Evaluating the LTC3884-1, 2-Phase, Single Output Synchronous Buck Converter with Power System Management

FEATURES

- Input voltage range: 7 V to 14 V
- Output voltage (V_{OUT}): 1 V to 1.8 V, 1.0 V (default)
- Max output current: 100 A
- Number of phases: 2
- Current sense
- Temperature monitor
- PMBus compliant with digital power system management

EVALUATION BOARD KIT CONTENTS

- DC3034A-A evaluation board

EQUIPMENT NEEDED

- DC power supplies
- Multimeters for voltage and current measurements
- Electronic load or resistive loads
- DC1613A (USB to I²C/PMBus dongle)
- Oscilloscope
- Function generator or alternative digital driver

ONLINE RESOURCES

- LtpowerPlay software

GENERAL DESCRIPTION

The demonstration circuit DC3034A-A is a 2-phase single-output, high efficiency, high density, synchronous buck converter with a 7 V to 14 V input range. The output can supply up to 100 A maximum load current with 1 V output. The demo board features the LTC3884-1 controller paired with the LTC7051 smart power stage to provide a 2-phase buck converter solution. The LTC3884-1 is a dual output PolyPhase step-down controller with digital power system management. The LTC7051 is a monolithic smart power stage that integrates high-speed drivers with low resistance half-bridge power switches plus comprehensive monitoring and protection circuitry in an electrically and thermally optimized package. Refer to the LTC3884-1 and LTC7051 data sheets for detailed information.

The DC3034A-A powers up to default settings and produces power based on configuration resistors (or with the default setting in the nonvolatile memory of the DC3034A-A) without the need for any serial bus communication, which allows easy evaluation of the DC-DC converter. To fully explore the extensive power system management features of the DC3034A-A, download the GUI software LTpowerPlay™ onto the PC and use the Analog Devices, Inc., I²C/SMBus/PMBus DC1613A dongle to connect to the board. LTpowerPlay reconfigures the device once connected and stores the configuration in an electrically erasable programmable read-only memory (EEPROM). LTpowerPlay also views the telemetry of voltage, current, temperature, and fault status of the demo board.

For more details and instructions of LtpowerPlay, see LTpowerplay Quick Start Procedure section.

EVALUATION BOARD PHOTOGRAPH

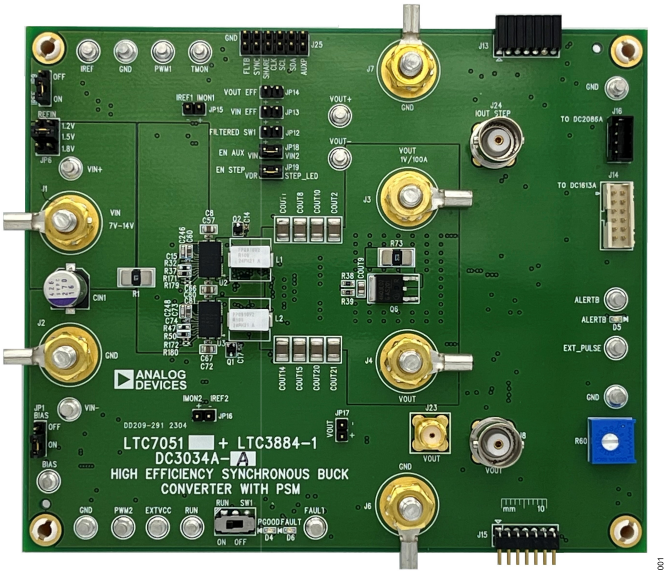

Figure 1. Single Output LTC7051 + LTC3884-1/DC3034A-A Demo Circuit

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REVISION HISTORY

12/2023—Revision 0: Initial Version

PERFORMANCE SUMMARY OF THE DC3034A-A

T_A = 25°C, unless otherwise specified.

Table 1. Performance Summary

Parameter	Test Conditions/Comments	Value
Input Voltage Range, V_{IN}		7 V to 14 V
Output Voltage, V_{OUT}	V_{IN} = 7 V to 14 V, I_{OUT} = 0 A to 100 A	1 V to 1.8 V, default 1.0 V
Maximum Output Current, I_{OUT}	V_{IN} = 7 V to 14 V, V_{OUT} = 1 V to 1.8 V	100 A
Typical Efficiency	V_{IN} = 12 V, V_{OUT} = 1.0 V, I_{OUT} = 100 A	89.7%
Default Switching Frequency		750 kHz

QUICK START PROCEDURE

The demonstration circuit DC3034A-A is easy to set up to evaluate the performances of the LTC3884-1 and LTC7051. See Figure 2 for the proper measurement of the equipment setup and refer to the following steps:

1. With power off, connect the input power supply (7 V to 14 V) to V_{IN} (J1) and GND (J2).
2. Connect the 1.0 V output load (initial load: no load) between V_{OUT} (J3 and J4) and GND (J6 and J7).
3. Set the default jumper position. Refer to Table 2.
4. Switch on the input power supply and check for the proper output voltage. V_{OUT} must be 1.0 V, ±0.5%.
5. 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.
6. Connect the dongle and control the output voltage from the GUI. See the LTpowerplay Quick Start Procedure section for details.

Table 2. Jumper Settings

Jumper	Default Position
JP1	On
JP6	1.5 V
JP9	On
JP12	Off
JP13	Off
JP14	Off
JP15	Off
JP16	Off
JP17	Off
JP18	On
JP19	On
SW1 Run	On

When measuring the efficiency of the DC3034A-A, it is recommended to monitor the V_{IN} and V_{OUT} at the locations close to the power stage. Two examples are as follows:

- Monitor V_{IN} across C218.
- Monitor V_{OUT} across COUT104.

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 must be soldered to the (+) and (−) terminals of an output capacitor. The ground ring of the probe must touch the (−) lead and the probe tip must touch the (+) lead.

When performing the load transient test, it is recommended to use a function generator to generate a pulse (~3% duty cycle with 10 Hz to 100 Hz frequency). Then apply this pulse to the EXT_PULSE (E7) and GND (E8) turrets. 22 mV/A is the ratio of the pulse voltage amplitude over the load current step. The dynamic circuit metal-oxide semiconductor field effect transistor (MOSFET) is off when EXT_PULSE is floating or grounded. Refer to the notes in the dynamic load circuit in the Evaluation Board Schematic section to optimally route the voltage sense points during load transient test. It is highly recommended to monitor the load voltage using J8 or J23, which are Kelvin connected to COUT9.

