

## 2A Monolithic Multichemistry Battery Charger for Solar Power

### DESCRIPTION

Demonstration circuit 1568A is a 2A monolithic multichemistry battery charger for solar power applications featuring the LT3652EDD. The LT3652 is a complete mid-power Li-Ion battery charger that can operate over a wide input voltage range. The charger employs a 3.3V float voltage feedback reference that allows the battery float voltage to be adjusted up to 14.4V. The LT3652 has an input voltage regulation loop which reduces charge current if the input falls below a programmed level, set with a resistor divider. The circuit provides CC/CV charging with a 2A maximum charge current that is programmed by

a sense resistor. A precondition feature trickle charges a low voltage battery, and bad battery detection provides a signal if the battery does not respond to preconditioning.

The LT3652EDD is available in a 12-lead (3mm × 3mm) DFN surface mount package with an exposed pad.

**Design files for this circuit board are available at <http://www.linear.com/demo>**

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### PERFORMANCE SUMMARY (T<sub>A</sub> = 25°C)

| PARAMETER                 | CONDITIONS                            | VALUE          |
|---------------------------|---------------------------------------|----------------|
| Input Voltage Range       |                                       | 11.5V to 32V   |
| V <sub>OUT</sub>          |                                       | 8.14V to 8.26V |
| Output Float Voltage      | Constant Voltage Mode                 | 8.2V           |
| Output Current Limit ILIM | V <sub>IN_REG</sub> Greater Than 2.7V | 2A             |

### OPERATING PRINCIPLES

LT3652 is a complete monolithic mid-power Li-Ion battery charger, addressing high input voltage applications with solutions that require a minimum of external components. The IC uses a 1MHz constant frequency, average-current mode step-down architecture.

The LT3652 maximizes efficiency during charging cycles by using a bootstrapped supply to drive the internal power switch. When the output voltage is programmed to 8.2V, the circuit provides full charge over a wide 11.5V to 32V input range. A precision threshold shutdown pin allows the incorporation of UVLO functionality using a simple resistor divider. The IC can also be put into a low current shutdown mode, in which the input supply bias is reduced to only 15 $\mu$ A.

The LT3652 charge current control allows maximum power point tracking (MPPT) use with solar panels. The overall maximum charge current is set using an external inductor current sense resistor. An input voltage regulation pin allows the charger to reduce the battery charge current if necessary so the solar panel produces the most power.

The LT3652 automatically enters a battery precondition mode if the sensed battery voltage is very low. In this mode, the charging current is reduced to 15% of the programmed maximum, as set by the inductor sense resistor, R<sub>SENSE</sub>. Once the battery voltage increases to the precondition threshold, the IC automatically increases

## OPERATING PRINCIPLES

maximum charging current to the full programmed value. DC1568A programs the output voltage to be 8.2V, and the 5.7V precondition threshold is internally set as a fraction of the programmed output voltage.

The LT3652 can use a charge current based C/10 termination scheme, which ends a charge cycle when the battery charge current falls to one-tenth the programmed maximum charge current. The LT3652 also contains an internal charge cycle control timer, for timer-based termination. When using the internal timer, the IC combines C/10 detection with a programmable time constraint, during which the charging cycle can continue beyond the C/10 level to “top off” a battery. The charge cycle terminates when a specific time elapses, typically three hours. When the timer based scheme is used, the IC also supports bad battery detection, which triggers a system fault if a battery stays in precondition mode for more than one-eighth of the total charge cycle time.

Once charging is terminated and the LT3652 is not actively charging, the IC automatically enters a low current standby mode where supply bias currents are reduced to  $< 100\mu\text{A}$ . If the battery voltage drops 2.5% from the full charge float voltage, the LT3652 engages an automatic charge cycle restart. The IC also automatically restarts a new charge cycle after a bad battery fault once the failed battery is removed and replaced with another battery.

The LT3652 includes provisions for a battery temperature monitoring circuit. This feature monitors battery temperature during the charging cycle using a thermistor, and suspends charging and signals a fault condition if the battery temperature moves outside a safe charging range of  $0^{\circ}\text{C}$  to  $50^{\circ}\text{C}$ .

