# LTC7880
# High Voltage Dual Step-up DC/DC Converter with Digital Power System Management

## DESCRIPTION

Demonstration circuit 2728A is a high voltage, dual output boost converter with 12V to 24V input range. The output voltage is adjustable from $V_{IN}$ to 48V. Each output can supply 5A maximum load current. The demo board has a LTC®7880 controller, which is a 60V dual output step-up controller with digital power system management. Please see LTC7880 data sheet for more detailed information.

DC2728A powers up to default settings and produces power based on configuration resistors or its nonvolatile memory (NVM) without the need for any serial bus communication. This allows easy evaluation of the DC/DC converter. To fully explore the extensive power system management features of the part, download the GUI software LTpowerPlay® onto your PC and use ADI's I²C/SMBus/PMBus dongle DC1613A to connect to the board. LTpowerPlay allows the user to reconfigure the part on-the-fly and store the configuration in EEPROM, view telemetry of voltage, current, temperature and fault status.

### GUI Download

The software can be downloaded from:

LTpowerPlay

For more details and instructions of LTpowerPlay, please refer to LTpowerPlay GUI for LTC7880 Quick Start Guide.

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



## BOARD PHOTO

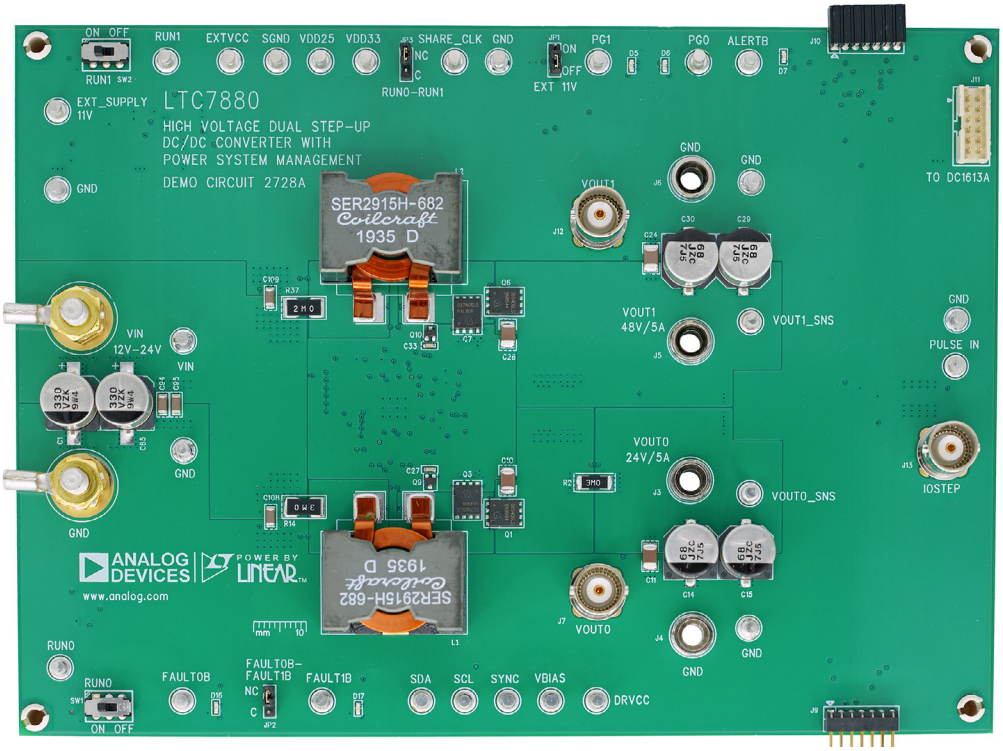



**Figure 1. Dual Output LTC7880/DC2728A Demo Circuit**

## PERFORMANCE SUMMARY

**Specifications are at $T_A$ = 25°C**

| PARAMETER | CONDITIONS | VALUE |
|---|---|---|
| Input Voltage Range | | 12V to 24V |
| Output Voltage, $V_{OUT0}$ | $V_{IN}$ = 12V to 24V, $I_{OUT0}$ = 0A to 5A | 24V to 48V, Default: 24V |
| Maximum Output Current, $I_{OUT0}$ | $V_{IN}$ = 12V to 24V, $V_{OUT0}$ = 24V to 48V | 5A |
| Output Voltage, $V_{OUT1}$ | $V_{IN}$ = 12V to 24V, $I_{OUT1}$ = 0A to 5A | 24V to 48V, Default: 48V |
| Maximum Output Current, $I_{OUT1}$ | $V_{IN}$ = 12V to 24V, $V_{OUT1}$ = 24V to 48V | 5A |
| Typical Efficiency of CH0 | $V_{IN}$ =12V, $V_{OUT0}$ = 24V, $I_{OUT0}$ = 5A | 98.1% (See Figure 5) |
| Typical Efficiency of CH1 | $V_{IN}$ = 12V, $V_{OUT1}$ = 48V, $I_{OUT1}$ = 5A | 97.1% (See Figure 6) |
| Default Switching Frequency | | 150kHz |

## QUICK START PROCEDURE

Demonstration circuit 2728A is easy to set up to evaluate the performance of the LTC7880. Refer to Figure 2 for the proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input power supply to $V_{IN}$ (12V to 24V) and GND (input return). Make sure the input power supply is capable of 35A at 12V.
2. Connect the 24V output load between $V_{OUT0}$ and GND (Initial Load: no load).
3. Connect the 48V output load between $V_{OUT1}$ and GND (Initial Load: no load).
4. Connect the DVMs to the input and outputs. Set default jumper position: SW1: ON; SW2: ON; JP1: OFF; JP2: NC; JP3: NC.
5. Turn on the input power supply and check for the proper output voltages. $V_{OUT0}$ should be 24V ± 0.5%, and $V_{OUT1}$ should be 48V ± 0.5%.
6. 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.
7. Connect the dongle and control the output voltages from the GUI. See the LTpowerPlay GUI for the LTC7880 Quick Start Guide for details.

