

## LTC3861EUHE High Current, Dual Output Synchronous Buck Converter

### DESCRIPTION

Demonstration circuit 1822B is a dual output synchronous buck converter featuring the [LTC®3861EUHE](#). The board provides two outputs of 1.5V/25A and 1.2V/25A from an input voltage of 7V to 14V at a switching frequency of 500kHz. The power stage consists of a 6mm × 6mm DrMOS and a 13mm × 13mm iron powder type inductor. An on-board 5V LT®3470 buck regulator provides the 5V bias for the LTC3861 and the DrMOS.

The demo board uses a high density, two sided drop-in layout. The power components, excluding the bulk output and input capacitors, fit within a 1.5" × 1.2" area on the top layer. The control circuit fits in a 1.1" × 1.0" area on the bottom layer. The package style for the LTC3861EUHE is a 36-lead 5mm × 6mm QFN.

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The main features of the board are:

- Remote sensing for each output, where the divider is placed before a high input impedance differential amplifier.
- CLKIN and CLKOUT pins.
- Optional resistors to tie the two outputs together.
- Connector and header to tie two or more boards together for up to 12-phase operation.
- Optional footprint for an LTC4449 gate driver and discrete MOSFETs.
- Optional footprint for a dual phase Delta power block.

**Design files for this circuit board are available.**

### PERFORMANCE SUMMARY (T<sub>A</sub> = 25°C), no airflow

| PARAMETER                                                   | CONDITION                                                                | VALUE         |
|-------------------------------------------------------------|--------------------------------------------------------------------------|---------------|
| Minimum Input Voltage                                       |                                                                          | 7V            |
| Maximum Input Voltage                                       |                                                                          | 14V           |
| Output Voltage V <sub>OUT1</sub>                            | I <sub>OUT1</sub> = 0A to 25A, V <sub>IN</sub> = 7V to 14V               | 1.5V ±2%      |
| Output Voltage V <sub>OUT2</sub>                            | I <sub>OUT2</sub> = 0A to 25A, V <sub>IN</sub> = 7V to 14V               | 1.2V ±2%      |
| V <sub>OUT1</sub> Maximum Output Current, I <sub>OUT1</sub> | V <sub>IN</sub> = 7V to 14V, V <sub>OUT1</sub> = 1.5V                    | 25A           |
| V <sub>OUT2</sub> Maximum Output Current, I <sub>OUT2</sub> | V <sub>IN</sub> = 7V to 14V, V <sub>OUT2</sub> = 1.2V                    | 25A           |
| Nominal Switching Frequency                                 |                                                                          | 500kHz        |
| Efficiency<br>(See Figure 2 and Figure 3)                   | V <sub>OUT1</sub> = 1.5V, I <sub>OUT1</sub> = 25A, V <sub>IN</sub> = 12V | 91.6% Typical |
|                                                             | V <sub>OUT2</sub> = 1.2V, I <sub>OUT2</sub> = 25A, V <sub>IN</sub> = 12V | 90.7% Typical |

Note: The DC1828B demo circuit and manual replaces the DC1828A. The demo board was modified slightly.

# DEMO MANUAL DC1822B

## QUICK START PROCEDURE

Demonstration circuit 1822B is easy to set up to evaluate the performance of the LTC3861EUHE. Please refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input supply, load and meters, as shown in Figure 1. Preset the load to 0A and  $V_{IN}$  supply to be 0V. Place jumpers in the following positions:

**JP1      RUN1      ON**

**JP2      RUN2      ON**

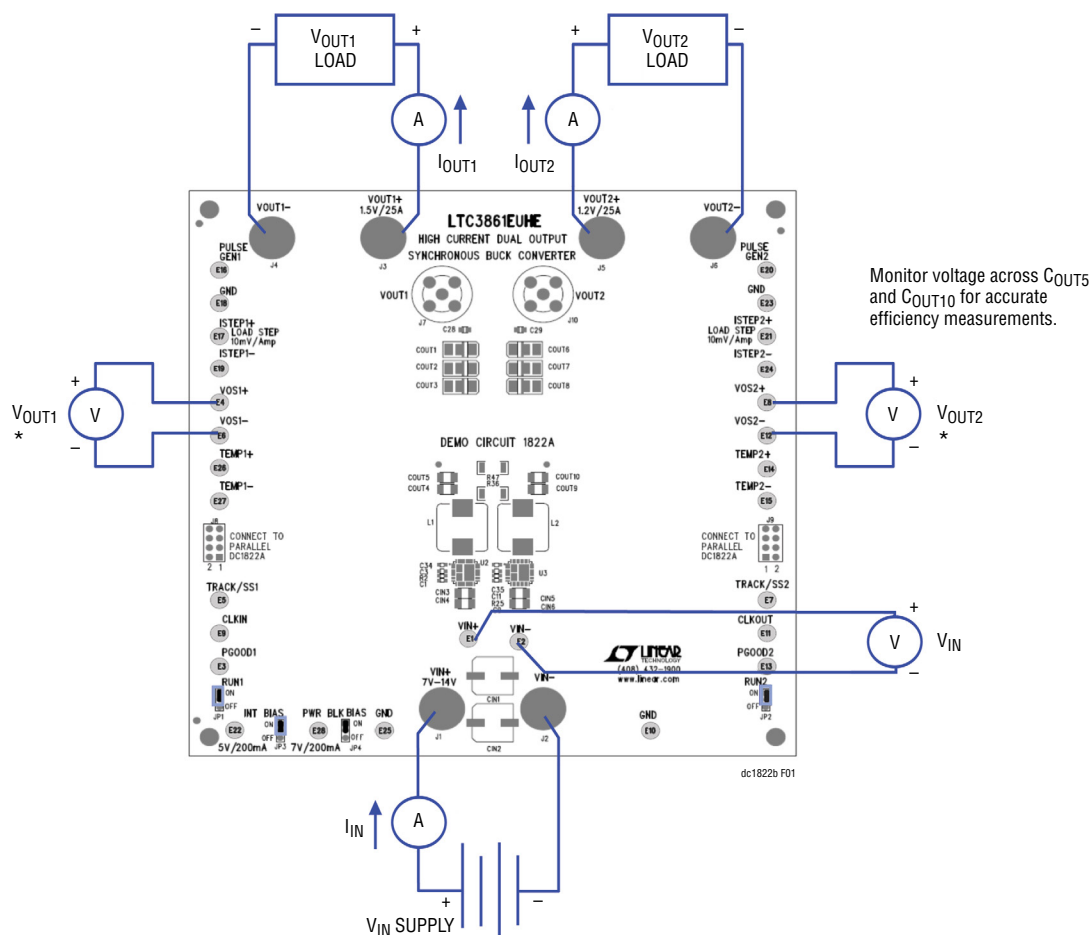
**JP3 INT BIAS ON**

2. Adjust the input voltage to be between 7V to 14V. VOUT1 should be  $1.5V \pm 2\%$ . VOUT2 should be  $1.2V \pm 2\%$ .

3. Next, apply 25A load to each output and re-measure  $V_{OUT}$ .
4. Once the DC regulation is confirmed, observe the output voltage ripple, load step response, efficiency and other parameters.

**NOTE 1.** Use the BNC connectors labeled VOUT1 or VOUT2 to measure the output voltage ripple.

**NOTE 2. Do not apply the load from the VOS1+ turret to the VOS1- turret or from the VOS2+ turret to the VOS2- turret.** These are connected to the sense traces for the output voltage. Heavy load currents applied across these turrets may damage these traces.

