

# Li-Ion Linear Battery Charger with LDOs

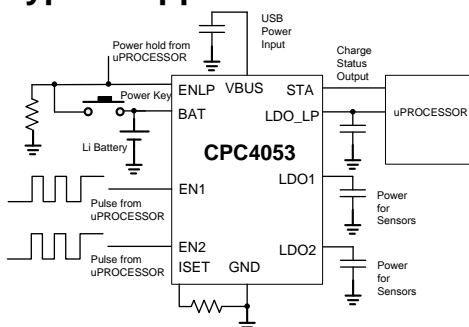
## Features

- Charges single-cell Li-Ion batteries with CC/CV algorithm and charge termination
- charge current from 10mA to 600 mA adjustable by external resistor
- Auto-recharge function
- Charging timeout
- Charge status output
- Linear charger with OVP,OCP and OTP
- 3.3V always-on 1.5uA I<sub>Q</sub> LDO
- Enable pulse configuration LDO output voltage
- ESD HBM ±4kV CDM ±2kV
- Package
  - SOT23-6L
  - MSOP-8L
  - DFN 1.5\*1.5 8L
  - DFN 2\*2 8L
  - QFN 2\*2 12L

## Applications

- Wearable devices
- IOT
- Smart watches
- Fitness and medical accessories
- Wireless sensor networks
- Bluetooth beacon
- Ant+ device
- Embedded camera
- Remote control

## Typical Application



## Description

The CPC4053/4 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 en pins on the basis of the CPC4053.

The CPC405X uses a CC/CV algorithm to charge the battery. The constant charging current can be programmed 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
CPC4050ST	None	1
CPC4050MS	ENLP	1
CPC4051DN	EN1	2
CPC4052DN	ENLP,EN1	2
CPC4053/4QN	ENLP,EN1,EN2	3

## Device Information

Part Number	Package	Size
CPC4050ST	SOT23-6L	2.9mm*1.6mm *1.2mm(H)
CPC4050MS	MSOP-8L	4.9mm*3.0mm *1.0mm(H)
CPC4051DN	DFN1.5*1.5 8L	1.5mm*1.5mm *0.45mm(H)
CPC4052DN	DFN 2*2 8L	2.0mm*2.0mm *0.75mm(H)
CPC4053/4QN	QFN 2*2 12L	2.0mm*2.0mm *0.55mm(H)

## Pin Configuration

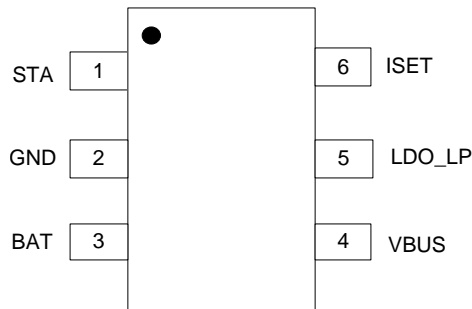


Figure 1 CPC4050 SOT23-6L Pin Assignment (Top View)

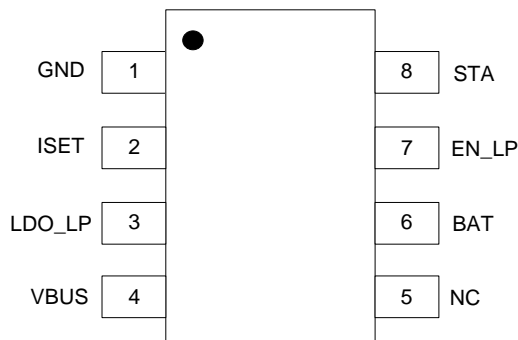


Figure 1 CPC4050 MSOP-8L Pin Assignment (Top View)

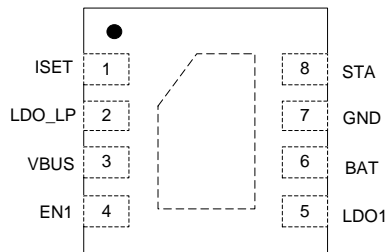


Figure 2 CPC4051 DFN 1.5\*1.5 8L Pin Assignment (Top View)

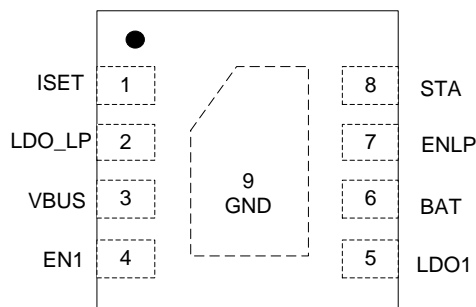


Figure 3 CPC4052 DFN 2\*2 8L Pin Assignment (Top View)

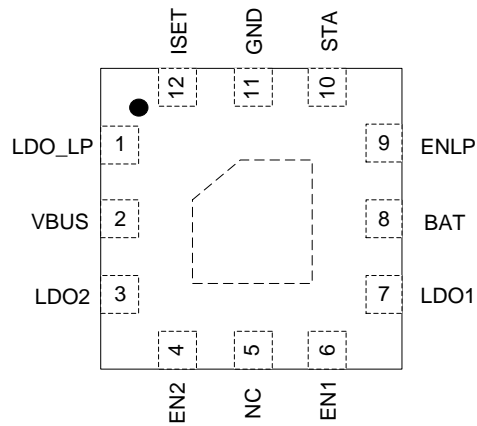


Figure 4 CPC4053 QFN 2\*2 12L Pin Assignment (Top View)