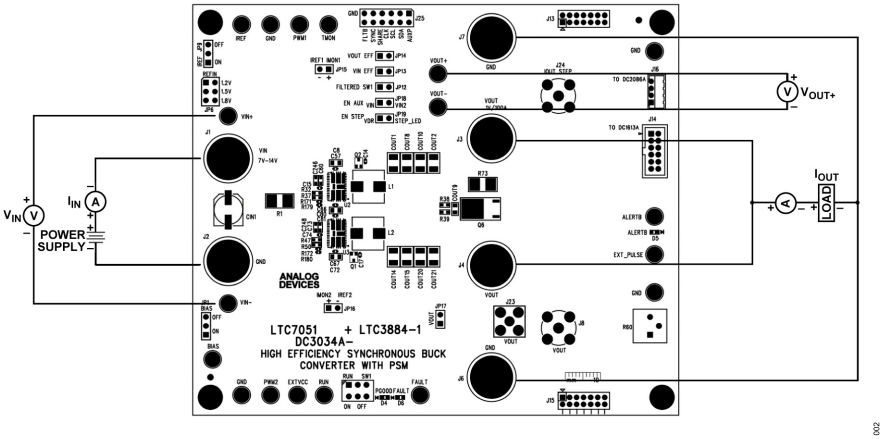

Figure 2. DC3034A-A Measurement Equipment Setup

QUICK START PROCEDURE

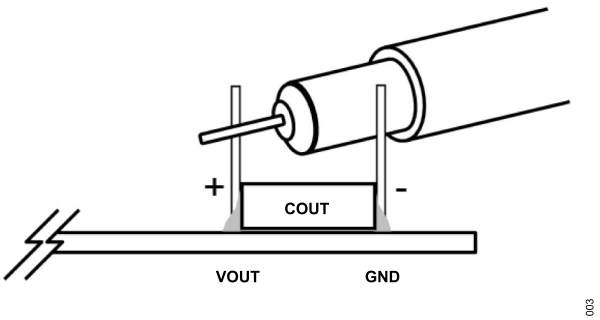

Figure 3. Measuring Output Voltage Ripple

CONNECTING A PC TO DC3034A-A

Use a PC to reconfigure the power management features of the LTC3884-1 such as nominal V_{OUT}, margin set points, overvoltage (OV)/undervoltage (UV) limits, current fault limits, temperature fault limits, sequencing parameters, fault log, fault responses, and other functionalities. The DC1613A dongle can be connected when V_{IN} is present.

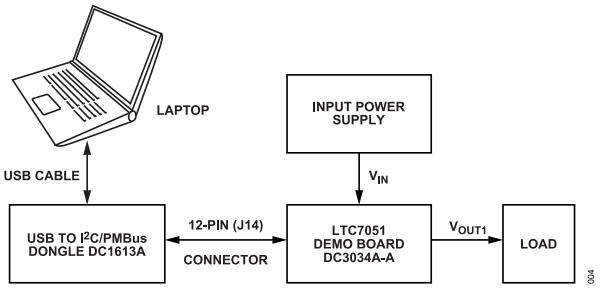

Figure 4. Demo Setup with PC

EFFICIENCY MEASUREMENT

The JP12 to JP14 headers are Kelvin connected close to the power stage for ideal efficiency measurement. For total V_{OUT} rail efficiency, including controller and smart power stage (SPS) bias conversion losses, refer to Figure 5. Check the following setup before measurement:

- Remove JP19.
- Remove the R58 bleeder resistor.

To measure the efficiency of a single LTC7051, refer to Figure 6. In this setup, the controller, SPS, and IREF biases are provided externally so as to not load the 12 V input. Additionally, the SPS bias power loss from the external power source is added to the efficiency calculation as shown in Figure 6.

Optionally, FILTERED SW1 (JP12) can be used as the V_{OUT} measurement to obtain efficiency of just the SPS (without inductor loss). JP12 is connected to the switching node through a filter composed of R173 and C26 to obtain the average voltage at the switch node. Check the following setup before measurement:

- Remove JP18 and JP19.
- Set JP1 to off.
- Set JP9 to off and remove JP6.
- Remove bleeder Resistor R58.
- Remove R167 and R168.
- Remove L2.
- Remove R44 and R50.
- Change R155 from 100 Ω to 0 Ω.
- Apply a 5 V power supply between the turrets of BIAS (E35) and GND (E36) for driving power. Measure the voltage and the current for driving power loss.
- Apply a 5 V power supply between the turrets of EXTVCC (E40) and GND (E36) for controller power.
- Apply a 1.5 V power supply between the turrets of IREF (E38) and GND (E39) for IREF voltage.

