# 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 $\overline{CHG}$ pin, which is an open-drain output. An internal thermal foldback function protects the charger from any thermal failure.

Two indication pins ($\overline{PPR}$ and $\overline{CHG}$) 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 -40ºC to +85ºC temperature range.

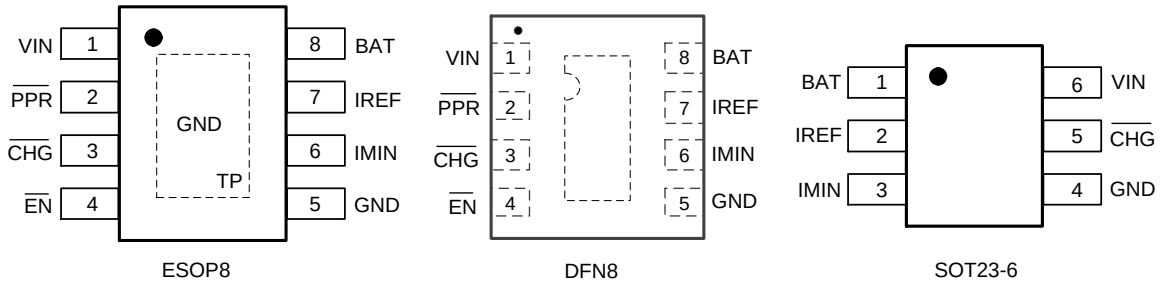
## Features

- 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

## Pin Configuration




TOP VIEW

## Pin Function

| Pin No. | | Name | Function |
|---|---|---|---|
| ESOP8/DFN8 | SOT23-6 | | |
| 1 | 6 | VIN | Power Supply Input. |
| 2 | | $\overline{PPR}$ | Indicator Output for Power Status. |
| 3 | 5 | $\overline{CHG}$ | Indicator Output for Charging Status. |
| 4 | | $\overline{EN}$ | 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: $I_{MIN} = 9700/R_{IMIN}$ (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: $I_{REF} = 12150/R_{IREF}$ (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. |

## 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**

| X OVP Voltage | | X BAT Voltage | | XX Package | |
|---|---|---|---|---|---|
| A/B | A: 6.8V<br>B:10.5V | L/H | L: 4.20V<br>H: 4.35V | S1 | ESOP8 |
| | | | | S2 | SOT23-6 |
| | | | | 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 RIREF (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 $\overline{CHG}$ pin, but the charger continues to output the 4.2V voltage. Figure 1 shows the typical charge waveforms after the power is on.

