

LTM4677

Dual 18A or Single 36A μ Module Regulator with Digital Power System Management
3x LTM4677; 108A

DESCRIPTION

Demonstration circuit 2143A-B is a high efficiency, high density, μ Module regulator with 4.5V to 16V input range. The output voltage is adjustable from 0.5V to 1.8V, and it can supply 108A maximum load current. The demo board has three LTM[®]4677 μ Module[®] regulators, and the LTM4677 is a dual 18A or single 36A step-down regulator with PMBus power system management. Please see the LTM4677 data sheet for more detailed information

DC2143A-B powers up to default settings and produces power based on configuration resistors 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[™] onto 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 LTM4677 Quick Start Guide in this document.

Design files for this circuit board are available at <http://www.linear.com/demo/DC2143A-B>

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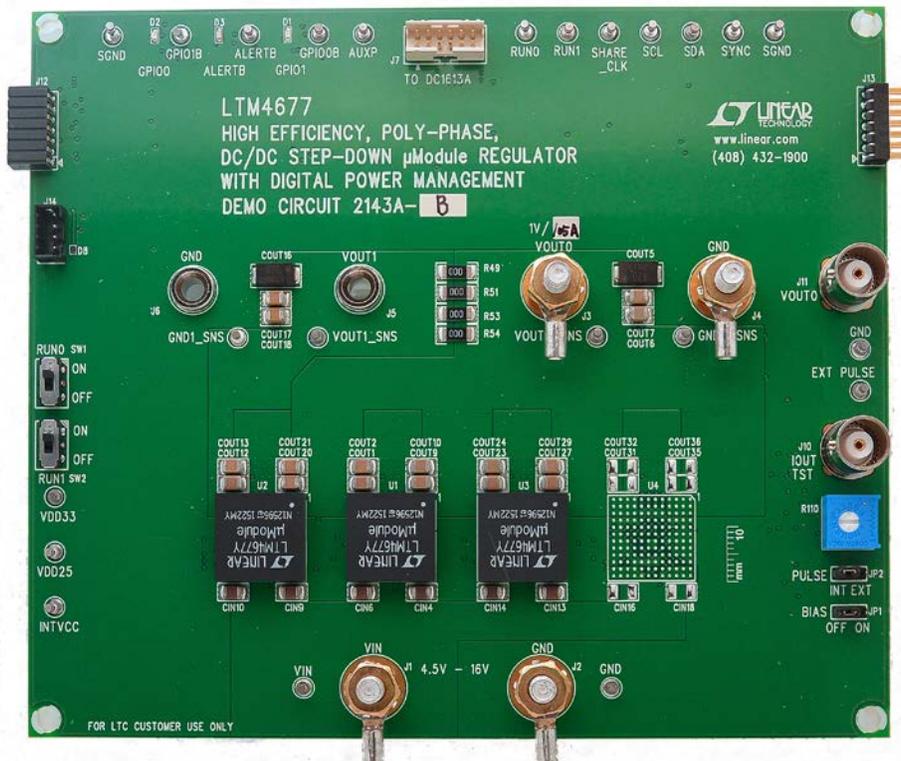


Figure 1. 3x LTM4677; 108A DC2143A-B Demo Circuit

DEMO MANUAL DC2143A-B

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

PARAMETER	CONDITION	VALUE
Input Voltage Range		4.5V to 16V
Output Voltage, V_{OUT0}	$V_{IN} = 4.5\text{V to }16\text{V}$, $I_{OUT0} = 0\text{A to }108\text{A}$	0.5V to 1.8V, Default: 1V
Maximum Output Current, I_{OUT0}	$V_{IN} = 4.5\text{V to }16\text{V}$, $V_{OUT} = 0.5\text{V to }1.8\text{V}$	108A
Typical Efficiency	$V_{IN} = 12\text{V}$, $V_{OUT} = 1.0\text{V}$, $I_{OUT} = 108\text{A}$	81.5%
Default Switching Frequency		500kHz

QUICK START PROCEDURE

Table 1. LTM4677 Demo Cards for Up to 144A Point-of-Load Regulation

MAXIMUM OUTPUT CURRENT	NUMBER OF OUTPUT VOLTAGES	NUMBER OF LTM4677 μ MODULE REGULATORS ON THE BOARD	DEMO BOARD NUMBER
Dual 18A	2	1	DC2066A
72A	1	2	DC2143A-A
108A	1	3	DC2143A-B
144A	1	4	DC2143A-C

Demonstration circuit 2143A-B is easy to set up to evaluate the performance of the LTM4677EY. Refer to Figure 2 for the proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input power supply to V_{IN} (4.5V to 16V) and GND (input return).
2. Connect the 1.0V output load between V_{OUT} and GND (Initial load: no load).
3. Connect the DVMs to the input and outputs. Set default switch position: SW1: ON; SW2: ON.
4. Turn on the input power supply and check for the proper output voltages. V_{OUT0} should be $1.0\text{V} \pm 1\%$.
5. Once the proper output voltages are established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage and other parameters.

6. Connect the dongle and control the output voltages from the GUI. See LTpowerPlay GUI for the LTM4677 Quick Start Guide for details.

Note: When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 3 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 DC2143A-B

You can use a PC to reconfigure the power management features of the LTM4677 such as: nominal V_{OUT} , margin set points, OV/UV limits, temperature fault limits, sequencing parameters, the fault log, fault responses, GPIOs and other functionality. The DC1613A dongle may be plugged when V_{IN} is present.

