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

General Description

The evaluation kit EVAL-LT7176-AZ is a dual-phase single-output monolithic DC/DC synchronous step-down regulator with a 2.7V to 4V input range featuring _LT®7176_. 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 LT7176 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^{2}C compliant serial interface. Refer to the LT7176 data sheet for more detailed information.

The EVAL-LT7176-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-LT7176-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^{2}C/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 NVM, 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 LT7176 data sheet gives a complete description of the part, operation, and application information. The data sheet must be read in conjunction with this demo manual for EVAL-LT7176-AZ.

For more details and instructions of the LTpowerPlay, refer to LTpowerPlay GUI for the LT7176 Quick Start Guide.

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		76		%

Quick Start Procedure

The EVAL-LT7176-AZ is easy to set up to evaluate the performance of the LT7176. See *Figure 1* for proper measurement equipment setup, and follow the procedure below:

1. Set an input power supply that is capable of 5V/7A. Then turn off the supply.
2. With power off, connect the supply to the input terminals V_{IN} and GND. Set the default jumper position: 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-LT7176-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.

    1) Voltmeters can be placed across the output terminals (VSENSE+, VSENSE-) to get accurate output voltage measurements.
    2) Voltmeters can be placed across the input terminals (VIN_SENSE, GND) to get accurate input voltage measurements.
    3) To achieve the best efficiency, remove R27 and R28, then populate 0Ω resistors for R58 and R59 on the bottom layer of the board.
    4) To achieve the best output accuracy, remove R58 and R59, then populate 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 LT7176 LTpowerPlay Quick Start Procedure for details.
11. The EVAL-LT7176-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-LT7176-AZ schematic.
12. The EVAL-LT7176-AZ is compatible with 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 LTpowerAnalyzer, refer to *LTpowerAnalyzer* for user guide, software and evaluation kit. Attach the load slammer via the on-board socket P1 for easy loop response and load transient test setup.

    NOTE: To test the loop response of the EVAL-LT7176-AZ, remove R27, R58, and R59, then populate a 0Ω resistor at R26 and a 20Ω resistor at R47 on the bottom layer of the board.

Connecting a PC to EVAL-LT7176-AZ

Use a PC to reconfigure the power management features of the LT7176, 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 may be plugged in when a V_{IN} is present. Figure 4 shows a demo setup of connecting a PC to EVAL-LT7176-AZ.
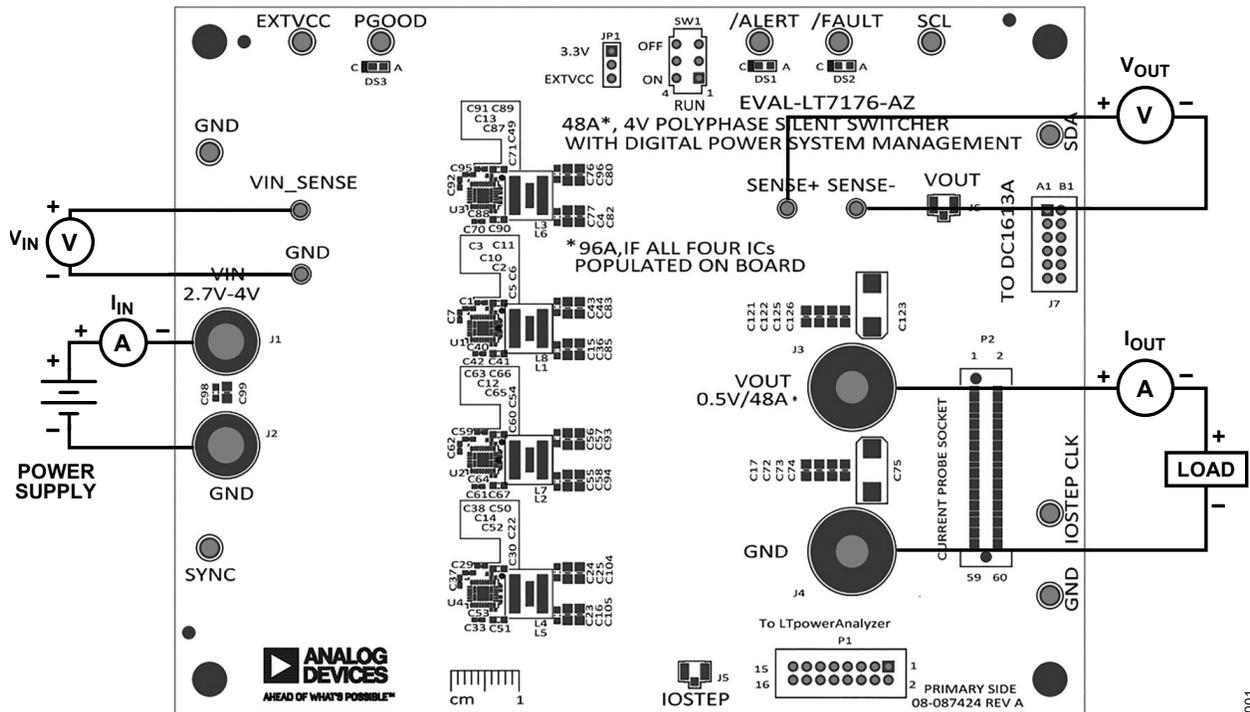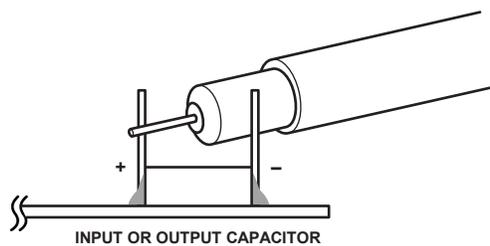