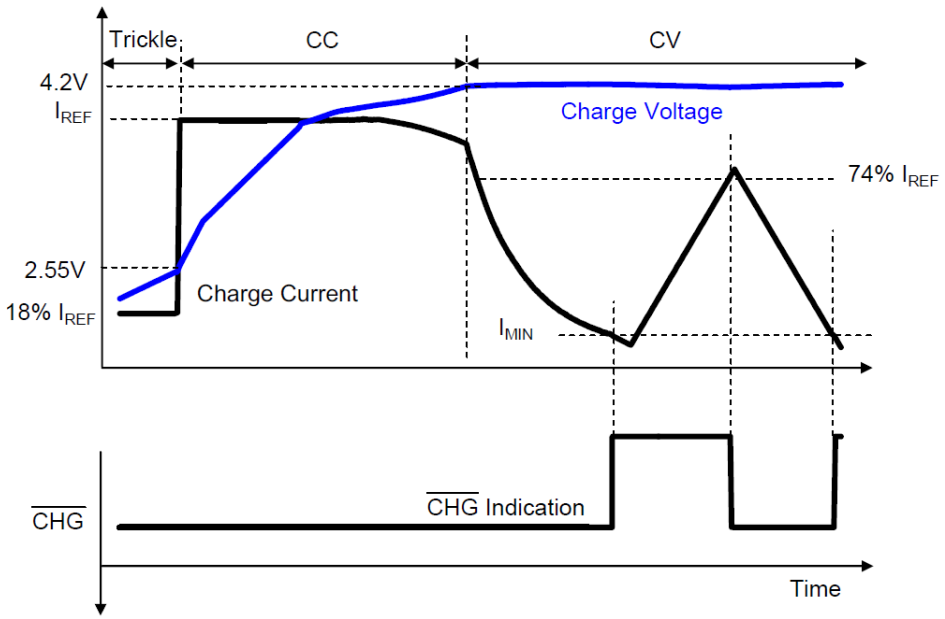



Figure1. Typical Charge Profile

### End of Charge Current

The EOC current level IMIN is programmable with the external resistor RIMIN. The $\overline{CHG}$ 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% IREF for the $\overline{CHG}$ 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 IMIN can be programmed by the following equation:

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

Where $R_{IMIN}$ is in kΩ。

### 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:

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

Where $R_{IREF}$ is in kΩ.

## Absolute Maximum Ratings

| Parameter | Rating | Unit |
|---|---|---|
| VIN to GND | -0.3 to 30 | V |
| $\overline{PPR}$ , $\overline{CHG}$ , $\overline{EN}$ , IMIN, IREF, BAT to GND. | -0.3 to 6 | V |
| Storage Temperature Range | -65 to 150 | ºC |
| **Package Thermal Resistance** | | |
| DFN8-3×3, $\theta_{JA}$ | 84 | ºC/W |
| DFN8-2×3, $\theta_{JA}$ | 110 | ºC/W |
| DFN8-2×2, $\theta_{JA}$ | 118 | ºC/W |
| ESOP8, $\theta_{JA}$ | 58 | ºC/W |
| Max Junction Temperature | 150 | ºC |
| Operating Temperature Range | -40 to 85 | ºC |
| Lead Temperature (Soldering 10 sec) | 260 | ºC |

## Electrical Characteristics

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

| Parameters | | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **RECOMMENDED OPERATING CONDITIONS** | | | | | | | |
| Maximum Supply Voltage | | | | -- | -- | 28 | V |
| Operating Supply Voltage | ET9515-6.8 | | | 4.55 | -- | 6.10 | V |
| | ET9515-10.5 | | | 4.55 | -- | 9.35 | |
| Programmed Charge Current | | | | 10 | -- | 1100 | mA |
| **POWER-ON RESET** | | | | | | | |
| Rising POR Threshold | | $V_{POR}$ | $V_{BAT}$ = 3.0V, $R_{IREF}$ = 120kΩ | 3.21 | 3.95 | 4.55 | V |
| Falling POR Threshold | | $V_{POR}$ | | 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 | $V_{OVPHYS}$ | | 140 | 220 | 300 | mV |
| | ET9515-10.5 | | | 245 | 340 | 430 | |
| **STANDBY CURRENT** | | | | | | | |
| BAT Pin Sink Current | | $I_{STANDBY}$ | The input is floating, $V_{BAT}$=4V | -- | 1 | 5 | μA |
| VIN Pin Supply Current | | $I_{VIN}$ | $V_{BAT}$ = 4.3V, $R_{IREF}$ = 24.3kΩ, charger disabled | -- | 200 | 275 | μA |
| VIN Pin Supply Current | | $I_{VIN}$ | $V_{BAT}$ = 4.3V, $R_{IREF}$ = 24.3kΩ, charger enabled | -- | 270 | 320 | μA |

