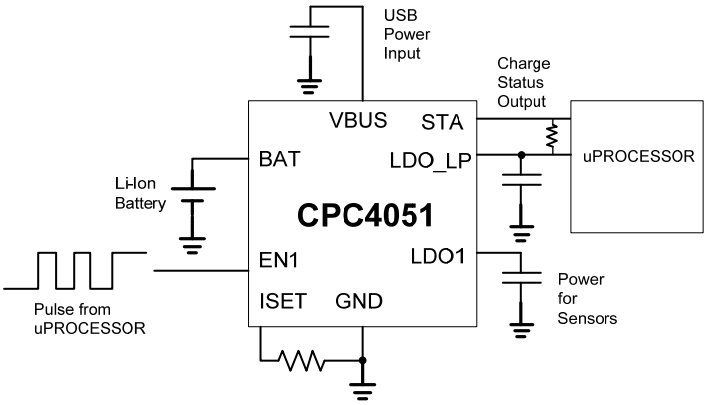


Figure 6 CPC4051 application

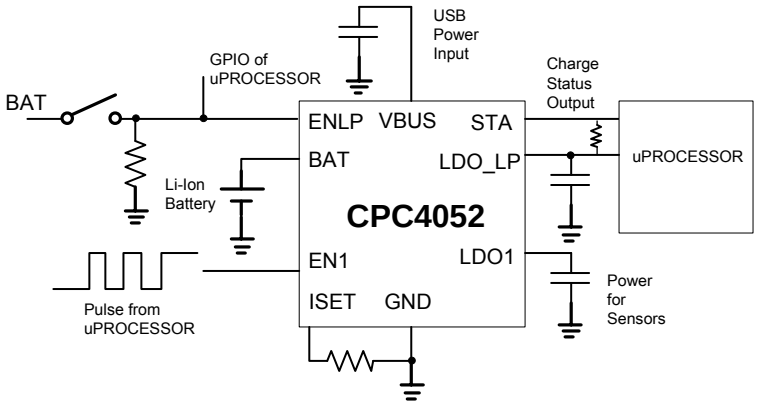


Figure 7 CPC4052 application

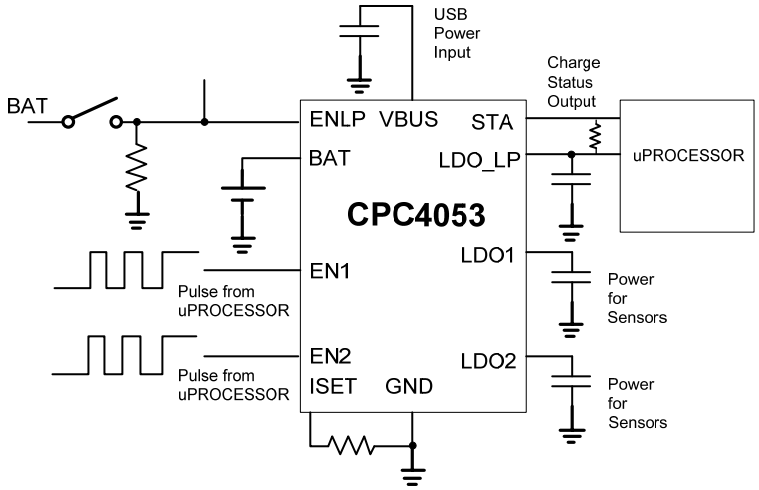


Figure 8 CPC4053 application

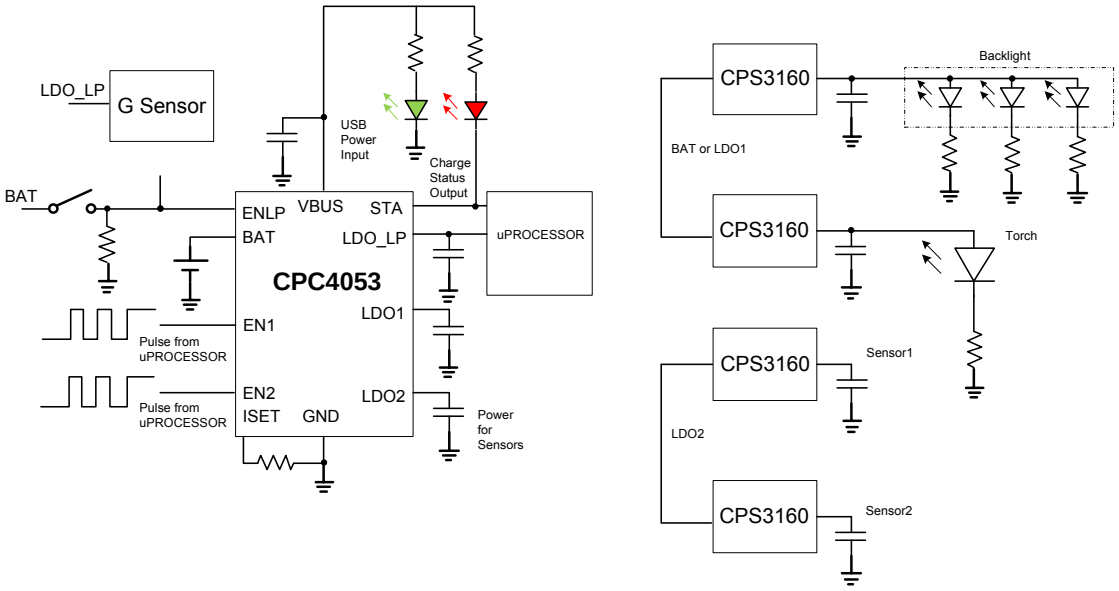


Figure 9 CPC4053 application with loadswitches

Absolute Maximum Ratings*

Parameter	Range
VBUS voltage range	-0.3V～7V
Other than IN and OUT Pins	-0.3～5.5V
Maximum junction temperature	150℃
Storage temperature range	-65℃~150℃
Working temperature range	-40℃～125℃
TSOT23 Junction to ambient thermal resistance θ_{JA}	180℃/W
DFN 1.5*1.5 Junction to ambient thermal resistance θ_{JA}	120℃/W
DFN 2*2 Junction to ambient thermal resistance θ_{JA}	80℃/W
QFN2*2 Junction to ambient thermal resistance θ_{JA}	100℃/W

***note：** Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratingsonly, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operatingconditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Parameter	Min	Typ	Max	Unit
Input voltage range V_{BUS}	4.5	5.0	5.5	V
BAT voltage range	2.9		4.2	V
Operating Ambient Temperature T_A	-40		125	℃

ESD Ratings

V_{ESD} Electrostatic discharge	Human-body model (HBM), per MIL-STD-883J Method 3015.9	±?V
	Charged-device model (CDM), per ANSI/ESDA/JEDECJS-002-2014	±?V

