

LT3650EDD-4.2/LT3650EDD-4.1 2A Monolithic Li-Ion Battery Chargers

DESCRIPTION

DC1229B is a 2A monolithic Li-Ion battery charger featuring the LT[®]3650EDD-4.2/LT3650EDD-4.1. The LT3650 is a complete mid-power Li-Ion battery charger that can operate over a wide input voltage range. The circuit provides CC/CV charging with a maximum charge current externally programmable up to 2A. A precondition feature trickle charges a low-voltage battery and bad battery detection provides

a signal if the battery doesn't respond to preconditioning. The LT3650EDD 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>

LT, LT, LTC, LTM, Linear Technology and the Linear logo are registered trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

PERFORMANCE SUMMARY (T_A = 25°C)

PARAMETER	CONDITIONS	VALUE
Input Voltage Range		7.5V to 32V
V _{OUT}		3.7V to 4.24V
Output Float Voltage	Constant Voltage Mode	4.2V/4.1V
Output Current Limit I _{LIM}	R _{RNG} = 20kΩ	2A

OPERATING PRINCIPLES

LT3650 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. Internal reverse voltage protection allows direct connection to the input supply without a blocking diode for single-cell applications (LT3650-4.2/LT3650-4.1).

NOTE: A blocking diode on the input supply connection is recommended to prevent the input from ringing below ground with a battery on the output.

The LT3650 incorporates a 2A switch that is driven by a bootstrapped supply to maximize efficiency during charging cycles. Wide input range allows operation to full charge from 5V ±5% (single cell) to 36V. A precision-threshold shutdown pin allows 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 15µA.

The LT3650 incorporates several degrees of charge current control freedom. The overall maximum charge current is set using an external inductor current sense resistor. A maximum charge current programming pin allows dynamic manipulation of the battery charge current. The LT3650 also incorporates a system input-supply current limit control feature that servos the battery charge current to accommodate overall system load requirements.

The LT3650 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_{SENSE}. Once the battery voltage climbs above an internally set threshold of 2.9V/cell, the IC automatically increases maximum charging current to the full programmed value.

OPERATING PRINCIPLES

The LT3650 can use a charge-current based 'C/10' termination scheme, which ends a charge cycle when the battery charge current falls to 1/10th the programmed maximum charge current. The LT3650 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 3 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 1/8th of the total charge cycle time.

Once charging is terminated and the LT3650 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 LT3650 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 LT3650 contains 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°C to 50°C .

The LT3650 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.

QUICK START PROCEDURE

DC1229 is easy to set up to evaluate the performance of the LT3650EDD-4.2/LT3650EDD-4.1.

Use a blocking diode on the input supply connection, and short twisted pair leads for the 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 Setting:

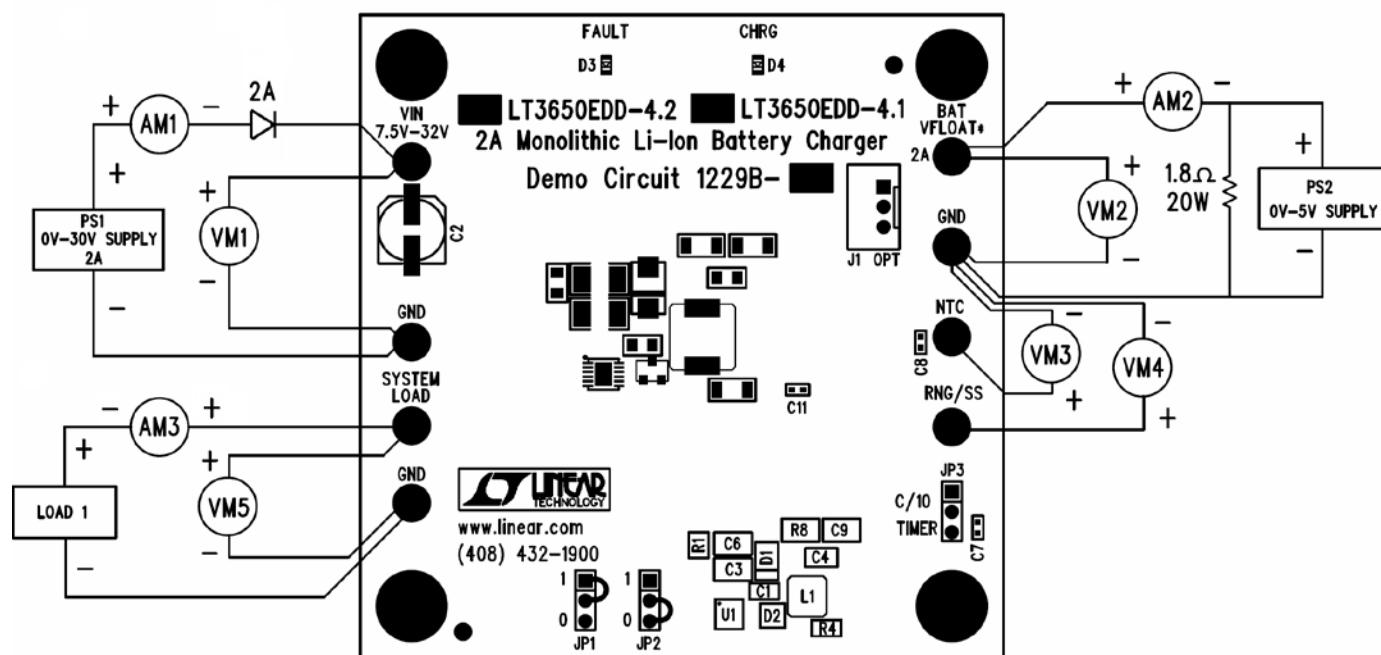
JP1 = 1 **PS1 = OFF**
JP2 = 1 **PS2 = OFF**
JP3 = C/10

- Turn on PS2 and slowly increase the voltage until V_{BAT} is 2.7V while monitoring the current into the BAT pin. If the current is less than 5mA, turn on PS1. Increase PS1 until V_{IN} is 5V while monitoring the input current. If the current is less than 5mA, increase PS1 until V_{IN} is 12V.
- Verify that the battery charging current, I_{BAT} , is between 200mA and 300mA. The CHRG LED should be on and the FAULT LED should be off.

- Increase PS2 until V_{BAT} is 3.6V. Verify the input current, I_{IN} , is between 700mA and 850mA, the battery current, I_{BAT} , is between 1.875A and 2.225A and that the CHRG LED is on.
- Increase PS2 until V_{BAT} is 4.25V. Verify the battery charging current, I_{BAT} , is less than 5mA and that the CHRG LED is off.
- Decrease PS2 until V_{BAT} is 3.9V. Verify the battery current, I_{BAT} , is between 1.875A and 2.225A and that the CHRG LED is on.
- Decrease PS2 until V_{BAT} is 3.6V. Connect a 10k resistor from the RNG/SS pin to ground. Verify the charging current, I_{BAT} , is between 850mA and 1.0A. Verify the voltage, V_{RNG} , on the RNG/SS turret is between 450mV and 550mV and the voltage V_{NTC} on the NTC turret is between 1.8V and 1.9V. Remove the 10k resistor from the RNG/SS pin to ground.
- Set JP1 to SHDN. Verify the charging current, I_{BAT} , is less than 5mA and that the FAULT LED and the CHRG LED are off.

QUICK START PROCEDURE

9. Set JP1 to RUN. Connect a jumper from the NTC pin to ground. Verify the charging current, I_{BAT} , is less than 5mA and that the FAULT LED and the CHRГ LED are on.
10. Remove the jumper from NTC to ground. Verify the charging current, I_{BAT} , is between 1.875A and 2.225A and that the FAULT LED is off and the CHRГ LED is on.
11. Turn on LOAD1 and set to 1A. Verify the voltage, V_{SYSTEM} , on the system load turret is approximately equal to V_{IN} .
12. Turn off PS1, PS2 and LOAD1.



Note: Put a blocking diode between the input supply and the V_{IN} terminal. Kelvin connect the voltage meters directly to the board terminals as shown on the diagram. Use twisted pair input and output leads.

