# LTC3884EUK

# PolyPhase Single 240A Output Synchronous Buck Converter with Power System Management

## DESCRIPTION

Demonstration circuit 2084A is a high efficiency, high density, single-output Buck converter with a 10V to 14V input voltage range. The output voltage is adjustable from 0.5V to 1.5V and can supply up to 240A of load current. The demo board features the LTC®3884, a dual output PolyPhase® step-down controller for ultralow DCR sensing with digital power system management. Please see the LTC3884 data sheet for more detailed information.

The DC2084A powers up to default settings and produces power based on configuration resistors or with its non-volatile memory 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® on-to your PC and use LTC'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:

http://www.linear.com/ltpowerplay

For more details and instructions of LTpowerPlay, please refer to LTpowerPlay GUI for LTC3884 demo manual.

**Design files for this circuit board are available at http://www.linear.com/demo/DC2084A**

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## PERFORMANCE SUMMARY

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

| PARAMETER | CONDITIONS | VALUE |
|---|---|---|
| Input Voltage Range | | 10V to 14V |
| Output Voltage, $V_{OUT}$ | $V_{IN}$ = 10V to 14V, Single Output, $I_{OUT}$ = 0A to 240A | Default: 1V |
| Maximum Output Current, $I_{OUT}$ | $V_{IN}$ = 10V to 14V, Single Output, $V_{OUT}$ = 0.5V to 1.5V[1] | 240A |
| Typical Efficiency | $V_{IN}$ = 12V, Single Output, $V_{OUT}$ = 1.0V, 240A Load | 90.4% |
| Peak Efficiency | $V_{IN}$ = 12V, Single Output, $V_{OUT}$ = 1.0V, 140A Load | 91.3% |
| Default Switching Frequency | | 425kHz |

**Note 1:** For $V_{OUT}$ < 0.75V, $f_{SW}$ needs to be reduced due to $t_{ON(MIN)}$ limitation.

## QUICK START PROCEDURE

Demonstration circuit 2084A is easy to set up to evaluate the performance of the LTC3884. 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 $V_{IN}$ (10V to 14V) 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: JP1: OFF; JP2: LOWDCR; JP3: RANGE_HIGH; JP4: OFF; JP5: INT; SW2: OFF.
5. Turn on the input power supply and adjust voltage to 12V.

   NOTE: Make sure that the input voltage does not exceed 14V.
6. Turn on the switch: SW2: ON.
7. Check for the proper output voltages from $V_{OUT}^+$ to $V_{OUT}^-$.
8. Once the proper output voltage is established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage and other parameters.
9. Connect the dongle and control the output voltage from the GUI. See the LTpowerPlay Quick Start Procedure section for details.

Note: When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 2 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.

### Connecting a PC to DC2084A

You can use a PC to reconfigure the power management features of the LTC3884 such as: nominal $V_{OUT}$, margin set points, OV/UV limits, temperature fault limits, sequencing parameters, the fault log, fault responses and other functionality. The DC1613A dongle may be plugged when $V_{IN}$ is present.

