

EVALUATION KIT  
AVAILABLE**MAXIM**

# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

## General Description

The MAX1508 is an intelligent, stand-alone constant-current, constant-voltage (CCCV), thermally regulated linear charger for a single-cell lithium-ion (Li+) battery. The MAX1508 integrates the current-sense circuit, MOS pass element, and thermal-regulation circuitry, and also eliminates the reverse-blocking Schottky diode, to create the simplest and smallest charging solution for hand-held equipment.

The MAX1508 functions as a stand-alone charger to control the charging sequence from the prequalification state through fast-charge, top-off charge, and full-charge indication. The MAX1508Y and MAX1508Z eliminate the prequalification state to allow startup into a load without a battery.

Proprietary thermal-regulation circuitry limits the die temperature to +100°C when fast charging or while exposed to high ambient temperatures, allowing maximum charging current without damaging the IC.

The MAX1508 achieves high flexibility by providing an adjustable fast-charge current by an external resistor. Other features include the charging status (CHG) of the battery, an active-low control input (EN) for the MAX1508 and MAX1508Z (active-high control input for the MAX1508Y), and an active-low input power-source detection output (ACOK).

The MAX1508 accepts a +4.25V to +13V supply, but disables charging when the input voltage exceeds +7V to protect against unqualified or faulty AC adapters. The MAX1508 operates over the extended temperature range (-40°C to +85°C) and is available in a compact 8-pin thermally enhanced 3mm x 3mm thin DFN package with 0.8mm height.

## Applications

Cellular and Cordless Phones  
PDAs  
Digital Cameras and MP3 Players  
USB Appliances  
Charging Cradles and Docks  
Bluetooth™ Equipment

*Typical Operating Circuit appears at end of data sheet.*

*Bluetooth is a trademark of Ericsson.*

## Features

- ◆ Stand-Alone Linear 1-Cell Li+ Battery Charger
- ◆ No External FET, Reverse-Blocking Diode, or Current-Sense Resistor Required
- ◆ Programmable Fast-Charge Current (0.8A max)
- ◆ Proprietary Die-Temperature Regulation Control (+100°C)
- ◆ +4.25V to +13V Input Voltage Range with Input Overvoltage Protection (OVP) Above +7V
- ◆ Charge-Current Monitor for Fuel Gauging
- ◆ Low Dropout Voltage—130mV at 0.425A
- ◆ Input Power-Source Detection Output (ACOK)
- ◆ Soft-Start Limits Inrush Current
- ◆ No Prequalification State for the MAX1508Y and MAX1508Z
- ◆ Charge Status Output (CHG) for LED or Microprocessor Interface
- ◆ Small 3mm x 3mm 8-Pin Thin DFN Package, 0.8mm High
- ◆ Active-Low Charge Enable (EN) (MAX1508 and MAX1508Z)
- ◆ Active-High Charge Enable (EN) (MAX1508Y)

## Ordering Information

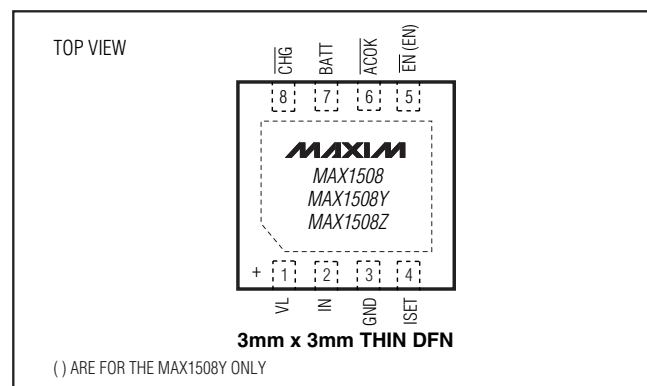
| PART         | TEMP RANGE     | PIN-PACKAGE    | TOP MARK |
|--------------|----------------|----------------|----------|
| MAX1508ETA-T | -40°C to +85°C | 8 Thin DFN-EP* | AHF      |
| MAX1508ETA+T | -40°C to +85°C | 8 Thin DFN-EP* | AHF      |

\*EP = Exposed paddle.

+Denotes lead-free package.

Ordering Information continued at end of data sheet.

## Pin Configuration

**MAXIM**

Maxim Integrated Products 1

**For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).**

**MAX1508/MAX1508Y/MAX1508Z**

# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

## ABSOLUTE MAXIMUM RATINGS

IN,  $\overline{\text{CHG}}$  to GND ..... -0.3V to +14V  
 VL, BATT, ISET,  $\overline{\text{EN}}$ , EN,  $\overline{\text{ACOK}}$  to GND ..... -0.3V to +6V  
 VL to IN ..... -14V to +0.3V  
 IN to BATT Continuous Current ..... 0.9A  
 Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )  
 8-Pin TDFN (derate 24.4mW/°C above +70°C) ..... 1951mW

Short-Circuit Duration ..... Continuous  
 Operating Temperature Range ..... -40°C to +85°C  
 Junction Temperature ..... +150°C  
 Storage Temperature Range ..... -65°C to +150°C  
 Lead Temperature (soldering, 10s) ..... +300°C

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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

( $V_{\text{IN}} = 5\text{V}$ ,  $V_{\text{BATT}} = 4.0\text{V}$ ,  $\overline{\text{ACOK}} = \overline{\text{EN}} = \overline{\text{CHG}}$  = unconnected (for the MAX1508 and MAX1508Z), EN = VL (for the MAX1508Y),  $R_{\text{ISET}} = 2.8\text{k}\Omega$  to GND,  $C_{\text{VL}} = 0.47\mu\text{F}$ , BATT bypassed to GND with  $1\mu\text{F}$ ,  $T_A = -40^\circ\text{C}$  to +85°C, unless otherwise noted. Typical values are at  $T_A = +25^\circ\text{C}$ .) (Note 1)

