

## LT8210

# High Voltage, High Efficiency Synchronous Buck-Boost Converter with Input to Output Pass-Through

## DESCRIPTION

Demonstration circuit 2814A-A is a high voltage, high efficiency synchronous buck-boost DC/DC converter with an input voltage range of 8V to 80V. After the part has started, the input voltage can run down to 3.5V. It can supply a 3A maximum load current with an output range of 8V to 16V. The demo board features the [LT8210EUJ](#) controller. The constant frequency current mode architecture allows a phase-lockable frequency of up to 400kHz, while an optional input or output current feedback loop provides support for applications such as battery charging. With a wide input range, wide output range, and seamless transfers between operation modes, the LT8210 is ideal for industrial, automotive, medical, military, and avionics applications.

The converter has four modes of operation: burst, pulse skip, forced continuous mode, or pass-through. Pass-through is a feature that passes the input directly to the

output when the input voltage is within a user programmable window. Switching losses drop to zero and efficiency is maximized. For input voltage above or below the pass-through window, the buck or boost regulation loops maintain the output at the set maximum or minimum values, respectively. Reverse input protection is also implemented on this demo board.

The available versions of the DC2814A are:

**DC2814A-A:** 8V to 40V<sub>IN</sub>, 80V<sub>IN</sub> Surge (60s), Operates Down to 3.5V<sub>IN</sub> after Start-Up, V<sub>OUT</sub> = 8V to 16V at 3A

**DC2814A-B:** 9V to 36V<sub>IN</sub>, 80V<sub>IN</sub> Surge (60s), V<sub>OUT</sub> = 24V to 36V at 2.5A

**DC2814A-C:** 26V to 80V<sub>IN</sub>, V<sub>OUT</sub> = 36V to 56V at 2A

[Design files for this circuit board are available.](#)

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## PERFORMANCE SUMMARY

Specifications are at T<sub>A</sub> = 25°C

| PARAMETER                                | CONDITIONS  | VALUE  |
|--|---|--|
| Input Voltage Range, V <sub>IN</sub>     |   | 8V to 40V Continuous, 80V Surge (60 Seconds)<br>(Operates Down to 3.5V after Start-Up) |
| Output Voltage, V <sub>OUT</sub>         | V <sub>IN</sub> = 3.5V (8V Start-Up) to 80V, I <sub>OUT</sub> = 0A to 3A  | 8V to 16V  |
| Maximum Output Current, I <sub>OUT</sub> | V <sub>IN</sub> = 3.5V (8V Start-Up) to 80V, V <sub>OUT</sub> = 8V to 16V | 3A   |
| Default Operating Frequency              |   | 385kHz (R <sub>T</sub> = 16.9k)  |
| Typical Efficiency                       | 6V <sub>IN</sub> , 8V <sub>OUT</sub> (Boost), 3A                          | 94%  |
|  | 8V <sub>IN</sub> , 8V <sub>OUT</sub> (Buck-Boost), 3A                     | 94%  |
|  | 12V <sub>IN</sub> , 12V <sub>OUT</sub> (Pass-Through), 3A                 | 98%  |
|  | 17V <sub>IN</sub> , 16V <sub>OUT</sub> (Buck-Boost), 3A                   | 95%  |
|  | 30V <sub>IN</sub> , 16V <sub>OUT</sub> (Buck), 3A                         | 94%  |

# DEMO MANUAL DC2814A-A

## QUICK START PROCEDURE

Demonstration circuit 2814A-A is easy to set up to evaluate the performance of the LT8210. Refer to the following procedure:

1. With power off, connect the input power supply to  $V_{IN}$  (8V to 40V) and GND (input return).
2. Connect the 8V to 16V output load between  $V_{OUT}$  and GND.
3. Connect the DVMs to the input and the output.
4. Turn on the input power supply and then check for the proper output voltages.  $V_{OUT}$  should be between 8V to 16V, depending on the input voltage (see Figure 4).
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. After the part starts, the input voltage can be reduced to as low as 3.5V.
7. The input voltage may be raised up to 80V for short periods of time.

Note: When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 1 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.

