

1A Single-chip Li Battery Charger

General Description

The ET9515 is a cost-effective, fully integrated high input voltage single-cell Li-ion battery charger. The charger uses a CC/CV charge profile required by Li-ion battery. The charger accepts an input voltage up to 28V but is disabled when the input voltage exceeds the OVP threshold, typically 6.8V (ET9515-6.8) or 10.5V (ET9515-10.5), to prevent excessive power dissipation. The 28V rating eliminates the over-voltage protection circuit required in a low input voltage charger.

The charge current and the end-of-charge (EOC) current are programmable with external resistors. When the battery voltage is lower than typically 2.55V, the charger preconditions the battery with typically 18% of the programmed charge current. When the charge current reduces to the programmable EOC current level during the CV charge phase, an EOC indication is provided by the $\overline{\text{CHG}}$ pin, which is an open-drain output. An internal thermal foldback function protects the charger from any thermal failure.

Two indication pins ($\overline{\text{PPR}}$ and $\overline{\text{CHG}}$) allow simple interface to a microprocessor or LEDs. When no adapter is attached or when disabled, the charger draws less than 1uA leakage current from the battery.

The ET9515 is available in Green DFN8(3×3), DFN8(2×3), DFN8(2×2), SOT23-6 and ESOP8 (Exposed Pad) packages and is rated over the -40°C to +85°C temperature range.

Features

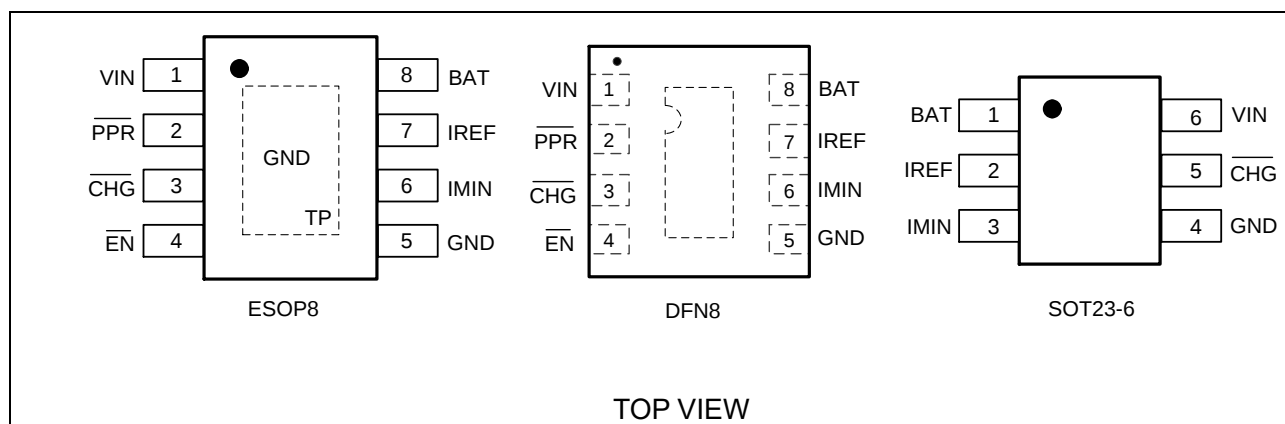
- Complete Charger for Single-Cell Li-ion or Polymer Batteries
- Integrated Pass Element and Current Sensor
- No External Blocking Diode Required, Low Component Count and Cost
- Programmable Charge Current
- Programmable End-of-Charge Current
- Charge Current Thermal Foldback for Thermal Protection
- 2.55V Trickle Charge Threshold
- 6.8V Input Over-Voltage Protection for ET9515A
- 10.5V Input Over-Voltage Protection for ET9515B
- 28V Maximum Voltage for the Power Input
- Power Presence and Charge Indications
- 1μA Leakage Current off the Battery When No Input Power Attached or Charger Disabled
- Available in Green DFN8, SOT23-6 and SOIC-8 (Exposed Pad) Packages

