LTC7820EUFD High Efficiency, Charge Pump DC/DC Converter

DESCRIPTION

Demonstration circuit 2543B is a high efficiency, high density, open loop charge pump (inductorless) DC/DC converter. This demo board is a voltage divider which achieves a 2:1 step-down ratio from an input voltage from 36V to 60V. The output voltage is a fixed ratio of half of the input voltage ($V_{IN}/2$) and can supply a 10A load current. This demo board has the option to deliver a 20A maximum load with the addition of 15 chip capacitors. See Figure 8 and Figure 10 for the details.

The DC2543B provides a very high efficiency solution of 98.7% when converting $48V_{IN}$ to $24V_{OUT}$ at 10A as shown in Figure 3. When configured for a 20A output, an efficiency of up to 98.4% is achievable for a $48V_{IN}$ to $24V_{OUT}$ at 20A as shown in Figure 8.

The demo board features the LTC®7820, a fixed ratio high voltage high power switched capacitor/charge pump controller in a 4mm × 5mm QFN package. Please see LTC7820 data sheet for more detailed information.

The DC2543B needs to be powered on with no load current or a very small load current (less than 50mA) with the default setup. Large load current can be applied after V_O is established. The board offers a disconnect FET option which is controlled by the LTC7820 FAULT pin to disconnect the load during startup as shown in the schematic. Please refer to "Voltage Divider Prebalance Before Switching" section in the LTC7820 data sheet for more details regarding the startup of the voltage divider. The board also features some protection functions such as overcurrent and thermal shutdown to make it a reliable solution.

Design files for this circuit board are available.

PERFORMANCE SUMMARY

Specifications are at $T_A = 25°C$

PARAMETER	CONDITION	VALUE
Input Voltage Range		36V to 60V
Output Voltage, V_{OUT}	V_{IN} = 36 to 60V, I_{OUT} = 0A to 10A	$V_{IN}/2$
Maximum Output Current, I_{OUT}	V_{IN} = 36 to 60V, $V_{OUT} = V_{IN}/2$	10A
Typical Efficiency	V_{IN} = 48V, V_{OUT} = 24V, I_{OUT} = 10A	98.7%
Peak Efficiency	V_{IN} = 48V, V_{OUT} = 24V	99%
Switching Frequency		200kHz

NOTE: DC2543B demo board includes a Schottky diode added across the output. This manual describes the demo board entitled "Demo Circuit 2543B." The DC2543B replaces the DC2543A.

QUICK START PROCEDURE

Demonstration circuit 2543B is easy to set up to evaluate the performance of the LTC7820. 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 V_{IN} (36V to 60V) and GND (input return).
2. Connect the output loads between V_{OUT} 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: SW1 (RUN): OFF; JP2 (BIAS): ON.
5. Turn on the input power supply and adjust voltage to 48V.

   NOTE: Make sure that the input voltage does not exceed 60V.
6. Turn on the switches: SW1: ON.
7. Check for the proper output voltages from $V_{O\_SNS}^+$ to $V_{O\_SNS}^-$.
8. Once the proper output voltage is established, adjust the loads within the operating range and measure the efficiency, output ripple voltage and other parameters.
9. After completing all tests, adjust the load to 0A, power off the input power supply.

Notes:

1. 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.
2. When doing the load step test with the on-board dynamic load circuit, please make sure the load step-up pulse duty cycle does not exceed 2% and the pulse duration is less than 500μs so that the temperature of the MOSFETs Q9, Q23 in the dynamic load circuit stay in the safe region. Instead of using the on-board dynamic load circuit, an electric load can also be used for the load step test, which does not have the 2% maximum duty cycle limit for the load step.
3. It is recommended to set the electronic load in CR (constant resistance) mode for evaluation of the DC2543B board. Some electronic loads draw negative current in CC (constant current) mode when evaluating the output overcurrent protection feature of DC2543B, which can violate the absolute maximum voltage rating –0.3V for V_{LOW} pin.