   **NOTE:** 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.

# QUICK START PROCEDURE

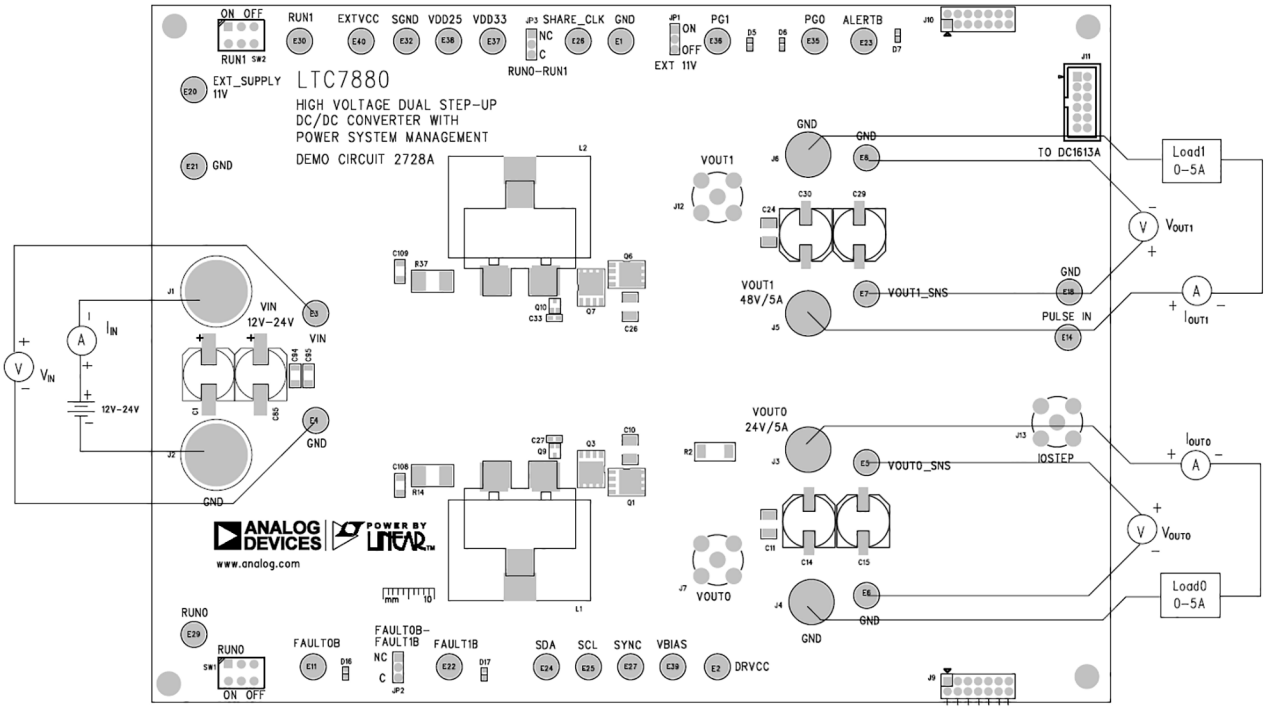



**Figure 2. Proper Measurement Equipment Setup**

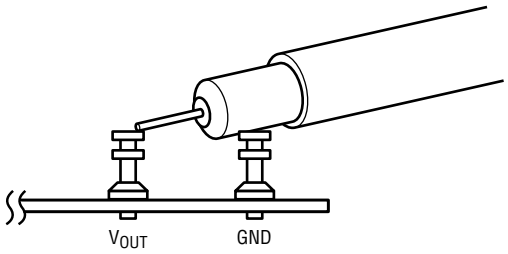



**Figure 3. Proper Measurement Equipment Setup**

# QUICK START PROCEDURE

### Connecting a PC to DC2728A

You can use a PC to reconfigure the power management features of the LTC7880 such as: nominal $V_{OUT}$, margin set points, OV/UV limits, temperature fault limits, sequencing parameters, the fault log, fault responses, GPIOs and other functionalities. The DC1613A dongle may be plugged when $V_{IN}$ is present.