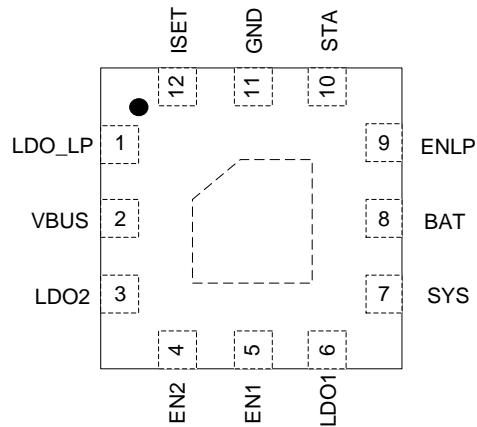


Figure 5 CPC4054 QFN 2\*2 12L Pin Assignment (Top View)

## Pin Description

### CPC4050ST

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

### CPC4050MS

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
ENLP	I	Enable pin of LDO_LP, no pull down or pull up resistor, do not left floating

**CPC4051**

Name	I/O	Description
ISET	I	Charge Current Program
EN1	I	Configuration pin of LDO1, 850k pull down resistor inside
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, no pull down or pull up resistor, do not left floating
EN1	I	Configuration pin of LDO1, 850k pull down resistor inside
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, no pull down or pull up resistor, do not left floating
EN1	I	Configuration pin of LDO1, 850k pull down resistor inside
EN2	I	Configuration pin of LDO2, 850k pull down resistor inside
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
NC	/	None

**CPC4054**

Name	I/O	Description
ISET	I	Charge Current Program
ENLP	I	Enable pin of LDO_LP, no pull down or pull up resistor, do not left floating
EN1	I	Configuration pin of LDO1, 850k pull down resistor inside
EN2	I	Configuration pin of LDO2, 850k pull down resistor inside
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
SYS	P	Power of LDOs input

