28V, 1A Single Cell Li-Ion & Li-Pol Linear Battery Charger

General Description

The DS6521 series of devices are highly integrated Li-Ion and Li-Pol linear chargers devices targeted at space-limited portable applications.

The battery is charged in three phases: conditioning, constant current and constant voltage. In all charge phases, an internal control loop monitors the IC junction temperature and reduces the charge current if an internal temperature threshold is exceeded.

The charger power stage and charge current sense functions are fully integrated. The charger function has high accuracy current and voltage regulation loops, charge status display, and charge termination.

The fast charge current value is also programmable via an external resistor.

Features

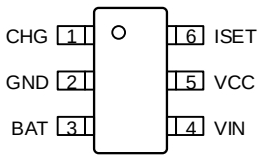
- 28V Input Rating; with 6V Input Overvoltage Protection
- 1% Charge Voltage Accuracy
- Programmable Charger Current 50mA to 1A
- 125°C Thermal Regulation
- Programmable Termination Charge Current 5mA to 100mA
- Fixed ISET / 10 for Pre-Charge Current
- Operation over JEITA Range via Battery NTC – 1/2 Fast-Charge-Current at Cold, and 4.05V at Hot
- Very Low Battery leakage Current 0.1uA
- Prevent Battery Reverse Connection Function
- SOT-23-6 & ESOP-8 & DFN2x2-10L & DFN2x3-10L & DFN3x3-10L Package Available

Applications

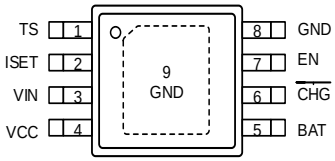
- Laptop, Palmtops and PDAs
- Smart Phones
- MP3 Players
- Low-Power Handheld Devices

Pin Configurations

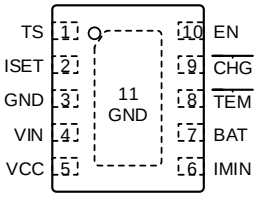
SOT-23-6



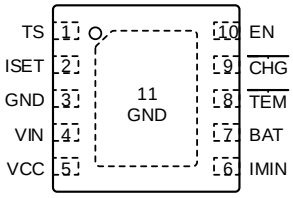
ESOP-8



DFN2x2-10L & DFN2x3-10L



DFN3x3-10L



Ordering Information

DS6521XTYY

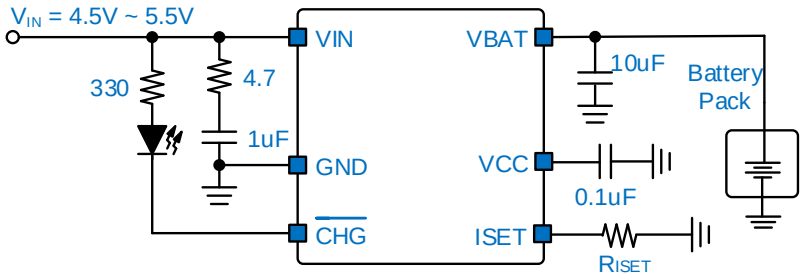
Designator	Description	Symbol	Description
X	V_{BAT}	A	4.2V
		B	4.35V
T	TS Mode	F	0℃ & 45℃
		J	JEITA
		N	No TS Functionality
YY	Package type	S6	SOT-23-6
		F8	ESOP-8L
		D22	DFN2x2-10L
		D23	DFN2x3-10L
		D33	DFN3x3-10L

Example : V_{BAT} = 4.2V, TS Mode = 0℃ & 45℃ , DFN2x2-10L. Part no = DS6521AFD22 .