| PARAMETER                               | CONDITIONS                                                                              |                                    | MIN   | TYP  | MAX   | UNITS         |
|-----------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------|-------|------|-------|---------------|
| Input Voltage Range                     |                                                                                         |                                    | 0     |      | 13    | V             |
| Input Operating Range                   |                                                                                         |                                    | 4.25  |      | 6.50  | V             |
| $\overline{\text{ACOK}}$ Trip Point, IN | $V_{\text{IN}} - V_{\text{BATT}}$ , $V_{\text{IN}}$ rising                              |                                    | 20    | 40   | 60    | mV            |
|                                         | $V_{\text{IN}} - V_{\text{BATT}}$ , $V_{\text{IN}}$ falling                             |                                    | 15    | 30   | 45    |               |
| Overvoltage Lockout Trip Point          | $V_{\text{IN}}$ rising                                                                  |                                    | 6.5   | 7    | 7.5   | V             |
|                                         | $V_{\text{IN}}$ hysteresis                                                              |                                    |       | 0.11 |       |               |
| IN Input Current                        | Charging ( $I_{\text{IN}} - I_{\text{BATT}}$ )                                          |                                    |       | 1    | 2     | mA            |
|                                         | Disabled, $\overline{\text{EN}} = \text{VL}$ (MAX1508/MAX1508Z),<br>EN = GND (MAX1508Y) |                                    |       | 0.8  | 1.5   |               |
|                                         | OFF state ( $V_{\text{IN}} = V_{\text{BATT}} = 4.0\text{V}$ )                           |                                    |       |      | 0.065 |               |
| VL Output Voltage                       | $I_{\text{VL}} = 100\mu\text{A}$                                                        |                                    |       | 3.3  |       | V             |
| VL Load Regulation                      | $I_{\text{VL}} = 100\mu\text{A}$ to 2mA                                                 |                                    |       | -71  | -200  | mV            |
| VL Temperature Coefficient              | $I_{\text{VL}} = 100\mu\text{A}$                                                        |                                    |       | -2   |       | mV/°C         |
| VL Undervoltage Lockout Trip Point      | $V_{\text{IN}}$ rising                                                                  |                                    |       | 2.95 |       | V             |
|                                         | Hysteresis                                                                              |                                    |       | 0.17 |       |               |
| BATT Input Current                      | $V_{\text{IN}} = 0$ to 4V                                                               |                                    |       | 3    | 10    | $\mu\text{A}$ |
|                                         | $\overline{\text{EN}} = \text{VL}$ (MAX1508/MAX1508Z), EN = GND<br>(MAX1508Y)           |                                    |       | 4    | 10    |               |
| Maximum RMS Charge Current              |                                                                                         |                                    |       | 0.8  |       | A             |
| Battery Regulation Voltage              | $I_{\text{BATT}} = 0$                                                                   | $T_A = 0^\circ\text{C}$ to +85°C   | 4.162 | 4.2  | 4.238 | V             |
|                                         |                                                                                         | $T_A = -40^\circ\text{C}$ to +85°C | 4.150 | 4.2  | 4.250 |               |
| BATT Removal Detection Threshold        | $V_{\text{BATT}}$ rising                                                                |                                    | 4.4   | 4.67 | 4.9   | V             |

# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{IN} = 5V$ ,  $V_{BATT} = 4.0V$ ,  $\overline{ACOK} = \overline{EN} = \overline{CHG}$  = unconnected (for the MAX1508 and MAX1508Z),  $EN = VL$  (for the MAX1508Y,)  $R_{ISET} = 2.8k\Omega$  to GND,  $C_{VL} = 0.47\mu F$ , BATT bypassed to GND with  $1\mu F$ ,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Note 1)

| PARAMETER                                                                             | CONDITIONS                                                              | MIN                 | TYP   | MAX   | UNITS      |
|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------|-------|-------|------------|
| BATT Removal Detection-Threshold Hysteresis                                           |                                                                         |                     | 200   |       | mV         |
| Minimum BATT Bypass Capacitance                                                       |                                                                         |                     | 1     |       | $\mu F/A$  |
| Fast-Charge Current-Loop System Accuracy                                              | $V_{BATT} = 3.5V$                                                       | 478                 | 520   | 562   | mA         |
| Precharge Current System Accuracy                                                     | Percentage of the fast-charge current, $V_{BATT} = 2.2V$ (MAX1508 only) | 5                   | 10    | 15    | %          |
| Die-Temperature-Regulation Set Point                                                  |                                                                         |                     | 100   |       | $^\circ C$ |
| $V_{BATT}$ Precharge Threshold Voltage                                                | $V_{BATT}$ rising (MAX1508 only)                                        | 2.3                 | 2.5   | 2.7   | V          |
| Current-Sense Amplifier Gain, $I_{SET}$ to $I_{BATT}$ in Fast-Charge Mode             | $I_{BATT} = 500mA$ , $V_{ISET} = 1.4V$                                  | 0.880               | 0.958 | 1.035 | mA/A       |
| Regulator Dropout Voltage ( $V_{IN} - V_{BATT}$ )                                     | $V_{BATT} = 4.1V$ , $I_{BATT} = 425mA$                                  |                     | 130   | 200   | mV         |
| $\overline{EN}$ or EN Logic Input Low Voltage                                         | $4.25V < V_{IN} < 6.5V$                                                 |                     |       | 0.52  | V          |
| $\overline{EN}$ or EN Logic Input High Voltage                                        | $4.25V < V_{IN} < 6.5V$                                                 | 1.3                 |       |       | V          |
| $\overline{EN}$ or EN Internal Pulldown Resistor                                      | (MAX1508 and MAX1508Z only)                                             | 100                 | 200   | 400   | $k\Omega$  |
| $\overline{CHG}$ Output Low Current                                                   | $V_{\overline{CHG}} = 1V$                                               | 5                   | 12    | 20    | mA         |
| $\overline{CHG}$ Output High Leakage Current                                          | $V_{\overline{CHG}} = 13V$                                              | $T_A = +25^\circ C$ |       | 1     | $\mu A$    |
|                                                                                       |                                                                         | $T_A = +85^\circ C$ |       | 0.002 |            |
| $\overline{ACOK}$ Output Low Voltage                                                  | $I_{\overline{ACOK}} = 0.5mA$                                           |                     |       | 0.4   | V          |
| $\overline{ACOK}$ Output High Leakage Current                                         | $V_{\overline{ACOK}} = 5.5V$                                            | $T_A = +25^\circ C$ |       | 1     | $\mu A$    |
|                                                                                       |                                                                         | $T_A = +85^\circ C$ |       | 0.002 |            |
| Full-Battery Detection Current Threshold (as a Percentage of the Fast-Charge Current) | $I_{BATT}$ falling                                                      | 5                   | 10    | 15    | %          |