Applications

- Blue-Tooth Devices
- Handheld Devices

ET9515

Pin Configuration



Pin Function

Pin No.		Name	Function
ESOP8/DFN8	SOT23-6		
1	6	VIN	Power Supply Input.
2		PPR	Indicator Output for Power Status.
3	5	CHG	Indicator Output for Charging Status.
4		EN	Enable Input. Drive to high to disable the charger. When this pin is driven to low or left floating, the charger is enabled. This pin has an internal pull-down resistor.
5	4	GND	System Ground.
6	3	IMIN	End-of-Charge (EOC) Current Programming Pin. Connect a resistor between this pin and the GND pin to set the EOC current. The EOC current IMIN can be programmed by the following equation: $I_{MIN} = 9700/R_{IMIN} \text{ (mA)}$ Where R _{IMIN} is in KΩ.
7	2	IREF	Charge-Current Programming and Monitoring Pin. Connect a resistor between this pin and the GND pin to set the charge current limit determined by the following equation: $I_{REF} = 12150/R_{IREF} \text{ (mA)}$ Where R _{IREF} is in KΩ.
8	1	BAT	Charger Output Pin.
TP		GND	Exposed Thermal Pad. Must be electrically connected to the GND.

ET9515

Product Information

MODEL	V _{BAT} (V)	V _{OVP} (V)	PACKAGE	PRODUCT NAME
ET9515	4.2V	6.8V	ESOP8	ET9515ALS1
		6.8V	SOT23-6	ET9515ALS2
		6.8V	DFN8-3×3	ET9515ALT1
		6.8V	DFN8-2×3	ET9515ALT2
		6.8V	DFN8-2×2	ET9515ALT3
		6.8V	ESOP8	ET9515ALT4
		10.5V	ESOP8	ET9515BLS1
		10.5V	SOT23-6	ET9515BLS2
		10.5V	DFN8-3×3	ET9515BLT1
		10.5V	DFN8-2×3	ET9515BLT2
		10.5V	DFN8-2×2	ET9515BLT3
	4.35V	6.8V	ESOP8	ET9515AHS1
		6.8V	SOT23-6	ET9515AHS2
		6.8V	DFN8-3×3	ET9515AHT1
		6.8V	DFN8-2×3	ET9515AHT2
		6.8V	DFN8-2×2	ET9515AHT3
		10.5V	ESOP8	ET9515BHS1
		10.5V	SOT23-6	ET9515BHS2
		10.5V	DFN8-3×3	ET9515BHT1
		10.5V	DFN8-2×3	ET9515BHT2
		10.5V	DFN8-2×2	ET9515BHT3

ET 9515 X X XX

<u>X</u> OVP Voltage		<u>X</u> BAT Voltage		<u>XX</u> Package	
A/B	A: 6.8V	L/H	L: 4.20V	S1	ESOP8
				S2	SOT23-6
	B:10.5V		H: 4.35V	T1	DFN8-3×3
				T2	DFN8-2×3
				T3	DFN8-2×2

Functional Description

The ET9515 charges a Li-ion battery using a CC/CV profile. The constant current IREF is set with the external resistor RREF (see Figure 1) and the constant voltage is fixed at 4.2V. If the battery voltage is below a typical 2.55V trickle charge threshold, the ET9515 charges the battery with a trickle current of 18% of IREF until the battery voltage rises above the trickle charge threshold. Fast charge CC mode is maintained at the rate determined by programming IREF until the cell voltage rises to 4.2V. When the battery voltage reaches 4.2V, the charger enters a CV mode and regulates the battery voltage at 4.2V to fully charge the battery without the risk of over charge. Upon reaching an end-of-charge (EOC) current, the charger indicates the charge completion with the $\overline{\text{CHG}}$ pin, but the charger continues to output the 4.2V voltage. Figure 1 shows the typical charge waveforms after the power is on.