The LT3652 contains two digital open collector outputs, which provide charger status and signal fault conditions. These binary coded pins signal battery charging, standby or shutdown modes, battery temperature faults and bad battery faults.

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## QUICK START PROCEDURE

DC1568A is easy to set up to evaluate the performance of the LT3652EDD.

Using short twisted-pair leads for any power connections, with all loads and power supplies off, refer to Figure 1 for the proper measurement and equipment setup.

Follow the procedure below:

1. Jumper and power supply settings:

|                   |                  |
|-------------------|------------------|
| <b>JP1 = 1</b>    | <b>JP4 = 1</b>   |
| <b>JP2 = 1</b>    | <b>PS1 = OFF</b> |
| <b>JP3 = C/10</b> | <b>PS2 = OFF</b> |

2. Turn on PS2 and slowly increase the voltage until  $V_{\text{BAT}}$  is 5.4V while monitoring the current into the BAT pin. If the current is less than 5mA, turn on PS1. Increase PS1 until  $V_{\text{IN}}$  is 12V while monitoring the input current.

3. Verify that the battery charging current,  $I_{\text{BAT}}$ , is between 250mA and 350mA. The CHRG LED should be on and the FAULT LED should be off.

4. Increase PS2 until  $V_{\text{BAT}}$  is 7.2V. Verify that the input current,  $I_{\text{IN}}$ , is between 1.3A and 1.7A, the battery current,  $I_{\text{BAT}}$ , is between 1.775A and 2.225A and that the CHRG LED is on.

5. Increase PS2 until  $V_{\text{BAT}}$  is 8.5V. Verify that the battery charging current,  $I_{\text{BAT}}$ , is less than 5mA and that the CHRG LED is off.

6. Decrease PS2 until  $V_{\text{BAT}}$  is 7.8V. Verify that the battery current,  $I_{\text{BAT}}$ , is between 1.775A and 2.225A and that the CHRG LED is on.

7. Set JP1 to 0. Verify that the charging current,  $I_{\text{BAT}}$ , is less than 5mA and that the FAULT LED and the CHRG LED are off.

8. Set JP1 to 1. Connect a jumper from the NTC pin to ground. Verify that the charging current,  $I_{\text{BAT}}$ , is less than 5mA and that the FAULT LED and the CHRG LED are on.

## QUICK START PROCEDURE

9. Remove the jumper from NTC to ground. Verify that the charging current,  $I_{BAT}$ , is between 1.775A and 2.225A, that the FAULT LED is off and the CHRГ LED is on.
  10. Turn on LOAD1 and set to 1A. Verify that the voltage,  $V_{SYSTEM}$ , on the SYSTEM LOAD turret is approximately equal to  $V_{IN}$ .
  11. Set JP2 to 0. Verify that the battery charging current is less than 5mA and that the CHRГ LED is off.
  12. Increase PS1 until  $V_{IN}$  is 14V. Verify that the charging current is between 1.775A and 2.225A and that the CHRГ LED is on. Set JP2 to 1.
  13. Set JP4 to 0. Setting JP4 to 0 turns off the charge current when  $V_{IN}$  is less than 17.7V. Verify that the battery charging current is less than 5mA and that the CHRГ LED is off.
  14. Increase PS1 until  $V_{IN}$  is 17.7V. Verify that the charging current is between 1.775A and 2.225A and that the CHRГ LED is on. Set JP4 to 1.
  15. Turn off PS1, PS2 and LOAD1.
- NOTE: All connections from equipment should be Kelvin-connected directly to the board pins which they are connected to on the diagram in Figure 1, and any input or output leads should be twisted pair.