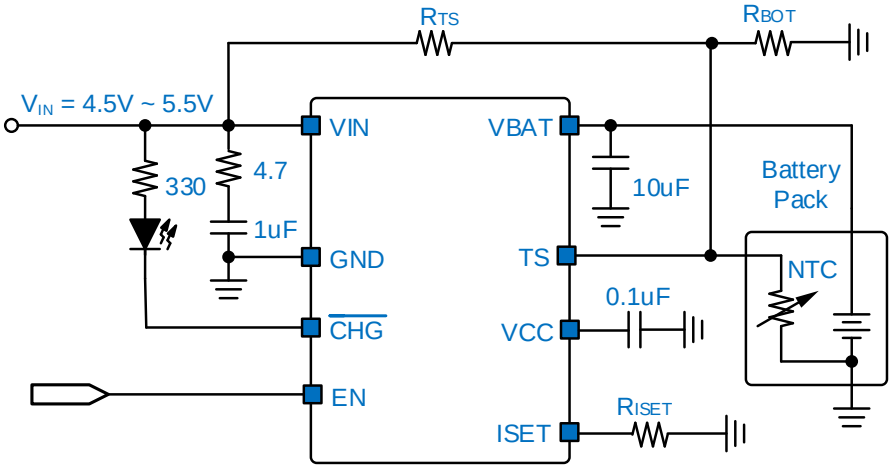
Description of Functional Pins

Pin No			Pin Name	Pin Function
DFN2x2-10L DFN2x3-10L DFN3X3-10L	ESOP-8	SOT23-6		
1	1		TS	Temperature sense terminal connected to 10K & 100K at 25°C NTC thermistor, in the battery pack.
2	2	6	ISET	Programs the Fast Charge Current Setting. External resistor from ISET to GND defines fast charge current value.
3	8	2	GND	Ground .
4	3	4	VIN	Input of Supply Voltage .
5	4	5	VCC	Internal regulator output, it is recommended to connect an external 0.1uF ~ 1uF capacitor to ground .
6			IMIN	Programs the Termination Charge Current Setting. External resistor from IMIN to GND defines the value of termination charge current.
7	5	3	BAT	Battery Connection. System Load may be connected. Expected range of bypass capacitors 10μF to 22μF.
8			$\overline{\text{TEM}}$	Low (FET on) means that the charging current is less than the Termination Current, and open drain (FET off) means that the charging current is greater than the Termination Current.
9	6	1	$\overline{\text{CHG}}$	Low (FET on) indicates charging and Open Drain (FET off) indicates no Charging or Charge complete.
10	7		EN	CHIP Enable .
Exposed Pad	Exposed Pad		PGND	Substrate of Chip. Leave floating or tie to GND.

