LT8603
42V, Low I_Q, Quad Output Triple Monolithic Buck Converter and Boost Controller

DESCRIPTION

Demonstration Circuit 2114A features the LT®8603 with triple monolithic buck regulators and a boost controller. The demo circuit is designed for 8.0V, 5.0V, 3.3V, and 1.8V outputs from a nominal 12V input. The 4th channel is set as a boost converter and is powered from a wide input range with output VOUT4 regulated at 8V if 3V < V_{IN} < 8.5V. It works as diode pass through if the input is above 8.5V. The two high voltage buck regulators are powered from the boost converter. 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. Thanks to the pre-boost converter, they can ride through a cold crank in automotive applications while providing constant output voltages 5V and 3.3V. The low voltage buck is powered from the VOUT2 (3.3V), and the output VOUT3 is regulated at 1.8V with 1.8A maximum load current.

All regulators are synchronized to an internal oscillator that can be programmed with one resistor at the RT pin. Programmable frequency allows optimization between efficiency and external component size. To avoid the audio band, the demo circuit 2114A sets the switching frequency at 2MHz for the three buck regulators, and the boost 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, and 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 boost channel 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.

The demo board has an EMI filter installed on the bottom layer. The conducted and radiated EMI performance of the board is shown on Figure 4 with 1A load at each of the buck outputs at nominal input 14V. It shows the circuit passes the CISPR 25 Class 5, Peak Limit.

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 Demo Circuit 2114A.

Design files for this circuit board are available at http://www.linear.com/demo/DC2114A

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operation Input Voltage Range*		3	14	42	V
Minimum Start-Up, $V_{IN(MIN)}$				4.5	V
Standby Current when Switching	IOUT1,2,3,4 = 0mA, VIN = 12V		40		µA
Channel 4 Output Voltage, VOUT4	2V < VIN < 8.5V, IOUT4 = 1A	7.68	8	8.32	V
	8.5V < VIN		V_{IN} – 0.5		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

PERFORMANCE SUMMARY Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Maximum Output Current, IOUT1	VIN = 12V	1.5			A
Maximum Output Current, IOUT2	VIN = 12V, IOUT3 = 0A	2.5			A
Maximum Output Current, IOUT3	VIN = 12V, IOUT2,4 = 0A	1.8			A
Maximum Output Current, IOUT4	VIN = 4V, IOUT1,2,3 = 0A	1.5			A
Switching Frequency, Channel 1~3	VIN = 12V, IOUT1,2,3 = 1.0A	1.85	2	2.15	MHz
Switching Frequency, Channel 4	VIN = 4V, IOUT4 = 1.0A	370	400	430	kHz
Efficiency, Channel 4	VIN = 3.3V, IOUT4 = 1.5A		85		%
Efficiency, CH1, 5V	VIN =12V, IOUT1 = 1.5A		90		%
Efficiency, CH2, 3.3V	VIN =12V, IOUT2 = 2.5A		84		%
Efficiency, CH3, 1.8V	PVIN3 = 3.3V, IOUT3 = 1.8A		83		%
Efficiency, Overall	VIN = 12V, IOUT1,2,3 = 1.0A		80		%

*Refer to data sheet derating curve to determine the maximum input voltage and load.

QUICK START PROCEDURE

Demo Circuit 2114A 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 VIN 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. Set the DC power supply at 6V. Turn on the power at the input.

   NOTE: Make sure that the input voltage is always within spec. Refer to data sheet on the switching waveforms in high VIN condition and the Burst Mode® operation in light load. The minimum startup voltage for the boost converter (and the board) is 4.5V. Once it starts, the circuit maintains the output regulation with input going down below 3V at light load.

3. Check for the proper switching frequency and output voltage at Channel 4 when it runs as a boost converter. The boost output is set at 8V (±4%).

   NOTE: If the boost 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.

   NOTE: The boost converter output current capability depends on the input voltage applied to the demo circuit.

   NOTE: The output voltage at the boost converter is V_{IN} – 0.5V when the input is higher than 8.5V. The maximum V_{IN} is 42V.

   NOTE: By default, the switching frequency of the boost 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 inductor 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 5.0V (±4%), 3.3V (±4%), 1.8V (±4%) for the Channels 1, 2 and 3, respectively.