QUICK START PROCEDURE

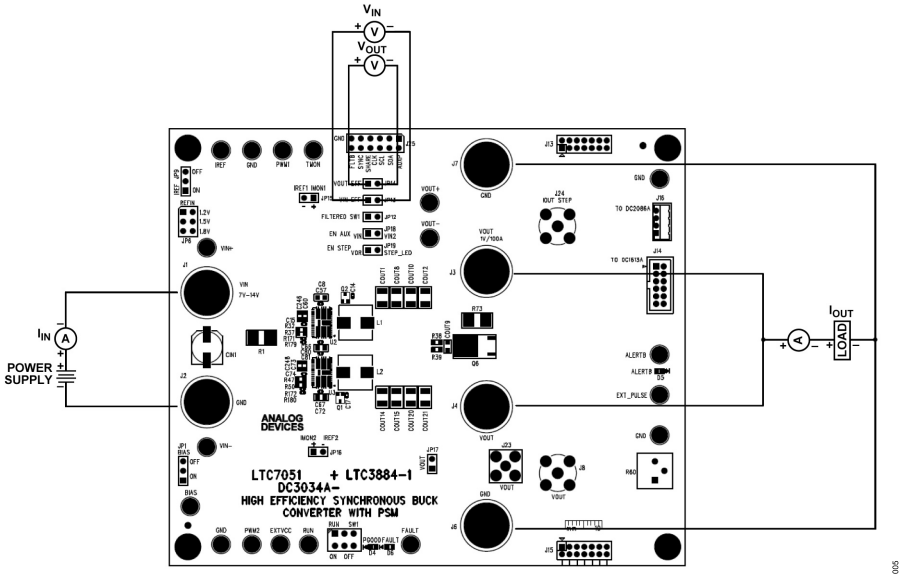

Figure 5. Measuring Setup for DC3034A-A Efficiency

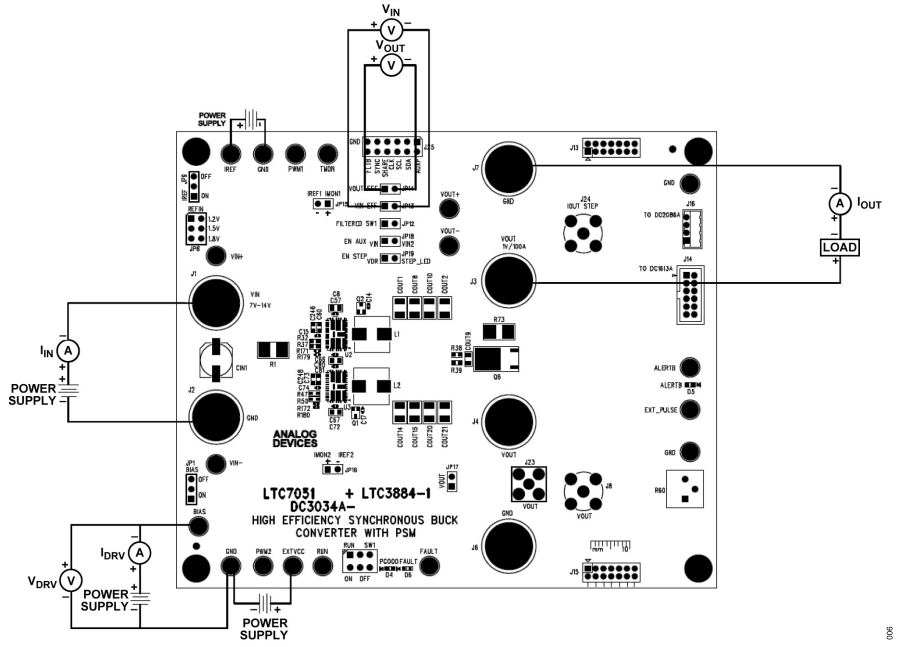

Figure 6. Measuring Setup for LTC7051 Efficiency

QUICK START PROCEDURE

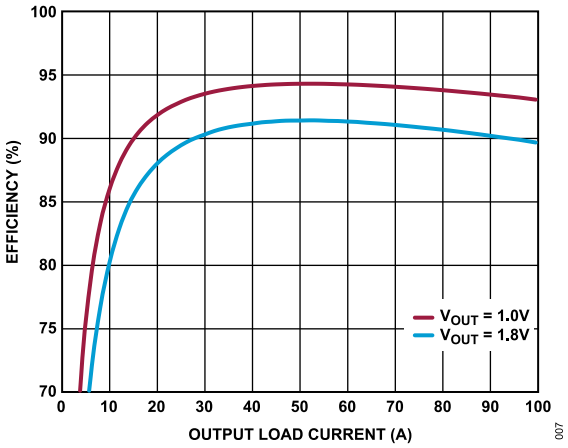

Figure 7. DC3034A-A Efficiency vs. Load Current on V_{OUT}

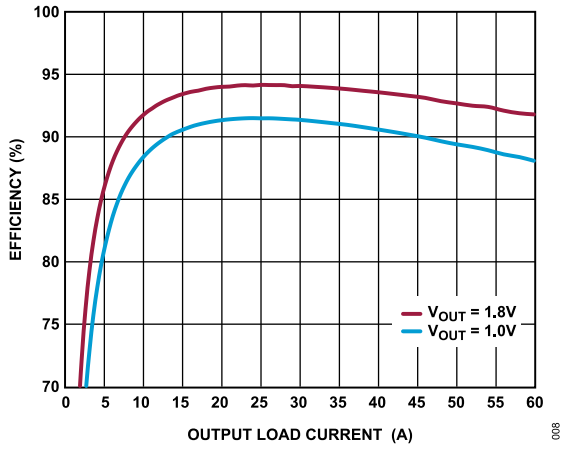

Figure 8. LTC7051 Efficiency vs. Load Current on V_{OUT}

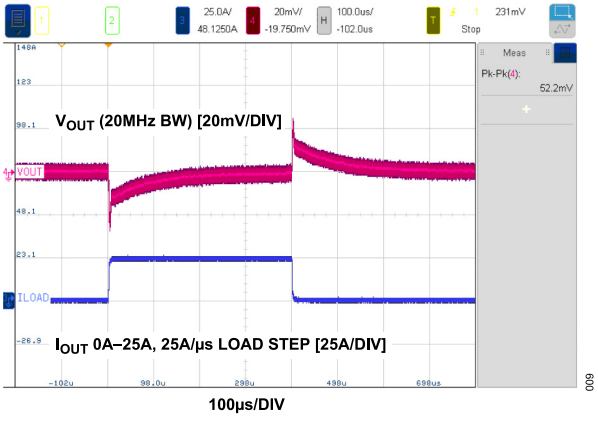

Figure 9. V_{OUT} Load Transient Response at V_{IN} = 12 V, V_{OUT1} = 1.0 V

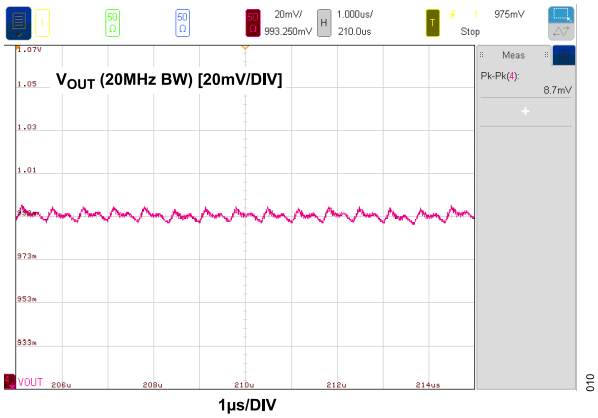

Figure 10. V_{OUT} Voltage Ripple at V_{IN} = 12 V, V_{OUT1} = 1.0 V, I_{OUT1} = 100 A

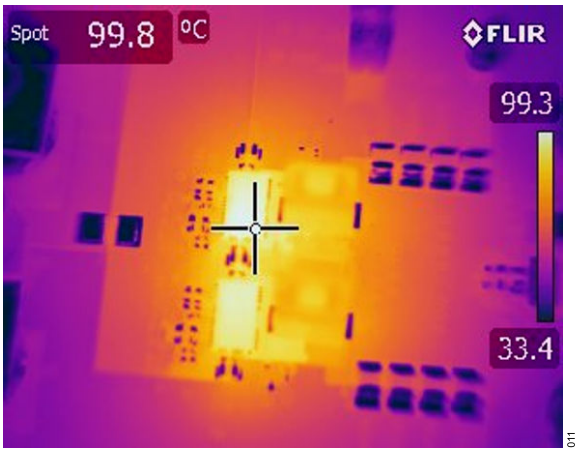

Figure 11. Thermal at V_{IN} = 12 V, V_{OUT} = 1.0 V, I_{OUT} = 100 A, T_A = 22°C, No Airflow

LTPOWERPLAY SOFTWARE GUI

LTpowerPlay is a powerful Windows-based development environment that supports Analog Devices power system management ICs and micromodules, including the LTM4675, LTM4676, LTM4677, LTM4678, LTM4680, LTM4700, LTC3880, LTC3882, LTC3883, LTC3884, and LTC3888-1. This software supports a variety of different tasks. 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) 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 setup to program or adjust the power management scheme in a system, or to diagnose power issues when enabling output rails. LTpowerPlay utilizes the DC1613A USB to I^2C/SMBus/PMBus controller to communicate with one of many potential targets, including the LTM4675, LTM4676, LTM4677, LTM4678, LTM4680, LTM4700, LTC3880, LTC3882, LTC3883, LTC3884, and LTC3888-1 demo systems, or a customer board. This software also provides an automatic update feature to keep the software current with the latest set of device drivers and documentation. Download the LTpowerPlay software from: www.analog.com/ltpowerplay.