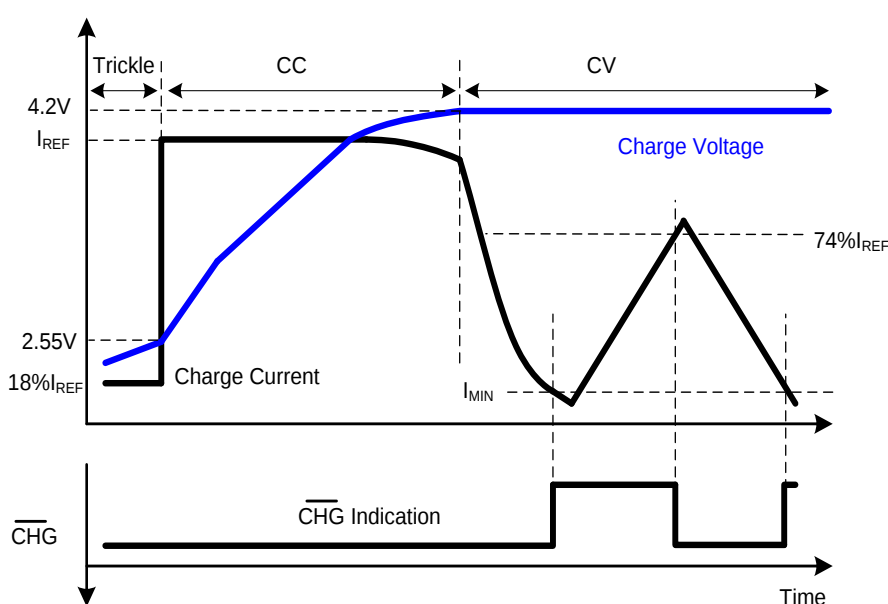


Figure1. Typical Charge Profile

End of Charge Current

The EOC current level I_{MIN} is programmable with the external resistor R_{IMIN}. The $\overline{\text{CHG}}$ pin turns to low when the trickle charge starts and rises to high impedance at the EOC. After the EOC is reached, the charge current has to rise to typically 74% I_{REF} for the $\overline{\text{CHG}}$ pin to turn on again, as shown in Figure 1. The current surge after EOC can be caused by a load connected to the battery.

The EOC current I_{MIN} can be programmed by the following equation:

$$I_{\text{MIN}} = 9700 / R_{\text{IMIN}} \text{ (mA)}$$

Where R_{IMIN} is in k Ω .

Thermal Foldback

A thermal foldback function reduces the charge current anytime when the die temperature reaches typically 115°C. This function guarantees safe operation when the printed circuit board (PCB) is not capable of dissipating the heat generated by the linear charger. The ET9515 accepts an input voltage up to 28V but disables charging when the input voltage exceeds the OVP threshold, typically 6.8V for ET9515-6.8 and 10.5V for ET9515-10.5, to protect against unqualified or faulty AC adapters.

$\overline{\text{PPR}}$ Indication

The $\overline{\text{PPR}}$ pin is an open-drain output to indicate the presence of the AC adapter. Whenever the input voltage is higher than the POR threshold, the $\overline{\text{PPR}}$ pin turns on the internal open-drain MOSFET to indicate a logic low signal, independent on the $\overline{\text{EN}}$ pin input. When the internal open-drain FET is turned off, the $\overline{\text{PPR}}$ pin leaks less than 20uA current. When turned on, the $\overline{\text{PPR}}$ pin is able to sink at least 15mA current under all operating conditions. The $\overline{\text{PPR}}$ pin can be used to drive an LED or to interface with a micro-processor.

$\overline{\text{CHG}}$ Indication

The $\overline{\text{CHG}}$ is an open-drain output capable of sinking at least 15mA current when the charger starts to charge, and turns off when the EOC current is reached. The $\overline{\text{CHG}}$ signal is interfaced either with a microprocessor GPIO or an LED for indication.

$\overline{\text{EN}}$ Input

$\overline{\text{EN}}$ is an active-low logic input to enable the charger. Drive the $\overline{\text{EN}}$ pin to low or leave it floating to enable the charger. This pin has a 200kΩ internal pull-down resistor so when left floating, the input is equivalent to logic low. Drive this pin to high to disable the charger. The threshold for high is given in the Electrical Characteristics table.

IREF Pin

The IREF pin has the two functions as described in the Pin Description section. When setting the fast charge current, the charge current is guaranteed to have 12% accuracy with the charge current set at 500mA. When monitoring the charge current, the accuracy of the IREF pin voltage vs. the actual charge current has the same accuracy as the gain from the IREF pin current to the actual charge current.

The charge current IREF can be programmed by the following equation:

$$I_{\text{REF}} = 12150 / R_{\text{IREF}} \text{ (mA)}$$

Where R_{IREF} is in kΩ.

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Absolute Maximum Ratings

Parameter	Rating	Unit
VIN to GND	-0.3 to 30	V
$\overline{\text{PPR}}$, $\overline{\text{CHG}}$, $\overline{\text{EN}}$, I _{MIN} , I _{REF} , BAT to GND.	-0.3 to 6	V
Storage Temperature Range	-65 to 150	°C
Package Thermal Resistance		
DFN8-3×3, θ_{JA}	84	°C/W
DFN8-2×3, θ_{JA}	110	°C/W
DFN8-2×2, θ_{JA}	118	°C/W
ESOP8, θ_{JA}	58	°C/W
Max Junction Temperature	150	°C
Operating Temperature Range	-40 to 85	°C
Lead Temperature (Soldering 10 sec)	260	°C

Electrical Characteristics

(V_{IN} = 5V, R_{IMIN} = 243kΩ, T_A = 25°C, unless otherwise noted.)

