

Polyphase Single 160A Output Synchronous Buck Converter with Power System Management

DESCRIPTION

Demonstration circuit 2283A is a high efficiency, high density, single-output Buck converter with 7V to 14V input range. The output voltage is adjustable from 0.5V to 1.5V, and can supply up to 160A of load current with a 1V output. The demo board offers the option to be configured as a dual-output converter, contact factory for details. V_{OUT0} can supply a 40A maximum load current and V_{OUT1} can supply a 120A maximum load current. The demo board features the LTC3884, a dual output poly phase step-down controller for ultra-low DCR sensing with digital power system management. Please see [LTC®3884](#) data sheet for more detailed information.

DC2283A powers up to default settings and produces power based on configuration resistors or with its non-volatile memory without the need for any serial bus communication. This allows easy evaluation of the DC/DC converter. To fully

explore the extensive power system management features of the part, download the GUI software LTpowerPlay™ on-to your PC and use LTC's I2C/SMBus/PMBus dongle DC1613A to connect to the board. LTpowerPlay allows the user to reconfigure the part on the fly and store the configuration in EEPROM, view telemetry of voltage, current, temperature and fault status.

GUI Download

The software can be downloaded from:

<http://www.linear.com/ltpowerplay>

For more details and instructions of LTpowerPlay, please refer to LTpowerPlay GUI for LTC3884 demo manual.

Design files for this circuit board are available at
<http://www.linear.com/demo/DC2283A>

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PERFORMANCE SUMMARY

Specifications are at $T_A = 25^\circ\text{C}$

PARAMETER	CONDITIONS	VALUE
Input Voltage Range		7V to 14V
Output Voltage, V_{OUT1}	$V_{IN} = 7\text{V to } 14\text{V}$, Single Output, $I_{OUT} = 0\text{A to } 160\text{A}^{(1)}$	Default: 1V
Maximum Output Current, $I_{OUT} = I_{OUT0} + I_{OUT1}$	$V_{IN} = 7\text{V to } 14\text{V}$, Single Output, $V_{OUT1} = 0.5\text{V to } 1.5\text{V}^{(2)}$	160A
Typical Efficiency	$V_{IN} = 12\text{V}$, Single Output, $V_{OUT1} = 1.0\text{V}$, 160A Load	89.6%
Peak Efficiency	$V_{IN} = 12\text{V}$, Single Output, $V_{OUT1} = 1.0\text{V}$, 90A Load	90.7%
Default Switching Frequency		425kHz

Note 1: Both V_{OUT0} and V_{OUT1} terminals need to be used when drawing > 100A output current.

Note 2: For $V_{OUT1} < 0.75\text{V}$, f_{SW} needs to be reduced due to $t_{ON(MIN)}$ limitation.

DEMO MANUAL DC2283A

QUICK START PROCEDURE

Demonstration circuit 2283A is easy to set up to evaluate the performance of the LTC3884. Refer to Figure 1 for the proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input power supply to VIN (7V – 14V) and GND (input return).
2. Connect the output loads between VOUT0/ VOUT1 and GND (Initial load: no load). Refer to Figure 1.
3. Connect the DVMs to the input and output.
4. Check the default jumper/switch position: JP1: OFF; JP4: OFF; JP5: INT; SW1: OFF; SW2: OFF.
5. Turn on the input power supply and adjust voltage to 12V;

NOTE: Make sure that the input voltage does not exceed 14V.

6. Turn on the switches: SW1:ON; SW2:ON;

7. Check for the proper output voltages from VOUT1+ to VOUT1-.
8. Once the proper output voltage is established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage and other parameters.
9. Connect the dongle and control the output voltage from the GUI. See “LTpowerPlay Quick Start Guide” session for details.

Notes:

1. As stated in the Description section, demonstration circuit 2283A provides an option to be configured as a dual-output converter. When the board is set up as a single-output converter (the default setup), four 0Ω shunt resistors are populated to short VOUT0 and VOUT1. Please follow Figure 1 to set up the connection of two loads to the output terminals to avoid board damage.

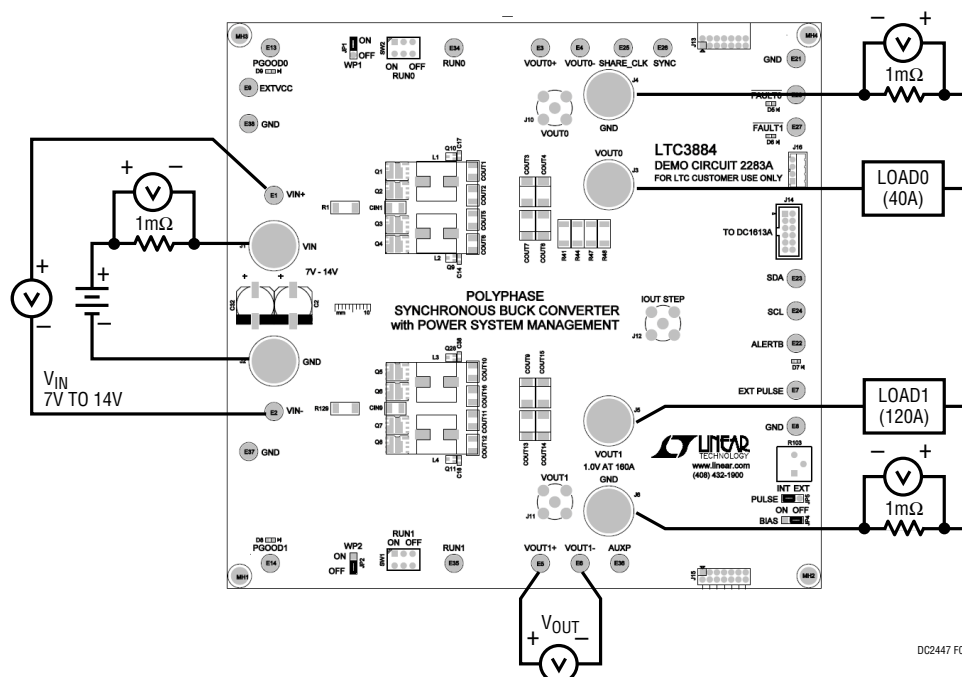


Figure 1. Proper Measurement Equipment Setup

DC2447 F01

QUICK START PROCEDURE

2. When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 2 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (–) terminals of an output capacitor. The probe's ground ring needs to touch the (–) lead and the probe tip needs to touch the (+) lead.