Latch-up Ratings

Trigger Current	perJEDEC STANDARD NO.78E NOVEMBER 2016	±?mA

Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Unit
V_{VBUS}	Input Voltage Range of VBUS	4.5		6.5	V
I_{SHDN}	ENLP=0 (CPC4052/3) No power on VBUS		0.1	0.5	uA
I_{Q_LP}	Quiescent Supply Current of LDO_LP No power on VBUS		2		uA
I_{Q_LDO}	Quiescent Supply Current of 1 channel LDO. No load, powered by battery.		20		uA
I_{CHA_FINISH}	Quiescent Supply Current ofVBUS when battery charging finished		30		uA
I_{CHA}	Constant charging current ISET=100mA	95	100	105	mA
I_{CHA_range}	Charging current range	10		600	mA
V_{LIM}	Max voltage of BAT	4.18	4.2	4.22	V
V_{PRE_CHA}	Pre-charge to normal charge battery voltage threshold	2.85	2.9	2.95	V
V_{ISET}	The voltage of ISET	0.97	1	1.03	V
V_{UVLO}	Threshold of VBUS UVLO	3.6	3.8	4.0	V
V_{UVLO_HYS}	Hysteresis of VBUS UVLO		0.2		V
V_{OVP}	Threshold of VBUS OVP	5.9	6.2	6.5	V
V_{OVP_HYS}	Hysteresis of VBUS OVP		0.3		V
T_{TO}	**Charge timeout**	**4.5**	**6**	**7.5**	**hour**
V_{LDO_LP}	Output of LDO_LP	3.2	3.3	3.4	V
V_{LDO1}	**Output of LDO1 (none in CPC4050)**	**0.9**		**3.3**	**V**
V_{LDO2}	Output of LDO2 (CPC4053)	0.9		3.3	V
IO_{LDO_LP}	**Overload protection of LDO_LP, V_{LDO_LP}<1.5V, VBAT=3.8V**	**68**	**90**		**mA**
IO_{LDO1}	**Current limit of LDO1 (none in CPC4050)**	**64**	**80**	**96**	**mA**
IO_{LDO2}	Current limit of LDO2 (CPC4053)	64	80	96	mA
V_{EN_H}	ENLP,EN1, EN2 Rising Threshold VBAT=4.2V	1.3			V
V_{EN_L}	ENLP,EN1, EN2 Falling Threshold			0.4	V
T_{SHDN}	EN1, EN2Shutdown delay (none in CPC4050)			2	ms
OTP	Over temperature of the switch		145		℃
OTP_HYS	Hysteresis of OTP		25		℃

Applications Information

Battery charger

The CPC405X allows single-cell Li-Ion and Li-Poly battery chemistry to be charged up to a 4.2 V using a CC/CV charging algorithm. The charging cycle starts when a valid input voltage source (V_{UVLO}< VBUS< V_{OVP}) is detected and signaled by the STA pin toggling from a high impedance state to a low logic level.

If the battery is deeply discharged (the battery voltage is lower than V_{PRE_CHA}), the CPC405X charger enters the pre-charge phase and starts charging in constant-current mode with the 20% of charge current set.

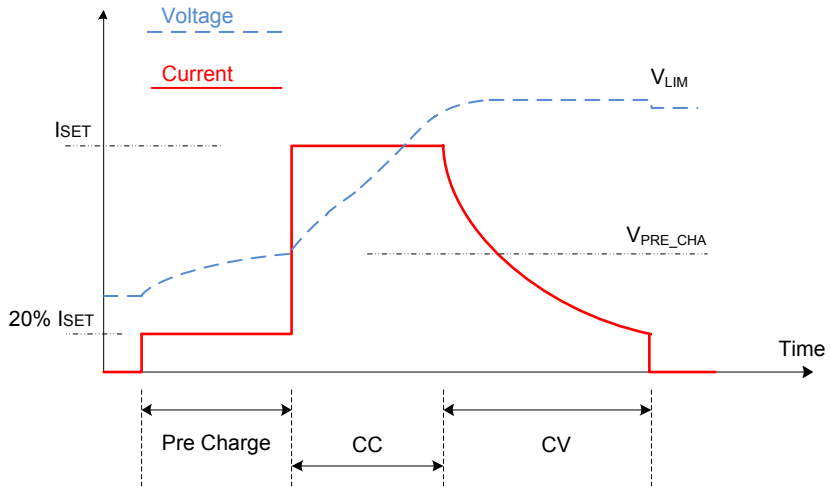


Figure 10 Charging Profile

Input OVP(over voltage protection), charge OCP(over current protection), charge timeout protection, recharge cycle, OTP(over temperature protection). Many of the above protection to protect the charge of the various abnormalities in the process will not damage the battery. Charging current should not exceed 1C, charging cut-off voltage should not exceed 4.2V.

LDOs

The low power LDO itself consumes only 2uA current, constant 3.3V output.It is not recommended to start the lowpower LDO with a load of more than 10mA because of an undesired overshoot.