QUICK START PROCEDURE

NOTE: Do not overload the buck regulators simultaneously at high line unless a proper thermal cooling method such as air flow or heat sink is applied.

NOTE: If there is no output, temporarily disconnect the load of the corresponding channels to make sure that the loads are not set too high, and the Headers of EN/UVLO, TRKSS1, TRKSS2, RUN3 are set in the 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.

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

   NOTE: 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 skip 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.

   NOTE: 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 VIN or VOUT capacitor terminals. See Figure 2 for proper scope probe technique. Figure 6 show the output ripples at the output terminals with additional 10μF cap at C13, C19 and C23.

6. The EMI filter is assembled on the bottom layer of the demo circuit. Connect the EMI test facility to the terminals of VEMI+ and VEMI– with very short wires. Connect proper resistor loads to the output terminals of the demo circuit with very short wires. Figure 4 shows the demo circuit 2114A passes the conducted and radiated EMI standard CISPR 25 Class 5 Peak Limit.

7. The switching frequency (f_{SW4}) of the boost channel is set at 1/5 of the channel 2. To modify the boost converter for different switching frequency, change the R24, R25, R26, R27 accordingly.

QUICK START PROCEDURE

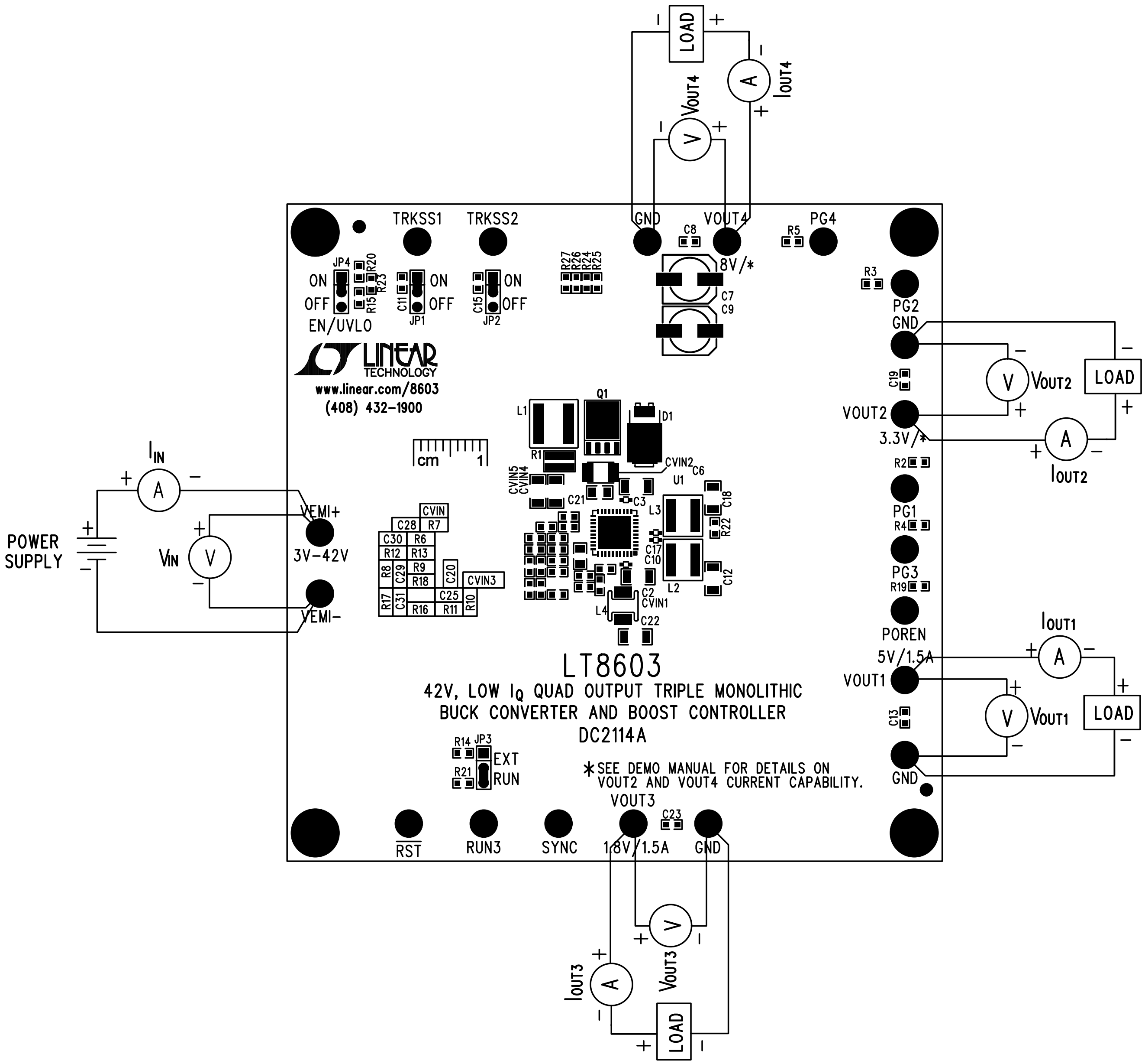


Figure 1. Proper Measurement Equipment Setup for DC2114A

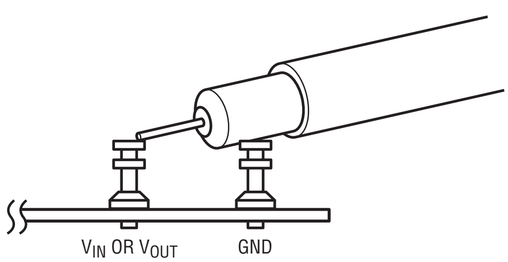


Figure 2. Proper Scope Probe Placement for Measuring Input or Output Ripple

QUICK START PROCEDURE

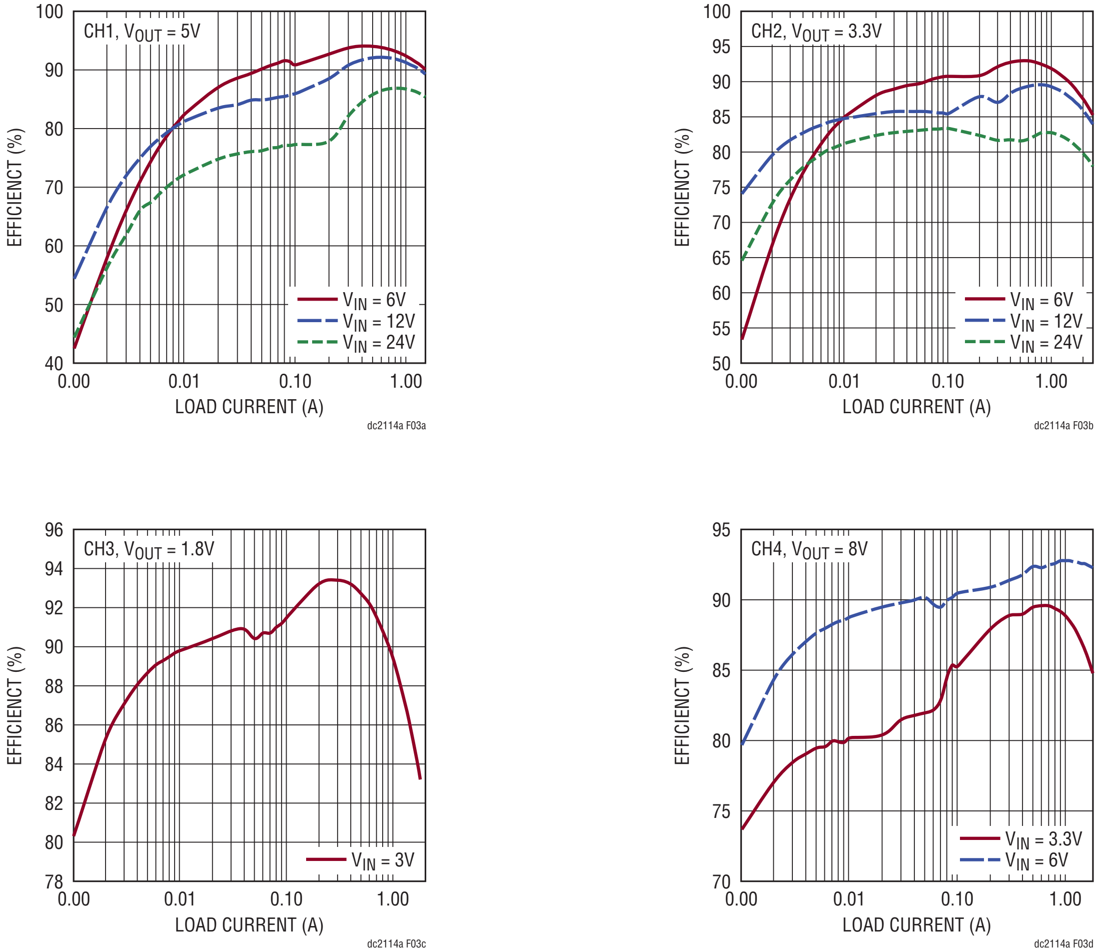


Figure 3. Typical Efficiency Curves, Burst Mode Operation

QUICK START PROCEDURE

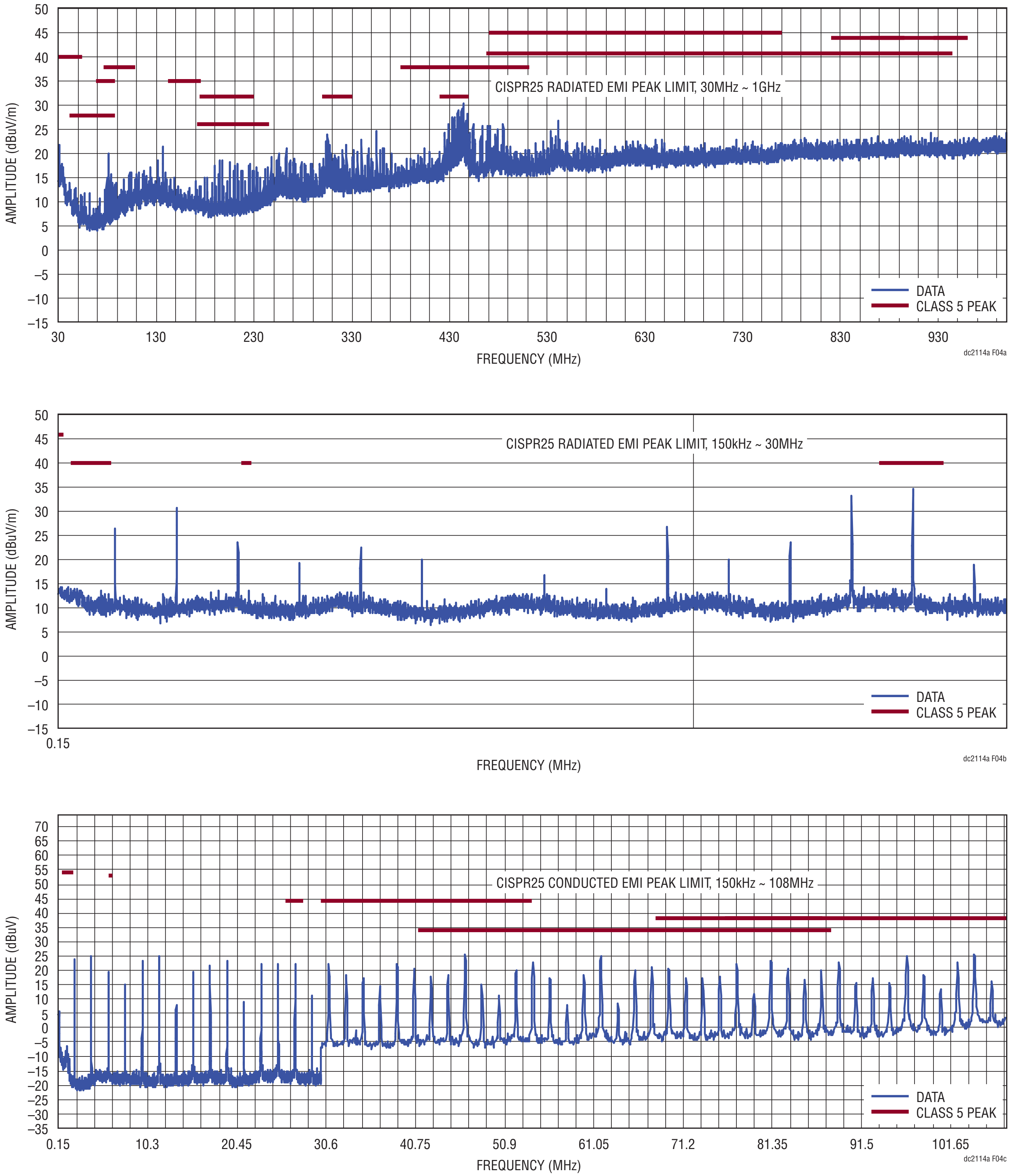
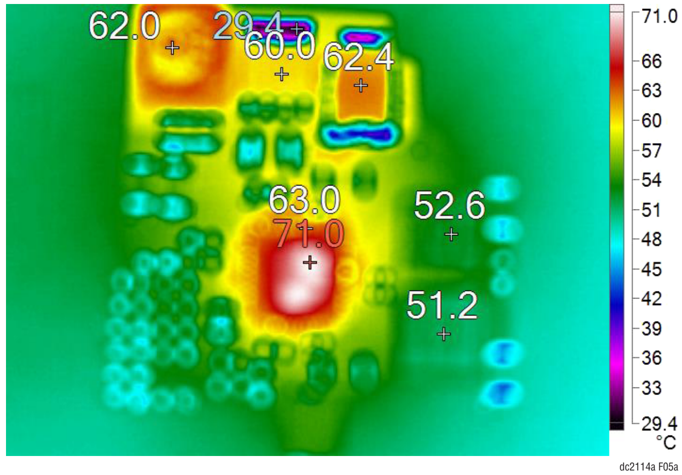
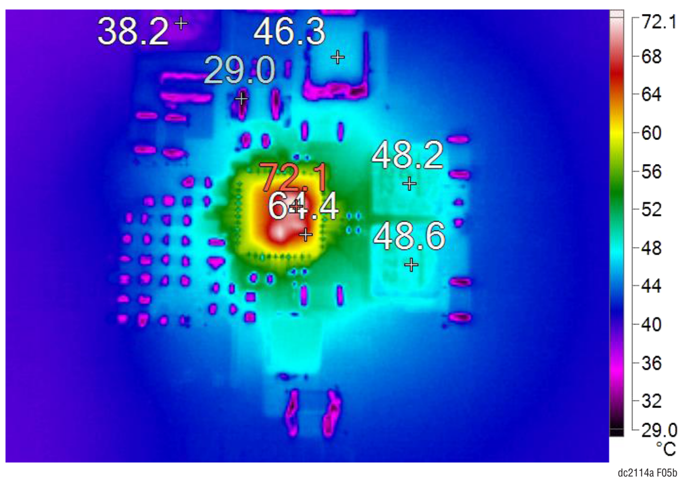