QUICK START PROCEDURE

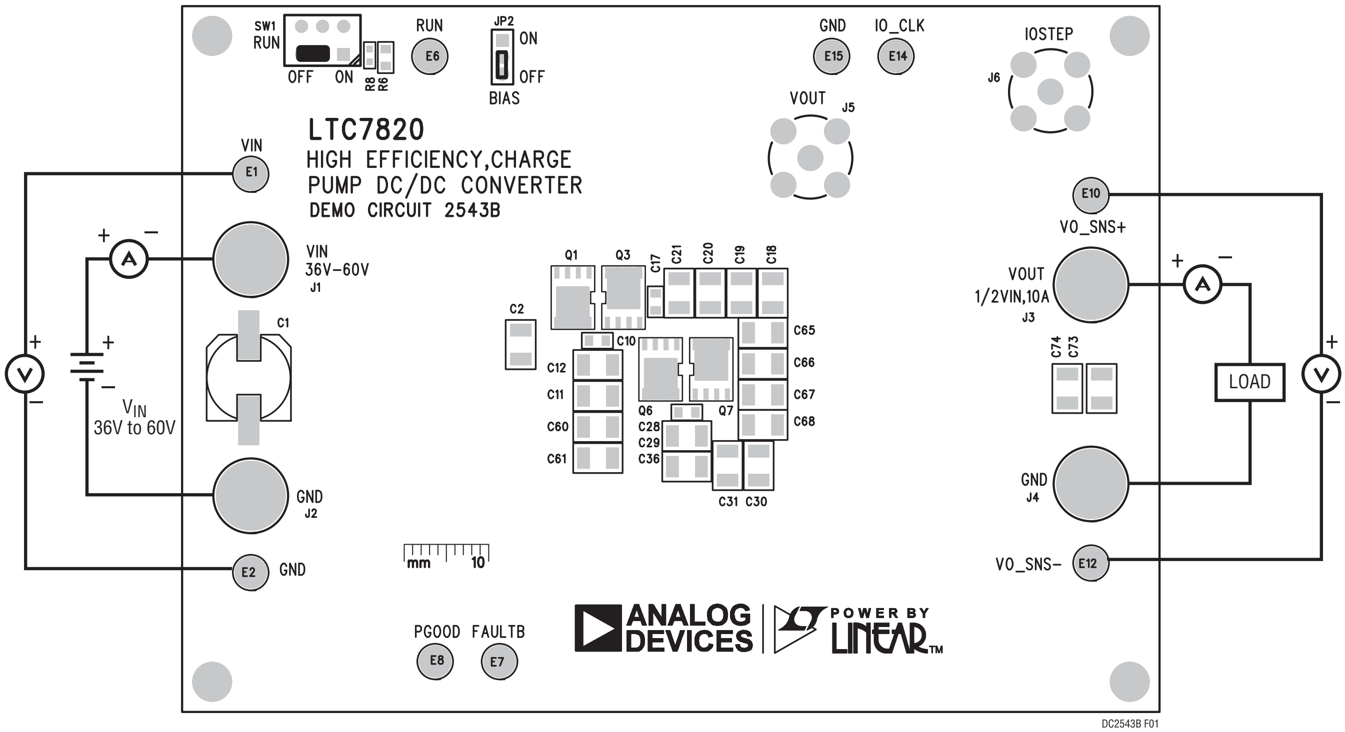


Figure 1. Proper Measurement Equipment Setup

Note: It is recommended to set the electronic load in CR (constant resistance) mode for evaluation of the DC2543B board. Some electronic loads draw negative current in CC (constant current) mode when evaluating the output overcurrent protection feature of DC2543B, which can violate the absolute maximum voltage rating –0.3V for V_{LOW} pin.

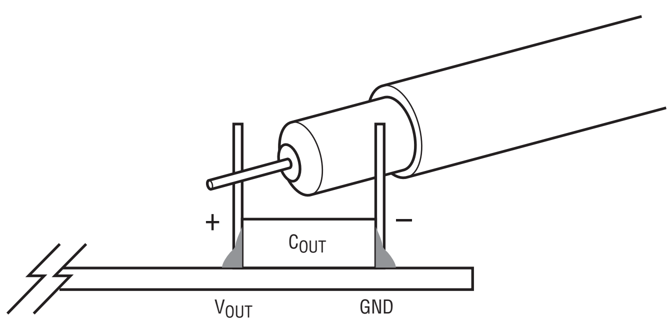


Figure 2. Measuring Output Voltage Ripple

QUICK START PROCEDURE

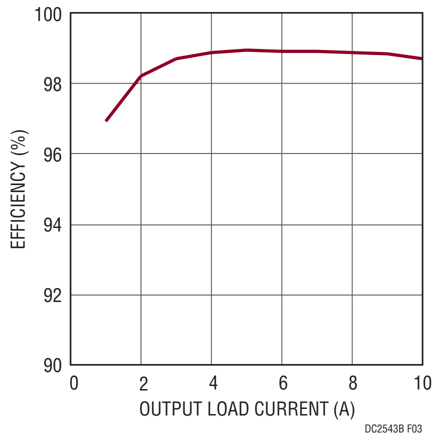


Figure 3. Efficiency vs Load Current at V_{IN} = 48V, V_{OUT} = 24V, f_{SW} = 200kHz

