Evaluation Board User Guide

EVAL-LT7176P-1-AZ

4V, PolyPhase Silent Switcher Step-Down Regulator with Digital Power System Management 2xLT7176-1, 48A

General Description

The EVAL-LT7176P-1-AZ evaluation kit is a dual-phase single-output monolithic DC/DC synchronous step-down regulator with a 2.7V to 4V input range featuring the LT7176P-1. With 3V to 12V $EXTV_{CC}$ provided, the input voltage can be as low as 1.5V. The output can supply 48A continuous load current. The Silent Switcher® regulator structure is incorporated into the LT7176P-1 to minimize EMI and reduce PCB layout sensitivity. It also integrates digital power system management functionality, allowing for programmability and telemetry with a PMBus/I^2C-compliant serial interface. Refer to the LT7176P-1 data sheet for more information.

The EVAL-LT7176P-1-AZ evaluation board is designed for 0.5V output with a switching frequency set at 1.5MHz. The controlled on-time valley current-mode control with 25ns typical minimum on-time enables a high switching frequency at a low output voltage with excellent transient response in a small overall solution size.

The EVAL-LT7176P-1-AZ powers up to default settings and produces power based on the NVM configuration without the need for any serial bus communication. This allows easy evaluation of the DC/DC converter. To fully explore the power system management features of the part, download the GUI software LTpowerPlay® onto the PC and use ADI's I^2C/SMBus/PMBus dongle DC1613A to connect to the board. LTpowerPlay allows the user to reconfigure the part on the fly, store the configuration in NVM, and view telemetry of voltage, current, temperature, and fault status. The NVM can be programmed up to three times.

GUI Download

The software can be downloaded from LTpowerPlay.

The LT7176P-1 data sheet describes the part, operation, and application information. Read the data sheet in conjunction with this EVAL-LT7176P-1-AZ demo manual.

For more details and instructions of the LTpowerPlay, see the LTpowerPlay Quick Start Procedure section.

Performance Summary

Specifications are at T_A = 25°C.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		2.7		4	V
Default Output Voltage	V_{OUT}			0.5		V
Maximum Continuous Output Current	I_{OUT}			48		A
Switching Frequency	f_{SW}		1.35	1.5	1.65	MHz
Efficiency	Eff	V_{IN} = 3.3V, I_{OUT} = 40A		80		%

Quick Start Procedure

The EVAL-LT7176P-1-AZ is easy to set up to evaluate the performance of the LT7176P-1. See *Figure 1* for proper measurement equipment setup, and use the following procedure:

1. Set an input power supply that is capable of 5V/7A and then turn off the power.
2. With the power off, connect the supply to the input terminals V_{IN} and GND. Set the default jumper position to SW1: ON.
3. Turn on the power at the input.

   Note: Make sure that the input voltage never exceeds 4V.
4. Check for the proper output voltages of 0.5V ±0.25% (0.49875V~0.50125V). Turn off the power at the input.
5. Once the proper output voltage is established, connect variable loads capable of sinking 48A at 0.5V to the output terminals V_{OUT} and GND. Set the current to 0A.
6. If efficiency measurements are desired, ammeters can be put in series with the power supply to measure the EVAL-LT7176P-1-AZ's input current and in series with the output load to measure the output current or by directly reading the output current from the electronic load.
   a) Voltmeters can be placed across the output terminals (VSENSE+, VSENSE-) to get accurate output voltage measurements.
   b) Voltmeters can be placed across the input terminals (VIN_SENSE, GND) to get accurate input voltage measurements.
   c) To achieve the best efficiency, remove resistors R27 and R28, then populate the 0Ω resistors for R58 and R59 on the bottom layer of the board.
   d) To achieve the best output accuracy, remove resistors R58 and R59, then populate the 0Ω resistors for R27 and R28 on the bottom layer of the board.
7. Turn on the power at the input.

   Note: If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
8. Once the proper output voltages are established again, adjust the load and/or input within the operating range and observe the output voltage regulation, ripple voltage, efficiency, and other desired parameters.
9. 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 setup. 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.

   In addition, the output voltage ripple can be also measured at the J6 V_{OUT} test point. J6 is designed for a 50Ω coaxial U.FL cable to minimize high-frequency noise that could otherwise couple into the oscilloscope probes. See *Figure 3* for the proper coaxial cable setup.
10. Connect the dongle and control the output voltages from the GUI. See the *LTpowerPlay Quick Start Procedure* section for details.
11. The EVAL-LT7176P-1-AZ includes an onboard load transient circuit. To test the load transient response, apply a pulsed signal from a signal generator between the IOSTEPCLK and GND turrets on the board. Measure the voltage across the sensing resistor R7 at the IOSTEP test point to observe the current (VIOSTEP/10mΩ). Adjust the pulse amplitude to achieve the desired transient, and modify the rising and falling edges of the pulse to set the required ramp rate. For more details, refer to the load transient circuit in the EVAL-LT7176P-1-AZ schematic.
12. The EVAL-LT7176P-1-AZ is compatible with the LTpowerAnalyzer and can be connected to the LTpowerAnalyzer board at the P1 Molex socket with a 16-pin ribbon cable. LTpowerAnalyzer features the measurements of loop response, transient response, and output impedance. For details and instructions of the LTpowerAnalyzer, refer to LtpowerAnalyzer on the Analog Devices website to access the user guide, software, and evaluation kit. Attach the load slammer through the on-board socket P1 for easy loop response and load transient test setup.

    Note: To test the loop response of the EVAL-LT7176P-1-AZ, remove resistors R27, R58, and R59, then populate a 0Ω resistor at R28 and a 20Ω resistor at R47 on the bottom layer of the board.

Connecting a PC to EVAL-LT7176P-1-AZ

Use a PC to reconfigure the power management features of the LT7176P-1, such as V_{OUT}, current limit, switching frequency, OV/UV limits, control loop compensation, temperature fault limits, sequencing parameters, fault responses, and other functionalities. The DC1613A dongle can be plugged in when a V_{IN} is present. *Figure 4* shows a demo setup of connecting a PC to EVAL-LT7176P-1-AZ.