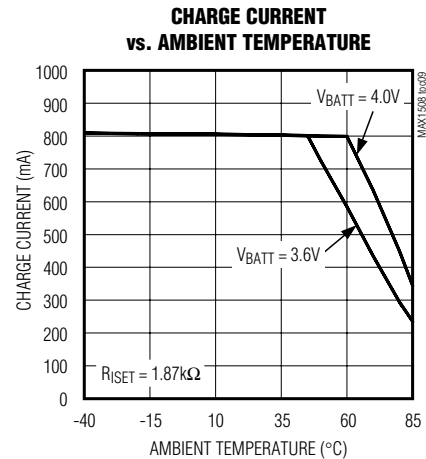
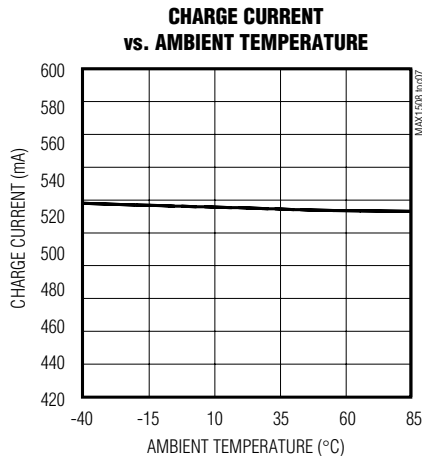
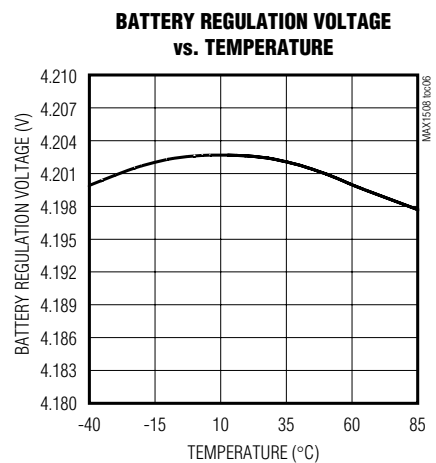
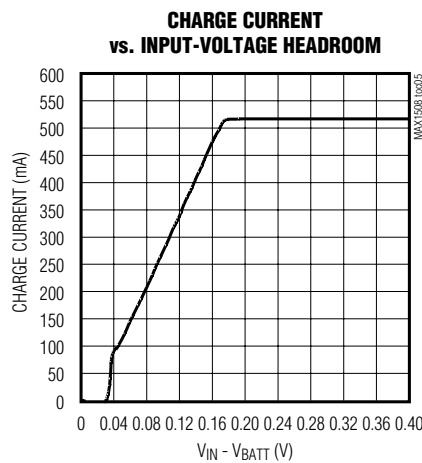
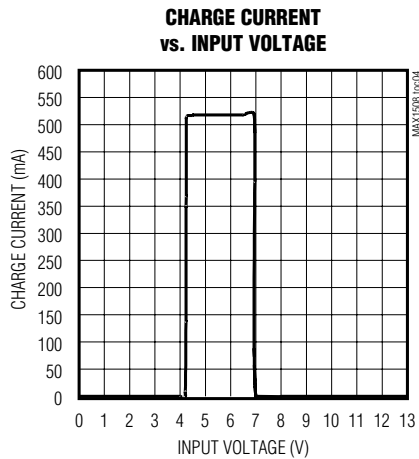
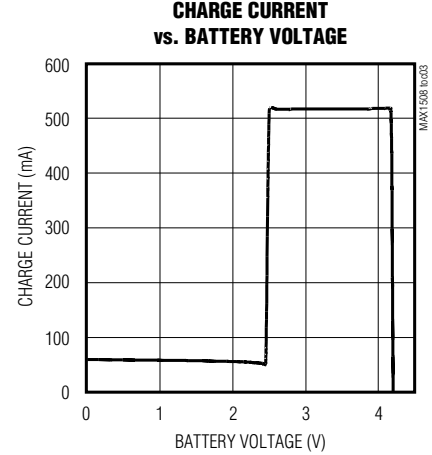
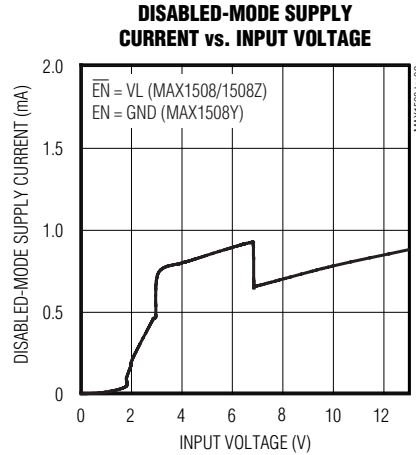
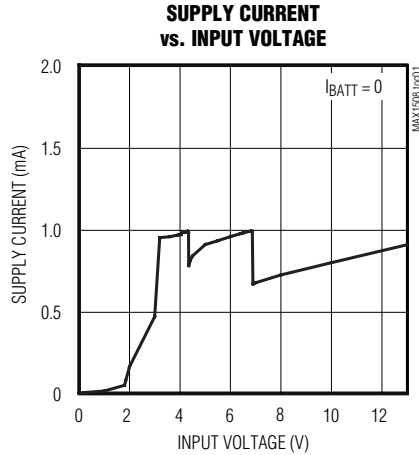
**Note 1:** Limits are 100% production tested at  $T_A = +25^\circ C$ . Limits over operating temperature range are guaranteed through correlation using statistical quality control (SQC) methods.