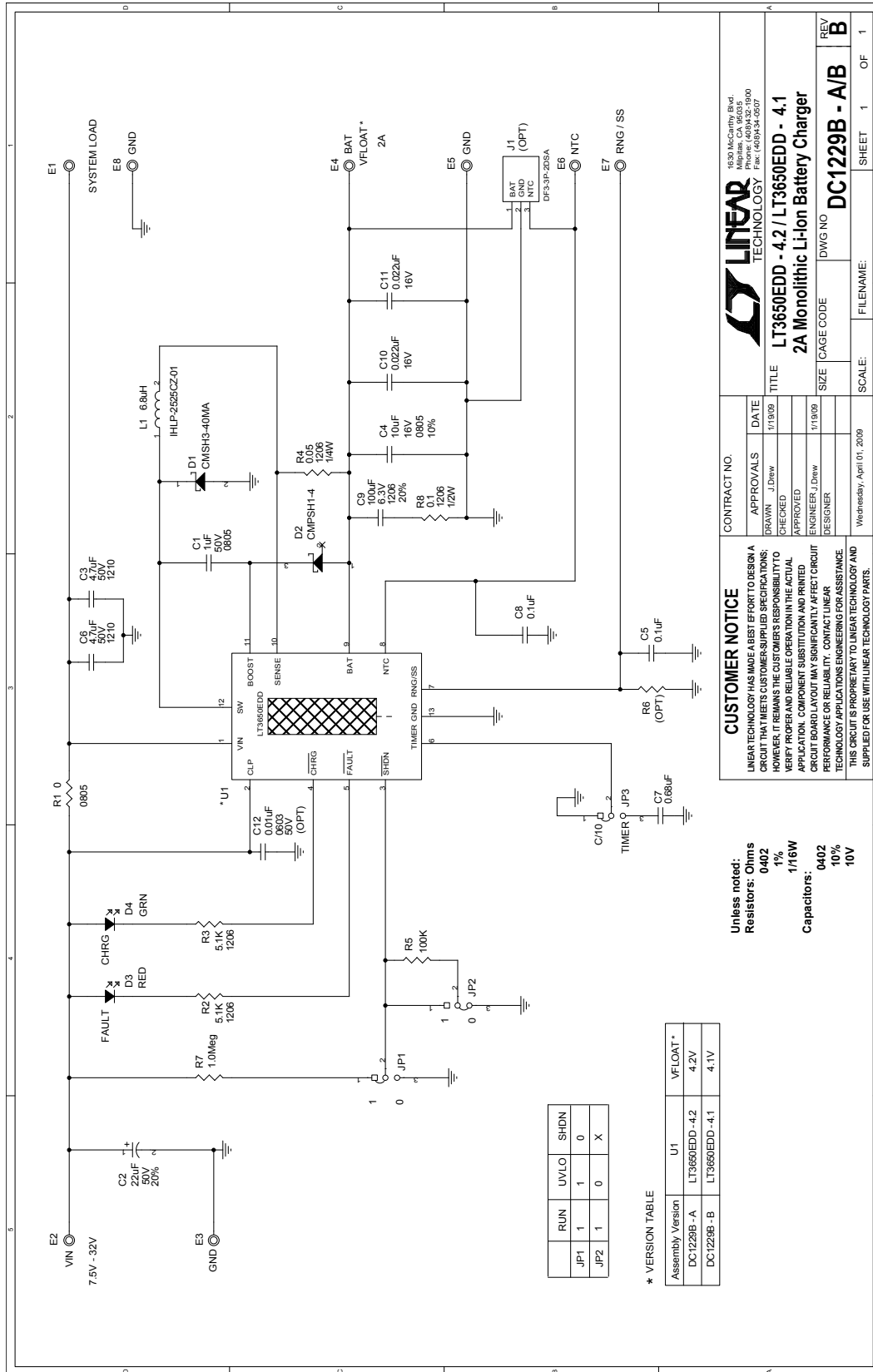
Figure 1. Proper Measurement Equipment Setup

