

LT8551 High Power Boost Converter Based on the Phase Expander

DESCRIPTION

Demonstration circuit 2896A-B demonstrates a high power boost converter and features the [LT®8551](#) the phase expander with internal gate drivers. The DC2896A-B employs [LTC3769](#), a single-phase boost controller as primary controller and LT8551 as the phase expander which added four more power phases. The increased number of power sections connected to the LT8551, results in greater higher level output power without a corresponding increase in the difficulty of the design or a sacrifice of primary controller LTC3769 features.

The input voltage range of DC2896A-B is from 10V to 46V and the output is 48V. The maximum input current is 12A per power section, so the maximum input current of DC2896A-B is 60A. It's reflected to 30A of output current and output power of 1,440W at an input voltage of 24V. Correspondingly output current will drop to 14.5A and output power will to 720W at a 12V input voltage, to keep the input current at the same level of 60A. Both values will increase at higher voltages. The input current value can be increased above 60A, if heat sinks are installed, see parts list below.

The switching frequency is 250kHz and at a 24V input to 48V_{OUT} at full load, the efficiency of DC2896A-B is 98%. As the input voltage decreases, the output current should be decreased as well, to prevent saturation of the DC2896A-B inductors, the derating curve presented on Figure 3. Efficiency curves presented on Figure 4.

DC2896A-B resistors R114 to R119 program the phase relationship between the power sections, by setting the Total Distinct Phase Number (TDPN). For increasing efficiency and reducing switching losses at light loads DC2896A-B supports disconnecting some power sections. This mode of operation designated as the stage shedding and it is programmed by the jumper J3 STAGE SHED. Jumper JP1 programs the LT8551 SYNC pin and it allows DC2896A-B to be synchronized to an external clock. The print circuit board of DC2896A also supports

two phase expander controllers, the [LT8561](#) and [LT8551](#), with versions DC2896A-A and DC2896A-B correspondingly. The table [1] in the electrical schematic describes differences between both versions, including controller biasing and gate drive voltages.

DC2896A-B has jumper SHDN (JP2) for manually enable or disable controller. The SYNC (E19) input can be used to sync LT8551 with an external signal. There are also terminals that make it easy to monitor the control logic of the LT8551 functional. The current sense resistors R_{SNS1} to R_{SNS5} used for implementation of current mode control, monitoring and sharing current between the phases. To further increase efficiency DC2896A-B supports optional DCR sensing of inductors L1 to L5

DC2896A-B includes sense line filters and filter options for inputs to the LT8551 in accordance with data sheet recommendations. Undervoltage shutdown, switching frequency and LT8551 ILIM current limit levels can all be adjusted by resistors or resistor jumpers. DC2896A-B comes with a housekeeping circuit based on U3 controller. It reduces the power dissipation that would otherwise occur at high input voltages in regulator transistor Q21. The housekeeping circuit also stabilizes converter biasing at sudden input voltage drops.

A high level of available output power without a corresponding high level of design complexity makes the LT8551 attractive for high power DC bus and battery systems in commercial, industrial and automotive settings. DC2896A-B features the LT8551EUKG in a thermally enhanced 52-pin 7mm × 8mm QFN package. The LT8551 and LTC3769 data sheets must be read in conjunction with this demo manual to properly use or modify DC2896A-B.

Design files for this circuit board are available.

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DEMO MANUAL DC2896A-B

PERFORMANCE SUMMARY

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

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------------------|--|-----|-----|-----|-------|
| Minimum Input Voltage, V_{IN} | | | | 10 | V |
| Maximum Input Voltage, V_{IN} | | 46 | | | V |
| Output Voltage, V_{OUT} | | | 48 | | V |
| Input Current, I_{IN} | | | | 60 | A |
| Efficiency | $V_{IN} = 24\text{V}$, $I_{OUT} = 30\text{A}$ | | 98 | | % |
| Switching Frequency | | 250 | | | kHz |

QUICK START PROCEDURE

To evaluate the performance of DC2896A-B follow procedure below.