Connecting a PC to DC2283A

You can use a PC to reconfigure the power management features of the LTC3884 such as: nominal V_{OUT} , margin set points, OV/UV limits, temperature fault limits, sequencing parameters, the fault log, fault responses and other functionality. The DC1613A dongle may be plugged when V_{IN} is present.

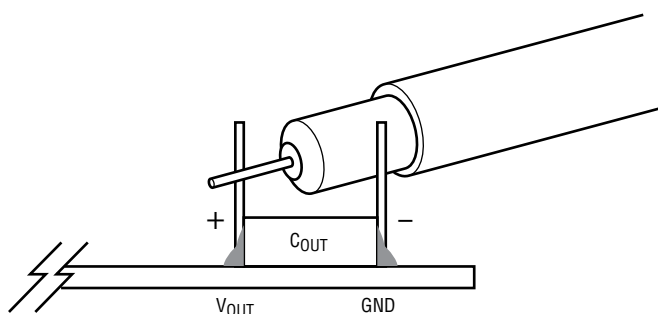


Figure 2. Measuring Output Voltage Ripple

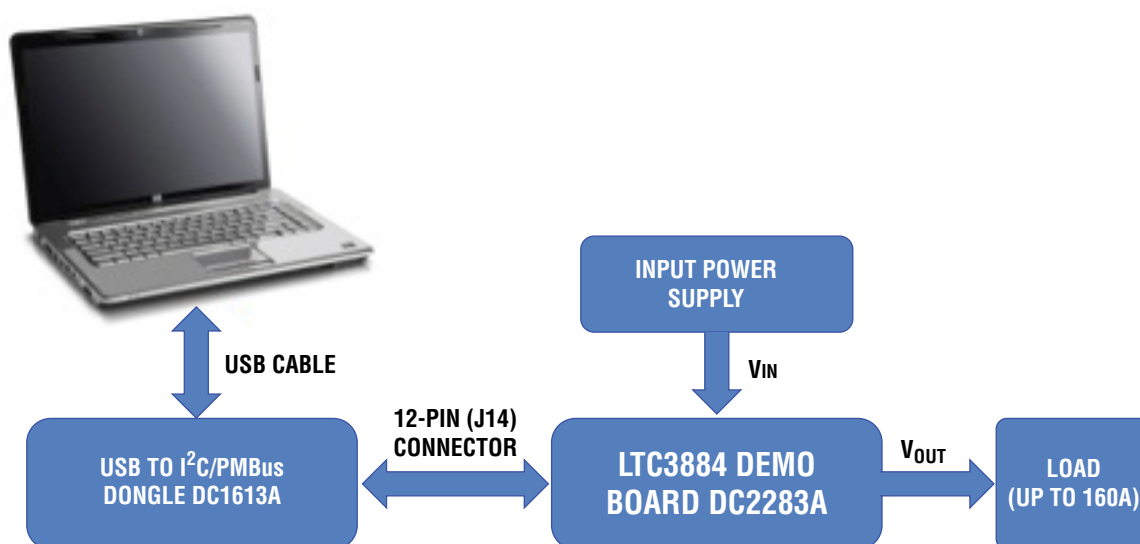


Figure 3. Demo Setup with PC

QUICK START PROCEDURE

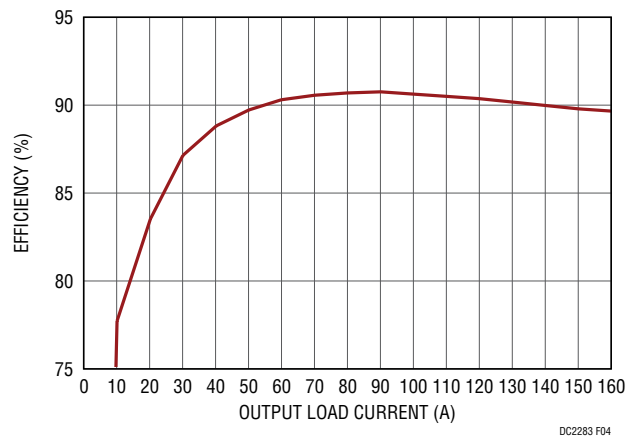


Figure 4. Efficiency vs Load Current at $V_{IN} = 12V$, $V_{OUT1} = 1V$, $f_{SW} = 425kHz$

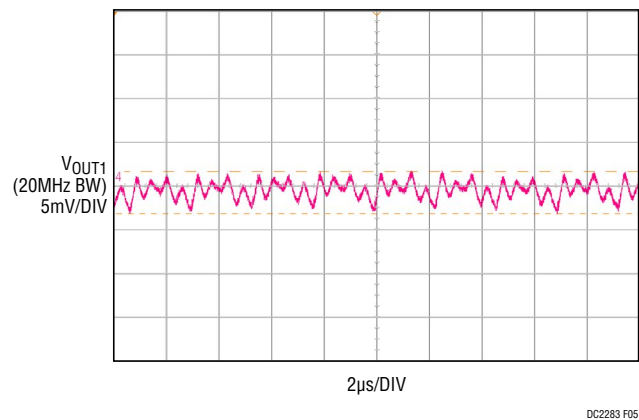


Figure 5. Output Voltage Ripple at $V_{IN} = 12V$, $V_{OUT1} = 1V$, $I_{OUT} = 160A$ ($I_{OUT0} = 40A$, $I_{OUT1} = 120A$)