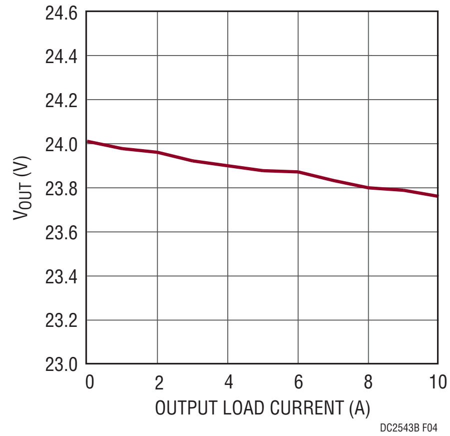


Figure 4. Load Regulation for 10A Design at V_{IN} = 48V, V_{OUT} = 24V, f_{SW} = 200kHz

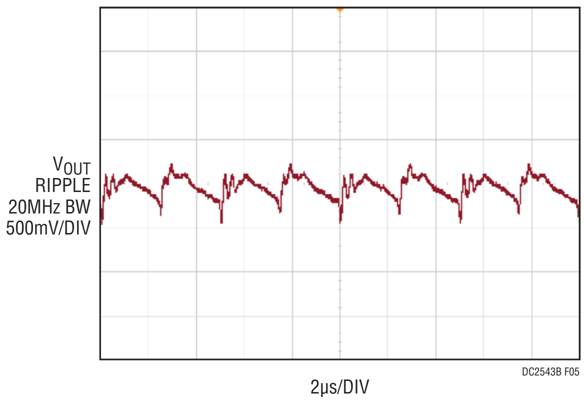


Figure 5. Output Voltage Ripple at V_{IN} = 48V, V_{OUT} = 24V, I_{OUT} = 10A, f_{SW} = 200kHz

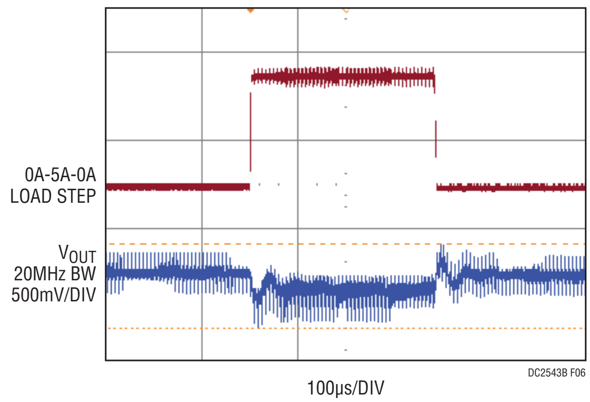


Figure 6. Load Step at V_{IN} = 48V, V_{OUT} = 24V

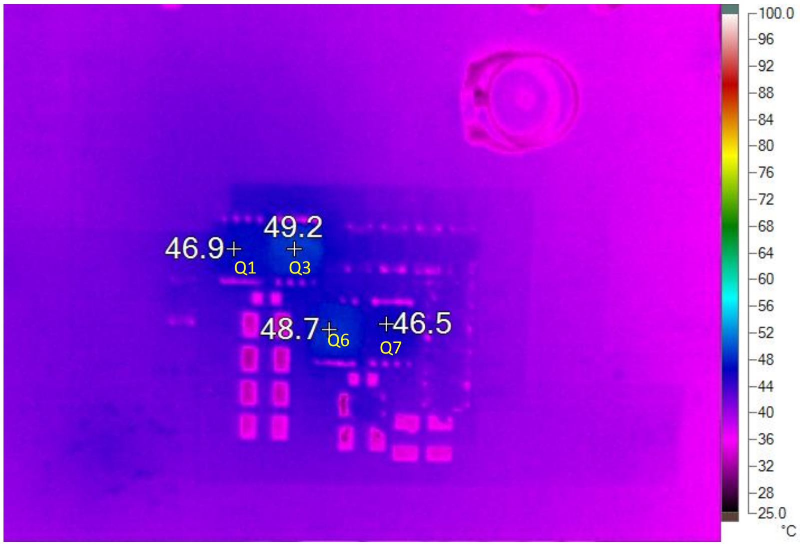


Figure 7. Thermal performance V_{IN} = 48V, V_{OUT} = 24V, I_{OUT} = 10A, T_A = 23°C, No Airflow

