LTC3370EUH 4-Channel 8A Configurable Buck DC/DCs

DESCRIPTION

Demonstration circuit 2311A is a 4-output power supply featuring the LTC®3370. The LTC3370 has four current mode synchronous buck regulators which can be configured to share eight individual 1A power stages to create one of eight combinations of 1A, 2A, 3A and 4A regulators. The DC2311A is set up as four 2A buck regulators but can be modified to one of the other seven configurations.

The input range of the LTC3370 is ideal for single cell Li-Ion/Polymer battery applications. The buck regulators are enabled via external precision threshold enable pins to allow hardwired power up sequences.

The LTC3370 has a default operating frequency of 2MHz but can be set between 1MHz to 3MHz using an external resistor. The LTC3370 also has a PLL/MODE pin which allows the internal oscillator to synchronize to an external clock from 1MHz to 3MHz or configure the regulators to forced continuous mode or burst mode.

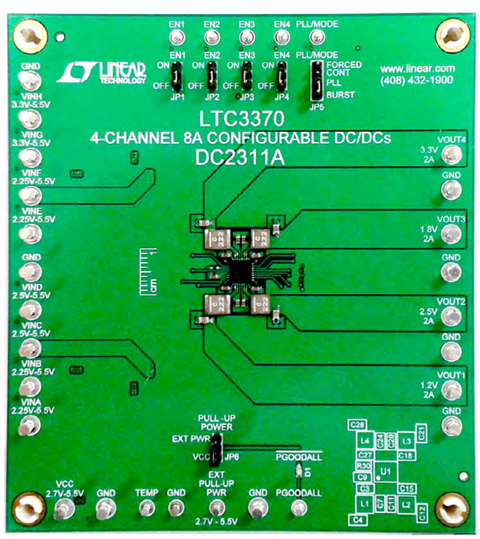
Refer to the LTC3370 data sheet for more details on the electrical and timing specifications.

Design files for this circuit board are available at http://www.linear.com/demo/DC2311A.

PERFORMANCE SUMMARY Specifications are at T_A = 25°C

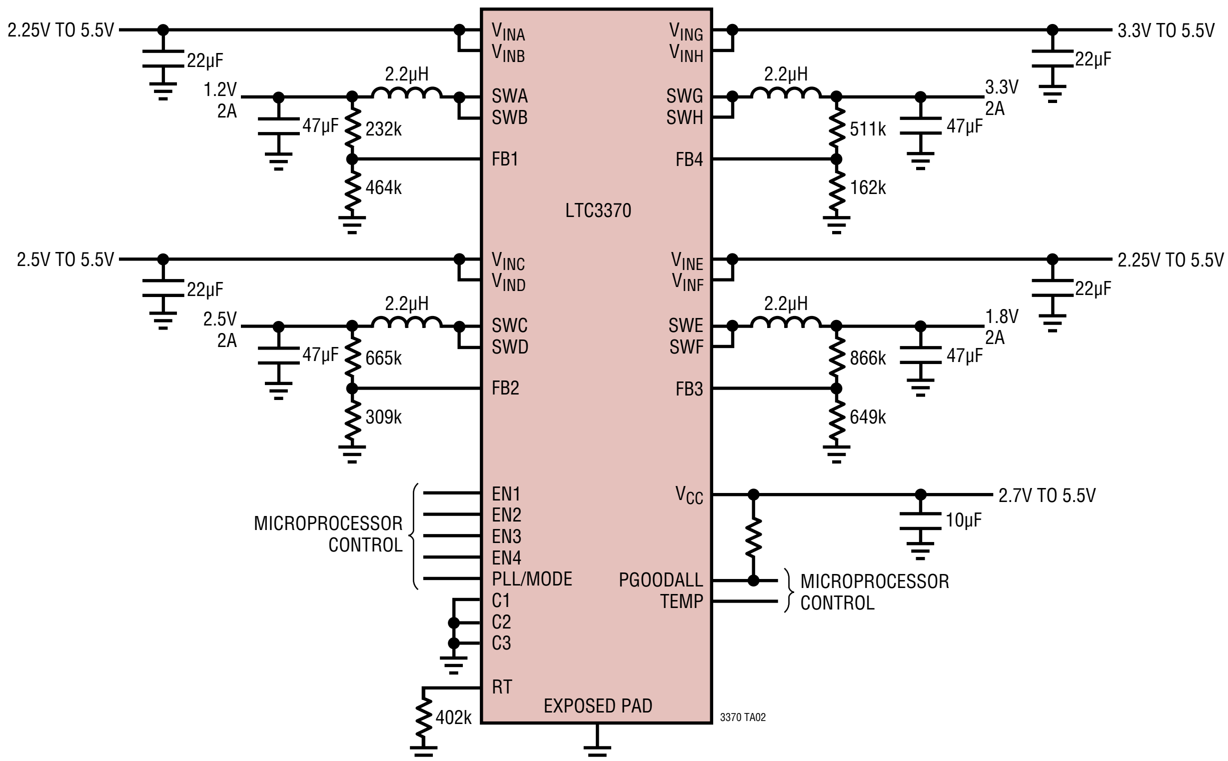
Input Supply Range (VINA-H)		2.25		5.5	V
VCC Operating Voltage		2.7		5.5	V
V_{OUT1}	0 to 2A		1.2		V
V_{OUT2}	0 to 2A, V_{INCD} > 2.5V		2.5		V
V_{OUT3}	0 to 2A		1.8		V
V_{OUT4}	0 to 2A, V_{INGH} > 3.3V		3.3		V