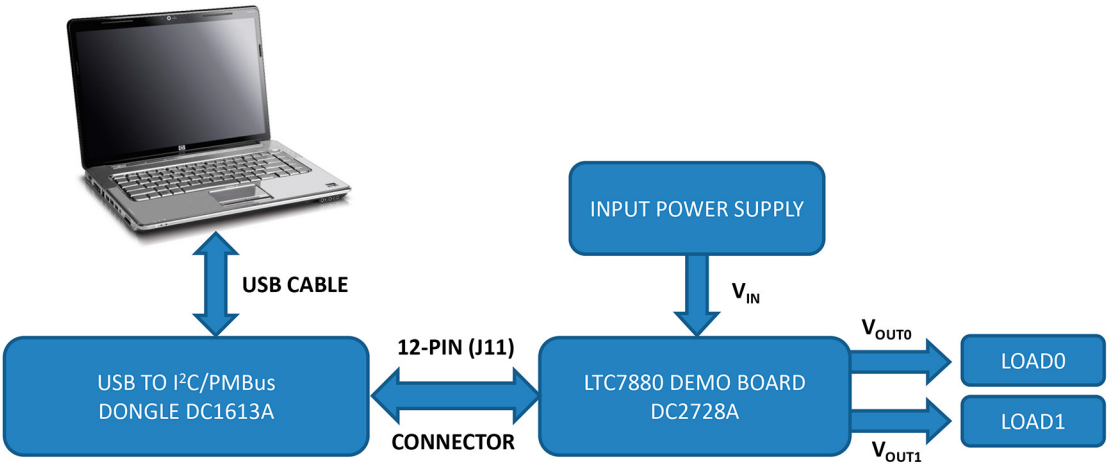



**Figure 4. Demo Setup with PC**

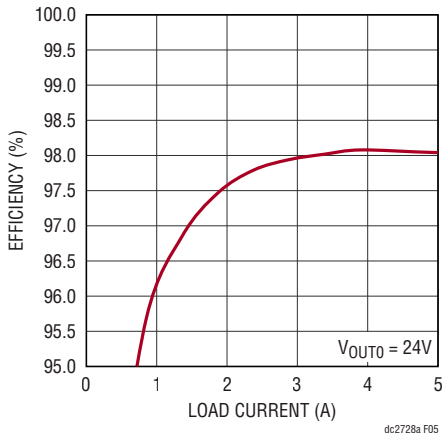



**Figure 5. Efficiency vs Load Current on CH0 (CH1 is Disabled)**

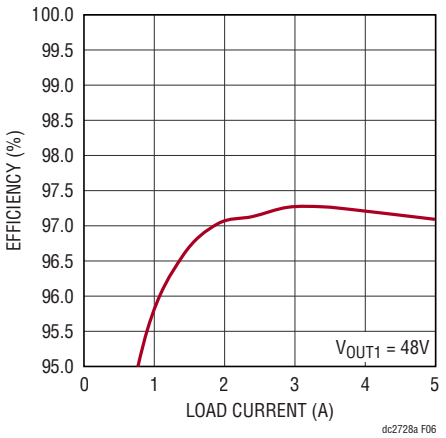



**Figure 6. Efficiency vs Load Current on CH1 (CH0 is Disabled)**

## QUICK START PROCEDURE

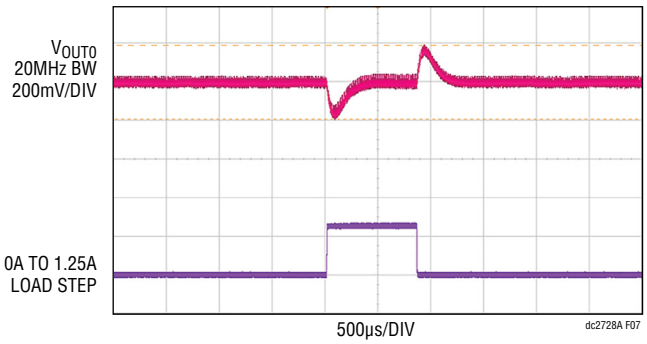



Figure 7. $V_{OUT0}$ Load Transient Response at $V_{IN}$ = 12V, $V_{OUT0}$ = 24V

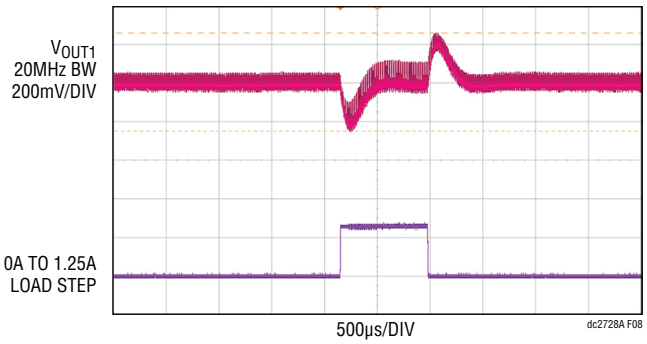



Figure 8. $V_{OUT1}$ Load Transient Response at $V_{IN}$ = 12V, $V_{OUT1}$ = 48V

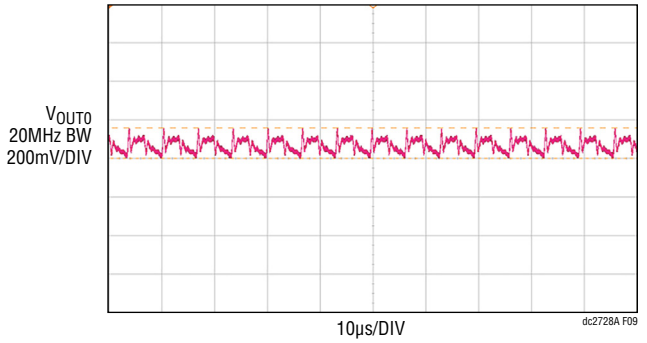



Figure 9. $V_{OUT0}$ Voltage Ripple at $V_{IN}$ = 12V, $V_{OUT0}$ = 24V, $I_{OUT0}$ = 5A

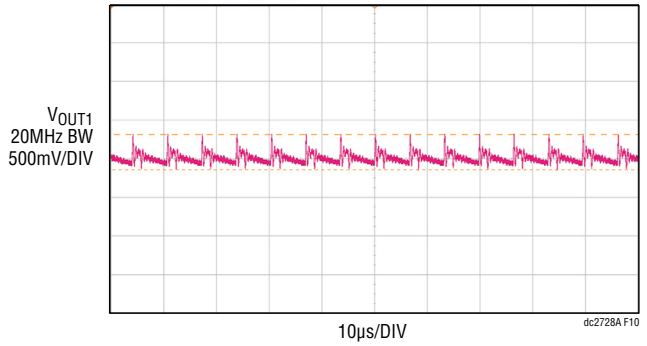



Figure 10. $V_{OUT1}$ Voltage Ripple at $V_{IN}$ = 12V, $V_{OUT1}$ = 48V, $I_{OUT1}$ = 5A

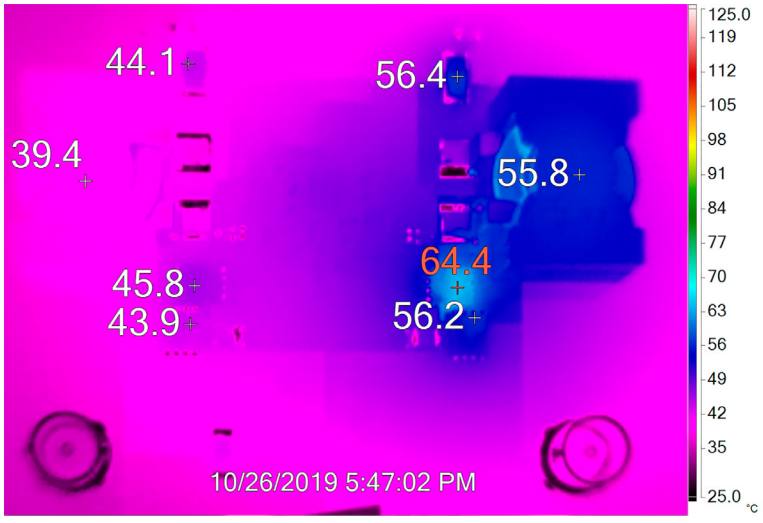



Figure 11. Thermal at $V_{IN}$ =12V, $V_{OUT0}$ = 24V, $I_{OUT0}$ = 5A, $V_{OUT1}$ = 48V, $I_{OUT1}$ = 5A, $T_A$ = 25°C, No Airflow

## LTPOWERPLAY SOFTWARE GUI

LTpowerPlay is a powerful Windows-based development environment that supports Analog Devices power system management ICs and µModule® products, including LTM4675, LTM4676, LTM4677, LTM4678, LTM4680, LTM4700, LTM4664, LTC3880, LTC3882, LTC3883, LTC3884 and LTC7880. The software supports a variety of different tasks. You can use LTpowerPlay to evaluate Analog Devices ICs by connecting to a demo board system. LTpowerPlay can also be used in an offline mode (with no hardware present) in order to build a multichip configuration file that can be saved and reloaded at a later time. LTpowerPlay provides unprecedented diagnostic and debug features. It becomes a valuable diagnostic tool during board bring-up to program or tweak the power management scheme in a system, or to diagnose power issues when bringing up rails. LTpowerPlay utilizes the DC1613A USB-to-SMBus controller to communicate with one of many potential targets, including LTM4675, LTM4676, LTM4677, LTM4678, LTM4680, LTM4700, LTM4664, LTC3880, LTC3882, LTC3883, LTC3884 and LTC7880's demo system, or a customer board. The software also provides an automatic update feature to keep the software current with the latest set of device drivers and documentation. The LTpowerPlay software can be downloaded from:

LTpowerPlay

To access technical support documents for ADI Digital Power Products visit the LTpowerPlay Help menu. Online help also available through the LTpowerPlay.