## Typical Applications

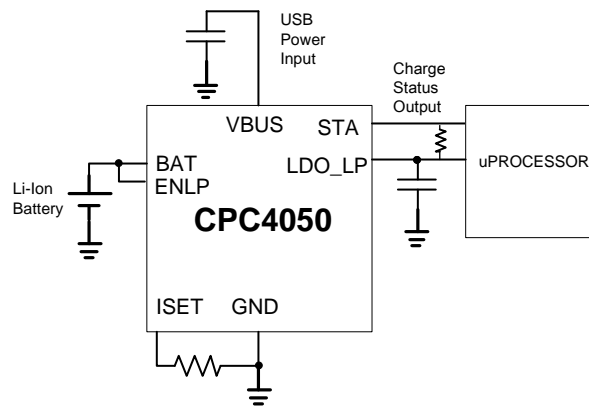


Figure 6 CPC4050 application

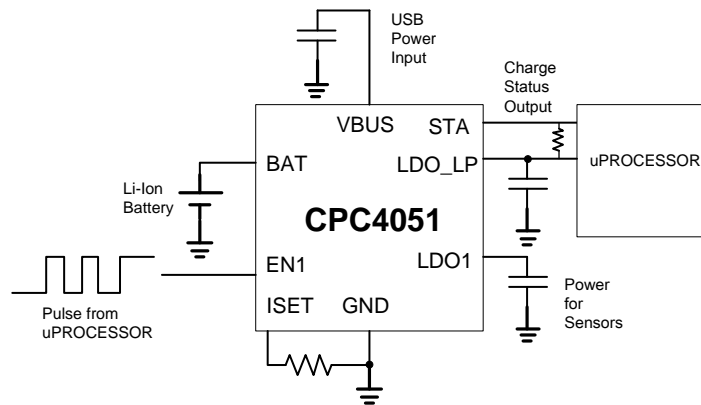


Figure 7 CPC4051 application

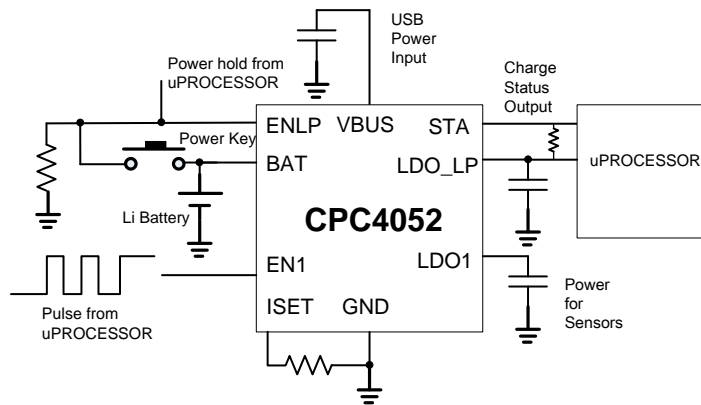


Figure 8 CPC4052 application

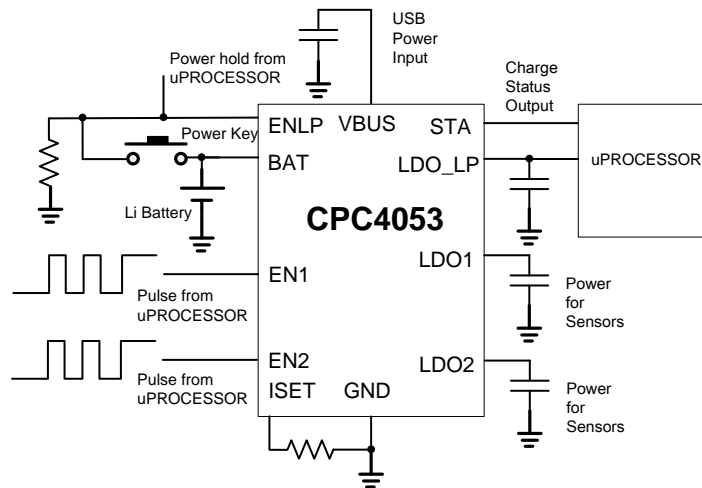


Figure 9 CPC4053 application

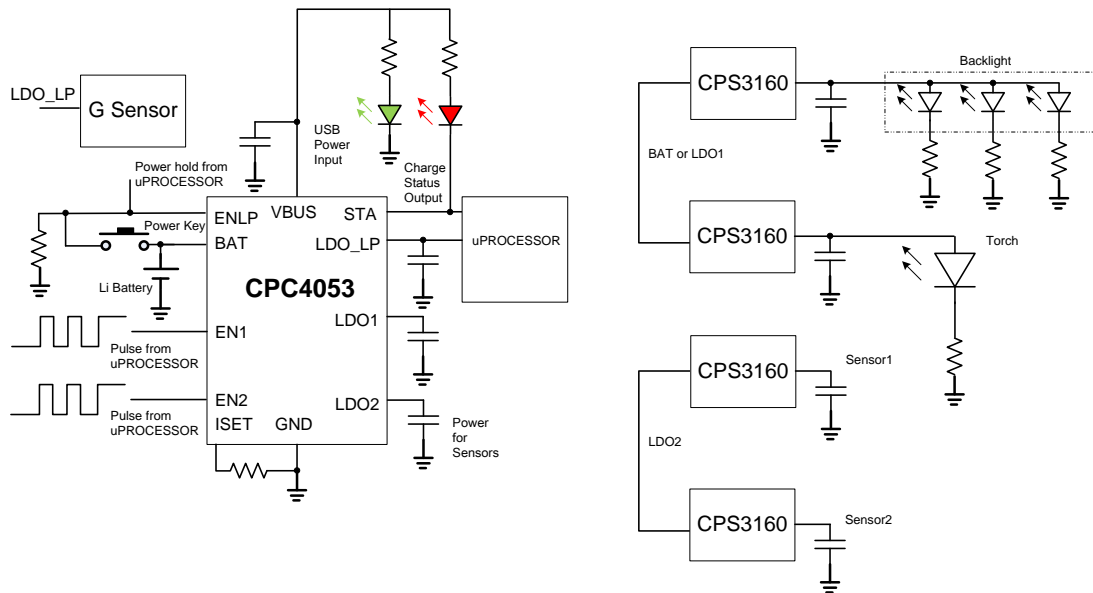


Figure 10 CPC4053 application with loadswitches

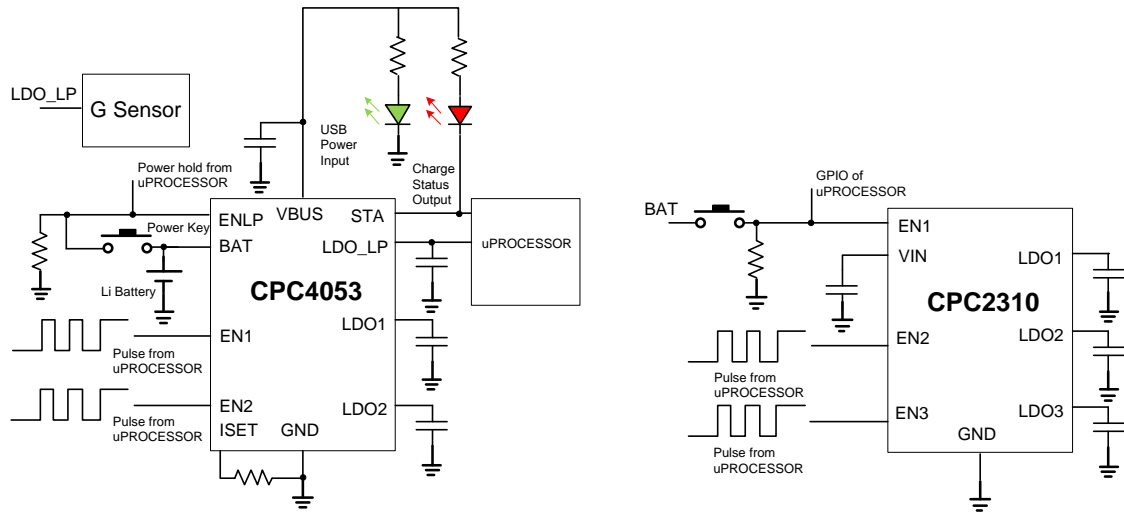


Figure 11 CPC4053 application with multichannel LDO

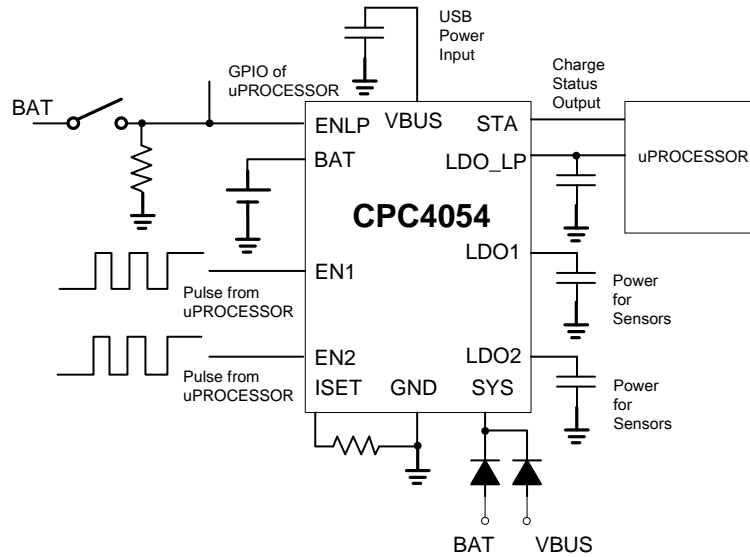


Figure 12 CPC4054 application



## Absolute Maximum Ratings\*

Parameter	Range
VBUS voltage range	-0.3V~7V
Other than IN and OUT Pins	-0.3V~5.5V
Maximum junction temperature	150
Storage temperature range	-65 ~150
SOT23 Junction to ambient thermal resistance $\theta_{JA}$	180 /W
MSOP8 Junction to ambient thermal resistance $\theta_{JA}$	180 /W
DFN 1.5*1.5 Junction to ambient thermal resistance $\theta_{JA}$	120 /W
DFN 2*2 Junction to ambient thermal resistance $\theta_{JA}$	80 /W
QFN 2*2 Junction to ambient thermal resistance $\theta_{JA}$	80 /W