MAX1508/MAX1508Y/MAX1508Z

# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

## Typical Operating Characteristics

( $V_{IN} = 5V$ ,  $V_{BATT} = 4.0V$ ,  $\overline{ACOK} = \overline{EN} = \overline{CHG} = \text{unconnected}$ ,  $EN = VL$  (MAX1508Y),  $R_{ISET} = 2.8k\Omega$  to GND,  $C_{IN} = 1\mu F$ ,  $C_{BATT} = 1\mu F$ ,  $C_{VL} = 0.47\mu F$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

## Pin Description

| PIN | NAME              | FUNCTION                                                                                                                                                                                                                                                                                                                                             |
|-----|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | VL                | Internally Generated Logic Supply for Chip. Bypass VL to GND with a 0.47μF capacitor.                                                                                                                                                                                                                                                                |
| 2   | IN                | Input Supply Voltage. Bypass IN to GND with a 1μF capacitor to improve line noise and transient rejection.                                                                                                                                                                                                                                           |
| 3   | GND               | Ground. Connect GND and exposed pad to a large copper trace for maximum power dissipation.                                                                                                                                                                                                                                                           |
| 4   | ISET              | Charge-Current Program and Fast-Charge Current Monitor. Output current from ISET is 0.958mA per amp of battery charging current. The charging current is set by connecting a resistor from ISET to GND. Fast-charge current = $1461V / R_{ISET}\Omega$ .                                                                                             |
| 5   | $\overline{EN}$   | Logic-Level Enable Input (MAX1508/1508Z). Drive $\overline{EN}$ high to disable charger. Pull $\overline{EN}$ low or float for normal operation. EN has an internal 200kΩ pulldown resistor.                                                                                                                                                         |
|     | EN                | Logic-Level Enable Input (MAX1508Y). Drive EN low to disable charger. Drive EN high for normal operation.                                                                                                                                                                                                                                            |
| 6   | $\overline{ACOK}$ | Input Power-Detection Output. The open-drain $\overline{ACOK}$ output asserts low when $+4.25V \leq V_{IN} \leq +7V$ and $V_{IN} - V_{BATT} \geq 40mV$ . $\overline{ACOK}$ requires an external 100kΩ pullup resistor. $\overline{ACOK}$ is high impedance in shutdown.                                                                              |
| 7   | BATT              | Li+ Battery Connection. Bypass BATT to GND with a capacitor of at least 1μF per ampere of charge current.                                                                                                                                                                                                                                            |
| 8   | $\overline{CHG}$  | Charging Indicator, Open-Drain Output. $\overline{CHG}$ goes low (and can turn on an LED) when charging begins. $\overline{CHG}$ is high impedance when the battery current drops below 10% of the fast-charging current, or when $\overline{EN}$ is high. Connect a pullup resistor to the μP's I/O voltage when interfacing with a μP logic input. |
| —   | PAD               | Exposed Pad. Connect exposed pad to a large copper trace for maximum power dissipation. The pad is internally connected to GND.                                                                                                                                                                                                                      |

## Detailed Description

The MAX1508 charger uses voltage, current, and thermal-control loops to charge a single Li+ cell and to protect the battery (Figure 1). When a Li+ battery with a cell voltage below 2.5V is inserted, the MAX1508 charger enters the prequalification stage where it precharges that cell with 10% of the user-programmed fast-charge current. There is no prequalification stage for the MAX1508Z and MAX1508Y in order to allow startup into a load without a battery. The  $\overline{CHG}$  indicator output is driven low (Figure 2) to indicate entry into the prequalification state. Once the cell has passed 2.5V, the charger soft-starts before it enters the fast-charge stage. The fast-charge current level is programmed through a resistor from ISET to ground. As the battery voltage approaches 4.2V, the charging current is reduced. If the battery current drops to less than 10% of the fast-charging current, the  $\overline{CHG}$  indicator goes high impedance, signaling the battery is fully charged. At this point the MAX1508 enters a constant voltage-regulation mode to maintain the battery at full charge. If, at any point while charging the battery, the die temperature approaches +100°C, the MAX1508 reduces the charging current so the die temperature does not exceed the temperature-regulation set point.

The thermal-regulation loop limits the MAX1508 die temperature to +100°C by reducing the charge current as necessary (see the *Thermal Regulation* section).

This feature not only protects the MAX1508 from overheating, but also allows higher charge current without risking damage to the system.

### MAX1508/MAX1508Z $\overline{EN}$ Charger Enable Input

$\overline{EN}$  is a logic input (active low) to enable the charger. Drive  $\overline{EN}$  low, leave floating, or connect to GND to enable the charger control circuitry. Drive  $\overline{EN}$  high to disable the charger control circuitry.  $\overline{EN}$  has a 200kΩ internal pulldown resistance.

### MAX1508Y EN Charger Enable Input

EN is a logic input (active high) to enable the charger. Drive EN high to enable the charger control circuitry. Drive EN low to disable the charger control circuitry.

### $\overline{ACOK}$ Output

Active-Low Output. The open-drain  $\overline{ACOK}$  output asserts low when  $+4.25V < V_{IN} < +7V$  and  $V_{IN} - V_{BATT} > 40mV$ .  $\overline{ACOK}$  requires an external 100kΩ pullup resistor to the system's logic I/O voltage.  $\overline{ACOK}$  is high impedance in shutdown.

### VL Internal Voltage Regulator

The MAX1508 linear charger contains an internal linear regulator available on the VL output pin. VL requires a 0.47μF ceramic bypass capacitor to GND. VL is regulated to 3.3V whenever the input voltage is above 3.5V.

### Soft-Start

An analog soft-start algorithm activates when entering fast-charge mode. When the prequalification state is complete (VBATT exceeds +2.5V), the charging current ramps up in 3ms to the full charging current. This reduces the inrush current on the input supply. Since the MAX1508Y and MAX1508Z do not have a prequalification state, they automatically enter soft-start upon activation.



# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

MAX1508/MAX1508Y/MAX1508Z

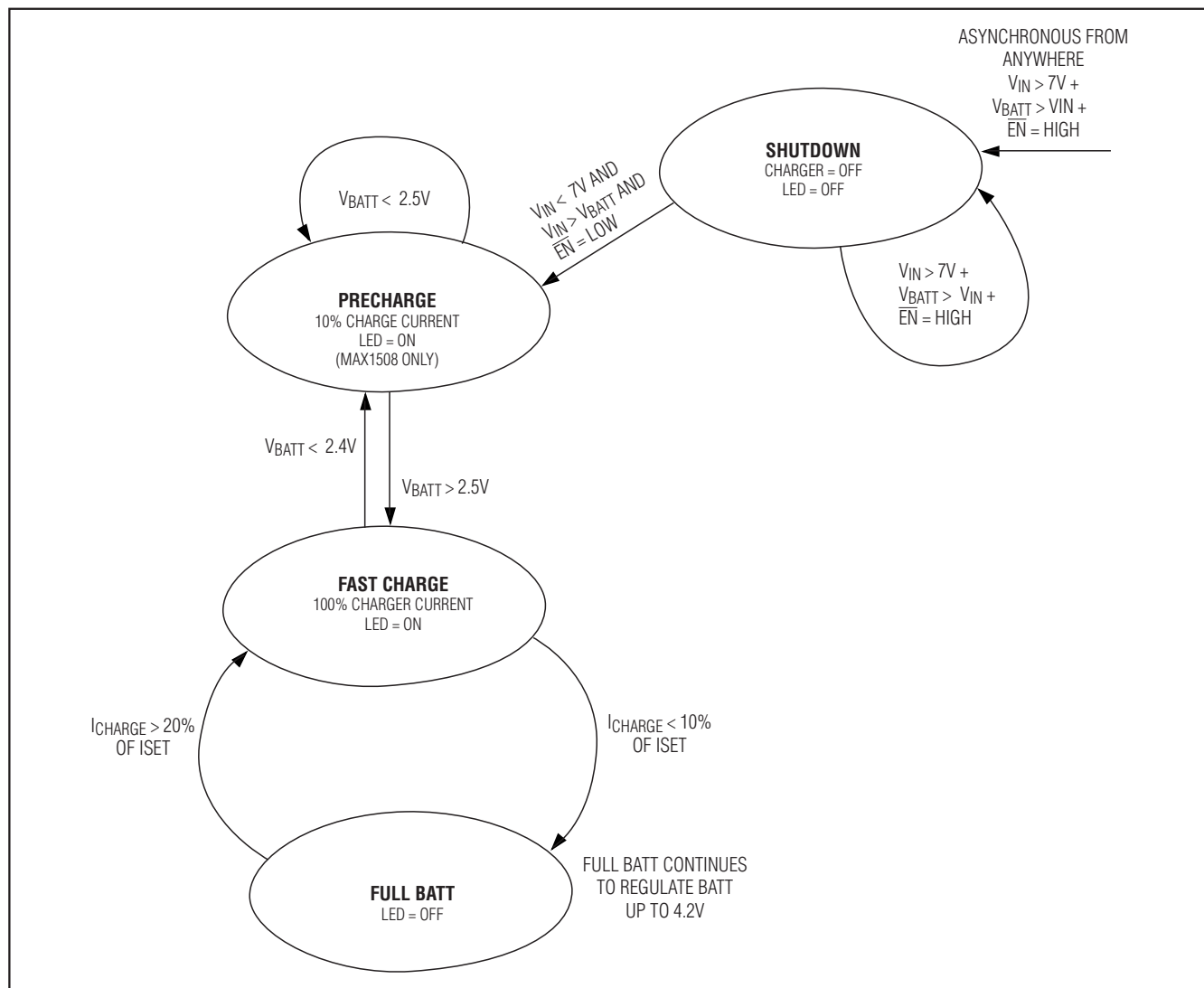


Figure 2. Charge State Diagram

## Applications Information

### Charge-Current Selection

The maximum charging current is programmed by an external  $R_{ISET}$  resistor connected from ISET to GND. Select the  $R_{ISET}$  value based on the following formula:

$$I_{FAST} = 1461V / R_{ISET}\Omega$$

where  $I_{FAST}$  is in amps and  $R_{ISET}$  is in ohms. ISET can also be used to monitor the fast-charge current level. The output current from the ISET pin is 0.958mA per amp of charging current. The output voltage at ISET is proportional to the charging current as follows:

$$V_{ISET} = (I_{CHG} \times R_{ISET}) / 1044$$

The voltage at ISET is nominally 1.4V at the selected fast-charge current, and falls with charging current as the cell becomes fully charged.

### Thermal Regulation

The MAX1508 features a proprietary thermal-regulation circuit to protect both the IC and the system from excessive heat. When the MAX1508's die temperature reaches +100°C, the charge current is reduced to prevent any additional increase in the die temperature. An active thermal loop does not indicate a fault condition. Thermal regulation allows the MAX1508 to provide continuous charge to the battery under adverse conditions without causing excessive power dissipation.

# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

## Capacitor Selection

Connect a ceramic capacitor from BATT to GND for proper stability. Use a 1 $\mu$ F X5R ceramic capacitor for most applications.

Connect a 1 $\mu$ F ceramic capacitor from IN to GND. Use a larger input bypass capacitor for high input voltages or high charging currents to reduce supply noise.

Connect a 0.47 $\mu$ F ceramic capacitor from VL to GND.

## Thermal Considerations

The MAX1508 is in a thermally enhanced thin DFN package with exposed paddle. Connect the exposed paddle of the MAX1508 to a large copper ground plane to provide a thermal contact between the device and the circuit board. The exposed paddle transfers heat away from the device, allowing the MAX1508 to charge the battery with maximum current, while minimizing the increase in die temperature.

## DC Input Sources

The MAX1508 operates from well-regulated DC sources. The full-charging input voltage range is 4.25V to 7V. The device can stand up to 13V on the input without damage to the IC. If  $V_{IN}$  is greater than 7V, then the MAX1508 stops charging.