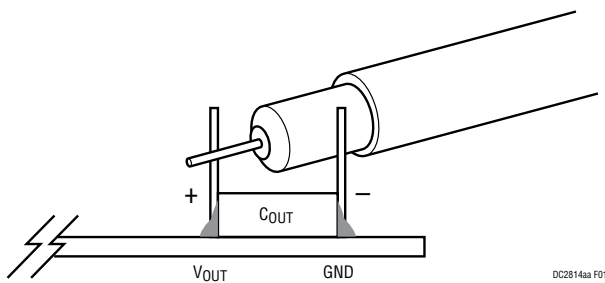


Figure 1. Measuring Output Voltage Ripple

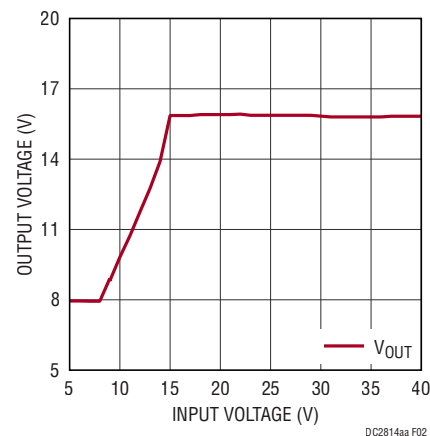


Figure 2. Output Voltage vs Input Voltage

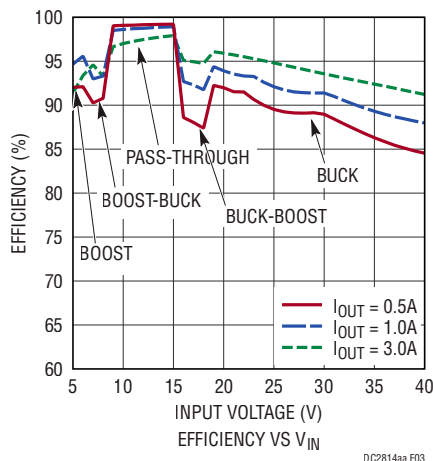


Figure 3. Efficiency vs  $V_{IN}$

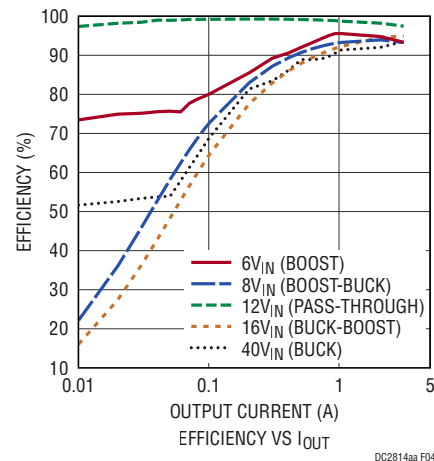
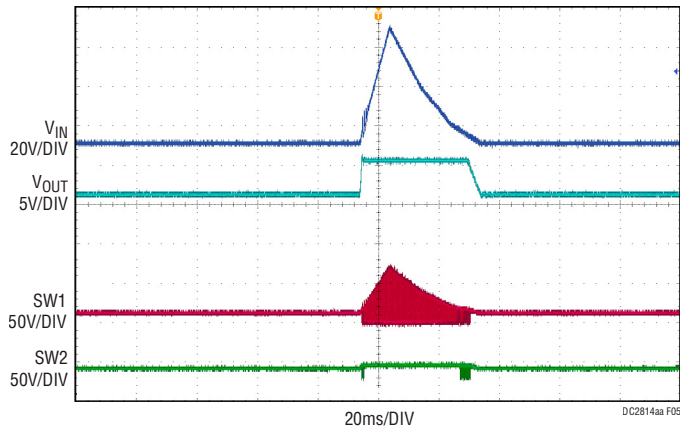
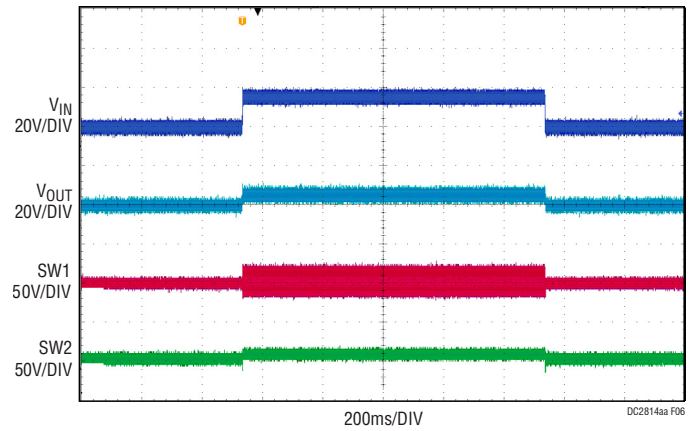


Figure 4. Efficiency vs  $I_{OUT}$

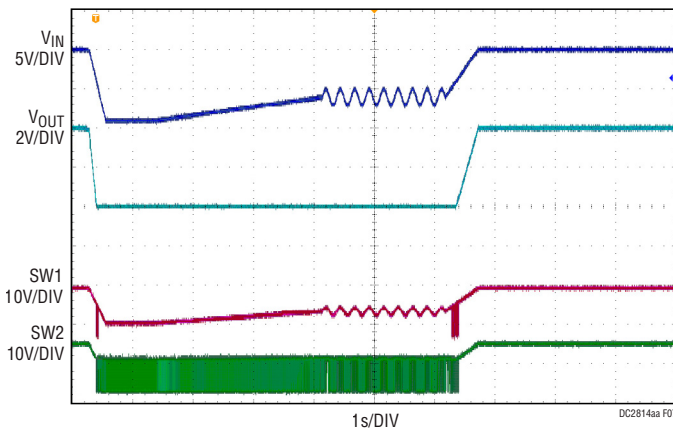
## TEST RESULTS



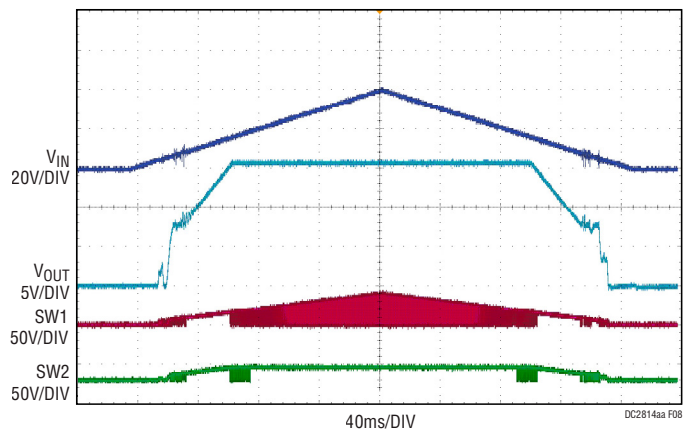
**Figure 5. ISO16750 4.6.4, Test A without Centralized Load Dump Suppression ( $I_{OUT} = 3A$ )**