DEMO MANUAL DC1229B

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	Capacitor, X7R, 1 μ F, 50V, 10%, 0805	Murata, GRM21BR71H105KA12B
2	2	C3, C6	Capacitor, X7R, 4.7 μ F, 50V, 10%, 1210	Murata, GRM32R71H475KA091B
3	1	C4	Capacitor, X7R, 10 μ F, 10V, 10%, 0805	Murata, GRM21BR71A106KE19B
4	2	C5, C8	Capacitor, Chip, X5R, 0.1 μ F, \pm 10%, 10V, 0402	AVX, 0402ZD104KAT2A
5	1	C7	Capacitor, X5R, 0.68 μ F, 10V, 10%, 0402	Murata, GRM155R61A684KE15D
6	1	C9	Capacitor, X5R, 100 μ F, 6.3V, 20%, 1206	Murata, GRM31CR60J107ME19L
7	1	D1	SMD, Schottky Barrier Rectifier	Central Semi, CMSH3-40MA
8	1	D2	SMD, Schottky Diode, SOT-23F	Central Semi, CMPSH1-4
9	1	L1	Power Inductor 6.8 μ H 20% 4.5A	Vishay, IHLP2525CZER6R8M011
10	1	R4	Resistor, Chip, 0.05 Ω , 1/2W, 1%, 1206	IRC, LRC-LR1206-01-R050-F
11	1	R5	Resistor, Chip, 100k, 1/16W, 1%, 0402	Vishay, CRCW0402100KFKED
12	1	R7	Resistor, Chip, 1M, 1/16W, 1%, 0402	Vishay, CRCW04021M00FKED
13	1	R8	Resistor, Chip, 0.1 Ω , 1/2W, 1%, 1206	IRC, LRC-LR1206-01-R100-F
14	1	U1 (Option A) U1 (Option B)	2A Monolithic Li-Ion Battery Charger	Linear Technology, LT3650EDD-4.2 Linear Technology, LT3650EDD-4.1
Optional Demo Circuit Components				
1	1	C2	Capacitor, SMT, 22 μ F, 50V, 20%	Sanyo, 50CE22BS
2	2	C10, C11	Capacitor, Chip, X7R, 0.022 μ F, \pm 10%, 16V, 0402	AVX, 0402YC223KAT2A
3	0	R6 (Opt)	Resistor, Chip, 0402	User Defined
4	1	D3	LED, Red	Panasonic, LNJ208R8ARA
5	1	D4	LED, Green	Lite-On, LTST-C190KGKT
6	1	R1	Resistor, Chip, 0, 1/16W, 0805	Vishay, CRCW08050000Z0EA
7	2	R2, R3	Resistor, Chip, 5.1K, 1/4W, 1%, 1206	Vishay, CRCW12065K10FKEA
8	0	C12 (Opt)	Capacitor, Chip, X7R, 0.01 μ F, \pm 10%, 50V, 0603	AVX, 06035C103KAT2A
Hardware				
1	8	E1-E8	Testpoint, Turret, .095"	Mill-Max, 2501-2-00-80-00-00-07-0
2	1	J1	Header, 3 Pins	Hirose Electric, DF3A-3P-2DSA
3	3	JP1, JP2, JP3	2MM Single Row Header, 3 Pin	Samtec, TMM-103-02-L-S
4	3	JP1, JP2, JP3	Shunt	Samtec, 2SN-BK-G
5	4		Stand-Off, Nylon 0.375" Tall (Snap-On)	Keystone, 8832 (Snap On)

SCHEMATIC DIAGRAM



CONTRACT NO.

CUSTOMER NOTICE
 LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A CIRCUIT THAT MEETS CUSTOMER SUPPLIER SPECIFICATIONS. HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY PROPER AND RELIABLE OPERATION IN THE ACTUAL APPLICATION. COMPONENT SUBSTITUTION AND PRINTED CIRCUIT BOARD LAYOUT MAY SIGNIFICANTLY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE. THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SUPPLIED FOR USE WITH LINEAR TECHNOLOGY PARTS.