Figure 1. Proper Measurement Equipment Setup

Figure 2. Scope Probe Placement for Measuring Input or Output Voltage Ripple
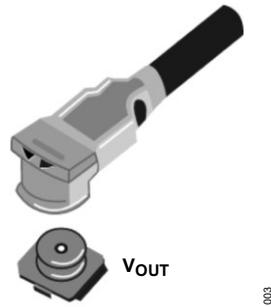
Figure 3. Coaxial Cable Placement for Measuring Output Voltage Ripple
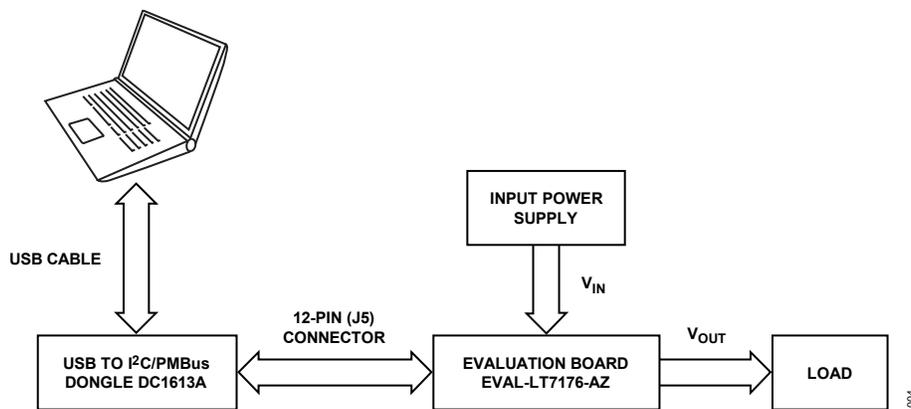
Figure 4. Demo Setup with PC
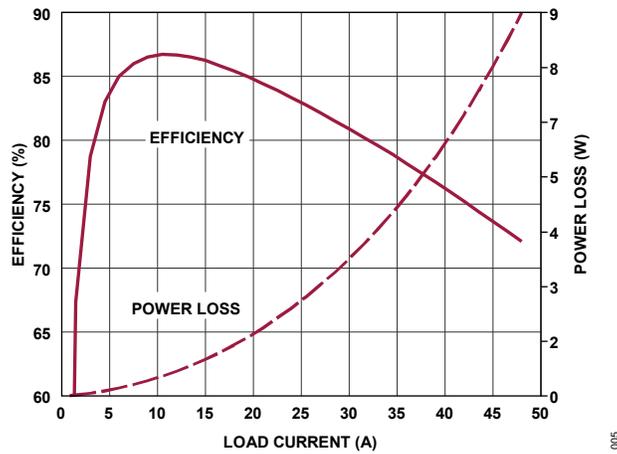
Typical Performance Characteristics

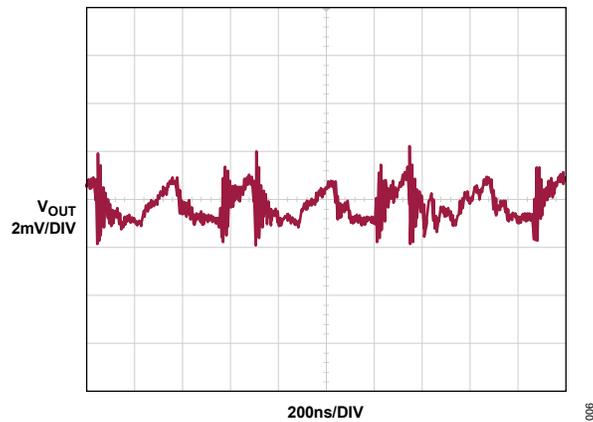*Figure 5. Efficiency vs. Load Current at 1.5MHz Switching Frequency*

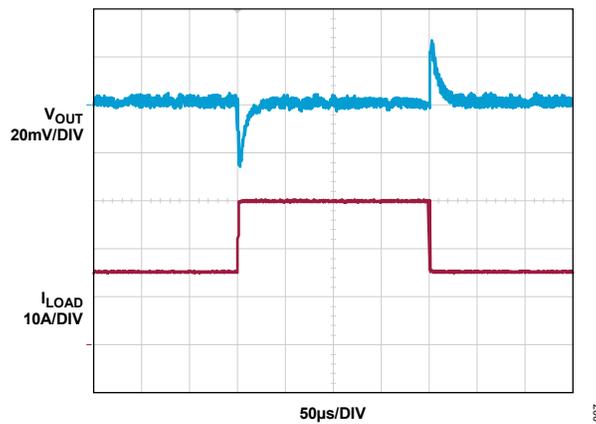*Figure 6. Output Voltage Ripple at V_{IN} = 3.3V, V_{OUT} = 0.5V, f_{SW} = 1.5MHz, I_{LOAD} = 48A*

Figure 7. Load Transient Response with Load Steps 15A to 20A to 15A
V_{IN} = 3.3V, V_{OUT} = 0.5V, f_{SW} = 1.5MHz; C_{OUT} = 2x10µF + 8x100µF,
Gm = 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 different 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) 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 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 *LTpowerPlay | Analog Devices*.

