LT8603
42V, Low I_Q, Quad Output Triple Monolithic Buck Converter with Boost Channel as SEPIC

DESCRIPTION

Demonstration circuit 2469A features the LT®8603 with triple monolithic buck regulators and the boost channel as SEPIC. The demo circuit is designed for 8V, 5V, 3.3V, and 1.8V outputs from a nominal 12V input. The 4th channel is set as a SEPIC converter and its output is regulated at 8V over a wide input range. The two high voltage buck regulators are powered from VOUT4. VOUT1 is regulated at 5V with 1.5A maximum output load current, and VOUT2 is at 3.3V with 2.5A maximum output load current. The low voltage buck is powered from VOUT2 (3.3V), and the output VOUT3 is regulated at 1.8V with 1.8A maximum load current. Thanks to the SEPIC converter, all four outputs can ride through a cold crank in automotive applications while providing regulated output voltages.

All regulators are synchronized to an internal oscillator that can be programmed with one resistor at RT pin. Programmable frequency allows optimization between efficiency and external component size. To avoid the audio band, the DC2469A sets the switching frequency at 2MHz for the three buck regulators, and the SEPIC converter is at 400kHz. At all frequencies, a 180° phase shift is maintained between 1 and 2 channels, reducing the input peak current and voltage ripple.

Many popular features such as soft-start, cycle-by-cycle current limit, power good for each of the four channels are packed in the 40-lead 6mm × 6mm QFN package to simplify the complex design of quad-output power converters. Each buck regulator can be independently disabled using its own TRKSS or RUN pin. The SEPIC can be disabled by pulling down both the FSEL4A and FSEL4B. The EN/UVLO can be used to shut down the circuit to reduce the input current to 1µA.

Table 1 summarizes the performance of the demo board at room temperature. The demo circuit can be easily modified for various automotive, transportation and industry applications. For applications that need 4th channel configured as a boost converter, the DC2114A should be used.

The LT8603 data sheet gives a complete description of the part, operation and application information. The data sheet must be read in conjunction with this quick start guide for DC2469A.

Design files for this circuit board are available at http://www.linear.com/demo/DC2469A

PERFORMANCE SUMMARY Specifications are at $T_A = 25°C$

Table 1.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operation Input Voltage Range		3	12	42	V
Minimum Start-Up, VIN_{MIN}				4.5	V
Standby Current When Switching	IOUT1,2,3,4 = 0mA, V_{IN} = 12V		40		µA
Channel 4 Output Voltage, VOUT4	IOUT4 = 1A	7.68	8	8.32	V
Channel 1 Output Voltage, VOUT1	IOUT1 = 1.5A	4.86	5	5.14	V
Channel 2 Output Voltage, VOUT2	IOUT2 = 2.5A	3.17	3.3	3.43	V
Channel 3 Output Voltage, VOUT3	IOUT3 = 1.8A	1.73	1.8	1.87	V
Maximum Output Current, IOUT1	V_{IN} = 12V	1.5			A
Maximum Output Current, IOUT2	V_{IN} = 12V, IOUT3 = 0A	2.5			A

PERFORMANCE SUMMARY

Table 1.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Output Current, IOUT3	V_{IN} = 12V, IOUT2 = 0A	1.8			A
Maximum Output Current, IOUT4	V_{IN} = 12V, IOUT1,2,3 = 0A	1.5			A
Switching Frequency, Channel 1~3	V_{IN} = 12V, IOUT1,2,3 = 1A	1.85	2	2.15	MHz
Switching Frequency, Channel 4	V_{IN} = 6V, IOUT4 = 1A	370	400	430	kHz
Efficiency, Channel 4	V_{IN} = 7V, IOUT4 = 2.5A		84		%
Efficiency, CH1, 5V	V_{IN} = 12V, IOUT1 = 1.5A		89		%
Efficiency, CH2, 3.3V	V_{IN} = 12V, IOUT2 = 2.5A		84		%
Efficiency, CH3, 1.8V	PVIN3 = 3.3V, IOUT3 = 1.8A		83		%
Efficiency, Overall	V_{IN} = 14V, IOUT1,2,3 = 1A		75		%

QUICK START PROCEDURE

Demonstration circuit 2469A is easy to set up to evaluate the performance of the LT8603. Refer to Figure 1 for proper equipment setup and follow these procedures.