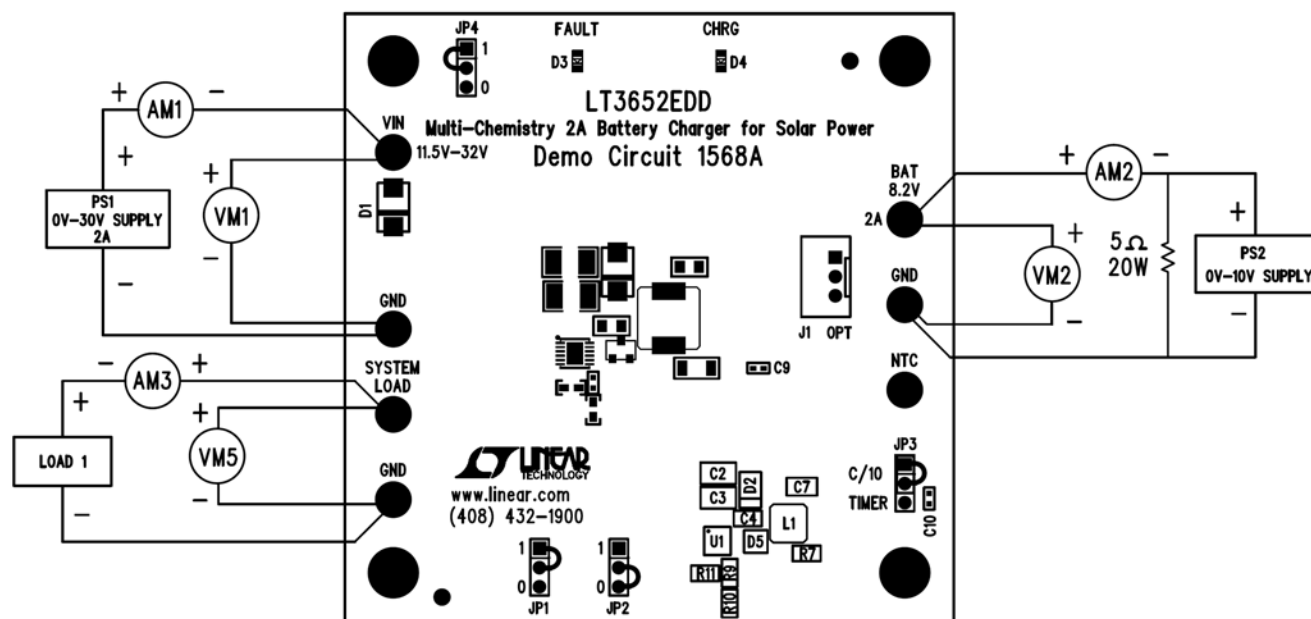


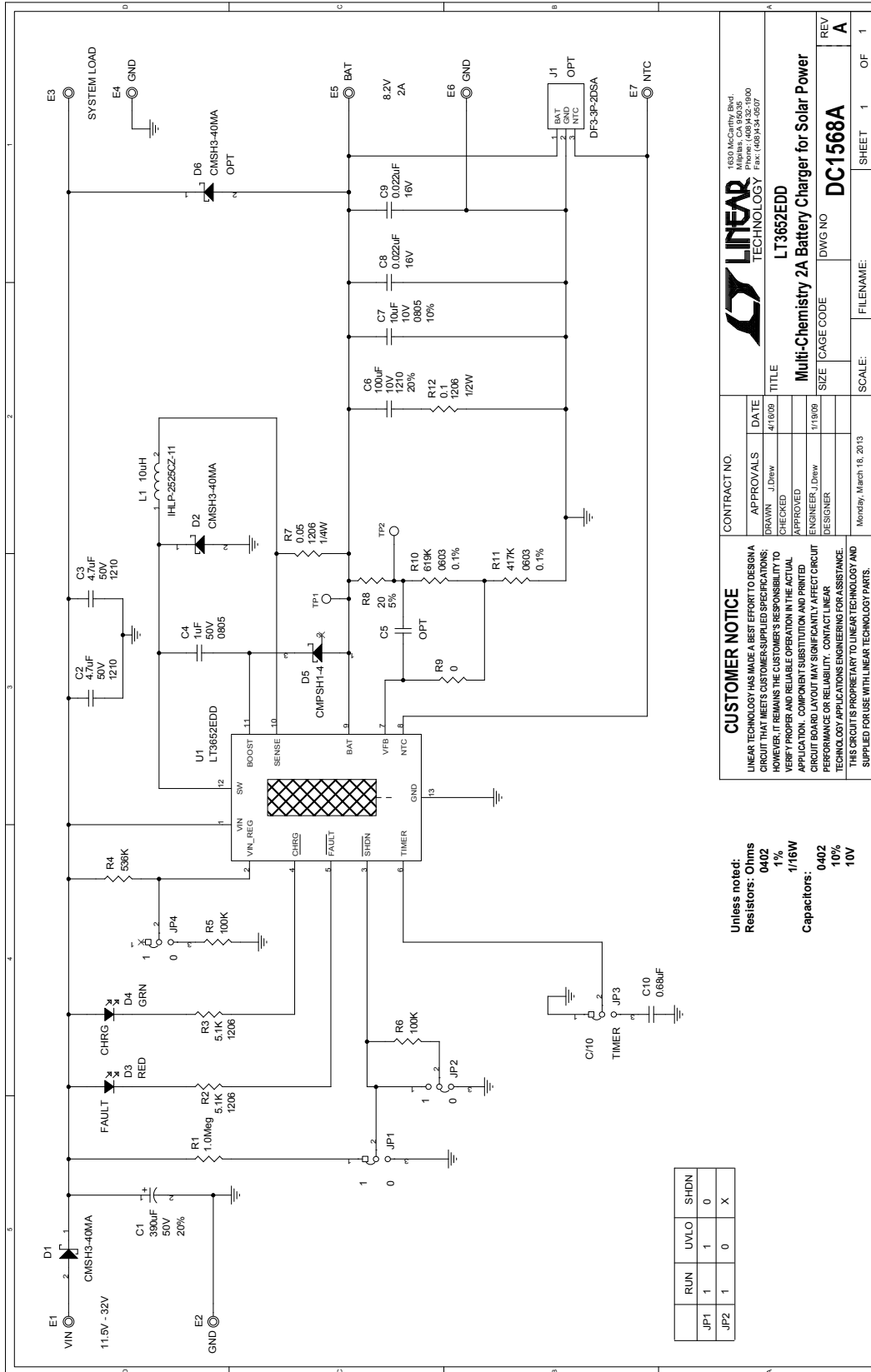
Figure 1. Proper Measurement Equipment Setup for the DC1568A