QUICK START PROCEDURE

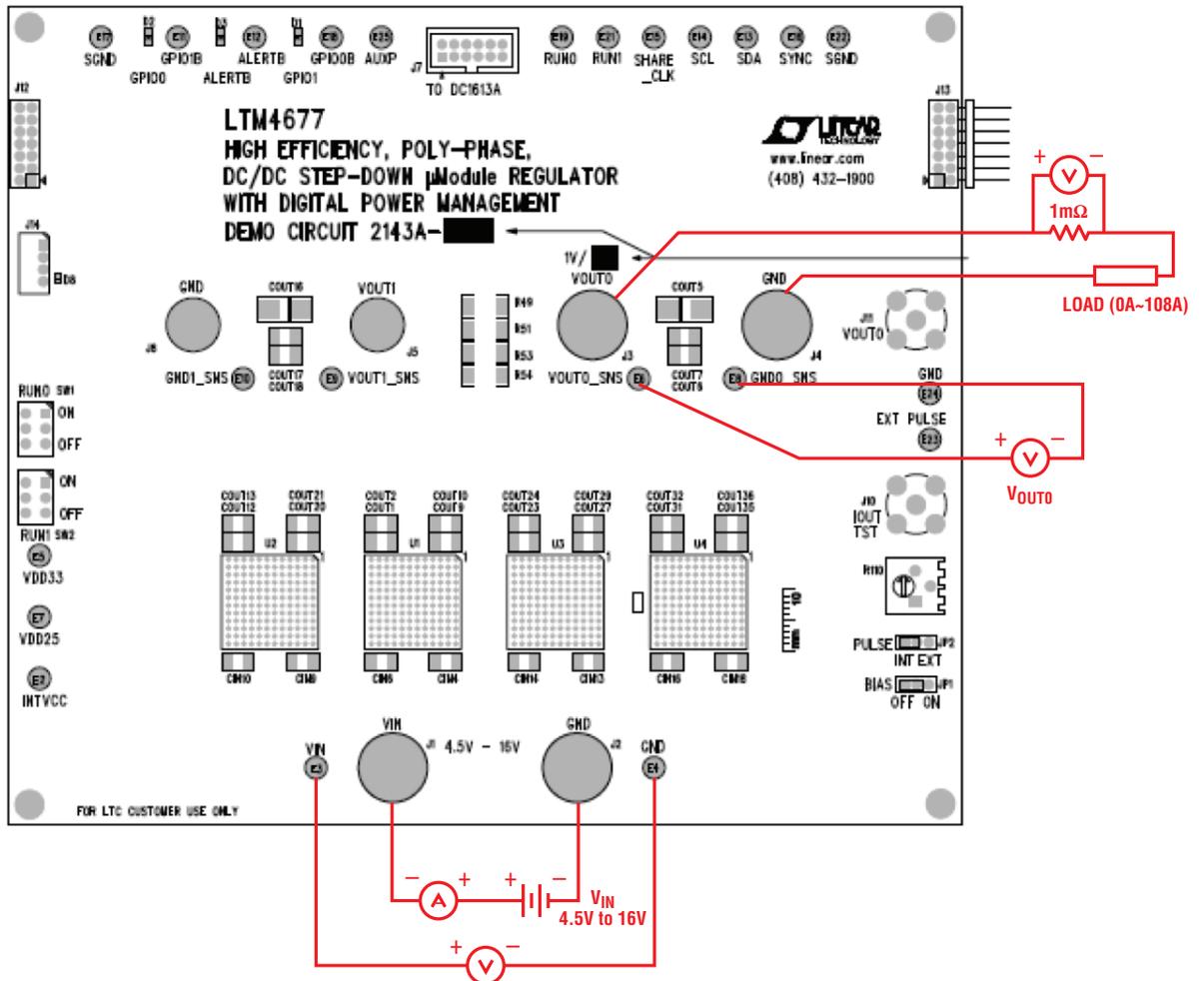


Figure 2. Proper Measurement Equipment Setup

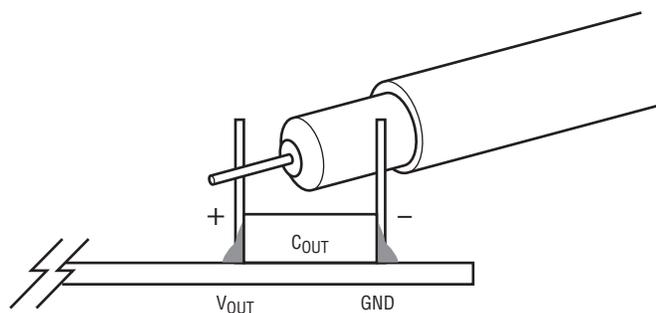


Figure 3. Measuring Output Voltage Ripple

QUICK START PROCEDURE

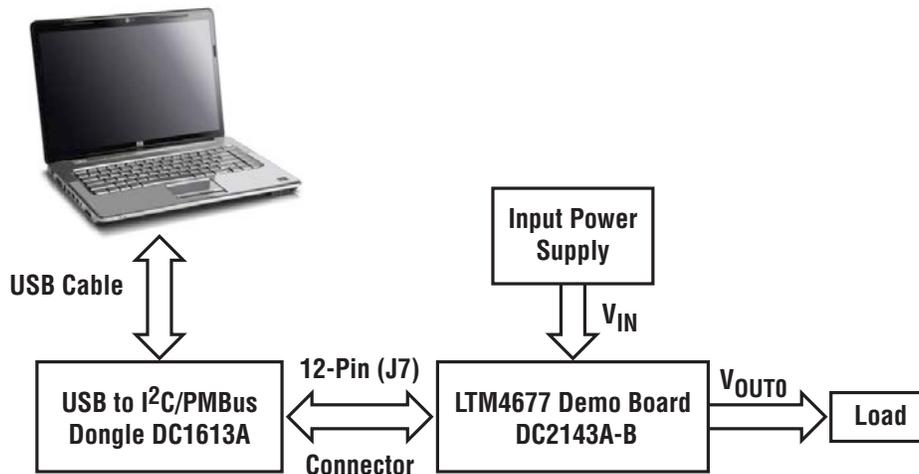


Figure 4. Demo Setup with PC

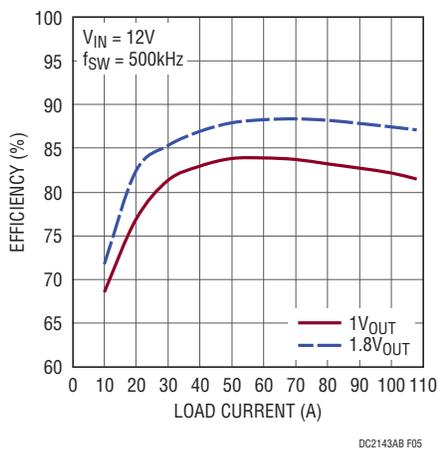


Figure 5. Efficiency vs Load Current for $V_{OUT} = 1V$ and $V_{OUT} = 1.8V$ at $V_{IN} = 12V$, $f_{SW} = 500kHz$

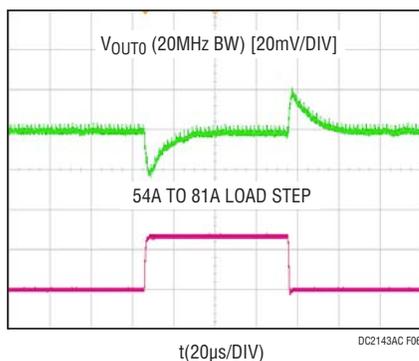


Figure 6. Output Voltage V_{OUTO} vs Load Current at $V_{IN} = 12V$, $V_{OUTO} = 1V$, $f_{SW} = 500kHz$

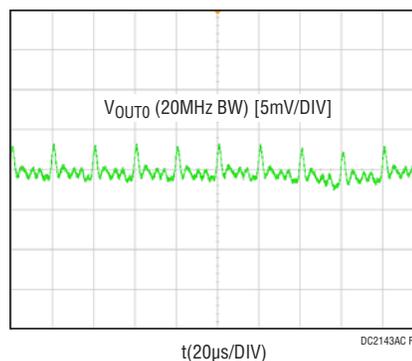


Figure 7. Output Voltage Ripple at $V_{IN} = 12V$, $V_{OUTO} = 1V$, $I_{OUTO} = 108A$, $f_{SW} = 500kHz$