1. With power off, connect the input power supply to the board through V_{IN} and GND terminals on the top layer. Connect the loads to the terminals VOUT1 and GND, VOUT2 and GND, VOUT3 and GND on the board. The default positions of the headers are given in Table 2.

Table 2. Default Positions of the Headers

NAME		POSITION
EN/UVLO	JP4	ON
TRKSS1	JP1	ON
TRKSS2	JP2	ON
RUN3	JP3	RUN

2. Turn on the power at the input. Increase V_{IN} to 4.5V. Make sure that the input voltage is always within spec. Refer to data sheet on the switching in high V_{IN} condition and the Burst Mode® operation in light load. The minimum start-up voltage for the SEPIC converter (and the board) is 4.5V. Once it starts, the circuit runs with input going down below 3V at light load.

3. Check for the proper switching frequency and output voltage at channel 4. The output is set at 8V (±4%). The SEPIC converter output current capability depends on the input voltage. If the 4th output is not regulated, temporarily disconnect the load, and disable the two high voltage buck regulators (channels 1, 2) as well. Check if the EN/UVLO is set in correct position. Check if too much load is applied to VOUT4. SEPIC does not have overcurrent or short-circuit protection capability.

   NOTE: By default, the switching frequency of the SEPIC converter is optimized with 400kHz with FSEL4A low and FSEL4B high. The switching frequency can be changed with RT, or different FSEL4A / FSEL4B settings. An accompanying change of inductors might be necessary to achieve desirable performance of the converter.

4. Check for the proper output voltages of the buck regulators. The output should be regulated at 5V (±4%), 3.3V (±4%), 1.8V (±4%) for the channels 1, 2 and 3, respectively. Do not overload the buck regulators simultaneously at high line unless proper thermal cooling method such as air flow or heat sink is applied. If there is no output, temporarily disconnect the load of the corresponding channels to make sure that the

QUICK START PROCEDURE

loads are not set too high, and the headers of EN/UVLO, TRKSS1, TRKSS2, RUN3 are set in right positions.

5. Once the proper output voltage is established, adjust the input voltage and load currents within the operating range, and observe the output voltage regulation, transient, ripple voltage, efficiency and other parameters. By default the circuit is set in low ripple Burst Mode operation with SYNC grounded. Remove R11, and add 0Ω at R10, the circuit is set in pulse-skipping mode. The circuit runs in full frequency with lower load current in this mode. To synchronize to an external clock, apply the external clock to the SYNC turret.

6. When measuring the input or output voltage ripples, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the V_{IN} or V_{OUT} capacitor terminals. See Figure 2 for proper scope probe technique.

NOTE: Refer to the thermal derating curves in LT8603 data sheet for high input voltage and/or high ambient temperature operations.