**\*note:** 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.

## 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	±4kV
	Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002-2014	±2kV

## Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Unit
V <sub>VBUS</sub>	Input Voltage Range of VBUS	4.5		6.5	V
I <sub>SHDN</sub>	ENLP=0 (CPC4052/3/4) No power on VBUS, T <sub>A</sub> =25		0.1	0.3	uA
I <sub>Q_LP</sub>	Quiescent Supply Current of LDO_LP No power on VBUS, T <sub>A</sub> =25		1.5	2.0	uA
I <sub>Q_LDO</sub>	Quiescent Supply Current of single channel LDO. No load, powered by battery.		25		uA
I <sub>CHA_FINISH</sub>	Quiescent Supply Current of VBUS when battery charging finished		30		uA
I <sub>CHA</sub>	Constant charging current ISET=100mA	90	100	110	mA
I <sub>CHA_range</sub>	Charging current range Programmed by external resistor	10		600	mA
V <sub>LIM</sub>	Max voltage of BAT (no-load battery voltage, When the charge is over) CPC405X	4.16		4.20	V
V <sub>LIM_H</sub>	Max voltage of BAT (no-load battery voltage, When the charge is over) CPC405XB	4.32		4.36	V
V <sub>PRE_CHA</sub>	Pre-charge to normal charge battery voltage threshold	2.8	2.9	3.0	V
V <sub>PRE_CHA_HYS</sub>	Hysteresis of Pre-charge voltage		0.2		V
V <sub>ISET</sub>	The voltage of ISET	0.97	1	1.03	V
V <sub>UVLO</sub>	Threshold of VBUS UVLO	3.6	3.8	4.0	V
V <sub>UVLO_HYS</sub>	Hysteresis of VBUS UVLO		0.2		V
V <sub>OVP</sub>	Threshold of VBUS OVP	5.9	6.2	6.5	V
V <sub>OVP_HYS</sub>	Hysteresis of VBUS OVP		0.3		V
T <sub>TO</sub>	Charge timeout	6	7.5	9	hour
V <sub>LDO_LP</sub>	Output of LDO_LP, only EN_LP=1	3.2	3.3	3.4	V
V <sub>LDO1</sub>	Output of LDO1 (CPC4051/2/3) Configured by EN1	0.9		3.3	V
V <sub>LDO2</sub>	Output of LDO2 (CPC4053) Configured by EN2	0.9		3.3	V
V <sub>LDO_accuracy</sub>	The accuracy of LDO1 & LDO2	-4		4	%
RO <sub>LDO_LP</sub>	Output resistor of LDO_LP, VBAT=3.4V		1.02		Ω
RO <sub>LDO</sub>	Output resistor of LDO1 and LDO2, VBAT=3.4V		0.96		Ω

IO <sub>LDO_LP</sub>	Current limit of LDO_LP	160	200	240	mA
IO <sub>LDO1</sub>	Current limit of LDO1 (CPC4051/2/3/4)	240	300	360	mA
IO <sub>LDO2</sub>	Current limit of LDO2 (CPC4053/4)	240	300	360	mA
V <sub>EN_H</sub>	ENLP,EN1,EN2 Rising Threshold, VBAT=4.2V	1.3			V
V <sub>EN_L</sub>	ENLP,EN1,EN2 Falling Threshold			0.4	V
R <sub>PD</sub>	Pull down resistor on EN1 & EN2		850k		Ω
T <sub>SHDN</sub>	EN1, EN2 Shutdown 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 (4.35V on CPC405XB) using a CC/CV charging algorithm. The charging cycle starts when a valid input voltage source ( $V_{UVLO} < V_{BUS} < V_{OVP}$ ) 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.

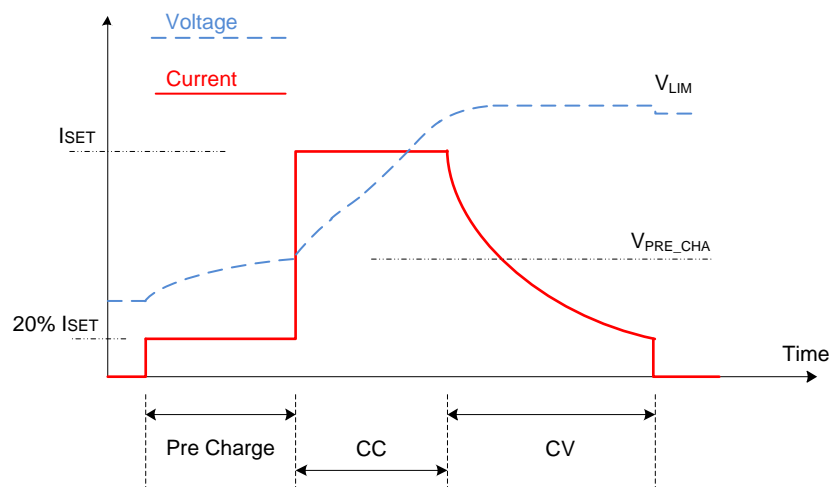


Figure 13 Charging Profile

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 1.5uA current, constant 3.3V output.