QUICK START PROCEDURE

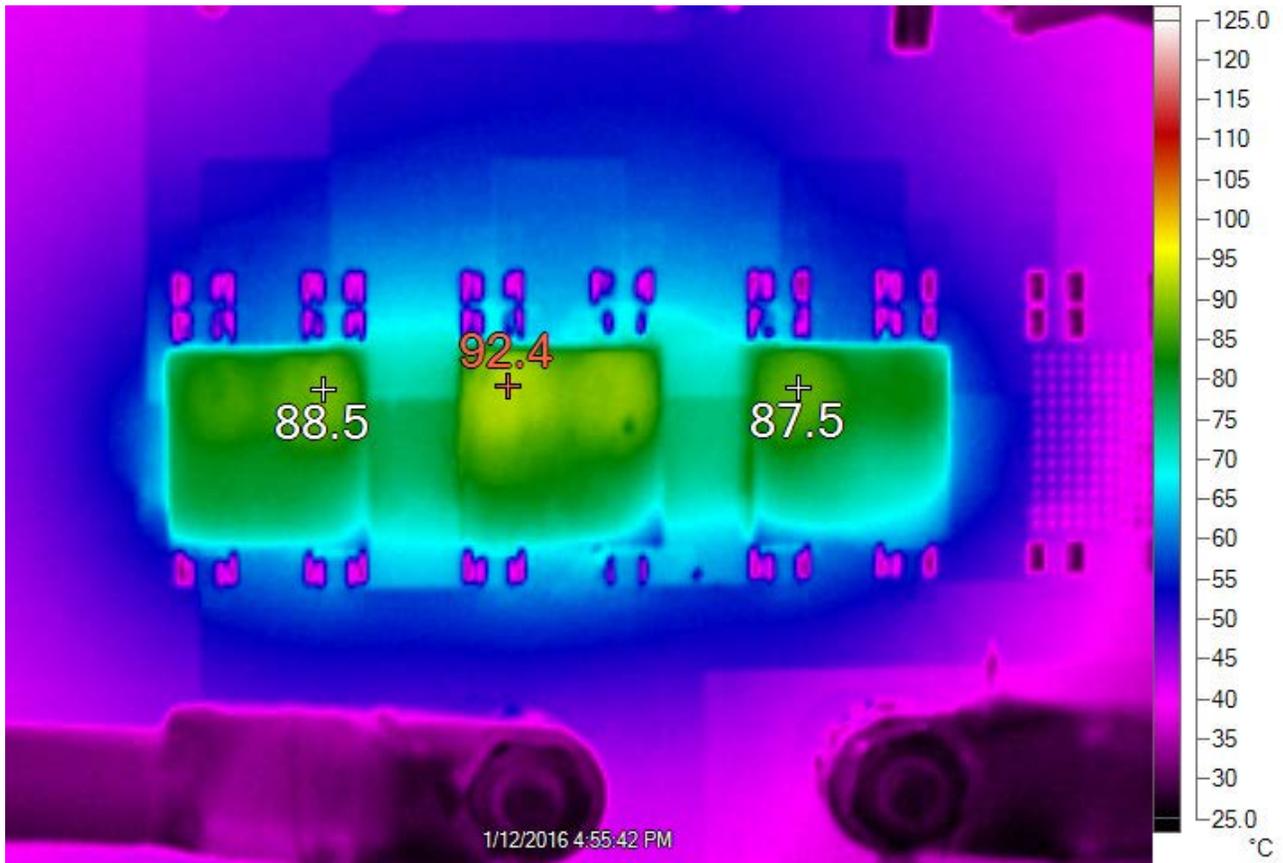


Figure 8. Thermal Performance at $V_{IN} = 12V$, $V_{OUT0} = 1V$, $I_{OUT0} = 108A$, $T_A = 23.8^{\circ}C$, Air Flow 400LFM

LTPOWERPLAY SOFTWARE GUI

LTpowerPlay is a powerful Windows based development environment that supports Linear Technology power system management ICs, including the LTM4677, LTC3880, LTC3883, 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 LTM4677, the LTC3880 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://www.linear.com/ltpowerplay>

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

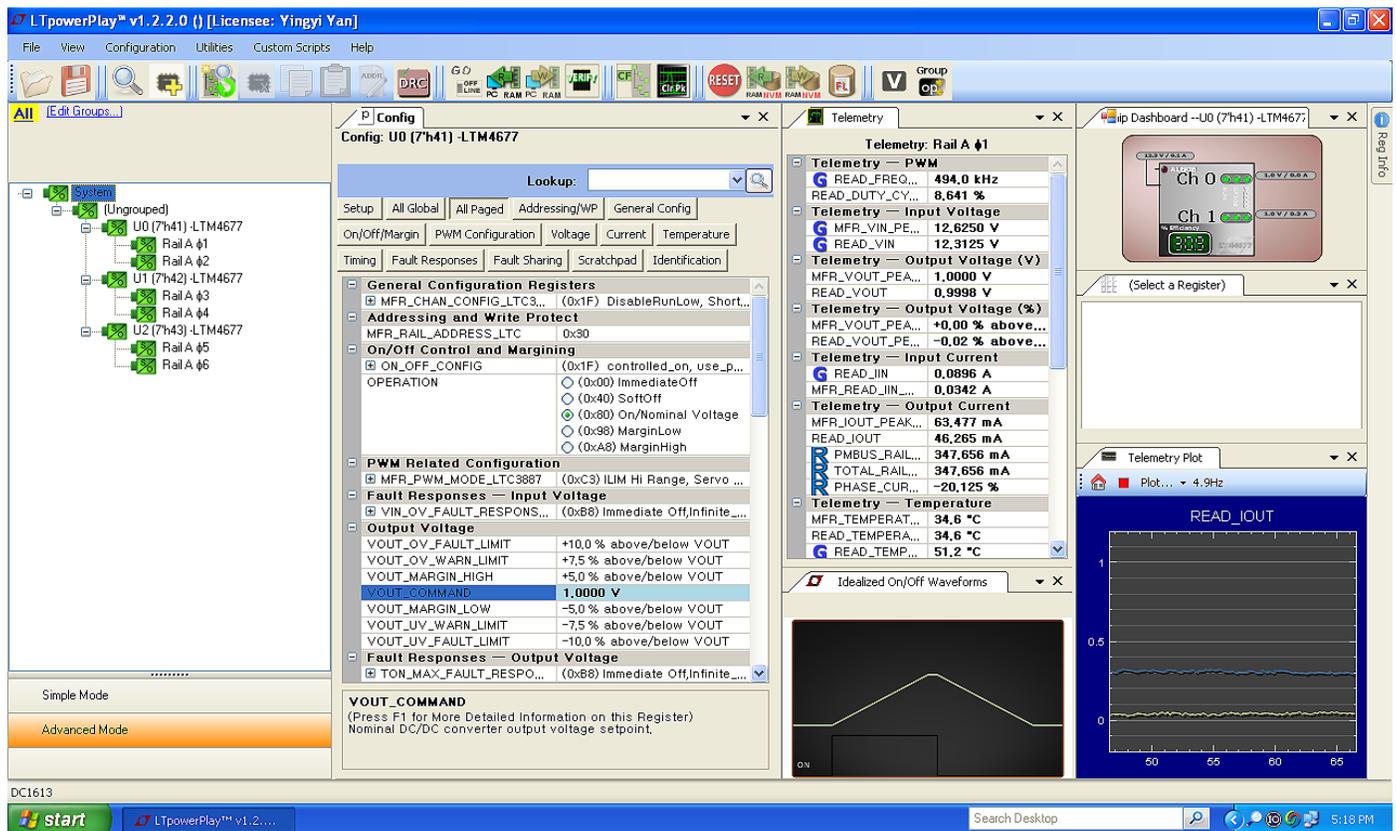
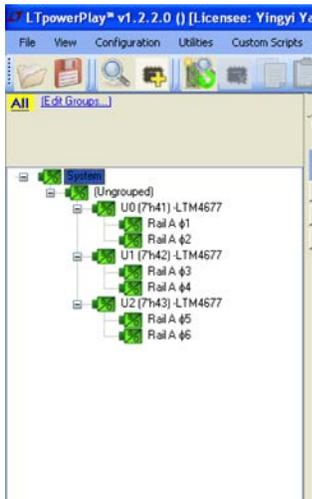