Figure 4. DC2114A Conducted and Radiated Peak EMI - Passes CISPR25-Class 5 Limits. Condition: V_{IN} = 14V, $I_{OUT1,2,3}$ = 1A, f_{SW} = 2MHz

QUICK START PROCEDURE



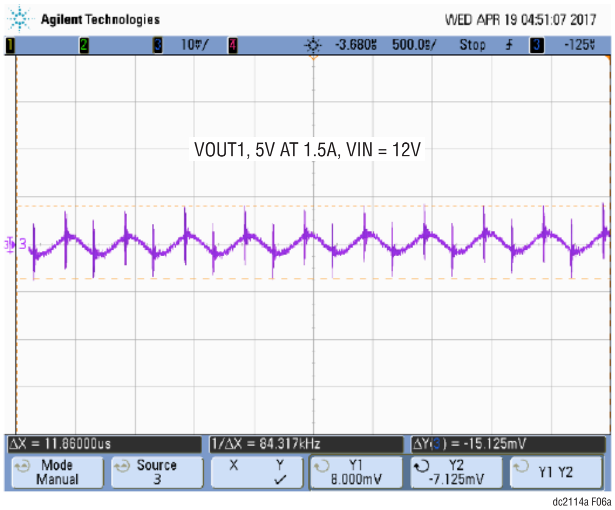
A. VIN = 3.3V



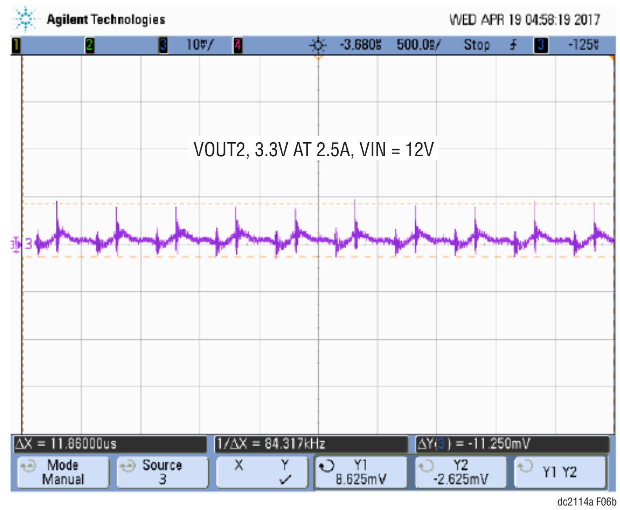
B. V_{IN} = 24V

Figure 5. Thermal Image Top View, IOUT1 = 1A, IOUT2 = 1A, IOUT3 = 1.5A, T_A = 25°C, f_{SW} = 2MHz