Parameters		Symbol	Conditions	Min	Typ	Max	Unit
RECOMMENDED OPERATING CONDITIONS							
Maximum Supply Voltage		V _{IN}		--	--	28	V
Operating Supply Voltage	ET9515-6.8			4.55	--	6.10	V
	ET9515-10.5			4.55	--	9.35	
Programmed Charge Current		I _{REF}		10	--	1100	mA
POWER-ON RESET							
Rising POR Threshold		V _{POR_RISE}	V _{BAT} = 3.0V, R _{IREF} = 120kΩ	3.21	3.95	4.55	V
Falling POR Threshold		V _{POR_FALL}		2.86	3.60	4.35	V
OVER-VOLTAGE PROTECTION							
Over-Voltage Protection Threshold	ET9515-6.8	V _{OVP}	V _{BAT} = 4.3V, R _{IREF} = 120kΩ	6.10	6.80	7.26	V
	ET9515-10.5			9.35	10.50	11.15	
OVP Threshold Hysteresis	ET9515-6.8	V _{OVP} PHYS		140	220	300	mV
	ET9515-10.5			245	340	430	
STANDBY CURRENT							
BAT Pin Sleep Current		I _{BAT_SLEEP}	The input is floating, V _{BAT} =4V	--	1	5	μA
VIN Pin Supply Current		I _{Q_STANDBY}	V _{BAT} = 4.3V, R _{IREF} = 24.3kΩ, charger disabled	--	200	275	μA
VIN Pin Supply Current		I _Q	V _{BAT} = 4.3V, R _{IREF} = 24.3kΩ, charger enabled	--	270	320	μA

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Electrical Characteristics(Continued)

Parameters	Symbol	Conditions	Min	Typ	Max	Unit
VOLTAGE REGULATION						
Output Voltage	V_{BATT}	$R_{IREF} = 24.3k\Omega$, $4.55V < V_{IN} < 6.10V$,	4.152	4.2	4.248	V
		$R_{IREF} = 24.3k\Omega$, $4.55V < V_{IN} < 6.10V$,	4.305	4.35	4.395	
PMOS On Resistance	$R_{DS(ON)}$	$V_{BAT} = 3.8V$, charge current = 500mA, $R_{IREF} = 10k\Omega$	--	0.5	--	Ω
CHARGE CURRENT						
IREF Pin Output Voltage	V_{IREF}	$V_{BAT} = 3.8V$, $R_{IREF} = 120k\Omega$	--	1.215	--	V
Constant Charge Current	I_{REF}	$R_{IREF} = 24.3k\Omega$, $V_{BAT} = 2.8V$ to $3.8V$	450	500	550	mA
Trickle Charge Current	I_{TRK}	$R_{IREF} = 24.3k\Omega$, $V_{BAT} = 2.4V$	70	90	110	mA
Accuracy of Trickle Charge Current ⁽¹⁾	$I_{TRK_ACCURACY}$	$V_{BAT}=3.8V$, $I_{REF}>500mA$		20		%
		$V_{BAT}=3.8V$, $100mA \leq I_{REF} \leq 500mA$		25		%
		$V_{BAT}=3.8V$, $10mA \leq I_{REF} \leq 100mA$		30		%
End-of-Charge Current ⁽¹⁾	I_{MIN}	$R_{IREF} = 24.3k\Omega$, $R_{IMIN}=243k\Omega$	32	40	48	mA
Accuracy of End-of-Charge Current ⁽¹⁾	$I_{MIN_ACCURACY}$	$I_{MIN_SETTING}=2mA$	0.5	2	3.5	mA
		$I_{MIN_SETTING}=5mA$	3	5	7	mA
		$I_{MIN_SETTING}>10mA$		20		%
EOC Rising Threshold		$R_{IREF} = 24.3k\Omega$	315	370	435	mA
PRECONDITIONING CHARGE THRESHOLD						
Preconditioning Charge Threshold Voltage	V_{PRE}	$R_{IREF} = 120k\Omega$	2.40	2.55	2.70	V
Preconditioning Voltage Hysteresis	V_{PRE_HYS}	$R_{IREF} = 120k\Omega$	20	100	190	mV
INTERNAL TEMPERATURE MONITORING						
Charge Current Foldback Threshold ⁽¹⁾	T_{FOLD}		--	115	--	$^{\circ}C$
LOGIC INPUT AND OUTPUTS						
$\overline{EN}$ Pin Logic Input High	V_{IH}		1.5	--	--	V
$\overline{EN}$ Pin Logic Input Low	V_{IL}		--	--	0.4	V
EN Pin Internal Pull Down Resistance	R_{EN}		--	200	--	$k\Omega$