## QUICK START PROCEDURE

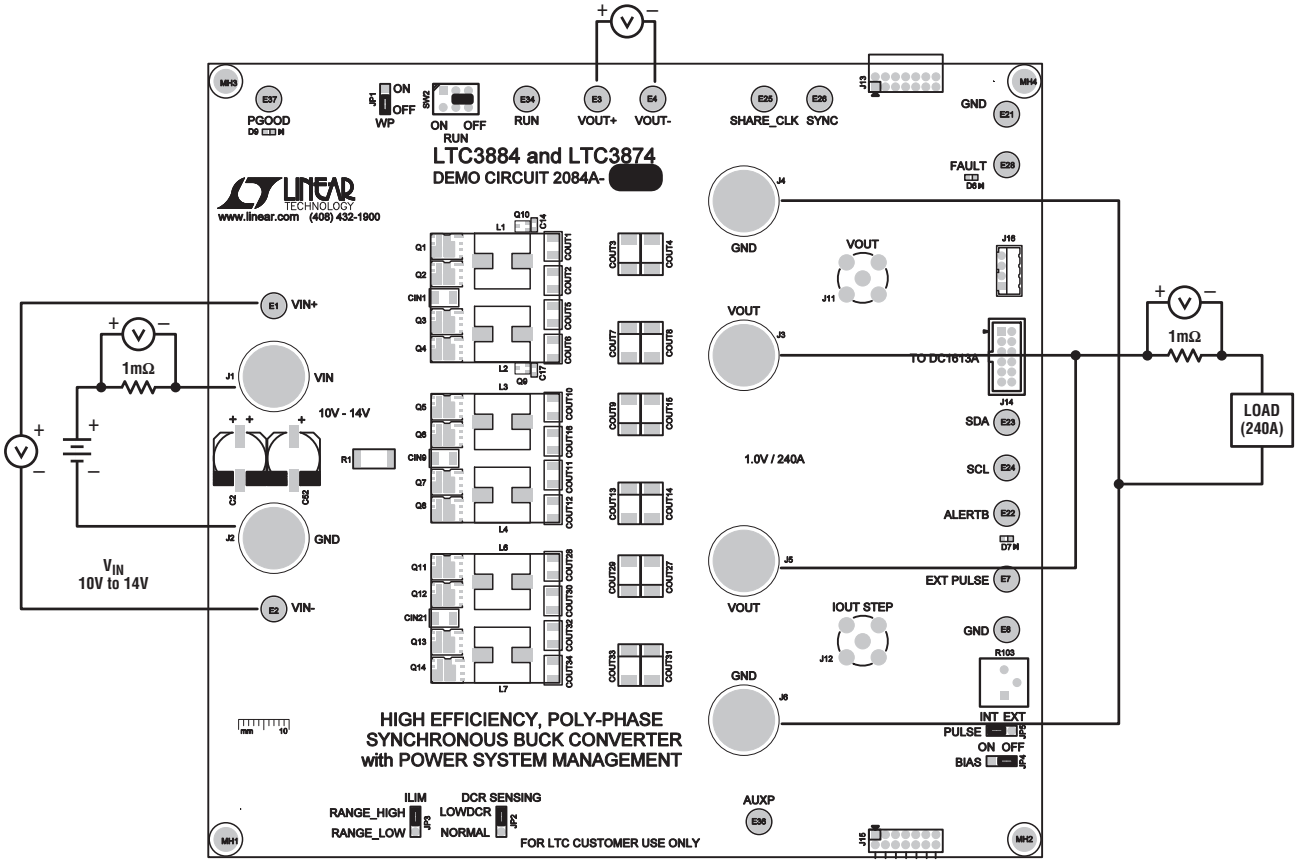



**Figure 1. Proper Measurement Equipment Setup**

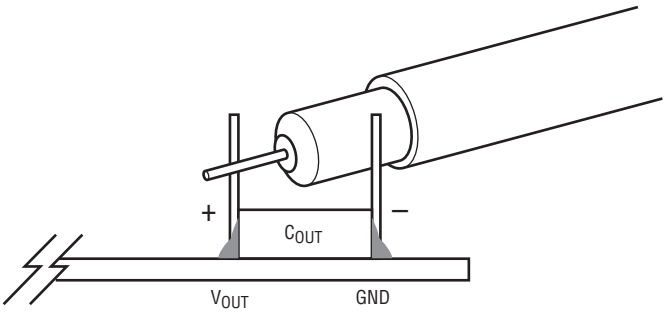



**Figure 2. Measuring Output Voltage Ripple**

## QUICK START PROCEDURE

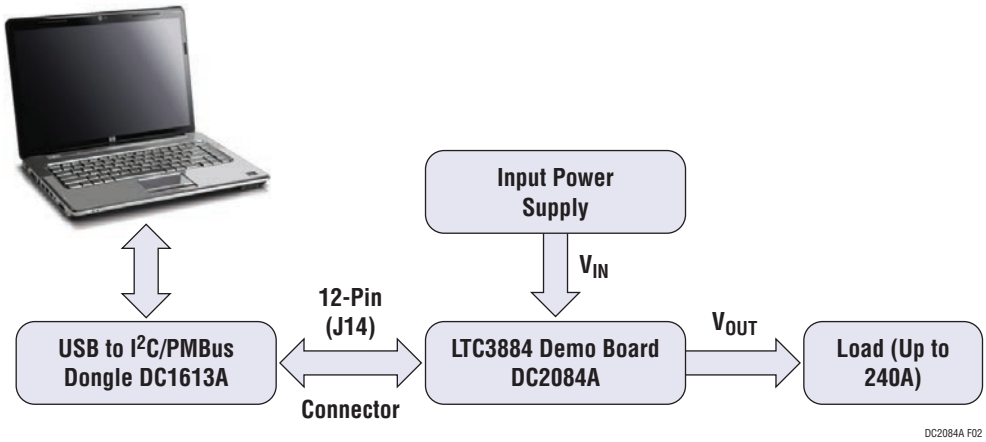



**Figure 3. Demo Setup with PC**

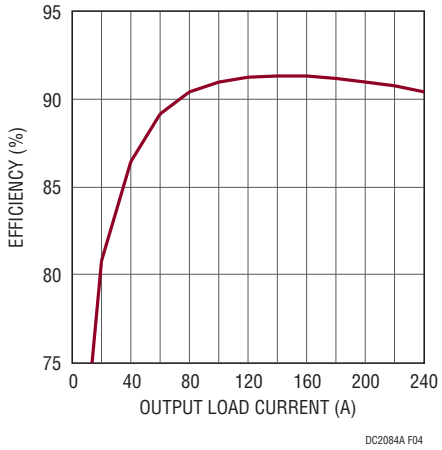



**Figure 4. Efficiency vs Load Current at $V_{IN}$ = 12V, $V_{OUT}$ = 1V, $f_{SW}$ = 425kHz**

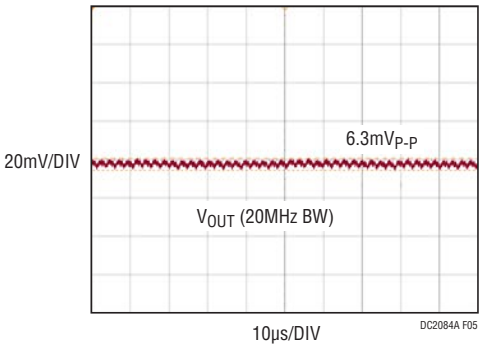



**Figure 5. Output Voltage Ripple at $V_{IN}$ = 12V, $V_{OUT}$ = 1V, $I_{OUT}$ = 240A**

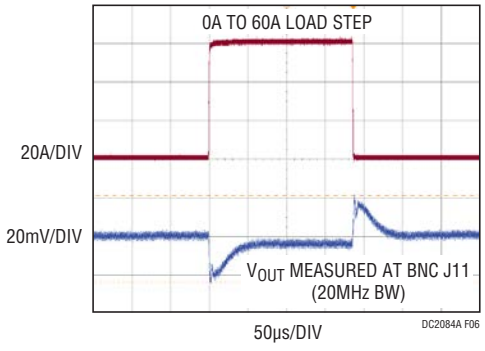



**Figure 6. Transient Response at $V_{IN}$ = 12V, $V_{OUT}$ = 1V**

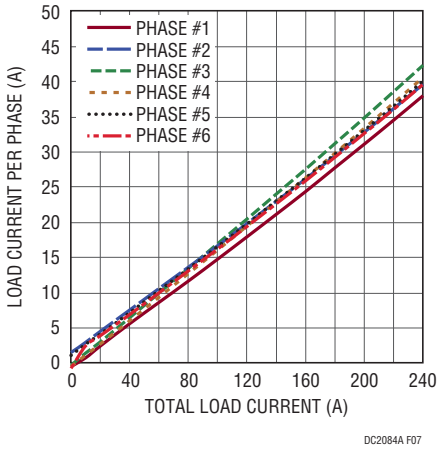



**Figure 7. Current Sharing vs Load Current at $V_{IN}$ = 12V, $V_{OUT}$ = 1V, $f_{SW}$ = 425kHz**

## QUICK START PROCEDURE

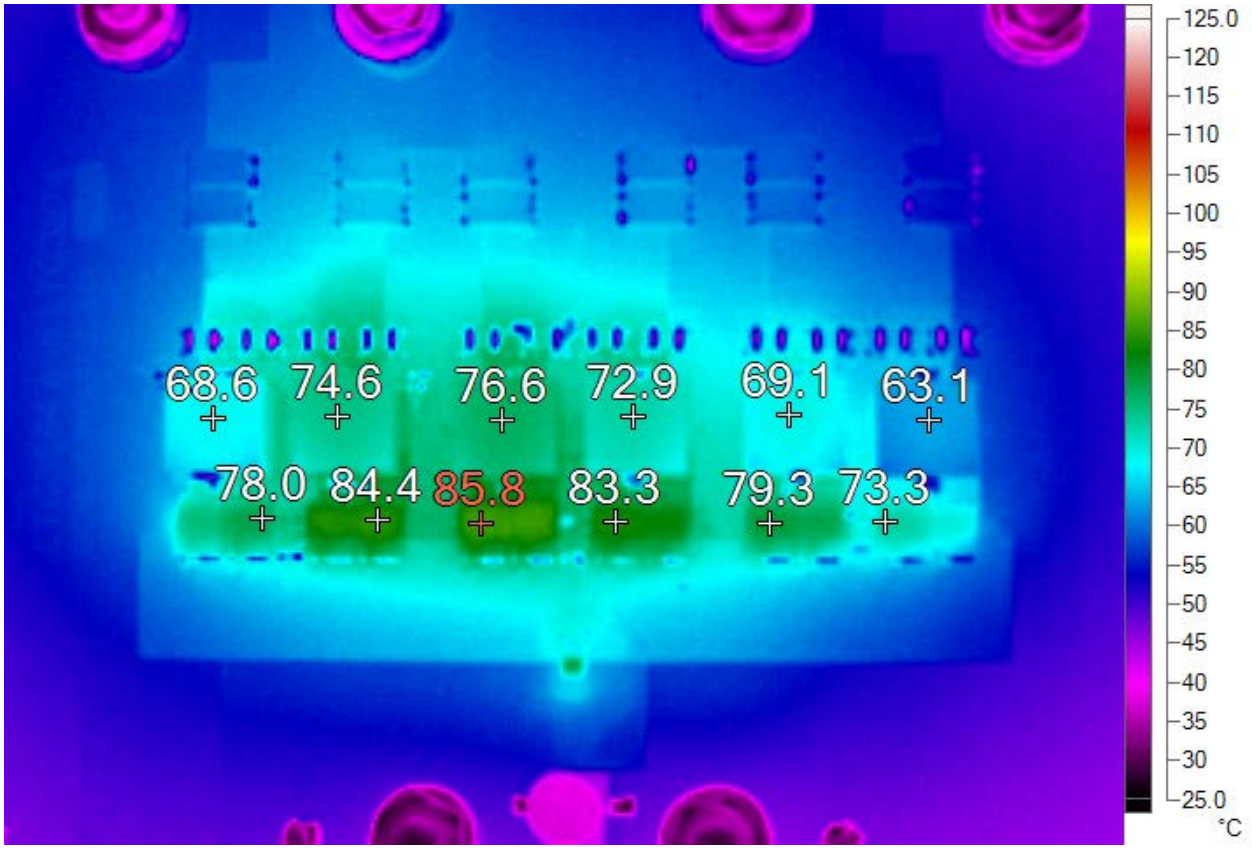