## Electrical Characteristics(Continued)

| Parameters | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **VOLTAGE REGULATION** | | | | | | |
| Output Voltage | $V_{CH}$ | $R_{IREF}$ = 24.3kΩ, 4.55V < $V_{IN}$< 6.10V, | 4.152 | 4.2 | 4.248 | V |
| | | $R_{IREF}$ = 24.3kΩ, 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, $R_{IREF}$ = 10kΩ | -- | 0.5 | -- | Ω |
| **CHARGE CURRENT** | | | | | | |
| IREF Pin Output Voltage | $V_{IREF}$ | $V_{BAT}$ = 3.8V, $R_{IREF}$ = 120kΩ | -- | 1.215 | -- | V |
| Constant Charge Current | $I_{REF}$ | $R_{IREF}$ = 24.3kΩ, $V_{BAT}$ = 2.8V to 3.8V | 450 | 500 | 550 | mA |
| Trickle Charge Current | $I_{TRK}$ | $R_{IREF}$ = 24.3kΩ, $V_{BAT}$ = 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≤$I_{REF}$≤500mA | | 25 | | % |
| | | $V_{BAT}$=3.8V，10mA≤$I_{REF}$≤100mA | | 30 | | % |
| End-of-Charge Current (1) | $I_{MIN}$ | $R_{IREF}$ = 24.3kΩ | 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 | | $R_{IREF}$ = 24.3kΩ | 315 | 370 | 435 | mA |
| **PRECONDITIONING CHARGE THRESHOLD** | | | | | | |
| Preconditioning Charge Threshold Voltage | $V_{MIN}$ | $R_{IREF}$ = 120kΩ | 2.40 | 2.55 | 2.70 | V |
| Preconditioning Voltage Hysteresis | $V_{MINHYS}$ | $R_{IREF}$ = 120kΩ | 20 | 100 | 190 | mV |
| **INTERNAL TEMPERATURE MONITORING** | | | | | | |
| Charge Current Foldback Threshold(1) | $T_{FOLD}$ | | -- | 115 | -- | ℃ |
| **LOGIC INPUT AND OUTPUTS** | | | | | | |
| $\overline{EN}$ Pin Logic Input High | | | 1.5 | -- | -- | V |
| $\overline{EN}$ Pin Logic Input Low | | | -- | -- | 0.4 | V |
| $\overline{EN}$ Pin Internal Pull Down Resistance | | | -- | 200 | -- | kΩ |
| $\overline{CHG}$ Sink Current when LOW | | Pin Voltage = 1V | 15 | 24 | -- | mA |

## Electrical Characteristics(Continued)

| Parameters | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $\overline{CHG}$ Leakage Current when High Impedance | | $V_{CHG}$= 5.5V | -- | -- | 20 | μA |
| $\overline{PPR}$ Sink Current when LOW | | Pin Voltage = 1V | 15 | 24 | -- | mA |
| $\overline{PPR}$ Leakage Current when High Impedance | | $V_{PPR}$= 5.5V | -- | -- | 20 | μA |