QUICK START PROCEDURE

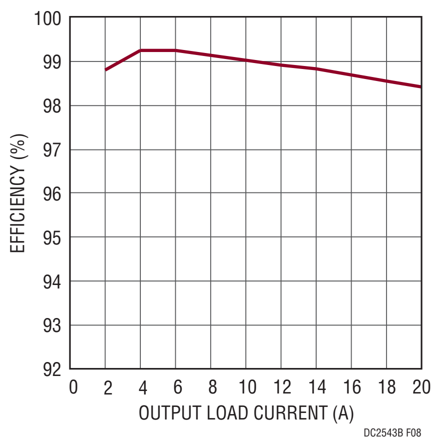


Figure 8. Efficiency vs Load Current at V_{IN} = 48V, V_{OUT} = 24V, f_{SW} = 200kHz*

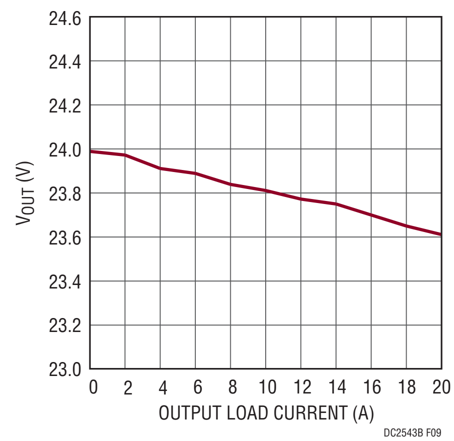


Figure 9. Load Regulation for 20A Design at V_{IN} = 48V, V_{OUT} = 24V, f_{SW} = 200kHz*

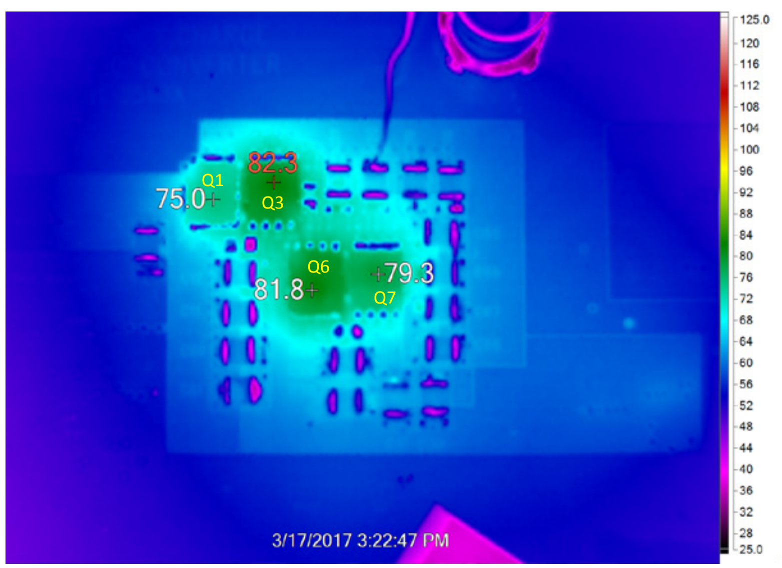


Figure 10. Thermal performance at V_{IN} = 48V, V_{OUT} = 24V, I_{OUT} = 20A T_A = 23°C, No Airflow*

* **Note:** Additional C11, C12, C60, C61, C22-C25, C69-C72, C30, C31, and C36 (10µF/50V, MURATA GRM32ER71H106KA12L) are populated; RS1 is changed to 2.5mΩ (WSL20102L500FEB18) for this test.