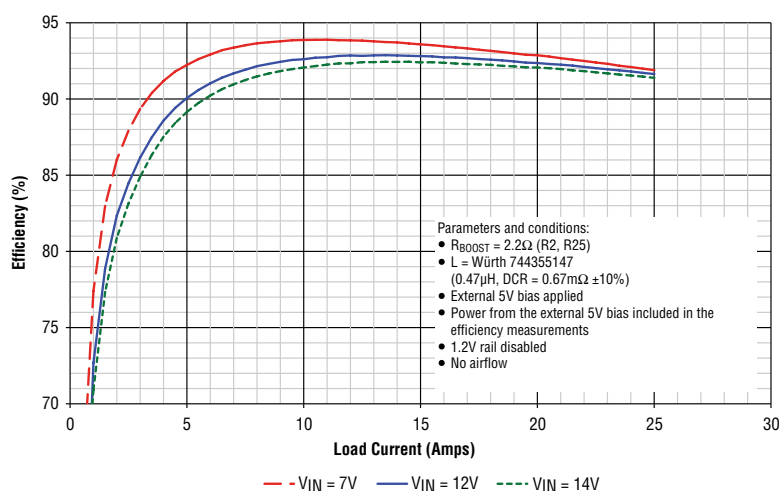


### Figure 1. Proper Measurement Equipment Setup

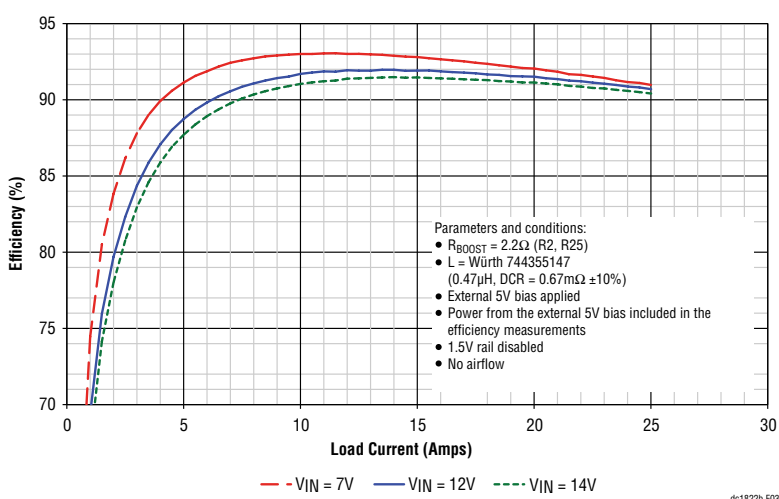
## QUICK START PROCEDURE

### DYNAMIC LOAD CIRCUIT (OPTIONAL)

1. Preset the amplitude of a pulse generator to 0.0V and the duty cycle to 5% or less.
2. Connect the scope to the VOUT BNC connectors for the rail under test with a coax cable. To monitor the load step current, connect the scope probe across the ISTEP $\pm$  turrets for that rail.
3. Connect the output of the pulse generator to the PULSE GEN turret for the rail under test and connect the return to one of the GND turrets.
4. With the converter running, slowly increase the amplitude of the pulse generator output to provide the desired load step pulse height. The scaling for the load step signal is 10mV/Amp. See Figure 4 and Figure 5 for transient response curves with a 50% load change.

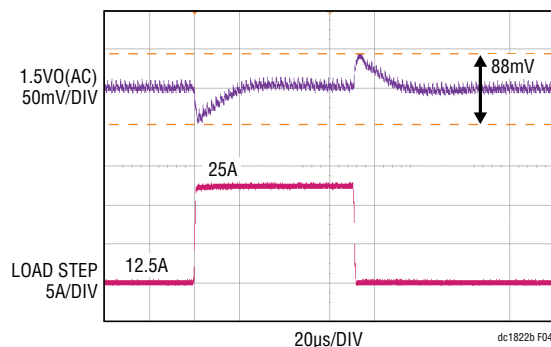


**Figure 2. Efficiency Curves for the 1.5V Rail of the DC1822B.**  
 $f_{\text{SW}} = 500\text{kHz}$  with the FDMF6820A DrMOS

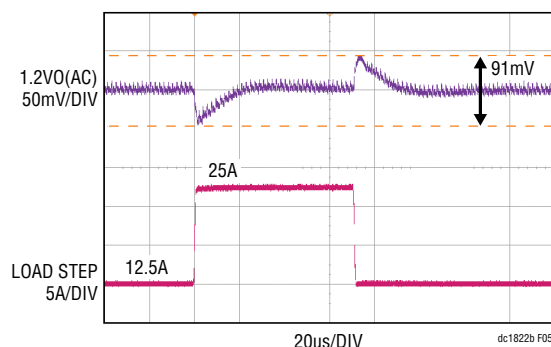


**Figure 3. Efficiency Curves for the 1.2V Rail of the DC1822B.**  
 $f_{\text{SW}} = 500\text{kHz}$  with the FDMF6820A DrMOS

## QUICK START PROCEDURE



**Figure 4. Load Step Response of the DC1822B 1.5V Rail at  $V_{IN} = 12V$ .  
 $C_{OUT} = 3 \times \text{Sanyo 2R5TPE330M9} \parallel 2 \times 100\mu F \text{ X5R 6.3V 1210}$ ,  $L = 0.47\mu H$ ,  
 $f_{SW} = 500kHz$**



**Figure 5. Load Step Response of the DC1822B 1.2V Rail at  $V_{IN} = 12V$ .  
 $C_{OUT} = 3 \times \text{Sanyo 2R5TPE330M9} \parallel 2 \times 100\mu F \text{ X5R 6.3V 1210}$ ,  $L = 0.47\mu H$ ,  
 $f_{SW} = 500kHz$**

### SINGLE OUTPUT/DUAL PHASE OPERATION

A single output/dual phase converter may be preferred for higher output current applications. The optional components required to tie the phases together are found on the bottom of the schematic shown in Figure 8. To tie the two outputs together, make the following modifications:

1. Stuff  $0\Omega$  at R36 and R47 to tie the two outputs together.
2. Select one rail to be the master.
  - If VOUT1 is the master, then stuff  $0\Omega$  at R51 to disable the error amplifier for phase 2. Also stuff  $0\Omega$  at R52.
  - If VOUT2 is the master, then stuff  $0\Omega$  at R49 to disable the error amplifier for phase 1. Also stuff  $0\Omega$  at R50.
3. Remove the  $0\Omega$  jumper at R13 and stuff a  $100pF$  capacitor at C14 for the IAVG signal.