**Figure 8. Thermal Performance at $V_{IN}$ = 12V, $V_{OUT}$ = 1V, $I_{OUT}$ = 240A, $T_A$ = 23°C, 200LFM Airflow**

## LTpowerPlay SOFTWARE GUI

LTpowerPlay is a powerful Windows based development environment that supports Linear Technology power system management ICs, including the LTM4676, LTC3880, LTC3883, LTC3884, LTC2974 and LTC2978. The software supports a variety of different tasks. You can use LTpowerPlay to evaluate Linear Technology 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 the LTM4676, the LTC3880, LTC3884 and the LTC3883'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:

http://www.linear.com/ltpowerplay

To access technical support documents for LTC Digital Power Products visit Help. View online help on the LTpowerPlay menu.

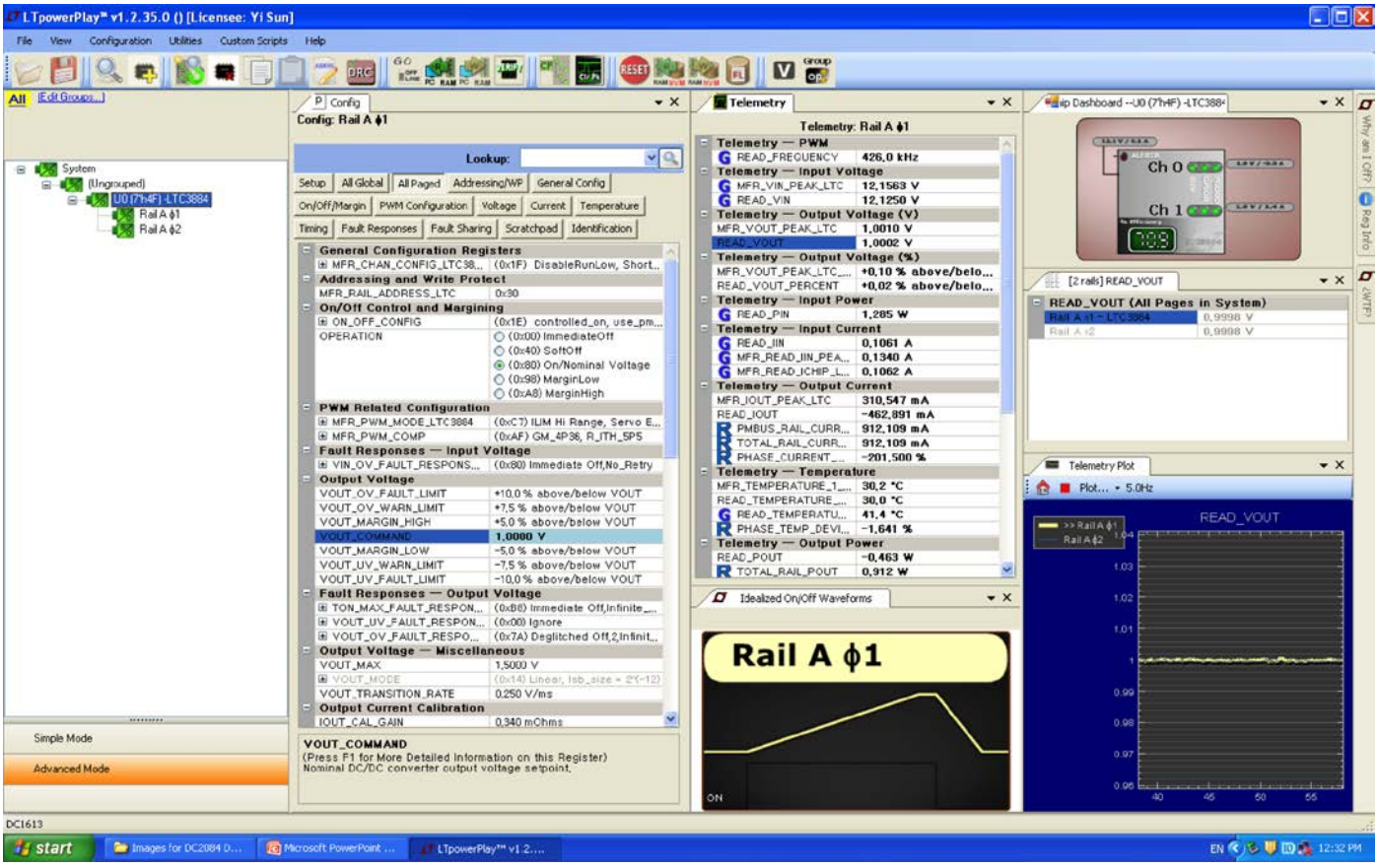



**Figure 9. LTpowerPlay Main Interface**

## LTpowerPlay QUICK START PROCEDURE

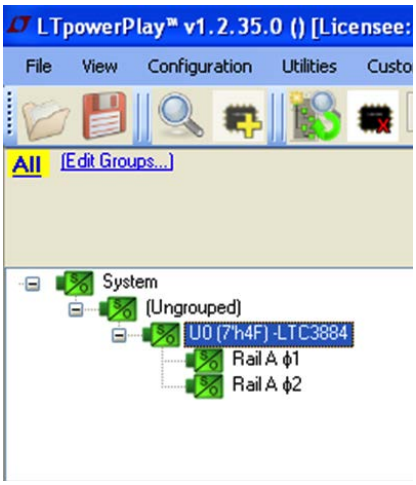
The following procedure describes how to use LTpowerPlay to monitor and change the settings of LTC3884.