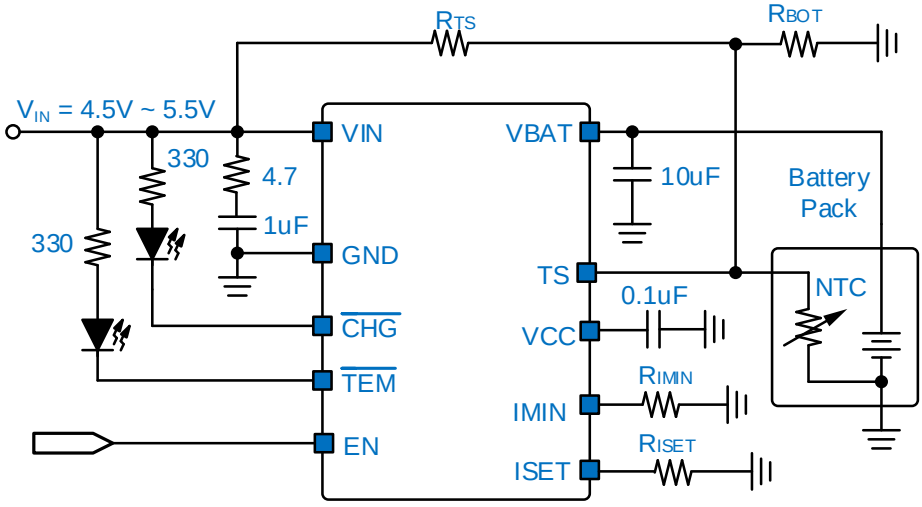
Typical Application Circuits



SOT-23-6

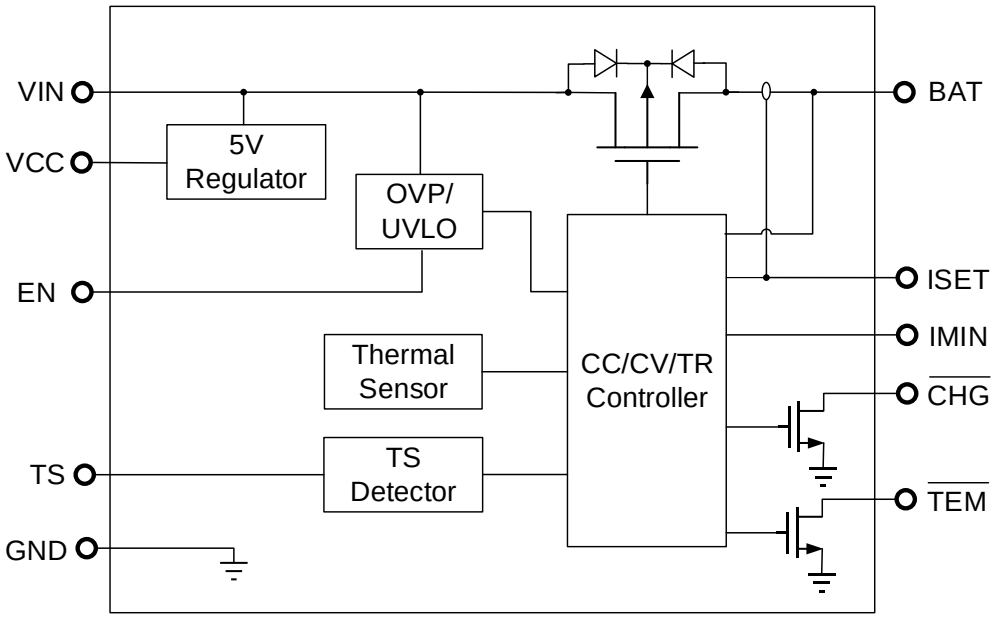


ESOP-8L



DFN2x2-10L & DFN2x3-10L & DFN3x3-10L

Function Block Diagram



Absolute Maximum Ratings (Note 1)

VIN / EN / $\overline{CHG}$ / $\overline{TEM}$ to GND ---------- -0.3V to 28V

BAT to GND ---------- -0.3V to 15V

Other to GND ---------- -0.3V to 6V

Package Thermal Resistance (Note 2)

SOT-23-6, θ_{JA} ---------- 220 °C /W

ESOP-8 , θ_{JA} ---------- 75 °C /W

DFN2x2-10L, θ_{JA} ---------- 95 °C /W

DFN2x3-10L, θ_{JA} ---------- 85 °C /W

DFN3x3-10L, θ_{JA} ---------- 70 °C /W

Lead Temperature (Soldering, 10 sec.) ---------- 260 °C

Junction Temperature ---------- 150 °C

Storage Temperature Range ---------- -60 °C to 150 °C

ESD Susceptibility

HBM ---------- 2KV

MM ---------- 200V

Recommended Operating Conditions

Input Voltage VIN ---------- 4.5V to 24V

Junction Temperature Range ---------- -40 °C to 125 °C

Ambient Temperature Range ---------- -40 °C to 85 °C

Electrical Characteristics

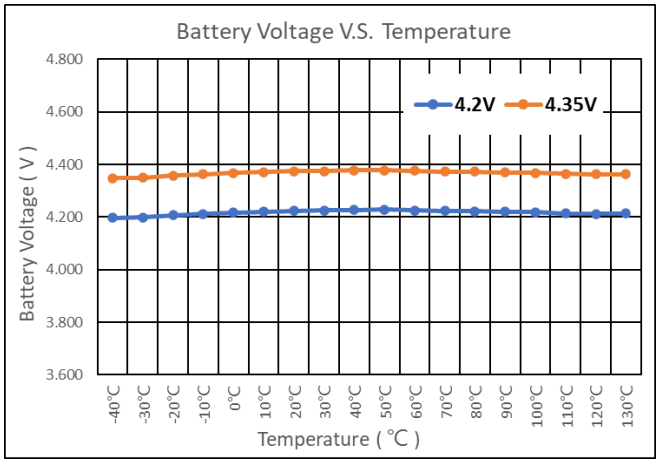
(V_{IN} =5V, T_A=25°C unless otherwise specified)