1. Read LT8551 data sheet, conduct visual inspection of DC2896A-B, locating input/output terminals and control jumpers.
2. Prepare to use the SHDN terminal to control the startup. Connect the SHDN terminal to GND by setting jumper SHDN (JP2) into OFF position.
3. Set the STAGE SHED MODE jumper JP3 to ENABLE if phase shedding is desired or to DESABLE if phase shedding is not desired.
4. Set the SYNC jumper JP1 to fixed frequency by inserting jumper into FIX FQ position.
5. Check the phase selection, TDPN SET, by inspecting connections resistors R114 to R119.
6. Connect the input power supply with power off, load and meters as shown on Figure 1.

7. Make sure that input power supply is 1,600W and output current at least 70A, the same related to load, it should be at least 1,600W and 60V rating.
8. After connections are made, turn on the input power supply and verify that input voltage between 12V and 46V.
9. Set output load to 0A.
10. Set jumper SHDN (JP2) into ON position, you should observe 48V on the output terminals and the load.
11. Once the proper output voltage is established, adjust the load and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

NOTE: If the output voltage is low, try startup again using SHDN with the load disconnected. The load may cause low output if some of the DC2896A-B power sections are inadvertently disconnected and not able to deliver power. It is possible the input supply may current limit and cause DC2896A-B to have low output. In more extreme cases it is possible that the load may be set too high for DC2896A-B.