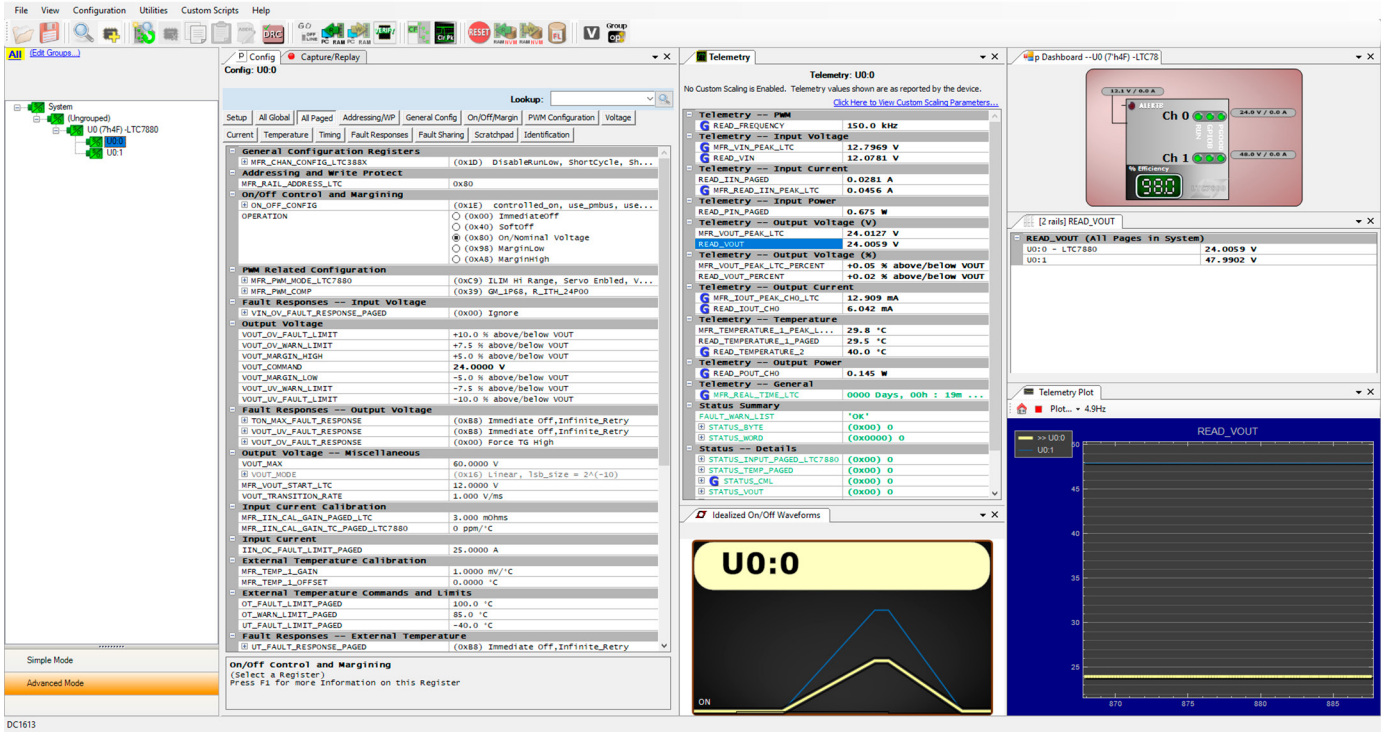



**Figure 12. LTpowerPlay Main Interface**

## LTPOWERPLAY QUICK START PROCEDURE

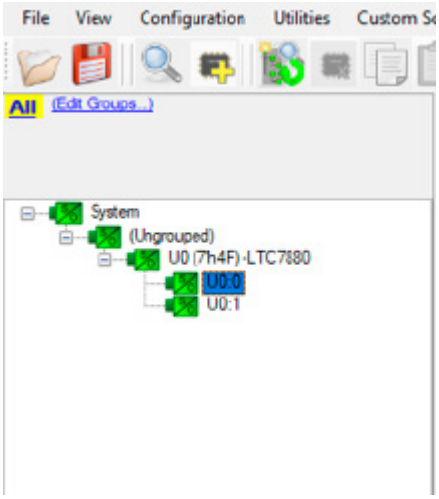
The following procedure describes how to use LTpowerPlay to monitor and change the settings of LTC7880.

1. Download and install the LTPowerPlay GUI:

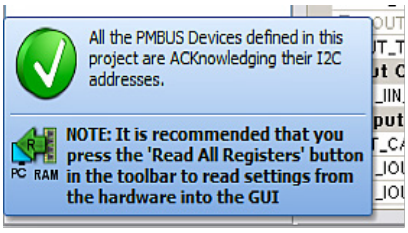
   LTpowerPlay

2. Launch the LTpowerPlay GUI.

a. The GUI should automatically identify the DC2728A. The system tree on the left-hand side should look like this:

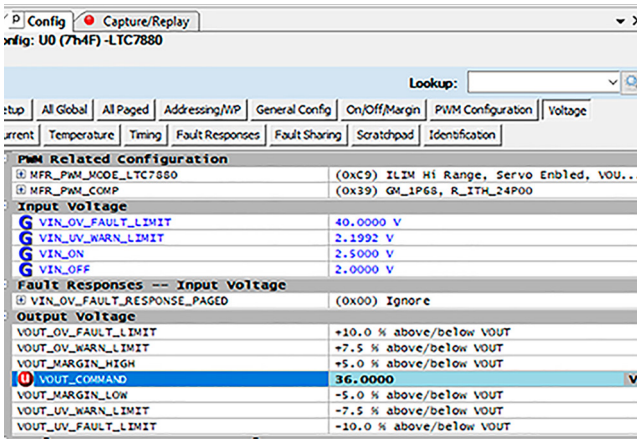



b. A green message box shows for a few seconds in the lower left hand corner, confirming that LTC7880 is communicating:



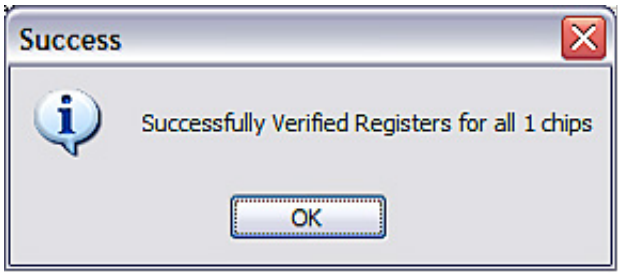

c. In the Toolbar, click the "R" (RAM to PC) icon to read the RAM from the LTC7880. This reads the configuration from the RAM of LTC7880 and loads it into the GUI.


d. If you want to change the output voltage to a different value, like 36V. In the Config tab, type in 36 in the VOUT_COMMAND box, like this:




Then, click the "W" (PC to RAM) icon to write these register values to the LTC7880. After finishing this step, you will see the output voltage will change to 36V.


If the write is successful, you will see the following message:




e. You can save the changes into the NVM. In the tool bar, click "RAM to NVM" button, as following:


f. Save the demo board configuration to a (*.proj) file. Click the Save icon and save the file. Name it whatever you want.

## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components** | | | | |
| 1 | 2 | C1, C85 | CAP., 330µF, HYBRID, 35V, 20%, SMD | PANASONIC, EEHZK1V331P |
| 2 | 3 | C3, C37, C38 | CAP., 2.2µF, X5R, 50V, 10%, 0603 | MURATA, GRM188R61H225KE11D |
| 3 | 4 | C4, C5, C27, C33 | CAP., 0.01µF, X7R, 100V, 10%, 0603 | AVX, 06031C103KAT2A |
| 4 | 3 | C6, C13, C28 | CAP., 0.001µF, X7R, 100V, 10%, 0603 | AVX, 06031C102KAT2A |
| 5 | 2 | C9, C23 | CAP., 0.1µF, X7R, 100V, 10%, 0603 | AVX, 06031C104KAT2A |
| 6 | 8 | C10-C12, C24-C26, C88, C93 | CAP., 4.7µF, X7S, 100V, 10%, 1210 | TDK, C3225X7S2A475K200AB |
| 7 | 8 | C14, C15, C16, C17, C29, C30, C31, C32 | CAP., 68µF, ALUM. ELECT., 63V, 20%, 10mm × 10.2mm SMD, AEC-Q200 | PANASONIC, EEHZC1J680P |
| 8 | 2 | C18, C34 | CAP., 0.0047µF, X7R, 50V, 10%, 0603 | SAMSUNG, CL10B472KB8NNNC |
| 9 | 2 | C20, C36 | CAP., 100pF, C0G, 50V, 5%, 0603 | AVX, 06035A101JAT2A |
| 10 | 2 | C39, C40 | CAP., 4.7µF, X5R, 35V, 10%, 0603 | MURATA, ZRB18AR6YA475KE05L |
| 11 | 1 | C77 | CAP., 1000pF, C0G, 100V, 5%,0805 | MURATA, GRM2195C2A102JA01D |
| 12 | 8 | C94, C95, C104-C109 | CAP., 22µF, 20%, 35V, JB, 1206 | TDK, C3216JB1V226M160AC |
| 13 | 3 | D1, D2, D15 | DIODE, SCHOTTKY, 100V, 1A, POWER DI-123, AEC-Q101 | DIODES, INC., DFLS1100-7 |
| 14 | 2 | L1, L2 | IND., 6.8µH, HIGH CURRENT, 10%, 30A, 2.06mΩ, 2815 SMD | COILCRAFT, SER2915H-682KL |
| 15 | 4 | Q1, Q2, Q5, Q6 | MOSFET, N-CH, 60V, 64A, PG-TDSON-8 | INFINEON, BSC065N06LS5ATMA1 |
| 16 | 4 | Q3, Q4, Q7, Q8 | MOSFET, N-CH, 60V, 100A, PG-TDSON-8 | INFINEON, BSC027N06LS5ATMA1 |
| 17 | 2 | Q9, Q10 | MOSFET, PNP, 40V, 0.2A, SC70-3 | DIODES, INC., MMST3906-F |
| 18 | 1 | R2 | RES., 0.003Ω, 1%, 1W, 2010 | PANASONIC, ERJMP3MF3M0U |
| 19 | 2 | R3, R4 | RES., 1k, 5%, 1/10W, 0603, AEC-Q200 | VISHAY, CRCW06031K00JNEA |
| 20 | 9 | R10, R11, R13, R15, R16, R18, R23, R25, R28 | RES., 10k,5%, 1/10W, 0603 | VISHAY, CRCW060310K0JNEA |
| 21 | 2 | R12, R38 | RES, 2Ω, 5%, 1/10W, 0603 | VISHAY CRCW06032R00JNEA |
| 22 | 1 | R14 | RES., 0.003Ω, 1%, 3W, 2512 | PANASONIC, ERJMP4QF3M0U |
| 23 | 10 | R17, R21, R22, R30, R43-R45, R175, R177, R178 | RES., 0Ω, 1/10W, 0603 | VISHAY CRCW06030000Z0EA |
| 24 | 4 | R24, R26, R50, R51 | RES., 10Ω, 5%, 1/10W, 0603 | VISHAY CRCW060310R0JNEA |
| 25 | 1 | R37 | RES., 0.002Ω, 1%, 3W, 2512 | PANASONIC, ERJMP4QF2M0U |
| 26 | 1 | R92 | RES.,1.0Ω, 5%, 1/2W, 0805 | PANASONIC, ERJ6DQJ1R0V |
| 27 | 1 | U1 | IC, 60V DUAL OUTPUT STEP-UP CONTROLLER WITH PSM, 52-LEAD (7mm × 8mm), QFN | ADI., LTC7880IUKG#PBF |
| **Additional Demo Board Circuit Components** | | | | |
| 1 | 0 | C19, C35, C71, C73 | OPT, 0603 | |
| 2 | 2 | C70, C103 | CAP., 1.0µF, X7S, 100V, 10%, 0805 | MURATA, GRJ21BC72A105KE11L |
| 3 | 1 | C72 | CAP., 0.047µF, X7R, 25V, 10%, 0603 | AVX, 06033C473KAT2A |
| 4 | 1 | C74 | CAP., 2.2µF, X7R, 100V, 10%, 1210 | AVX, 12101C225KAT2A |
| 5 | 0 | C75 | OPT, 1210 | |
| 6 | 1 | C76 | CAP., 0.1µF, X7R, 100V, 10%, 0603 | AVX, 06031C104KAT2A |
| 7 | 1 | C78 | CAP., 0.22µF, X7R, 100V, 10%, 0805 | MURATA, GRM21AR72A224KAC5L |