**Figure 6. LV124 E-04, Jumpstart ( $I_{OUT} = 3A$ )**



**Figure 7. ISO16750 4.6.3, Starting Profile ( $I_{OUT} = 1.5A$ )**



**Figure 8.  $V_{IN}$  Range ( $I_{OUT} = 3A$ )**

TEST RESULTS

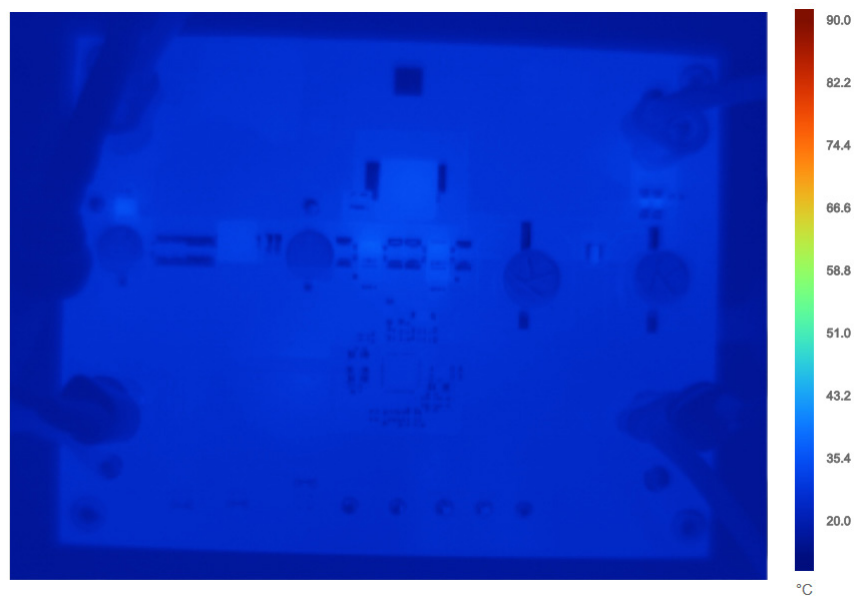


Figure 9. DC2814A-A Thermal Performance at 6V<sub>IN</sub> (Boost), 8V<sub>OUT</sub>, 3A Load Current

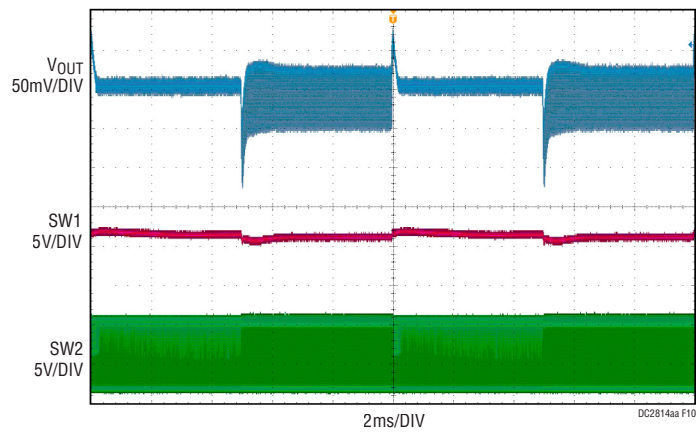


Figure 10. DC2814A-A Load Transients at 6V<sub>IN</sub> (Boost), 8V<sub>OUT</sub>, 0.3A to 2.7A Load Current

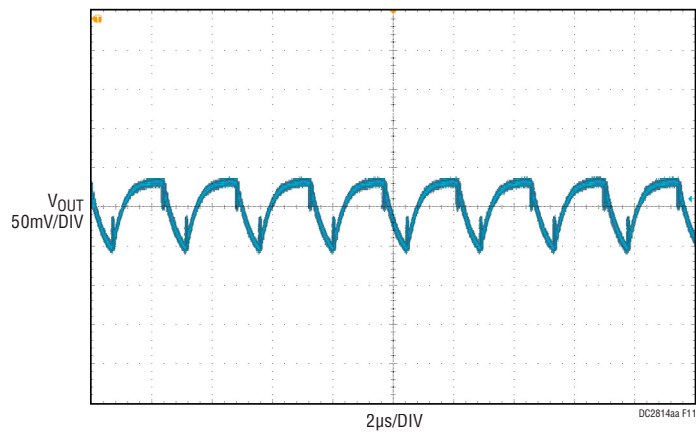


Figure 11. DC2814A-A Output Voltage Ripple at 6V<sub>IN</sub> (Boost), 8V<sub>OUT</sub>, 3A Load Current

## TEST RESULTS

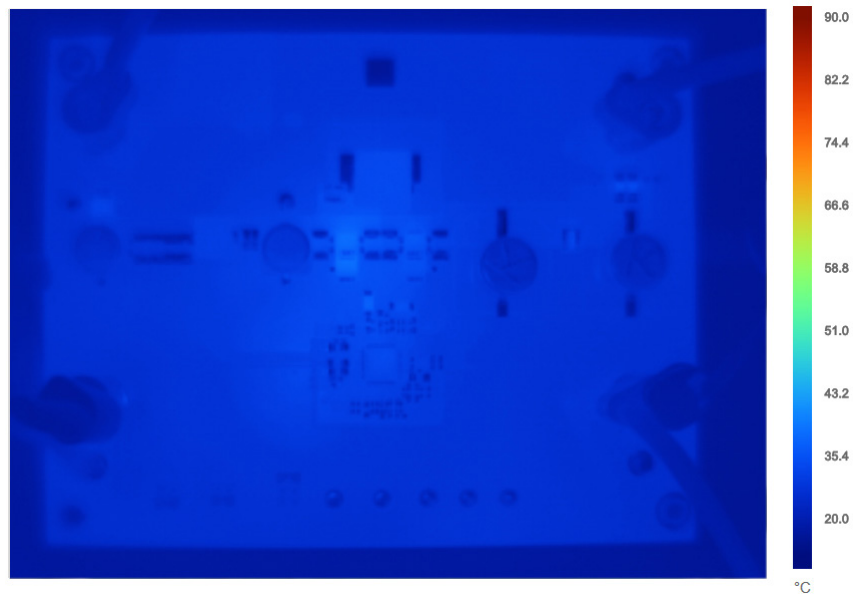


Figure 12. DC2814A-A Thermal Performance at  $8V_{IN}$  (Buck-Boost),  $8V_{OUT}$ , 3A Load Current