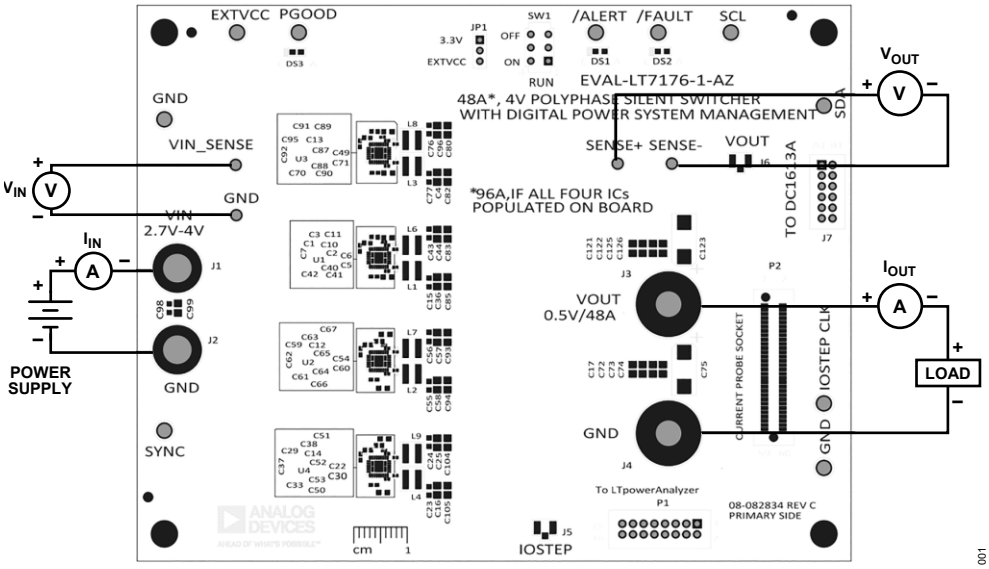


Figure 1. Proper Measurement Equipment Setup

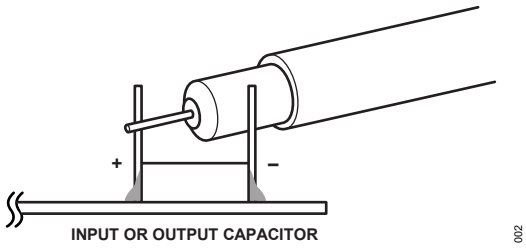


Figure 2. Scope Probe Placement for Measuring Input or Output Voltage Ripple

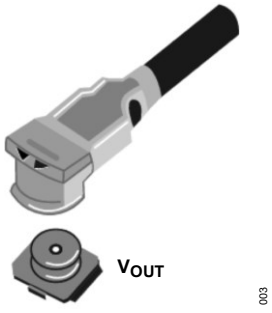


Figure 3. Coaxial Cable Placement for Measuring Output Voltage Ripple

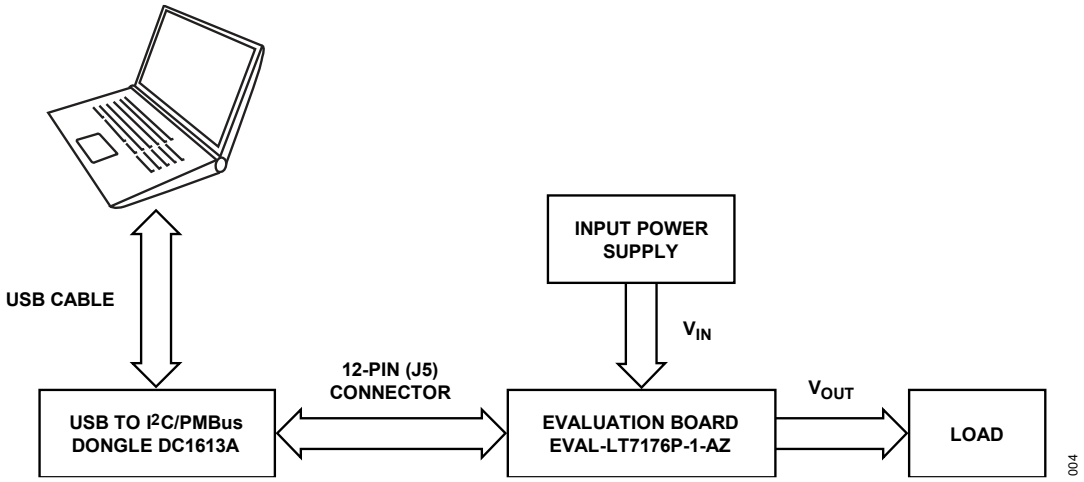


Figure 4. Demo Setup with PC

Typical Performance Characteristics

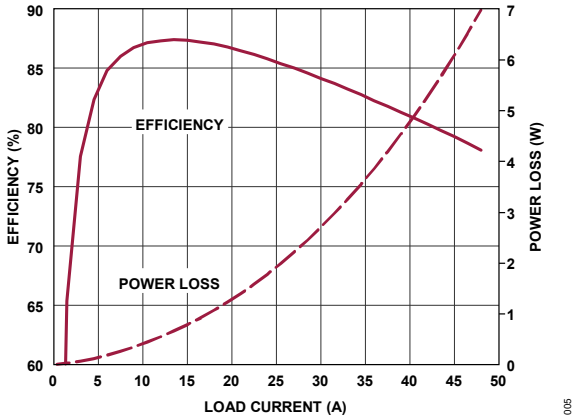


Figure 5. Efficiency vs. Load Current at 1.5MHz Switching Frequency

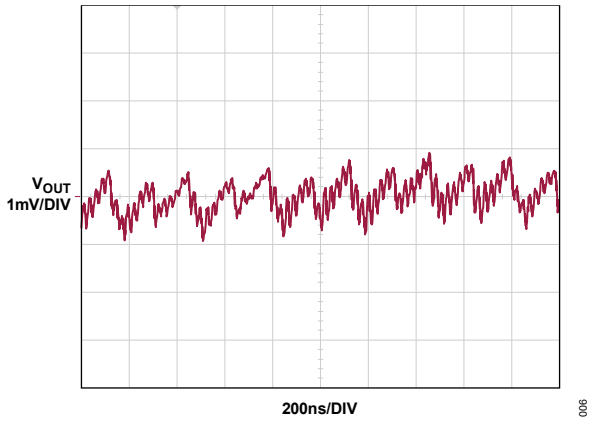


Figure 6. Output Voltage Ripple at V_{IN} = 3.3V, V_{OUT} = 0.5V, f_{SW} = 1.5MHz, I_{LOAD} = 48A

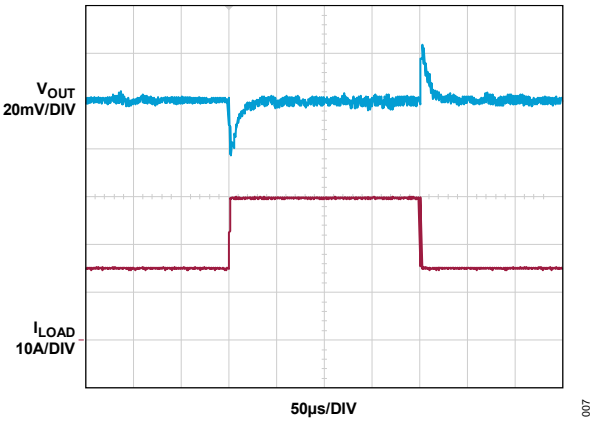


Figure 7. Load Transient Response with Load Steps 15A to 30A to 15A

V_{IN} = 3.3V, V_{OUT} = 0.5V, f_{SW} = 1.5MHz; C_{OUT} = 2 x 10µF + 8 x 100µF, G_m = 2400µF, C_{TH} = 5600pF, R_{TH} = 1.4kΩ, R_{ITHP} = 33pF

LTpowerPlay Software GUI

LTpowerPlay is a powerful, Windows®-based development environment supporting Analog Devices' Digital Power System Management (DPSM) ICs and µModule® regulators. The software supports a variety of tasks. Use LTpowerPlay to evaluate Analog Devices' ICs by connecting to an evaluation board system. LTpowerPlay can also be used in offline mode (with no hardware present) 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 demo systems 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 the Analog Devices website.