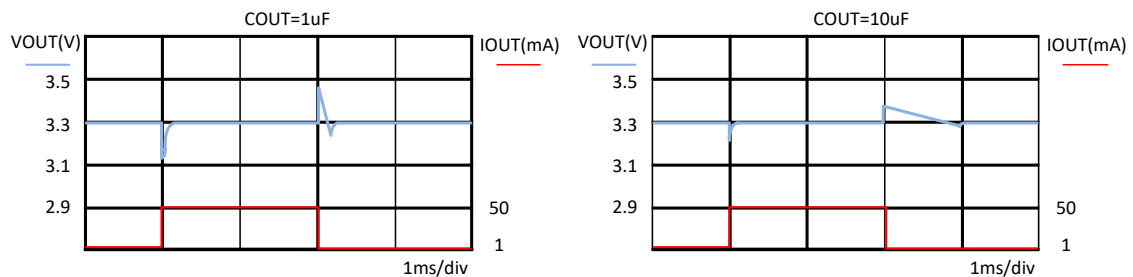
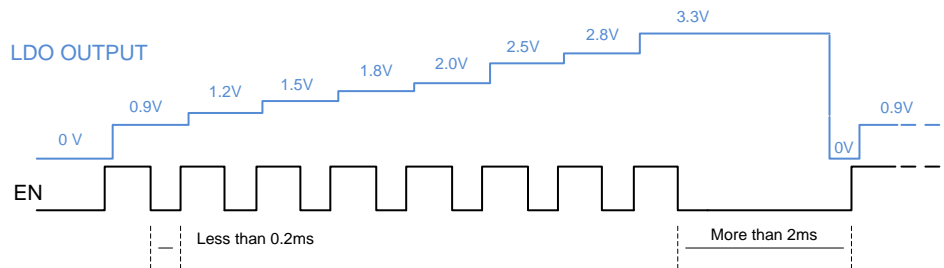


Figure 14 Load transient of LDO\_LP

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



**Figure 15 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 multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 1.5 ohm resistor in series with an X5R ceramic capacitor will minimize start-up voltage 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. When the load exceeds 100mA, it is recommended to use capacitors larger than 4.7uF. When the instantaneous load of 200mA or more, as long as the average load does not exceed 200mA, LDO can still work properly. To avoid excessive output ripple, it is recommended to use 10uF or more capacitors.

**ISET resistor:** The charge current is programmed using a single resistor from the ISET pin to ground. The charging current setting formula is as follow

$$ISET = 850V/R$$

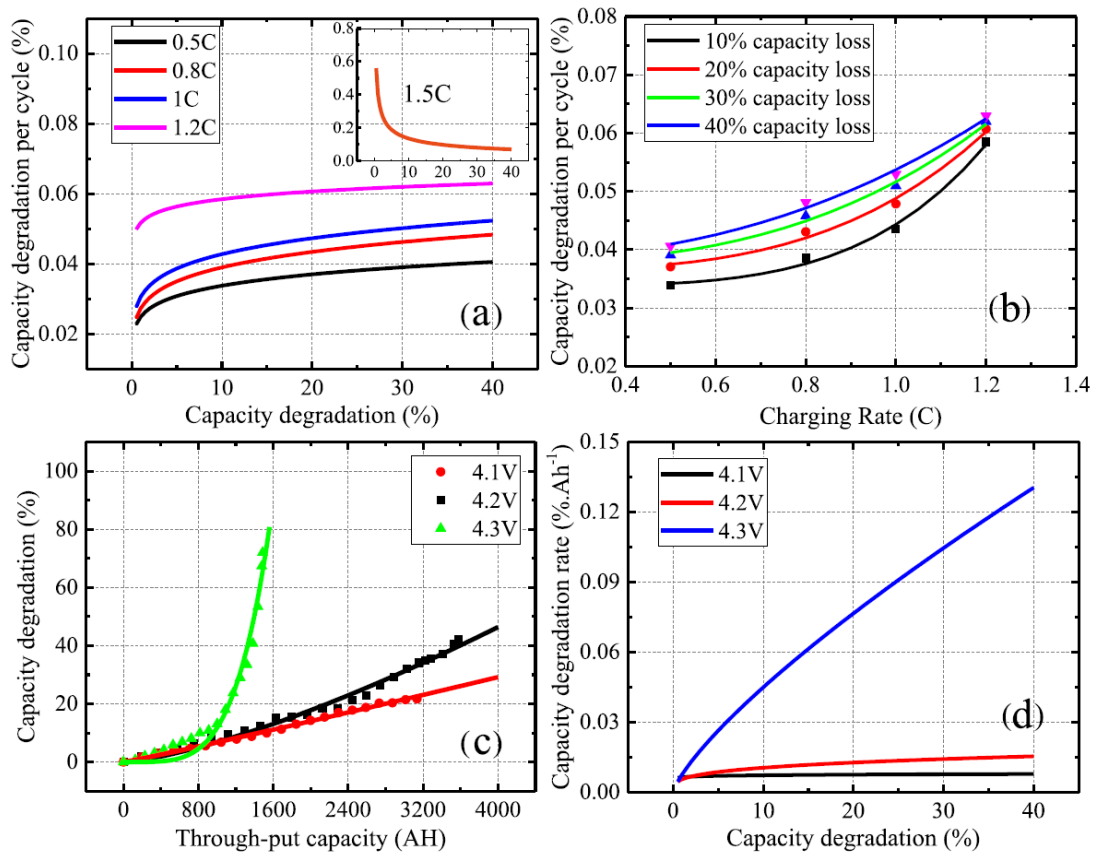
It is recommended to use a 1% resistor.