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Electrical Characteristics(Continued)

Parameters	Symbol	Conditions	Min	Typ	Max	Unit
CHG Sink Current when LOW	$I_{SINK-CHG}$	Pin Voltage = 0.1V	15	24	--	mA
$\overline{CHG}$ Leakage Current when High Impedance	$I_{LEAK-CHG}$	$V_{CHG} = 5.5V$	--	--	20	μA
PPR Sink Current when LOW	$I_{SINK-PPR}$	Pin Voltage = 0.1V	15	24	--	mA
PPR Leakage Current when High Impedance	$I_{LEAK-PPR}$	$V_{PPR} = 5.5V$	--	--	20	μA

Note (1): Guaranteed by design and characterization. not a FT item.

Application Circuits

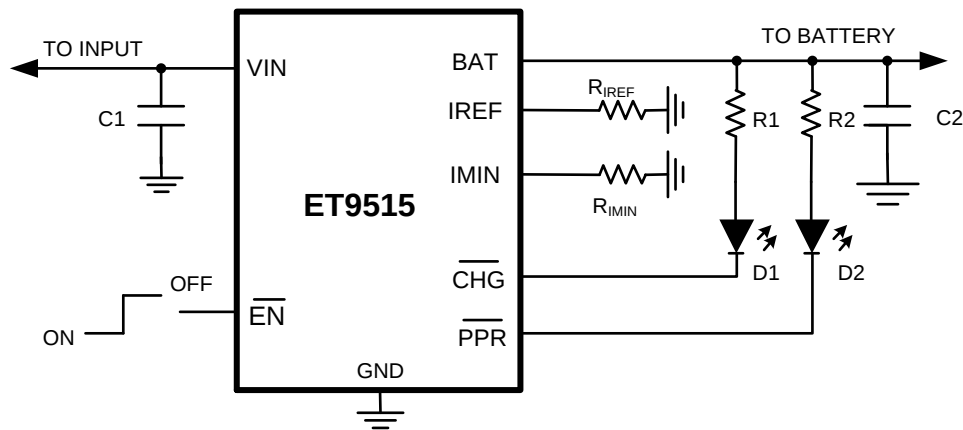