The output voltage of the other two LDOs is controlled by the respective enable pins.

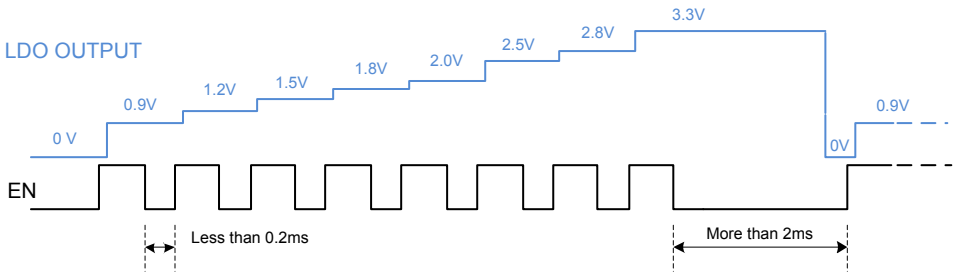


Figure 11 EN pulse vs LDO Output

The number of pulses on the EN pin set the LDO output voltage. If the output needs 1.8V, then send 4 pulses is ok, if you need to change from 1.8V to 3.3V, then send four pulses. If you want to change from 1.8V to 1.2V, first pull down more than 2ms, and then send two pulses, rather than continue to send 6 pulses, although it can get 1.2V, but the output will experience a maximum of 3.3V.

Passive device selection

VBUS capacitors: Many types of capacitors can be used for input bypassing,however, caution must be exercised when using multilayerceramic capacitors. Because of the self-resonant andhigh Q characteristics of some types of ceramic capacitors,high voltage transients can be generated under somestart-up conditions, such as connecting the charger inputto a live power source. Adding a 1.5 ohmresistor in serieswith an X5R ceramic capacitor will minimize start-upvoltage transients.A 10uF 10V X5R ceramic capacitor is suitable.

LDO output capacitors: A 6V 1uF to 10uF X5R ceramic capacitor is suitable for each channel.

ISET resistor: The charge current is programmed using a single resistorfrom the ISET pin to ground. The charging current setting formula is as follow
ISET= 1000V/R
It is recommended to use a 1% resistor.

VBAT capacitors: Usually do not need, but want to replace the battery when the system is still powered, it is recommended to connect a 1uF 6V capacitor.

Load switches for more power path

A system may require more than 3 different voltage power paths, but not at the same time. Can be increased by the loadswitches to achieve multi-channel multiplexing power supply.