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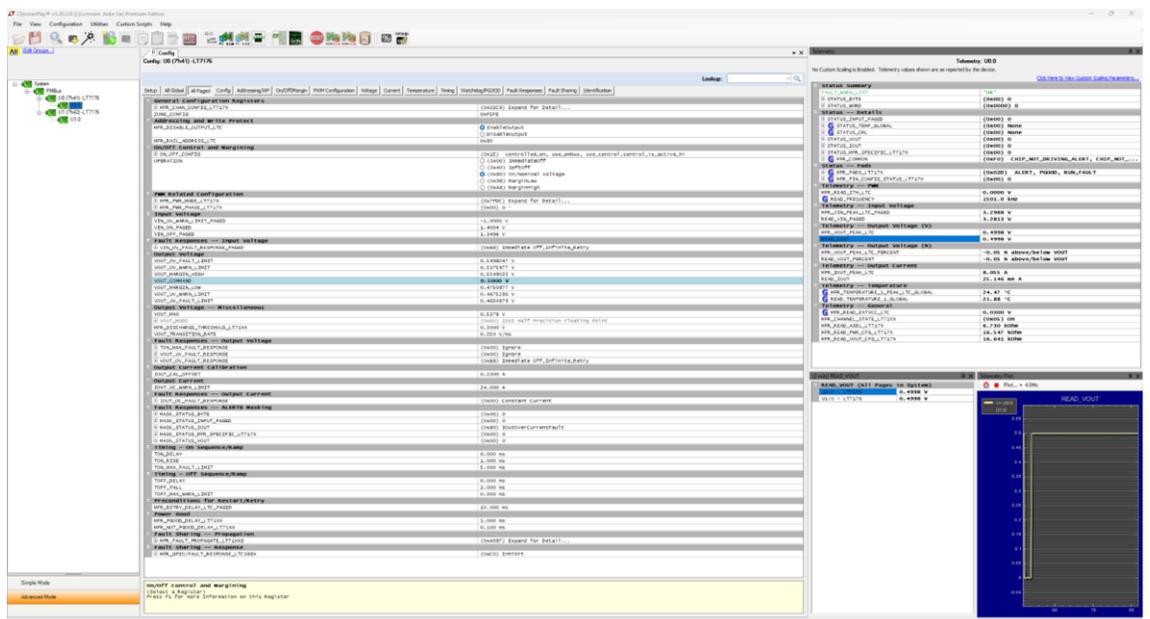

*Figure 8. LTpowerPlay Main Interface*

LTpowerPlay Quick Start Procedure

The following procedure describes how to use LTpowerPlay to monitor and change the settings of LT7176.

1. Download and install the LTPowerPlay GUI: *LTpowerPlay | Analog Devices*.

2. Launch the LTpowerPlay GUI.

3. The GUI should automatically identify the EVAL-LT7176-AZ. The system tree on the left-hand side should look like the image below.
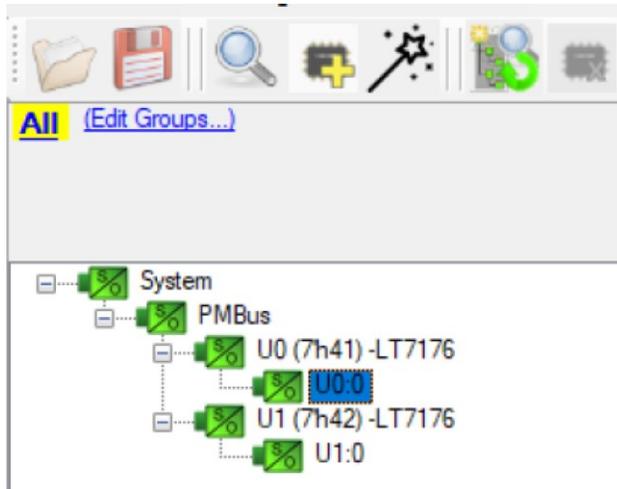
4. A green message box shows for a few seconds in the lower left-hand corner, confirming that LT7176 is communicating:
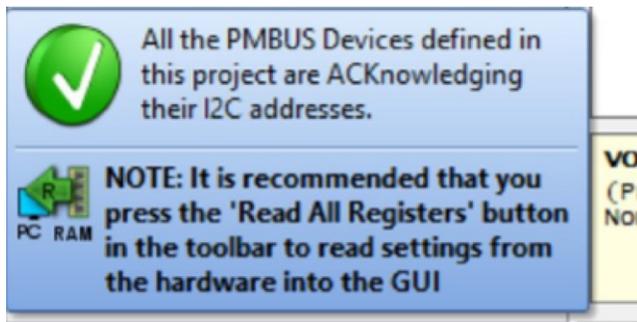
5. In the toolbar, click the **R** (RAM to PC) icon to read the RAM from the LT7176. This reads the configuration from the RAM of the LT7176 and loads it into the GUI.

6. To change the output voltage to a different value, like 0.6V, in the **Config** tab, type in 0.6 in the **VOUT_COMMAND** box under the **Voltage** tab, as shown below.

PWM Related Configuration	
⊞ MFR_PWM_MODE_LT717X	(0x1FE4) Expand for Detail...
Input Voltage	
VIN_UV_WARN_LIMIT_PAGED	-1.0000 V
VIN_ON_PAGED	1.4004 V
VIN_OFF_PAGED	1.3496 V
Fault Responses -- Input Voltage	
⊞ VIN_OV_FAULT_RESPONSE_PAGED	(0x88) Immediate Off,Infinite_Retry
Output Voltage	
VOUT_OV_FAULT_LIMIT	+10.0 % above/below VOUT
VOUT_OV_WARN_LIMIT	+7.5 % above/below VOUT
VOUT_MARGIN_HIGH	+5.0 % above/below VOUT
ⓞ VOUT_COMMAND	0.6001 V
VOUT_MARGIN_LOW	-5.0 % above/below VOUT
VOUT_UV_WARN_LIMIT	-6.5 % above/below VOUT
VOUT_UV_FAULT_LIMIT	-7.0 % above/below VOUT

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7. Then, click the **W** (PC to RAM) icon to write the register values to the LT7176. After finishing this step, the output voltage changes to 0.6V.

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8. If the write is successful, the following message appears.