PARTS LIST

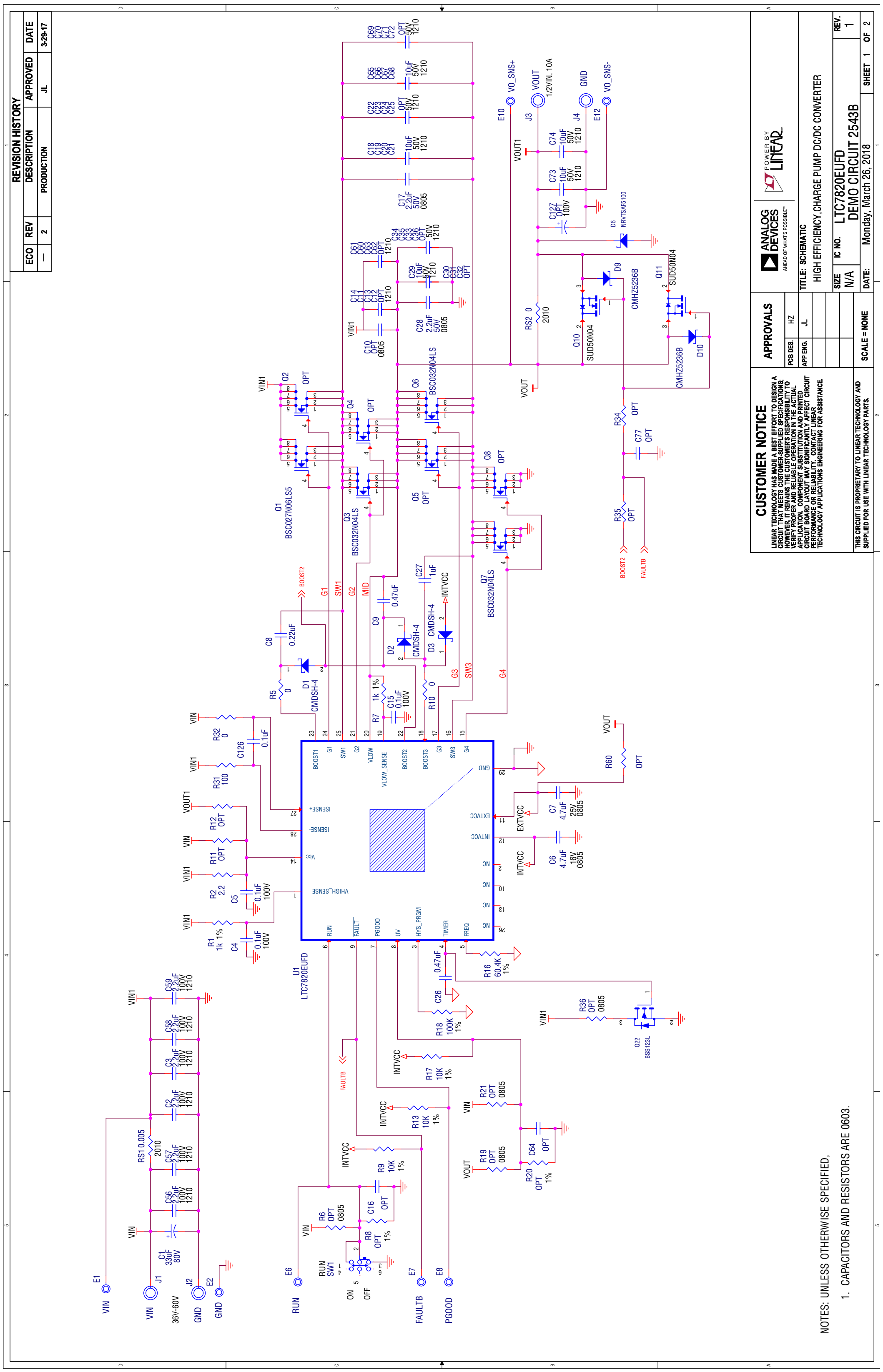
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	CAP, 33µF 20% 80V ELEC	PANASONIC EEHZA1K330P
2	8	C2, C3, C47, C49, C56, C57, C58, C59	CAP, 1210 2.2µF 10% 100V X7R	MURATA GRM32DR72A225KA12
3	4	C4, C5, C15, C126	CAP, 0603 0.1µF 10% 100V X7R	MURATA GRM188R72A104KA35D
4	2	C6, C7	CAP, 0805 4.7µF 10% 16V X7R	MURATA GRM21BR71C475KA73K
5	1	C8	CAP, 0603 0.22µF 10% 25V X7R	MURATA GRM188R71E224KA88D
6	2	C9, C26	CAP, 0603 0.47µF 10% 25V X7R	MURATA GRM188R71E474KA12D
7	2	C17, C28	CAP, 0805 2.2µF 10% 50V X7R	TDK C2012X7R1H225K125AC
8	11	C18, C19, C20, C21, C29, C66, C67	CAP, 1210 10µF 10% 50V X7R	MURATA GRM32ER71H106KA12L
9		C68, C73, C74, C65		
10	2	C27, C50	CAP, 0603 1µF 10% 50V X5R	MURATA GRM188R61H105K
11	2	C52, C53	CAP, 1210 22µF 10% 25V X5R	AVX 12103D226KAT2A
12	1	C54	CAP, 0603 47nF 10% 25V X7R	AVX 06033C473KAT2A
13	1	C55	CAP, 0603 470pF 10% 50V X7R	MURATA GRM188R71H471KA01D
14	3	D1, D2, D3	DIODE, SCHOTTKY	CENTRAL SEMI. CMDSH-4E TR
15	1	D6*	DIODE, SCHOTTKY	ON SEMI, NRVTSAF5100E
16	2	D9, D10	DIODE, ZENER	CENTRAL SEMI. CMHZ5236B TR
17	1	L2	IND, 68µH	COILCRAFT., LPS6225-683MRB
18	1	Q1	XSTR, N-CHANNEL MOSFET	INFINEON BSC027N06LS5
19	3	Q3, Q6, Q7	XSTR, N-CHANNEL MOSFET	INFINEON BSC032N04LS
20	4	Q9, Q10, Q11, Q23	XSTR, N-CH 40V 14A TO-252	VISHAY SUD50N04-8M8P-4GE3
21	1	Q22	TRANSISTOR., SOT-23	FAIRCHILD., BSS123L
22	1	RS1	RES., CHIP, 0.005, 1%, 2010	VISHAY, WSL20105L000FEA
23	1	RS2	RES, 2010 0Ω JUMPER	VISHAY WSL201000000ZEA9
24	2	R1, R7	RES, 0603 1kΩ 1%	VISHAY CRCW06031K00FKEA
25	1	R2	RES, 0603 2.2Ω 5%	YAGEO RC0603JR-072R2L
26	4	R5, R10, R24, R32	RES, 0603 0Ω JUMPER	VISHAY CRCW06030000Z0EA
27	4	R9, R13, R17, R28	RES, 0603 10kΩ 1%	NIC NRC06F1002TRF
28	1	R16	RES, 0603 60.4kΩ 1%	VISHAY CRCW060360K4FKEA
29	1	R18	RES, 0603 100kΩ 1%	VISHAY CRCW0603100KFKEA
30	1	R26	RES, 0603 154kΩ 1%	YAGEO RC0603FR-07154KL
31	1	R27	RES, 0603 20kΩ 5%	VISHAY CRCW060320K0JNEA
32	1	R29	RES, 0603 80.6kΩ 1%	YAGEO RC0603FR-0780K6L
33	1	R30	RES. 2010 1Ω 1% 1W	IRC LRC-LR2010-01-1R00-F
34	1	R31	RES, 0603 100Ω 5%	VISHAY CRCW0603100R0JNEA
35	1	U1	IC, LTC7820EUFD, QFN 4mm × 5mm	ANALOG DEVICES, LTC7820EUFD#PBF
36	1	U2	IC, LTC3630AEMSE	ANALOG DEVICES, LTC3630EMSE#PBF