Capacity degradation of Li-ion battery at different charging conditions

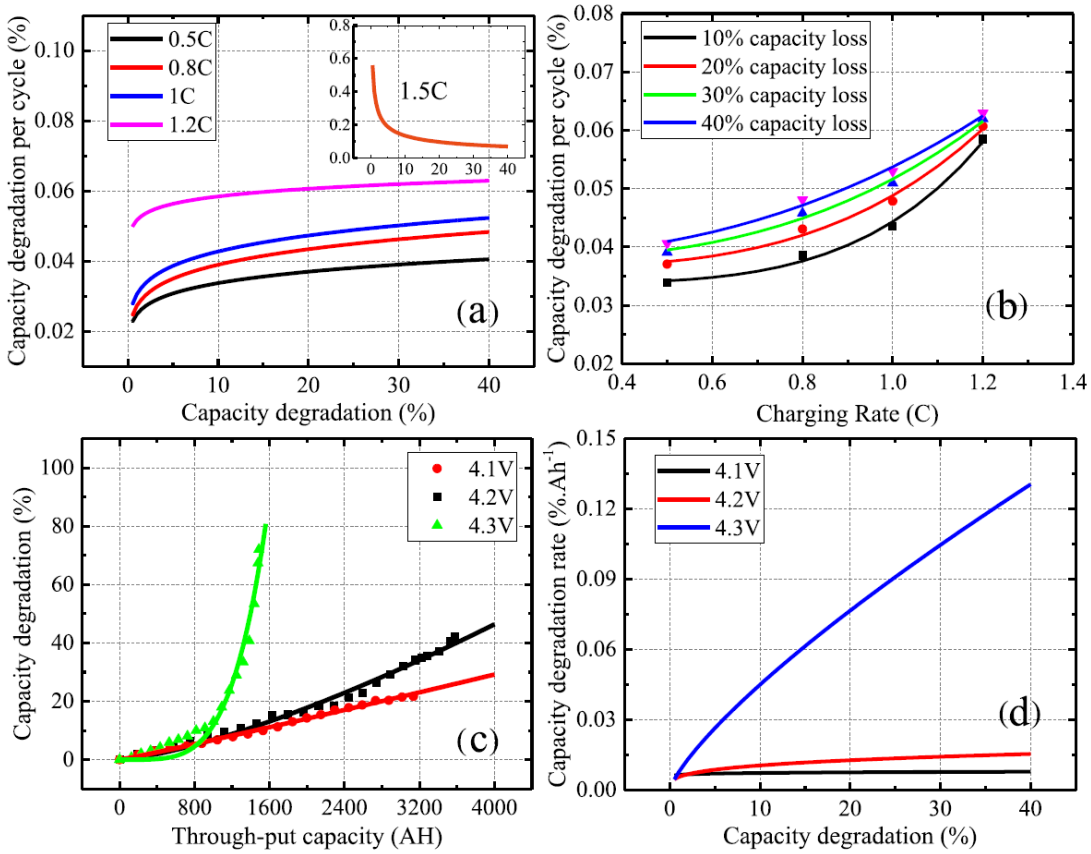


Figure 12 Capacity degradation

(a) Capacity degradation speed at different battery aging states.

(b) Capacity degradation speed at different charging current rates.

(c) The capacity degradation of the testedbatteries upon continuous cycle aging at different cut-off voltages.

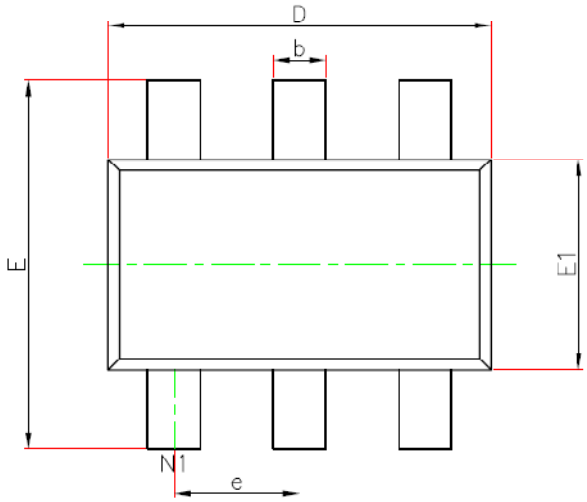
(d) Capacity degradation rate at different cut-off voltages.

References

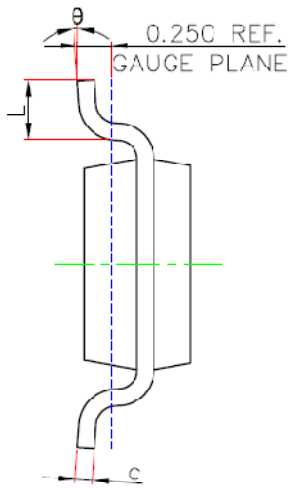
[1] Lithium-ion battery aging mechanisms and life model under different charging stresses, Journal of Power Sources 336(2017)103~114.