QUICK START PROCEDURE

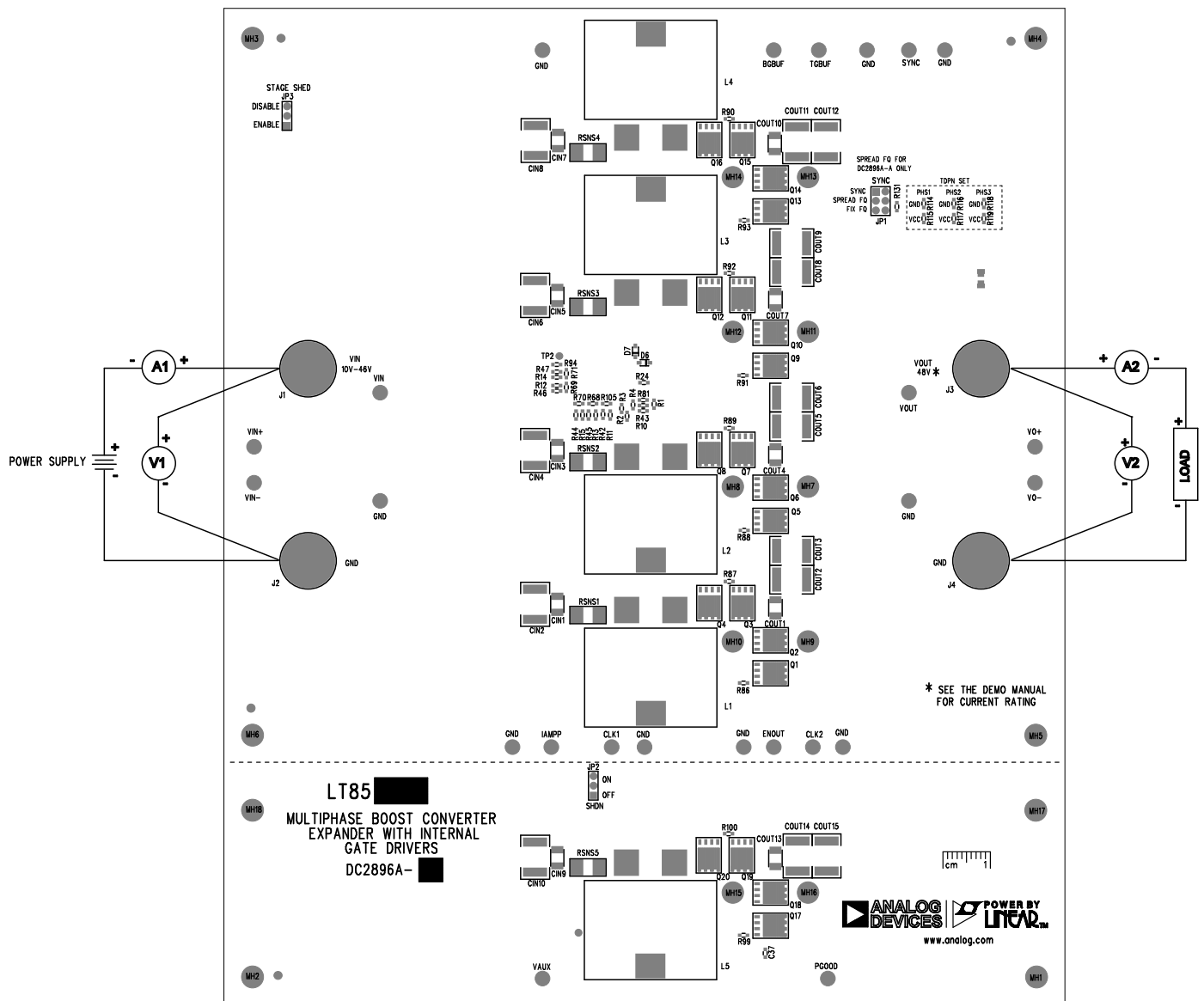


Figure 1. Proper Equipment Setup for DC2896A-B

QUICK START PROCEDURE

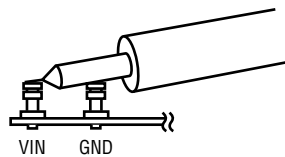


Figure 2. Measuring Input or Output Ripple

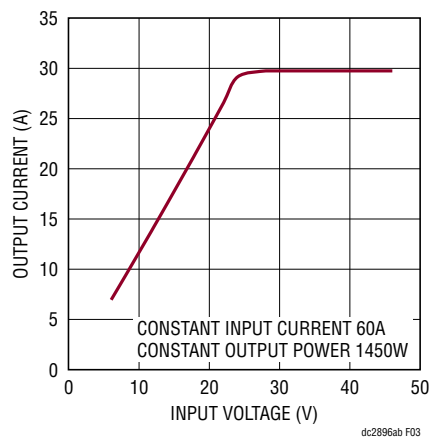


Figure 3. Derating Guidelines, Output Current vs Input Voltage

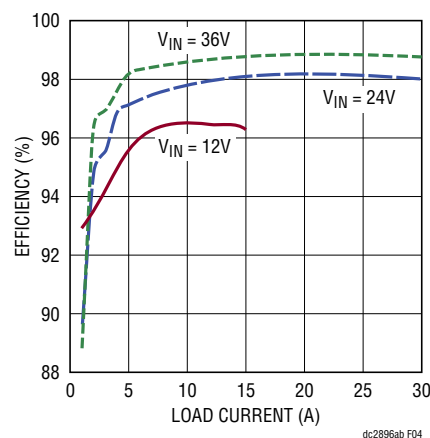


Figure 4. Efficiency vs Output Current and Input Voltage, V_{OUT} Is 48V



QUICK START PROCEDURE

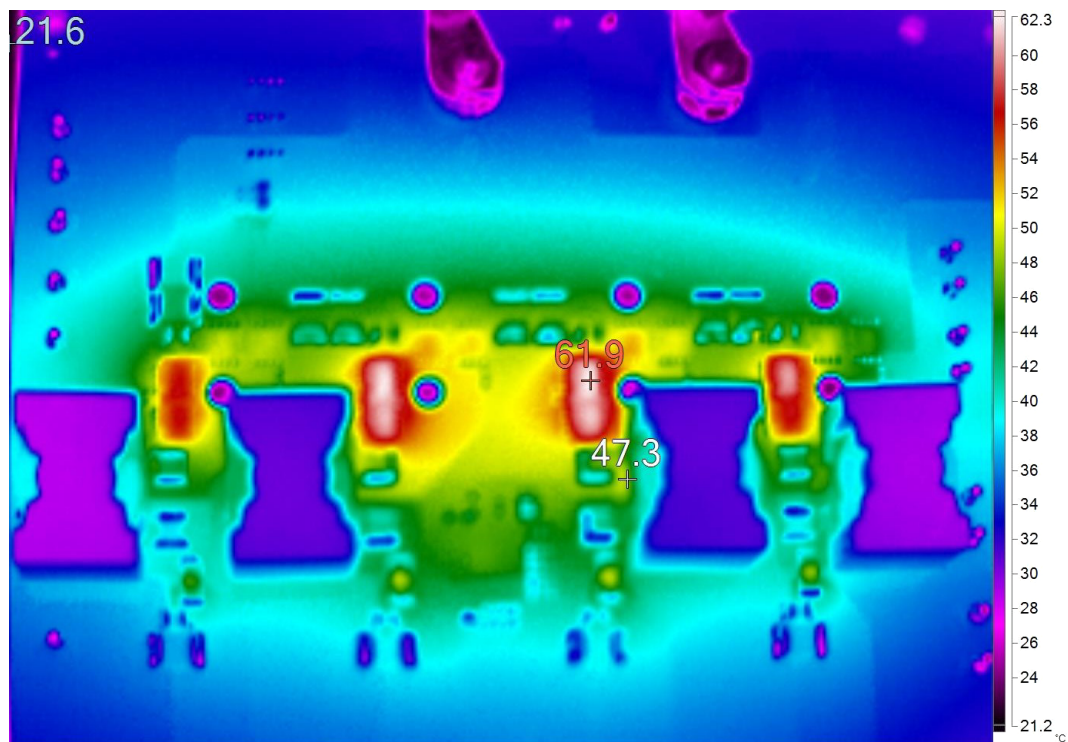


Figure 6. Thermal Map of Four Phases of LT8551 Multiphase Boost Converter Expander.
Input Voltage 24V, Output 48V at 25A, Convection Cooling, No Air Flow

PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|------------------------------------|-----|---|---|---|
| Required Circuit Components | | | | |
| 1 | 2 | C1, C23 | CAP., 1 μ F, X7R, 50V, 10%, 1206 | AVX, 12065C105KAT2A |
| 2 | 2 | C2, C33 | CAP., 2.2 μ F, X5R, 25V, 10%, 0603 | MURATA, GRM188R61E225KA12D |
| 3 | 1 | C3 | CAP., 10 μ F, X5R, 16V, 10%, 0603 | AVX, 0603YD106KAT2A |
| 4 | 13 | C4, C5, C7-C13, C15, C30, C35, C55 | CAP., 1000pF, X7R, 25V, 10%, 0603 | AVX, 06033C102KAT2A |
| 5 | 1 | C6 | CAP., 100pF, X7R, 16V, 10%, 0603 | AVX, 0603YC101KAT2A |
| 6 | 1 | C16 | CAP., 10 μ F, ALUM. ELECT., 100V, 20%, 6.3x7.7 | SUN ELECTRONIC INDUSTRIES CORP, 100CE10BS |
| 7 | 5 | C17-C20, C22 | CAP., 0.22 μ F, X5R, 16V, 10%, 0603 | AVX, 0603YD224KAT2A |
| 8 | 4 | C21, C27, C34, C37 | CAP., 0.1 μ F, X7R, 50V, 10%, 0603 | AVX, 06035C104KAT2A |
| 9 | 1 | C24 | CAP., 1 μ F, X7R, 16V, 10%, 0603 | AVX, 0603YC105KAT2A |
| 10 | 1 | C25 | CAP., 1 μ F, X5R, 25V, 10%, 0603 | AVX, 06033D105KAT2A |
| 11 | 1 | C26 | CAP., 4.7pF, C0G, 25V, 10%, 0603 | AVX, 06033A4R7KAT2A |
| 12 | 1 | C28 | CAP., 2.2 μ F, X7R, 100V, 10%, 1210 | AVX, 12101C225KAT2A |
| 13 | 1 | C29 | CAP., 4.7 μ F, X7R, 25V, 10%, 0805 | AVX, 08053C475KAT2A |