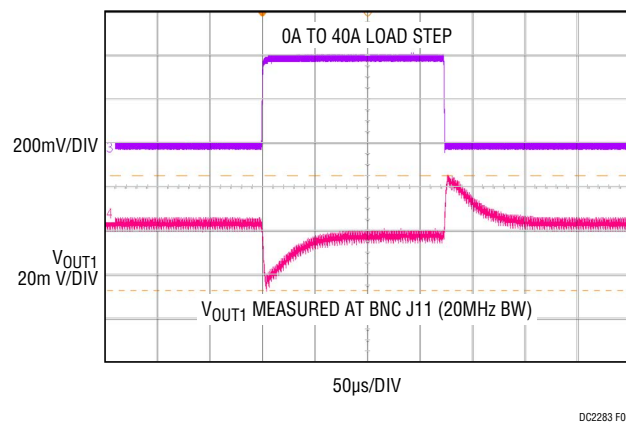


Figure 6. Transient Response at $V_{IN} = 12V$, $V_{OUT1} = 1V$

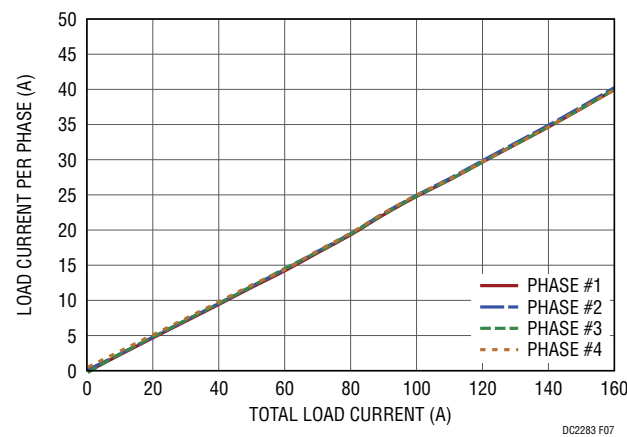


Figure 7. Current Sharing vs Load Current at $V_{IN} = 12V$, $V_{OUT1} = 1V$, $f_{SW} = 425kHz$

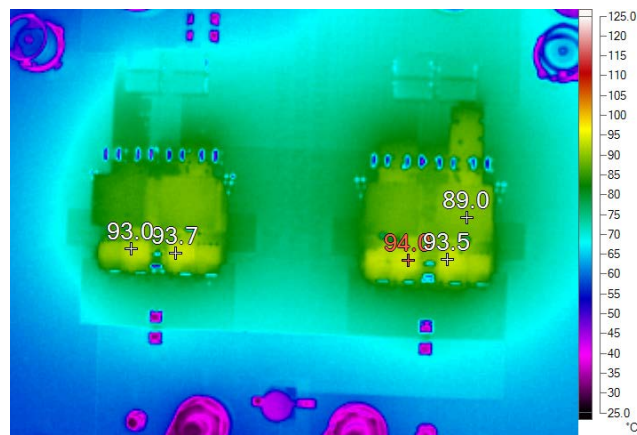


Figure 8. Thermal Performance at $V_{IN} = 12V$, $V_{OUT1} = 1V$, $I_{OUT} = 160A$, $T_A = 23^{\circ}C$, No Airflow

LTpowerPlay SOFTWARE GUI

LTpowerPlay is a powerful Windows based development environment that supports Linear Technology power system management ICs, including the LTM4676, LTC3880, LTC3883, LTC3884, LTC2974 and LTC2978. The software supports a variety of different tasks. You can use LTpowerPlay to evaluate Linear Technology ICs by connecting to a demo board system. LTpowerPlay can also be used in an offline mode (with no hardware present) in order to build a multichip configuration file that can be saved and reloaded at a later time. LTpowerPlay provides unprecedented diagnostic and debug features. It becomes a valuable diagnostic tool during board bring-up to program or tweak the power management scheme in a system, or to diagnose power issues when bringing up

rails. LTpowerPlay utilizes the DC1613A USB-to-SMBus controller to communicate with one of many potential targets, including the LTM4676, the LTC3880, LTC3884 and the LTC3883's demo system, or a customer board. The software also provides an automatic update feature to keep the software current with the latest set of device drivers and documentation. The LTpowerPlay software can be downloaded from:

<http://linear.com/ltpowerplay>

To access technical support documents for LTC Digital Power Products visit Help. View online help on the LTpowerPlay menu.