To access technical support documents for Analog Devices' digital power products, visit the LTpowerPlay **Help** menu. Online help is also available through LTpowerPlay.

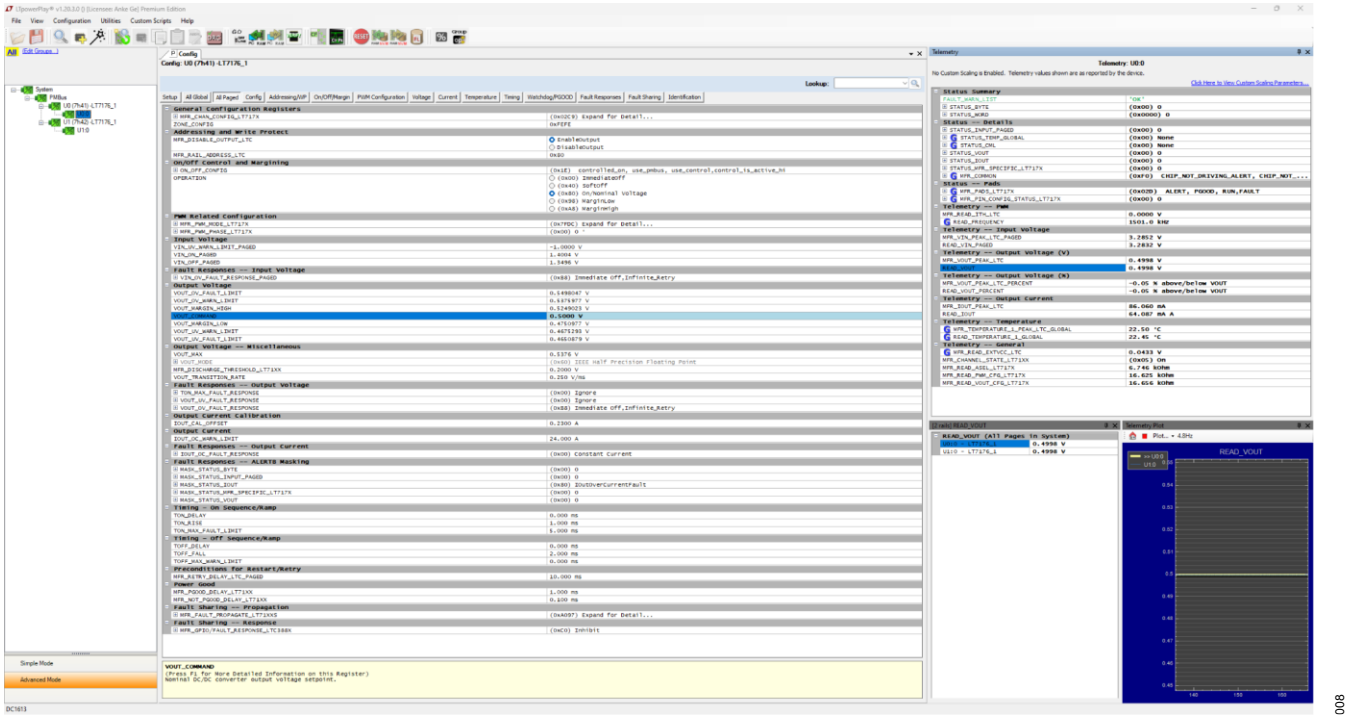


Figure 8. LTpowerPlay Main Interface

LTpowerPlay Quick Start Procedure

The following procedure describes how to use LTpowerPlay to monitor and change the settings of the LT7176P-1.

1. Download and install the LTpowerPlay GUI.
2. Launch the LTpowerPlay GUI. The GUI automatically identifies the EVAL-LT7176P-1-AZ. The system tree on the left-hand side appears as shown in *Figure 9*.

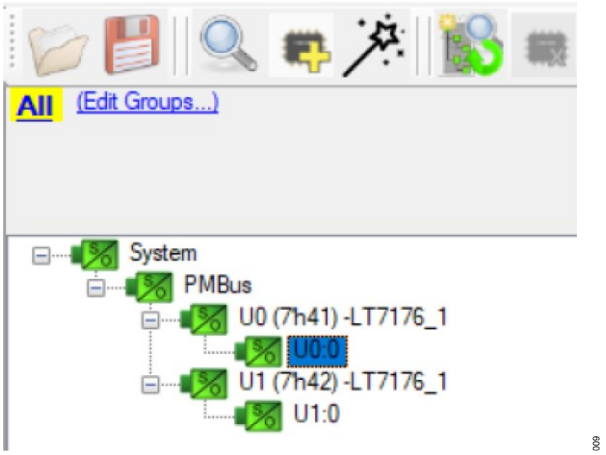


Figure 9. LtpowerPlay GUI System Tree

3. A green message box (*Figure 10*) shows for a few seconds in the lower left-hand corner, confirming that the LT7176P-1 is communicating:

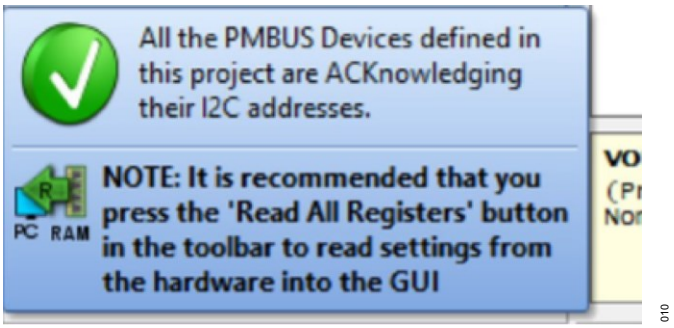


Figure 10. LT7176P-1 Communication Popup Window

4. In the toolbar, click the **R** (RAM to PC) icon (*Figure 11*) to read the RAM from the LT7176P-1. Performing this action reads the configuration from the RAM of the LT7176P-1 and loads it into the GUI.

Figure 11. R (RAM to PC) Icon

5. To change the output voltage to a different value (i.e., 0.6V), in the **Config** tab, type in 0.6 in the **VOUT_COMMAND** box under the **Voltage** tab, as shown in *Figure 12*.