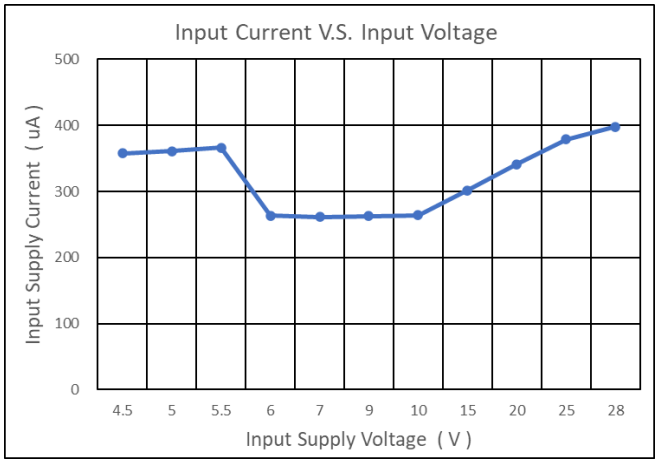
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Voltage	V_{IN}		4.5	--	24	V
UVLO Threshold Voltage	V_{IN_UVLO}	V_{IN} Rising	--	4.5	--	V
UVLO Hysteresis Voltage	V_{UVLO_HYS}	V_{IN} Falling	--	4.0	--	V
Input Over-Voltage Protection	V_{OVP}	V_{IN} Rising		6.0		V
Input Over-Voltage Protection Hysteresis	V_{OVP_HYS}			0.2		V
Input Supply Current (Charge mode)	I_{QA}	EN = High, V_{IN} = 5V,no load on OUT terminal,		350		μA
Input Standby Current	I_{QS}	EN = 0V, V_{IN} = 5V		80		μA
Battery leakage current into BAT terminal	I_{BAT}	V_{IN} = 0V, V_{BAT} = 4.2V	--	0.1	--	μA
Reverse Battery Current into BAT terminal	I_{RBAT}	V_{BAT} = -4.2V		800		μA
Enable Threshold Voltage	V_{IH}	EN Rising	1.5			V
	V_{IL}	EN Falling			0.4	
EN Input Current	I_{EN}	V_{EN} = 5V		10	100	nA
Battery Regulation Voltage	V_{BAT} / Type A	I_{CHG} = 25mA	4.16	4.2	4.24	V
	V_{BAT} / Type B		4.31	4.35	4.39	
Recharger Battery Voltage	V_{BAT} / Type A	CHG Low to Open		4.0		V
	V_{BAT} / Type B			4.125		
Fast-Charger Current	I_{CHG}	R_{ISET} = KΩ	50		1000	mA
		I_{CHG} > 100mA	-10		10	%
		I_{CHG} < 100mA	-10		10	mA
Pre-Charger Current	I_{PRE}	Percentage of I_{CHG}		10		%
Termination Charger Current	I_{MIN}	R_{IMIN} = KΩ	5		100	mA
Termination Delay Time	T_{TEM}	I_{MIN} to CHG		16.7		mS
Pre-charge to Fast-charge transition threshold	V_{LOWV}	V_{BAT} Rising	--	2.8	--	V
Fast-charge to Pre-charge transition threshold	V_{HOWV}	V_{BAT} Falling	--	2.5	--	V
Low temperature CHG Pending	V_{TS}-0°C	Percentage of V_{IN}	--	75	--	%
Hysteresis at 0°C	V_{HYS}-0°C		--	1	--	%
Low temperature, half charge	V_{TS}-10°C	Percentage of V_{IN}	--	67	--	%
Hysteresis at 10°C	V_{HYS}-10°C		--	1	--	%
High temperature at 4.1V	V_{TS}-45°C	Percentage of V_{IN}	--	35	--	%
Hysteresis at 45°C	V_{HYS}-45°C		--	1	--	%
High temperature Disable	V_{TS}-60°C	Percentage of V_{IN}	--	25	--	%
Hysteresis at 60°C	V_{HYS}-60°C		--	1	--	%
Temperature regulation limit	$T_{J(REG)}$			125		°C
Thermal shutdown temperature	T_{J_OFF}			155		°C

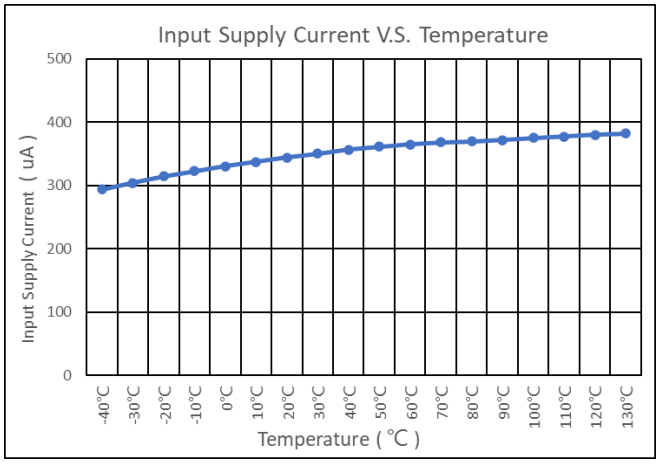
Note 1. Stresses beyond those listed “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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

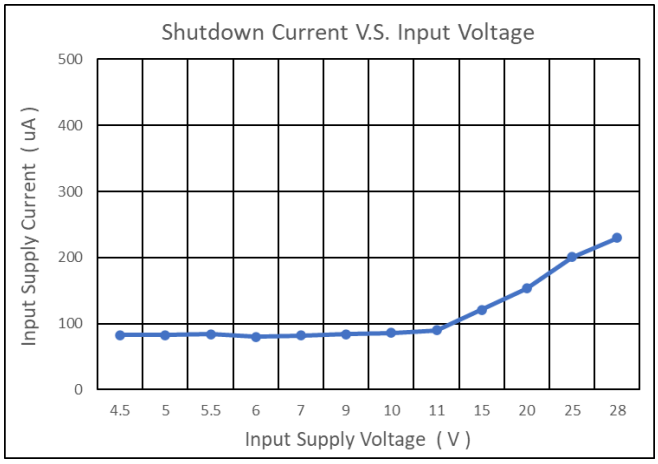
Note 2. θ_{JA} is measured at T_A = 25°C on a DSTECH EVB board.