QUICK START PROCEDURE

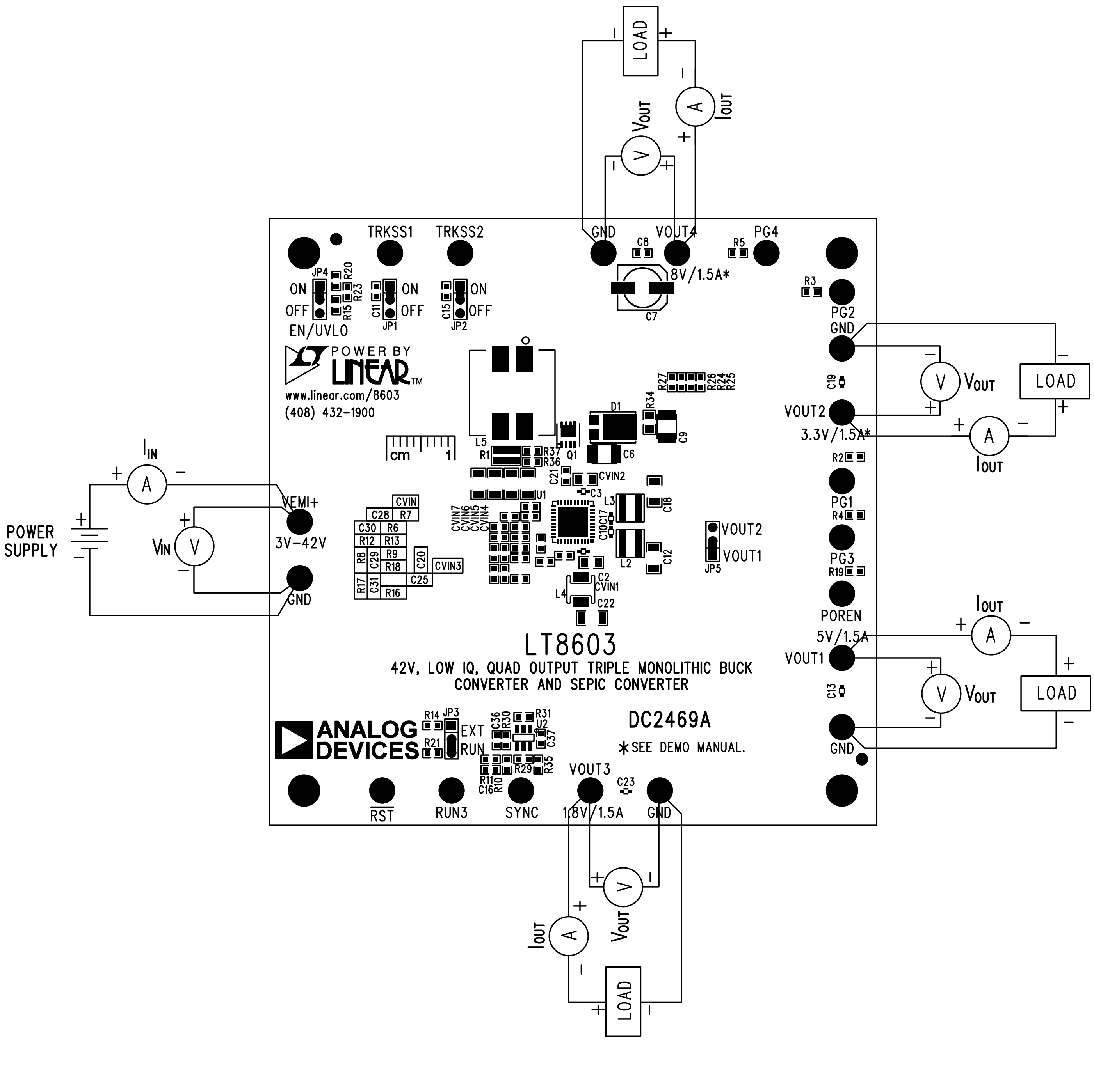


Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE

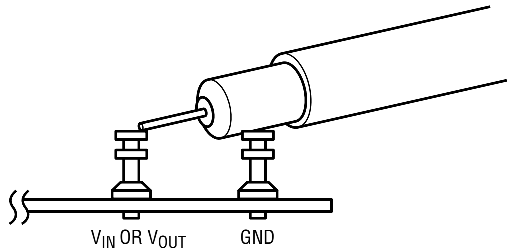
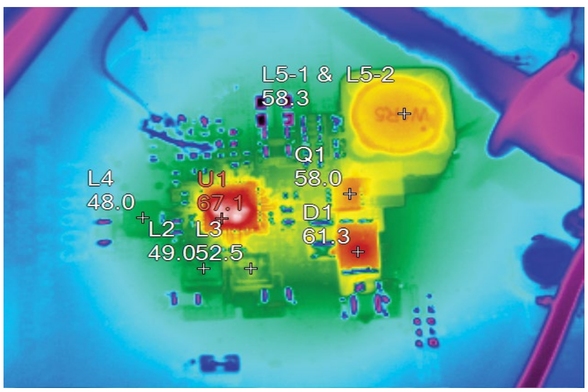
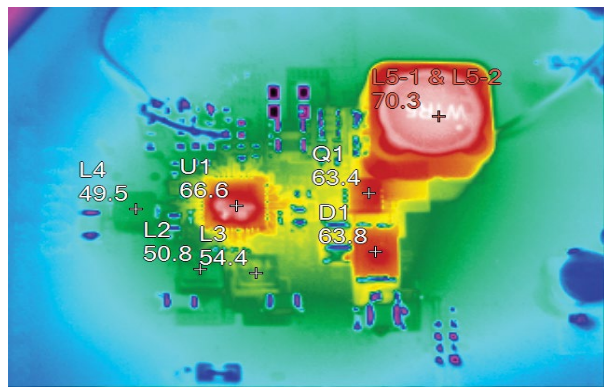