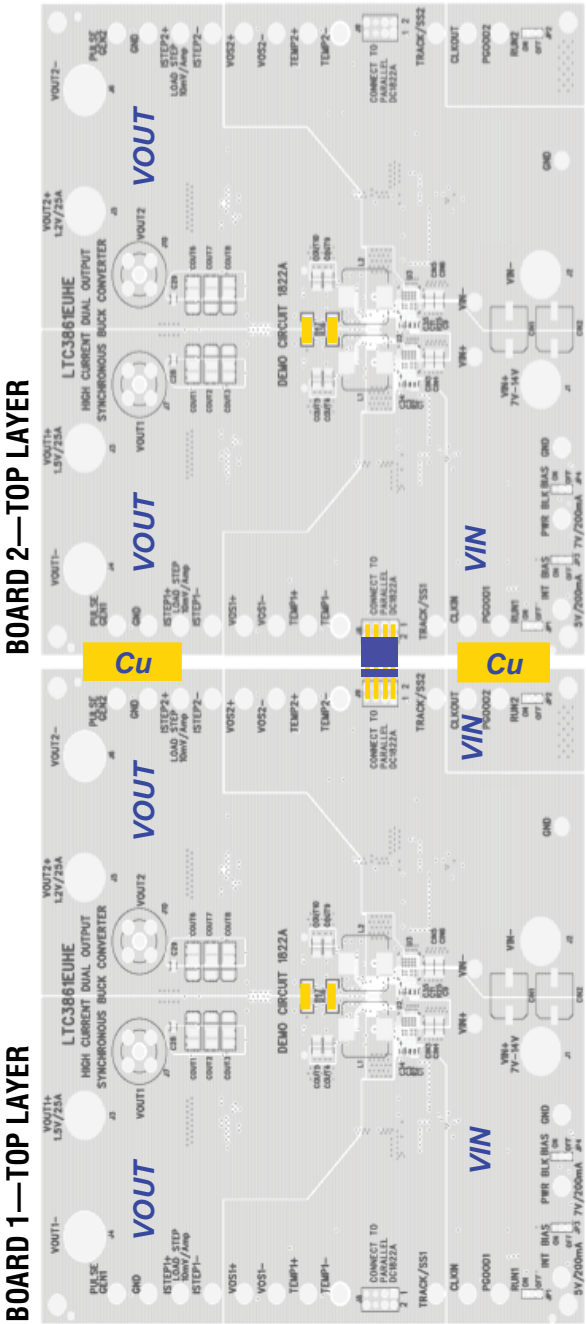
4. Stuff  $0\Omega$  at R53, R48 and R54 to tie the COMP, TRK/SS and RUN pins together.

5. Remove the redundant compensation components.

### PARALLELING BOARDS

The DC1822B demo boards can be tied together to form a converter with up to 12 phases. To tie the boards together, place the boards side-by-side and then connect the boards by connecting J8 of one board to J9 of the other. This will connect the IAVG, COMP, TRK/SS and signal ground signals together. Next, use copper strips to tie the VOUT planes, the VIN planes and GND planes of the two adjacent boards together. The board has exposed copper along the edges of the board for this purpose. Figure 6 shows how to set up a 4-phase converter and Figure 7 shows how to set up a 3-phase plus single phase converter.

QUICK START PROCEDURE

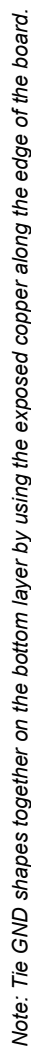


Note: Tie GND shapes together on the bottom layer by using the exposed copper along the edge of the board.

|          | VOUT1 TO<br>VOUT2<br>R36 & R47 | ILIM1 TO<br>VCC<br>R50 | ILIM1 R<br>R17 | ILIM2 TO<br>VCC<br>R52 | ILIM2 R<br>R24 | FB1 TO<br>VCC<br>R49 | FB2 TO<br>VCC<br>R51 | TRK/SS1<br>TO<br>TRK/SS2<br>R48 | COMP1<br>TO<br>COMP2<br>R53 | RUN1 TO<br>RUN2<br>R54 | PHASE MODE<br>SETTING |     | I AVG PIN |     |
|----------|--------------------------------|------------------------|----------------|------------------------|----------------|----------------------|----------------------|---------------------------------|-----------------------------|------------------------|-----------------------|-----|-----------|-----|
|          |                                |                        |                |                        |                |                      |                      |                                 |                             |                        | R41                   | R42 | C14       | R13 |
| BOARD #1 | 0.0mΩ                          | NS                     | STUFF          | 0Ω                     | NS             | NS                   | 0Ω                   | 0Ω                              | 0Ω                          | 0Ω                     | NS                    | NS  | 100pF     | NS  |
| BOARD #2 | 0.0mΩ                          | NS                     | STUFF          | 0Ω                     | NS             | 0Ω                   | 0Ω                   | 0Ω                              | 0Ω                          | 0Ω                     | NS                    | NS  | 100pF     | NS  |

Figure 6. Setup of a 4-Phase Converter; Phase 1 of Board 1 is the Master

dc1822a R06

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|          | VOUT1 TO<br>VOUT2<br>R36 & R47 | ILIM1 TO<br>VCC<br>R50 | ILIM2 TO<br>VCC<br>R52 | ILIM2 R<br>R24 | FB1 TO<br>VCC<br>R49 | FB2 TO<br>VCC<br>R51 | TRK/SS1<br>TO<br>TRK/SS2<br>R48 | COMP1<br>TO<br>COMP2<br>R53 | RUN1 TO<br>RUN2<br>R54 | PHASE MODE<br>SETTING<br>R41 R42 | IAVG PIN<br>C14 R13 |
|----------|--------------------------------|------------------------|------------------------|----------------|----------------------|----------------------|---------------------------------|-----------------------------|------------------------|----------------------------------|---------------------|
| BOARD #1 | 0.0mΩ                          | NS                     | 0Ω                     | NS             | NS                   | 0Ω                   | 0Ω                              | 0Ω                          | 0Ω                     | NS                               | 100pF               |
| BOARD #2 | NS                             | NS                     | NS                     | STUFF          | 0Ω                   | NS                   | NS                              | NS                          | NS                     | 0Ω                               | 100pF               |