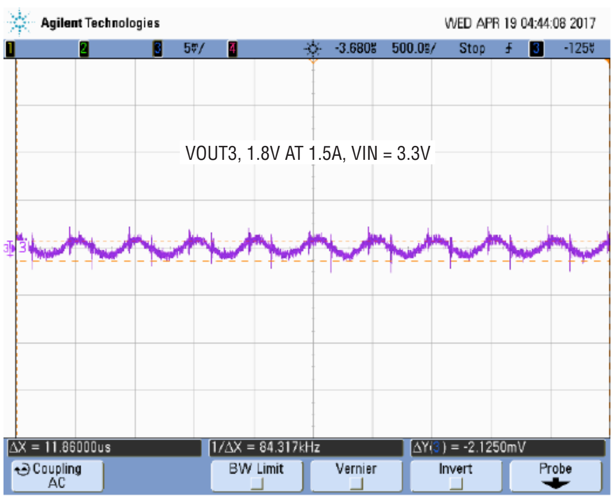
QUICK START PROCEDURE



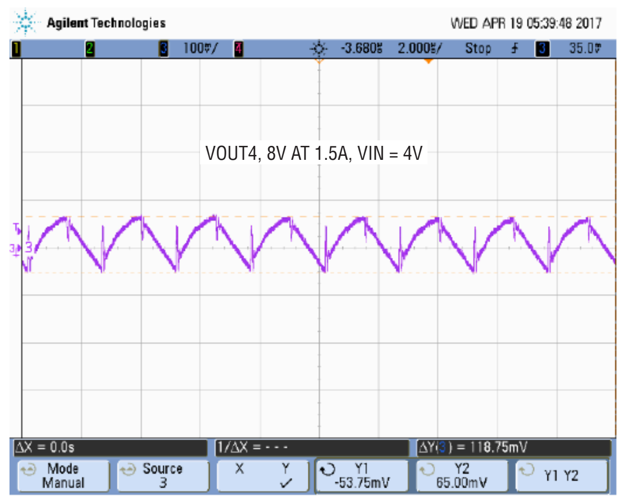
A. VOUT1 RIPPLE



B. VOUT2 RIPPLE



C. VOUT3 RIPPLE



D. VOUT4 RIPPLE

Figure 6. LT8603 Output Ripples at VOUT1, VOUT2, VOUT3, VOUT4

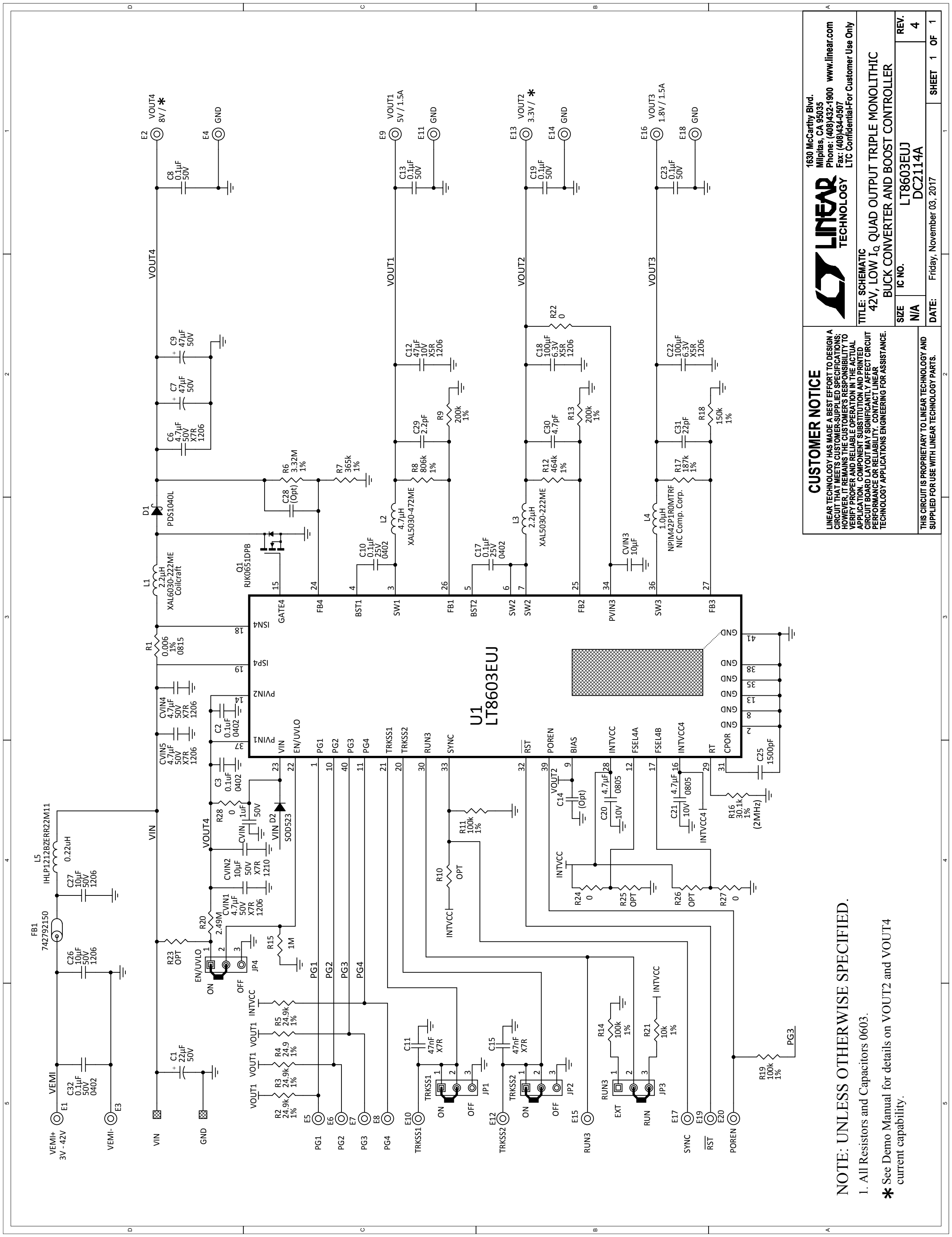
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	CVIN	CAP., X5R 1µF 50V 10% 0603	TDK C1608X5R1H105KT
2	4	CVIN1, CVIN4, CVIN5, C6	CAP., X7R 4.7µF 50V 10% 1206	TDK C3216X7R1H475KT
3	1	CVIN2	CAP., X7R 10µF 50V 10% 1210	MURATA GRM32ER71H106KA12L
4	1	CVIN3	CAP., X5R 10µF 6.3V 20% 0603	MURATA GRM188R60J106ME47D
5	1	C1	CAP., ALUM 22µF 50V 10%	SUN ELECT. IND. 50CE22BSS
6	2	C7, C9	CAP., ALUM 47µF 50V 20%	SUN ELECT. IND. 50CE47BS
7	4	C8, C13, C19, C23	CAP., X7R 0.1µF 50V 10% 0603	MURATA GRM188R71H104KA93D
8	2	C11, C15	CAP., X7R 47nF 25V 20% 0603	AVX 06033C473MAT2A
9	1	C12	CAP., X5R 47µF 10V 10% 1206	MURATA GRM31CR61A476ME15L
10	2	C18, C22	CAP., X5R 100µF 6.3V 10% 1206	MURATA GRM31CR60J107KE39L
11	2	C20, C21	CAP., X7R 4.7µF 10V 10% 0805	MURATA GRM21BR71A475KA73K
12	1	C25	CAP., X7R 1500pF 25V 20% 0603	AVX 06033C152MAT2A
13	2	C26, C27	CAP., X5R 10µF 50V 10% 1206	MURATA GRM31CR61H106KA12L