**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 16 Capacity degradation**

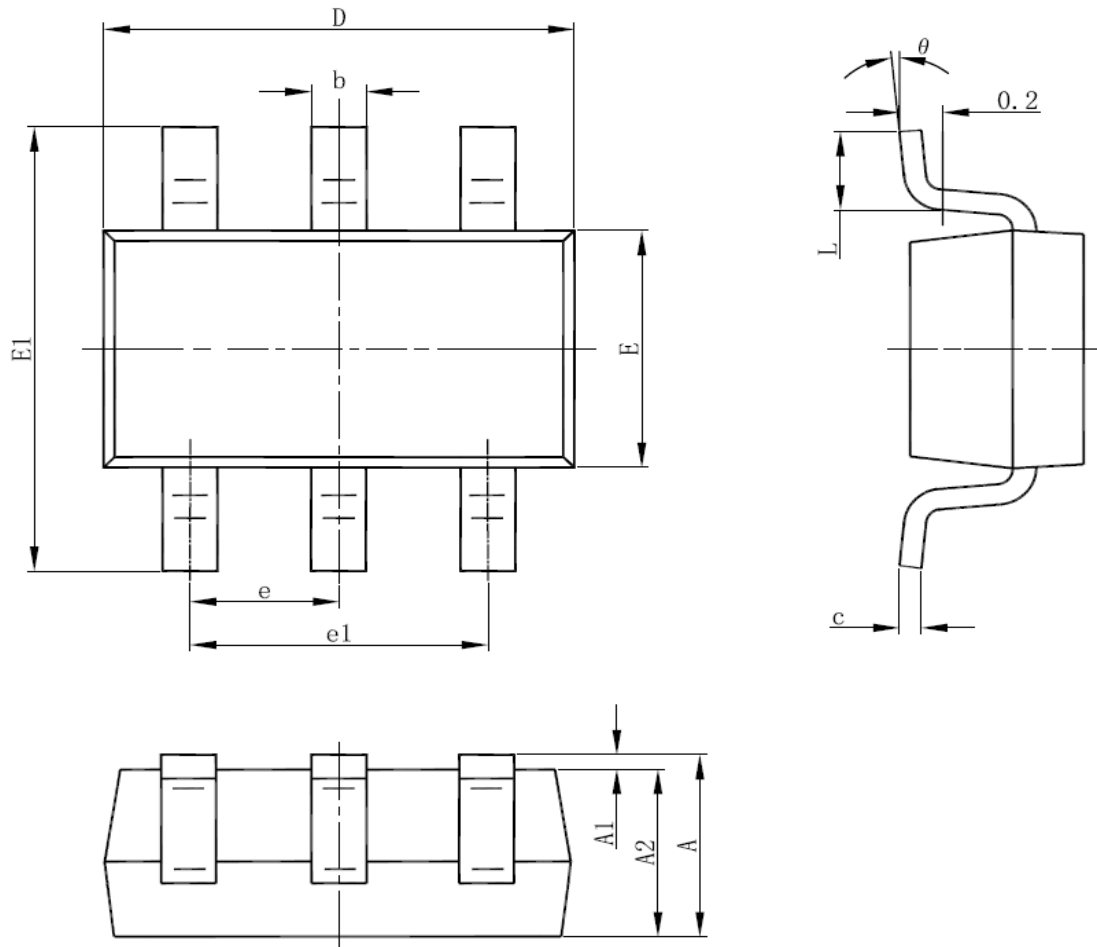
- (a) Capacity degradation speed at different battery aging states.
- (b) Capacity degradation speed at different charging current rates.
- (c) The capacity degradation of the tested batteries upon continuous cycle aging at different cut-off voltages.
- (d) Capacity degradation rate at different cut-off voltages.