Package Description

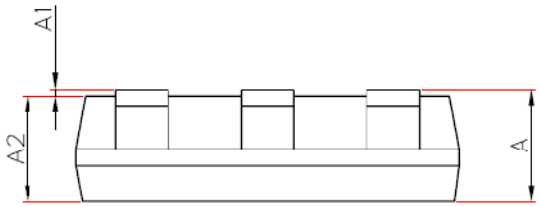
TSOT23-6L



TOP VIEW



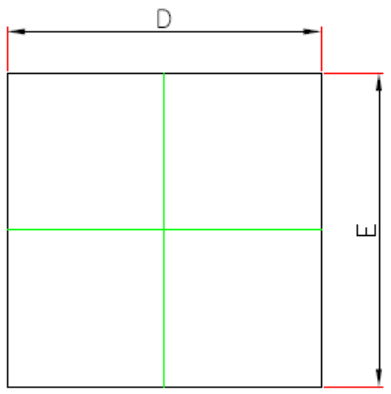
SIDE VIEW



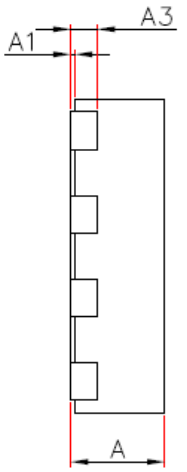
SIDE VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	------	1.100	------	0.043
A1	0.000	0.100	0.000	0.004
A2	0.700	1.000	0.028	0.039
D	2.850	2.950	0.112	0.116
E	2.650	2.950	0.104	0.116
E1	1.550	1.650	0.061	0.065
b	0.300	0.500	0.012	0.020
c	0.080	0.200	0.003	0.008
e	0.950(BSC)		0.037(BSC)	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

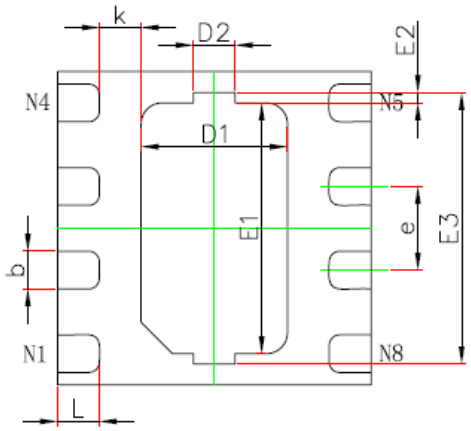
DFN1.5*1.58L



TOP VIEW



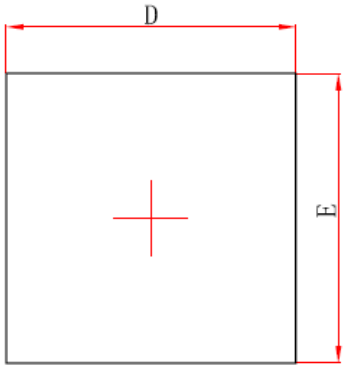
SIDE VIEW



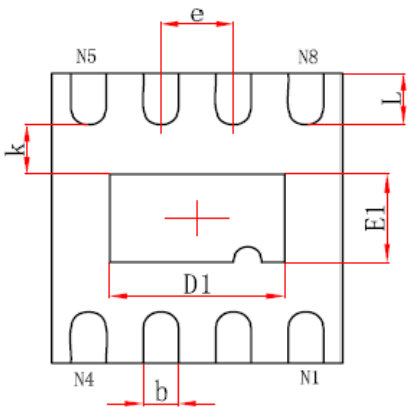
BOTTOM VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.400	0.500	0.016	0.020
A1	0.000	0.050	0.000	0.002
A3	0.127REF		0.005REF	
D	1.450	1.550	0.057	0.061
E	1.450	1.550	0.057	0.061
D1	0.600	0.800	0.024	0.031
D2	0.200REF		0.008REF	
E1	1.100	1.300	0.043	0.051
E2	0.050REF		0.002REF	
E3	1.200	1.400	0.047	0.055
k	0.200REF		0.008REF	
b	0.150	0.250	0.006	0.010
e	0.400BSC		0.016BSC	
L	0.150	0.250	0.006	0.010