Figure 2. Proper Scope Probe Placement for Measuring Input or Output Ripple



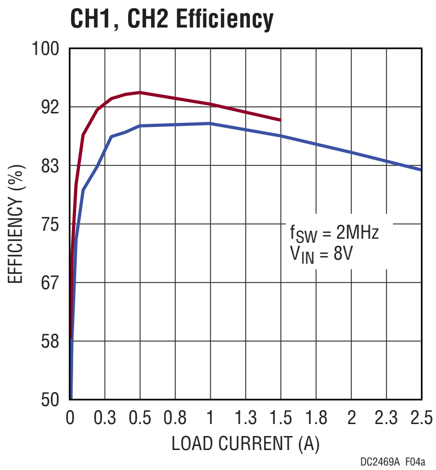
A) V_{IN} = 6V



B) V_{IN} = 24V

Figure 3. Thermal Image Top View, IOUT1 = 1A, IOUT2 = 1A, IOUT3 = 1A, T_A = 25°C, F_{SW} = 2MHz

QUICK START PROCEDURE



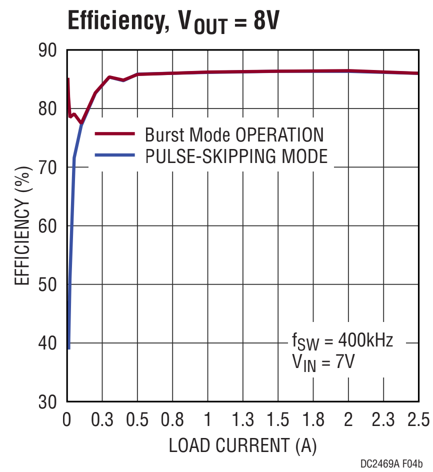


Figure 4. Load Transient from 50mA to 450mA at VOUT4, V_{IN} = 5V, F_{SW} = 400kHz, Burst Mode Operation