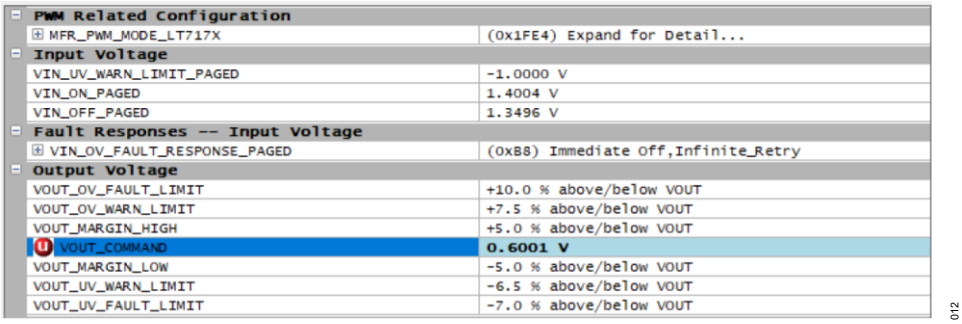


Figure 12. VOUT_COMMAND Box

6. Then, click the **W** (PC to RAM) icon (*Figure 13*) to write the register values to the LT7176P-1. After finishing this step, the output voltage changes to 0.6V.

Figure 13. Figure 13. W (PC to RAM) Icon

7. If the write is successful, the following **Success** message appears (*Figure 14*).

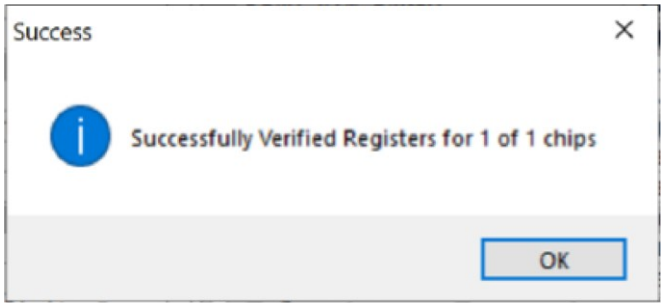


Figure 14. Figure 14. Successful Write Message

8. To save the changes to NVM in the toolbar, click the **RAM to NVM** button (*Figure 15*).

Figure 15. RAM to NVM Icon

9. Save the evaluation board configuration to a (*.proj) file. Click the **Save** icon and save the file with a new name.
10. *For evaluations of mulitple LT7176P-1s in parallel, it is recommended to change the MFR_RAIL_ADDRRESS_LTC of all LT7176P-1 to a same value other than 0x80, any MFR_ADDRESS_LTC, or any of the illegel values listed in the LT7176_LT7176P-1_PMBUS_USER_GUIDE. Write the register values to LT7176P-1, then rebuild the system tree by click the **Re-enmulating** button (*Figure 16*).

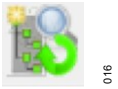


Figure 16. Re-emulating Icon/Button

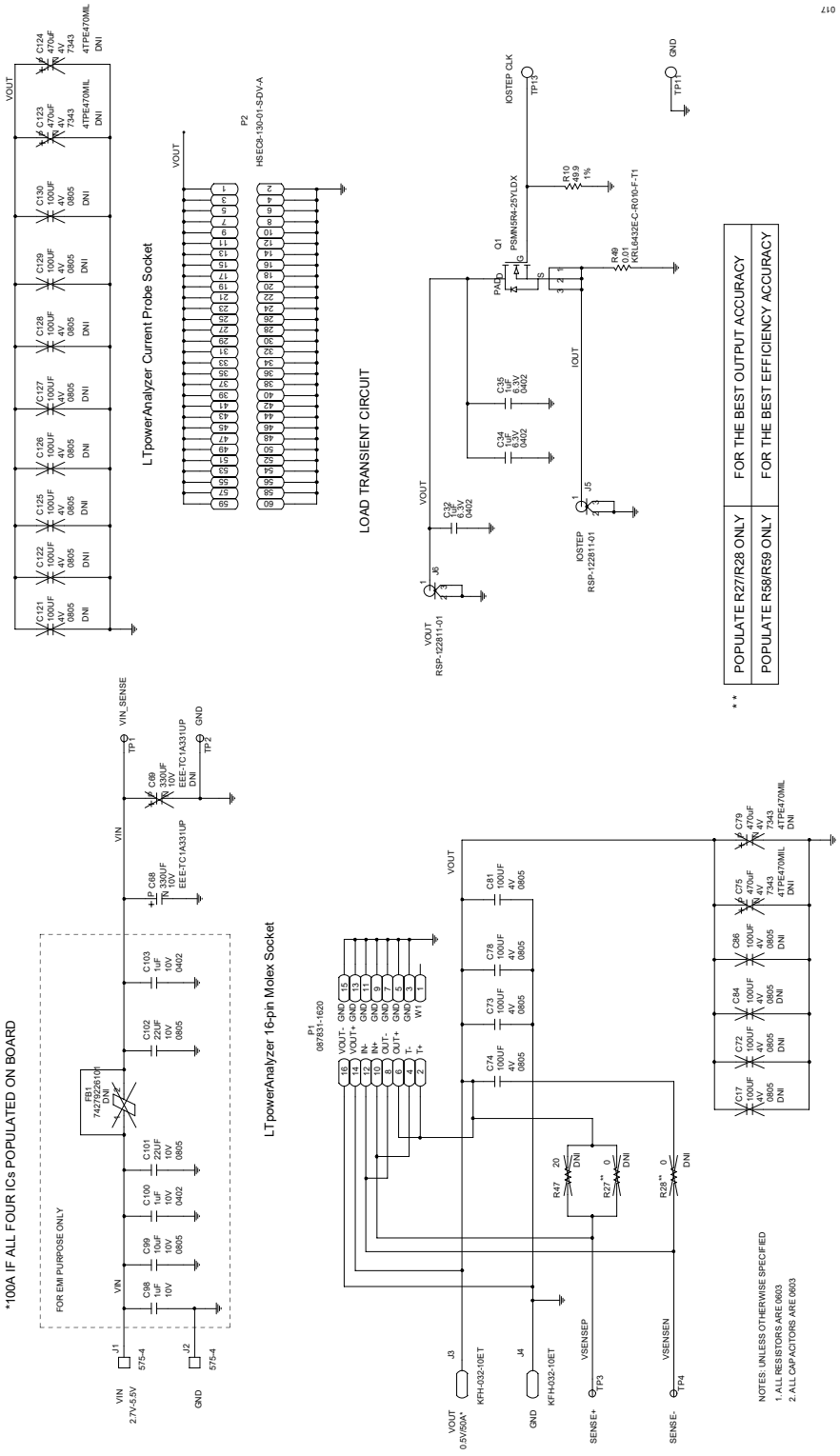
Note that after this step, LTPowerPlay automatically synchronizes setting changes of all LT7176P-1s, and the write functions would send PMBus commands to MFR_RAIL_ADDRESS_LTC instead of MFR_ADDRESS_LTC of each LT7176P-1.