Success ✕

ⓘ Successfully Verified Registers for 1 of 1 chips

OK

014
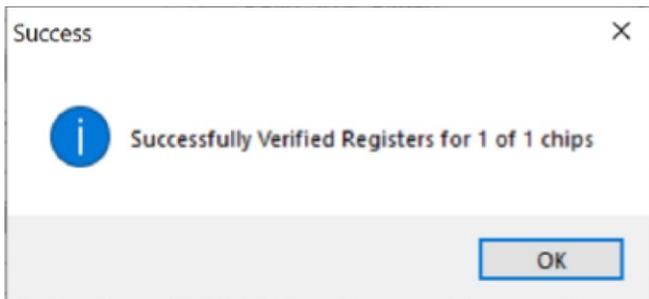
9. To save the changes to NVM in the tool bar, click the **RAM to NVM** button.

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10. Save the evaluation board configuration to a (*.proj) file. Click the **Save** icon and save the file with a new name.

11. * For evaluations of mulitple LT7176 in parallel, it is recommended to change the MFR_RAIL_ADDRRESS_LTC of all LT7176 to a same value other than 0x80, any MFR_ADDRESS_LTC, or any of the illegel values listed in the LT7176_LT7176_PMBUS_USER_GUIDE. Write the register values to LT7176, then rebuild the system tree by click the 'Re-enmulating' button.

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Please note that after this step, LTPowerPlay would automatically synchronize setting changes of all LT7176, and the write functions would send PMBus commands to MFR_RAIL_ADDRESS_LTC instead of MFR_ADDRESS_LTC of each LT7176.