Figure 9. LTpowerPlay Main Interface

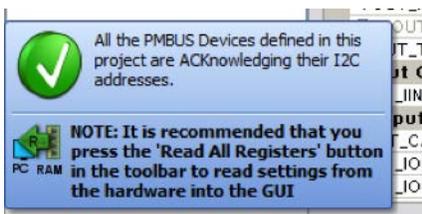
LTPowerPLAY QUICK START PROCEDURE

The following procedure describes how to use LTPowerPlay to monitor and change the settings of LTM4677.

1. Download and install the LTPowerPlay GUI:
<http://www.linear.com/ltpowerplay>
2. Launch the LTPowerPlay GUI.
 - a. The GUI should automatically identify the DC2143A-B. The system tree on the left hand side should look like this:



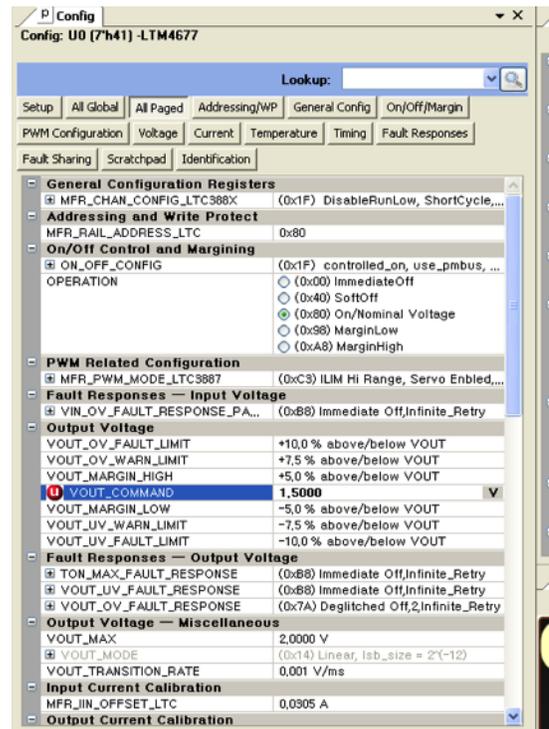
- b. A green message box shows for a few seconds in the lower left hand corner, confirming that LTM4677 is communicating:



- c. In the Toolbar, click the “R” (RAM to PC) icon to read the RAM from the TM4677. This reads the configuration from the RAM of LTM4677 and loads it into the GUI.



- d. If you want to change the output voltage to a different value, like 1.5V. In the Config tab, type in 1.5 in the VOUT_COMMAND box, like this:



Then, click the “W” (PC to RAM) icon to write these register values to the LTM4677. After finishing this step, you will see the output voltage will change to 1.5V.



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



- e. You can save the changes into the NVM. In the toolbar, 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. Name it whatever you want.