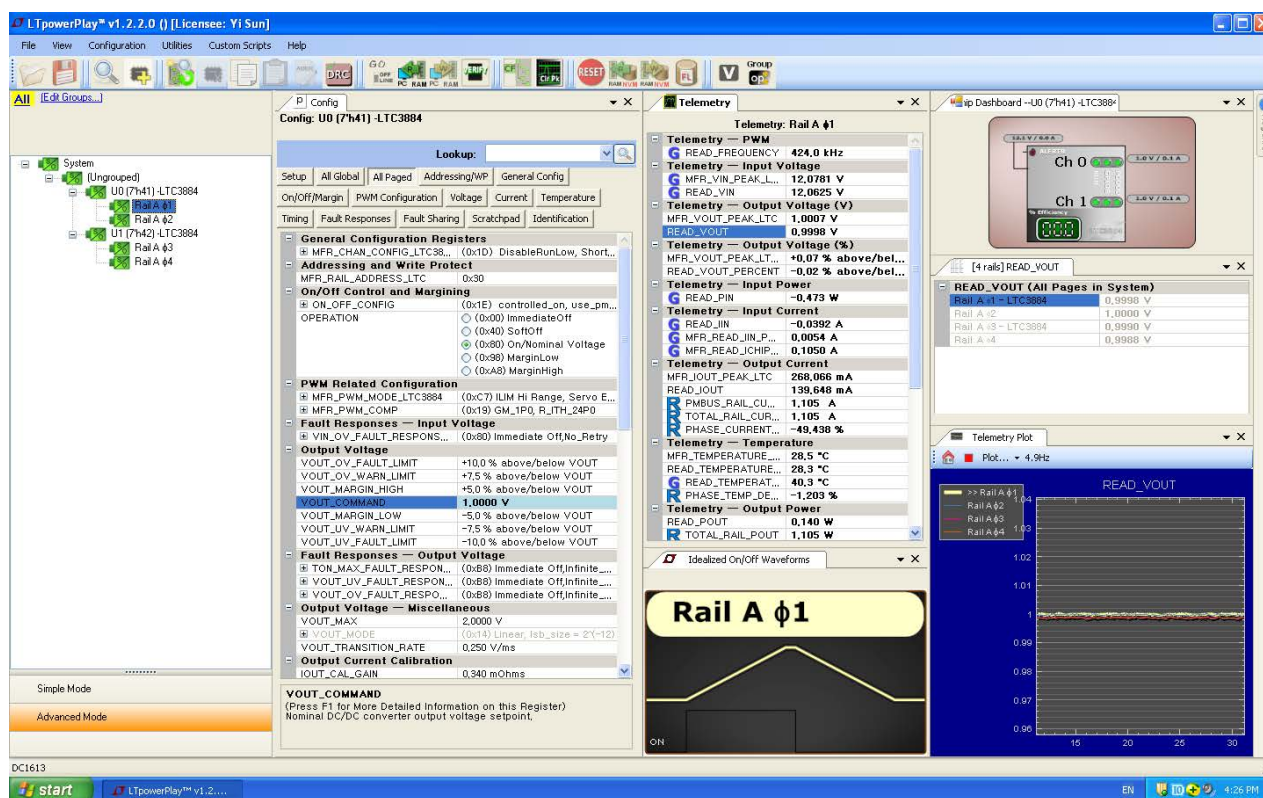


Figure 9. LTpowerPlay Main Interface

DEMO MANUAL DC2283A

LTpowerPlay QUICK START PROCEDURE

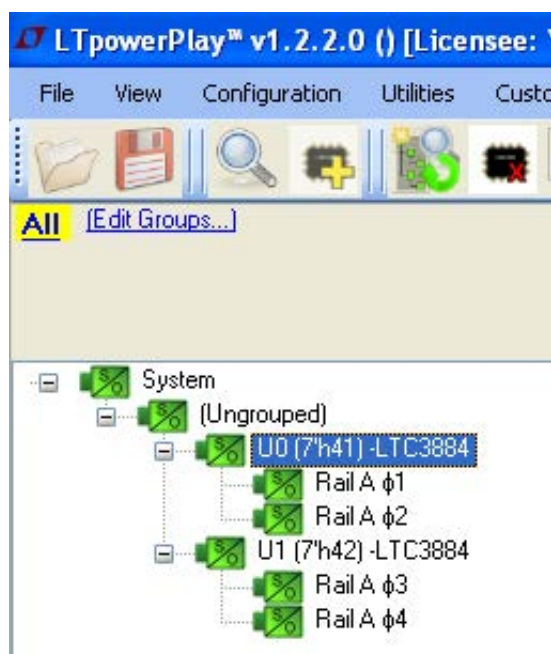
The following procedure describes how to use LTpowerPlay to monitor and change the settings of LTC3884.

1. Download and install the LTpowerPlay GUI:

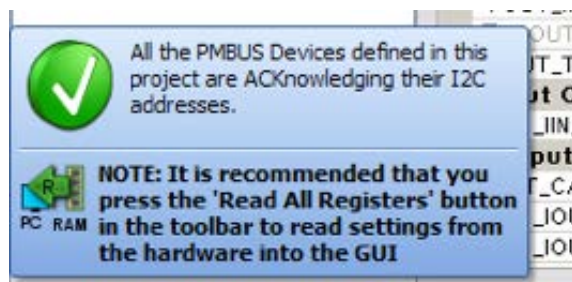
<http://linear.com/ltpowerplay>

2. Launch the LTpowerPlay GUI.

- a. The GUI should automatically identify the DC2283A. The system tree on the left hand side should look like this:



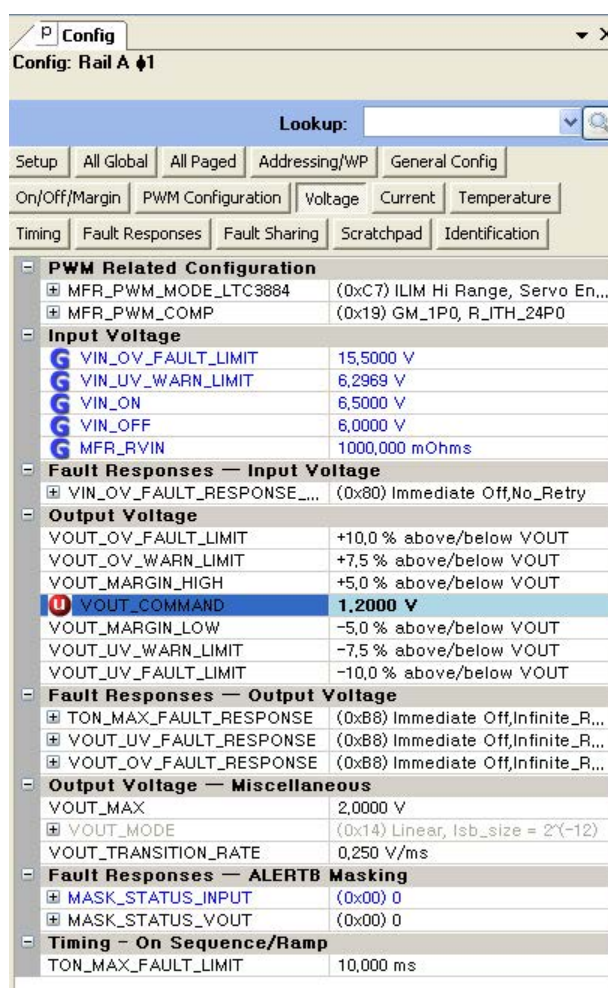
- b. A green message box shows for a few seconds in the lower left hand corner, confirming that LTC3884 is communicating:



- c. In the Toolbar, click the “R” (RAM to PC) icon to read the RAM from the LTC3884. This reads the configuration from the RAM of LTC3884 and loads it into the GUI.



- d. If you want to change the output voltage to a different value, like 1.2V. In the Config tab, type in 1.2 in the VOUT_COMMAND box, like this:



LTpowerPlay QUICK START PROCEDURE

Then, click the “W” (PC to RAM) icon to write these register values to the LTC3884. After finishing this step, you will see the output voltage will change to 1.2V.



If the write is successful, you will see the following message:



e. You can save the changes into the NVM. In the tool bar, click “RAM to NVM” button, as following



f. Save the demo board configuration to a (*.proj) file. Click the Save icon and save the file with a user filename.

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	16	CIN1, CIN2, CIN3, CIN4, CIN5, CIN6, CIN7, CIN8, CIN9, CIN10, CIN11, CIN12, CIN13, CIN14, CIN15, CIN16	CAP, 1210 22μF 10% 25V X7R	MURATA, GRM32ER71E226KE15L
2	16	COUT1, COUT2, COUT5, COUT6, COUT10, COUT11, COUT12, COUT16, COUT19, COUT20, COUT24, COUT25, COUT27, COUT28, C34, C35	CAP, 1210 100μF 20% 6.3V X5R	TDK, C3225X5R0J107M
3	12	COUT3, COUT4, COUT7, COUT8, COUT9, COUT13, COUT14, COUT15, COUT17, COUT18, COUT22, COUT23	CAP, 7343 470μF 20% 2.5V	PANASONIC, ETPF470M5H
4	6	C7, COUT21, COUT26, C36, C41, C42	CAP, 0603 1μF 20% 25V X5R	AVX, 06033D105MAT2A
5	2	C1, C47	CAP, 0603 2.2μF 20% 6.3V X5R	TDK, C1608X5R0J225M
6	2	C2, C32	CAP, 270μF 20% 16V OSCON	PANASONIC, 16SVP6270M
7	2	C3, C23	CAP, 0805 2.2μF 10% 16V X5R	TDK, C2012X5R1C225K125AC
8	4	C4, C6, C24, C29	CAP, 0603 4.7μF 10% 10V X5R	AVX, 0603ZD475KAT2A
9	4	C8, C15, C37, C46	CAP, 0603 0.1μF 10% 25V X7R	AVX, 06033C104KAT2A
10	4	C9, C16, C21, C33	CAP, 0603 220nF 10% 25V X7R	TDK, C1608X7R1E224K080AC
11	2	C10, C40	CAP, 0603 150pF 5% 50V NP0	AVX, 06035A151JAT2A
12	1	C11	CAP, 0603 3.3nF 5% 50V C0G	MURATA, GRM1885C1H332JA01D
13	6	C14, C17, C18, C27, C28, C38	CAP, 0603 10nF 10% 25V X7R	AVX, 06033C103KAT2A
14	1	C20	CAP, 0603 47pF 5% 50V NP0	AVX, 06035A470JAT2A
15	2	C30, C44	CAP, 1210 100μF 20% 10V X5R	MURATA, GRM32ER61A107ME20L
16	1	C31	CAP, 1210 10μF 10% 16V X7R	MURATA, GRM32DR71C106KA01L

