

## LTC7820EUF 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<sup>®</sup>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.](#)

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

| PARAMETER                         | CONDITION   | VALUE      |
|-----------------------------------|---|------------|
| Input Voltage Range               |   | 36V to 60V |
| Output Voltage, $V_{OUT}$         | $V_{IN} = 36$ to $60\text{V}$ , $I_{OUT} = 0\text{A}$ to $10\text{A}$   | $V_{IN}/2$ |
| Maximum Output Current, $I_{OUT}$ | $V_{IN} = 36$ to $60\text{V}$ , $V_{OUT} = V_{IN}/2$                    | 10A        |
| Typical Efficiency                | $V_{IN} = 48\text{V}$ , $V_{OUT} = 24\text{V}$ , $I_{OUT} = 10\text{A}$ | 98.7%      |
| Peak Efficiency                   | $V_{IN} = 48\text{V}$ , $V_{OUT} = 24\text{V}$                          | 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 500 $\mu$ s 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

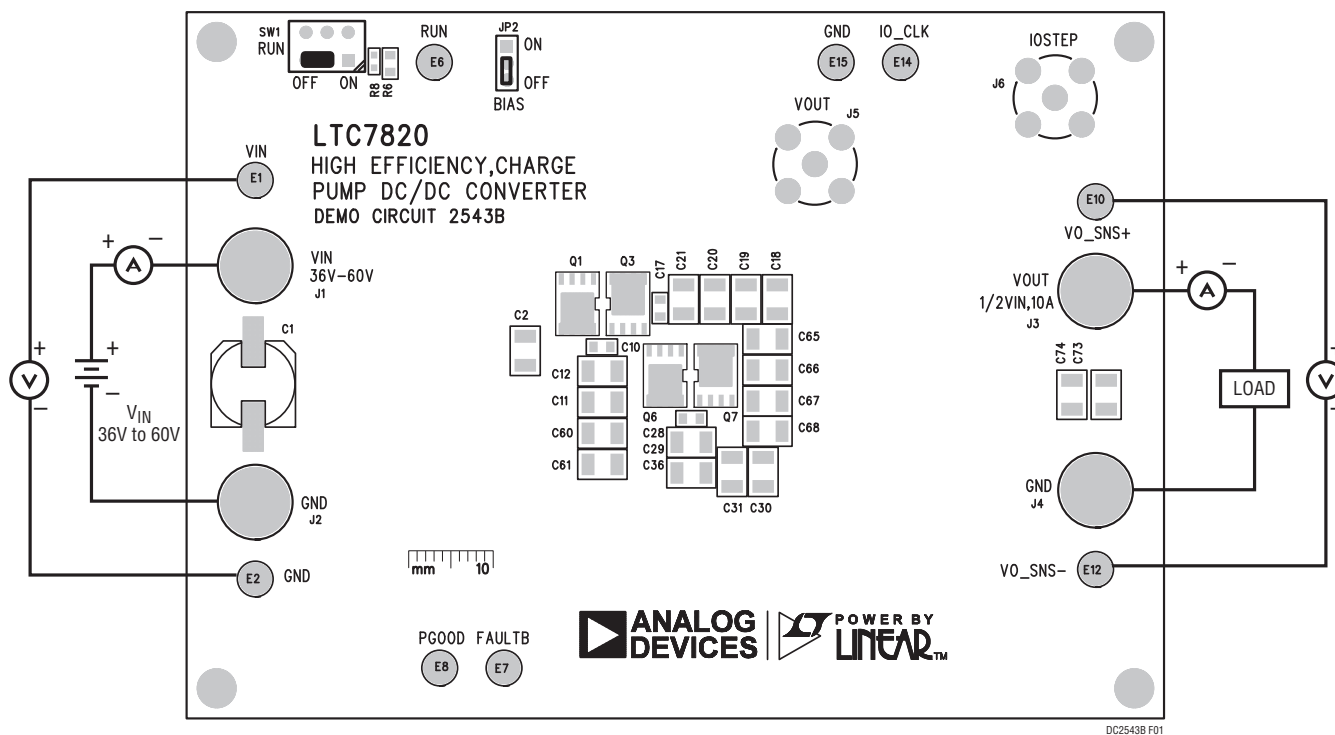


Figure 1. Proper Measurement Equipment Setup

**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.

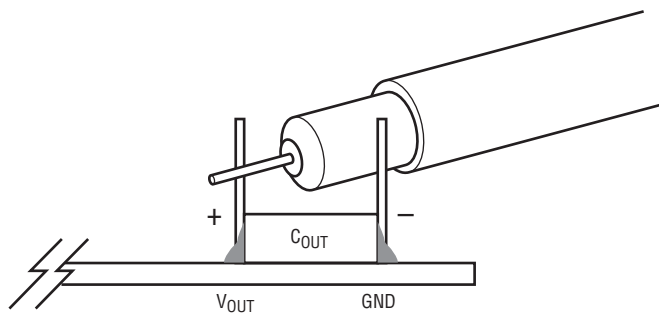


Figure 2. Measuring Output Voltage Ripple

## QUICK START PROCEDURE

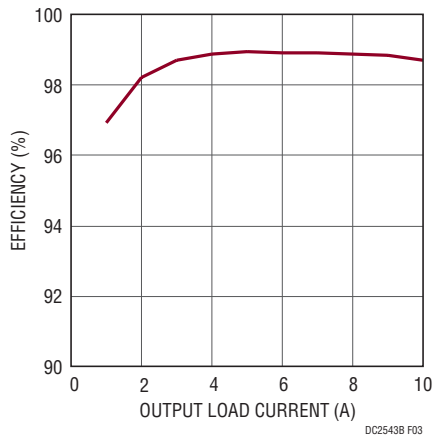


Figure 3. Efficiency vs Load Current at  $V_{IN} = 48V$ ,  $V_{OUT} = 24V$ ,  $f_{SW} = 200kHz$

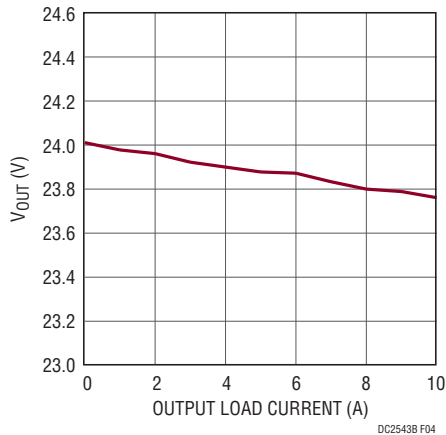


Figure 4. Load Regulation for 10A Design at  $V_{IN} = 48V$ ,  $V_{OUT} = 24V$ ,  $f_{SW} = 200kHz$

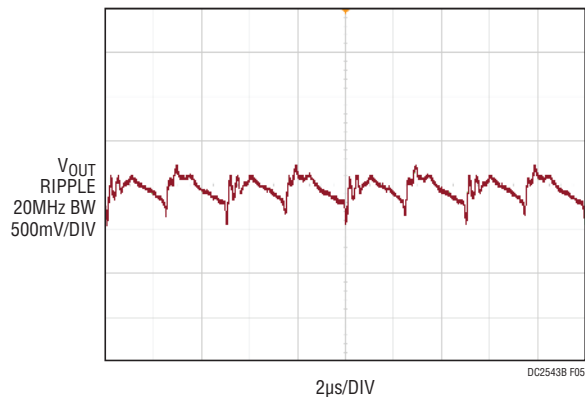


Figure 5. Output Voltage Ripple at  $V_{IN} = 48V$ ,  $V_{OUT} = 24V$ ,  $I_{OUT} = 10A$ ,  $f_{SW} = 200kHz$