Bill of Materials

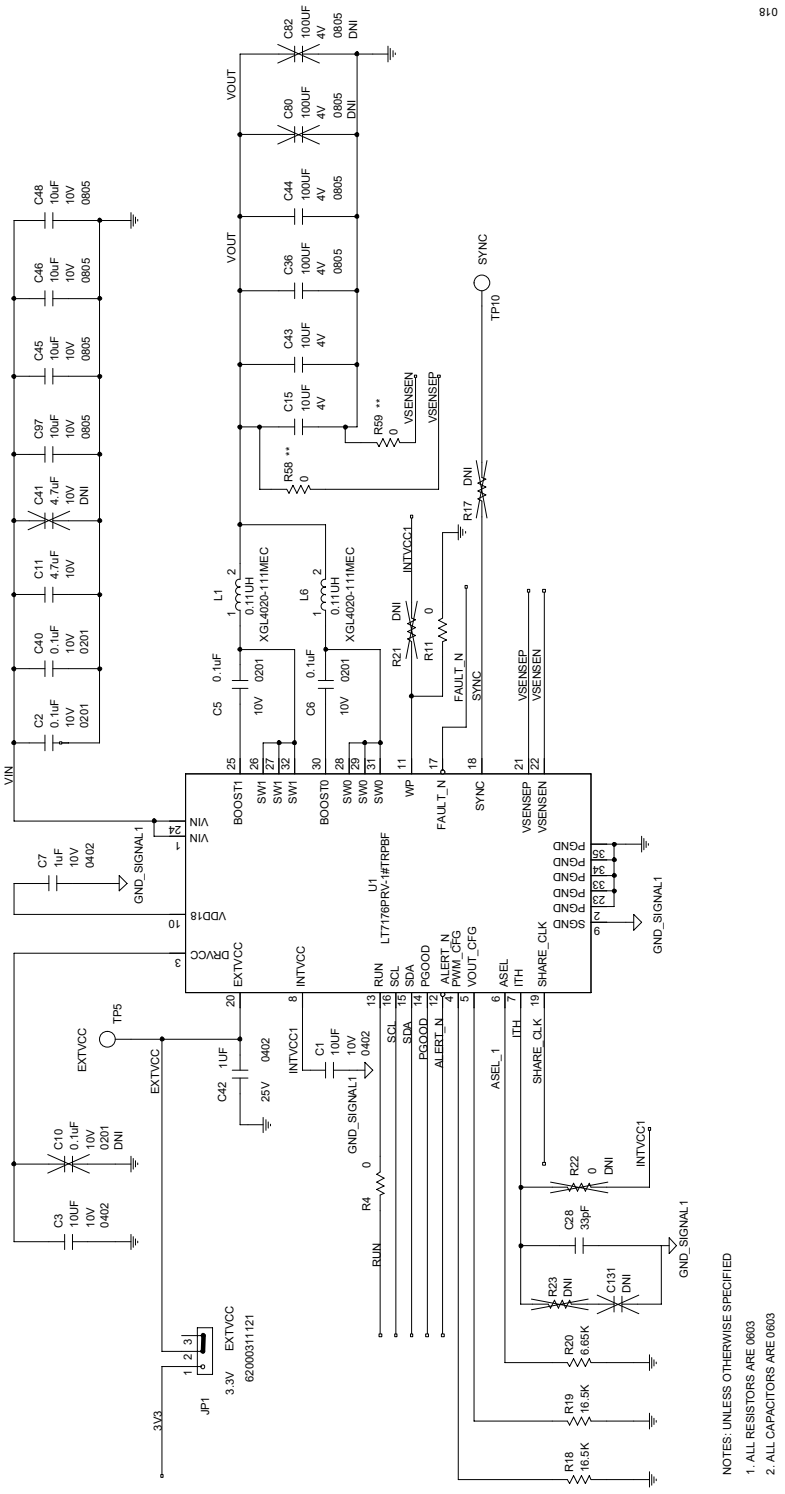
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
CIRCUIT COMPONNENTS				
1	4	C1, C3, C59, C63	Ceramic capacitors, 10µF, 10V, 20%, X5R, 0402	Samsung, CL05A106MP8NUB8
2	4	C7, C62, C100, C103	Ceramic capacitors, 10µF, 10V, 10%, X7S, 0805	TDK, C1005X7S1A105K050BC
3	2	C101, C102	Ceramic capacitors, 22µF, 20%, 10V, X7R, 0805	Murata, GRM21BZ71A226ME15L
4	3	C8, C106, C107	Ceramic capacitors, 1µF, 25V, 10%, X7R, 0603, AEC-Q200	Murata, GCM188R71E105KA64D
5	1	C108	Ceramic capacitors, 22µF, 25V, 20%, X6S, 0805, AEC-Q200	Murata, GRT21BC81A226ME13L
6	9	C45, C46, C48, C97, C99, C109, C110, C111, C112	Ceramic capacitors, 10µF, 10V, 10%, X7R, 0805	Samsung, CL21B106KPQNNNE
7	2	C11, C66	Ceramic capacitors, 4.7µF, 10V, 10%, X5R, 0603	Kemet, C0603C475K8PACTU
8	4	C15, C43, C55, C56	Ceramic capacitors, 10µF, 4V, 10%, X7T, 0603, AEC-Q200	TDK, CGA3E1X7T0G106M080AC
9	4	C9, C18, C20, C21	Ceramic capacitors, 4.7µF, 25V, 10%, X6S, 0603	Murata, GRM188C81E475KE11D
10	2	C19, C28	Ceramic capacitors, 33pF, 50V, 5%, C0G, 0603	Yageo, CC0603JRNPO9BN330
11	8	C2, C5, C6, C40, C54, C60, C64, C65	Ceramic capacitors, 0.1µF, 10V, 10%, X7S, 0201	Murata, GRM033C71A104KE14D
12	1	C31	Ceramic capacitor, 0.1µF, 10V, 10%, X7R, 0603	Kemet, C0603C104K8RACTU
13	3	C32, C34, C35	Ceramic capacitors, 1µF, 6.3V, 10%, X7R, 0402	MURATA, GRM155R70J105KA12D
14	8	C36, C44, C57, C58, C73, C74, C78, C81	Ceramic capacitors, 100µF, 4V, 20%, X6S, 0805	Murata, GRM21BC80G107ME15K
15	1	C39	Ceramic capacitor, 10µF, 10V, 20%, X5R, 0402	Murata, GRM155R61A106ME11D
16	2	C42, C61	Ceramic capacitors, 1µF, 25V, 10%, X5R, 0402, AEC-Q200	Murata, GRT155R61E105KE01D
17	1	C47	Ceramic capacitor, 5600pF, 50V, 5%, X7R, 0603	AVX, 06035C562JAT2A
18	1	C68	Capacitor aluminium, 330µF, 10V, 20%, 0.2Ω, 0.41A, 3000H, AEC-Q200	Panasonic, EEE-TC1A331UP
19	1	C98	Ceramic capacitor, 1µF, 10V, 10%, X7R, 0603	Kemet, C0603C105K8RACTU
20	2	DS1, DS2	LED uni-color amber, 595nm, 1.9V	Broadcom limited, HSMA-C197
21	1	DS3	LED green, 570nm, 2.2V, 2LD, 0603	Broadcom limited, HSMG-C190
22	4	L1, L2, L6, L7	Inductor, 0.11µH, 20%, 29A, 0.0017Ω, DCR	Coilcraft Inc., XGL4020-111MEC
23	1	Q1	Transistor MOSFET, N-channel, 25V, 70A	Nexperia, PSMN5R4-25YLDX
24	1	Q2	Transistor MOSFET, N-channel, 60V, 0.3A, SOT-23	Vishay, 2N7002K-T1-GE3
25	1	R1	Resistor SMD, 6.81kΩ, 1%, 1/10W, 0603, AEC-Q200	Panasonic, ERJ-3EKF6811V
26	1	R10	Resistor SMD, 49.9Ω, 1%, 1/10W, 0603, AEC-Q200	Panasonic, ERJ-3EKF49R9V
27	6	R4, R7, R11, R37, R58, R59	Resistor SMD, 0Ω, jumper, 1/10W, 0603, AEC-Q200, precision power	Vishay, CRCW06030000Z0EA
28	3	R3, R12, R26	Resistor SMD, 866Ω, 1%, 1/10W, 0603, AEC-Q200	Panasonic, ERJ-3EKF8660V
29	2	R6, R13	Resistor SMD, 4.99kΩ, 1%, 1/10W, 0603, AEC-Q200	Panasonic, ERJ-3EKF4991V
30	1	R14	Resistor SMD, 1MΩ, 1%, 1/10W, 0603, AEC-Q200	Panasonic, ERJ-3EKF1004V
31	3	R18, R19, R39	Resistor SMD, 16.5kΩ, 1%, 1/10W, 0603, AEC-Q200	Panasonic, ERJ-3EKF1652V
32	3	R2, R9, R52	Resistor SMD, 10kΩ, 1/10W, 1%, 0603, AEC-Q200	Vishay, CRCW060310K0FKEA
33	1	R20	Resistor SMD, 6.65kΩ,1%, 1/10W, 0603, AEC-Q200	Vishay, CRCW06036K65FKEA
34	1	R38	Resistor SMD, 25.5kΩ,1%, 1/10W, 0603, AEC-Q200	Panasonic, ERJ-3EKF2552V