Typical Characteristics









Application Guideline

Power-Down or Undervoltage Lockout (UVLO)

The DS6521 is in power down mode if the VIN terminal voltage is less than UVLO. The part is considered “dead” and all the terminals are high impedance. Once the VIN voltage rises above the UVLO threshold the IC will enter Active mode.

Power-up

The IC is alive after the VIN voltage ramps above UVLO, resets all logic, and starts to perform many of the continuous monitoring routines. Typically, the input voltage quickly rises through the UVLO and declares power good.

Over-Voltage Protection (OVP)

If the input source applies an overvoltage, the pass FET, if previously on, turns off after a deglitch (OVP). The $\overline{CHG}$ and $\overline{TEM}$ terminal goes to a high impedance state. Once the overvoltage returns to a normal voltage, charge continues and the $\overline{CHG}$ terminal goes low after a deglitch period.

Program the Termination Charge Current , IMIN

$I_{TEM} = K_T * (1 / R_{IMIN})$

From the Electrical Characteristics table:

- $K_T = 605$
- $R_{IMIN} = 605 * (1 / 50mA) = 12.1 K\Omega$

Selecting the closest standard value, use a 12.1 KΩ resistor between IMIN and GND to have I_{TEM}=50mA.

When the IMIN Pin floats :

$I_{TEM} = 1/10 * ICHG$

Program the Fast Charge Current , ISET

$I_{CHG} = V_{ISET} / R_{ISET} * 1000$

From the Electrical Characteristics table:

- $V_{ISET} = 1V$
- $R_{ISET} = 1V / 1A * 1000 = 1.0 K\Omega$

Selecting the closest standard value, use a 1.0 kΩ resistor between ISET and GND to have ICHG=1A .

When using I_{MIN} setting :

$I_{CHG} = K_C * (1 / R_{ISET}) + 0.92 * I_{TEM}$

From the Electrical Characteristics table:

- $K_C = 924.7$
- $I_{TEM} = 50mA$
- $R_{ISET} = 924.7 / (1000mA – 0.92 * 50mA)$

  $= 0.969 K\Omega$

Selecting the closest standard value, use a 976 Ω resistor between ISET and GND to have I_{CHG}=1A with I_{TEM}=50mA .

$\overline{CHG}$ and $\overline{TEM}$ LED Pull-up Source

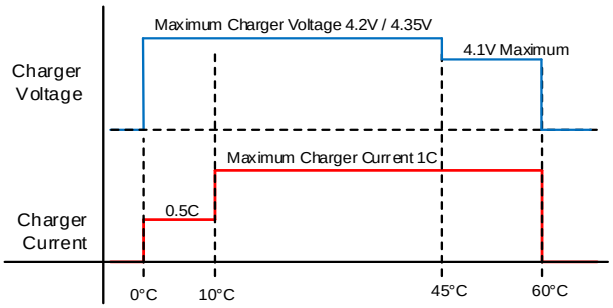
For host monitoring, a pull-up resistor is used between the "STATUS" terminal and the VCC of the host and for a visual indication a resistor in series with an LED is connected between the "STATUS" terminal and a power source. If the source is the BAT terminal, note that as the battery changes voltage, and the brightness of the LEDs vary.

Charging State	$\overline{CHG}$ FET/LED
Charge after VIN applied	ON
OVP or UVLO	OFF

Termination Charger Current State	$\overline{TEM}$ FET/LED
I_{CHG} more than the I_{TEM}	OFF
I_{CHG} Less than I_{TEM}	ON

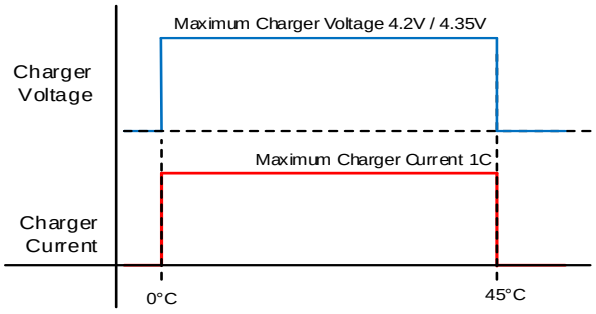
Temperature Sense (TS)

The TS function for the DS6521 is designed to follow the new JEITA temperature standard for Li-Ion and Li-Pol batteries. There are now four thresholds, 60°C, 45°C, 10°C, and 0°C. Normal operation occurs between 10°C and 45°C. If between 0°C and 10°C the charge current level is cut in half and if between 45°C and 60°C the regulation voltage is reduced to 4.1Vmax.