BOARD PHOTO

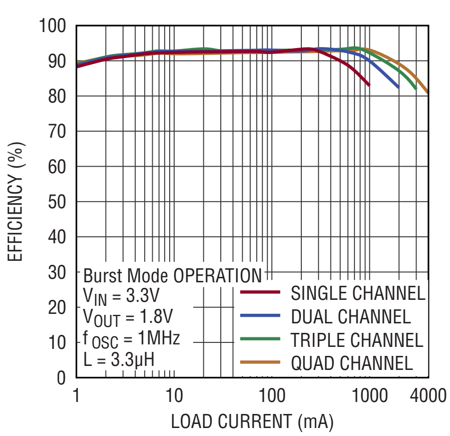


TYPICAL APPLICATION

4 × 2A Quad Buck Application



Buck Efficiency vs I_{LOAD}



C3	C2	C1	BUCK1	BUCK2	BUCK3	BUCK4
0	0	0	2A	2A	2A	2A
0	0	1	3A	1A	2A	2A
0	1	0	3A	1A	1A	3A
0	1	1	4A	1A	1A	2A
1	0	0	3A	2A	–	3A
1	0	1	4A	–	2A	2A
1	1	0	4A	–	1A	3A
1	1	1	4A	–	–	4A

QUICK START PROCEDURE

The DC2311A is easy to set up to evaluate the performance of the LTC3370. Refer to Figure 1 and Figure 2 for proper measurement equipment setup and follow the evaluation procedure below.

NOTE. When measuring the input or output voltage ripple, 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} and GND terminals. See Figure 2 for proper scope probe technique.

1. Set the JP1 – JP4 jumpers on the DC2311A board to the ON position.
2. Set the JP5 jumper on the DC2311A board to the BURST position.
3. Set the JP6 jumper on the DC2311A board to the V_{CC} position.
4. With power off, connect a 0V to 6V, 50mA power supply (PS5) to V_{CC} input terminal and GND with a series ammeter and a voltmeter as shown in Figure 1.
5. Turn on and set the PS5 to a desired input voltage between 2.7V and 5.5V.
6. With a digital volt meter, measure the voltage on the temp pin. This represents the die temperature,

   $(V_{TEMP} – 45mV)/7mV = °C$. 220mV = 25°C
7. With power off, connect 0V to 6V, 2A power supplies to each input pair (PS1-PS4), V_{INAB}, V_{INC}/V_{IND}, V_{INE}/V_{INF}, V_{ING}/V_{INH} and GND with a series ammeter and a voltmeter as shown in Figure 1. A single 0V to 6V, 10A supply can be used instead to supply all V_{IN} inputs and the V_{CC} input simultaneously.
8. Turn on and set the PS1 input power supply to 5.0V and observe that V_{OUT1} regulates to 1.2V.

   NOTE. Make sure that the input voltage does not exceed 6V.
9. With power off, connect a 0A to 2A load to V_{OUT1} and GND with a series ammeter and a voltmeter as shown in Figure 1.
10. Slowly increase the load from 0A to 2A and observe the output voltage. The output ripple may also be observed using an oscilloscope with the probe connected as shown in Figure 2.
11. Set Load1 to 100mA.
12. Repeat steps 8 to 11 for each output using their respective power supplies and loads. Each output voltage should regulate to the voltage indicated on the silkscreen of the DC2311A.
13. Momentarily short V_{OUT1} to ground with a clip lead and observe that the PGOODALL LED, D1, on the demo board illuminates. The LED shuts off when the short is removed.
14. With Load1 set to 100mA, observe the burst mode ripple on V_{OUT1}.
15. Set the JP5 jumper on the DC2311A board to the FORCED CONT position and observe the forced continuous mode ripple on V_{OUT1}.
16. With an oscilloscope using two probes each set to 1V/Div vertical scale and 1µs/Div horizontal scale, compare the phase between SWAB to SWCD, SWEF, and then SWGH. Observe that the switch nodes are 90°, 270°, and 180° out of phase respectively with SWAB.
17. Set the JP5 jumper on the DC2311A board to the PLL position.
18. Set a pulse generator to output a 0V to 5V pulse at 2MHz, 50% Duty cycle and connect it to the PLL/MODE terminal and GND.
19. Change the frequency of the pulse generator from 2MHz to 3MHz and observe how the frequency of SWAB follows the pulse generator.
20. Set LOAD1 greater than 1.0A. With an oscilloscope probe on SWAB, remove the pulse signal to the PLL/MODE terminal and observe how the switch frequency settles from 3MHz back to 2MHz.
21. Refer to the LTC3370 data sheet for more details on how the LTC3370 operates.
22. When done, turn off all loads and power supplies.