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

## Application Circuits

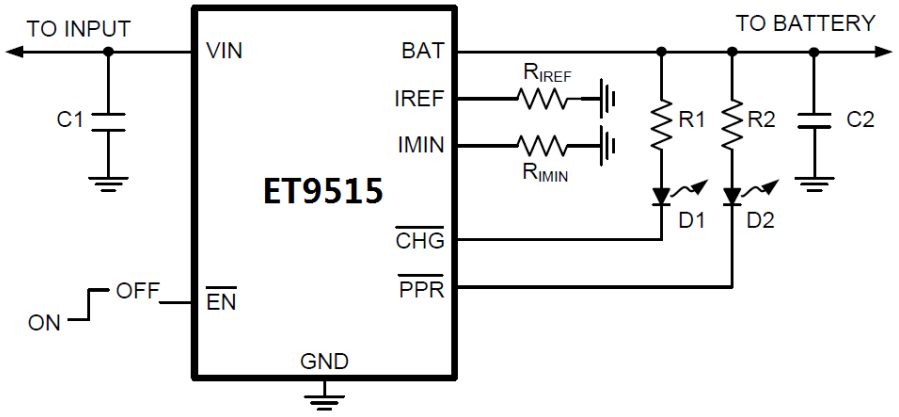



Figure 2. Application Circuit Interfacing to Indication LEDs

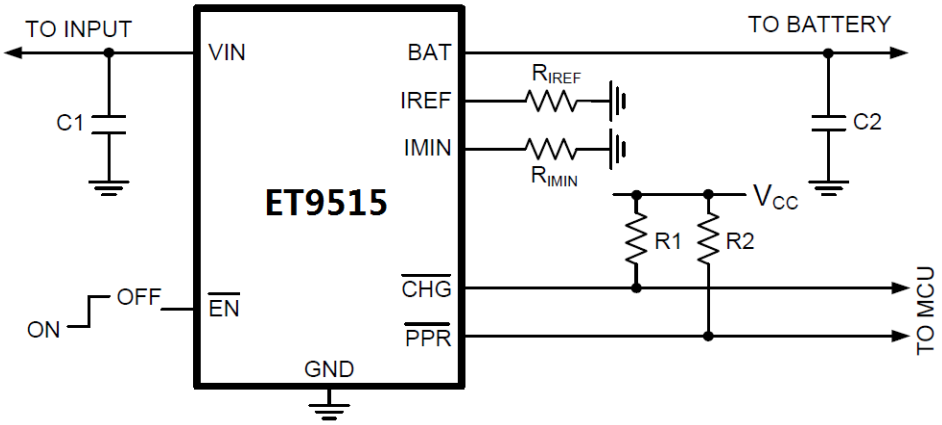
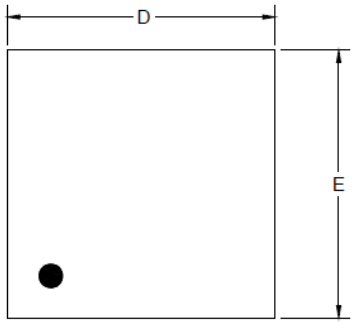


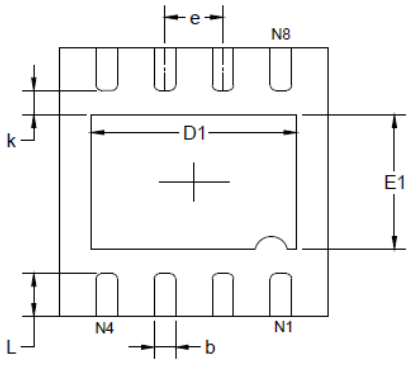

Figure 3. Application Circuit with the Indication Signals Interfacing to an MCU

## Package Dimension

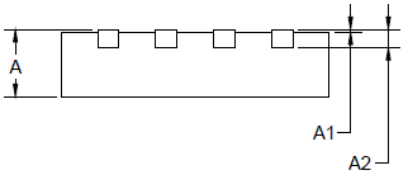
### DFN8-3×3



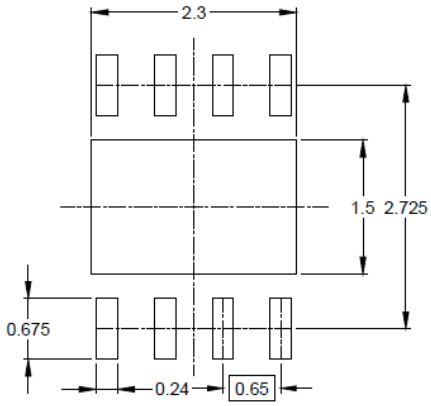

TOP VIEW




BOTTOM VIEW



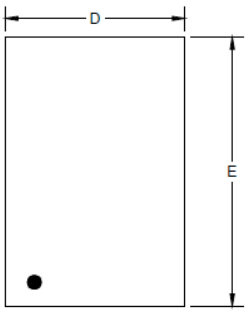

SIDE VIEW



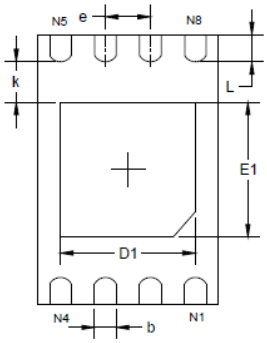

RECOMMENDED LAND PATTERN (Unit: mm)

| 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 | 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 |