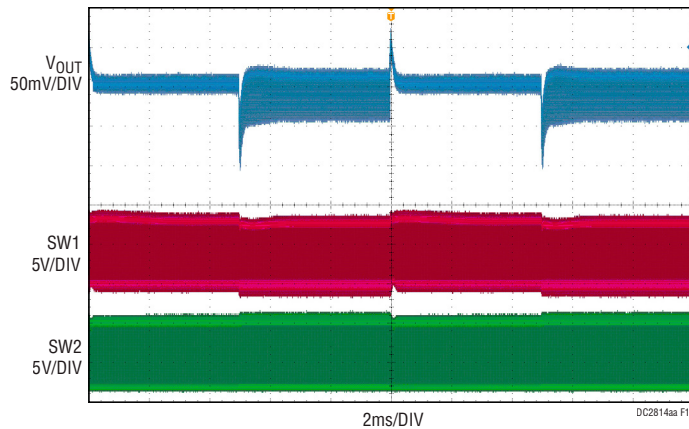


Figure 13. DC2814A-A Load Transients at  $7.5V_{IN}$  (Buck-Boost),  $8V_{OUT}$ , 0.3A to 2.7A Load Current

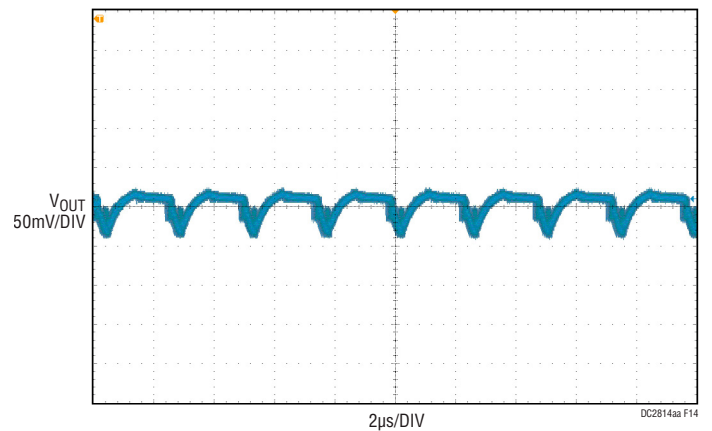


Figure 14. DC2814A-A Output Voltage Ripple at  $8V_{IN}$  (Buck-Boost),  $8V_{OUT}$ , 3A Load Current

TEST RESULTS

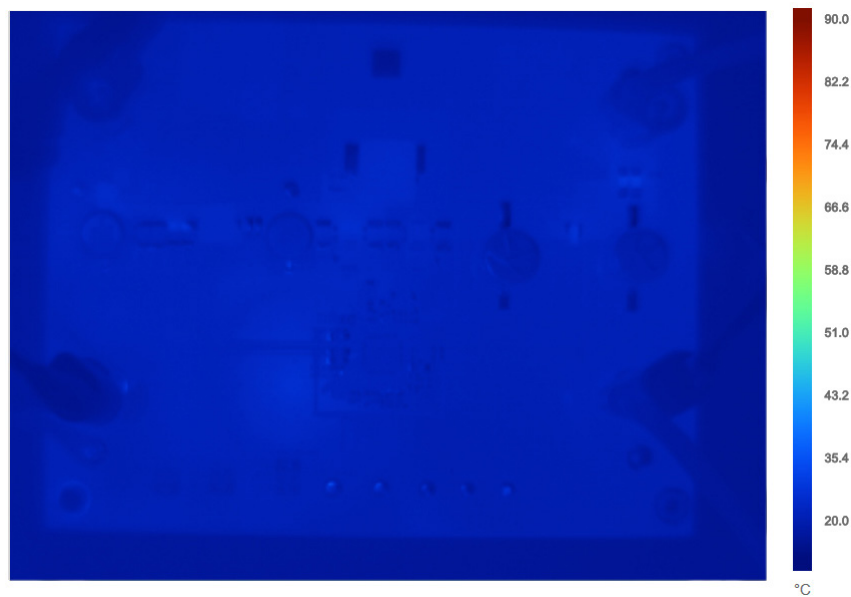


Figure 15. DC2814A-A Thermal Performance at 12V<sub>IN</sub> (Pass-Through), 12V<sub>OUT</sub>, 3A Load Current

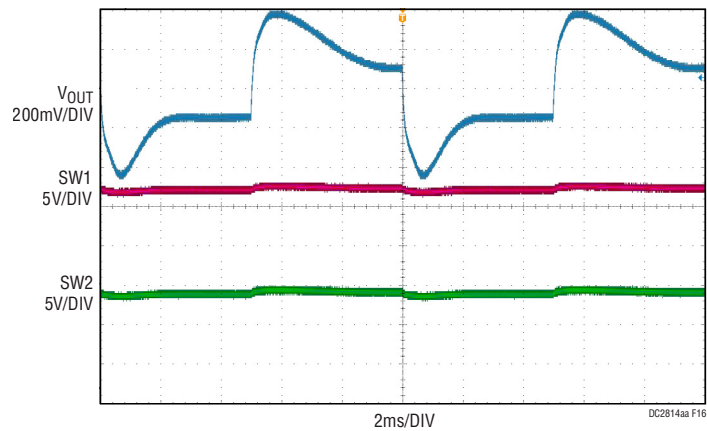


Figure 16. DC2814A-A Load Transients at 12V<sub>IN</sub> (Pass-Through), 12V<sub>OUT</sub>, 0.3A to 2.7A Load Current

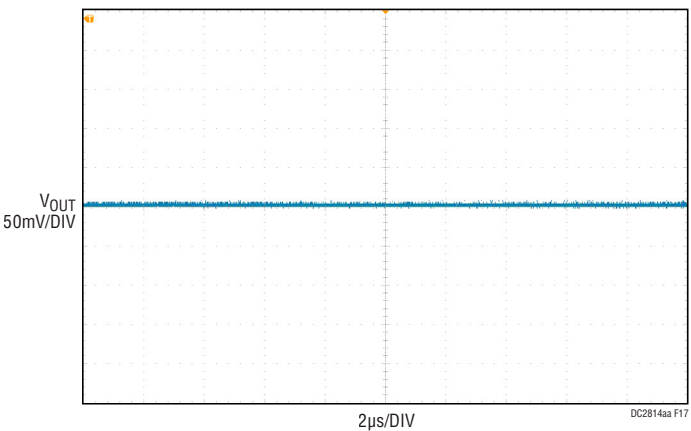


Figure 17. DC2814A-A Output Voltage Ripple at 12V<sub>IN</sub> (Pass-Through), 12V<sub>OUT</sub>, 3A Load Current