**Figure 7. Setup of a 3-Phase Plus Single Phase Converter; Phase 1 of Board 1 Is the Master of the 3-Phase Rail**

dc1822a F07

## PARTS LIST

| ITEM                                       | QTY | REFERENCE                                            | PART DESCRIPTION                        | MANUFACTURER/PART NUMBER       |
|--------------------------------------------|-----|------------------------------------------------------|-----------------------------------------|--------------------------------|
| <b>DC1822B Required Circuit Components</b> |     |                                                      |                                         |                                |
| 1                                          | 4   | C1, C7, C8, C9                                       | CAP, 0.22 $\mu$ F, 10%, 25V, X7R, 0603  | AVX 06033C224KAT2A             |
| 2                                          | 2   | C1-1, C1-2                                           | CAP, 1500pF, 10%, 50V, GOG, 0603        | MURATA,GRM1885C1H152JA01D      |
| 3                                          | 2   | C2-1, C2-2                                           | CAP, 100pF, 5%, 25V, NPO, 0603          | AVX 06033A101JAT2A             |
| 4                                          | 2   | C28, C29                                             | CAP, 10 $\mu$ F, 20%, 6.3V, X5R, 0805   | AVX 08056D106MAT2A             |
| 5                                          | 4   | C3, C11, C34, C35                                    | CAP, 2.2 $\mu$ F, 10%, 16V, X7R, 0603   | MURATA GRM188R61C225KE15D      |
| 6                                          | 2   | C3-1, C3-2                                           | CAP, 3300pF, 10%, 50V X7R, 0603         | AVX 06035C332KAT2A             |
| 7                                          | 1   | C6                                                   | CAP, 1 $\mu$ F, 20%, 25V, X5R, 0603     | AVX 06033D105MAT2A             |
| 8                                          | 1   | CIN2                                                 | CAP, 180 $\mu$ F, 20%, 16V, OSCON       | SANYO 16SVP180MX               |
| 9                                          | 4   | CIN3, CIN4, CIN5, CIN6                               | CAP, 22 $\mu$ F, 20%, 16V, X5R, 1210    | AVX 1210YD226MAT2A             |
| 10                                         | 6   | COUT1-COUT3, COUT6-COUT8                             | CAP, 330 $\mu$ F, 20%, 2.5V POSCAP 7343 | SANYO 2R5TPE330M9              |
| 11                                         | 4   | COUT4, COUT5, COUT9, COUT10                          | CAP, 100 $\mu$ F, 20%, 6.3V, X5R, 1210  | AVX 12106D107MAT2A             |
| 12                                         | 2   | L1,L2                                                | IND, 0.47 $\mu$ H, 20%                  | WURTH 744355147                |
| 13                                         | 2   | R1, R45                                              | RES, 18.2k, 1%, 1/10W, 0603             | VISHAY CRCW060318K2FKEA        |
| 14                                         | 4   | R11, R18, R39, R43                                   | RES, 10 $\Omega$ , 1%, 1/10W, 0603      | VISHAY CRCW060310R0FKEA        |
| 15                                         | 2   | R17, R24                                             | RES, 53.6k, 1%, 1/10W, 0603             | VISHAY CRCW060353K6FKEA        |
| 16                                         | 2   | R2, R25                                              | RES, 2.2 $\Omega$ , 1%, 1/16W, 0603     | VISHAY CRCW06032R20FKEA        |
| 17                                         | 2   | R20, R38                                             | RES, 2.87k, 1%, 1/10W, 0603             | VISHAY CRCW06032K87FKEA        |
| 18                                         | 1   | R2-1                                                 | RES, 9.76k, 1%, 1/16W, 0603             | VISHAY CRCW06039K76FKEA        |
| 19                                         | 1   | R2-2                                                 | RES, 9.31k, 1%, 1/16W, 0603             | VISHAY CRCW06039K31FKEA        |
| 20                                         | 3   | R3, R16, R26                                         | RES, 1 $\Omega$ , 1%, 1/10W, 0603       | YAGEO RC0603FR-071RL           |
| 21                                         | 2   | R3-1, R3-2                                           | RES, 280 $\Omega$ , 1%, 1/10W, 0603     | VISHAY CRCW0603280RFKEA        |
| 22                                         | 1   | R37                                                  | RES, 34k, 1%, 1/10W, 0603               | VISHAY CRCW060334K0FKEA        |
| 23                                         | 2   | R8, R44                                              | RES, 100k, 1%, 1/10W, 0603              | VISHAY CRCW0603100KFKEA        |
| 24                                         | 9   | R9, R12, R13, R19, R21-R23, R32, R73                 | RES, 0 $\Omega$ , JUMPER, 0603          | VISHAY CRCW06030000Z0EA        |
| 25                                         | 11  | RB-1, RB-2, RT-2, R1-1, R1-2, R4-R6, R29, R30, R46   | RES, 10k, 1%, 1/10W, 0603               | VISHAY CRCW060310K0FKEA        |
| 26                                         | 1   | RT-1                                                 | RES, 15k, 1%, 1/10W, 0603               | YAGEO RC0603FR-0715KL          |
| 27                                         | 1   | U1                                                   | I.C., LTC3861EUHE                       | ANALOG DEVICES LTC3861EUHE#PBF |
| 28                                         | 2   | U2, U3                                               | MOSFET, DrMOS, DC-DC, 3.3V, PWM         | FAIRCHILD FDMF6820A            |
| <b>Additional Circuit Components</b>       |     |                                                      |                                         |                                |
| 1                                          | 1   | C17                                                  | CAP, 0.22 $\mu$ F, 10%, 25V, X7R, 0603  | AVX 06033C224KAT2A             |
| 2                                          | 1   | C18                                                  | CAP, 1 $\mu$ F, 20%, 25V, X5R, 0603     | AVX 06033D105MAT2A             |
| 3                                          | 1   | C19                                                  | CAP, 22 $\mu$ F, 20%, 16V, X5R, 1210    | AVX 1210YD226MAT2A             |
| 4                                          | 2   | C2, C4, C5, C10, C12-C16, C20, C22-C25, C27, C30-C33 | CAP, 0603                               | OPT                            |
| 5                                          | 1   | C21                                                  | CAP, 22pF, 10%, 25V, NPO, 0603          | AVX 06033A220KAT2A             |
| 6                                          | 1   | C26                                                  | CAP, 1 $\mu$ F, 20%, 25V, X5R, 0603     | AVX 06033D105MAT2A             |
| 7                                          | 0   | CIN1                                                 | CAP, SVP, F8                            | OPT                            |
| 8                                          | 0   | CIN7-CIN14, COUT11-COUT17                            | CAP, 1210                               | OPT                            |
| 9                                          | 0   | COUT15-COUT17, COUT22-COUT24                         | CAP, 7343                               | OPT                            |
| 10                                         | 0   | D1                                                   | DIODE, BAV170, SOT23                    | OPT                            |