To access technical support documents for Analog Devices digital power system management products, visit LTpowerPlay.

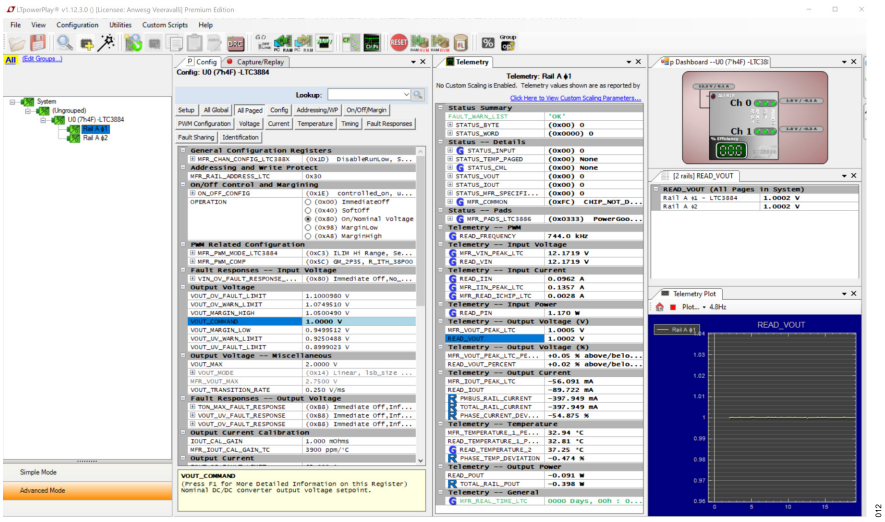

Figure 12. LTpowerPlay Main Interface (DC3034A-A)

LTPOWERPLAY QUICK START PROCEDURE

The following procedure describes how to use LTpowerPlay to monitor and change the settings of the LTC38884-1:

1. Download and install the LTpowerPlay GUI at www.analog.com/ltpowerplay.
2. Launch the LTpowerPlay GUI. The GUI must automatically identify the DC3034A-A. Figure 13 shows the system tree.

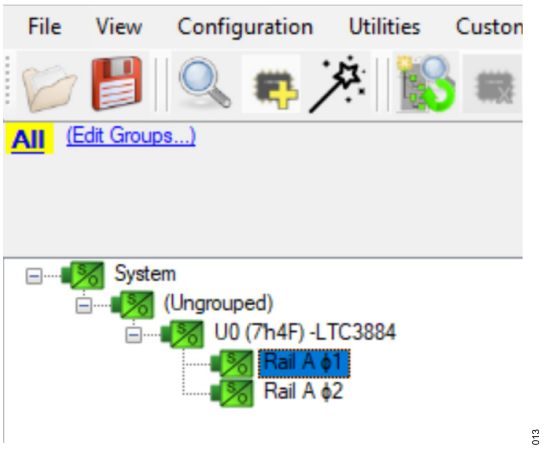

Figure 13. System Tree

3. In the lower left corner of the screen, a message opens to confirm that the LTC3884-1 is communicating as shown in Figure 14.

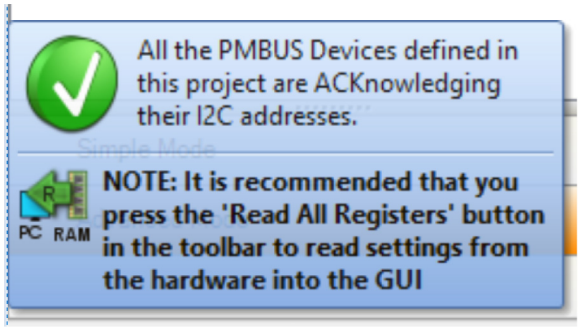

Figure 14. Confirmation Message

4. In the toolbar, click the icon shown in Figure 15 to read the configuration from the RAM of the LTC3884-1 and load it into the GUI.

Figure 15. RAM to PC Icon

5. To change the output voltage to a different value, in the **Voltage** tab, type 1.2000 V in the VOUT_COMMAND box as shown in Figure 16.

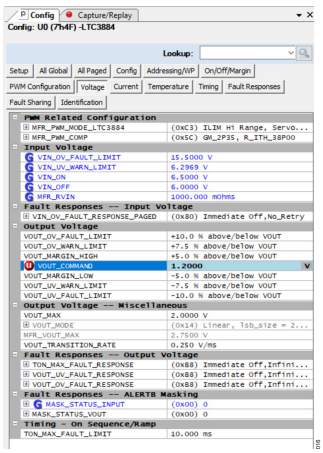

Figure 16. Configuration Tab

6. Then, click the icon shown in Figure 17 to write the register values to the LTC3884-1. After this step, the output voltage changes to 1.5 V.