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	Analog Devices Supplied,08_087424a
2	4	C7, C62, C100, C103	Ceramic capacitors, 1μF, 10V, 10%, X7S, 0402	Samsung, CL05A106MP5NUNC
3	2	C101, C102	Ceramic capacitors, 22μF, 20%, 10V, X7R, 0805	TDK, C1005X7S1A105K050BC
4	3	C8, C106, C107	Ceramic capacitors, 1μF, 25V, 10%, X7R, 0603, AEC-Q200	Murata, GRM21BZ71A226ME15L
5	1	C108	Ceramic capacitors, 22μF, 25V, 20%, X6S, 0805, AEC-Q200	Murata, GCM188R71E105KA64D
6	9	C45, C46, C48, C97, C99, C109, C110, C111, C112	Ceramic capacitors, 10μF, 10V, 10%, X7R, 0805	Murata, GRT21BC81A226ME13L
7	2	C11, C66	Ceramic capacitors, 4.7μF, 16V, 10%, X5R, 0603, low ESR	Samsung, CL21B106KPQNNNE
8	4	C15, C43, C55, C56	Ceramic capacitors, 10μF, 4V, 10%, X7T, 0603, AEC-Q200	TDK, C1608X5R1C475K080AC
9	4	C9, C18, C20, C21	Ceramic capacitors, 4.7μF, 25V, 10%, X6S, 0603	TDK, CGA3E1X7T0G106M080AC
10	2	C19, C28	Ceramic capacitors, 33pF, 50V, 5%, C0G, 0603	Murata, GRM188C81E475KE11D
11	8	C2, C5, C6, C40, C54, C60, C64, C65	Ceramic capacitors, 0.1μF, 10V, 10%, X7S, 0201	Yageo, CC0603JRNPO9BN330
12	1	C31	Ceramic capacitor, 0.1μF, 10V, 10%, X7R, 0603	Murata, GRM033C71A104KE14D
13	3	C32, C34, C35	Ceramic capacitors, 1μF, 6.3V, 10%, X7R, 0402	Kemet, C0603C104K8RACTU
14	8	C36, C44, C57, C58, C73, C74, C78, C81	Ceramic capacitors, 100μF, 4V, 20%, X6S, 0805	Murata, GRM155R70J105KA12D
15	1	C39	Ceramic capacitor, 0.01μF, 25V, 10%, X7R, 0603	Murata, GRM21BC80G107ME15K
16	2	C42, C61	Ceramic capacitors, 1μF, 25V, 10%, X5R, 0402, AEC-Q200	Samsung, CL10B103KA8NNNC
17	1	C47	Ceramic capacitor, 5600pF, 50V, 5%, X7R, 0603	Murata, GRT155R61E105KE01D
18	1	C68	Capacitor aluminium, 330μF, 10V, 20%, 0.2Ω, 0.41A, 3000H, AEC-Q200	AVX, 06035C562JAT2A
19	1	C98	Ceramic capacitor, 1μF, 10V, 10%, X7R, 0603	Panasonic, EEE-TC1A331UP
20	2	DS1, DS2	LED uni-color amber, 595nm, 1.9V	Kemet, C0603C105K8RACTU
21	1	DS3	LED green, 570nm, 2.2V, 2LD, 0603	Broadcom limited, HSMA-C197
22	2	L1, L2	Ind power shielded wirewound, 65nH, 20%, 0.00063Ω, maximum DCR, AEC-Q200	Coilcraft Inc., XGL6030-650MEC
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, LT7176RV#TRPBF
40	1	U5	IC EEPROM, 2Kbit, I^{2}C 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, TP11, TP12, TP13, TP14, 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
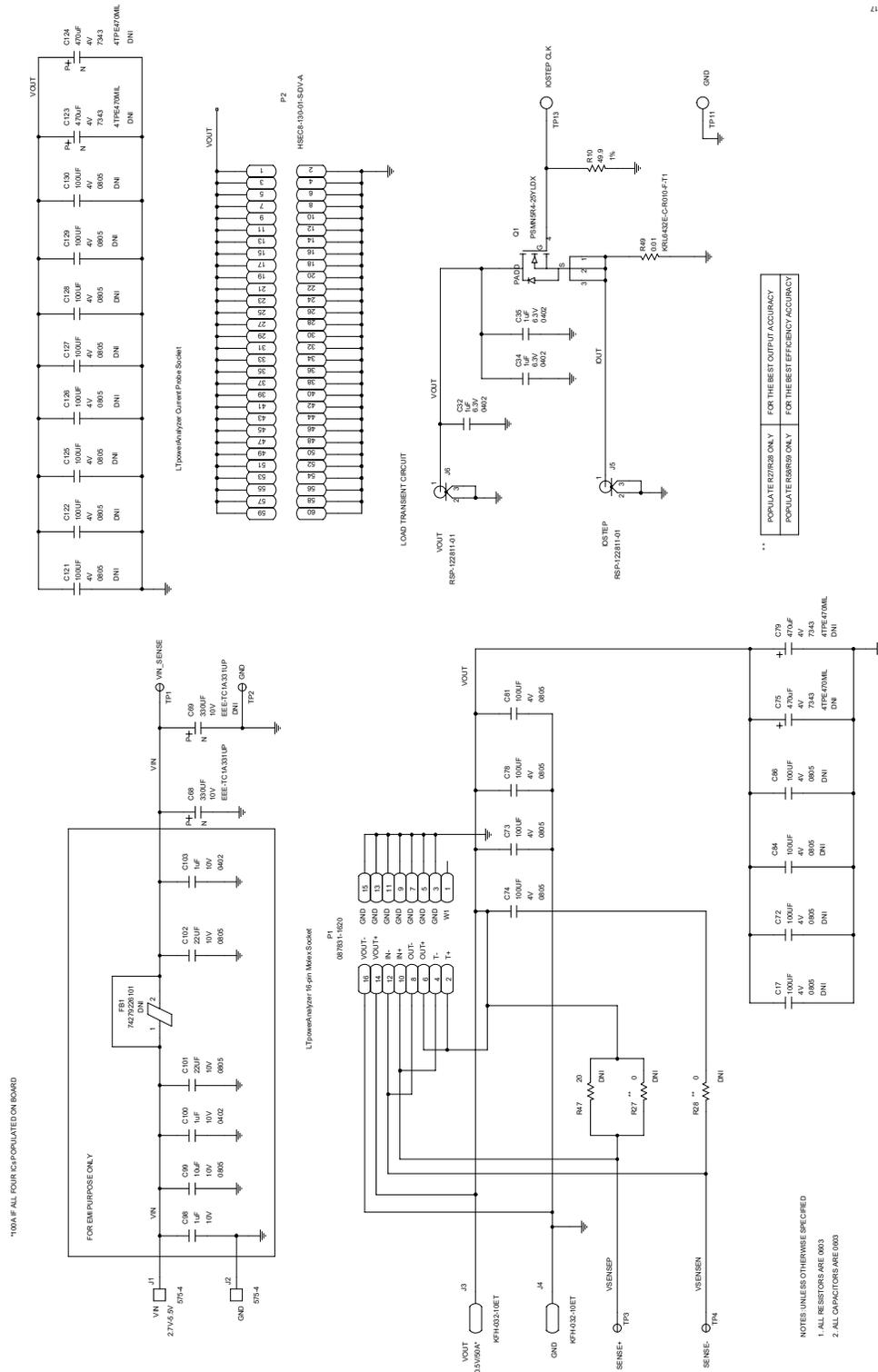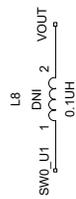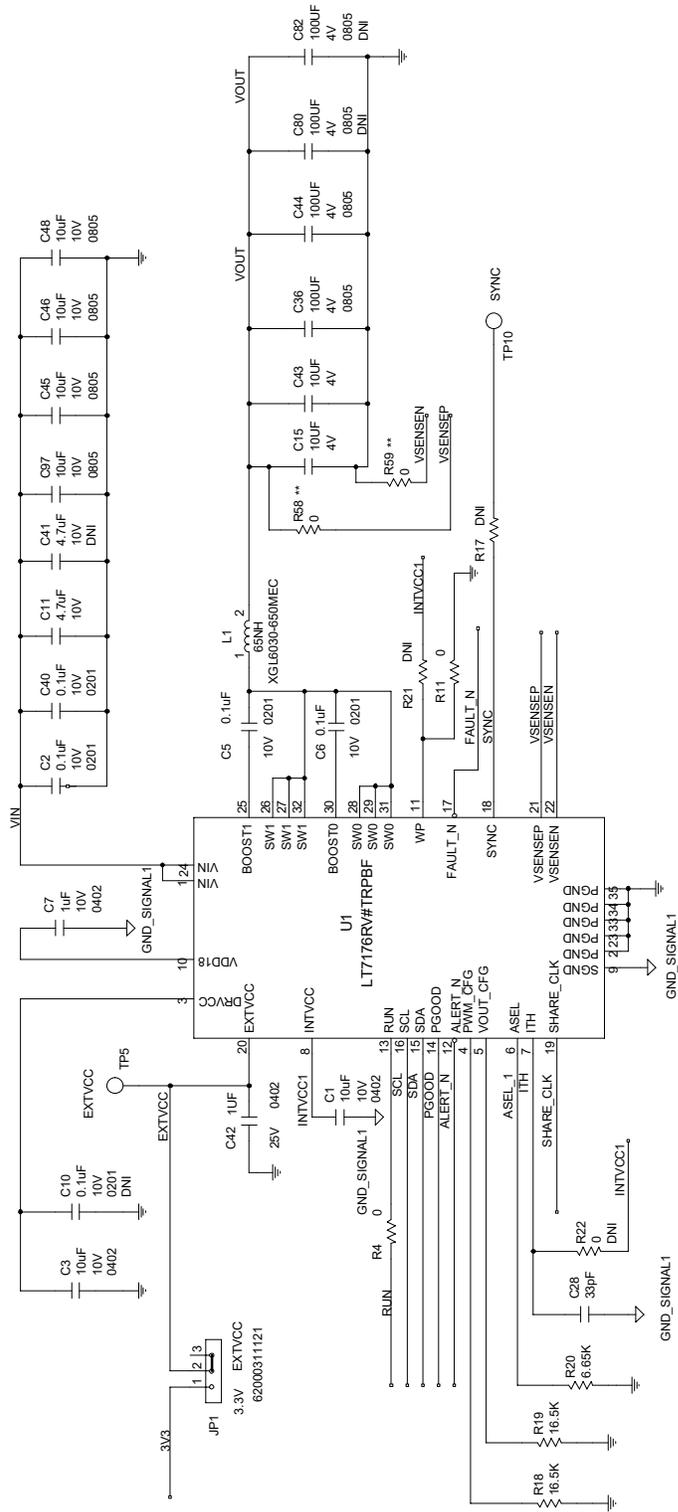
Schematic Diagram (continued)