DEMO MANUAL DC2283A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
17	2	C39, C50	CAP, 0603 100nF 20% 16V X7R	AVX, 0603YC104MAT2A
18	1	C43	CAP, 0603 220pF 10% 50V X7R	AVX, 06035C221KAT2A
19	1	C49	CAP, 0603 47nF 10% 25V X7R	AVX, 06033C473KAT2A
20	2	R1, R129	RES, 2010 0.002 Ω 1% 1W	VISHAY, WSL20102L000FEA
21	2	R2, R60	RES, 0603 1 Ω 1% 1/10W	VISHAY, CRCW06031R00FKEA
22	25	R3, R4, R15, R19, R39, R40, R42, R43, R45, R46, R53, R91, R109, R113, R114, R116, R117, R127, R132, R137, R140, R147, R148, R149, R156	RES, 0603 0 Ω JUMPER	VISHAY, CRCW06030000Z0EA
23	14	R6, R7, R8, R10, R29, R30, R33, R34, R49, R50, R98, R123, R124, R131	RES, 0603 10k Ω 5% 1/10W	VISHAY, CRCW060310K0JNEA
24	4	R9, R11, R12, R13	RES, 0603 2k Ω 5% 1/10W	VISHAY, CRCW06032K00JNEA
25	4	R14, R20, R135, R143	RES, 0603 715 Ω 1% 1/10W	VISHAY, CRCW0603715RFKEA
26	2	R18, R21	RES, 0603 10 Ω 1% 1/10W	VISHAY, CRCW060310R0FKEA
27	2	R22, R108	RES, 0603 30.1k Ω 1% 1/10W	VISHAY, CRCW060330K1FKEA
28	1	R23	RES, 0603 1.96k Ω 1% 1/10W	VISHAY, CRCW06031K96FKEA
29	6	R41, R44, R47, R48, R88, R90	RES, 2010 0 Ω JUMPER	VISHAY, CRCW20100000Z0EF
30	2	R69, R70	RES, 0603 10 Ω 5% 1/10W	VISHAY, CRCW060310R0JNEA
31	4	R79, R80, R125, R130	RES, 0603 200 Ω 5% 1/10W	VISHAY, CRCW0603200RJNEA
32	1	R81	RES, 0603 127 Ω 1% 1/10W	VISHAY, CRCW0603127RFKEA
33	1	R89	RES, 0603 2 Ω 5% 1/10W	VISHAY, CRCW06032R00JNEA
34	1	R92	RES, 0603 3.3 Ω 1% 1/10W	VISHAY, CRCW06033R30FKEA
35	1	R93	RES, 0603 154k Ω 1% 1/10W	VISHAY, CRCW0603154KFKEA
36	1	R94	RES, 0603 1M Ω 5% 1/10W	VISHAY, CRCW06031M00JNEA
37	3	R95, R96, R107	RES, 0603 20k Ω 5% 1/10W	VISHAY, CRCW060320K0JNEA
38	1	R97	RES, 0603 681k Ω 1% 1/10W	VISHAY, CRCW0603681KFKEA
39	1	R99	RES, 0603 301 Ω 1% 1/10W	VISHAY, CRCW0603301RFKEA
40	1	R100	RES, 0603 82.5 Ω 5% 1/10W	VISHAY, CRCW060382R5FKEA
41	1	R102	RES, 2512 0.01 Ω 1% 1W	VISHAY, WSL2512R0100FEA
42	1	R103	RES, VARIABLE 5k	BOURNS, 3386P-1-502-LF
43	1	R104	RES, 0603 1k Ω 1% 1/10W	VISHAY, CRCW06031K00FKEA
44	1	R105	RES, 0603 118k Ω 1% 1/10W	VISHAY, CRCW0603118KFKEA
45	1	R106	RES, 0603 80.6k Ω 1% 1/10W	VISHAY, CRCW060380K6FKEA
46	2	R128, R150	RES, 0603 4.99k Ω 1% 1/10W	VISHAY, CRCW06034K99FKEA
47	2	R144, R155	RES, 0603 15.8k Ω 1% 1/10W	VISHAY, CRCW060315K8FKEA
48	1	R153	RES, 0603 3.57k Ω 1% 1/10W	VISHAY, CRCW06033K57FKEA
49	4	D1, D2, D3, D4	DIODE, SCHOTTKY 30V, 100mA	CENTRAL SEMI, CMDSH-3 TR
50	4	D5, D6, D8, D9	LED, 0603 GREEN	WURTH ELEKTRONIK, 150060GS75000
51	1	D7	LED, 0603 RED	WURTH ELEKTRONIK, 150060SS75000
52	2	D12, D13	DIODE, ULTRA LOW SCHOTTKY RECTIFIER	NXP SEMI., PMEG2005AEL, 315
53	4	L1, L2, L3, L4	IND, 0.25 μ H	WURTH ELEKTRONIK, 744301025
54	1	L5	IND, 68 μ H	SUMIDA, CDRH105RNP-680NC

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
55	8	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8	XSTR, DUAL CHANNEL OptiMOS MOSFET	INFINEON, BSG0811ND
56	4	Q9, Q10, Q11, Q28	XSTR, PNP GENERAL PURPOSE	DIODES INC., MMST3906-7-F
57	3	Q20, Q29, Q30	XSTR, P-CHANNEL DMOS FET	DIODES INC., DMP3130L-7
58	4	Q21, Q22, Q25, Q26	XSTR, N-CHANNEL DMOS FET	FAIRCHILD, 2N7002
59	2	Q23, Q24	XSTR, MOSFET, N-CHANNEL 40V	VISHAY, SUD50N04-8M8P-4GE3
60	1	U1	IC, LTC3884	LINEAR TECH., LTC3884IUK#10EE-1PBF-ES
61	1	U2	IC, LTC3884	LINEAR TECH., LTC3884IUK#10EF-1PBF-ES
62	1	U4	IC, SYNCHRONOUS STEP-DOWN CONVERTER	LINEAR TECH., LTC3630EMSE#PBF
63	1	U5	IC, LTC6992IS6-1	LINEAR TECH., LTC6992IS6-1#PBF
64	1	U6	IC, SINGLE OP AMP	LINEAR TECH., LT1803IS5#PBF
65	1	U7	IC, 2k EEPROM	MICROCHIP, 24LC024-I/ST