# DEMO MANUAL DC1568A

## PARTS LIST

| ITEM  | QTY | REFERENCE | PART DESCRIPTION                                  | MANUFACTURER/PART NUMBER          |
|---|-----|-----------|---|-----------------------------------|
| <b>Required Circuit Components</b>            |     |           |   |                                   |
| 1   | 2   | C2, C3    | CAP, X7R, 4.7µF, 50V, 10%, 1210                   | MURATA, GRM32ER71H475KA88L        |
| 2   | 1   | C4        | CAP, X7R, 1µF, 50V, 10%, 0805                     | MURATA, GRM21BR71H105KA12B        |
| 3   | 1   | C6        | CAP, X5R, 100µF, 10V, 20%, 1210                   | TAIYO YUDEN, LMK325BJ107MM-T      |
| 4   | 1   | C7        | CAP, X7R, 10µF, 10V, 10%, 0805                    | MURATA, GRM21BR71A106KE51L        |
| 5   | 1   | C10       | CAP, X5R, 0.68µF, 10V, 10%, 0402                  | MURATA, GRM155R61A684KE15D        |
| 6   | 2   | D1, D2    | SMD, SCHOTTKY BARRIER RECTIFIER                   | CENTRAL SEMI, CSMH3-40MA          |
| 7   | 1   | D5        | SMD, SCHOTTKY DIODE, SOT-23F                      | CENTRAL SEMI, CMPSH1-4            |
| 8   | 1   | L1        | POWER INDUCTOR, 10µH, 20%, 3.5A                   | VISHAY, IHLP2525CZER100M11        |
| 9   | 1   | R1        | RES., CHIP, 1M, 1/16W, 1%, 0402                   | VISHAY, CRCW04021M00FKED          |
| 10  | 1   | R4        | RES., CHIP, 536k, 1/16W, 1%, 0402                 | VISHAY, CRCW0402536KFKED          |
| 11  | 2   | R5, R6    | RES., CHIP, 100k, 1/16W, 1%, 0402                 | VISHAY, CRCW0402100KFKED          |
| 12  | 1   | R7        | RES., CHIP, 0.05Ω, 1/2W, 1%, 1206                 | SUSUMU, RL1632R-R050-F            |
| 13  | 1   | R10       | RES., CHIP, 619k, 1/16W, 0.1%, 0603               | NIC, NTR06B6193DTRF               |
| 14  | 1   | R11       | RES., CHIP, 417k, 1/16W, 0.1%, 0603               | NIC, NTR06B4173DTRF               |
| 15  | 1   | R12       | RES., CHIP, 0.1Ω, 1/2W, 1%, 1206                  | SUSUMU, RL1632R-R100-F            |
| 16  | 1   | U1        | MULTICHEMISTRY 2A BATTERY CHARGER FOR SOLAR POWER | LINEAR TECHNOLOGY, LT3652EDD      |
| <b>Optional Demo Board Circuit Components</b> |     |           |   |                                   |
| 1   | 1   | C1        | CAP, SMT, 390µF, 50V, 20%                         | SUNCON, 50CE390BS                 |
| 2   | 0   | C5        | CAP, OPT, 0402                                    | CUSTOMER SELECTABLE               |
| 3   | 2   | C8, C9    | CAP, CHIP, X7R, 0.022µF, ±10%, 16V, 0402          | AVX, 0402YC223KAT2A               |
| 4   | 1   | D3        | LED, RED  | PANASONIC, LNJ208R8ARA            |
| 5   | 1   | D4        | LED, GREEN  | LITE-ON, LTST-C190KGKT            |
| 6   | 0   | D6        | SMD, SCHOTTKY BARRIER RECTIFIER                   | CENTRAL SEMI, CSMH3-40MA          |
| 7   | 2   | R2, R3    | RES., CHIP, 5.1k, 1/4W, 1%, 1206                  | VISHAY, CRCW12065K10FKEA          |
| 8   | 1   | R8        | RES., CHIP, 20, 1/16W, 5%, 0402                   | VISHAY, CRCW040220R0JNED          |
| 9   | 1   | R9        | RES., CHIP, 0, 1/16W, 5%, 0402                    | VISHAY, CRCW04020000Z0ED          |
| <b>Hardware, for Demo Board Only</b>          |     |           |   |                                   |
| 1   | 7   | E1-E7     | TESTPOINT, TURRET, 0.095"                         | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 2   | 0   | J1        | HEADER, 3 PINS                                    | HIROSE ELECTRIC, DF3A-3P-2DSA     |
| 3   | 4   | JP1-JP4   | 2MM SINGLE ROW HEADER, 3 PIN                      | SAMTEC, TMM-103-02-L-S            |
| 4   | 4   | JP1-JP4   | SHUNT   | SAMTEC, 2SN-BK-G                  |
| 5   | 4   |           | STAND-OFF, NYLON, 0.625" TALL (SNAP ON)           | KEYSTONE, 8834 (SNAP ON)          |

## SCHEMATIC DIAGRAM



**CONTRACT NO.**

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**APPROVALS**

| APPROVALS        | DATE    |
|------------------|---------|
| DRAWN: J.Drew    | 4/16/09 |
| CHECKED          |         |
| APPROVED         |         |
| ENGINEER: J.Drew | 1/19/09 |
| DESIGNER         |         |

**FILENAME:** Monday, March 18, 2013

**SCALE:**

**REV**

| REV | DESCRIPTION | DATE |
|-----|-------------|------|
| A   |             |      |

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**LT3652EDD**  
**Multi-Chemistry 2A Battery Charger for Solar Power**

**DC1568A**

**SIZE** [CAGE CODE] **DWG NO**

**SHEET** 1 **OF** 1

# DEMO MANUAL DC1568A

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