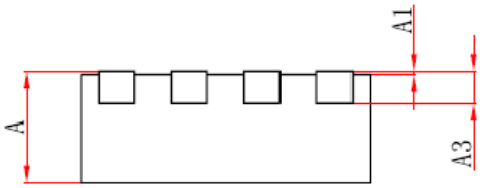
DFN2*2 8L



Top View



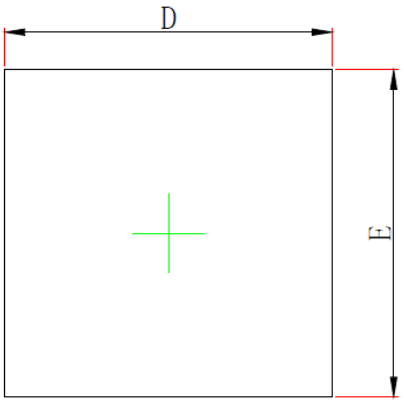
Bottom View



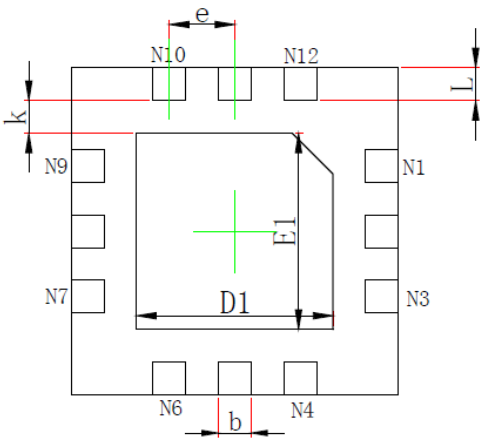
Side View

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF		0.008REF	
D	1.900	2.100	0.075	0.083
E	1.900	2.100	0.075	0.083
D1	1.100	1.300	0.043	0.051
E1	0.500	0.700	0.020	0.028
k	0.200MIN		0.008MIN	
b	0.180	0.300	0.007	0.012
e	0.500TYP		0.020TYP	
L	0.250	0.450	0.010	0.018

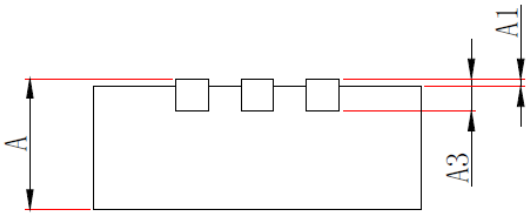
QFN2*2 12L



Top View



Bottom View



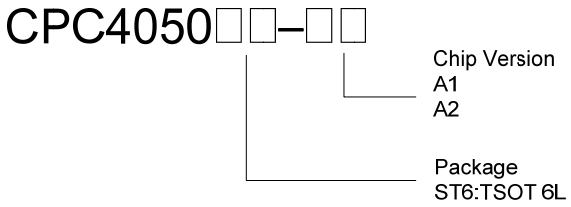
Side View

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF		0.008REF	
D	1.900	2.100	0.075	0.083
E	1.900	2.100	0.075	0.083
D1	1.100	1.300	0.043	0.051
E1	1.100	1.300	0.043	0.051
k	0.200REF		0.008REF	
b	0.170	0.270	0.007	0.011
e	0.400BSC		0.016BSC	
L	0.150	0.250	0.006	0.010

Ordering Information

Order Number	Temperature Range	Package	RoHS	Marking	Packing Type
CPC4050ST6-A1	-40℃～85℃	TSOT23-6L	YES	C4050/LLLL	3000 Pcs/reel
CPC4051DN8-A1	-40℃～85℃	DFN1.5*1.5-8L	YES	4051/LLL	3000 Pcs/reel
CPC4052DN8-A1	-40℃～85℃	DFN2*2-8L	YES	4052/LLL	3000 Pcs/reel
CPC4053QN12-A1	-40℃～85℃	QFN2*2-12L	YES	4053/LLL	3000 Pcs/reel

Note：”LLL”represents Lot No



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