Additional Demo Board Circuit Components

1	0	CIN17, CIN18, CIN19, CIN20, CIN21, CIN22, CIN23, CIN24	CAP, 1210 OPTION	OPTION
2	0	C5, C12, C13, C45, C48	CAP, 0603 OPTION	OPTION
3	0	C19 (OPTION)	CAP, 0603 1500pF 5% 50V COG	MURATA, GRM1885C1H152JA01D
4	0	R5, R16, R17, R24, R25, R26, R27, R28, R31, R32, R35, R36, R37, R38, R51, R56, R57, R59, R82, R83, R84, R87, R110, R111, R112, R115, R118, R119, R120, R121, R122, R126, R133, R134, R136, R138, R139, R141, R142, R145, R146, R151, R152, R154	RES, 0603 OPTION	OPTION
5	0	R85, R86, R101	RES, 2512 OPTION	OPTION
6	0	D10, D11	DIODE, SCHOTTKY 30V, 100mA OPTION	CENTRAL SEMI, CMDSH-3-TR OPTION
7	0	Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q27	XSTR, POWER MOSFET OPTION	OPTION

Hardware: For Demo Board Only

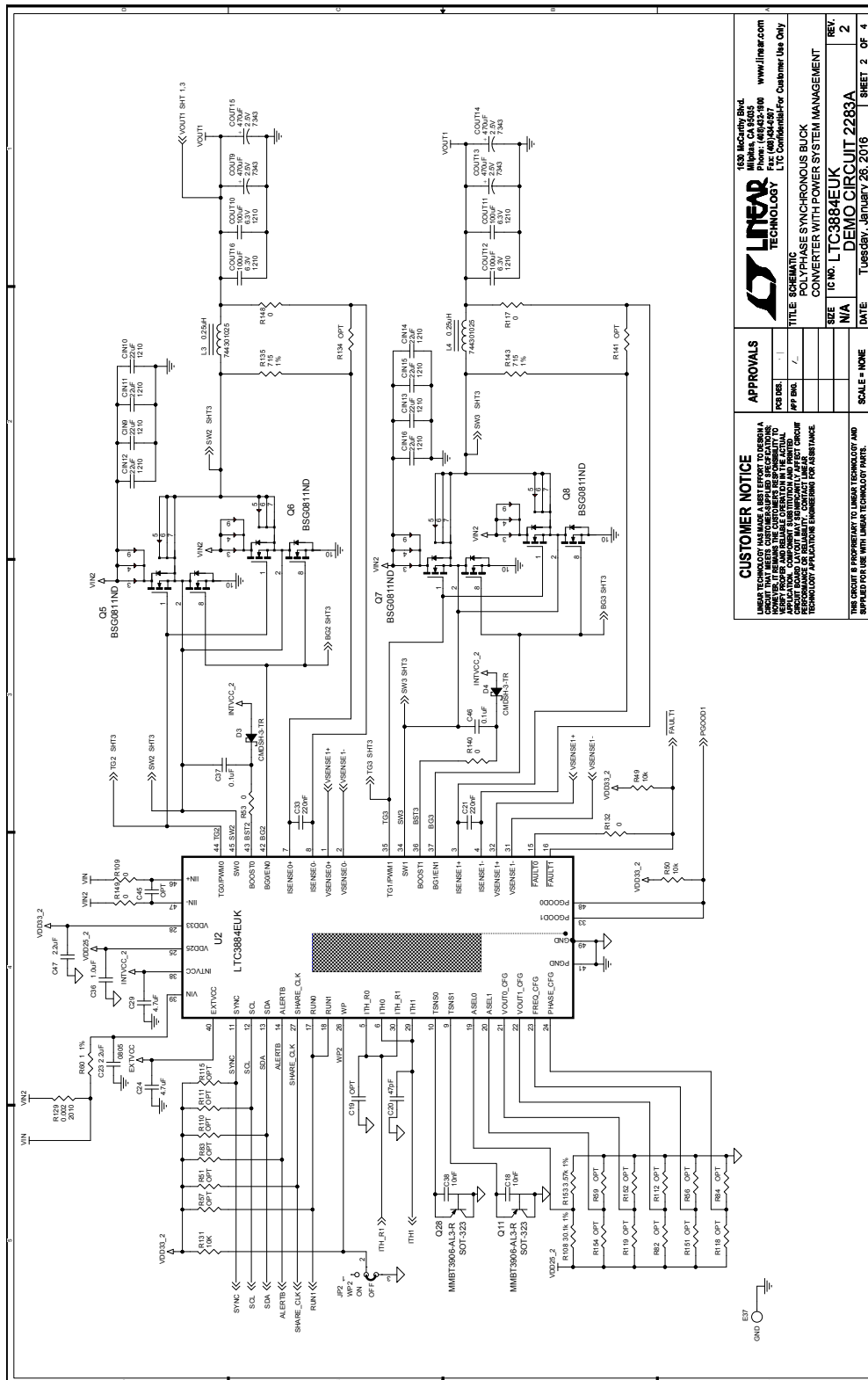
1	24	E1, E2, E3, E4, E5, E6, E7, E8, E9, E13, E14, E21, E22, E23, E24, E25, E26, E27, E28, E34, E35, E36, E37, E38	TEST POINT, TURRET, .094" MTG. HOLE	MILL MAX, 2501-2-00-80-00-00-07-0
2	4	JP1, JP2, JP4, JP5	HEADER, SINGLE ROW 3PIN	SULLINS, NRPN031PAEN-RC
3	6	J1, J2, J3, J4, J5, J6	STUD, TEST PIN	PEM, KFH-032-10
4	12	J1, J2, J3, J4, J5, J6 (x2)	NUT, BRASS 10-32	ANY, #10-32
5	6		LUG RING, #10	KEYSTONE, 8205
6	6		WASHER, #10 TIN PLATED BRASS	ANY, #10 EXT BZ TN
7	3	J10, J11, J12	CONN., BNC PC MOUNT RECEPT. JACK, 50Ω, TF-4 POST	AMPHENOL CONNEX, 112404
8	1	J13	CONN., HEADER, 2X7, 2mm, R/A (F)	SULLINS, NPPN072FJFN-RC
9	1	J14	HEADER, 12PIN 2mm STR DL	FCI, 98414-G06-12ULF
10	1	J15	CONN., HEADER, 2X7, 2mm, R/A (M)	MOLEX, 87760-1416
11	1	J16	HEADER, 4PIN 2mm STR DL	HIROSE, DF3A-4P-2DSA
12	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE, 8834
13	2	SW1, SW2	SWITCH, SUBMINIATURE SLIDE	C&K, JS202011CQN
14	4	XJP1, XJP2, XJP4, XJP5	SHUNT	SAMTEC, 2SN-BK-G