References

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

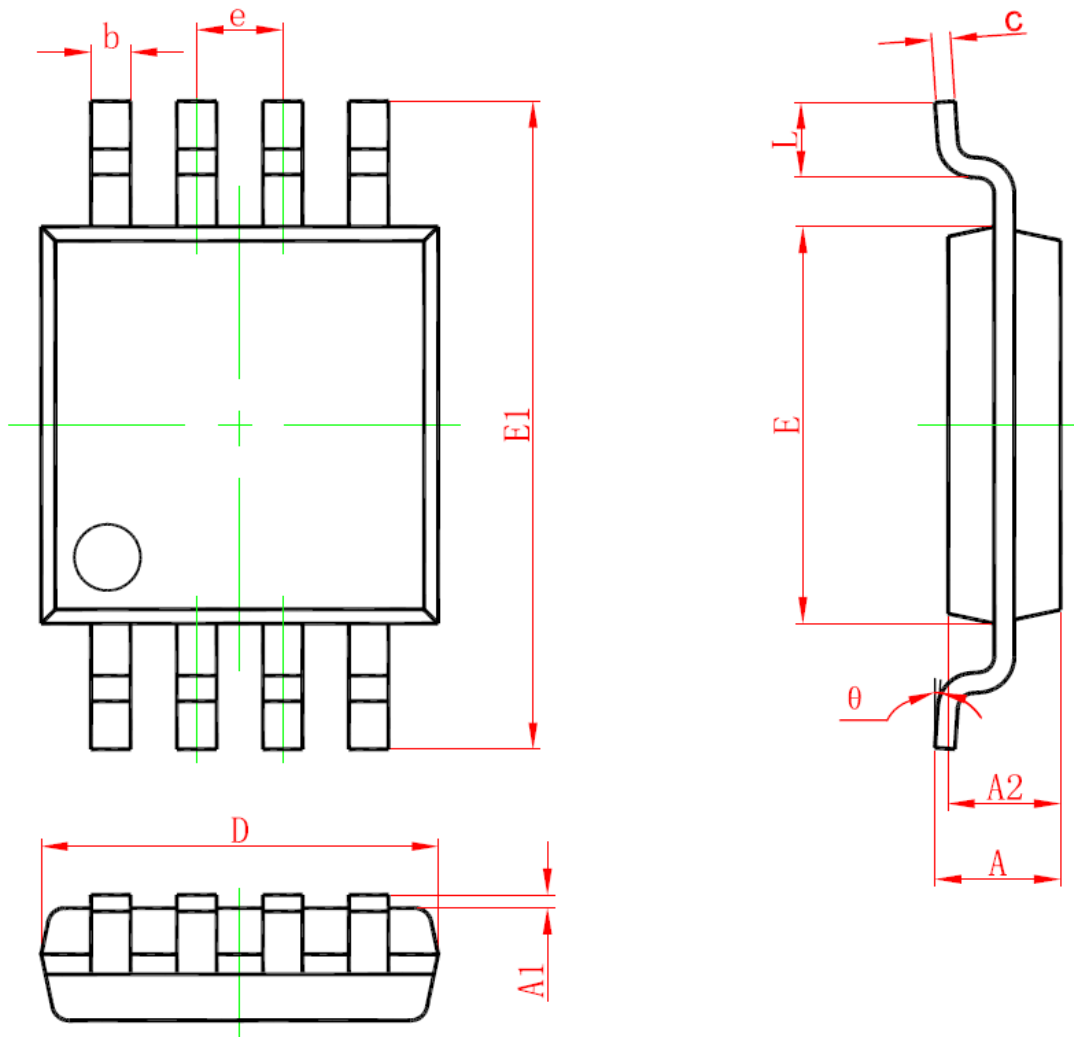
## Package Description

### SOT23-6L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.900(BSC)		0.075(BSC)	
L	0.300	0.600	0.012	0.024
$\theta$	0°	8°	0°	8°

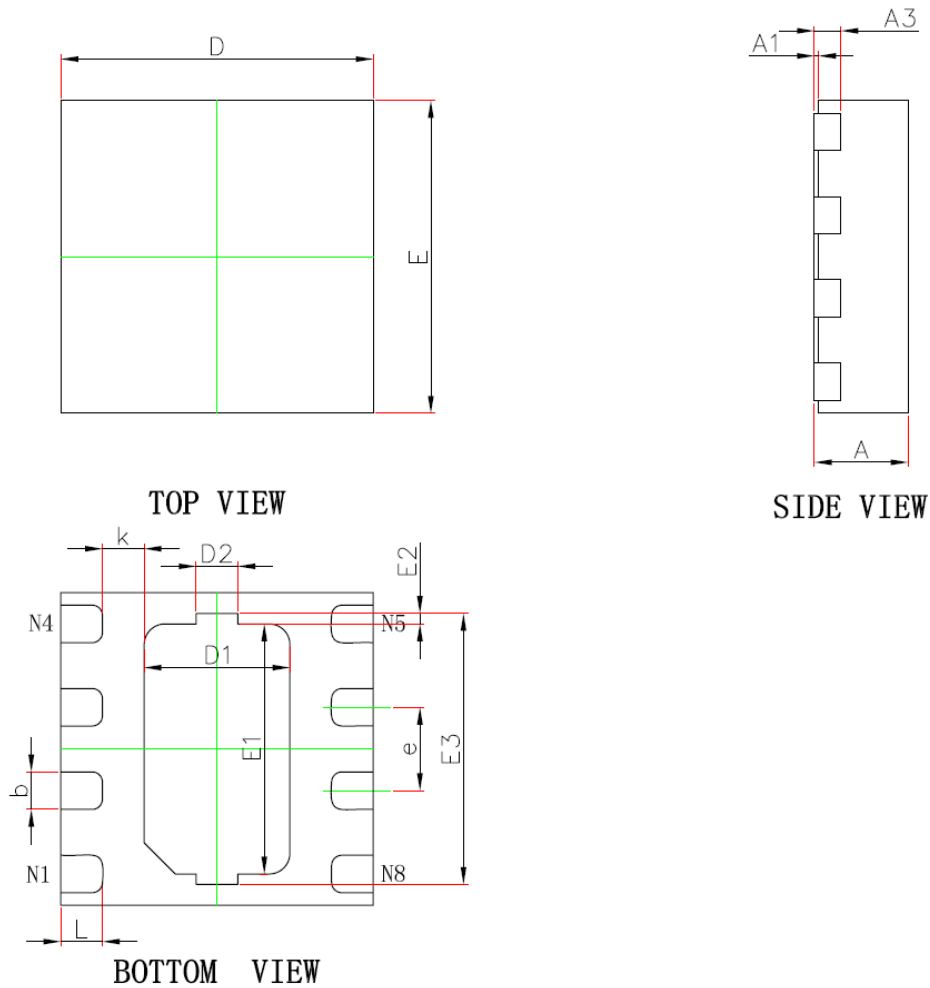
**MSOP 8L**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.650(BSC)		0.026(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
L	0.400	0.800	0.016	0.031
$\theta$	0°	6°	0°	6°