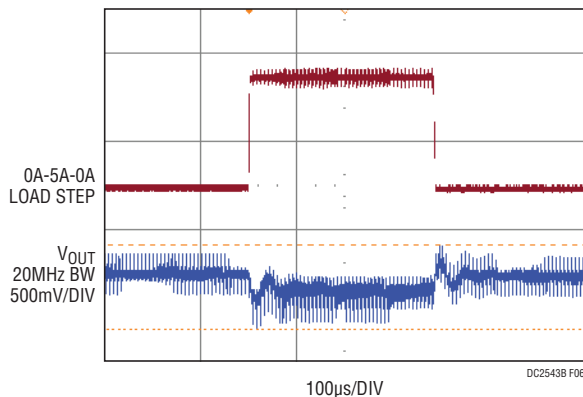


Figure 6. Load Step at  $V_{IN} = 48V$ ,  $V_{OUT} = 24V$

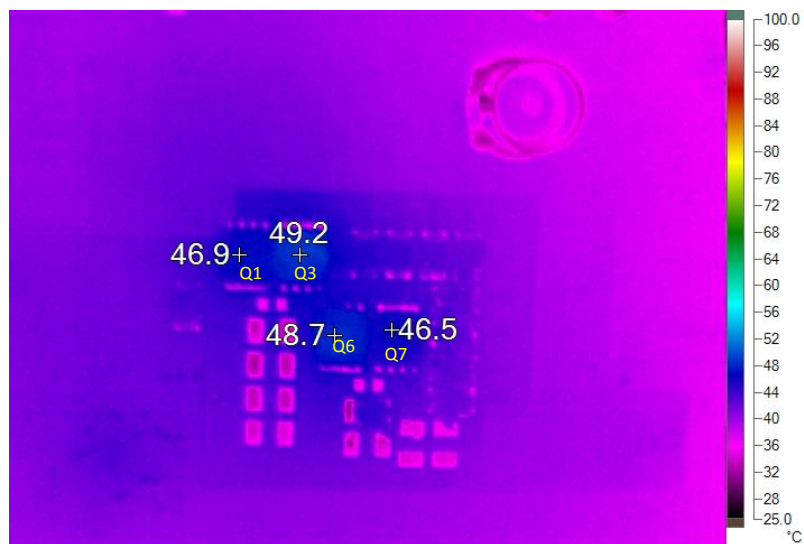
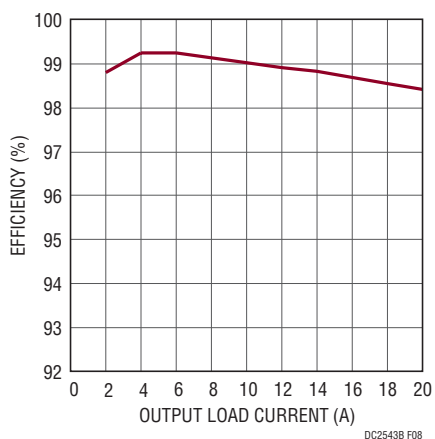
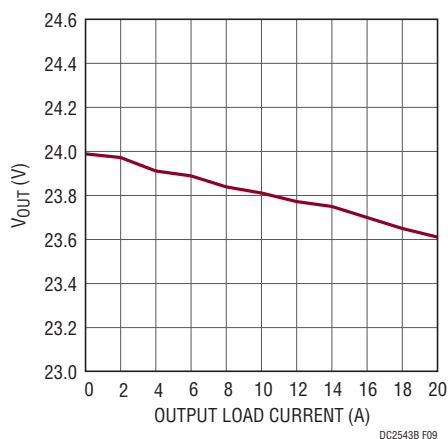


Figure 7. Thermal performance  $V_{IN} = 48V$ ,  $V_{OUT} = 24V$ ,  $I_{OUT} = 10A$ ,  $T_A = 23^{\circ}C$ , No Airflow

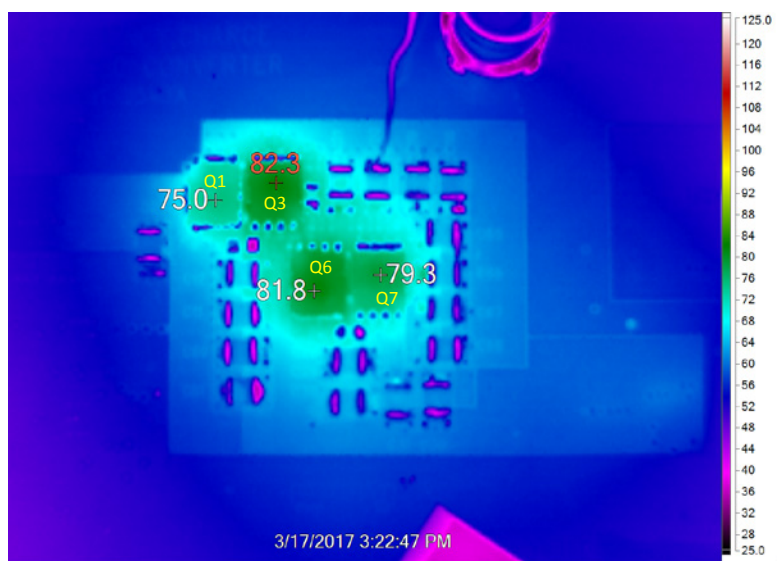
**QUICK START PROCEDURE**



**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  $V_{IN} = 48V$ ,  $V_{OUT} = 24V$ ,  $I_{OUT} = 20A$ ,  $T_A = 23^\circ C$ , 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.