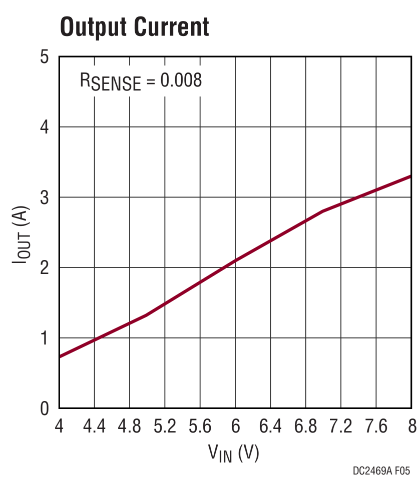


Figure 5. SEPIC Maximum Output Current vs Input Voltage

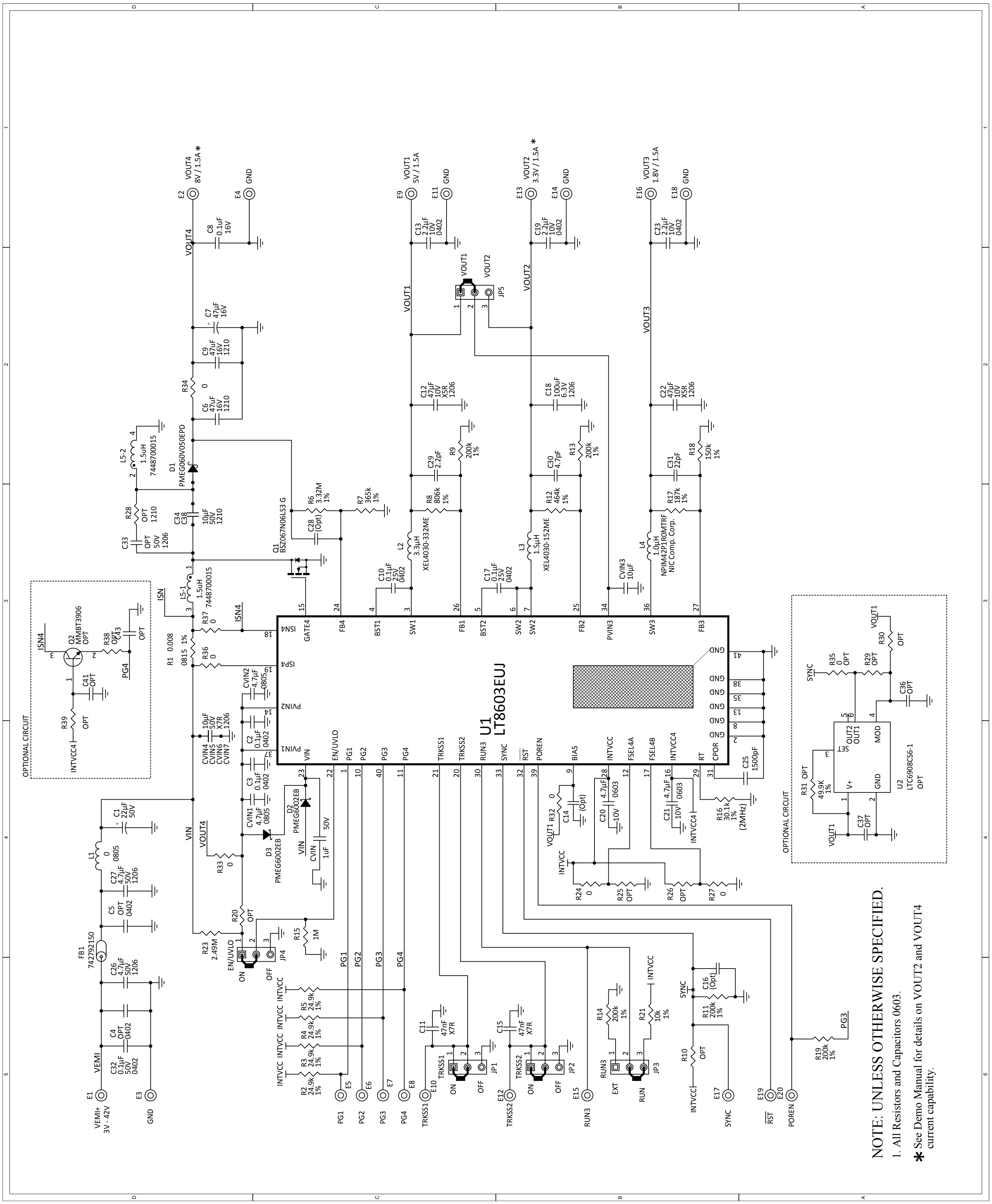
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	CVIN	Cap, X5R 1µF 50V 10% 0603	Murata, GRM188R61H105KAALD
2	2	C26, C27	Cap, X7R 4.7µF 50V 10% 1206	Murata, GRM31CR71H475KA12L
3	2	CVIN1, CVIN2	Cap, X7R 4.7µF 16V 10% 0805	Murata, GRM21BR71C475KA73L
4	1	CVIN3	Cap, X5R 10µF 6.3V 20% 0603	Murata, GRM188R60J106ME47D
5	4	CVIN4, CVIN5, CVIN6, CVIN7	Cap, X5R 10µF 50V 10% 1206	Murata, GRM31CR61H106KA12L
6	1	C1	Cap, Alum 22µF 50V 10%	Sun Elect Ind, 50CE22BSS
7	3	C2, C3, C32	Cap, X7R 0.1µF 50V 10% 0402	Murata, GRM155R71H104KE14J
8	2	C6, C9	Cap, X5R 47µF 16V 10% 1210	Murata, GRM32ER61C476KE15K
9	1	C7	Cap, Alum 47µF 16V 20%	Sun Elect Ind, 16CE47BS
10	1	C8	Cap, X7R 0.1µF 50V 10% 0603	Murata, GRM188R71H104KA93D
11	2	C10, C17	Cap, X7R 0.1µF 16V 10% 0402	Murata, GRM155R71C104KA88D
12	2	C11, C15	Cap, X7R 47nF 25V 20% 0603	Murata, GRM188R71C473KA01D
13	2	C12, C22	Cap, X5R 47µF 10V 10% 1206	Murata, GRM31CR61A476KE15L
14	3	C13, C19, C23	Cap, X7R 2.2µF 10V 10% 0402	Murata, GRM155R61A225KE95D
15	1	C18	Cap, X5R 100µF 6.3V 20% 1206	Murata, GRM31CR60J107ME39K
16	2	C20, C21	Cap, X7R 4.7µF 10V 10% 0603	Murata, GRM188R61A475KE15D
17	1	C25	Cap, C0G 1500pF 25V 5% 0603	Murata, GRM1885C1E152JA01D
18	1	C29	Cap, C0G 2.2pF 50V ±0.25pF 0603	Murata, GRM1885C1H2R2CA01D
19	1	C30	Cap, C0G 4.7pF 50V ±0.25pF 0603	Murata, GRM1885C1H4R7CA01D
20	1	C31	Cap, C0G 22pF 50V 5% 0603	Murata, GRM1885C1H220JA01D
21	2	C34, C38	Cap, X7R 10µF 50V 10% 1210	Murata, GRM32ER71H106KA12L
22	1	D1	Schottky Rectifier, 60V, 5A, SOT1289	Nexperia, PMEG060V050EPD
23	2	D2, D3	Schottky Rectifier, 0.2A, SOD523	NXP, PMEG6002EB
24	1	FB1	BEAD, 4A 1206	Wurth Elektronik, 742792150
25	1	L1	Res, Jumper, Chip, 0Ω 0805	Vishay, CRCW08050000Z0EA
26	1	L2	Inductor, 3.3µH XEL4030	Coilcraft, XEL4030-332ME
27	1	L3	Inductor, 1.5µH XEL4030	Coilcraft, XEL4030-152ME
28	1	L4	Inductor, 1µH NPIM42P	NIC Comp Corp, NPIM42P1R0MTRF
29	1	L5	Inductor, 1.5µH	Wurth Elektronik, 7448700015
30	1	Q1	MOSFET-N Channel, PG-TSDSON-8	Infineon, BSZ067N06LS3 G
31	1	R1	RES, CHIP, 0.008, 1W, 1%, 0815	Susumu, RL3720WT-R008-F
32	4	R2, R3, R4, R5	Res, Chip 24.9k 0.1W 1% 0603	Vishay, CRCW060324K9FKEA
33	1	R6	Res, Chip 3.32M 0.1W 1% 0603	Vishay, CRCW06033M32FKEA
34	1	R7	Res, Chip 365k 0.1W 1% 0603	Vishay, CRCW0603365KFKEA
35	1	R8	Res, Chip 806k 0.1W 1% 0603	Vishay, CRCW0603806KFKEA
36	5	R9, R11, R13, R14, R19	Res, Chip 200k 0.1W 1% 0603	Vishay, CRCW0603200KFKEA
37	1	R12	Res, Chip 464k 0.1W 1% 0603	Vishay, CRCW0603464KFKEA
38	1	R15	Res, Chip 1M 0.1W 1% 0603	Vishay, CRCW06031M00FKEA
39	1	R16	Res, Chip 30.1k 0.1W 1% 0603	Vishay, CRCW060330K1FKEA
40	1	R17	Res, Chip 187k 0.1W 1% 0603	Vishay, CRCW0603187KFKEA
41	1	R18	Res, Chip 150k 0.1W 1% 0603	Vishay, CRCW0603150KFKEA