DEMO MANUAL DC2143A-B

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	14	CIN1, CIN2, CIN4, CIN5, CIN6, CIN7, CIN8, CIN9, CIN10, CIN11, CIN12, CIN13, CIN14, CIN15	CAP, X5R, 10 μ F, 35V, 10%,1210	MURATA, GRM32ER6YA106KA12L
2	1	CIN3	CAP, 150 μ F, 35V, ALUMINUM ELECTR.	SUN ELECT., 35CE150AX
3	22	COUT1, COUT2, COUT3, COUT6, COUT7, COUT9, COUT10, COUT11, COUT12, COUT13, COUT14, COUT17, COUT18, COUT20, COUT21, COUT22 COUT23, COUT24, COUT25, COUT27, COUT29, COUT30	CAP, X5R, 100 μ F, 6.3V, 20% 1210	MURATA, GRM32ER60J107ME20K
4	8	COUT4, COUT5, COUT8, COUT15, COUT16, COUT19, COUT26, COUT28,	POSCAP, 470 μ F, 2.5V, SP-CAP, D3L	PANASONIC, EEF-LX0E471E4
5	1	C3	CAP, X7R, 220pF, 16V, 10%, 0603	AVX, 0603YC221KAT2A
6	1	C4	CAP, X7R, 6800pF, 16V, 10%,0603	AVX, 0603YC682KAT2A
7	4	C5, C12, C33, C34	CAP, X5R, 0.01 μ F, 16V, 10%,0603	AVX, 0603YD103KAT2A
8	1	C32	CAP, X5R, 0.1 μ F, 16V, 10%,0603	MURATA, GRM188R61C104KA01D
9	1	C64	CAP, X5R, 4.7 μ F, 25V,10%, 0603	MURATA, GRM188R61E475KE11D
10	2	C65, C68	CAP, X7R, 1 μ F, 25V,10%, 1206	MURATA, GRM31MR71E105KA01L
11	1	C66	CAP, X5R, 0.22 μ F, 25V,10%, 0805	AVX, 08053D224KAT2A
12	1	C67	CAP, X7R, 0.1 μ F, 25V,10%, 1206	AVX, 12063C104KAT2A
13	1	C69	CAP, X7R, 150pF, 25V,10%, 0603	AVX, 06033C151KAT2A
14	1	C70	CAP, X5R, 1 μ F, 25V,10%, 0805	MURATA, GRM216R61E105KA12D
15	2	D1, D2	SMT Chip LED, GREEN	Würth Elektronik, 150060GS75000
16	1	D3	SMT Chip LED, RED	Würth Elektronik, 150060SS75000
17	1	D8	DIODE SCHOTTKY 20V 500MA SOD882 2-PIN	NXP SEMI., PMEG2005AEL,315
18	1	Q2	MOSFET P-CH 20V 0.58A SOT-23	VISHAY, SI2365EDS-T1-GE3
19	2	Q3, Q4	MOSFET N-CH 60V 115MA SOT-23	FAIRCHILD, 2N7002K
20	2	Q11, Q12	MOSFET N-CH 30V 63A TO252	VISHAY, SUD50N04-8M8P-4GE3
21	1	Q19	MOSFET P-CH 30V 3.5A SOT-23	DIODES INC., DMP3130L-7
22	24	R2, R4, R18, R25, R26, R30, R32, R47, R48, R50, R56, R58, R60, R72, R74, R104, R120, R121, R122, R131, R135, R143	RES., CHIP, 0, 1%, 0603	VISHAY CRCW06030000Z0EA
23	15	R6, R7, R8, R9, R10, R11, R12, R15, R35, R36, R39, R64, R78, R116, R130	RES., CHIP, 10k, 1%, 0603	VISHAY CRCW060310K0FKEA
24	1	R14	RES., CHIP, 2k, 1%, 0603	VISHAY CRCW06032K00FKEA
25	4	R16, R41, R125, R129	RES., CHIP, 10, 1%, 0603	VISHAY CRCW060310R0FKEA
26	1	R19	RES., CHIP, 787, 1%, 0603	VISHAY CRCW0603787RFKFA
27	4	R49, R51, R53, R54	RES., CHIP, 0, 1%, 2010	VISHAY CRCW20100000Z0EF
28	2	R85, R124	RES., CHIP, 200, 1%, 0603	VISHAY CRCW0603200RFKFA
29	1	R86	RES., CHIP, 127, 1%, 0603	VISHAY CRCW0603127RFKFA
30	1	R105	RES., CHIP, 681k, 1%, 0603	VISHAY CRCW0603681KFKEA
31	1	R106	RES., CHIP, 3.3, 1%, 0603	VISHAY CRCW06033R30FKFA
32	1	R107	RES., CHIP, 82.5, 1%, 0603	VISHAY CRCW060382R5FKFA
33	2	R108, R118	RES., CHIP, 0.01, 1%, 2010	VISHAY, WSL2010R0100FEA
34	1	R109	RES., CHIP, 100k, 1%, 0603	VISHAY CRCW0603100KFKEA
35	1	R110	TRIMMING POTENTIOMETER, 5k	BOURNS, 3386P-1-502LF
36	2	R111, R115	RES., CHIP, 20k, 1%, 0603	VISHAY CRCW060320K0FKFA
37	1	R112	RES., CHIP, 100, 1%, 0603	VISHAY CRCW0603100RFKFA
38	1	R113	RES., CHIP, 1.4k, 1%, 0603	VISHAY CRCW06031K40FKFA
39	1	R114	RES., CHIP, 154k, 1%, 0603	VISHAY CRCW0603154KFKEA
40	1	R117	RES., CHIP, 2, 1%, 0603	VISHAY CRCW06032R00FKFA

dc2143abfa

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
41	1	R123	RES., CHIP, 1M, 1%, 0603	VISHAY CRCW06031M00FKEA
42	2	R134, R144	RES., CHIP, 4.99k, 1%, 0603	VISHAY CRCW06034K99FKEA
43	1	R141	RES., CHIP, 15.8k, 1%, 0603	VISHAY CRCW060315K8FKEA
44	3	U1, U2, U3	IC, LTM4677EY	LINEAR TECH., LTM4677EY#PBF
45	1	U6	IC., LT1129CS8-5, S8	LINEAR TECH. LT1129CS8-5#PBF
46	1	U7	IC., LTC6992-1, S6-TSOT	LINEAR TECH. LTC6992CS6-1#PBF
47	1	U8	IC., LT1803IS5, S5-TSOT	LINEAR TECH. LT1803IS5#PBF
48	1	U9	IC., EEPROM 2KBIT 400KHZ 8TSSOP	MICROCHIP, 24LC025-I/ST
49	2	R40, R42	RES., CHIP, 1.65k, 1%, 0603	VISHAY CRCW06031K65FKEA
50	2	R65, R66	RES., CHIP, 2.43k, 1%, 0603	VISHAY CRCW06032K43FKEA