35	1	R40	Resistor SMD, 11.8kΩ, 0.1%, 1/10W, 0603, AEC-Q200	Panasonic, ERA-3AEB1182V
36	1	R49	Resistor SMD, 0.01Ω, 1%, 3W, 2512, AEC-Q200, long side term	Susumu co, ltd, KRL6432E-C-R010-F-T1
37	2	R5, R8	Resistor SMD, 4.7kΩ, 1%, 1/10W, 0603, AEC-Q200	Vishay, CRCW06034K70FKEA
38	1	R53	Resistor SMD, 1.4kΩ, 1%, 1/10W, 0603, AEC-Q200	Panasonic, ERJ-3EKF1401V
39	2	U1, U2	Prelim IC-ADI 20A, 16V, single or dual-phase, step-down, silent switcher with digital power system management	Analog Devices, LT7176PRV-1#TRPBF
40	1	U5	IC EEPROM, 2Kbit, I^2C serial, EEPROM 400kHz	Microchip Technology, 24LC025-I/ST
41	2	U6, U7	IC-ADI, 18V, 12A, ideal diode	Analog Devices, *LTC4450AV#TRMPBF*
42	1	U8	IC-ADI 100mA, low noise, LDO micropower regulators IN TSOT-23	Analog Devices, *LT1761ES5-2.8#TRMPBF*
43	1	U9	IC-ADI or controller P-channel single, 0.14Ω, 5.5V, 10LD DFN, exposed pad	Analog Devices, *LTC4413EDD#PBF*
HARDWARE: FOR EVALUATION BOARD ONLY				
1	2	J1, J2	Connect-PCB, banana jack, female, non-insulated, through hole technology, swage, 0.218” length	Keystone Electronics, 575-4
2	2	J3, J4	Connect-PCB, threaded broaching stud, 625Mil length	Penn Engineering, KFH-032-10ET
3	2	J5, J6	Connect-PCB, coax RCPT male 0Hz to 6GHz, 50Ω	Samtec Inc., RSP-122811-01
4	1	J7	Connect-PCB, 12 position shrouder HDR, 2mm pitch, 4mm position height, 2.5mm solder tail	Amphenol, 98414-G06-12ULF
5	1	JP1	Connect-PCB, 3 position male HDR unshrouded single row straight, 2mm pitch, 2.70mm solder tail	Wurth Elektronik, 62000311121
6	1	P1	Connect-PCB, Milli-Grid header, vertical, 16 position, 2mm pitch, 2.5mm solder tail, 3.9mm post height	Molex, 087831-1620
7	1	P2	Connect-PCB, 60 position, vertical edge rate, card socket	Samtec Inc., HSEC8-130-01-S-DV-A
8	4	TP1, TP2, TP3, TP4	Connect-PCB, solder terminal turrets for clip leads	Mill-Max, 2308-2-00-80-00-00-07-0
9	10	TP5, TP6, TP7, TP9, TP10–TP15	Connect-PCB, solder terminal test point turret 0.094" mounting hole PCB 0.062” thick	Mill-Max, 2501-2-00-80-00-00-07-0

Schematic Diagram



Schematic Diagram (continued)