# DEMO MANUAL DC1822B

## PARTS LIST

| ITEM | QTY | REFERENCE                                                                                      | PART DESCRIPTION                   | MANUFACTURER/PART NUMBER    |
|------|-----|------------------------------------------------------------------------------------------------|------------------------------------|-----------------------------|
| 11   | 0   | D2, D3                                                                                         | CMDSH-3                            | OPT                         |
| 12   | 1   | L3                                                                                             | IND, 33 $\mu$ H, -53DLC            | TOKO A914BYW-330M=P3        |
| 13   | 0   | L4                                                                                             | INDUCTOR, -53LDC                   | OPT                         |
| 14   | 0   | PB1                                                                                            | DC/DC Converters, D12S1R845A       | OPT                         |
| 15   | 2   | Q1, Q2                                                                                         | MOSFET, 30V N-CHANNEL, DPAK        | VISHAY SUD50N03-12P-E3      |
| 16   | 0   | Q3, Q4, Q7, Q8                                                                                 | BSC050NE2LS                        | OPT                         |
| 17   | 0   | Q5, Q6, Q9, Q10                                                                                | BSC010NE2LS                        | OPT                         |
| 18   | 0   | R10, R14, R15, R27, R28, R31, R33-R35, R41, R42, R47-R55, R62, R64-R67, R69, R71, R72, R74-R81 | RES, 0603                          | OPT                         |
| 19   | 2   | R56, R58                                                                                       | RES, 10k, 1%, 1/10W, 0603          | VISHAY CRCW060310K0FKEA     |
| 20   | 2   | R57, R60                                                                                       | RES, 0.010 $\Omega$ , 1%, 1W, 2010 | IRC LRC-LRF2010LF-01-R010-F |
| 21   | 1   | R59                                                                                            | RES, 0 $\Omega$ , JUMPER, 1206     | VISHAY CRCW12060000Z0EA     |
| 22   | 1   | R61                                                                                            | RES, 604k, 1%, 1/16W, 0603         | VISHAY CRCW0603604KFKEA     |
| 23   | 1   | R63                                                                                            | RES, 200k, 1%, 1/16W, 0603         | VISHAY CRCW0603200KFKEA     |
| 24   | 1   | U4                                                                                             | BUCK REGULATOR, LT3470ETS8         | ANALOG DEVICES LT3470ETS8   |
| 25   | 0   | U5                                                                                             | BUCK REGULATOR, LT3470ETS8         | OPT                         |
| 26   | 0   | U8, U9                                                                                         | N-CHANNEL MOSFET DRIVER, LTC4449   | OPT                         |