Figure 2. Application Circuit Interfacing to Indication LEDs

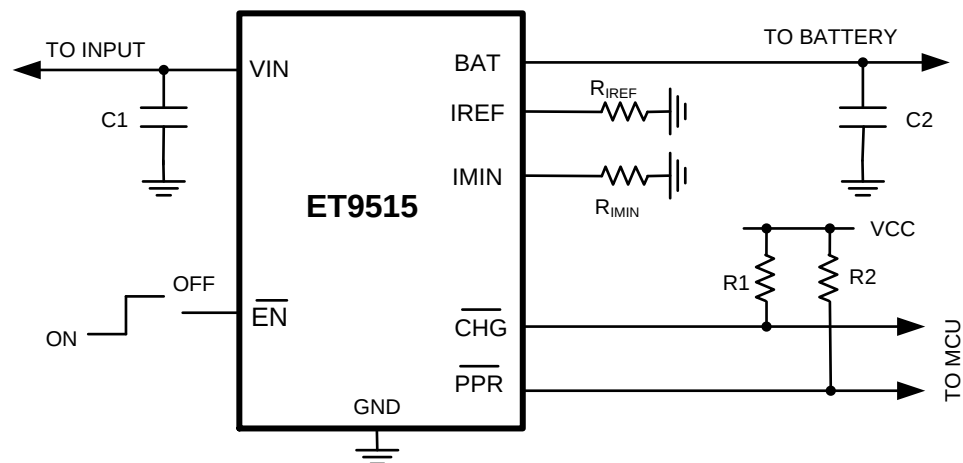
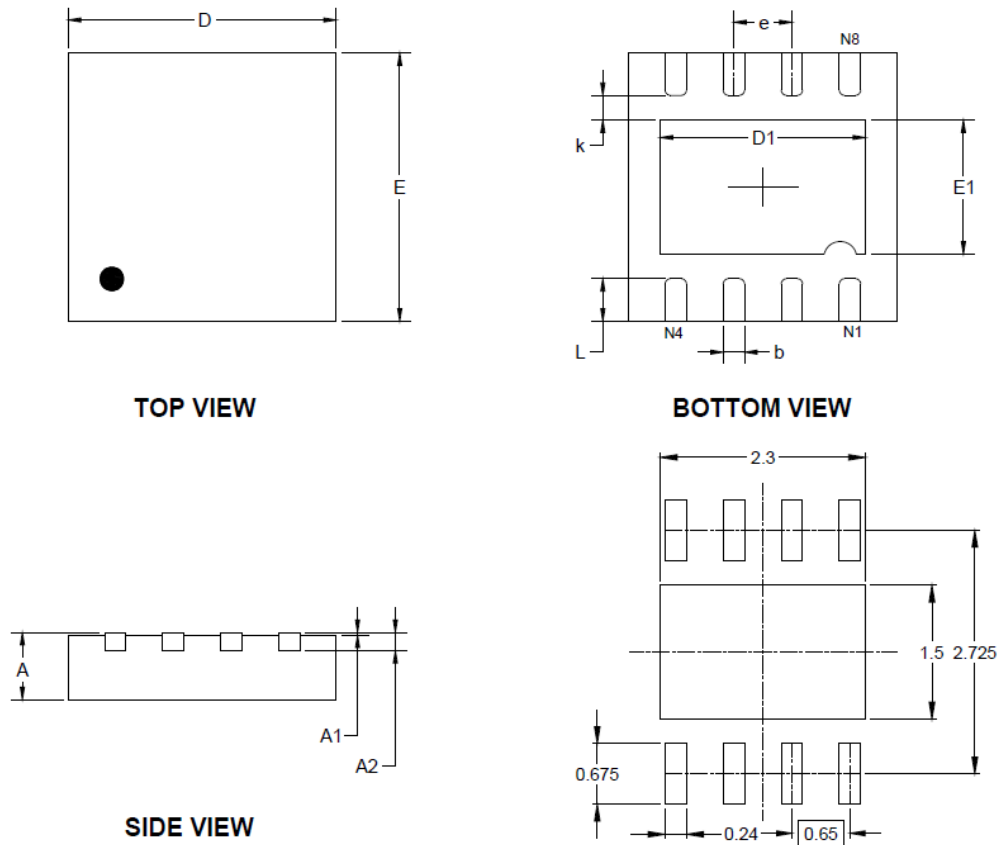


Figure 3. Application Circuit with the Indication Signals Interfacing to an MCU

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Package Dimension

DFN8-3×3

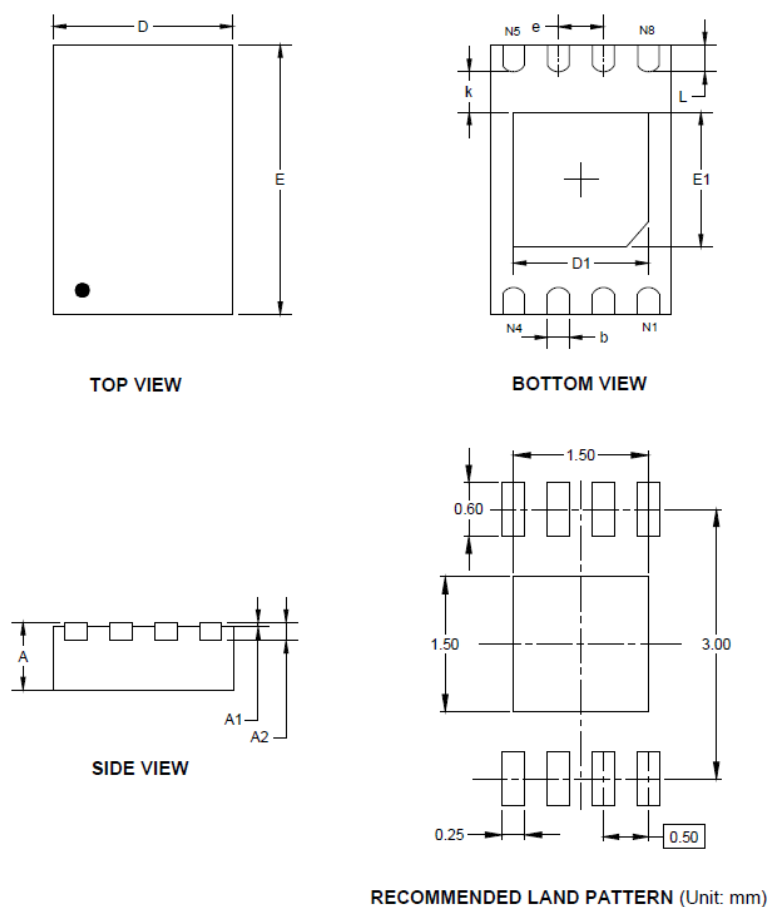


RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.200	2.400	0.087	0.094
E	2.900	3.100	0.114	0.122
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.650 TYP		0.026 TYP	
L	0.375	0.575	0.015	0.023