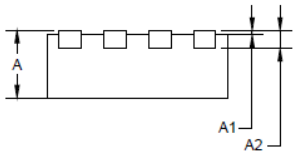
**DFN8-2×3**



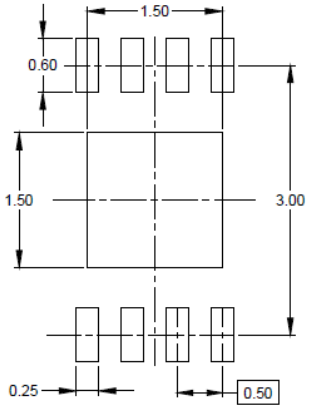

TOP VIEW




BOTTOM VIEW




SIDE VIEW

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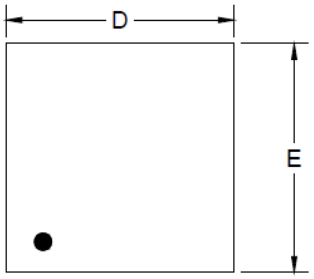
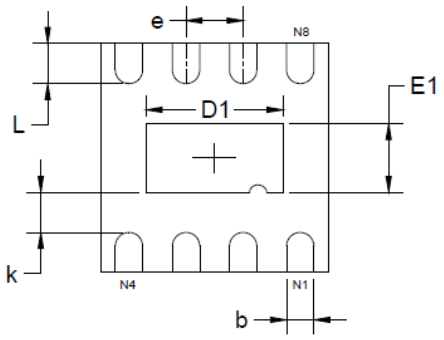
| | MIN | MAX | MIN | MAX |
| A | 0.700 | 0.800 | 0.028 | 0.031 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A2 | 0.203 REF | | 0.008 REF | |
| D | 1.924 | 2.076 | 0.076 | 0.082 |
| D1 | 1.400 | 1.600 | 0.055 | 0.063 |
| E | 2.924 | 3.076 | 0.115 | 0.121 |
| E1 | 1.400 | 1.600 | 0.055 | 0.063 |
| k | 0.200 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 |

**DFN8-2×2**




TOP VIEW

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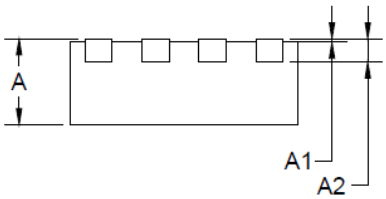
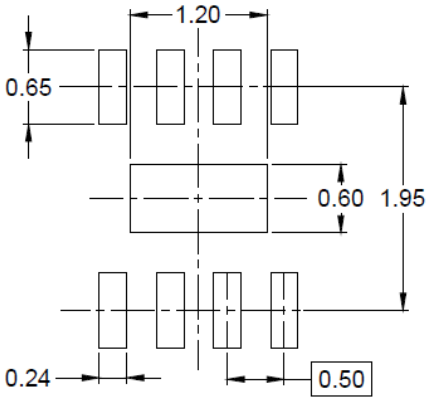



SIDE VIEW

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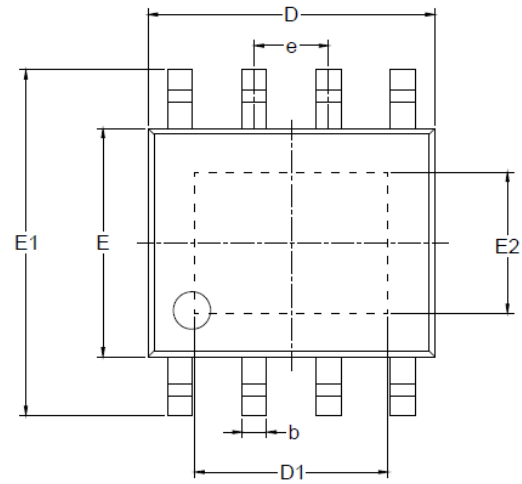
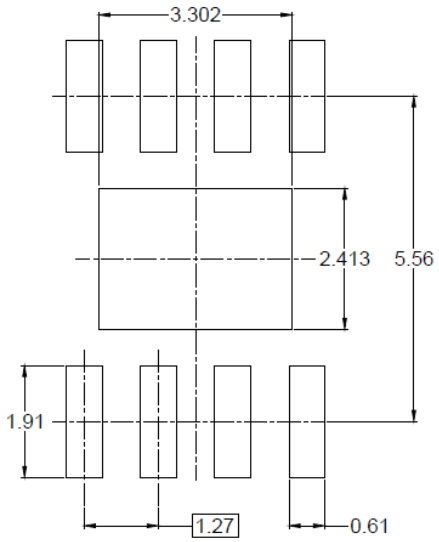
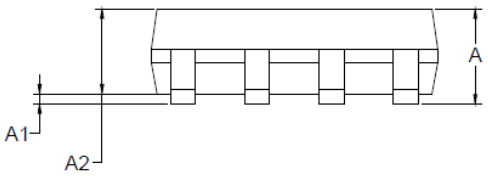
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A2 | 0.203 REF | | 0.008 REF | |
| D | 1.900 | 2.100 | 0.075 | 0.083 |
| D1 | 1.100 | 1.300 | 0.043 | 0.051 |
| E | 1.900 | 2.100 | 0.075 | 0.083 |
| E1 | 0.500 | 0.700 | 0.020 | 0.028 |
| k | 0.200 MIN | | 0.008 MIN | |
| b | 0.180 | 0.300 | 0.007 | 0.012 |
| e | 0.500 TYP | | 0.020 TYP | |
| L | 0.250 | 0.450 | 0.010 | 0.018 |