Additional Demo Board Circuit Components

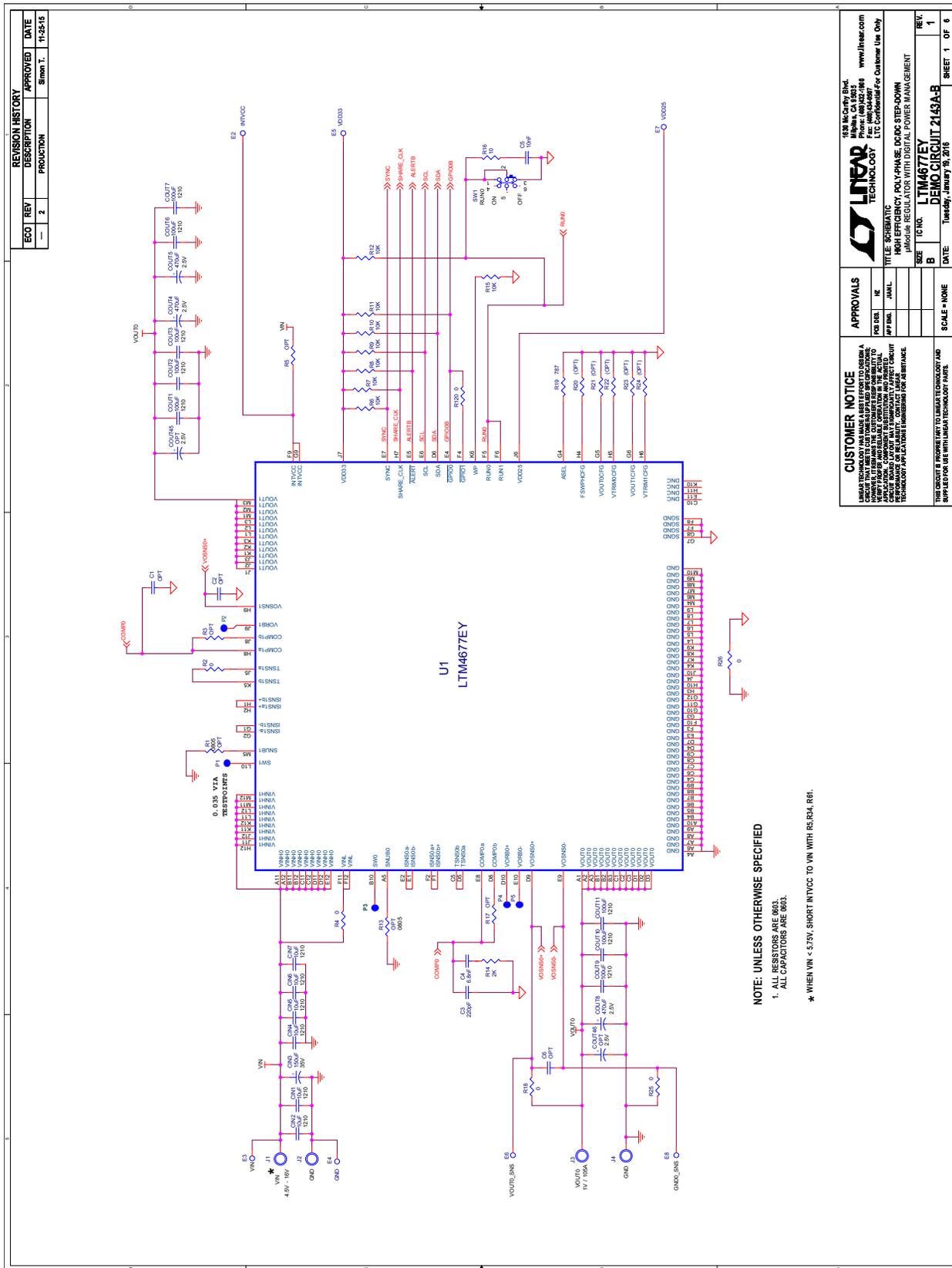
1	0	CIN16, CIN17, CIN18, CIN19,	CAP, OPTIONAL 1210	
2	0	COUT31, COUT32, COUT33, COUT35, COUT36, COUT37	CAP, OPTIONAL 1210	
3	0	COUT34, COUT38	OPTIONAL, D3L	
4	0	COUT39, COUT40, COUT41, COUT42,	OPTIONAL D3L	
5		COUT43, COUT44, COUT45, COUT46		
6	0	R80	RES., CHIP, OPTIONAL, 0603	
7	0	R79	RES., CHIP, OPTIONAL, 0603	
8	0	U4	IC, OPTIONAL	
9	0	C1, C2, C6, C8, C9, C10, C11, C13, C14,	OPTIONAL 0603	
10		C15, C16, C17, C18, C19, C20		
11	0	C7	OPTIONAL 0603	
12	0	D4, D5	DIODE SOD323 OPTIONAL	
13	0	R1, R3, R5, R13, R17, R20, R21, R22, R23, R24, R27, R28, R29, R31, R33, R34, R37, R38, R43, R44, R45, R46, R57, R59, R61, R62, R63, R67, R68, R69, R70, R71, R73, R75, R76, R77, R81, R82, R83, R84, R119, R126, R127, R128, R132, R133, R136, R137, R139, R140, R142	RES., OPTIONAL 0603	
14	0	R102, R103	RES., OPTIONAL 2512	
15	0	R138	RES., OPTIONAL 1206	

Hardware: For Demo Board Only

1	23	E2-E19, E21-E25	TESTPOINT, TURRET, .062"	MILL-MAX, 2308-2-00-80-00-00-07-0
2	2	JP1, JP2	CONN., HEADER, 1X3, 2mm	Wurth Elektronik, 62000311121
3	2	JP1, JP2	SHUNT, 2mm	Wurth Elektronik, 60800213421
4	4	J1, J2, J3, J4	STUD, TEST PIN	PEM, KFH-032-10
5	8	J1, J2, J3, J4 (x2)	NUT, BRASS 10-32	ANY, #10-32M/S
6	4	J1, J2, J3, J4	RING, LUG #10	KEYSTONE, 8205
7	4	J1, J2, J3, J4	WASHER, TIN PLATED BRASS	ANY, #10
8	2	J5, J6	JACK, BANANA	KEYSTONE, 575-4
9	1	J7	CONN HEADER 12POS 2MM STR DL PCB	FCI, 98414-G06-12ULF
10	2	J10, J11	CONN, BNC, 5PINS	CONNEX, 112404
11	1	J12	CONN RECEPT 2MM DUAL R/A 14POS (F)	SULLINS, NPPN072FJFN-RC
12	1	J13	HEADER, 14POS 2MM R/A GOLD (M)	MOLEX, 87760-1416
13	1	J14	HEADER, 4 PINS, SHROUDED	HIROSE, DF3A-4P-2DSA
14	2	SW1, SW2	SWITCH, SLIDE DPDT 300MA 6V	C&K., JS202011CQN
15	4	(STAND-OFF)	STAND-OFF, NYLON 0.50" Tall, SNAP ON	WURTH ELEKTRONIK, 702935000
16	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT 2143A
17	2		STENCIL (TOP AND BOTTOM)	STENCIL DC2143A

DEMO MANUAL DC2143A-B

SCHEMATIC DIAGRAM



REVISION HISTORY			
ECO	REV	DESCRIPTION	APPROVED DATE
—	2	PRODUCTION	Simon T. 11-25-15

CUSTOMER NOTICE
 LINEAR TECHNOLOGY MAKES NO WARRANTY OR REPRESENTATION, WHETHER EXPRESS OR IMPLIED, REGARDING THE ACTUAL PERFORMANCE OF THIS PRODUCT IN THE FIELD. CUSTOMERS ARE ADVISED THAT THIS IS A DEMO CIRCUIT AND NOT A RECOMMENDED DESIGN. LINEAR TECHNOLOGY ACCEPTS NO LIABILITY FOR DAMAGES OF ANY KIND ARISING FROM THE USE OF THIS PRODUCT.