# DEMO MANUAL DC2543B

## PARTS LIST

| ITEM                               | QTY | REFERENCE                            | PART DESCRIPTION                      | MANUFACTURER/PART NUMBER        |
|------------------------------------|-----|--------------------------------------|---------------------------------------|---------------------------------|
| <b>Required Circuit Components</b> |     |                                      |                                       |                                 |
| 1                                  | 1   | C1                                   | CAP, 33 $\mu$ F 20% 80V ELEC          | PANASONIC EEHZA1K330P           |
| 2                                  | 8   | C2, C3, C47, C49, C56, C57, C58, C59 | CAP, 1210 2.2 $\mu$ F 10% 100V X7R    | MURATA GRM32DR72A225KA12        |
| 3                                  | 4   | C4, C5, C15, C126                    | CAP, 0603 0.1 $\mu$ F 10% 100V X7R    | MURATA GRM188R72A104KA35D       |
| 4                                  | 2   | C6, C7                               | CAP, 0805 4.7 $\mu$ F 10% 16V X7R     | MURATA GRM21BR71C475KA73K       |
| 5                                  | 1   | C8                                   | CAP, 0603 0.22 $\mu$ F 10% 25V X7R    | MURATA GRM188R71E224KA88D       |
| 6                                  | 2   | C9, C26                              | CAP, 0603 0.47 $\mu$ F 10% 25V X7R    | MURATA GRM188R71E474KA12D       |
| 7                                  | 2   | C17, C28                             | CAP, 0805 2.2 $\mu$ F 10% 50V X7R     | TDK C2012X7R1H225K125AC         |
| 8                                  | 11  | C18, C19, C20, C21, C29, C66, C67    | CAP, 1210 10 $\mu$ F 10% 50V X7R      | MURATA GRM32ER71H106KA12L       |
| 9                                  |     | C68, C73, C74, C65                   |                                       |                                 |
| 10                                 | 2   | C27, C50                             | CAP, 0603 1 $\mu$ F 10% 50V X5R       | MURATA GRM188R61H105K           |
| 11                                 | 2   | C52, C53                             | CAP, 1210 22 $\mu$ F 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, 68 $\mu$ H                       | 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 0 $\Omega$ JUMPER           | VISHAY WSL201000000ZEA9         |
| 24                                 | 2   | R1, R7                               | RES, 0603 1k $\Omega$ 1%              | VISHAY CRCW06031K00FKEA         |
| 25                                 | 1   | R2                                   | RES, 0603 2.2 $\Omega$ 5%             | YAGEO RC0603JR-072R2L           |
| 26                                 | 4   | R5, R10, R24, R32                    | RES, 0603 0 $\Omega$ JUMPER           | VISHAY CRCW06030000Z0EA         |
| 27                                 | 4   | R9, R13, R17, R28                    | RES, 0603 10k $\Omega$ 1%             | NIC NRC06F1002TRF               |
| 28                                 | 1   | R16                                  | RES, 0603 60.4k $\Omega$ 1%           | VISHAY CRCW060360K4FKEA         |
| 29                                 | 1   | R18                                  | RES, 0603 100k $\Omega$ 1%            | VISHAY CRCW0603100KFKEA         |
| 30                                 | 1   | R26                                  | RES, 0603 154k $\Omega$ 1%            | YAGEO RC0603FR-07154KL          |
| 31                                 | 1   | R27                                  | RES, 0603 20k $\Omega$ 5%             | VISHAY CRCW060320K0JNEA         |
| 32                                 | 1   | R29                                  | RES, 0603 80.6k $\Omega$ 1%           | YAGEO RC0603FR-0780K6L          |
| 33                                 | 1   | R30                                  | RES. 2010 1 $\Omega$ 1% 1W            | IRC LRC-LR2010-01-1R00-F        |
| 34                                 | 1   | R31                                  | RES, 0603 100 $\Omega$ 5%             | VISHAY CRCW0603100R0JNEA        |
| 35                                 | 1   | U1                                   | IC, LTC7820EUFD, QFN 4mm $\times$ 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  |  |