PARTS LIST

Additional Demo Board Circuit Components				
1	0	C10-C14, C16, C33, C34, C35, C36, C60-C64, C51, C77	CAPACITOR, OPT	
2	0	C30-C32, C22-C25, C69-C72, C127		
3	0	Q2, Q4, Q5,Q8 OPT	MOSFET, OPT	
4	0	R6, R19, R2, R36, R8, R11, R12, R20, R34, R35, R60	RESISTOR, OPT	
Hardware: For Demo Board Only				
1	9	E1, E2, E6-E8, E10, E12, E14, E15	TURRET	MILL-MAX 2501-2-00-80-00-00-07-0
2	1	JP2	HEADER, 3 PIN 2mm	WURTH ELEKTRONIK 62000311121
3	4	J1, J2, J3, J4	JACK, BANANA	KEYSTONE, 575-4
4	2	J5, J6	CONN, BNC, 5 PINS	CONNEX, 112404
5	1	SW1	SWITCH, SUBMINIATURE SLIDE	C&K COMPONENTS, JS202011CQN
6	1	XJP2	SHUNT 2mm	WURTH ELEKTRONIK 60800213421
7	4	STANDOFF	STANDOFF, SNAP ON	KEYSTONE 8833

***Note:** D6 is for negative voltage clamping on V_{OUT} of DC2543B board in output overcurrent test with electronic load. Some electronic loads draw negative current in CC mode when evaluating the output overcurrent protection feature of DC2543B, which can violate the absolute maximum voltage rating –0.3V for V_{LOW} pin without D6 populated.