APPROVALS

DESIGNER	DATE
APP'D	DATE

SCALE = NONE

DATE = Tuesday, January 19, 2016

REV. 1

SHEET 1 OF 6

1330 McCarty Blvd.
 Fremont, CA 94538
 Tel: (925) 466-6000
 Fax: (925) 466-6007
 www.linear.com

LINEAR TECHNOLOGY

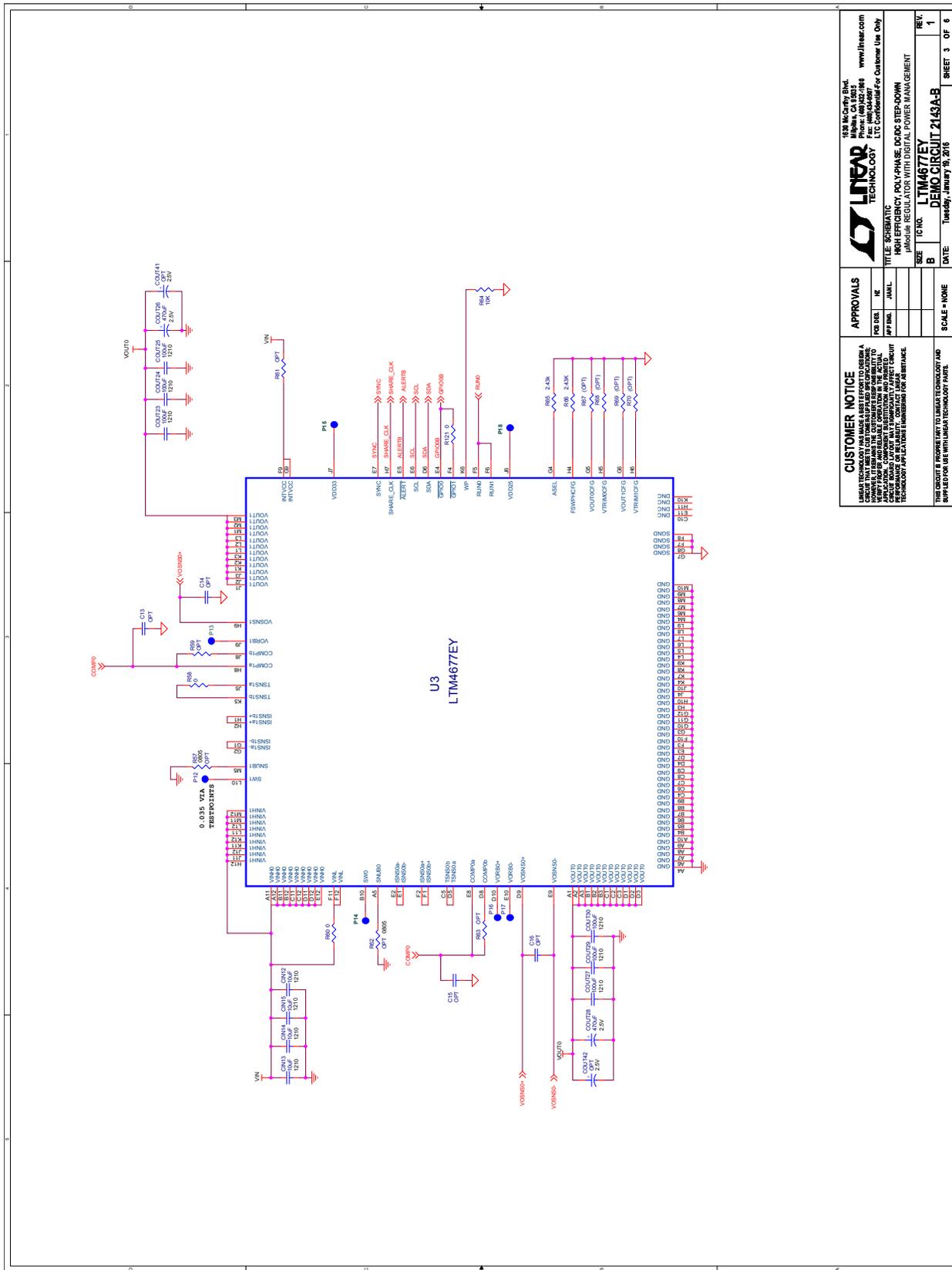
TITLES: SCHEMATIC
HIGH EFFICIENCY POLY-PHASE DC/DC STEP-DOWN
µPOWER REGULATOR WITH DIGITAL POWER MANAGEMENT

SIZE 16.00
SCALE NONE
REV. 1
DATE Tuesday, January 19, 2016
SHEET 1 OF 6

NOTE: UNLESS OTHERWISE SPECIFIED
 1. ALL RESISTORS ARE 0603.
 ALL CAPACITORS ARE 0603.
 * WHEN VIN < 5.75V, SHORT INTVCC TO VIN WITH RS4, R81.