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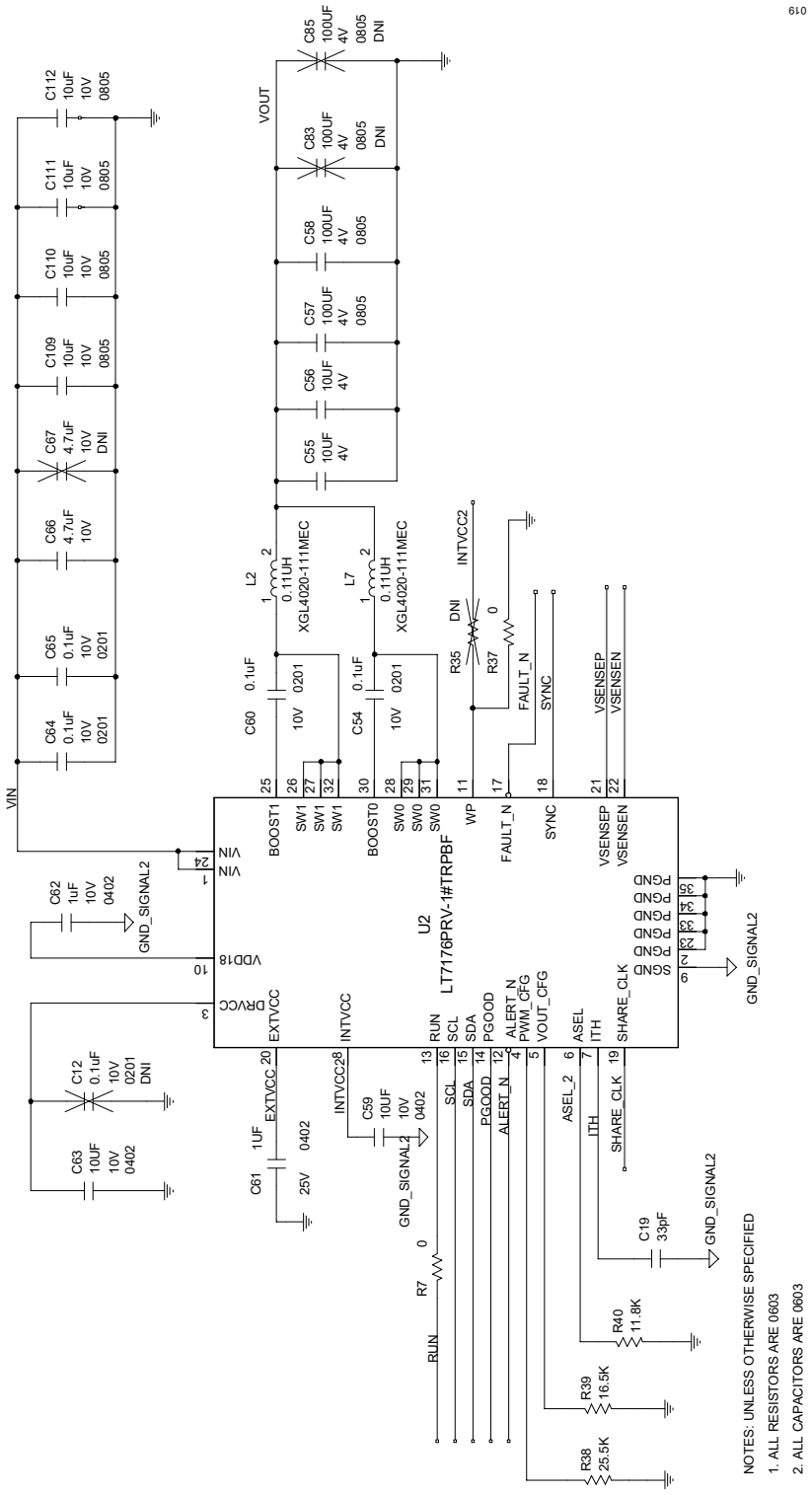
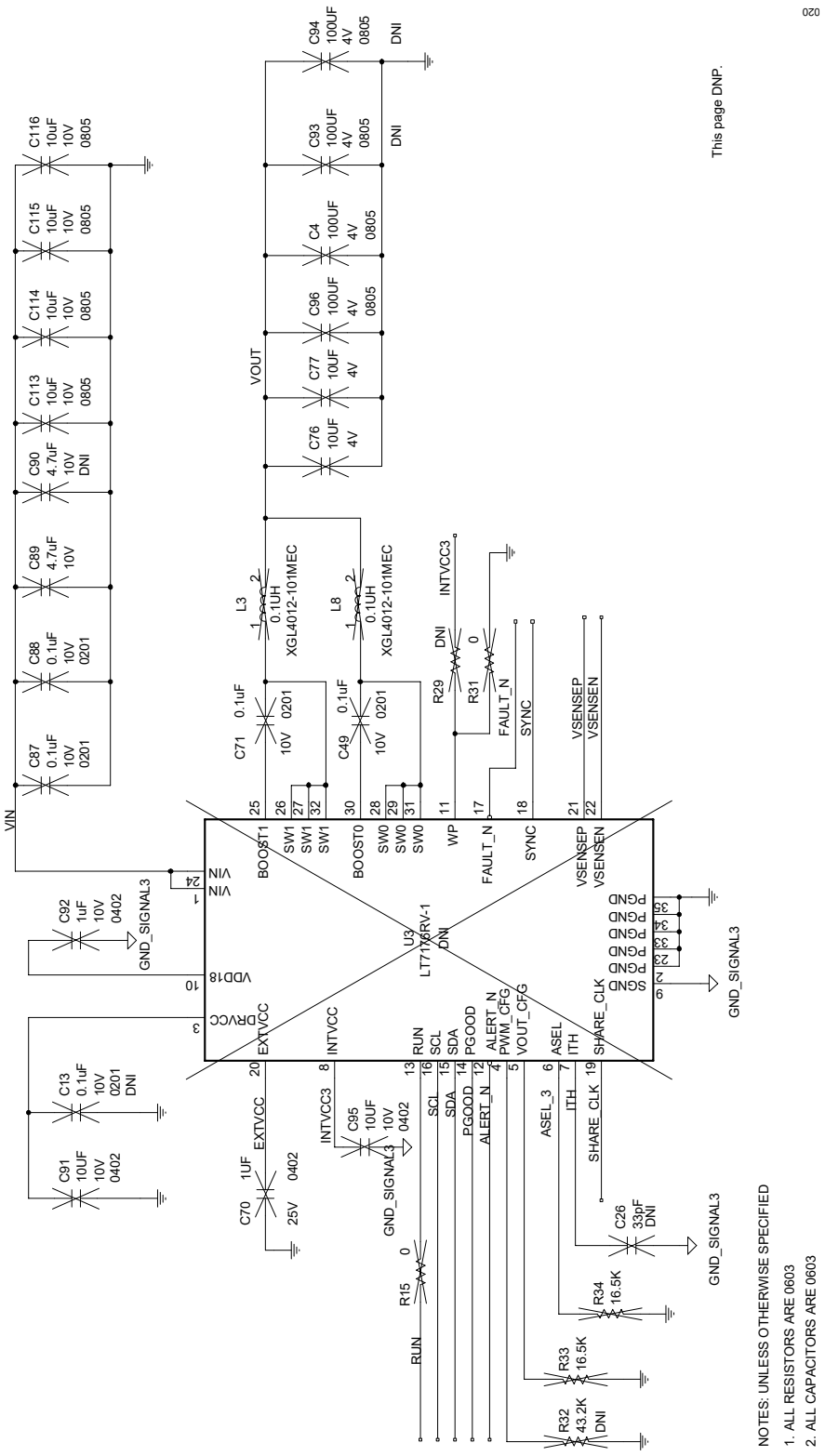


Schematic Diagram (continued)