## TEST RESULTS

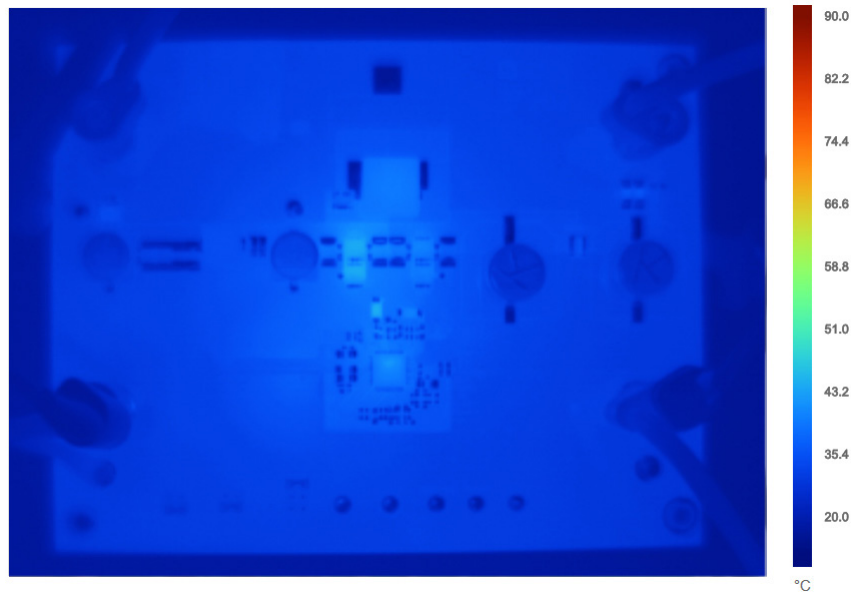


Figure 18. DC2814A-A Thermal Performance at 17V<sub>IN</sub> (Buck-Boost), 16V<sub>OUT</sub>, 3A Load Current

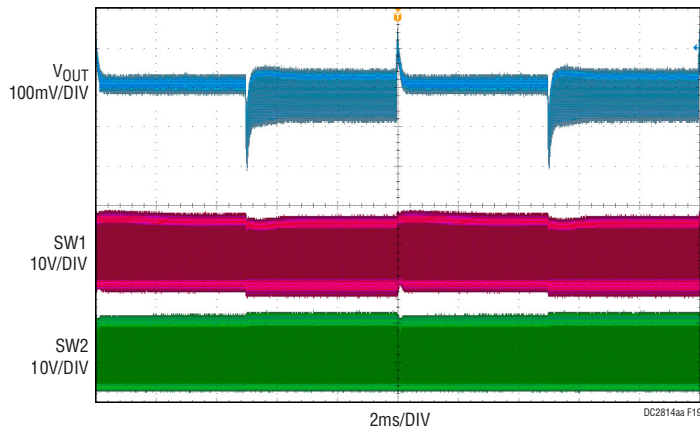


Figure 19. DC2814A-A Load Transients at 17V<sub>IN</sub> (Buck-Boost), 16V<sub>OUT</sub>, 0.3A to 2.7A Load Current

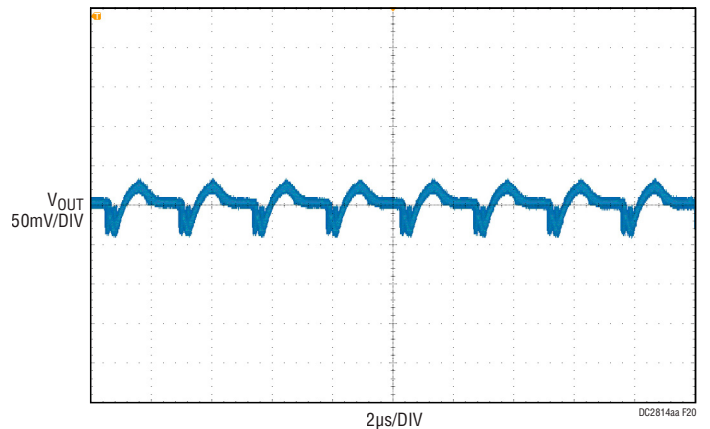


Figure 20. DC2814A-A Output Voltage Ripple at 17V<sub>IN</sub> (Buck-Boost), 16V<sub>OUT</sub>, 3A Load Current

TEST RESULTS

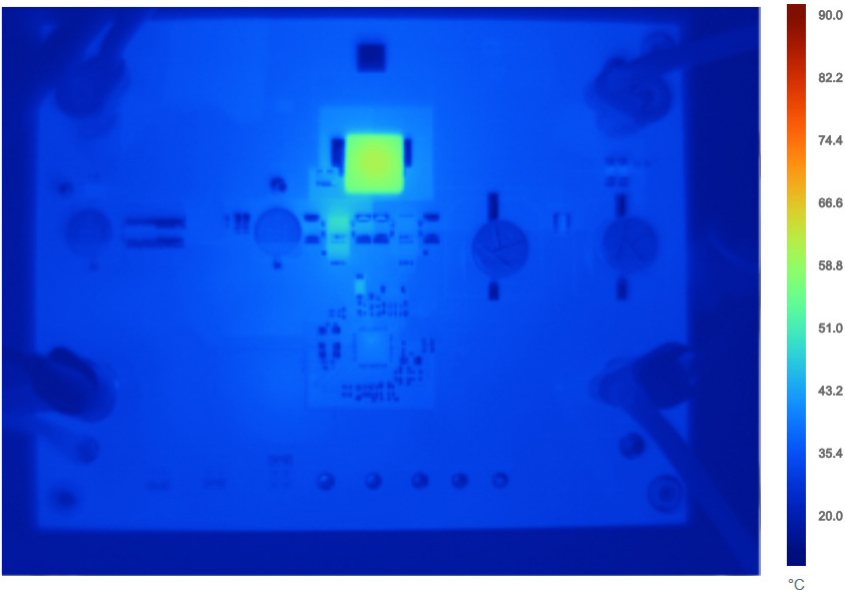


Figure 21. DC2814A-A Thermal Performance at 30V<sub>IN</sub> (Buck), 16V<sub>OUT</sub>, 3A Load Current