JEITA Mode

The TS function of DS6521 is designed to comply with the new temperature protection of lithium-ion and lithium polymer battery temperature standards. There are now two thresholds, 45°C and 0°C. Normal operation occurs between 0°C and 45°C.

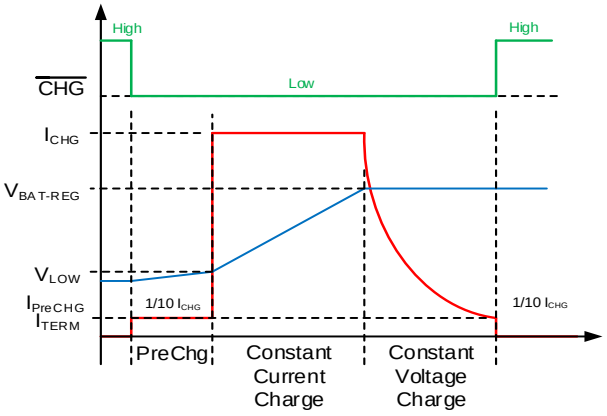


Standard Mode

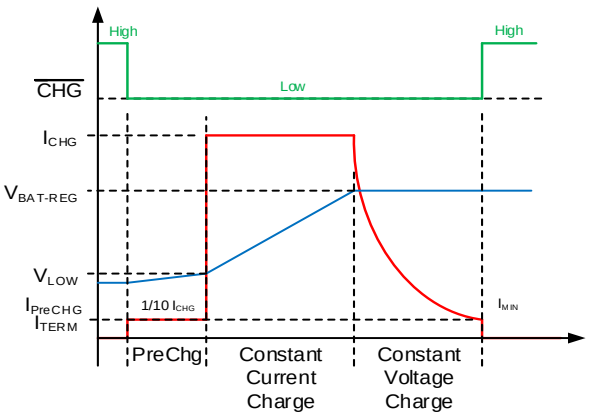
The TS feature is implemented using RTS form VIN Series with the thermistor (designed for use with a 10K NTC β = 3380) connected from the TS terminal to GND. If this feature is not needed, connecting TS and GND direct to allow normal operation without temperature sense function.

Charge Cycle

I_{MIN} Pin Floating Type :



I_{MIN} Pin Pull Down by Resistor Type :



Thermal Application

For continuous operation, do not exceed the absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated as below:

T_A=25°C, DSTECH PCB,

The max PD(Max) = (125°C − 25°C) / (220°C/W) = 0.45W for SOT-23-5 packages.

The max PD(Max) = (125°C − 25°C) / (75°C/W) = 1.33W for ESOP-8L packages.

The max PD(Max) = (125°C − 25°C) / (95°C/W) = 1.05W for DFN2x2-10L packages.

The max PD(Max) = (125°C − 25°C) / (85°C/W) = 1.18W for DFN2x3-10L packages.

The max PD(Max) = (125°C − 25°C) / (70°C/W) = 1.42W for DFN3x3-10L packages.

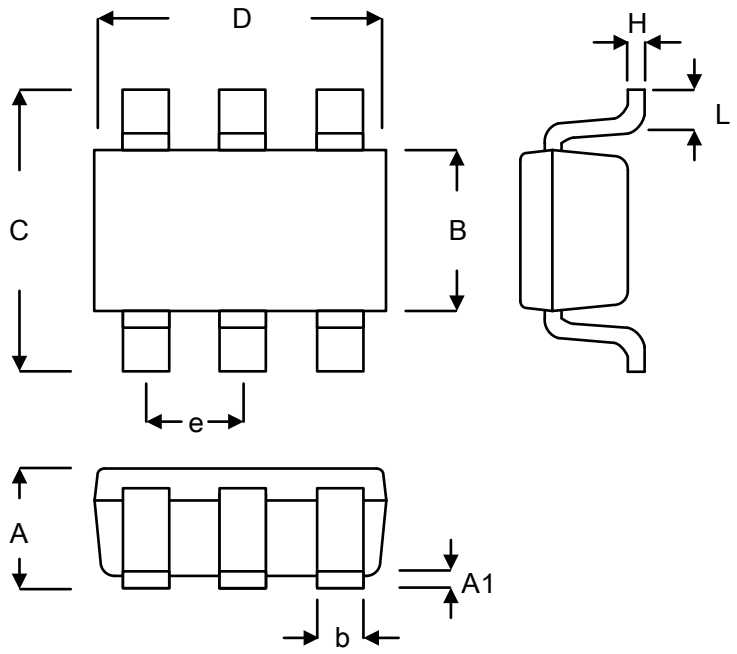
Power dissipation (PD) is equal to the product of the output current and the voltage drop across the output pass element, as shown in the equation below:

PD = (VIN – VOUT) × ICHG

Layout Consideration

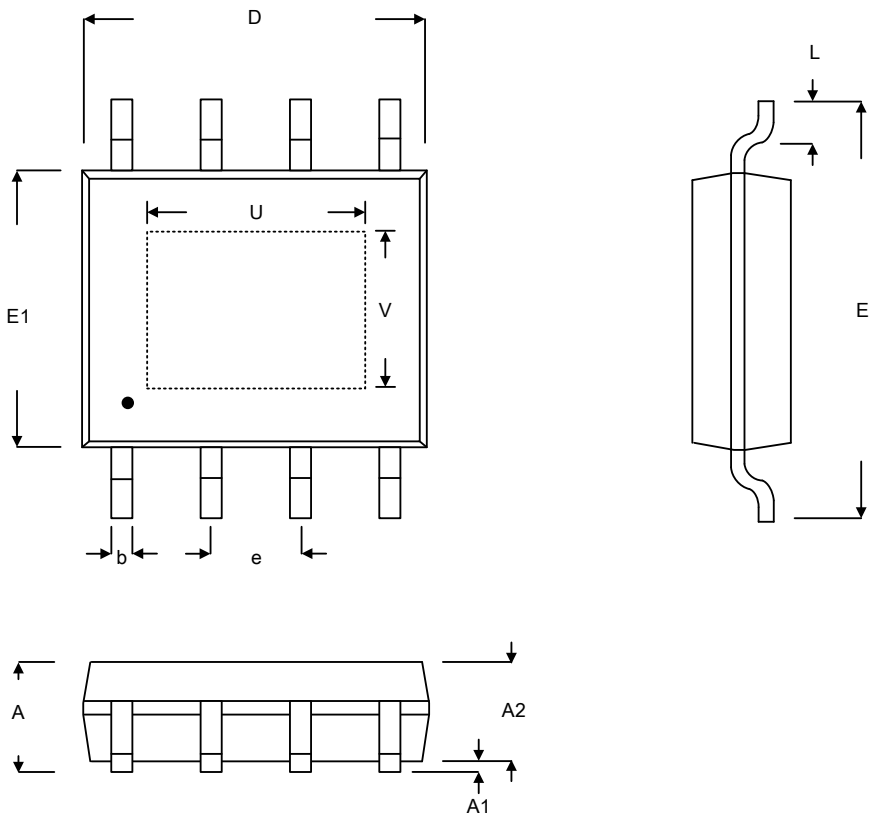
By placing input and output capacitors on the same side of the PCB as the Charger, and placing them as close as is practical to the package can achieve the best performance. The ground connections for input and output capacitors must be back to the DS6521 ground pin using as wide and as short of a copper trace as is practical. Connections using long trace lengths, narrow trace widths, and/or connections through via must be avoided. These add parasitic inductances and resistance that results in worse performance especially during transient conditions.

Package Information:



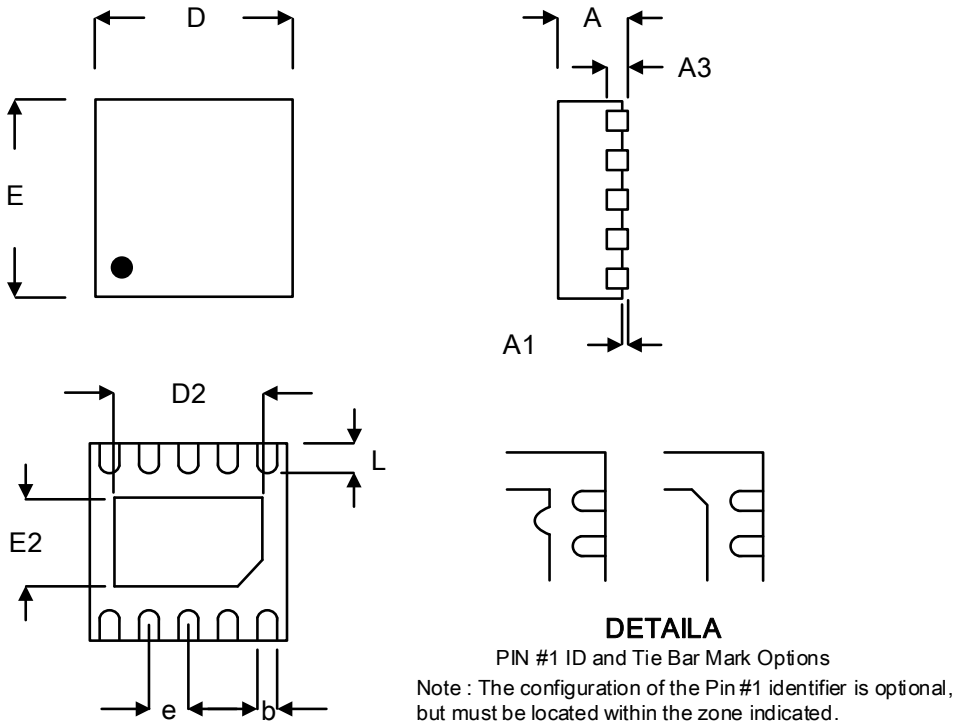
Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.356	0.559	0.014	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