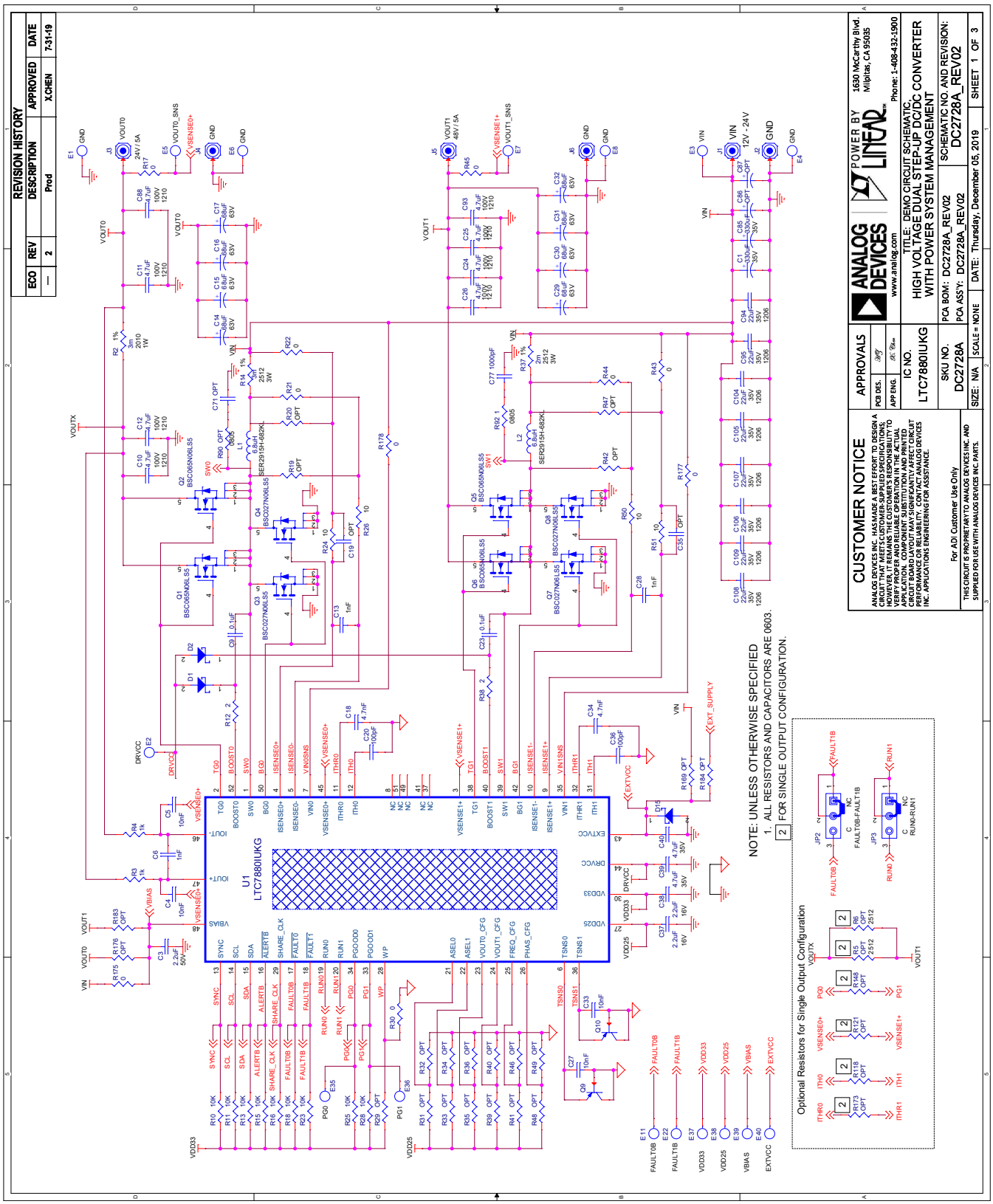
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| 8 | 2 | C79, C80 | CAP., 100µF, X5R, 16V, 20%, 1210 | TAIYO YUDEN, EMK325ABJ107MM-T |
| 9 | 1 | C81 | CAP., 220pF, X7R, 50V, 10%, 0603 | AVX, 06035C221KAT2A |
| 10 | 2 | C82, C83 | CAP., 0.01µF, X7R, 100V, 10%, 0603 | AVX, 06031C103KAT2A |
| 11 | 1 | C84 | CAP., 0.1µF, 20%, 25V, X5R, 0603 | AVX, 06033D104KAT2A |
| 12 | 0 | C86, C87 | OPT, 10mm × 10.2mm | |
| 13 | 1 | C110 | CAP., 1µF, X5R, 50V, 10%, 0603 | MURATA, GRT188R61H105KE13D |
| 14 | 2 | D5, D6 | LED, GREEN, COLORLESS DIFFUSED, 0603 | OSRAM, LS L29K-G2J1-24-Z |
| 15 | 3 | D7, D16, D17 | LED, RED, COLORLESS DIFFUSED, 0603 | OSRAM, LS L29K-H1J2-1-Z |
| 16 | 3 | D8, D9, D12 | OPT | |
| 17 | 1 | L5 | IND., 68µH, PWR, ±30%, 1.65A, 201mΩ, SMD 10.5mm × 10.3mm × 5.1mm | SUMIDA, CDRH105RNP-680NC |
| 18 | 1 | Q19 | MOSFET, N-CH 80V TO-263 | INFINEON, IPB031N08N5 |
| 19 | 3 | Q20, Q30, Q31 | MOSFET, P-CH, 20V, 5.9A, SOT-23, TO-236 | VISHAY, SI2365EDS-T1-GE3 |
| 20 | 2 | Q22, Q23 | MOSFET, N-CHAN,60V,115mA,SOT-23 | FAIRCHILD SEMI., 2N7002 |
| 21 | 0 | Q27 | OPT, SOT23 | |
| 22 | 0 | R5, R6 | OPT,2512 | |
| 23 | 0 | R19, R20, R29, R31-R36, R39-R42, R46-R48, R49, R100-R105, R108, R110, R111, R116-R118, R121, R144, R145, R147, R148, R169, R173, R176, R183, R184 | OPT, 0603 | |
| 24 | 2 | R87, R88 | RES., 200Ω, 5%, 1/10W, 0603 | VISHAY CRCW0603200RJNEA |
| 25 | 4 | R89, R97, R112, R113 | RES., 10k, 5%, 1/10W, 0603 | VISHAY, CRCW060310K0JNEA |
| 26 | 0 | R90 | OT, 0805 | |
| 27 | 1 | R91 | RES., 1Ω, 1%, 1W, 2010, SENSE, AEC-Q200 | WELWYN COMPONENTS/TT ELECT., LRC-LR2010-01-1R00-F |
| 28 | 3 | R93, R179, R180 | RES., 127Ω, 1%, 1/10W, 0603 | VISHAY CRCW0603127RFKEA |
| 29 | 1 | R96 | RES., 127k, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ-3EKF1273V |
| 30 | 3 | R98, R106, R109, R132, R174 | RES., 0Ω, 1/10W, 0603 | VISHAY CRCW06030000Z0EA |
| 31 | 1 | R99 | RES., 220k, 5%, 1/10W, 0603 | VISHAY CRCW0603220KJNEA |
| 32 | 0 | R107, R163 | OPT, 1206 | |
| 33 | 2 | R114, R115 | RES., 10Ω,5%, 1/10W, 0603 | VISHAY CRCW060310R0JNEA |
| 34 | 2 | R119, R120 | RES., 4.99k, 1%, 1/10W, 0603 | VISHAY CRCW06034K99FKEA |
| 35 | 1 | R146 | RES., 4.7Ω, 1%, 1/8W, 0805 | VISHAY, CRCW08054R70FKEA |
| 36 | 1 | R157 | RES, 2Ω, 5%, 1/10W ,0603 | VISHAY CRCW06032R00JNEA |
| 37 | 2 | R162, R185 | RES, 0Ω, JUMPER 1206 | VISHAY CRCW12060000Z0EA |
| 38 | 1 | U3 | IC, SYNCHR. STEP-DOWN CONVERTER, MSOP-16 | ANALOG DEVICES, LTC3630EMSE#PBF |
| 39 | 1 | U4 | IC, MEMORY, EEPROM, 2Kb (256×8), TSSOP-8, 400kHz | MICROCHIP, 24LC025-I/ST |