APPROVALS

APPROVALS	DATE
DRAWN: J.Drew	11/19/09
CHECKED	
APPROVED	
DESIGNER: J.Drew	11/19/09

LINEAR TECHNOLOGY
 1630 McCarty Blvd.
 Fremont, CA 94538-1690
 Phone: (408)432-1900
 Fax: (408)434-0907

TITLE
 LT3650EDD - 4.2 / LT3650EDD - 4.1
 2A Monolithic Li-Ion Battery Charger

SIZE (PAGE CODE) **DWG NO**
 DC1229B - A/B

SCALE: **FILENAME:** **SHEET 1 OF 1**



Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

DEMO MANUAL DC1229B

DEMONSTRATION BOARD IMPORTANT NOTICE

Linear Technology Corporation (LTC) provides the enclosed product(s) under the following **AS IS** conditions:

This demonstration board (DEMO BOARD) kit being sold or provided by Linear Technology is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not provided by LTC for commercial use. As such, the DEMO BOARD herein may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to product safety measures typically found in finished commercial goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may or may not meet the technical requirements of the directive, or other regulations.

If this evaluation kit does not meet the specifications recited in the DEMO BOARD manual the kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY THE SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user releases LTC from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. Also be aware that the products herein may not be regulatory compliant or agency certified (FCC, UL, CE, etc.).

No License is granted under any patent right or other intellectual property whatsoever. **LTC assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or any other intellectual property rights of any kind.**

LTC currently services a variety of customers for products around the world, and therefore this transaction **is not exclusive**.

Please read the DEMO BOARD manual prior to handling the product. Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged.**

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

Mailing Address:

Linear Technology
1630 McCarthy Blvd.
Milpitas, CA 95035

Copyright © 2004, Linear Technology Corporation

X-ON Electronics

Largest Supplier of Electrical and Electronic Components

Click to view similar products for [Power Management IC Development Tools](#) category:

Click to view products by [Analog Devices](#) manufacturer:

Other Similar products are found below :

[EVAL-ADM1168LQEBZ](#) [EVB-EP5348UI](#) [MIC23451-AAAYFL EV](#) [MIC5281YMME EV](#) [DA9063-EVAL](#) [ADP122-3.3-EVALZ](#) [ADP130-0.8-EVALZ](#) [ADP130-1.2-EVALZ](#) [ADP130-1.5-EVALZ](#) [ADP130-1.8-EVALZ](#) [ADP1714-3.3-EVALZ](#) [ADP1716-2.5-EVALZ](#) [ADP1740-1.5-EVALZ](#) [ADP1752-1.5-EVALZ](#) [ADP1828LC-EVALZ](#) [ADP1870-0.3-EVALZ](#) [ADP1871-0.6-EVALZ](#) [ADP1873-0.6-EVALZ](#) [ADP1874-0.3-EVALZ](#) [ADP1882-1.0-EVALZ](#) [ADP199CB-EVALZ](#) [ADP2102-1.25-EVALZ](#) [ADP2102-1.875EVALZ](#) [ADP2102-1.8-EVALZ](#) [ADP2102-2-EVALZ](#) [ADP2102-3-EVALZ](#) [ADP2102-4-EVALZ](#) [ADP2106-1.8-EVALZ](#) [ADP2147CB-110EVALZ](#) [AS3606-DB](#) [BQ24010EVM](#) [BQ24075TEVM](#) [BQ24155EVM](#) [BQ24157EVM-697](#) [BQ24160EVM-742](#) [BQ24296MEVM-655](#) [BQ25010EVM](#) [BQ3055EVM](#) [NCV891330PD50GEVB](#) [ISLUSBI2CKIT1Z](#) [LM2744EVAL](#) [LM2854EVAL](#) [LM3658SD-AEV/NOPB](#) [LM3658SDEV/NOPB](#) [LM3691TL-1.8EV/NOPB](#) [LM4510SDEV/NOPB](#) [LM5033SD-EVAL](#) [LP38512TS-1.8EV](#) [EVAL-ADM1186-1MBZ](#) [EVAL-ADM1186-2MBZ](#)