Figure 17. PC to RAM Icon

7. If the write is successful, the message shown in Figure 18 appears.

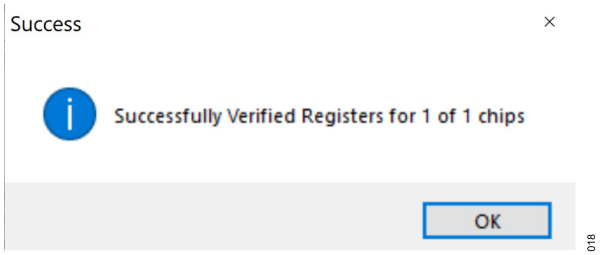

Figure 18. Pop Up Message for Successful Write

8. Save the changes into the nonvolatile memory (NVM). In the tool bar, click the icon shown in Figure 19.

Figure 19. RAM to NVM Icon

9. Save the demo board configuration to a *.PROJ file by clicking **Save**.

EVALUATION BOARD SCHEMATIC

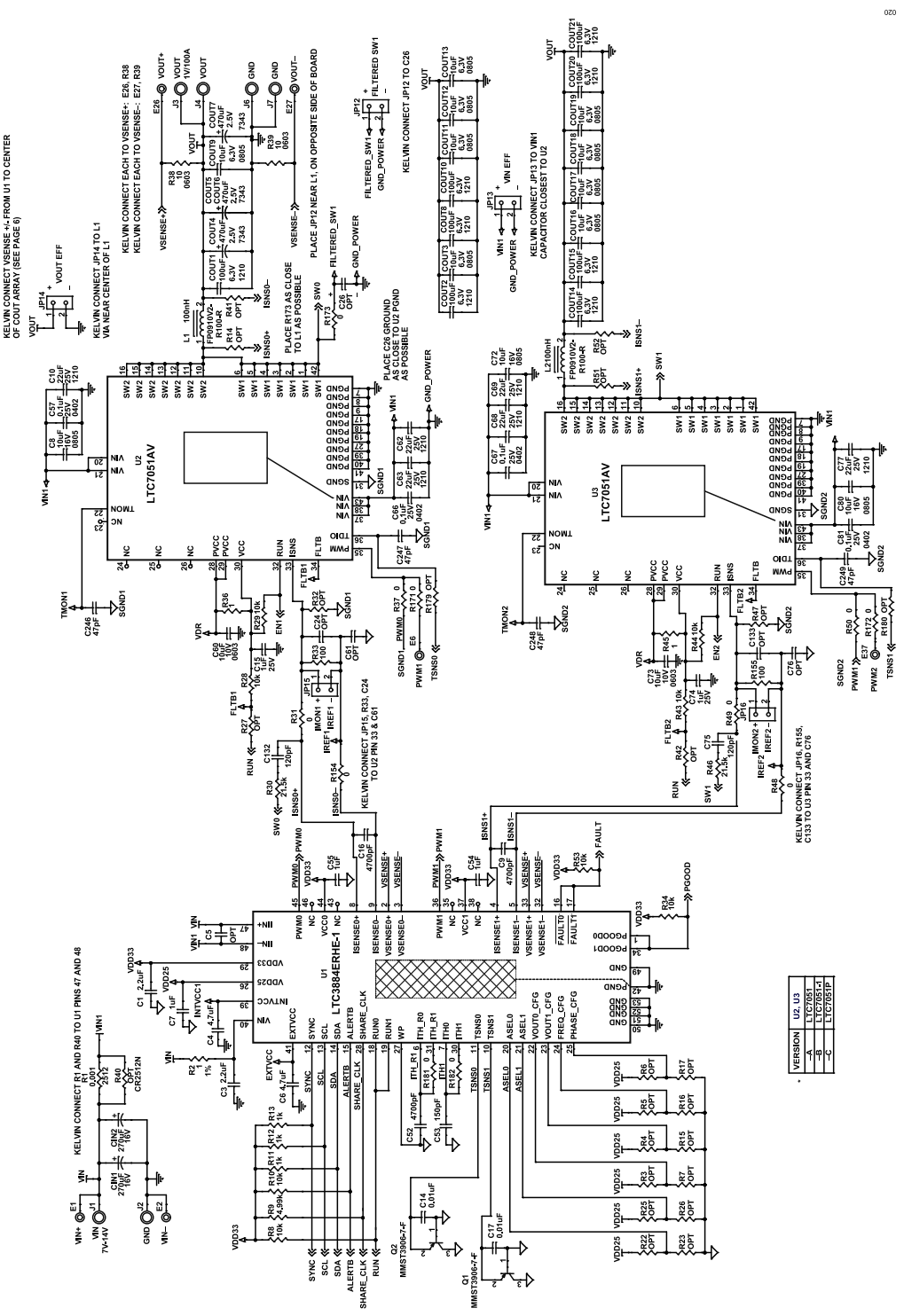

Figure 20. High Efficiency Synchronous Buck Converter with Power System Management (PSM); Controller and Power Stage Circuit

EVALUATION BOARD SCHEMATIC

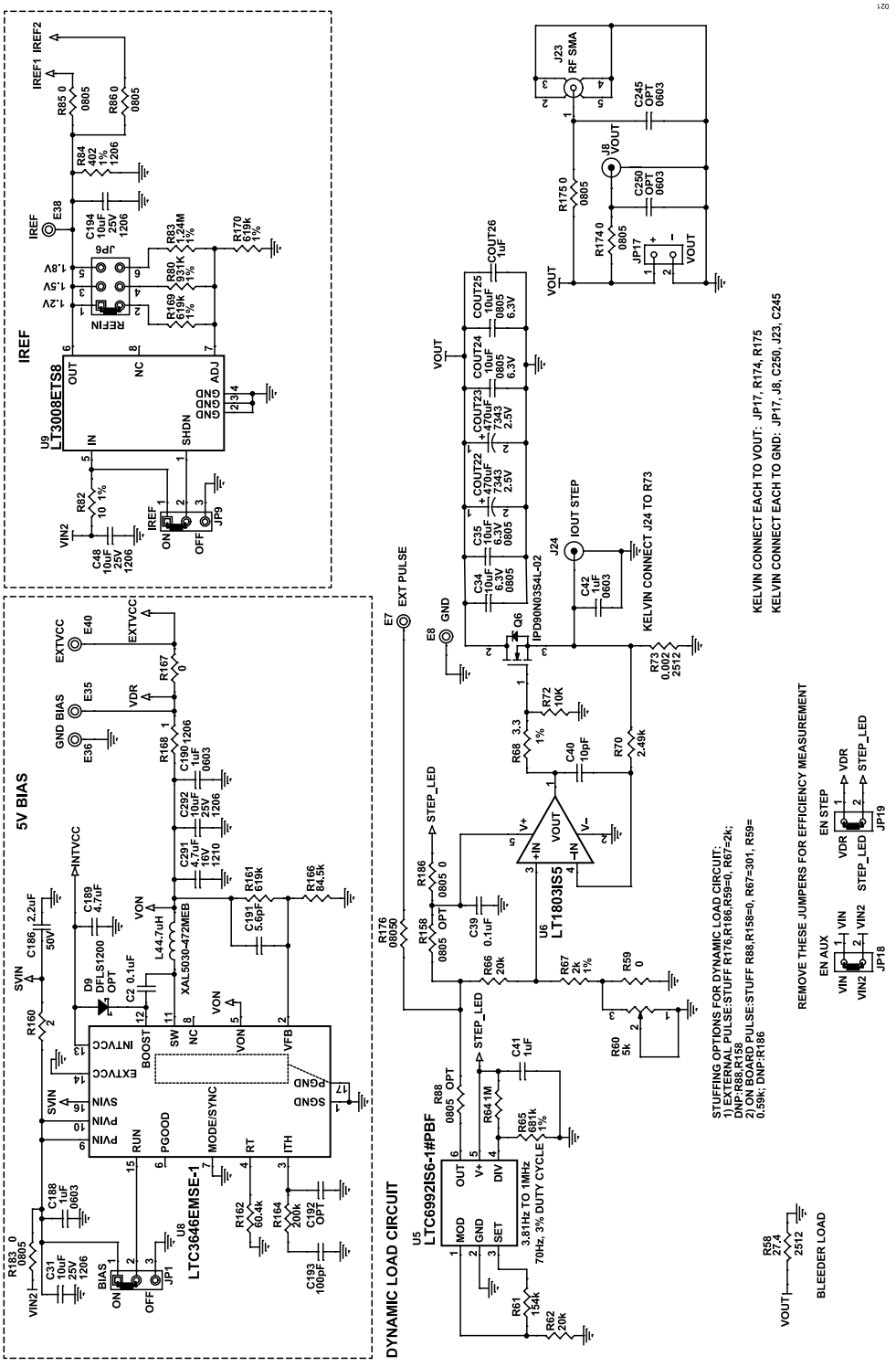

Figure 21. High Efficiency Synchronous Buck Converter with PSM; Bias, IREF, and Dynamic Load Circuits