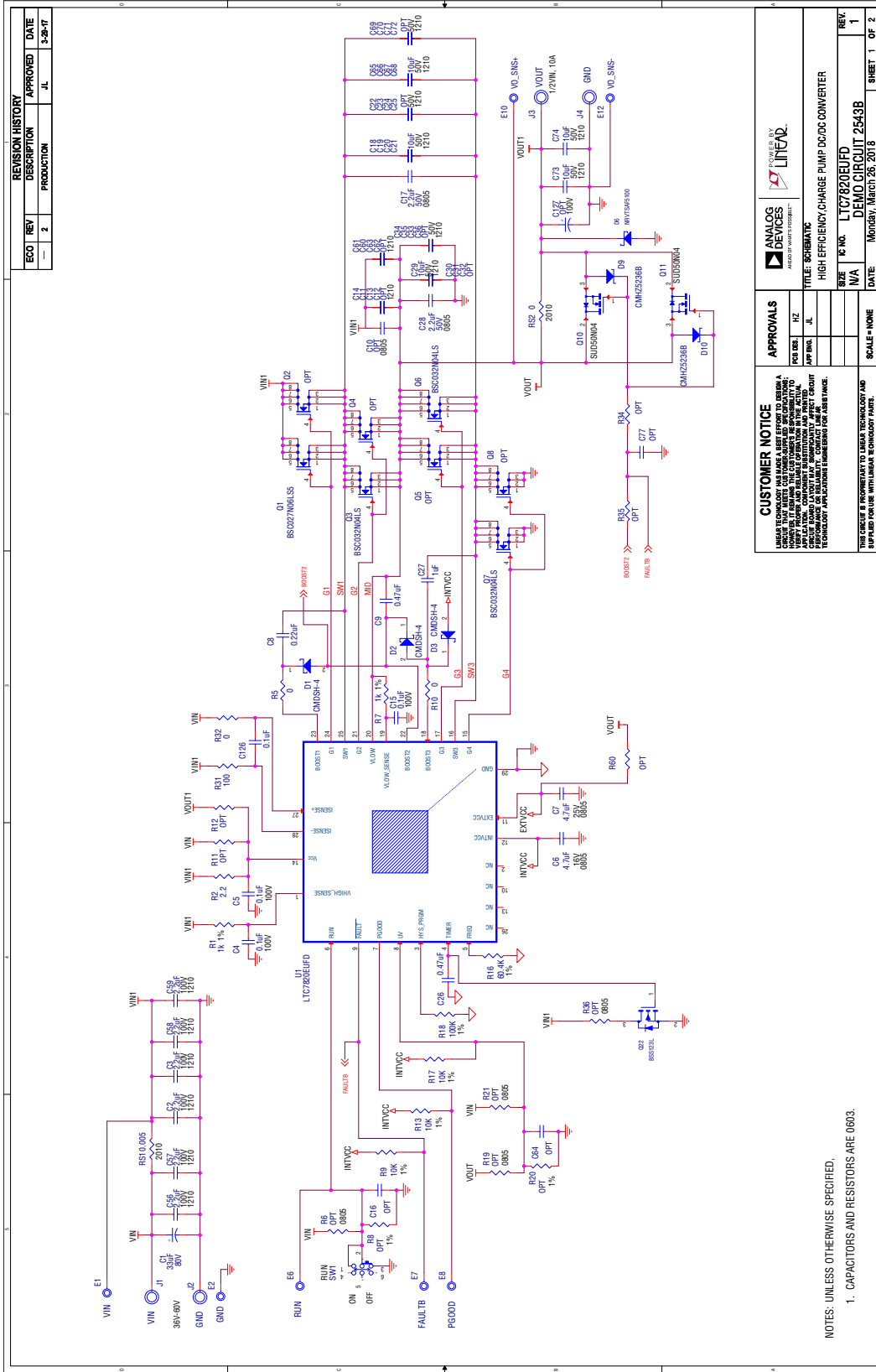
### Hardware: For Demo Board Only

|   |   |                                   |                            |                                  |
|---|---|-----------------------------------|----------------------------|----------------------------------|
| 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.

# DEMO MANUAL DC2543B

## SCHEMATIC DIAGRAM



| REVISION HISTORY |     |             |
|------------------|-----|-------------|
| ECO              | REV | DESCRIPTION |
| —                | 2   | PRODUCTION  |

| APPROVED |          |        |
|----------|----------|--------|
| DATE     | APPROVED | DATE   |
| —        | JL       | 3-9-17 |

| APPROVALS |     |      |
|-----------|-----|------|
| DESIGN    | REV | DATE |
| JL        | —   | —    |

| TITLE: SCHEMATIC   |                                   |                        |
|--|-----------------------------------|------------------------|
| FILE NO.   | REV                               | DATE                   |
| LTC7820ELFDC <td>1 <td>MONDAY, MARCH 28, 2018</td> </td> | 1 <td>MONDAY, MARCH 28, 2018</td> | MONDAY, MARCH 28, 2018 |