1. Download and install the LTPowerPlay GUI:

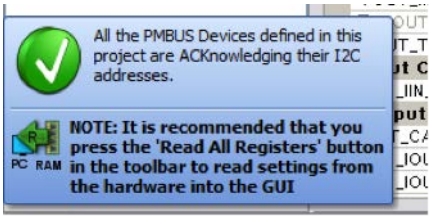
   http://www.linear.com/ltpowerplay

2. Launch the LTpowerPlay GUI.

   a. The GUI should automatically identify the DC2084A. The system tree on the left hand side should look like this:



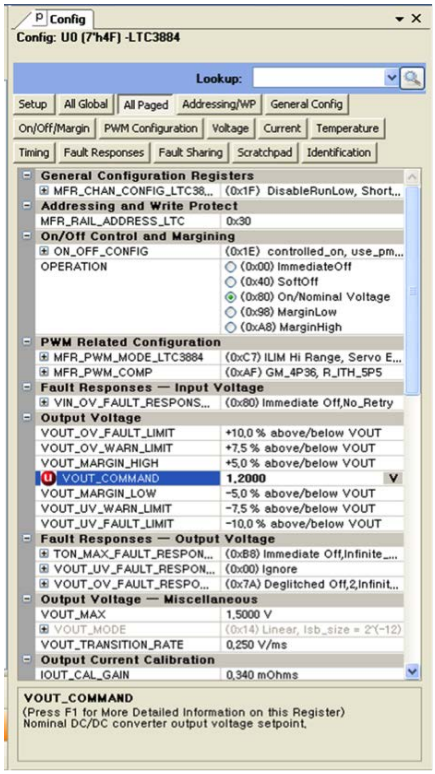

   b. A green message box shows for a few seconds in the lower left hand corner, confirming that LTC3884 is communicating:




   c. In the Toolbar, click the “R” (RAM to PC) icon to read the RAM from the LTC3884. This reads the configuration from the RAM of LTC3884 and loads it into the GUI.




   d. If you want to change the output voltage to a different value, like 1.2V. In the Config tab, type in 1.2 in the VOUT_COMMAND box, like this:




   Then, click the “W” (PC to RAM) icon to write these register values to the LTC3884. After finishing this step, you will see the output voltage will change to 1.2V.




   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 with a user filename.

## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components** | | | | |
| 1 | 24 | CIN1, CIN2, CIN3, CIN4, CIN5, CIN6, CIN7, CIN8, CIN9, CIN10, CIN11, CIN12, CIN13, CIN14, CIN15, CIN16, CIN21, CIN22, CIN23, CIN24, CIN25, CIN26, CIN27, CIN28 | CAP, 1210 22µF 10% 25V X7R | MURATA GRM32ER71E226KE15L |
| 2 | 19 | COUT1, COUT2, COUT5, COUT6, COUT10, COUT11, COUT12, COUT16, COUT19, COUT20, COUT24, COUT25, COUT28, COUT30, COUT32, COUT34, C34, C35, COUT41 | CAP, 1210 100µF 20% 6.3V X5R | TDK C3225X5R0J107M |
| 3 | 22 | COUT3, COUT4, COUT7, COUT8, COUT9, COUT13, COUT14, COUT15, COUT17, COUT18, COUT22, COUT23, COUT27, COUT29, COUT31, COUT33, COUT35, COUT36, COUT37, COUT38, COUT39, COUT40 | CAP, 7343 470µF 20% 2.5V TANT. POLYMER | PANASONIC ETPF470M5H |
| 4 | 6 | C7, C19, COUT26, C41, C42, C48 | CAP, 0603 1µF 20% 25V X5R | AVX 06033D105KAT2A |
| 5 | 1 | C1 | CAP, 0603 2.2µF 20% 6.3V X5R | TAIYO YUDEN JMK105BJ225MV-T |
| 6 | 4 | C2, C52, C53, C54 | CAP, 270µF 20% 16V OSCON | PANASONIC 16SVPC270M |
| 7 | 1 | C3 | CAP, 0805 2.2µF 10% 16V X7R | MURATA GRM21BR71C225KA12L |
| 8 | 6 | C4, C6, C18, C20, C46, C47 | CAP, 0603 4.7µF 10% 10V X5R | AVX 0603ZD475KAT2A |
| 9 | 6 | C8, C15, C25, C27, C37, C38 | CAP, 0603 0.1µF 10% 25V X5R | AVX 06033C104KAT2A |
| 10 | 6 | C9, C16, C21, C32, C33, C36 | CAP, 0603 220nF 10% 25V X7R | TDK C1608X7R1E224K |
| 11 | 1 | C12 | CAP, 0603 330pF 5% 50V C0G | MURATA GRM1885C1H331JD01D |
| 12 | 1 | C13 | CAP, 0603 6.8nF 10% 50V X7R | MURATA GRM188R71H682KA01B |
| 13 | 3 | C14, C17, C28 | CAP, 0603 10nF 10% 25V X7R | AVX 06033C103KAT2A |
| 14 | 2 | C23, C45 | CAP, 0603 22pF 5% 50V C0G | MURATA GRM1885C1H220JA01B |
| 15 | 2 | C30, C44 | CAP, 1210 100µF 20% 10V X5R | TAIYO YUDEN LMK325ABJ107MM-T |
| 16 | 1 | C31 | CAP, 1210 10µF 10% 16V X7R | MURATA GRM32DR71C106KA01 |
| 17 | 2 | C39, C50 | CAP, 0603 100nF 20% 16V X7R | AVX 0603YC104MAT2A |
| 18 | 1 | C40 | CAP, 0603 150pF 5% 50V NPO | AVX 06035A151JAT2A |
| 19 | 1 | C43 | CAP, 0603 220pF 10% 50V X7R | AVX 06035C221KAT2A |
| 20 | 1 | C49 | CAP, 0603 47nF 10% 25V X7R | AVX 06033C473KAT |
| 21 | 6 | D1, D2, D3, D4, D8, D12 | DIODE, SCHOTTKY 30V, 100mA | CENTRAL SEMI CMDSH-3-TR |
| 22 | 2 | D6, D9 | LED, 0603 GREEN | WURTH ELEKTRONIK 150060GS75000 |
| 23 | 1 | D7 | LED, 0603 RED | WURTH ELEKTRONIK 150060SS75000 |
| 24 | 1 | D13 | DIODE, ULTRA LOW SCHOTTKY RECTIFIER | NXP SEMI. PMEG2005AEL,315 |
| 25 | 6 | L1, L2, L3, L4, L6, L7 | IND, 0.25µH | WURTH ELEKTRONIK 744301025 |
| 26 | 1 | L5 | IND, 68µH | SUMIDA CDRH105RNP-680N |
| 27 | 12 | Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q11, Q12, Q13, Q14 | XSTR, DUAL CHANNEL OptiMOS MOSFET | INFINEON BSG0811ND |
| 28 | 2 | Q9, Q10 | XSTR, PNP GENERAL PURPOSE | DIODES INC. MMST3906-7-F |
| 29 | 2 | Q20, Q29 | XSTR, P-CHANNEL DMOS FET | DIODES INC. DMP3130L-7 |
| 30 | 2 | Q21, Q26 | XSTR, N-CHANNEL DMOS FET | FAIRCHILD 2N7002A |
| 31 | 2 | Q23, Q24 | XSTR, MOSFET, N-CHANNEL 30V | VISHAY SUD50N03-10CP-E3 |