14	5	C2, C3, C10, C17, C32	CAP., X7R 0.1µF 50V 10% 0402	MURATA GRM155R71H104KE14J
15	1	C29	CAP., C0G 2.2pF 50V ±0.25pF 0603	MURATA GRM1885C1H2R2CA01D
16	1	C30	CAP., C0G 4.7pF 50V ±0.25pF 0603	MURATA GRM1885C1H4R7CA01D
17	1	C31	CAP., C0G 22pF 50V 5% 0603	MURATA GRM1885C1H220JA01D
18	1	D1	SCHOTTKY DIODE, POWER-DI-5	DIODE INC. PDS1040L-13
19	1	L1	INDUCTOR, 2.2µH XAL6030	COILCRAFT XAL6030-222ME
20	1	L2	INDUCTOR, 4.7µH XAL5030	COILCRAFT XAL5030-472ME
21	1	L3	INDUCTOR, 2.2µH XAL5030	COILCRAFT XAL5030-222ME
22	1	L4	INDUCTOR, 1.0µH NPIM42P	NIC COMP. CORP. NPIM42P1R0MTRF
23	1	L5	INDUCTOR, 0.22µH IHLP1212BZ-M11	VISHAY, IHLP1212BZERR22M11
24	1	Q1	MOSFET-N CHANNEL, 60V/25A LFPAK	RENESAS RJK0651DPB-00-J5
25	1	R1	RES., CHIP, 0.006Ω 1W, 1%, 0815	SUSUMU, RL3720WT-R006-F
26	4	R2, R3, R4, R5	RES., CHIP 24.9k 0.1W 1% 0603	VISHAY CRCW060324K9FKEA
27	1	R6	RES., CHIP 3.32M 0.1W 1% 0603	VISHAY CRCW06033M32FKEA
28	1	R7	RES., CHIP 365k 0.1W 1% 0603	VISHAY CRCW0603365KFKEA
29	1	R8	RES., CHIP 806k 0.1W 1% 0603	VISHAY CRCW0603806KFKEA
30	2	R9, R13	RES., CHIP 200k 0.1W 1% 0603	VISHAY CRCW0603200KFKEA
31	3	R11, R14, R19	RES., CHIP 100k 0.1W 1% 0603	VISHAY CRCW0603100KFKEA
32	1	R12	RES., CHIP 464k 0.1W 1% 0603	VISHAY CRCW0603464KFKEA