### Hardware

|    |    |                        |                                                 |                                  |
|----|----|------------------------|-------------------------------------------------|----------------------------------|
| 1  | 27 | E1-E27                 | TESTPOINT, TURRET, 0.095"                       | MILL-MAX 2501-2-00-80-00-00-07-0 |
| 2  | 6  | J1-J6                  | STUD, TEST PIN                                  | PEM KFH-032-10                   |
| 3  | 12 | J1-J6                  | NUT, BRASS PL #10-32                            | ANY #10-32M/S                    |
| 4  | 6  | J1-J6                  | RING, LUG #10                                   | KEYSTONE 8205                    |
| 5  | 6  | J1-J6                  | WASHER, TIN, PLATED BRASS                       | ANY                              |
| 6  | 2  | J7, J10                | CON, BNC, 5 PINS                                | CONNEX 112404                    |
| 7  | 1  | J8                     | HEADER, DOBL ROW, RT ANGLE, 2 $\times$ 4, 8 PIN | MILL-MAX 802-10-008-20-001000    |
| 8  | 1  | J9                     | SOCKET, DBL ROW, RT ANGLE, 2 $\times$ 4, 8 PIN  | MILL-MAX 803-43-008-20-001000    |
| 9  | 4  | JP1, JP2, JP3, JP4     | HEADER, 3 PIN, 0.079" SINGLE ROW                | SAMTEC TMM-103-02-L-S            |
| 10 | 4  | MTGS AT 4 CORNERS      | STAND-OFF, NYLON 0.5"                           | KEYSTONE 8833 (SNAP-ON)          |
| 11 | 4  | XJP1, XJP2, XJP3, XJP4 | SHUNT, 0.079" CENTER                            | SAMTEC 2SN-BK-G                  |