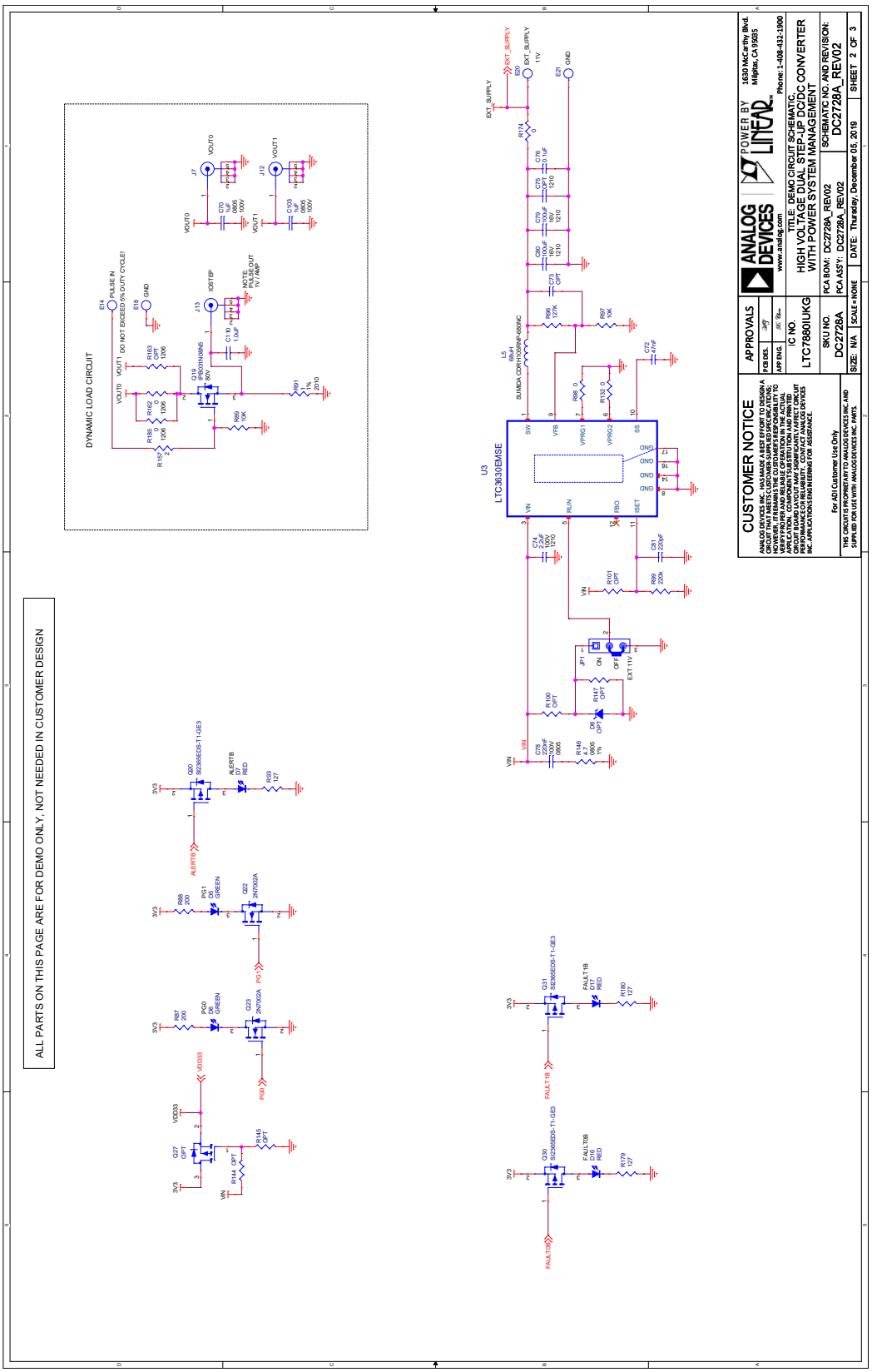
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Hardware: For Demo Board Only** | | | | |
| 1 | 27 | E1-E8, E11, E14, E18, E20-E27, E29, E30, E32, E35-E40 | TEST POINT, TURRET, 0.094, MTG. HOLE | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 2 | 3 | JP1, JP2, JP3 | CONN.,HDR,MALE,1×3, 2mm, THT, STR | WURTH ELEKTRONIK, 62000311121 |
| 3 | 2 | J1, J2 | STUD, FASTENER, #10-32 | PENNENGINEERING, KFH-032-10ET |
| 4 | 4 | J1, J2 x2 | NUT, BRASS 10-32 | ANY, 10-32M/S BR PL |
| 5 | 2 | J1, J2 | RING, LUG #10 | KEYSTONE, 8205 |
| 6 | 2 | J1, J2 | WASHER, TIN PLATED BRASS #10 | ANY, #10EXT BZ TN |
| 7 | 4 | J3, J4, J5, J6 | CONN.,BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE | KEYSTONE, 575-4 |
| 8 | 3 | J7, J12, J13 | CONN., RF, BNC, RCPT,THT, STR, 5-PIN | AMPHENOL CONNEX, 112404 |
| 9 | 1 | J9 | CONN.,HDR, MALE, 2×7,2mm, R/A THT | MOLEX, 87760-1416 |
| 10 | 1 | J10 | CONN.,HDR, FEMALE, 2×7, 2mm, R/A THT | SULLINS, NPPN072FJFN-RC |
| 11 | 1 | J11 | CONN.,HDR, SHROUDED, 2×6, 2mm, THT, VERT | FCI, 98414-G06-12ULF |
| 12 | 3 | XJP1, XJP2, XJP3 | CONN., SHUNT, FEMALE, 2 POS, 2mm | WURTH ELEKTRONIK, 60800213421 |
| 13 | 4 | STANDOFF | STANDOFF, NYLON, SNAP-ON, 0.625 (15.9mm) | KEYSTONE, 8834 |
| 14 | 1 | SW1,SW2 | SWITCH, SUB-MINIATURE SLIDE, DPDT, 0.3A, 6VDC, THT | C&K COMPONENTS, JS202011CQN |