EVALUATION BOARD SCHEMATIC

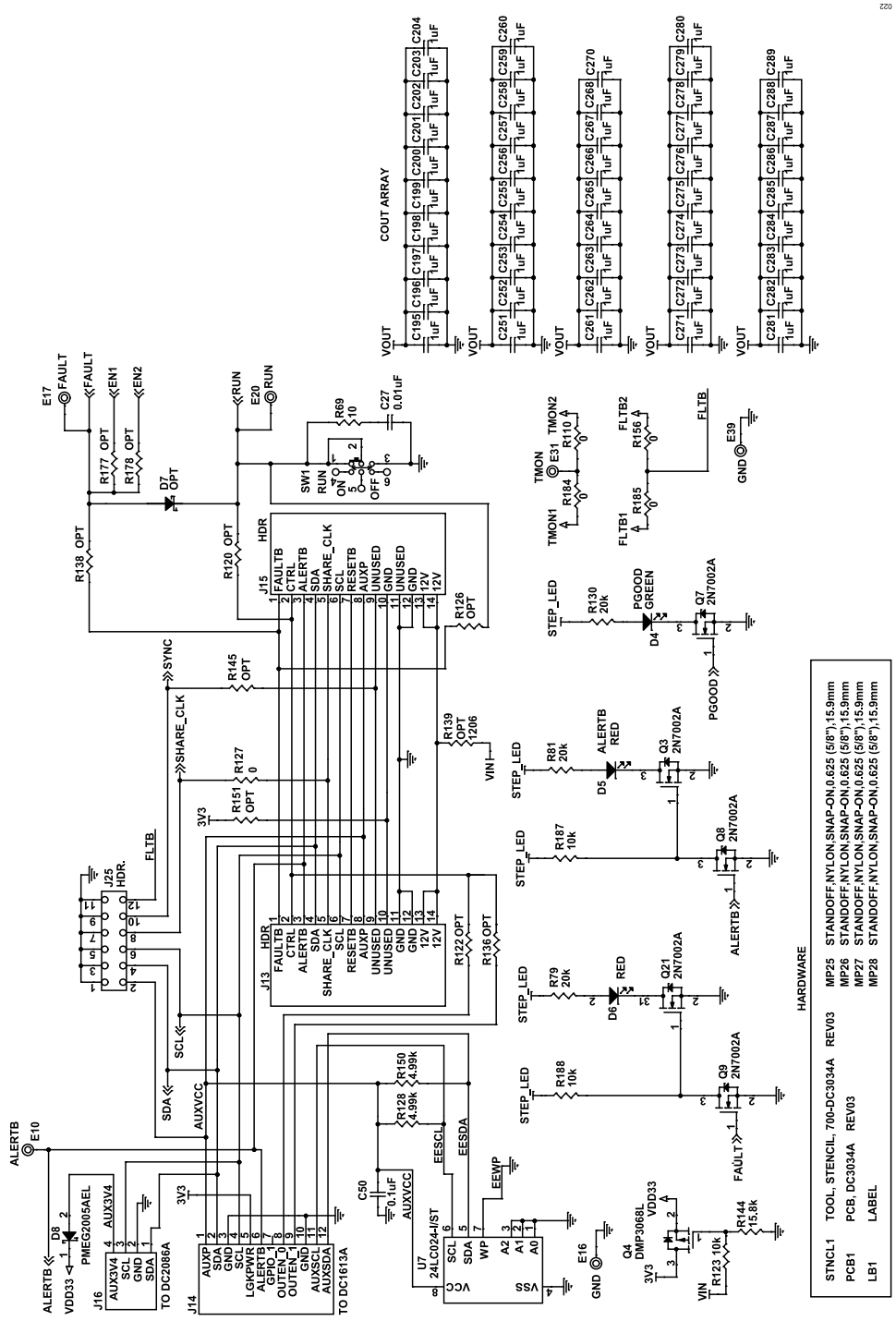

Figure 22. High Efficiency Synchronous Buck Converter with PSM; Demo Board Connectors and LED Indicator Circuits