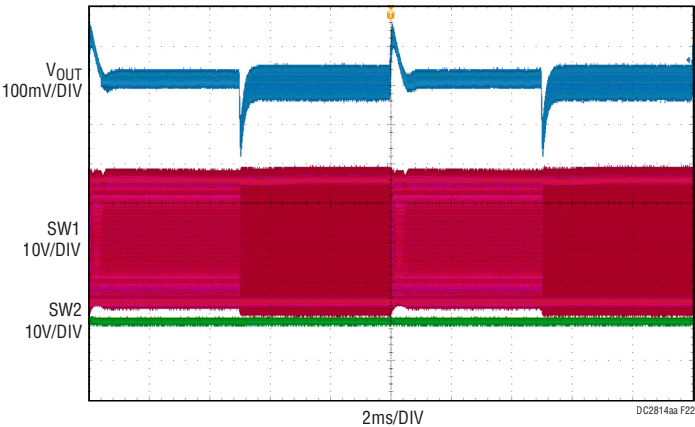


Figure 22. DC2814A-A Load Transients at 30V<sub>IN</sub> (Buck), 16V<sub>OUT</sub>, 0.3A to 2.7A Load Current

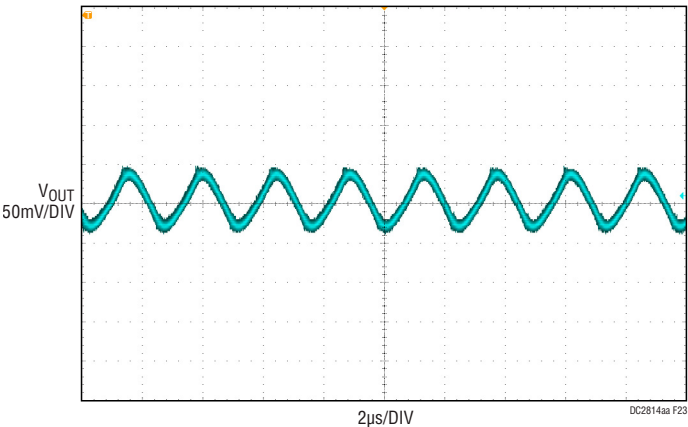


Figure 23. DC2814A-A Output Voltage Ripple at 30V<sub>IN</sub> (Buck), 16V<sub>OUT</sub>, 3A Load Current