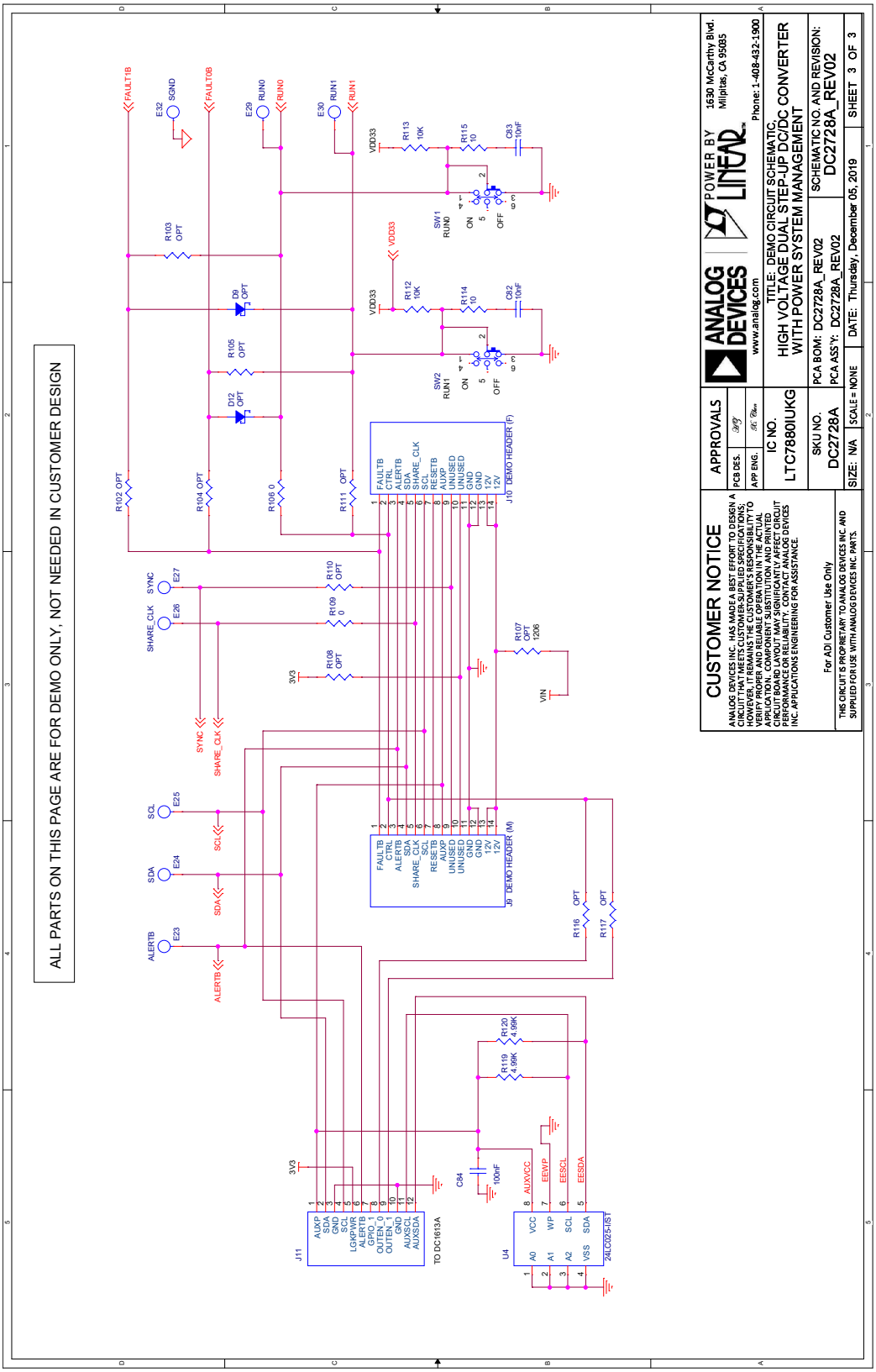
# SCHEMATIC DIAGRAM



## SCHEMATIC DIAGRAM



# 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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