NOTES: UNLESS OTHERWISE SPECIFIED
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2. ALL CAPACITORS ARE 0603
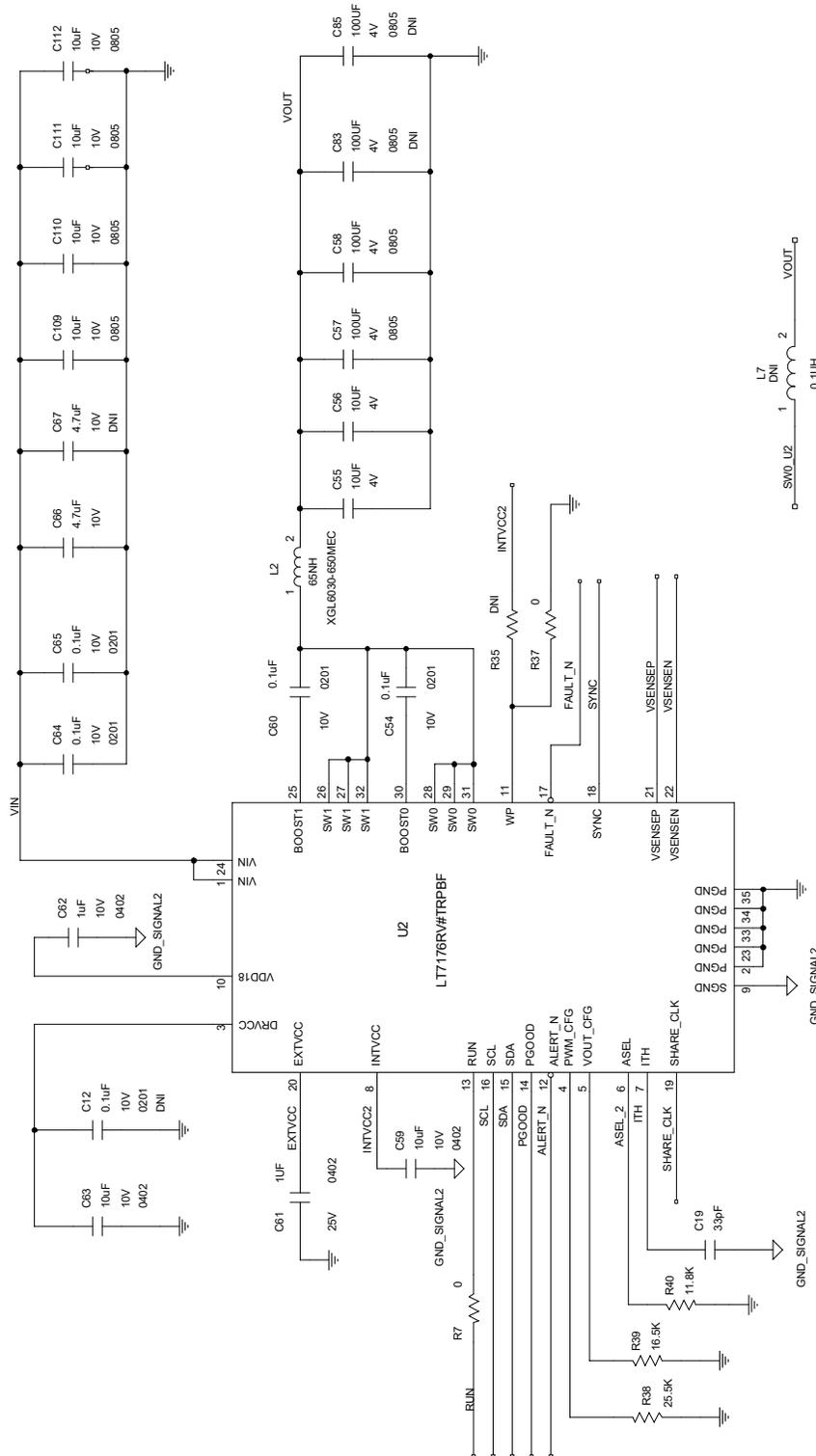
Schematic Diagram (continued)