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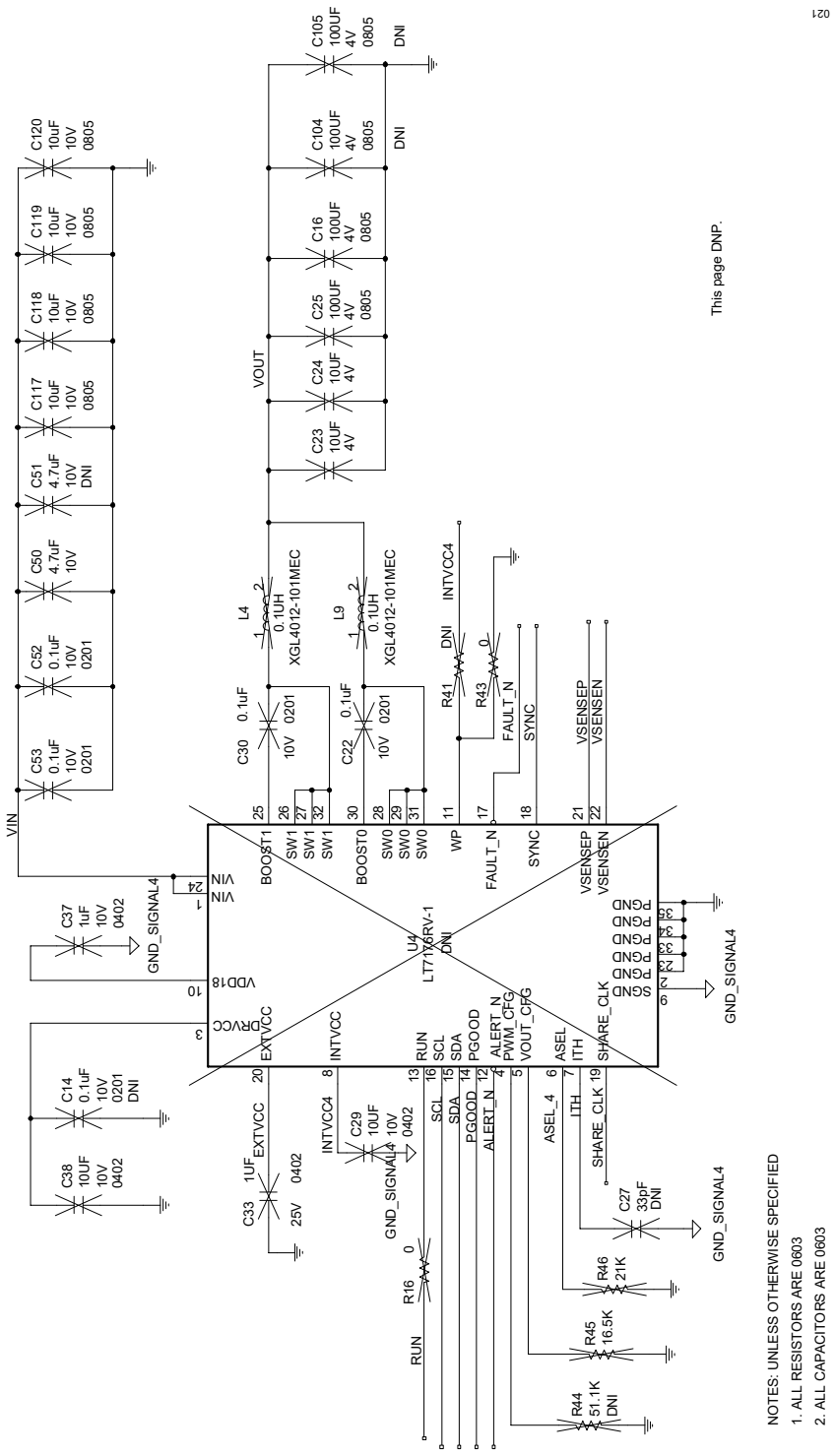
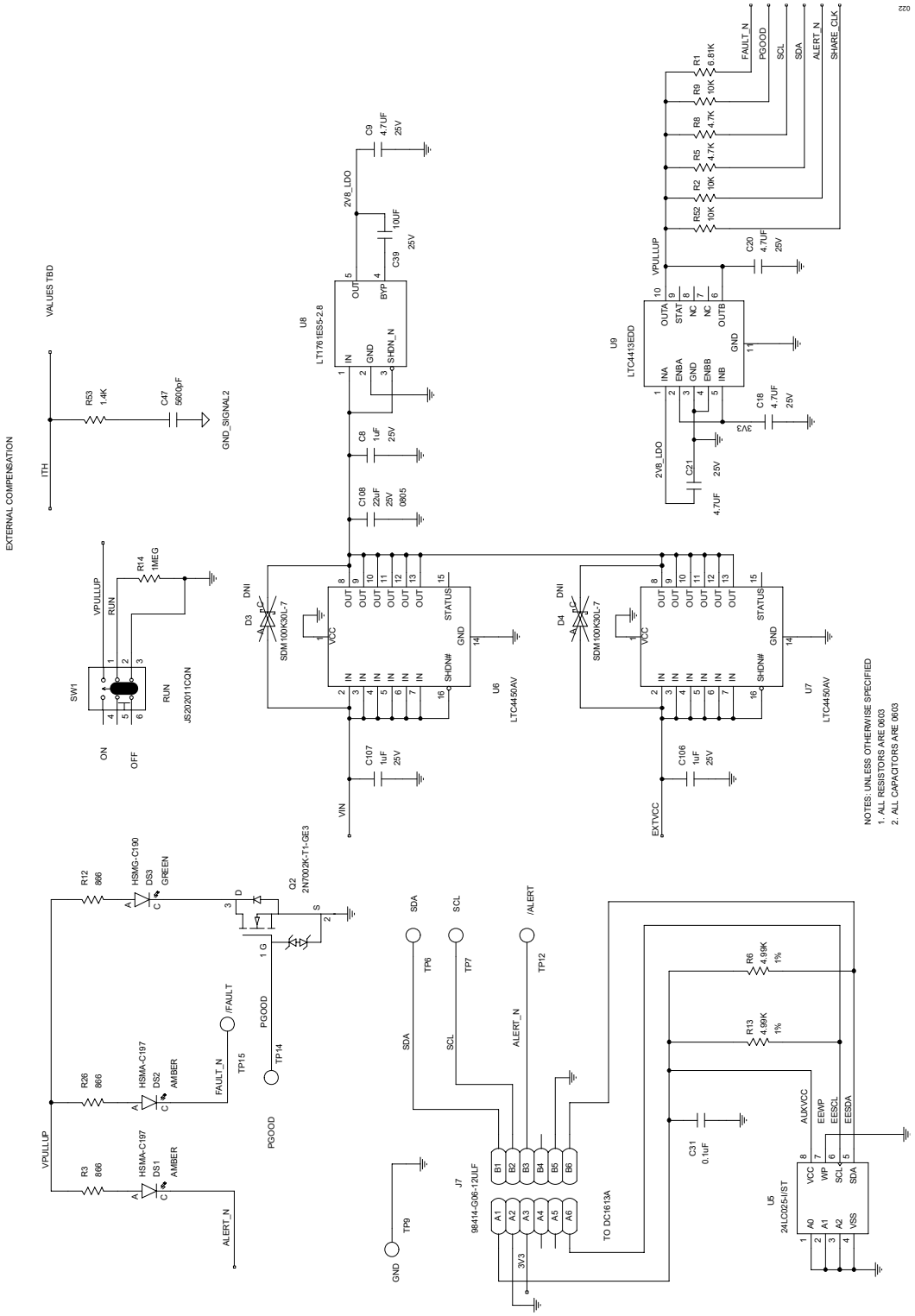


Schematic Diagram (continued)



Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	07/26	Initial release	—

Notes