33	1	R15	RES., CHIP 1M 0.1W 1% 0603	VISHAY CRCW06031M00FKEA
34	1	R16	RES., CHIP 30.1k 0.1W 1% 0603	VISHAY CRCW060330K1FKEA
35	1	R17	RES., CHIP 187k 0.1W 1% 0603	VISHAY CRCW0603187KFKEA
36	1	R18	RES., CHIP 150k 0.1W 1% 0603	VISHAY CRCW0603150KFKEA
37	1	R20	RES., CHIP 2.49M 0.1W 1% 0603	VISHAY CRCW06032M49FKEA
38	1	R21	RES., CHIP 10.0k 0.1W 1% 0603	VISHAY CRCW060310K0FKEA
39	4	R22, R24, R27, R28	RES., JUMPER, CHIP, 0Ω 0603	VISHAY CRCW06030000Z0EA
40	1	U1	BUCK REGULATOR QFN(40)(UJ)6MMX6MM	LINEAR TECH. CORP. LT8603EUJ
41	1	FB1	BEAD, 80Ω, 4A, 1206	WURTH ELEKTRONIK, 742792150

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Circuit Components				
1	0	C14 (OPT)	CAP., 0603	
2	0	C28 (OPT)	CAP., 0603	
3	0	D2 (OPT)	DIODE, SOD523	
4	0	R10 (OPT)	RES., 0603	
5	0	R23 (OPT)	RES., 0603	
6	0	R25 (OPT)	RES., 0603	
7	0	R26 (OPT)	RES., 0603	
Hardware: For Demo Board Only				
1	20	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19, E20	TURRET, TESTPOINT	MILL MAX 2501-2-00-80-00-00-07-0
3	4	JP1, JP2, JP3, JP4	HEADERS, 3 PINS 2MM CTRS.	WURTH ELEKTRONIK, 62000311121
4	4	XJP1, XJP2, XJP3, XJP4	SHUNT, 2MM CTRS.	SAMTEC 2SN-BK-G
5	4	MH1-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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