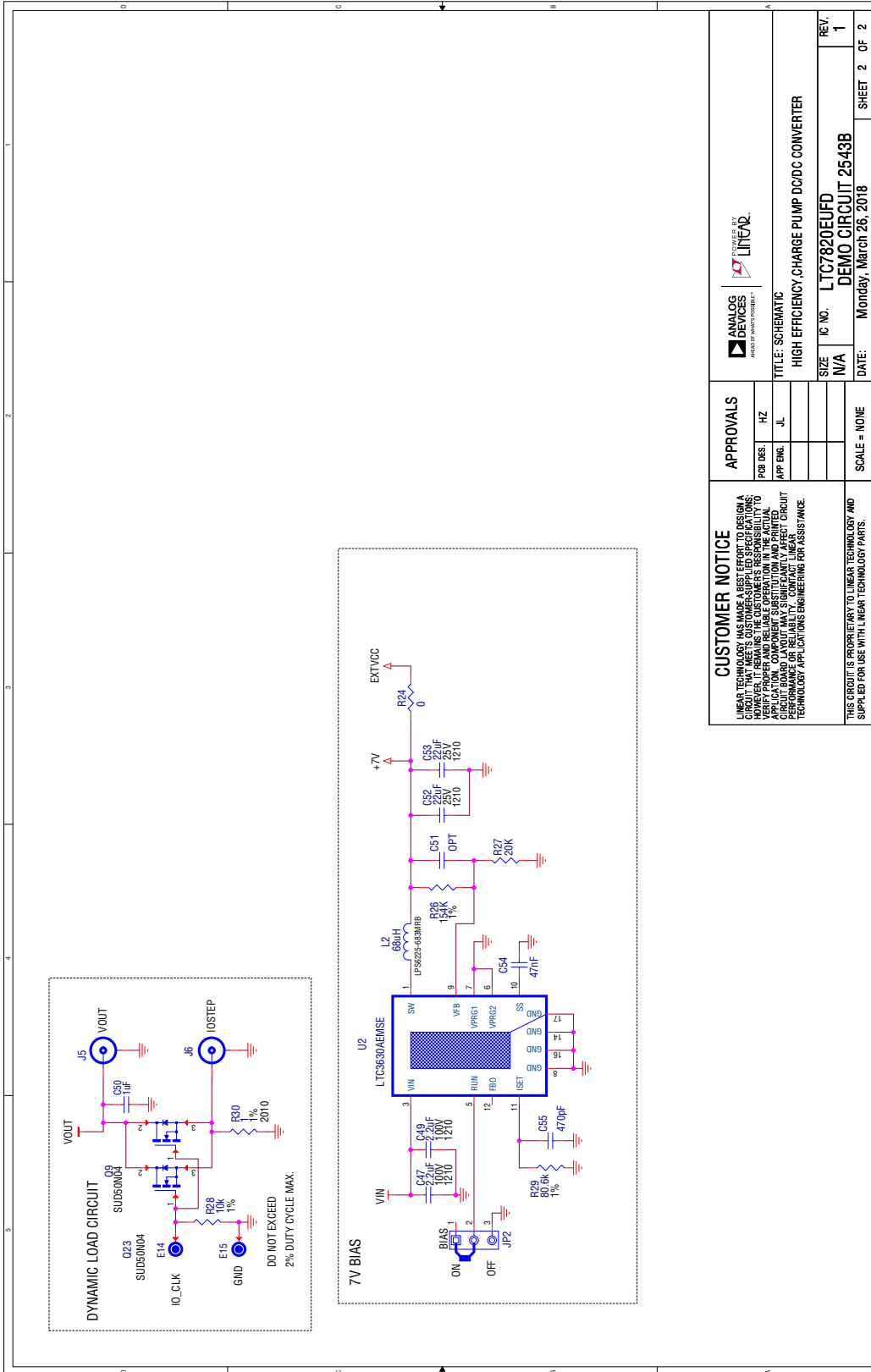
  

| CUSTOMER NOTICE |      |     |
|-----------------|------|-----|
| SCALE           | DATE | REV |
| NONE            | —    | 1   |

NOTES: UNLESS OTHERWISE SPECIFIED,  
1. CAPACITORS AND RESISTORS ARE 0805.



**SCHEMATIC DIAGRAM**





## 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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