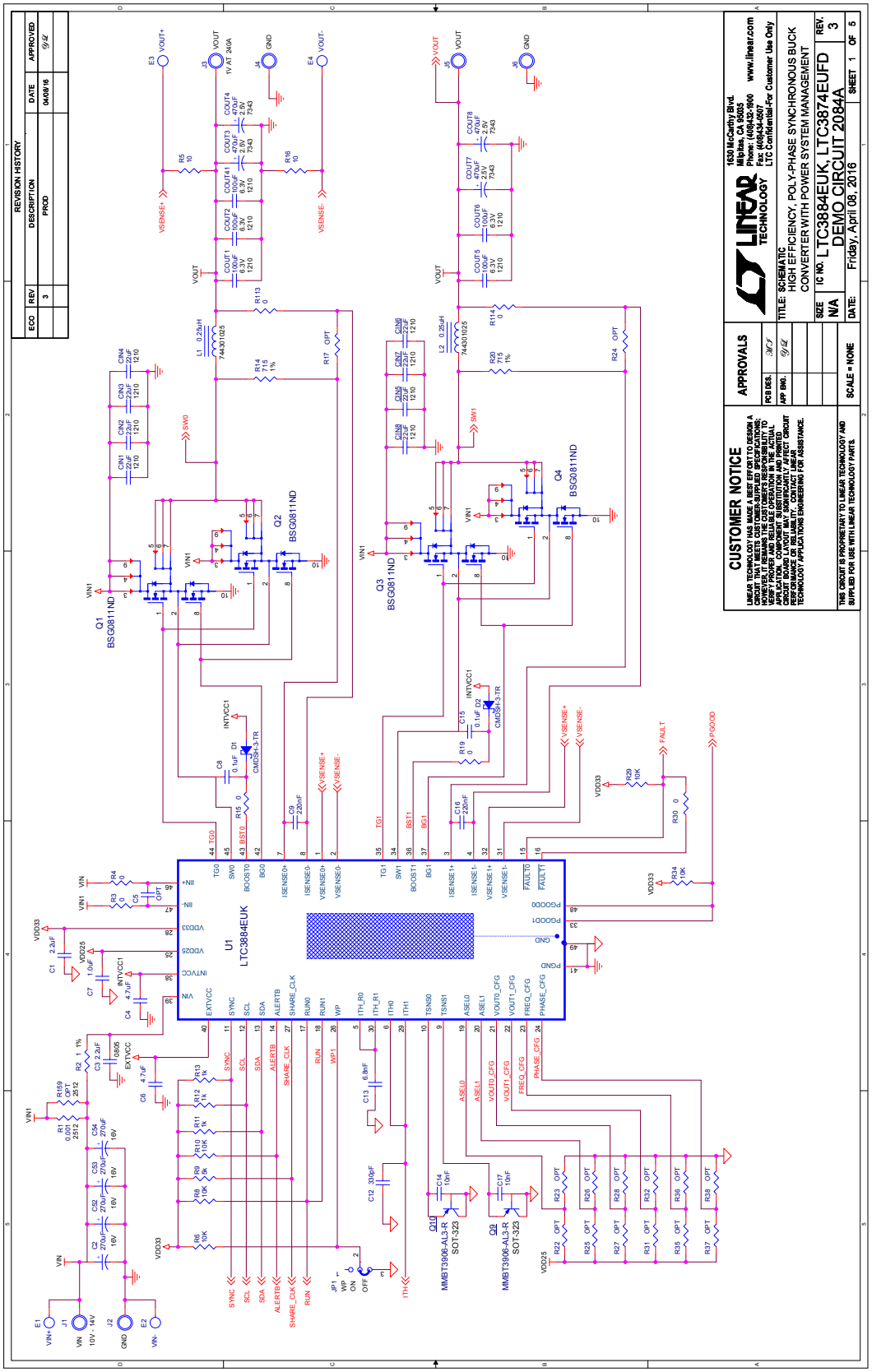
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| 32 | 1 | R1 | RES, 2512 0.001Ω 1% 1W | VISHAY WSL25121L000FEA |
| 33 | 1 | R2 | RES, 0603 1Ω 1% 1/10W | VISHAY CRCW06031R00FNEA |
| 34 | 23 | R3, R4, R15, R19, R30, R51, R52, R53, R54, R60, R83, R84, R91, R113, R114, R117, R118, R127, R137, R138, R140, R148, R149 | RES, 0603 0Ω JUMPER | VISHAY CRCW06030000Z0EA |
| 35 | 1 | R5 | RES, 0603 10Ω 1% 0.1W | VISHAY CRCW060310R0FKEA |
| 36 | 7 | R6, R8, R10, R56, R98, R108, R123 | RES, 0603 10kΩ 5% 0.1W | VISHAY CRCW060310K0JNEA |
| 37 | 1 | R9 | RES, 0603 5kΩ 5% 0.1W | VISHAY CRCW06035K00JNED |
| 38 | 3 | R11, R12, R13 | RES, 0603 1kΩ 5% 0.1W | VISHAY CRCW06031K00JNEA |
| 39 | 6 | R14, R20, R135, R143, R144, R157 | RES, 0603 715Ω 1% 0.1W | VISHAY CRCW0603715RFKEA |
| 40 | 1 | R16 | RES, 0603 10Ω 1% 1/10W | VISHAY CRCW060310R0FKEA |
| 41 | 2 | R29, R34 | RES, 0603 10kΩ 5% 0.1W | VISHAY CRCW060310K0JNEA |
| 42 | 2 | R49, R50 | RES, 0603 2Ω 1% 0.1W | VISHAY CRCW06032R00FNEA |
| 43 | 2 | R55, R58 | RES, 0603 100kΩ 5% 0.1W | VISHAY CRCW0603100KJNEA |
| 44 | 5 | R59, R95, R96, R107, R158 | RES, 0603 20kΩ 5% 0.1W | VISHAY CRCW060320K0JNEA |
| 45 | 1 | R70 | RES, 0603 10Ω 5% 0.1W | VISHAY CRCW060310R0JNEA |
| 46 | 2 | R79, R130 | RES, 0603 200Ω 5% 0.1W | VISHAY CRCW0603200RJNEA |
| 47 | 1 | R81 | RES, 0603 127Ω 1% 0.1W | VISHAY CRCW0603127RFKEA |
| 48 | 1 | R89 | RES, 0603 2Ω 5% 0.1W | VISHAY CRCW06032R00JNED |
| 49 | 1 | R92 | RES, 0603 3.3Ω 1% 0.1W | VISHAY CRCW06033R30FNEA |
| 50 | 1 | R93 | RES, 0603 154kΩ 5% 0.1W | VISHAY CRCW0603154KJNEA |
| 51 | 1 | R94 | RES, 0603 1MΩ 5% 0.1W | VISHAY CRCW06031M00JNEA |
| 52 | 1 | R97 | RES, 0603 681kΩ 1% 0.1W | VISHAY CRCW0603681KFEA |
| 53 | 1 | R99 | RES, 0603 301Ω 1% 0.1W | VISHAY CRCW0603301RFKEA |
| 54 | 1 | R100 | RES, 0603 82.5Ω 5% 0.1W | VISHAY CRCW060382R5FKEA |
| 55 | 2 | R101, R102 | RES, 2512 0.01Ω 1% 1W | VISHAY WSL2512R0100FEA |
| 56 | 1 | R103 | RES, VARIABLE 5K | BOURNS 3386P-1-502-LF |
| 57 | 1 | R104 | RES, 0603 1.21kΩ 1% 0.1W | VISHAY CRCW06031K21FKEA |
| 58 | 1 | R105 | RES, 0603 118kΩ 1% 0.1W | VISHAY CRCW0603118KFKEA |
| 59 | 1 | R106 | RES, 0603 80.6kΩ 1% 0.1W | VISHAY CRCW060380K6FKEA |
| 60 | 2 | R128, R150 | RES, 0603 4.99kΩ 1% 0.1W | VISHAY CRCW06034K99FKEA |
| 61 | 1 | R147 | RES, 0603 15.8kΩ 1% 0.1W | VISHAY CRCW060315K8FKEA |
| 62 | 1 | U1 | IC, DUAL OUTPUT STEP-DOWN CONTROLLER | LINEAR TECH. LTC3884EUK#10EV-1PBF-ES |
| 63 | 2 | U2, U7 | IC, STEP-DOWN SLAVE CONTROLLER | LINEAR TECH.LTC3874EUFD |
| 64 | 1 | U4 | IC, SYNCHRONOUS STEP-DOWN CONVERTER | LINEAR TECH. LTC3630EMSE |
| 65 | 1 | U5 | IC, TIMER BLOX: VOLTAGE CONTROLLED (PWM) | LINEAR TECH. LTC6992IS6-1 |
| 66 | 1 | U6 | IC, OP AMP | LINEAR TECH. LT1803IS5 |
| 67 | 1 | U8 | IC, SERIAL EEPROM | MICROCHIP 24LC024-I/ST |