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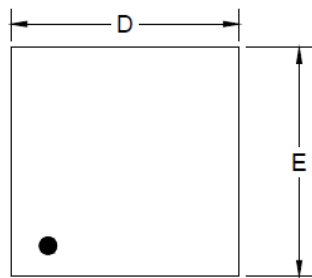
DFN8-2×3



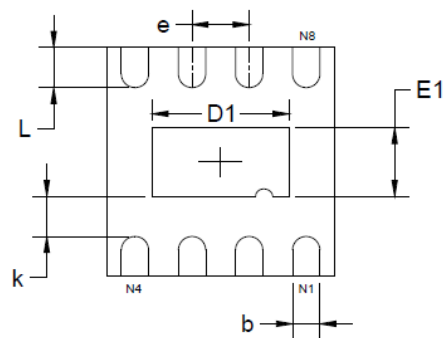
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.924	2.076	0.076	0.082
D1	1.400	1.600	0.055	0.063
E	2.924	3.076	0.115	0.121
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.200	0.300	0.008	0.012
e	0.500 TYP		0.020 TYP	
L	0.224	0.376	0.009	0.015

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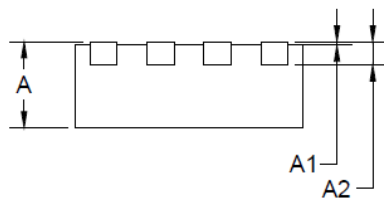
DFN8-2×2