## PARTS LIST

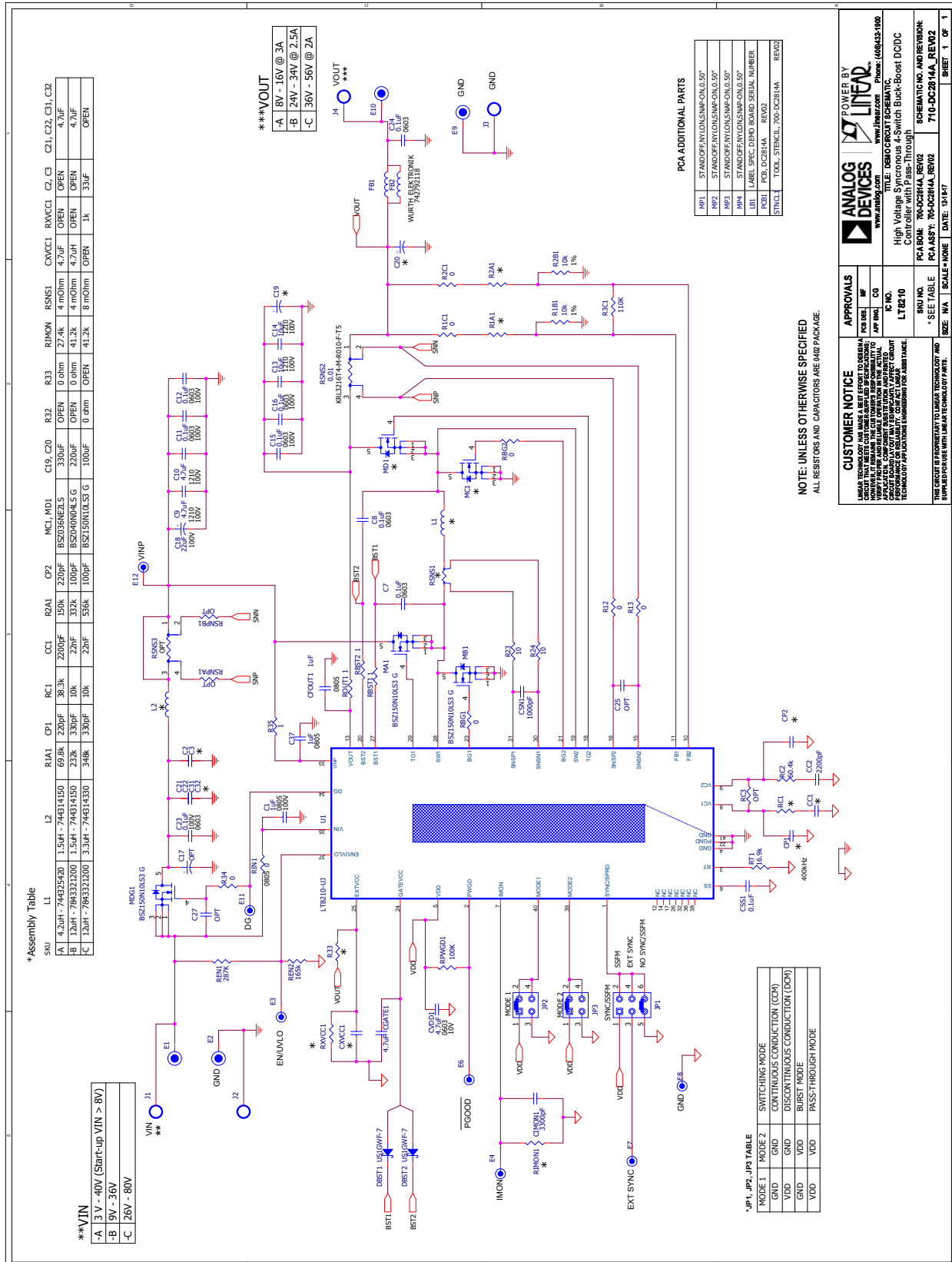
| ITEM                               | QTY | REFERENCE                    | PART DESCRIPTION  | MANUFACTURER/PART NUMBER  |
|------------------------------------|-----|------------------------------|---|---|
| <b>Required Circuit Components</b> |     |                              |   |   |
| 1                                  | 2   | C1, CFOUT1                   | CAP, 1 $\mu$ F, X7S, 100V, 10%, 0805, SOFT TERM                           | MURATA GRJ21BC72A105KE11L<br>TDK C2012X7S2A105K125AE                      |
| 2                                  | 5   | C7, C8, C11, C12, C23        | CAP, 0.1 $\mu$ F, X7S, 100V, 10%, 0603                                    | TAIYO YUDEN HMK107C7104KA-T<br>TDK C1608X7S2A104K080AB                    |
| 3                                  | 6   | C9, C10, C21, C22, C31, C32  | CAP, 4.7 $\mu$ F, X7S, 100V, 20%, 1210                                    | TDK C3225X7S2A475M200AB   |
| 4                                  | 2   | C13, C14                     | CAP, 10 $\mu$ F, X7R, 25V, 20%, 1210                                      | KEMET C1210C106M3RAC7800<br>TDK C3225X7R1E106M250AC                       |
| 5                                  | 3   | C15, C16, C24                | CAP, 0.1 $\mu$ F, X7R, 50V, 10%, 0603, AEC-Q200                           | TDK CGA3E2X7R1H104K080AA  |
| 6                                  | 1   | C18                          | CAP, 22 $\mu$ F, ALUM ELECT, 100V, 20%, 8x10.2mm SMD, AEC-Q200            | PANASONIC EEETG2A220UP  |
| 7                                  | 2   | C19, C20                     | CAP, 330 $\mu$ F, ALUM ELECT, 35V, 20%, SMD 10mm x 10.2mm                 | SUN ELECTRONIC INDUSTRIES CORP 35CE330AX                                  |
| 8                                  | 1   | C37                          | CAP, 1 $\mu$ F, X7S, 100V, 10%, 0805, SOFT TERM                           | AVX 08053C105KAT2A<br>MURATA GRJ21BC72A105KE11                            |
| 9                                  | 1   | CC1                          | CAP, 2200pF, X7R, 25V, 10%, 0402  | AVX 04023C222KAT2A  |
| 10                                 | 1   | CC2                          | CAP, 2200pF, X7R, 16V, 10%, 0402  | AVX 0402YC222KAT2A<br>KEMET C0402C222K4RACTU<br>MURATA GRM155R71C222KA01D |
| 11                                 | 1   | CGATE1                       | CAP, 4.7 $\mu$ F, X5R, 10V, 10%, 0402                                     | TDK C1005X5R1A475K050BC   |
| 12                                 | 1   | CIMON1                       | CAP, 3300pF, X7R, 16V, 10%, 0402  | AVX 0402YC332KAT2A<br>MURATA GRM15XR71C332KA86D                           |
| 13                                 | 2   | CP1, CP2                     | CAP, 220pF, NP0, 25V, 10%, 0402   | AVX 04023A221KAT2A  |
| 14                                 | 1   | CSN1                         | CAP, 1000pF, X7R, 16V, 10%, 0402  | AVX 0402YC102KAT2A<br>MURATA GRM155R71C102KA01D                           |
| 15                                 | 1   | CSS1                         | CAP, 0.1 $\mu$ F, X7R, 25V, 10%, 0402                                     | AVX 04023C104KAT2A<br>TAIYO YUDEN TMK105B7104KV-FR                        |
| 16                                 | 1   | CVDD1                        | CAP, 4.7 $\mu$ F, X5R, 10V, 10%, 0603                                     | TDK CGB3B1X5R1A475K055AC  |
| 17                                 | 1   | CXVCC1                       | CAP, 4.7 $\mu$ F, X5R, 16V, 20%, 0603                                     | TDK C1608X5R1C475M080AC   |
| 18                                 | 2   | DBST1, DBST2                 | DIODE, RECT, 400V, 1A, SOD123F, AEC-Q101                                  | DIODES INC US1GWF-7   |
| 19                                 | 4   | E1, E2, E9, E10              | TEST POINT, TURRET, 0.094", MTG HOLE                                      | MILL-MAX 2501-2-00-80-00-00-07-0  |
| 20                                 | 7   | E3, E4, E6, E7, E8, E11, E12 | TEST POINT, TURRET, 0.064", MTG HOLE                                      | MILL-MAX 2308-2-00-80-00-00-07-0  |
| 21                                 | 2   | FB1, FB2                     | IND, 600 $\Omega$ AT 100MHz, FERRITE BEAD, 25%, 2.5A, 70m $\Omega$ , 1206 | WURTH ELEKTRONIK 742792118  |
| 22                                 | 4   | J1, J2, J3, J4               | CONN, BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE                      | KEYSTONE 575-4  |
| 23                                 | 1   | JP1                          | CONN, HDR, MALE, 2x3, 2mm, VERT, STR, THT                                 | SAMTEC TMM-103-02-L-D   |
| 24                                 | 2   | JP2, JP3                     | CONN, HDR, MALE, 2x2, 2mm, VERT, STR, THT, 10 $\mu$ " Au                  | SAMTEC TMM-102-02-L-D   |
| 25                                 | 1   | L1                           | IND, 4.2 $\mu$ H, PWR, 20%, 11A, 7.1m $\Omega$ , 1050                     | WURTH ELEKTRONIK 744325420  |
| 26                                 | 1   | L2                           | IND, 1.5 $\mu$ H, PWR, 20%, 13A, 4.3m $\Omega$ , 7050                     | WURTH ELEKTRONIK 744314150  |
| 27                                 | 1   | LB1                          | LABEL SPEC, DEMO BOARD SERIAL NUMBER                                      | BRADY THT-96-717-10   |
| 28                                 | 3   | MA1, MB1, MDG1               | XSTR, MOSFET, N-CH, 100V, 40V, PG-TSDSON-8                                | INFINEON BSZ150N10LS3 G<br>INFINEON BSZ150N10LS3GATMA1                    |
| 29                                 | 2   | MC1, MD1                     | XSTR, MOSFET, N-CH, 25V, 16A, PG-TSDSON-8                                 | INFINEON BSZ036NE2LS<br>INFINEON BSZ036NE2LSATMA1                         |