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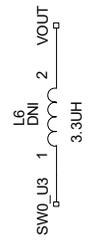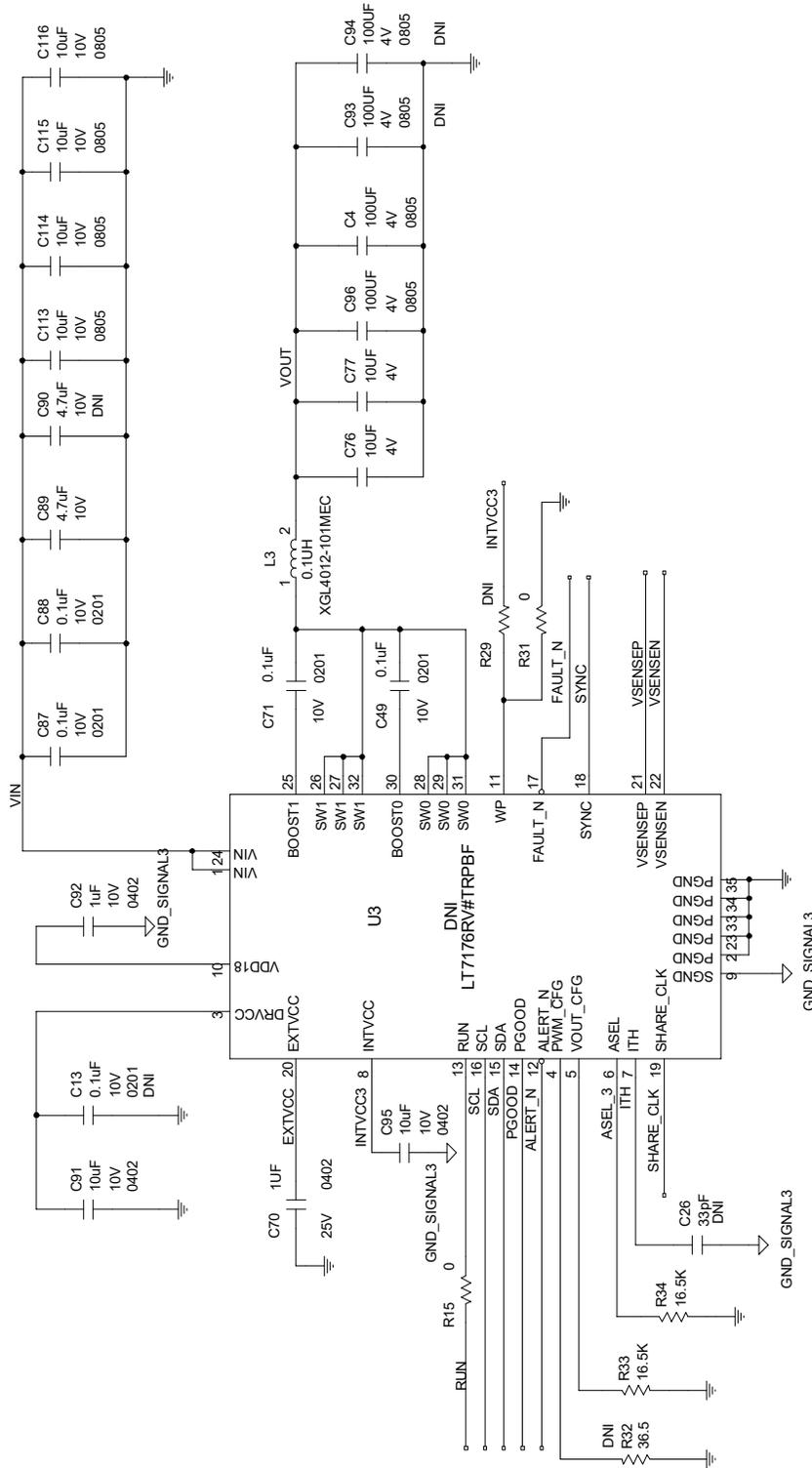
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Schematic Diagram (continued)