An appropriate power supply must provide at least 4.25V when sourcing the desired peak charging current. It also must stay below 6.5V when unloaded.

## Application Circuits

### Stand-Alone Li+ Charger

The MAX1508 provides a complete Li+ charging solution. The *Typical Operating Circuit* at the end of the data sheet shows the MAX1508 as a stand-alone Li+ battery charger. The 2.8k $\Omega$  resistor connected to ISET sets a charging current of 520mA. The LED indicates when either fast-charge or precharge qualification has begun. When the battery is full, the LED turns off.

## Microprocessor-Interfaced Charger

Figure 3 shows the MAX1508 as a  $\mu$ P-cooperated Li+ battery charger. The MAX1508 and MAX1508Z start charging the battery when  $\overline{EN}$  is low. The  $\mu$ P can drive  $\overline{EN}$  high to disable the charger (MAX1508 and MAX1508Z). The MAX1508's  $\overline{ACOK}$  output indicates the presence of a valid AC adapter to the  $\mu$ P.  $\overline{CHG}$  can be used to detect the charge status of a battery. By monitoring  $V_{ISET}$ , the system can measure the charge current.

## USB-Powered Li+ Charger

The universal serial bus (USB) provides a high-speed serial communication port as well as power for the remote device. The MAX1508 can be configured to charge its battery at the highest current possible from the host port. Figure 4 shows the MAX1508 as a USB battery charger. To make the circuit compatible with either 100mA or 500mA USB ports, the circuit initializes at 95mA charging current. The microprocessor then interrogates the host to determine its current capability. If the host port is capable, the charging current is increased to 435mA. The 435mA current was chosen to avoid exceeding the 500mA USB specification.

## Layout and Bypassing

Connect a 1 $\mu$ F ceramic input capacitor as close to the device as possible. Provide a large copper GND plane to allow the exposed paddle to sink heat away from the device. Connect the battery to BATT as close to the device as possible to provide accurate battery voltage sensing. Make all high-current traces short and wide to minimize voltage drops. For an example layout, refer to the MAX1507/MAX1508 evaluation kit layout.

## Chip Information

TRANSISTOR COUNT: 1812

PROCESS: BiCMOS

**Table 1.  $\overline{CHG}$  States**

| $\overline{EN}$<br>(MAX1508/MAX1508Z) | EN<br>(MAX1508Y) | $V_{IN}$                    | $V_{BATT}$  | $I_{BATT}$        | $\overline{CHG}$ | STATE            |
|---------------------------------------|------------------|-----------------------------|-------------|-------------------|------------------|------------------|
| X                                     | X                | $V_{BATT}$                  | $V_{IN}$    | 0                 | Hi-Z             | Shutdown         |
| Low                                   | High             | $4.25V \leq V_{IN} \leq 7V$ | $< 2.5V$    | 10% of $I_{FAST}$ | Low              | Prequalification |
| Low                                   | High             | $4.25V \leq V_{IN} \leq 7V$ | $\geq 2.5V$ | $I_{FAST}^*$      | Low              | Fast Charge      |
| Low                                   | High             | $4.25V \leq V_{IN} \leq 7V$ | 4.2V        | 10% of $I_{FAST}$ | Hi-Z             | Full Charge      |
| Low                                   | High             | $> 7V$                      | X           | 0                 | Hi-Z             | Overvoltage      |
| High                                  | Low              | X                           | X           | 0                 | Hi-Z             | Disabled         |

X = Don't care.

\* $I_{FAST}$  is reduced as necessary to maintain the die temperature at +100°C.



# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

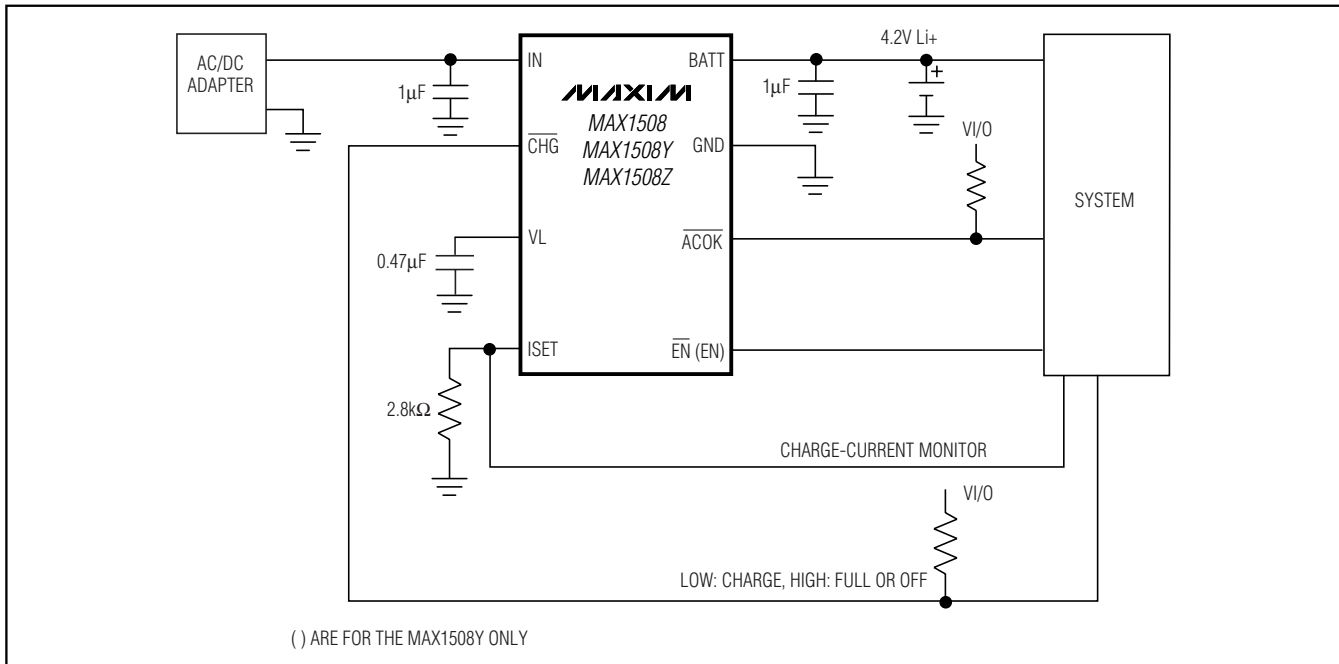


Figure 3.  $\mu$ P-Interfaced Li+ Battery Charger

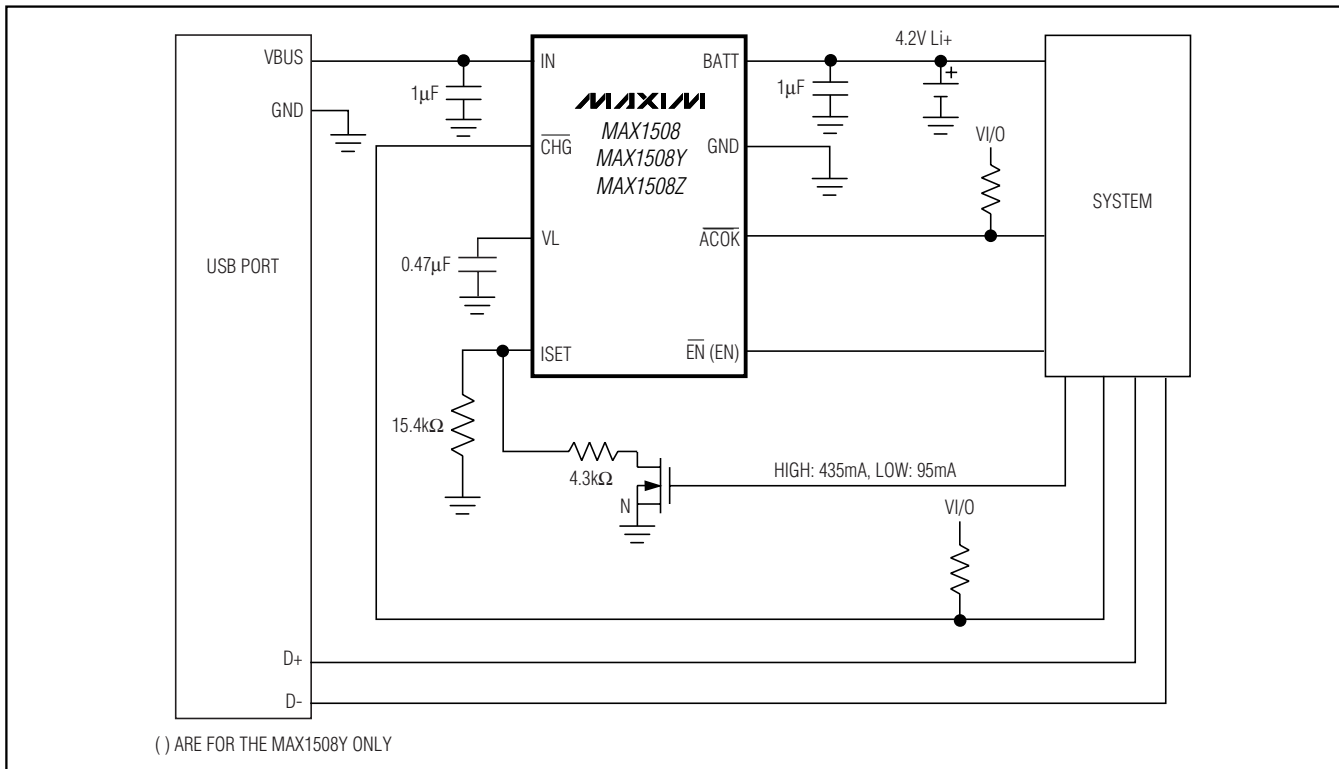


Figure 4. USB Battery Charger

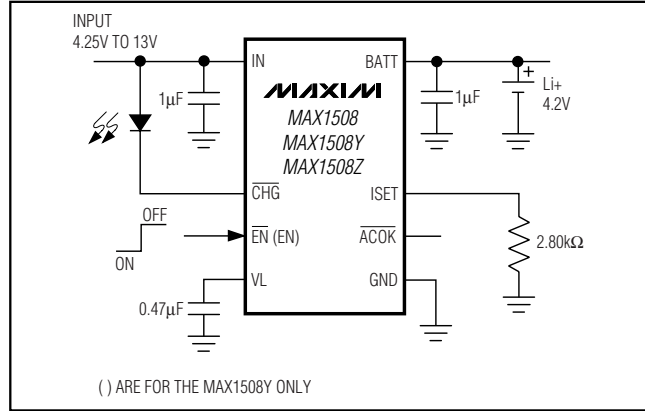
# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

## Ordering Information (continued)

| PART          | TEMP RANGE     | PIN-PACKAGE    | TOP MARK |
|---------------|----------------|----------------|----------|
| MAX1508YETA-T | -40°C to +85°C | 8 Thin DFN-EP* | AIL      |
| MAX1508YETA+T | -40°C to +85°C | 8 Thin DFN-EP* | AIL      |
| MAX1508ZETA-T | -40°C to +85°C | 8 Thin DFN-EP* | AIK      |
| MAX1508ZETA+T | -40°C to +85°C | 8 Thin DFN-EP* | AIK      |