SOT-23-6L



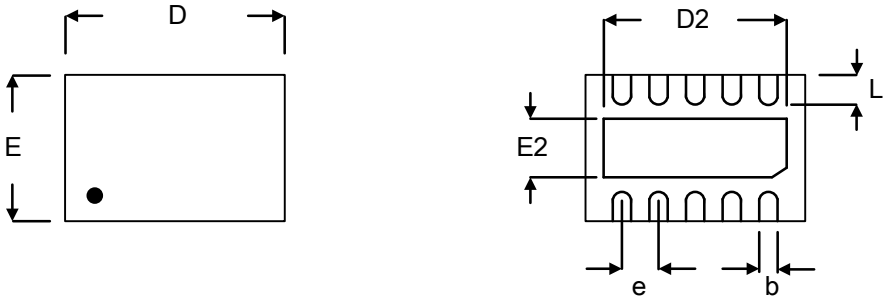
Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.300	1.800	0.051	0.071
A1	0.000	0.152	0.000	0.006
A2	1.300	1.500	0.051	0.059
b	0.330	0.510	0.013	0.020
D	4.800	5.000	0.189	0.197
e	1.270		0.050	
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
L	0.400	1.200	0.016	0.047
U	3.100		0.122	
V	2.210		0.087	

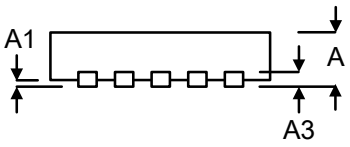
ESOP-8

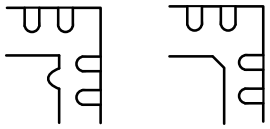


Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.150	0.250	0.006	0.010
D	1.900	2.100	0.075	0.083
D2	1.450	1.550	0.057	0.061
E	1.900	2.100	0.075	0.083
E2	0.850	0.950	0.033	0.037
e	0.400		0.016	
L	0.250	0.350	0.010	0.014

DFN2x2-10L







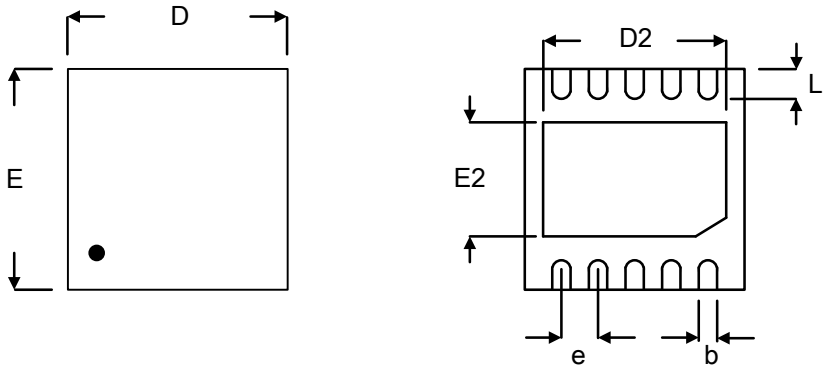
DETAILA

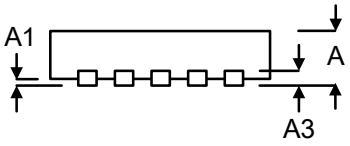
PIN #1 ID and Tie Bar Mark Options

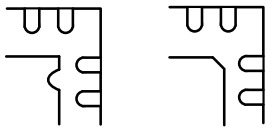
Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.203		0.008	
b	0.150	0.300	0.006	0.012
D	2.900	3.100	0.114	0.122
D2	2.400	2.600	0.094	0.102
E	1.900	2.100	0.075	0.083
E2	0.700	0.900	0.028	0.035
e	0.500		0.020	
L	0.200	0.400	0.008	0.016

DFN2x3-10L







DETAILA

PIN #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.150	0.300	0.006	0.012
D	2.900	3.100	0.114	0.122
D2	2.390	2.600	0.094	0.102
E	2.900	3.100	0.114	0.122
E2	1.450	1.800	0.057	0.071
e	0.500		0.020	
L	0.300	0.500	0.012	0.020

DFN3x3-10L