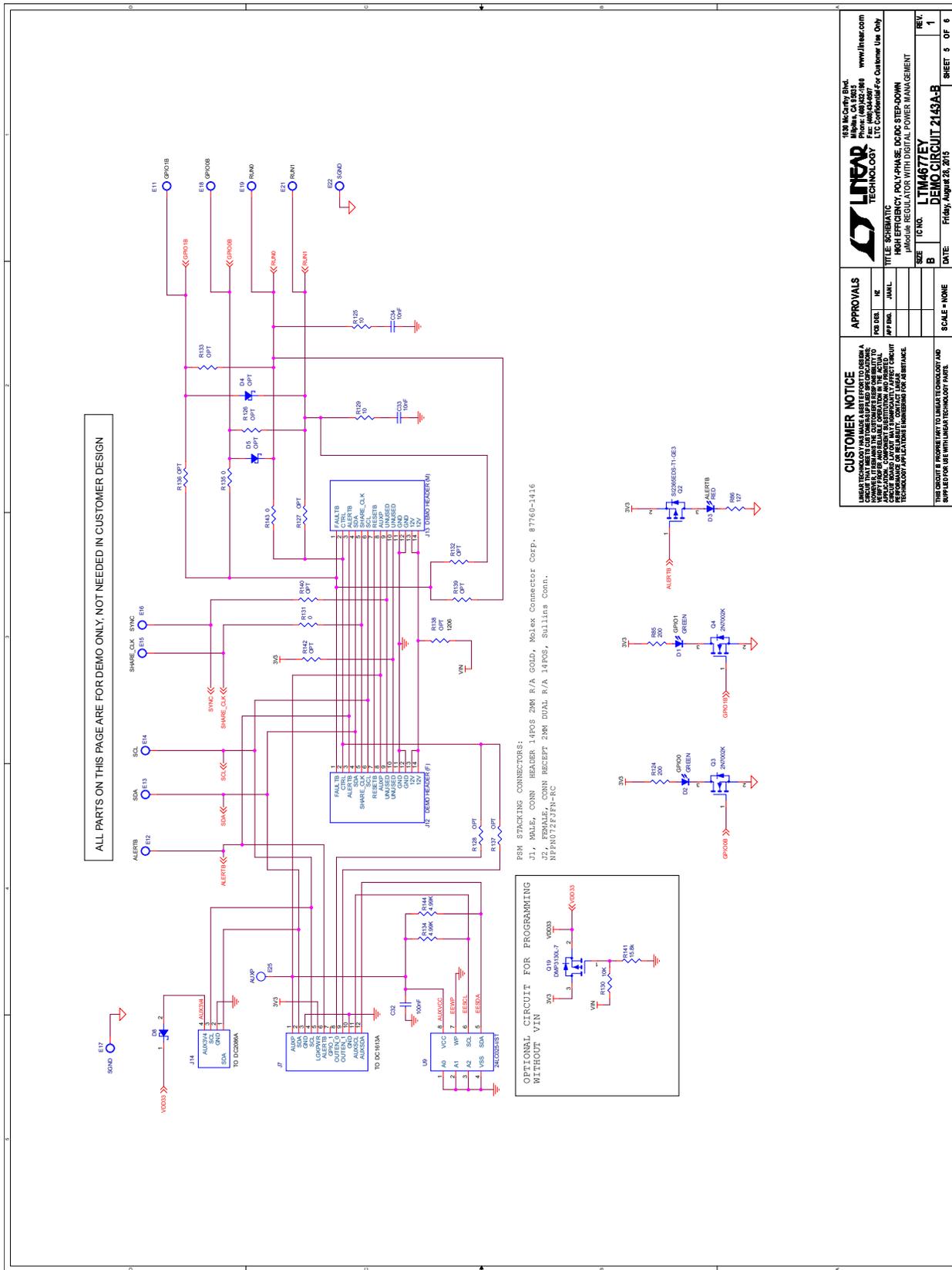
DEMO MANUAL DC2143A-B

SCHEMATIC DIAGRAM



DEMO MANUAL DC2143A-B

SCHEMATIC DIAGRAM

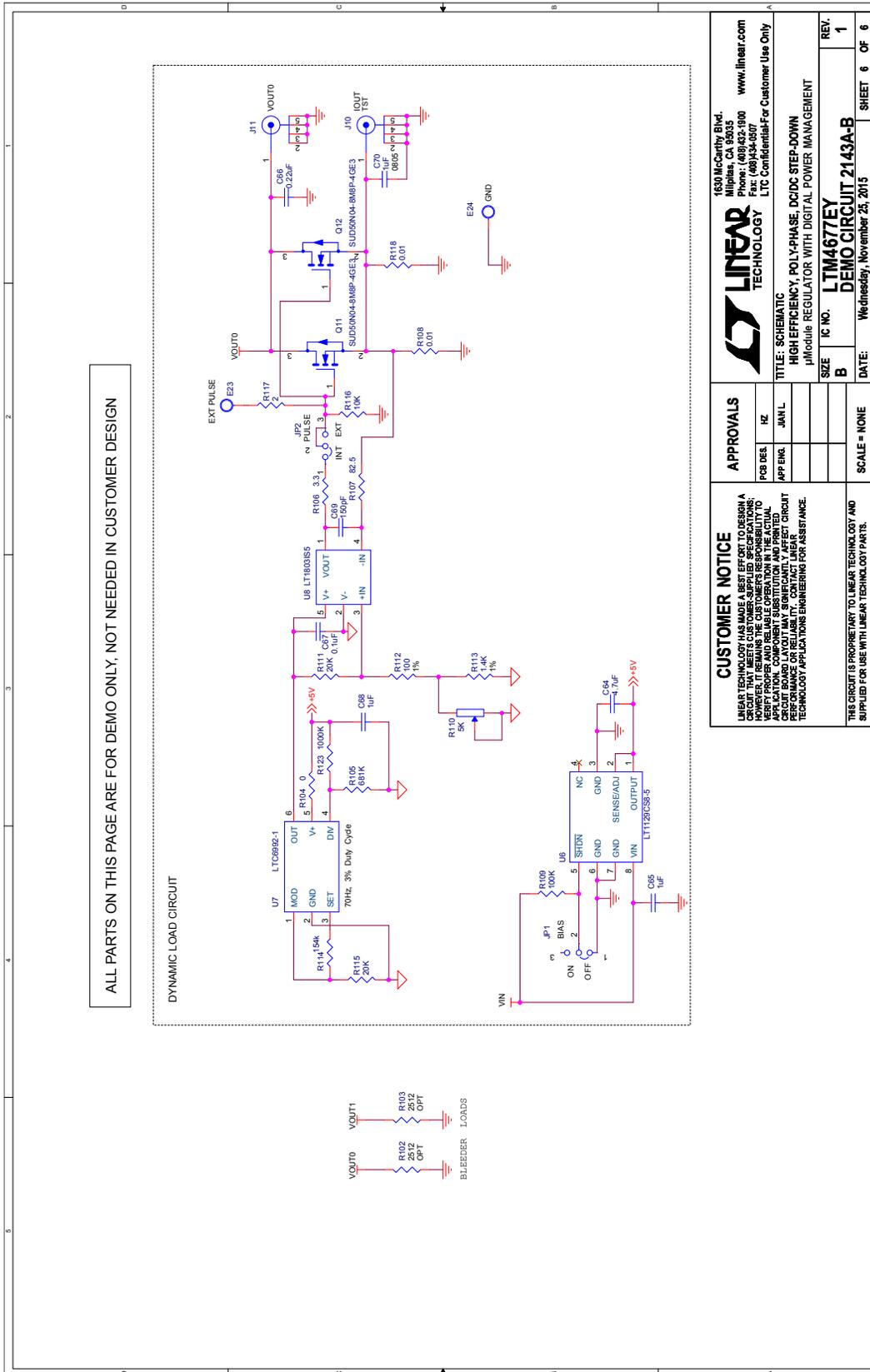


APPROVALS	
DESIGNED BY:	JML
CHECKED BY:	JML
DATE:	Friday, August 26, 2015
TITLE: SCHEMATIC	
PROJECT: HIGH EFFICIENCY POLY-PHASE DC/DC STEP-DOWN	
SCALE:	NONE
REV:	1
SHEET:	5 OF 6

LINEAR TECHNOLOGY MAKES NO WARRANTY OR REPRESENTATION, WHETHER EXPRESS OR IMPLIED, FOR THE ACTUAL PERFORMANCE OF THIS CIRCUIT OR THE ACTUAL OPERATION OF THIS CIRCUIT IN ANY APPLICATION. CUSTOMER SHOULD CONSULT WITH LINEAR TECHNOLOGY FOR APPLICATIONS ENGINEERING ASSISTANCE.



SCHEMATIC DIAGRAM



DEMO MANUAL DC2143A-B

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:

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Milpitas, CA 95035

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Компания «Life Electronics» занимается поставками электронных компонентов импортного и отечественного производства от производителей и со складов крупных дистрибьюторов Европы, Америки и Азии.

С конца 2013 года компания активно расширяет линейку поставок компонентов по направлению коаксиальный кабель, кварцевые генераторы и конденсаторы (керамические, пленочные, электролитические), за счёт заключения дистрибьюторских договоров

Мы предлагаем:

- Конкуренеспособные цены и скидки постоянным клиентам.
- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



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