dc2283af

SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM

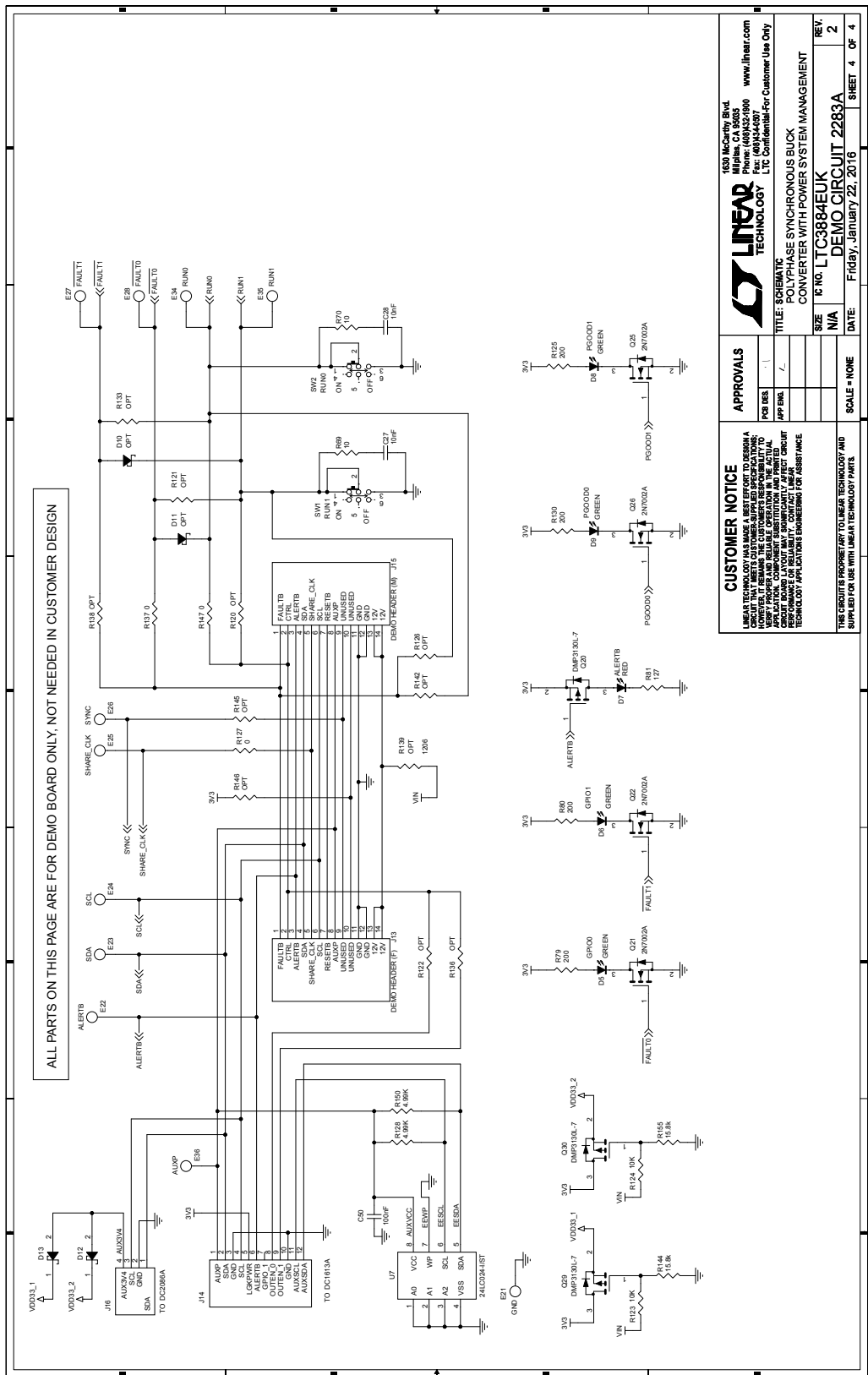


CUSTOMER NOTICE LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A DEMO CIRCUIT FOR THE LTC3884EUK. THE CUSTOMER IS RESPONSIBLE FOR THE PROPER DESIGN AND APPLICATION OF THE DEMO CIRCUIT. THE DEMO CIRCUIT IS NOT INTENDED FOR PRODUCTION OR REPRODUCTION. THE DEMO CIRCUIT IS PROVIDED AS A REFERENCE ONLY. THE CUSTOMER SHOULD CONSULT WITH LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.		APPROVALS PCB DES: _____ APP BAK: _____		130 McCarty Blvd. Milpitas, CA 95035 Phone: (408) 255-1000 FAX: (408) 255-1001 E-MAIL: LTC@LTC.COM WWW.LTC.COM
LINEAR TECHNOLOGY POLYPHASE SYNCHRONOUS BUCK CONVERTER WITH POWER SYSTEM MANAGEMENT DEMO CIRCUIT 2283A		TITLE SCHEMATIC SIZE 10.00 N/A DATE Tuesday, January 26, 2016		REV 2 SHEET 2 OF 4

SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



DEMO MANUAL DC2283A

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.

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