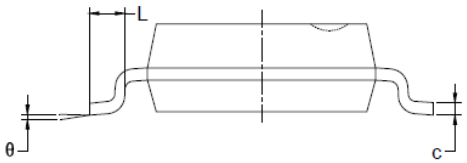
**ESOP8 (Exposed Pad)**



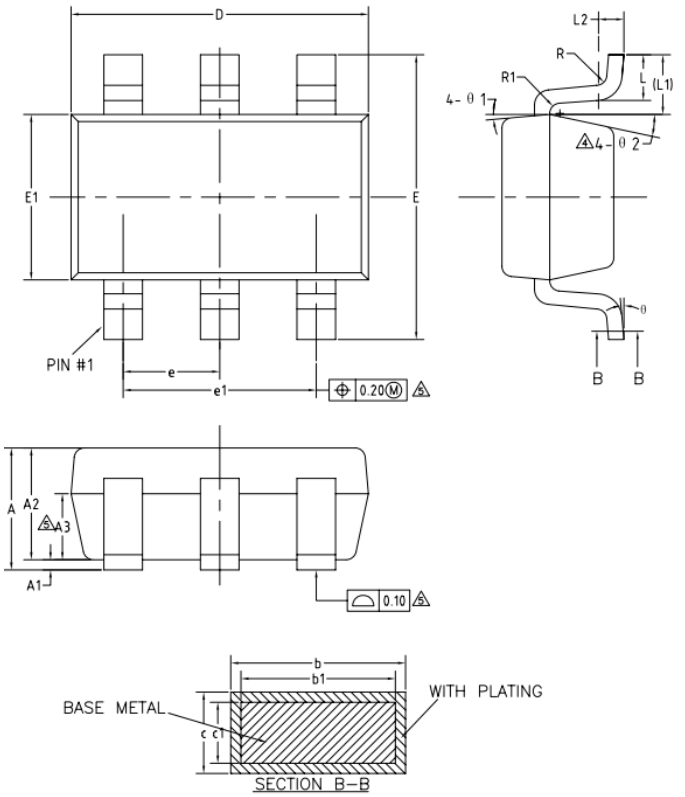

**RECOMMENDED LAND PATTERN** (Unit: mm)




| 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° |

**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 |
| ④ | e | 0.90 | 0.95 | 1.00 |
| ④ | e1 | 1.80 | 1.90 | 2.00 |
| | L | 0.35 | 0.45 | 0.60 |
| | L1 | | 0.59REF | |
| | L2 | | 0.25BSC | |
| ③ | R | 0.10 | – | – |
| ③ | R1 | 0.10 | – | 0.20 |
| | θ | 0° | – | 8° |
| | θ 1 | 3° | 5° | 7° |
| ④ | θ 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 | Liujy |
| 1.3 | 2023-2-22 | Update Typeset | Shibo | | |