ORDERING INFORMATION

BILL OF MATERIALS

Table 3. Required Circuit Components

Item	Qty.	Reference Designator	Description	Part No.	Manufacturer
1	2	C1, C3	Capacitor, 2.2 µF, X5R, 25 V,10%, 0402	GRM155R61E225KE11D	Murata
2	3	C2, C39, C50	Capacitor, 0.1 µF, X7R, 16 V, 20%, 0603	0603YC104MAT2A	AVX
3	2	C4, C6	Capacitor, 4.7 µF, X5R, 10 V, 10%, 0402	C1005X5R1A475K050BC	TDK
4	5	C7, C15, C54, C55, C74	Capacitor, 1 µF, X5R, 25 V, 10%, 0402	GRM155R61E105KA12D	Murata
5	3	C8, C72, C80	Capacitor, 10 µF, X7R, 16 V, 10%, 0805	EMK212BB7106KG-T	Taiyo Yuden
6	3	C9, C16, C52	Capacitor, 4700 pF, X7R, 50 V, 10%, 0402	04025C472KAT2A	AVX
7	6	C10, C62, C63, C68, C69, C77	Capacitor, 22 µF, X7R, 25 V, 10%, 1210	12103C226KAT2A	AVX
8	2	C14, C17	Capacitor, 0.01 µF, X7R, 50 V, 10%, 0402	C0402C103K5RAC7867	Kemet
9	1	C27	Capacitor, 0.01 µF, X7R, 25 V, 10%, 0603, AEC-Q200	06033C103K4Z2A	AVX
10	4	C31, C48, C194, C292	Capacitor, 10 µF, X7R, 25 V, 10%, 1206	C1206C106K3RACTU	Kemet
11	13	C34, C35, COUT3, COUT9, COUT11 to COUT13, COUT16 to COUT19, COUT24, COUT25	Capacitor, 10 µF, X7R, 6.3 V, 20%, 0805	08056C106MAT2A	AVX
12	1	C40	Capacitor, 10 pF, C0G, 50 V, 5%, 0603	06035A100JAT2A	AVX
13	5	C41, C42, C188, C190, COUT26	Capacitor, 1 µF, X5R, 16 V, 10%, 0603	0603YD105KAT2A	AVX
14	1	C53	Capacitor, 150 pF, C0G/NP0, 25 V, 5%, 0402	04023A151JAT2A	AVX
15	4	C57, C66, C67, C81	Capacitor, 0.1 µF, X5R, 25 V, 10%, 0402	04023D104KAT2A	AVX
16	2	C60, C73	Capacitor, 10 µF, X5R, 10 V, 10%, 0603	0603ZD106KAT2A	AVX
17	2	C75, C132	Capacitor, 120 pF, C0G, 50 V, 5%, 0603	06035A121JAT2A	AVX
18	1	C186	Capacitor, 2.2 µF, X7R, 50 V, 10%, 0805	08055C225KAT2A	AVX
19	1	C189	Capacitor, 4.7 µF, X7R, 16 V, 10%, 0603	GRM188Z71C475KE21	Murata
20	1	C191	Capacitor, 5.6 pF, C0G/NP0, 50 V, ±0.25 pF, 0603	06035A5R6CAT2A	AVX
21	1	C193	Capacitor, 100 pF, X7R, 25 V, 5%, 0603	06033C101JAT2A	AVX
22	48	C195 to C204, C251 to C268, C270 to C289	Capacitor, 1 µF, X7R, 6.3 V, 10%, 0402	GRM155R70J105KA12D	Murata
23	4	C246 to C249	Capacitor, 47 pF, C0G, 50 V, 5%, 0603	06035A470JAT2A	AVX
24	1	C291	Capacitor, 4.7 µF, X5R, 16 V, 20%, 1210	1210YD475MAT2A	AVX
25	2	CIN1, CIN2	Capacitor, 270 µF, aluminum, 16 V, 20%, surface-mount device (SMD) 8 mm × 11.9 mm, E12	16SVPC270M	Panasonic
26	8	COUT1, COUT2, COUT8, COUT10, COUT14, COUT15, COUT20, COUT21	Capacitor, 100 µF, X5R, 10 V, 20%, 1210	LMK325ABJ107MM-P	Taiyo Yuden
27	6	COUT4 to COUT7, COUT22, COUT23	Capacitor, 470 µF, tantalum, conductive polymer tantalum solic capacitor (POSCAP), 2.5 V, 20%, 7343, TPF series	ETPF470M5H	Panasonic
28	1	D4	LED, green, water clear, 0603	150060GS75000	Wurth Elektronik
29	2	D5, D6	LED, red, water clear, 0603	150060RS75000	Wurth Elektronik
30	1	D8	Diode, Schottky, 20 V, 0.5 A, SOD-882, leadless	PMEG2005AEL,315	Nexperia
31	2	L1, L2	Inductor, 100 nH, power, 10%, 80 A, 125 mΩ, 9 mm × 9.5 mm	FP0910V2-R100-R	Eaton
32	1	L4	Inductor, 4.7 µH, power, 20%, 5.9 A, 40 mΩ, 5.48 mm × 5.28 mm SMD, XAL5030, AEC-Q200	XAL5030-472MEB	Coilcraft
33	2	Q1, Q2	Transistor, positive negative positive (PNP), 40 V, 0.2 A, SOT-323, AEC-Q101	MMST3906-7-F	Diodes Inc.
34	5	Q3, Q7 to Q9, Q21	Transistor, MOSFET, N-channel, 60 V, 220 mA, SOT23-3, AEC-Q101	2N7002A-13	Diodes Inc.
35	1	Q4	Transistor, MOSFET, P-channel, 30 V, 3.3 A, SOT-23-3	DMP3068L-13	Diodes Inc.

ORDERING INFORMATION

Table 3. Required Circuit Components (Continued)

Item	Qty.	Reference Designator	Description	Part No.	Manufacturer
36	1	Q6	Transistor, MOSFET, N-channel, 30 V, 90 A, decawatt package (TO-252-3), AEC-Q101	IPD90N03S4L-02	Infineon Technologies
37	1	R1	Resistor, 0.001 Ω, 1%, 1 W, 2512, metal, sense, AEC-Q200	WSL25121L000FEA	Vishay
38	1	R2	Resistor,1 Ω, 1%, 1/10 W, 0603, AEC-Q200	NRC06F1R00TRF	NIC
39	8	R8, R10, R28, R29, R34, R43, R44, R53	Resistor, 10 kΩ, 5%, 1/16 W, 0402, AEC-Q200	NRC04J103TRF	NIC
40	1	R9	Resistor, 4.99 kΩ, 1%, 1/10 W, 0402, AEC-Q200	ERJ2RKF4991X	Panasonic
41	3	R11-R13	Resistor, 1 kΩ, 1%, 1/10 W, 0402, AEC-Q200	ERJ2RKF1001X	Panasonic
42	2	R30, R46	Resistor, 21.5 kΩ, 1%, 1/10 W, 0603	CRCW060321K5FKEA	Vishay
43	2	R33, R155	Resistor, 100 Ω, 1%, 1/10 W, 0603	RC0603FR-07100RL	YAGEO
44	2	R36, R45	Resistor, 1 Ω, 1%, 1/16 W, 0402, AEC-Q200	NRC04F1R00TRF	NIC
45	4	R38, R39, R69, R82	Resistor, 10 Ω, 1%, 1/10 W, 0603	CRCW060310R0FKEA	Vishay
46	1	R58	Resistor, 27.4 Ω, 1%, 1 W, 2512, AEC-Q200	ERJ1TNF27R4U	Panasonic
47	1	R60	Resistor, 5 kΩ, 10%, ½ W, through-hole technology (THT) 3/8 in square, 1-turn, top adjustment, potentiometer	3386P-1-502LF	Bourns, Inc.
48	1	R61	Resistor,154 kΩ, 1%, 1/10 W, 0603, AEC-Q200	NRC06F1543TRF	NIC
49	5	R62, R66, R79, R81, R130	Resistor, 20 kΩ, 1%, 1/10 W, 0603	NRC06F2002TRF	NIC
50	1	R64	Resistor, 1 MΩ, 1%, 1/10 W, 0603, AEC-Q200	NRC06F1004TRF	NIC
51	1	R65	Resistor, 681 kΩ, 1%, 1/10 W, 0603, AEC-Q200	NRC06F6813TRF	NIC
52	1	R67	Resistor, 2 kΩ, 1%, 1/10 W, 0603, AEC-Q200	CRCW06032K00FKEA	Vishay
53	1	R68	Resistor, 3.3 Ω, 1%, 1/10 W, 0603, AEC-Q200	CRCW06033R30FKEA	Vishay
54	1	R70	Resistor, 2.49 kΩ, 1%, 1/10 W, 0603	NRC06F2491TRF	NIC
55	4	R72, R123, R187, R188	Resistor, 10 kΩ, 1%, 1/10 W, 0603, AEC-Q200	ERJ3EKF1002V	Panasonic
56	1	R73	Resistor, 0.002 Ω, 1%, 1 W, 2512, sense	WSL25122L000FEA	Vishay
57	1	R80	Resistor, 931 kΩ, 1%, 1/10 W, 0603, AEC-Q200	ERJ3EKF9313V	Panasonic
58	1	R83	Resistor, 1.24 M Ω, 1%, 1/10 W, 0603, AEC-Q200	CRCW06031M24FKEA	Vishay
59	1	R84	Resistor, 402 Ω, 1%, ¼ W, 1206, AEC-Q200	CRCW1206402RFKEA	Vishay
60	2	R128, R150	Resistor, 4.99 kΩ, 1%, 1/10 W, 0603	ERJ3EKF4991V	Panasonic
61	1	R144	Resistor, 15.8 kΩ, 1%, 1/10 W, 0603, AEC-Q200	NRC06F1582TRF	NIC
62	1	R160	Resistor, 2 Ω, 1%, 1/10 W, 0603	CRCW06032R00FNEA	Vishay
63	3	R161, R169, R170	Resistor, 619 kΩ, 1%, 1/10 W, 0603, AEC-Q200	NRC06F6193TRF	NIC
64	1	R162	Resistor, 60.4 kΩ, 1%, 1/10 W, 0603, AEC-Q200	CRCW060360K4FKEA	Vishay
65	1	R164	Resistor, 200 kΩ, 1%, 1/10 W, 0603	NRC06F2003TRF	NIC
66	1	R166	Resistor, 84.5 kΩ, 1%, 1/10 W, 0603, AEC-Q200	NRC06F8452TRF	NIC
67	1	R168	Resistor, 1 Ω, 5%, ¼ W, 1206, pulse proof, AEC-Q200	CRCW12061R00JNEAIF	Vishay
68	1	SW1	Switch, slide, double pole double throw (DPDT), 0.3 A, 6V DC, through hole	JS202011CQN	C&K
69	1	U1	IC, step-down power, GQFN-48	LTC3884ERHE-1#PBF	Analog Devices
70	2	U2, U3	IC, monolithic driver and half bridge, LQFN-42	LTC7051AV#PBF	Analog Devices
71	1	U5	Oscillator, 3.81 Hz to 1 MHz, 5 pF, 90 ppm, TSOT23-6	LTC6992IS6-1#TRMPBF	Analog Devices
72	1	U6	IC, single R to R in/out op amp, TSOT23-5, 100 V/µs, 85 MHz	LT1803IS5#TRMPBF	Analog Devices
73	1	U7	IC, EEPROM, I^2C, TSSOP-8, 2 Kb (256 × 8), 400 kHz	24LC024-I/ST	Microchip
74	1	U8	40 V, 1 A, 100 µA IQ synchronous step-down converter, MSE-16	LTC3646EMSE-1#PBF	Analog Devices
75	1	U9	IC, 3µA IQ, 20 mA, 45 V low, drop out linear regulator, SOT-8	LT3008ETS8#TRPBF	Analog Devices