SCHEMATIC DIAGRAM



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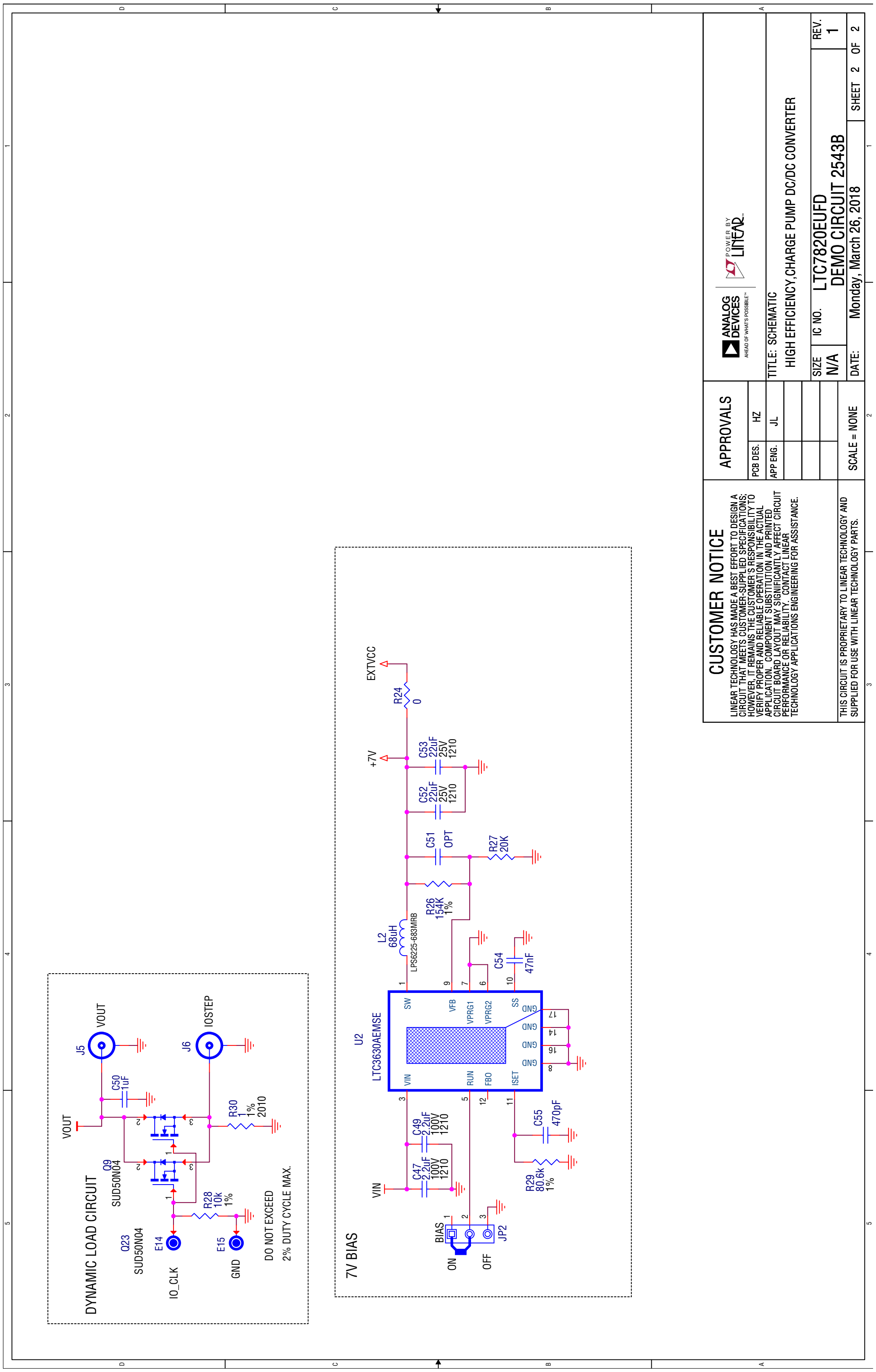
SCHEMATIC DIAGRAM



Rev. 0

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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