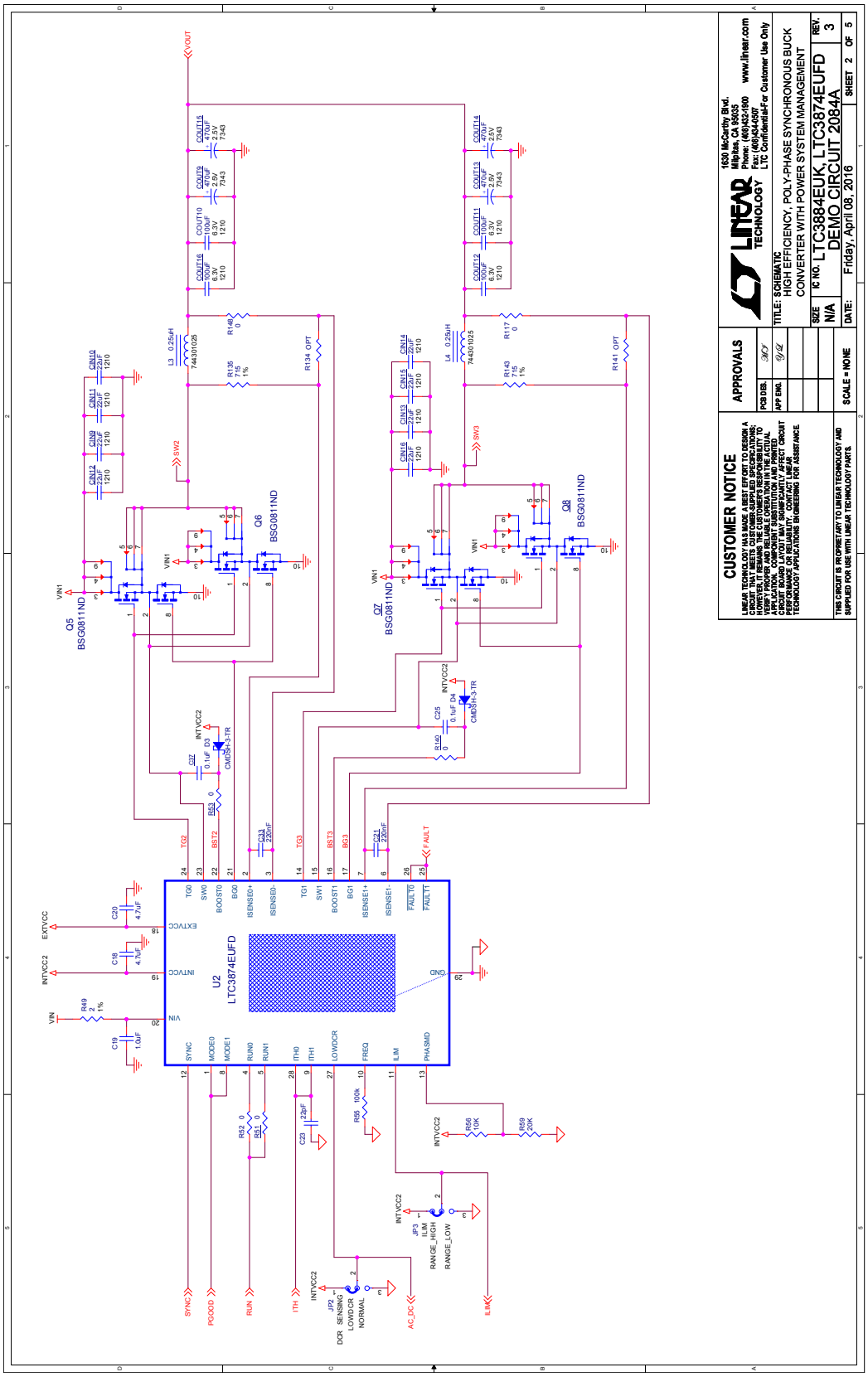
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Additional Demo Board Circuit Components** | | | | |
| 1 | 0 | C5, C51 | CAP, 0603 OPTION | OPTION |
| 2 | 0 | D11 | DIODE, SCHOTTKY 30V, 100mA OPTION | CENTRAL SEMI CMDSH-3-TR OPTION |
| 3 | 0 | R17, R22, R23, R24, R25, R26,R27, R28, R31, R32, R35, R36, R37, R38, R87, R122, R134, R136, R141, R142, R145, R146, R151, R156 | RES, 0603 OPTION | OPTION |
| 4 | 0 | R85, R159 | RES, 2512 OPTION | OPTION |
| 5 | 0 | R139 | RES, 1206 OPTION | OPTION |
| **Hardware: For Demo Board Only** | | | | |
| 1 | 16 | E1, E2, E3, E4, E7, E8, E21, E22, E23, E24, E25, E26, E28, E34, E36, E37 | TURRET | MILL MAX 2501-2-00-80-00-00-07-0 |
| 2 | 5 | JP1, JP2, JP3, JP4, JP5 | HEADER, SINGLE ROW 3-PIN | SAMTEC TMM-103-02-L-S |
| 3 | 6 | J1, J2, J3, J4, J5, J6 | STUD, TEST PIN | PEM KFH-032-10 |
| 4 | 14 | | NUT, BRASS 10-32 | ANY #10-32 |
| 5 | 7 | | LUG RING, #10 | KEYSTONE 8205 |
| 6 | 7 | | WASHER, #10 TIN PLATED BRASS | ANY #10 EXT BZ TN |
| 7 | 2 | J11, J12 | CONN, BNC, 5 PINS | CONNEX 112404 |
| 8 | 1 | J13 | CONN, SOCKET 14-PIN DUAL ROW R/A | SULLINSINC. NPPN072FJFN-RC |
| 9 | 1 | J14 | HEADER, 12-PIN 2mm STR DL | FCI 98414-G06-12ULF |
| 10 | 1 | J15 | HEADER, 14-PIN DUAL ROW R/A | MOLEX 87760-1416 |
| 11 | 1 | J16 | HEADER, 4-PIN 2mm STR DL | HIROSE DF3A-4P-2DSA |
| 12 | 4 | MH1, MH2, MH3, MH4 | STANDOFF, SNAP ON | KEYSTONE 8834 |
| 13 | 1 | SW2 | SWITCH, SUBMINATURE SLIDE | C&K JS202011CQN |
| 14 | 5 | XJP1, XJP2, XJP3, XJP4, XJP5 | SHUNT | SAMTEC 2SN-BK-G |