## SCHEMATIC DIAGRAM

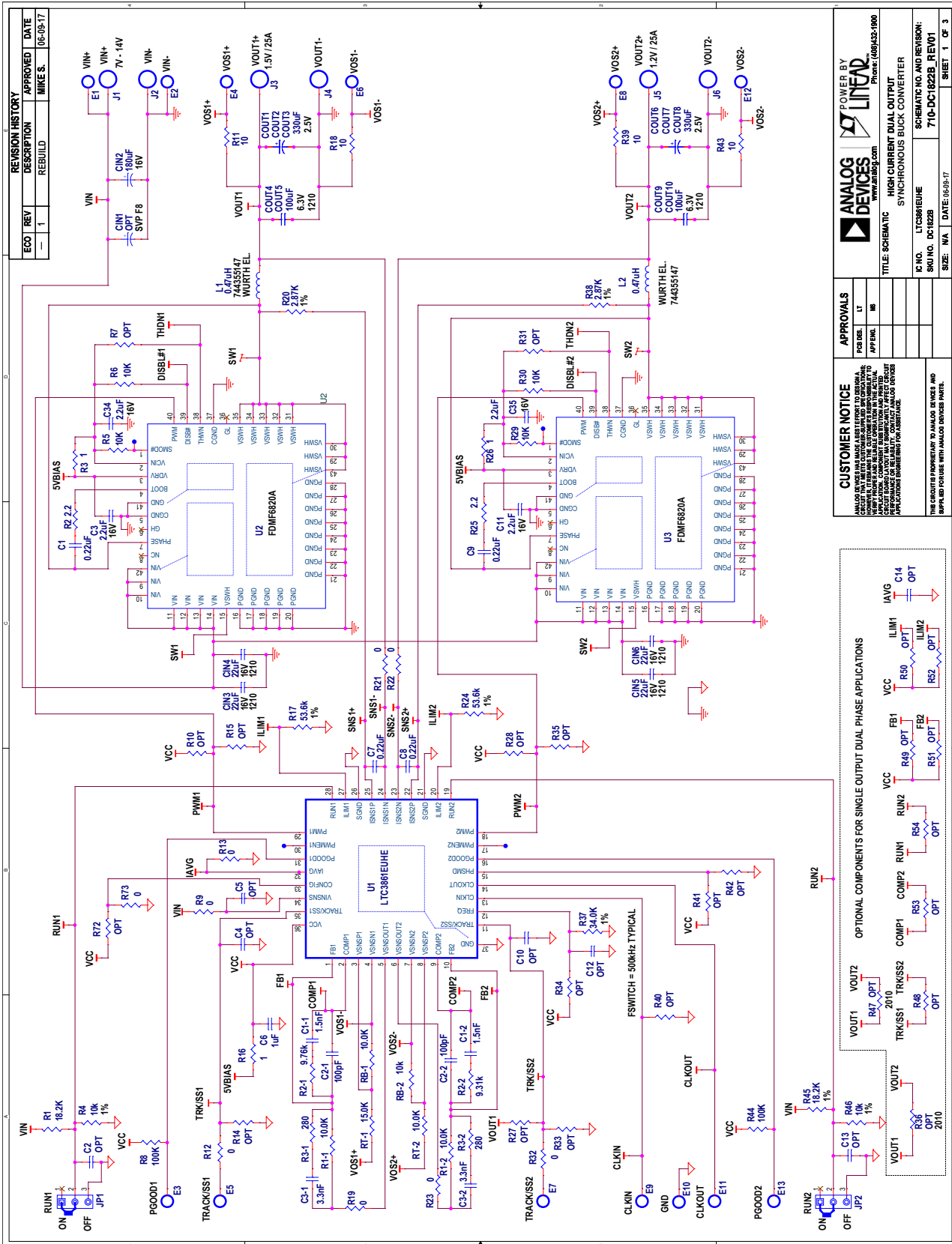
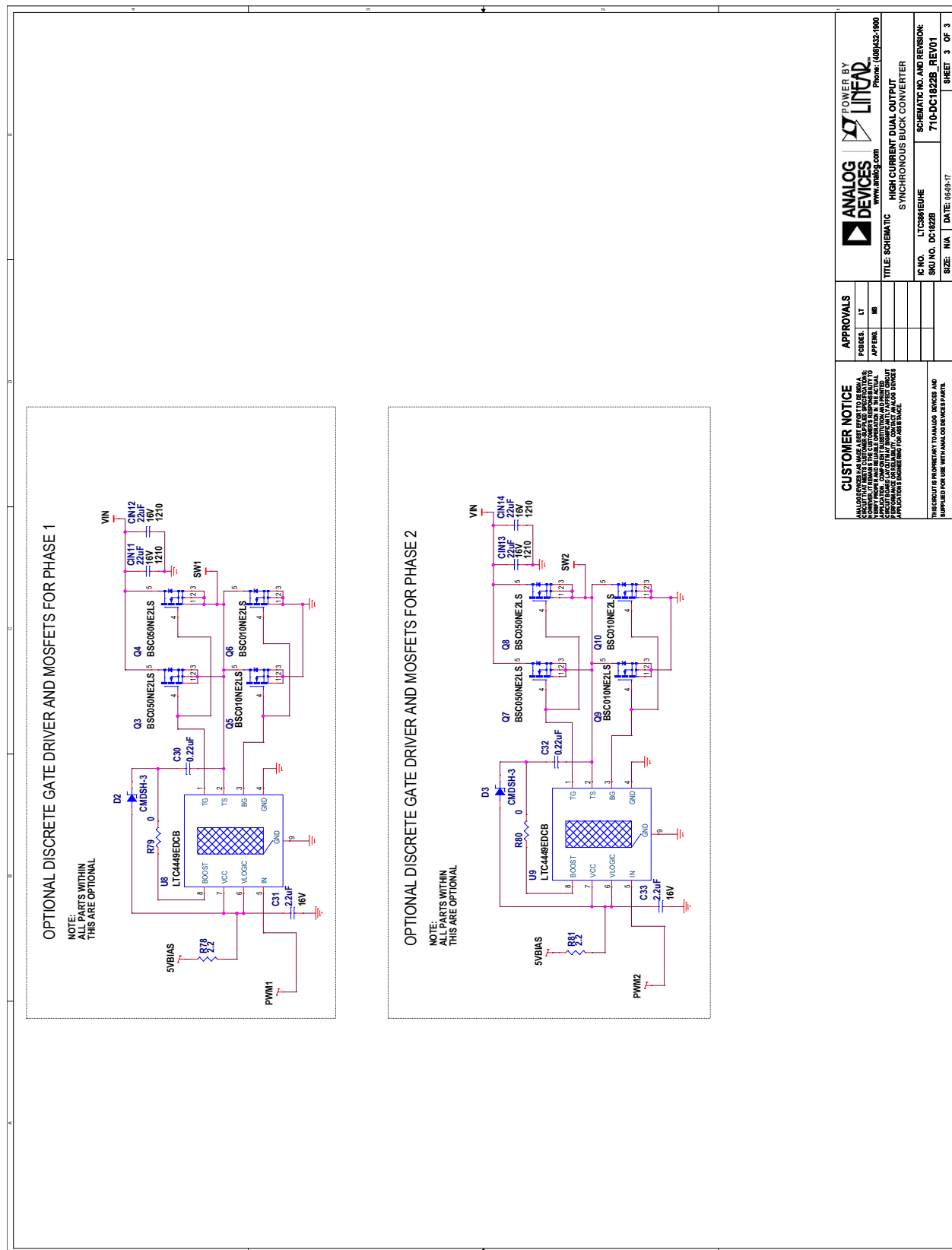


Figure 8. DC1822B Demo Circuit Schematic

## Downloaded from Arrow.com.



## SCHEMATIC DIAGRAM



### Figure 10. DC1822B Demo Circuit Schematic

**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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