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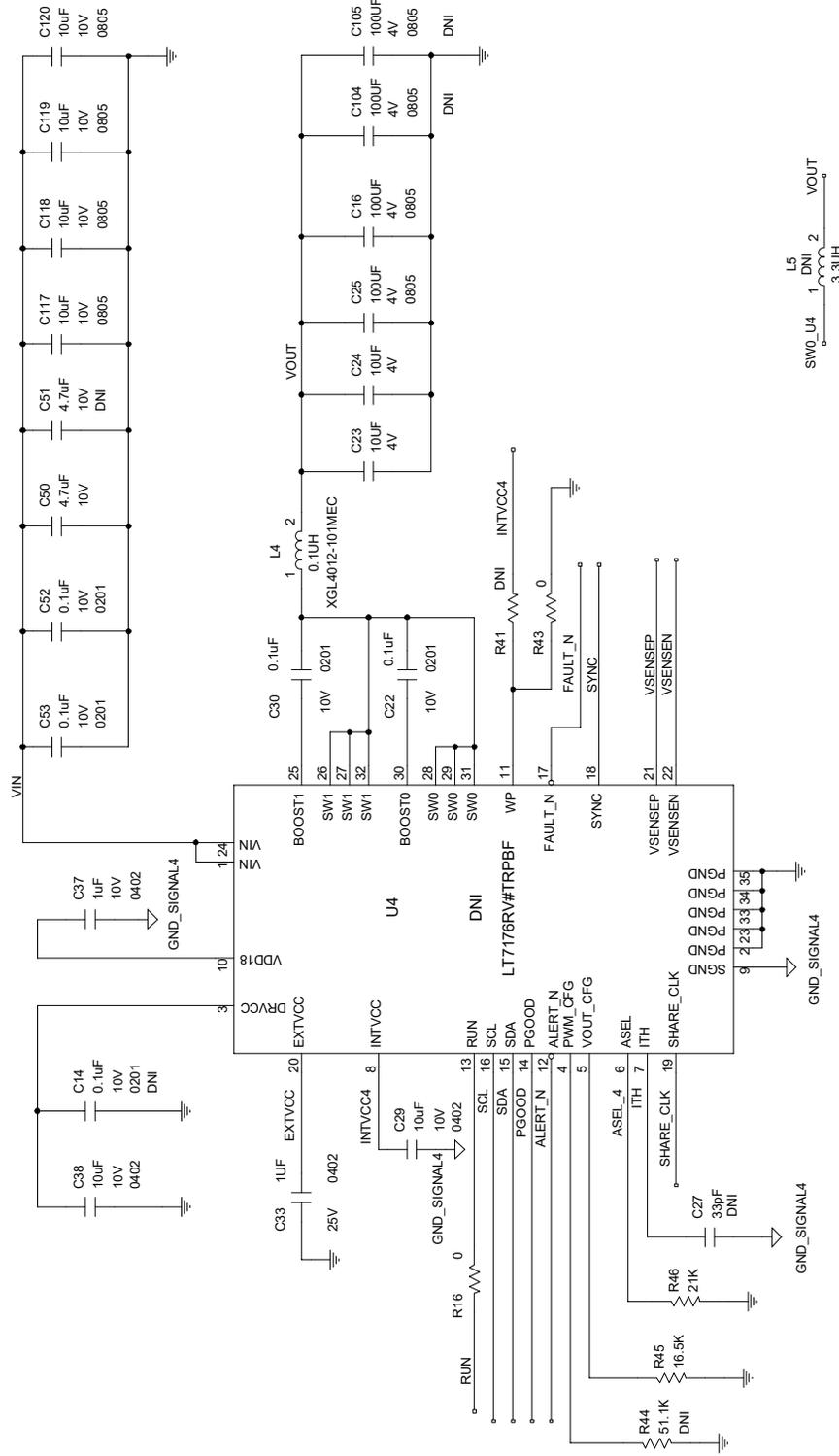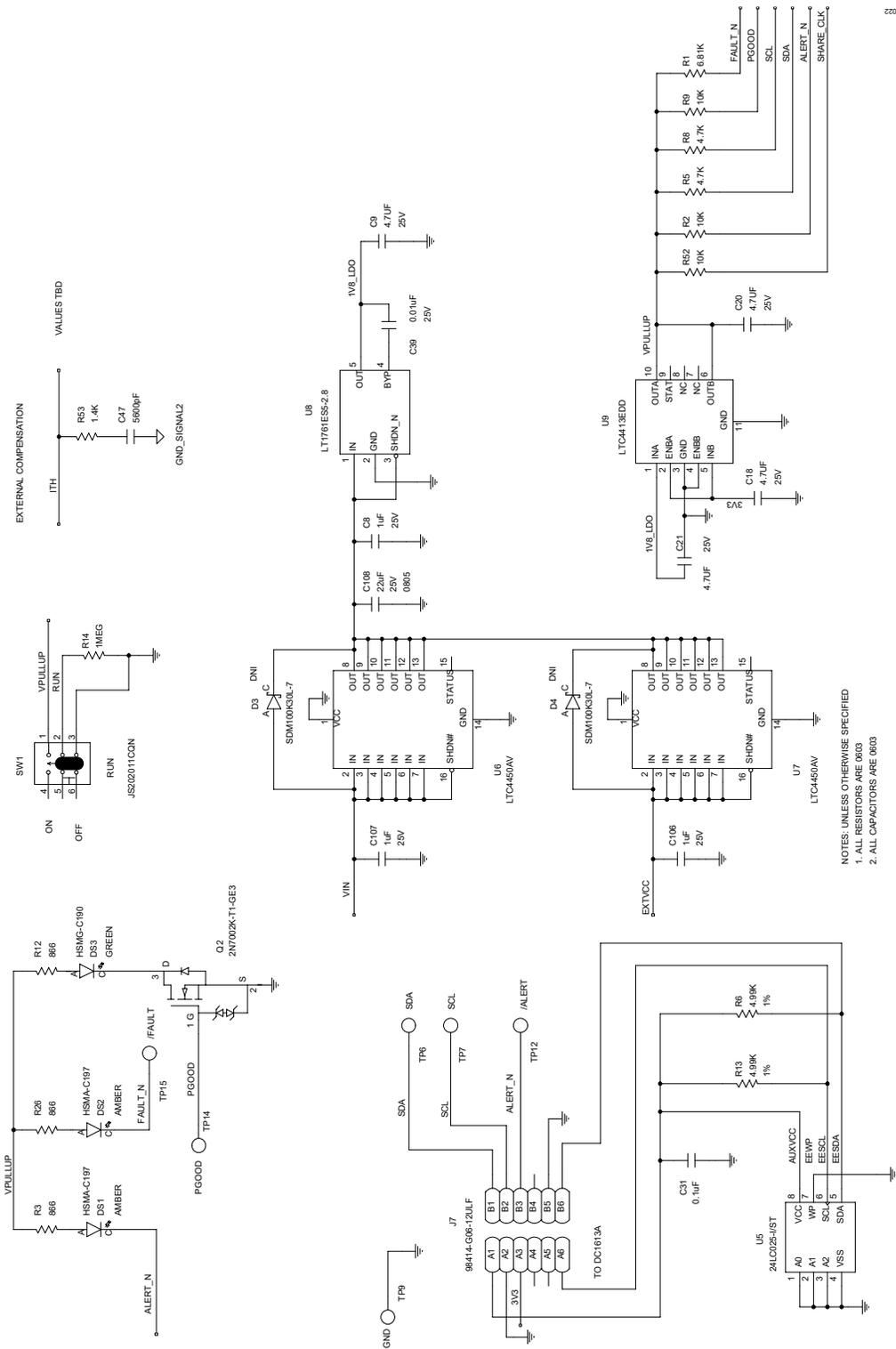
1. ALL RESISTORS ARE 0603
2. ALL CAPACITORS ARE 0603

Schematic Diagram (continued)

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	01/26	Initial release	—

Notes