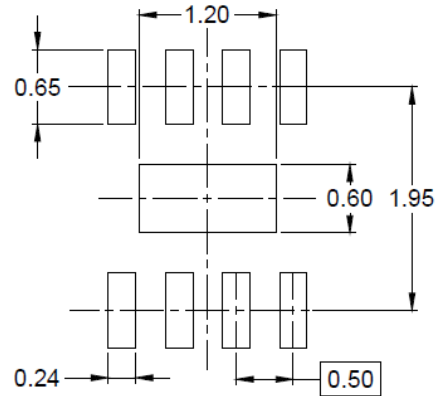
TOP VIEW



BOTTOM VIEW



SIDE VIEW

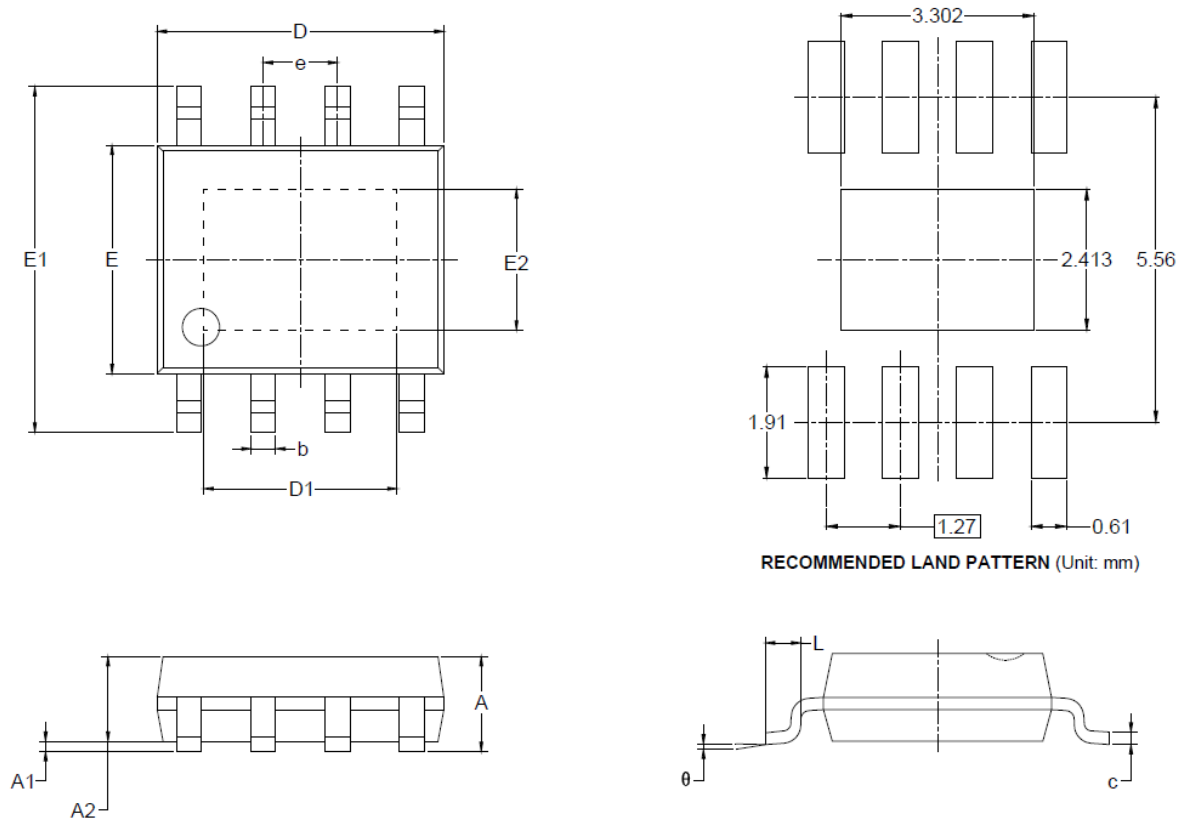


RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.300	0.043	0.051
E	1.900	2.100	0.075	0.083
E1	0.500	0.700	0.020	0.028
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.250	0.450	0.010	0.018

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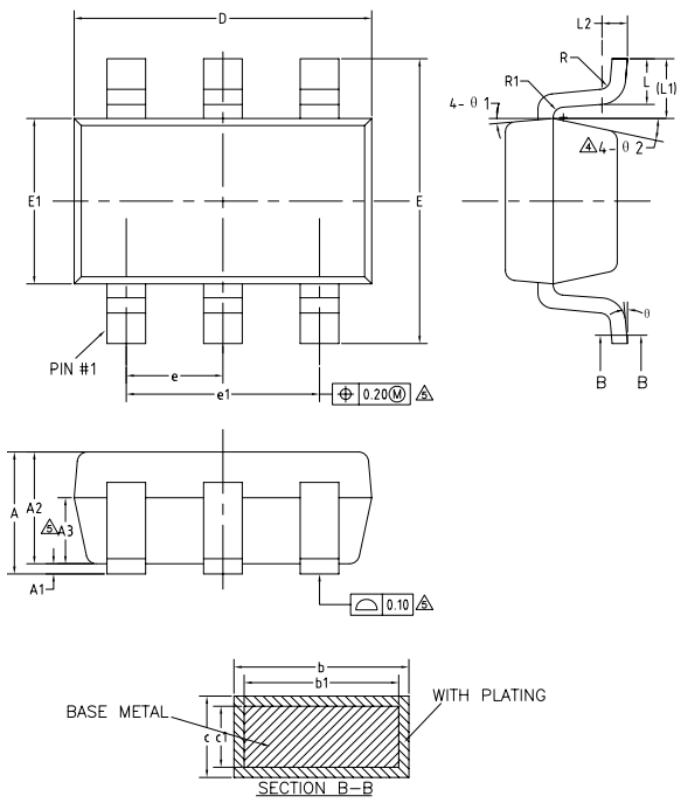
ESOP8 (Exposed Pad)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.700		0.067
A1	0.000	0.100	0.000	0.004
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

ET9515

SOT23-6



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	—	—	1.25
A1	0	—	0.15
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.36	—	0.50
b1	0.36	0.38	0.45
c	0.14	—	0.20
c1	0.14	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.726
e	0.90	0.95	1.00
e1	1.80	1.90	2.00
L	0.35	0.45	0.60
L1	—	0.59REF	—
L2	—	0.25BSC	—
R	0.10	—	—
R1	0.10	—	0.20
t	0°	—	8°
t 1	3°	5°	7°
t 2	6°	—	14°

Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2019-01-21	Original version	Xia Yong Jie	Xia Yong Jie	Liu Jia ying
1.1	2019-02-22	Update spec of I_{TRK} in EC table	Xia Yong Jie	Xia Yong Jie	Liu Jia ying
1.2	2020-04-20	Document check and formalize	Shibo	Shib	Liujiy
1.3	2023-2-22	Update Typeset	Shibo		
1.4	2023-8-31	Update I_{SINK} test voltage and typeset	Chen zuxiong		