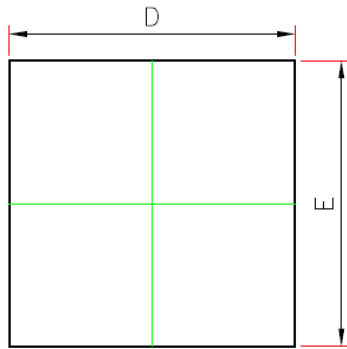


**DFN1.5\*1.5 8L**

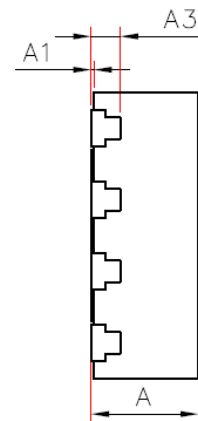


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.400	0.500	0.016	0.020
A1	0.000	0.050	0.000	0.002
A3	0.127REF		0.005REF	
D	1.450	1.550	0.057	0.061
E	1.450	1.550	0.057	0.061
D1	0.600	0.800	0.024	0.031
D2	0.200REF		0.008REF	
E1	1.100	1.300	0.043	0.051
E2	0.050REF		0.002REF	
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

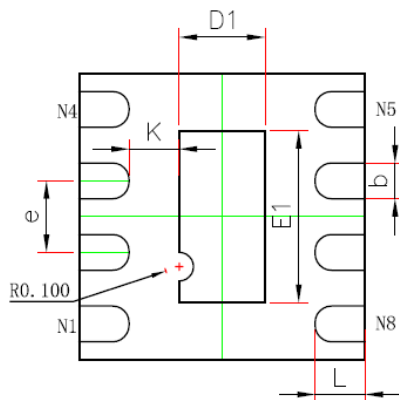
**DFN2\*2 8L**



**TOP VIEW**



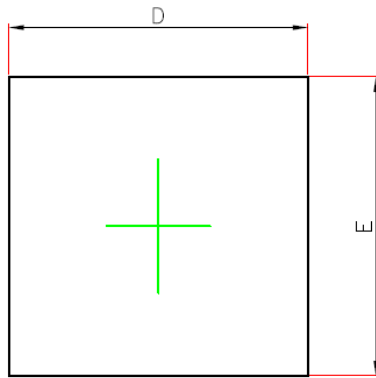
**SIDE VIEW**



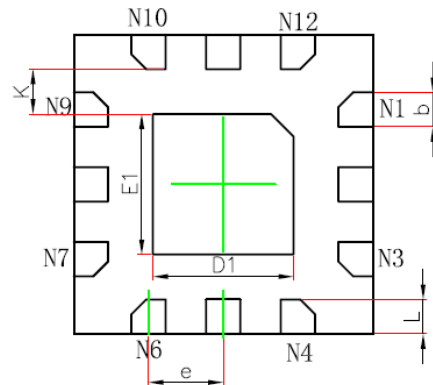
**BOTTOM VIEW**

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	0.500	0.700	0.020	0.028
E1	1.100	1.300	0.043	0.051
k	0.200MIN		0.008MIN	
b	0.200	0.300	0.008	0.012
e	0.500TYP		0.020TYP	
L	0.300	0.400	0.012	0.016

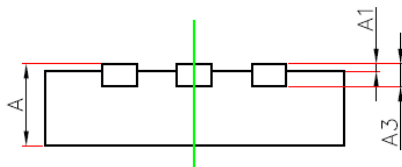
**QFN2\*2 12L**



**TOP VIEW**



**BOTTOM VIEW**



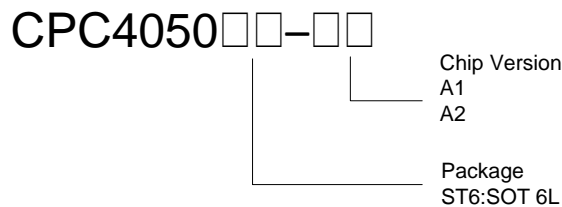
**SIDE VIEW**

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.500	0.600	0.020	0.024
A1	0.000	0.050	0.000	0.002
A3	0.152REF		0.006REF	
D	1.924	2.076	0.076	0.082
E	1.924	2.076	0.076	0.082
D1	0.840	1.040	0.033	0.041
E1	0.840	1.040	0.033	0.041
k	0.200REF		0.008REF	
b	0.180	0.280	0.007	0.011
e	0.500BSC		0.020BSC	
L	0.154	0.306	0.006	0.012

## Ordering Information

Order Number	Temperature Range	Package	RoHS	Marking	Packing Type
CPC4050ST6-A1	-40 ~85	SOT23-6L	YES	C4050/LLLL	3000 Pcs/reel
CPC4050MS8-A1	-40 ~85	MSOP-8L	YES	4050/LLL	4000 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	4000 Pcs/reel
CPC4053QN12-A1	-40 ~85	QFN2*2-12L	YES	4053/LLL	4000 Pcs/reel
CPC4054QN12-A1	-40 ~85	QFN2*2-12L	YES	4054/LLL	4000 Pcs/reel
CPC4050ST6-B1	-40 ~85	SOT23-6L	YES	C4B50/LLLL	3000 Pcs/reel
CPC4051DN8-B1	-40 ~85	DFN1.5*1.5-8L	YES	4B51/LLL	3000 Pcs/reel
CPC4052DN8-B1	-40 ~85	DFN2*2-8L	YES	4B52/LLL	4000 Pcs/reel
CPC4053QN12-B1	-40 ~85	QFN2*2-12L	YES	4B53/LLL	4000 Pcs/reel
CPC4054QN12-B1	-40 ~85	QFN2*2-12L	YES	4B54/LLL	4000 Pcs/reel

**Note:** "LLL" represents Lot No



## Version History

Version	Date	Description
V1.5	2018-7-27	fix SOT POD parameter
V1.6	2019-1-4	Adding CPC405XB 4.35V version
V2.0	2019-11-13	Modify the impedance of LDOs Modify the I <sub>Q</sub> of LDOs Modify the current limit of LDO_LP Adding a new product CPC4054
V2.1	2020-02-19	Modify packing type

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