ORDERING INFORMATION

Table 4. Additional Demo Board Circuit Components

Item	Qty.	Reference Designator	Description	Part No.	Manufacturer
1	0	C5	Capacitor, option, 0402		
2	0	C24, C26, C61, C76, C133, C192, C245, C250	Capacitor, option, 0603		
3	0	D7	Diode, option, SOD-323		
4	0	D9	Diode, option, Schottky, PowerDI-123		
5	0	R3 to R7, R15 to R17, R22, R23, R25 to R27, R42, R179, R180	Resistor, option, 0402		
6	0	R14, R32, R41, R47, R51, R52, R120, R122, R126, R136, R138, R145, R151, R177, R178	Resistor, option, 0603		
7	4	R31, R48, R49, R154	Resistor, 0 Ω, 1/10 W, 0603	CR0603-J/-000ELF	Bourns, Inc.
8	10	R37, R50, R59, R110, R127, R156, R167, R173, R184, R185	Resistor, 0 Ω, 1/10 W, 0603, AEC-Q200	CRCW06030000Z0EA	Vishay
9	0	R40	Resistor, option, 2512		
10	7	R85, R86, R174 to R176, R183, R186	Resistor, 0 Ω, 1/8 W, 0805	CRCW08050000Z0EA	Vishay
11	0	R88, R158	Resistor, option, 0805		
12	0	R139	Resistor, option, 1206		
13	2	R171, R172	Resistor, 0 Ω, 1/10 W, 0402, AEC-Q200	ERJ2GE0R00X	Panasonic
14	2	R181, R182	Resistor, 0 Ω, 1/16 W, 0402, AEC-Q200	NRC04ZOTRF	NIC

Table 5. Hardware

Item	Qty.	Reference Designator	Description	Part No.	Manufacturer
1	18	E1, E2, E6 to E8, E10, E16, E17, E20, E26, E27, E31, E35 to E40	Test point, turret, 0.094 in mounting hole, printed circuit board (PCB) 0.062 in thickness	2501-2-00-80-00-00-07-0	Mill-Max
2	6	J1 to J4, J6, J7	Evaluation board stud hardware set, #10-32	720-0010	Analog Devices
3	2	J8, J24	Connector, radio frequency (RF), Bayonet Neill-Concelman receptacle, jack, 5-pin, straight, through hole, 50 Ω	112404	Amphenol RF
4	1	J13	Connector, header, female, 2 × 7, 2 mm, right angle through hole	NPPN072FJFN-RC	Sullins Connector Solutions
5	1	J14	Connector, header, shrouded, male, 2 × 6, 2 mm, vertical, straight, through hole	98414-G06-12ULF	Amphenol
6	1	J15	Connector, header, male, 2 × 7, 2 mm, R/A through hole	0877601416	Molex
7	1	J16	Connector, header, shrouded, male, 1 × 4, 2 mm, vertical, straight, through hole	DF3A-4P-2DSA	Hirose Electric
8	1	J23	Connector, RF SubMiniature Version A (SMA), jack, through hole, straight, 50 Ω	132134	Amphenol RF
9	1	J25	Connector, header, male, 2 × 6, 2.54 mm, vertical, straight, through hole, 30 µin Au	TSW-106-07-S-D	Samtec
10	2	JP1, JP9	Connector, header, male, 1 × 3, 2.54 mm, vertical, straight, through hole	TSW-103-07-L-S	Samtec
11	1	JP6	Connector, header, male, 2 × 3, 2.54 mm, vertical, straight, through hole	TSW-103-07-L-D	Samtec
12	5	JP12 to JP14, JP18, JP19	Connector, header, male, 1 × 2, 2.54 mm, vertical, straight, through hole	61300211121	Wurth Elektronik
13	3	JP15 to JP17	Connector, header, header, 2 conductive polymer tantalum solid, 2.54 mm, straight, through hole	TSW-102-06-L-S	Samtec

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Table 5. Hardware (Continued)

Item	Qty.	Reference Designator	Description	Part No.	Manufacturer
14	4	MP25 to MP28	Standoff, nylon, snap on, 0.625 in, 15.9 mm	8834	Keystone
15	5	XJP1, XJP6, XJP9, XJP18, XJP19	Connector, shunt, female, 2 conductive polymer tantalum solid, 2.54 mm	SNT-100-BK-G	Samtec

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NOTES

I^2C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

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.