# DEMO MANUAL DC2814A-A

## PARTS LIST

| ITEM | QTY | REFERENCE  | PART DESCRIPTION   | MANUFACTURER/PART NUMBER   |
|------|-----|--|--|--|
| 30   | 4   | MP1, MP2, MP3, MP4                               | STANDOFF, NYLON, SNAP-ON, 0.50"                                | KEYSTONE 8833  |
| 31   | 1   | PCB1   | PCB, DC2814A   | PHASE 3 600-DC2814A  |
| 32   | 1   | R1A1   | RES, 69.8k $\Omega$ , 1%, 1/16W, 0402                          | VISHAY CRCW040269K8FKED  |
| 33   | 2   | R1B1, R2B1                                       | RES, 10k $\Omega$ , 1%, 1/16W, 0402, AEC-Q200                  | VISHAY CRCW040210K0FKED<br>NIC NRC04F1002TRF   |
| 34   | 8   | R1C1, R2C1, R12,<br>R13, R33, R34, RBG1,<br>RBG2 | RES, 0 $\Omega$ , 1/16W, 0402                                  | ROHM MCR01MZPJ000<br>VISHAY CRCW04020000Z0ED<br>NIC NRC04Z0TRF<br>YAGEO RC0402JR-070RL |
| 35   | 1   | R2A1   | RES, 150k $\Omega$ , 1%, 1/16W, 0402                           | VISHAY CRCW0402150KFKED  |
| 36   | 2   | R23, R24   | RES, 10 $\Omega$ , 1%, 1/16W, 0402, AEC-Q200                   | NIC NRC04F10R0TRF<br>VISHAY CRCW040210R0FKED   |
| 37   | 4   | R35, RBST1,<br>RBST2, ROUT1                      | RES, 1 $\Omega$ , 1%, 1/16W, 0402                              | VISHAY CRCW04021R00FKED  |
| 38   | 1   | RC1  | RES, AEC-Q200, 38.3k $\Omega$ , 1%, 1/16W, 0402                | VISHAY CRCW040238K3FKED  |
| 39   | 1   | RC2  | RES, 60.4k $\Omega$ , 1%, 1/16W, 0402                          | NIC NRC04F6042TRF<br>VISHAY CRCW040260K4FKED   |
| 40   | 1   | REN1   | RES, 287k $\Omega$ , 1%, 1/16W, 0402, AEC-Q200                 | VISHAY CRCW0402287KFKED  |
| 41   | 1   | REN2   | RES, 165k $\Omega$ , 1%, 1/16W, 0402, AEC-Q200                 | VISHAY CRCW0402165KFKED  |
| 42   | 1   | RIMON1   | RES, 27.4k $\Omega$ , 1%, 1/16W, 0402, AEC-Q200                | VISHAY CRCW040227K4FKED  |
| 43   | 1   | RIN1   | RES, 0 $\Omega$ , 1/8W, 0805                                   | VISHAY CRCW08050000Z0EA<br>YAGEO RC0805JR-070RL  |
| 44   | 1   | RPWGD1   | RES, 100k $\Omega$ , 1%, 1/16W, 0402, AEC-Q200                 | NIC NRC04F1003TRF<br>VISHAY CRCW0402100KFKED   |
| 45   | 1   | RSNS1  | RES, 0.004 $\Omega$ , 1%, 1W, 1206, 4-TERM, SENSE,<br>AEC-Q200 | SUSUMU KRL3216T4-M-R004-F-T1   |
| 46   | 1   | RSNS2  | RES, 0.01 $\Omega$ , 1%, 1W, 1206, 4-TERM, SENSE,<br>AEC-Q200  | SUSUMU KRL3216T4-M-R010-F-T5   |
| 47   | 1   | RT1  | RES, 16.9k $\Omega$ , 1%, 1/10W, 0603, AEC-Q200                | NIC NRC06F1692TRF<br>PANASONIC ERJ3EKF1692V<br>VISHAY CRCW060316K9FKEA                 |
| 48   | 1   | STNCL1   | TOOL, STENCIL, 700-DC2814A                                     | ANALOG DEVICES 830-DC2814A   |
| 49   | 1   | U1   | IC, 100V, BUCK-BOOST CONTROLLER, QFN-40 (6x6)                  | ANALOG DEVICES LT8210EUJ#PBF<br>ANALOG DEVICES LT8210EUJ#TRPBF                         |
| 50   | 3   | XJP1, XJP2, XJP3                                 | CONN, SHUNT, FEMALE, 2-POS, 2mm                                | SAMTEC 2SN-BK-G  |

## SCHEMATIC DIAGRAM



# DEMO MANUAL DC2814A-A

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## 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.

## Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.

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