| 14 | 1 | C31 | CAP., 0.015 μ F, X7R, 25V, 10%, 0603 | AVX, 06033C153KAT2A |
| 15 | 1 | C32 | CAP., 47 μ F, X5R, 16V, 20%, 1210 | AVX, 1210YD476MAT2A |
| 16 | 2 | C36, C57 | CAP., 0.01 μ F, X7R, 16V, 10%, 0603 | AVX, 0603YC103KAT2A |
| 17 | 1 | C58 | CAP., 22pF, C0G, 50V, 5%, 0603 | AVX, 06035A220JAT2A |
| 18 | 2 | C60, C61 | CAP., 100 μ F, ALUM. ELECT., 100V, 20%, 16x16.5mm SMD, RADIAL, Sn PLATING | SUN ELECTRONIC INDUSTRIES CORP, 100CE100BST |
| 19 | 2 | C62, C63 | CAP., 1000 μ F, ALUM. ELECT., 50V, 20%, 16x16.5mm SMD, RADIAL, AEC-Q200 | PANASONIC, EEEFK1H102AM |
| 20 | 5 | CIN1, CIN3, CIN5, CIN7, CIN9 | CAP., 10 μ F, X7R, 63V, 10%, 1210 | SAMSUNG, CL32B106KMVNNWE |
| 21 | 15 | CIN2, CIN4, CIN6, CIN8, CIN10, COUT2, COUT3, COUT5, COUT6, COUT8, COUT9, COUT11, COUT12, COUT14, COUT15 | CAP., 15 μ F, X7S, 100V, 20%, 2220, AEC-Q200 | TDK, CGA9P3X7S2A156M250KB |
| 22 | 5 | COUT1, COUT4, COUT7, COUT10, COUT13 | CAP., 4.7 μ F, X7S, 100V, 10%, 1210 | SAMSUNG, CL32Y475KCVZW6E |
| 23 | 5 | D1-D5 | DIODE, SCHOTTKY, 70V, 70mA, SOD-323, AEC-Q101 | INFINEON, BAS170W |
| 24 | 2 | D6, D7 | DIODE, SCHOTTKY, 100V, 250mA, SOD-323F, AEC-Q101 | NEXPERIA, BAT46WJ, 115 |
| 25 | 1 | D8 | DIODE, GP SWITCHING, 80V, 125mA, SOD523, AEC-Q10X | DIODES INC., 1N4448HWT-7 |
| 26 | 4 | J1-J4 | EVAL BOARD STUD HARDWARE SET, #10-32 | ANALOG DEVICES, 720-0010 |
| 27 | 5 | L1-L5 | IND., 10 μ H, PWR, 10%, 28A, 2.86m Ω , SMD, SHIELDED, AEC-Q200 | COILCRAFT, SER2918H-103KL |
| 28 | 1 | L6 | IND., 22 μ H, PWR, SHIELDED, 20%, 1.41A, 110m Ω , 7345, AEC-Q200 | WURTH ELEKTRONIK, 7447779122 |
| 29 | 10 | Q1, Q2, Q5, Q6, Q9, Q10, Q13, Q14, Q17, Q18 | XSTR., MOSFET, N-CH, 60V, 50A, PG-TDSON-8 | INFINEON, BSC100N06LS3 G |
| 30 | 10 | Q3, Q4, Q7, Q8, Q11, Q12, Q15, Q16, Q19, Q20 | XSTR., MOSFET, N-CH, 60V, 100A, PG-TDSON-8 | INFINEON, BSC027N06LS5 |
| 31 | 1 | Q21 | XSTR., MOSFET, P-CH, 100V, 3.7A, SOT-223-4L, AEC-Q101 | DIODES INC., ZXMP10A18GTA |