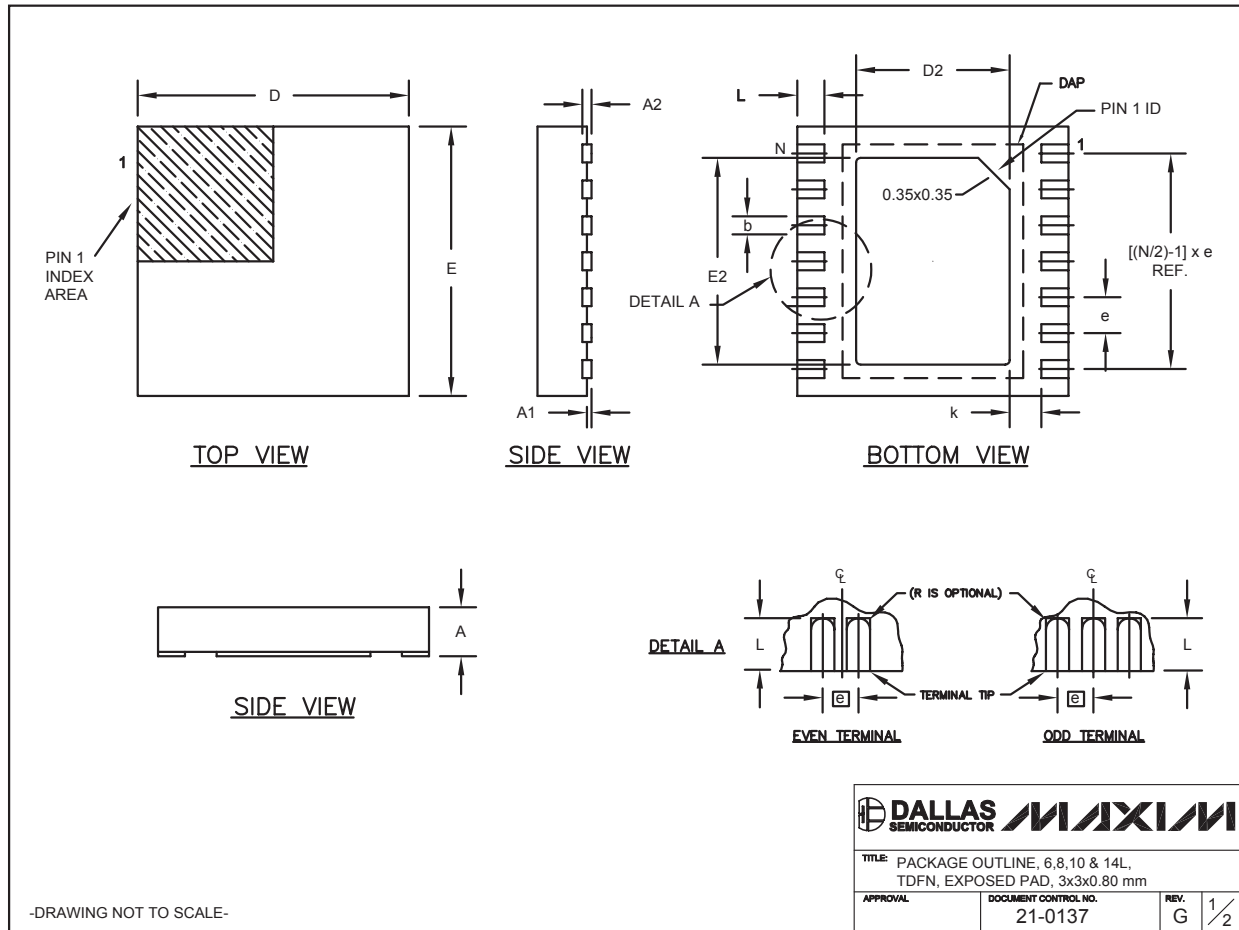
\*EP = Exposed paddle.  
+Denotes lead-free package.

## Typical Operating Circuit



## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



# Linear Li+ Battery Charger with Integrated Pass FET, Thermal Regulation, and ACOK in 3mm x 3mm TDFN

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

| COMMON DIMENSIONS |           |      |
|-------------------|-----------|------|
| SYMBOL            | MIN.      | MAX. |
| A                 | 0.70      | 0.80 |
| D                 | 2.90      | 3.10 |
| E                 | 2.90      | 3.10 |
| A1                | 0.00      | 0.05 |
| L                 | 0.20      | 0.40 |
| k                 | 0.25 MIN. |      |
| A2                | 0.20 REF. |      |

| PACKAGE VARIATIONS |    |           |           |          |                |           |               |                   |
|--------------------|----|-----------|-----------|----------|----------------|-----------|---------------|-------------------|
| PKG. CODE          | N  | D2        | E2        | e        | JEDEC SPEC     | b         | [(N/2)-1] x e | DOWNBONDS ALLOWED |
| T633-1             | 6  | 1.50±0.10 | 2.30±0.10 | 0.95 BSC | MO229 / WEEA   | 0.40±0.05 | 1.90 REF      | NO                |
| T633-2             | 6  | 1.50±0.10 | 2.30±0.10 | 0.95 BSC | MO229 / WEEA   | 0.40±0.05 | 1.90 REF      | NO                |
| T833-1             | 8  | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC   | 0.30±0.05 | 1.95 REF      | NO                |
| T833-2             | 8  | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC   | 0.30±0.05 | 1.95 REF      | NO                |
| T833-3             | 8  | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC   | 0.30±0.05 | 1.95 REF      | YES               |
| T1033-1            | 10 | 1.50±0.10 | 2.30±0.10 | 0.50 BSC | MO229 / WEED-3 | 0.25±0.05 | 2.00 REF      | NO                |
| T1433-1            | 14 | 1.70±0.10 | 2.30±0.10 | 0.40 BSC | ----           | 0.20±0.05 | 2.40 REF      | YES               |
| T1433-2            | 14 | 1.70±0.10 | 2.30±0.10 | 0.40 BSC | ----           | 0.20±0.05 | 2.40 REF      | NO                |

### NOTES:

1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY SHALL NOT EXCEED 0.08 mm.
3. WARPAGE SHALL NOT EXCEED 0.10 mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.
6. "N" IS THE TOTAL NUMBER OF LEADS.
7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.

-DRAWING NOT TO SCALE-

|                                                                                       |                                 |
|---------------------------------------------------------------------------------------|---------------------------------|
|  |                                 |
| TITLE: PACKAGE OUTLINE, 6,8,10 & 14L, TDFN, EXPOSED PAD, 3x3x0.80 mm                  |                                 |
| APPROVAL                                                                              | DOCUMENT CONTROL NO.<br>21-0137 |
| REV.<br>G                                                                             | 2/2                             |

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