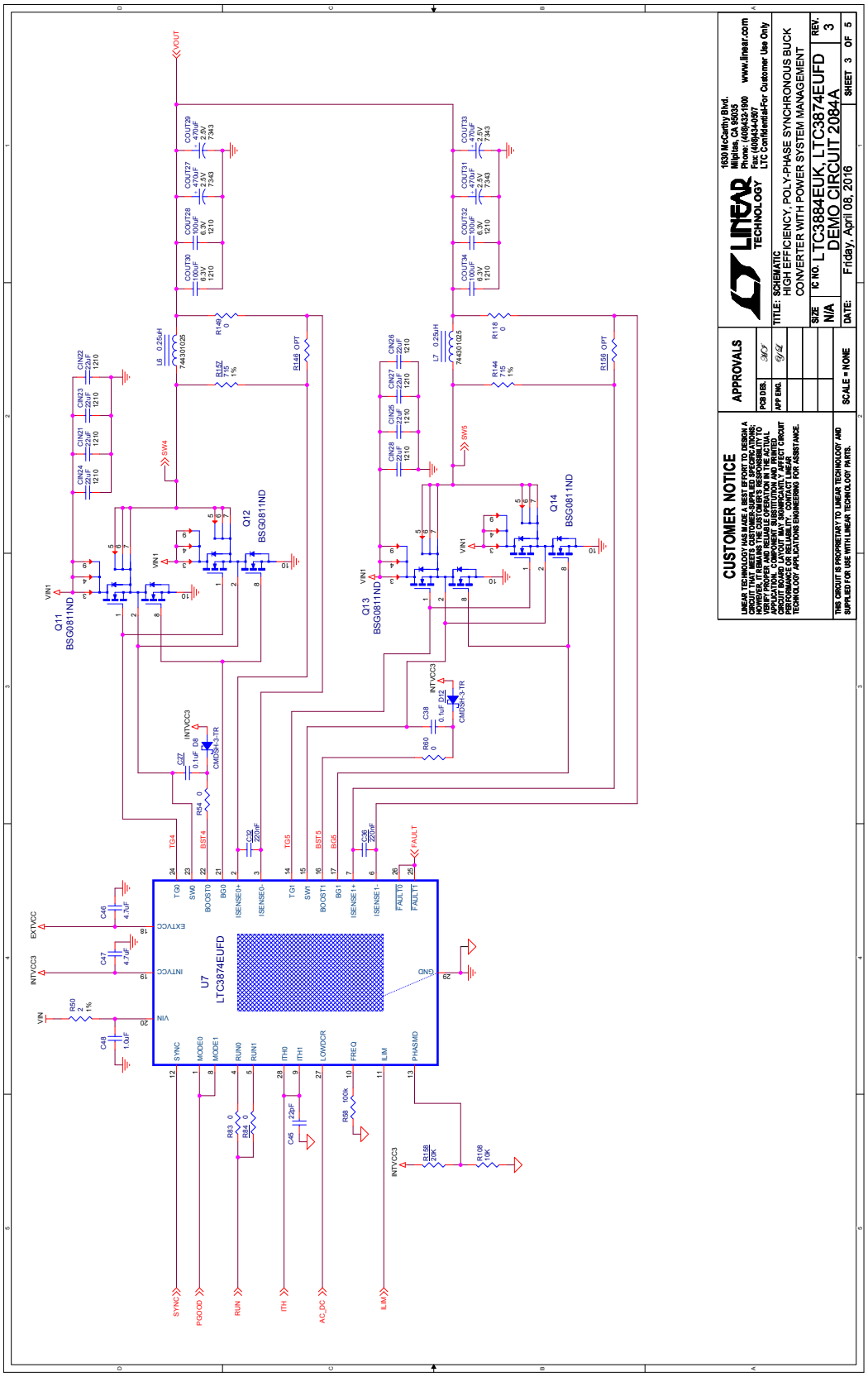
## SCHEMATIC DIAGRAM



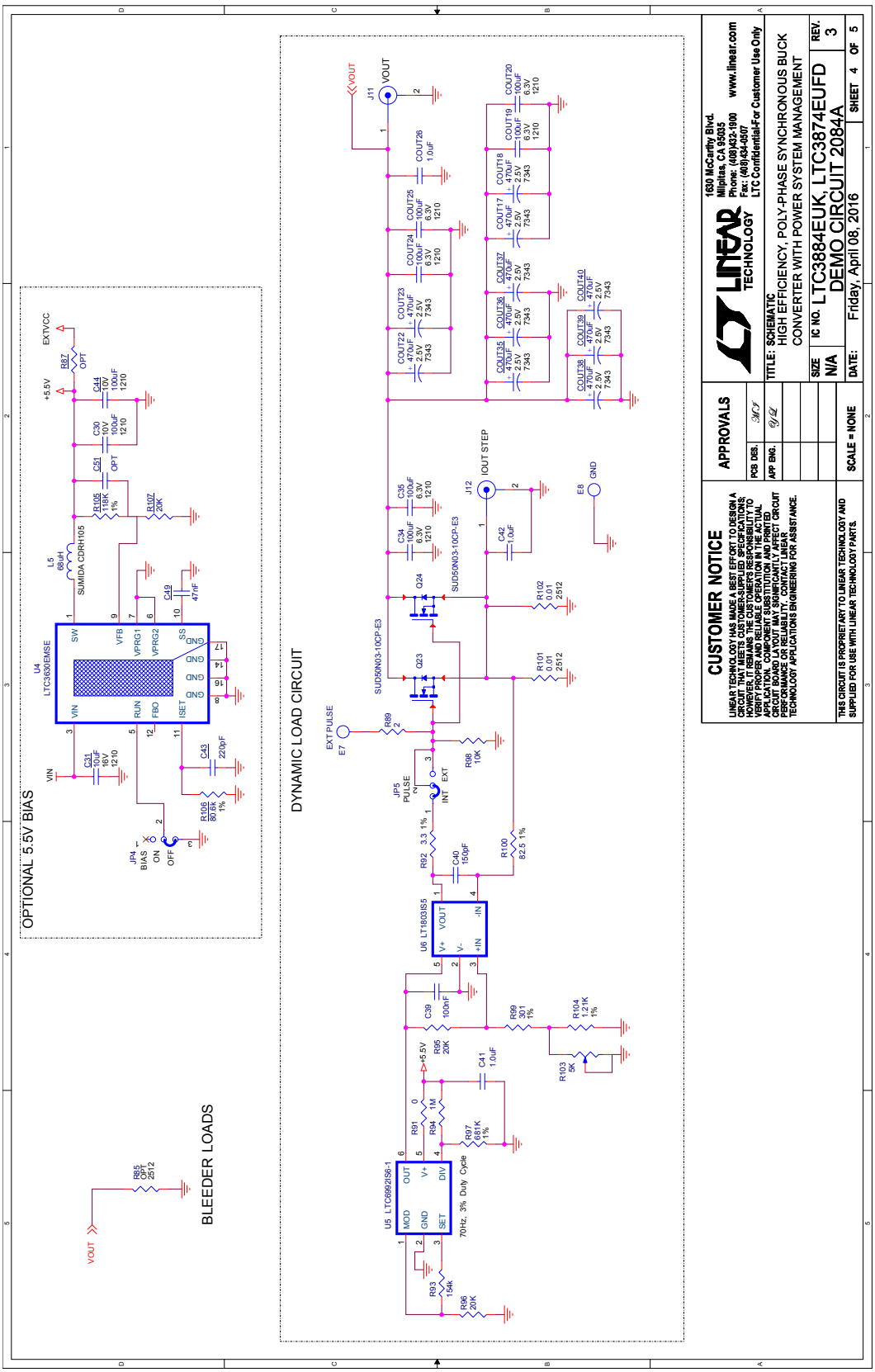
## SCHEMATIC DIAGRAM



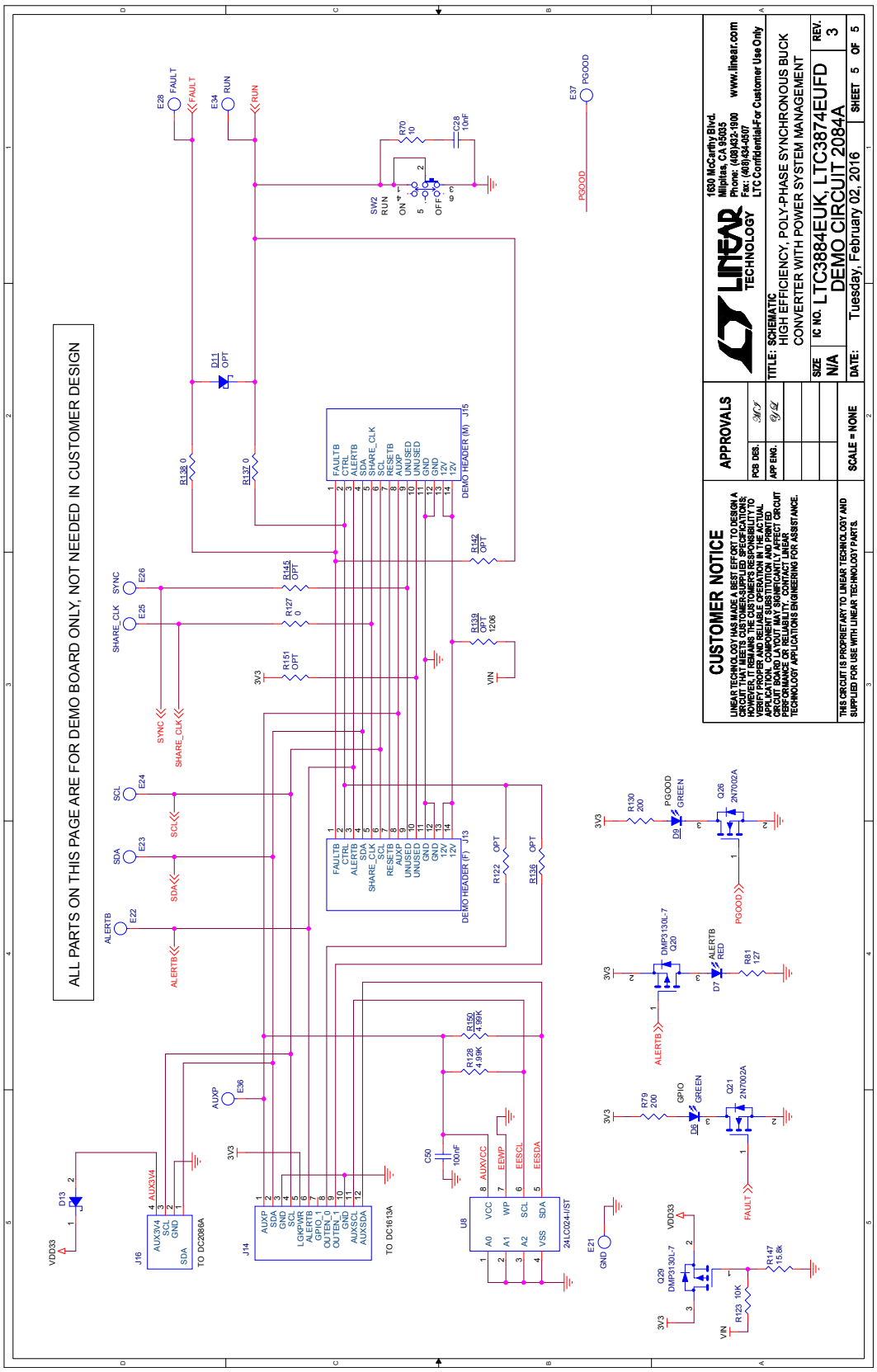
## SCHEMATIC DIAGRAM



## SCHEMATIC DIAGRAM



## SCHEMATIC DIAGRAM






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