DEMO MANUAL DC2896A-B

PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|------|-----|----------------------------|--|--------------------------------|
| 32 | 2 | R1, R2 | RES., 100k, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF1003V |
| 33 | 1 | R3 | RES., 14.3k, 1%, 1/10W, 0603, AEC-Q200 | VISHAY, CRCW060314K3FKEA |
| 34 | 3 | R4, R9, R16 | RES., 47k, 1%, 1/10W, 0603, AEC-Q200 | NIC, NRC06F4702TRF |
| 35 | 9 | R7, R11-R15, R21, R24, R25 | RES., 10 Ω , 1%, 1/10W, 0603 | VISHAY, CRCW060310R0FKEA |
| 36 | 1 | R8 | RES., 20 Ω , 5%, 1/10W, 0603, AEC-Q200 | VISHAY, CRCW060320R0JNEA |
| 37 | 1 | R17 | RES., 12.1k, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF1212V |
| 38 | 1 | R18 | RES., 464k, 1%, 1/10W, 0603 | SAMSUNG, RC1608F4643CS |
| 39 | 1 | R19 | RES., 7.87k, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF7871V |
| 40 | 1 | R20 | RES., 10k, 1%, 1/10W, 0603 | VISHAY, CRCW060310K0FKEC |
| 41 | 1 | R26 | RES., 10k, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF1002V |
| 42 | 1 | R27 | RES., 25.5k, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF2552V |
| 43 | 1 | R28 | RES., 162k, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF1623V |
| 44 | 2 | R29, R61 | RES., 1M, 1%, 1/10W, 0603, AEC-Q200 | VISHAY, CRCW06031M00FKEA |
| 45 | 1 | R34 | RES., 2 Ω , 1%, 1/10W, 0603 | VISHAY, CRCW06032R00FNEA |
| 46 | 1 | R42 | RES., 0 Ω , 1/10W, 0603 | BOURNS, CR0603-J/-000ELF |
| 47 | 1 | R82 | RES., 40.2k, 1%, 1/10W, 0603, AEC-Q200 | NIC, NRC06F4022TRF |
| 48 | 5 | RSNS1-RSNS5 | RES., 0.004 Ω , 1%, 3W, 2512, METAL, SENSE, AEC-Q200 | PANASONIC, ERJMS4SF4M0U |
| 49 | 1 | U1 | IC, GATE DRIVER BOOST CONVERTER, QFN-52 | ANALOG DEVICES, LT8551EUKG#PBF |
| 50 | 1 | U2 | IC, 60V LOW I _Q SYNCH. BOOST CTRLR., QFN-24 (UF) | ANALOG DEVICES, LTC3769EUF#PBF |
| 51 | 1 | U3 | IC, SYNCH. μ POWER STEP-DOWN REG., TSSOP-20 (FE16), 100V, 1A | ANALOG DEVICES, LT8631EFE#PBF |