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
42	1	R23	Res, Chip 2.49M 0.1W 1% 0603	Vishay, CRCW06032M49FKEA
43	1	R21	Res, Chip 10k 0.1W 1% 0603	Vishay, CRCW060310K0FKEA
44	6	R24, R27, R32, R33, R36, R37	Res, Jumper, Chip, 0Ω 0603	Vishay, CRCW06030000Z0EA
45	1	R34	Res, Jumper, Chip, 0Ω 0805	Vishay, CRCW08050000Z0EA
46	1	U1	IC, Buck Regulator QFN (40) (UJ)	Analog Device, LT8603EUJ
Additional Demo Board Circuit Components				
1	0	C4, C5	Cap, 0402	
2	0	C14, C16, C28, C36, C37, C41, C43	Cap, 0603	
3	0	C33	Cap, 1206	
4	0	Q2	NPN. MMBT3904, SOT-23	
5	0	R10, R20, R25, R26, R29, R30, R31, R35, R38, R39	Res, 0603	
6	0	R28	Res, 1210	
7	0	U2	IC, LTC6908CS6-1 TSOT-23-6	Analog Device, LTC6908CS6-1#PBF
Hardware: For Demo Board Only				
1	20	E1 to E20	Turret, Testpoint	Mill Max, 2501-2-00-80-00-00-07-0
2	5	JP1, JP2, JP3, JP4, JP5	Headers, 3 Pins 2mm Ctrs	Wurth Elektronik, 62000311121
3	5	XJP1, XJP2, XJP3, XJP4, XJP5	Shunt, 2mm Ctrs	Samtec, 2SN-BK-G
4	4	MH1 to MH4	STAND-OFF, NYLON 0.25" Tall (SNAP ON)	Wurth Electronik, 702931000

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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