Additional Demo Board Circuit Components

| | | | | |
|---|----|---|--------------------------------|--------------------------|
| 1 | 0 | C14, C38-C51, C53, C54, C56 | CAP., OPTION, 0603 | |
| 2 | 33 | R5, R10, R22, R44-R47, R64-R67, R86-R94, R99-R101, R112, R115, R117, R118, R121-R124, R129, R131 | RES., 0 Ω , 1/10W, 0603 | BOURNS, CR0603-J/-000ELF |
| 3 | 0 | R43, R50-R52, R54, R55, R68-R71, R76-R79, R81, R84, R85, R104, R105, R111, R113, R114, R116, R119, R120, R126, R128, R130 | RES., OPTION, 0603 | |
| 4 | 0 | R72-R75, R83 | RES., OPTION, 0805 | |

Hardware: For Demo Board Only

| | | | | |
|---|----|--|--|-----------------------------------|
| 1 | 24 | E1, E2, E4, E7, E9-E12, E16, E17, E19, E22, E28, E29, E34-E38, E40-E44 | TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK | MILL-MAX, 2308-2-00-80-00-00-07-0 |
| 2 | 1 | JP1 | CONN., HDR., MALE, 2x3, 2mm, VERT, ST, THT | WURTH ELEKTRONIK, 62000621121 |
| 3 | 2 | JP2, JP3 | CONN., HDR., MALE, 1x3, 2mm, VERT, ST, THT, NO SUBS. ALLOWED | WURTH ELEKTRONIK, 62000311121 |
| 4 | 4 | MP1-MP4 | STANDOFF, NYLON, SNAP-ON, 0.625 (5/8"), 15.9mm | KEYSTONE, 8834 |
| 5 | 3 | XJP1-XJP3 | CONN., SHUNT, FEMALE, 2 POS, 2mm | WURTH ELEKTRONIK, 60800213421 |

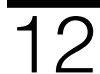


SCHEMATIC DIAGRAM





SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM

MP1
MP2
MP3
MP4
LB1
STNCL1
PCB1

STANDOFF,NYLON,SNAP-ON,0.625 (5/8"),15.9mm
STANDOFF,NYLON,SNAP-ON,0.625 (5/8"),15.9mm
STANDOFF,NYLON,SNAP-ON,0.625 (5/8"),15.9mm
STANDOFF,NYLON,SNAP-ON,0.625 (5/8"),15.9mm
LABEL
TOOL, STENCIL, 700-DC2896A REV02
PCB, DC2896A REV02

APPROVALS

PCB DES: LIT
APP ENG: VK

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TITLE: SCHEMATIC

MULTIPHASE BOOST CONVERTER EXPANDER
WITH INTERNAL GATE DRIVERS

IC NO. L78551/L78551EUK/LTC3769

SKU NO. DC2896A

SCHEMATIC NO. AND REVISION:
710-DC2896A_REV01

SIZE: N/A

DATE: 09-05-19

SHEET 5 OF 4

DEMO MANUAL DC2896A-B



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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