QUICK START PROCEDURE

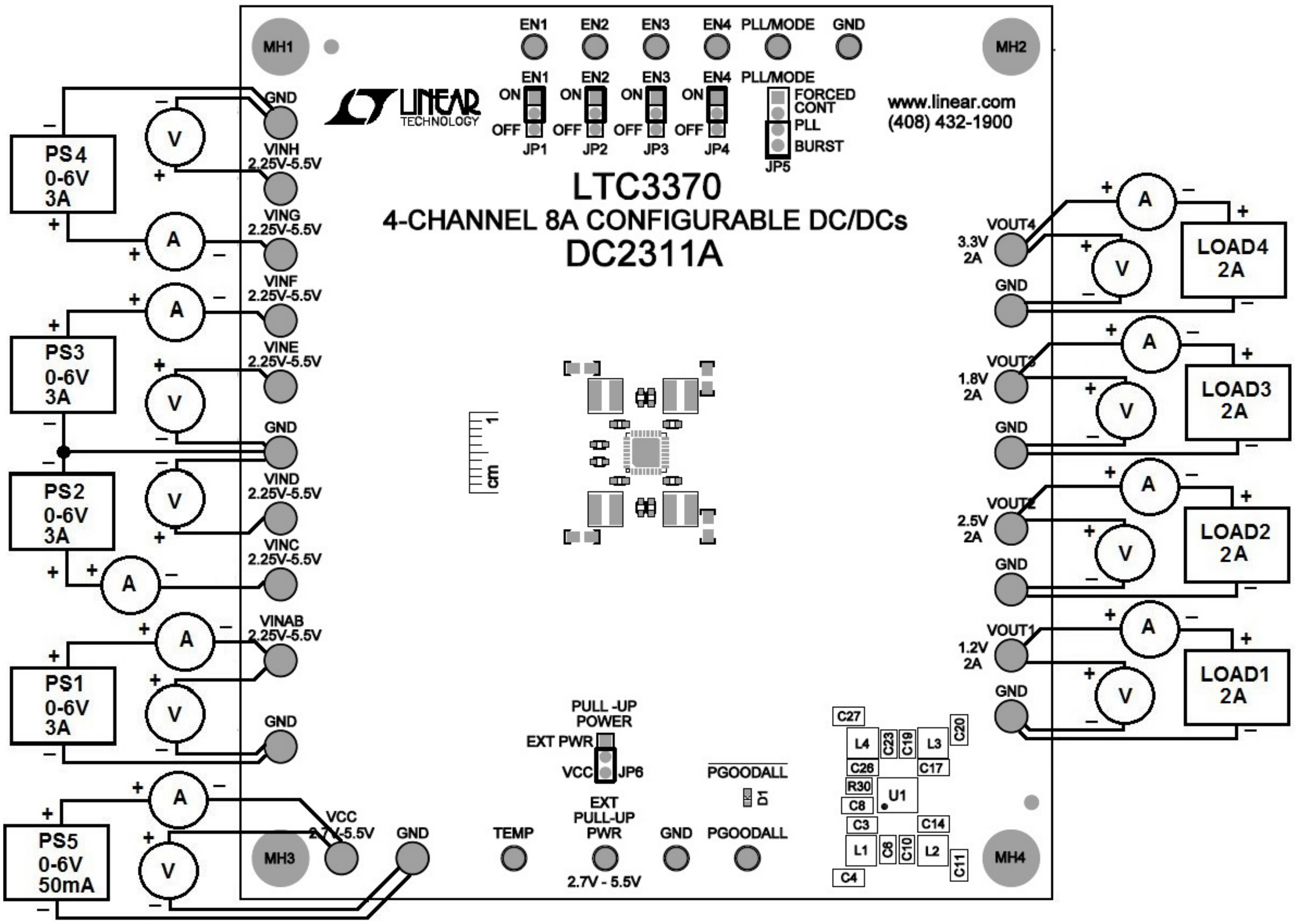


Figure 1. Proper Measurement Equipment Setup

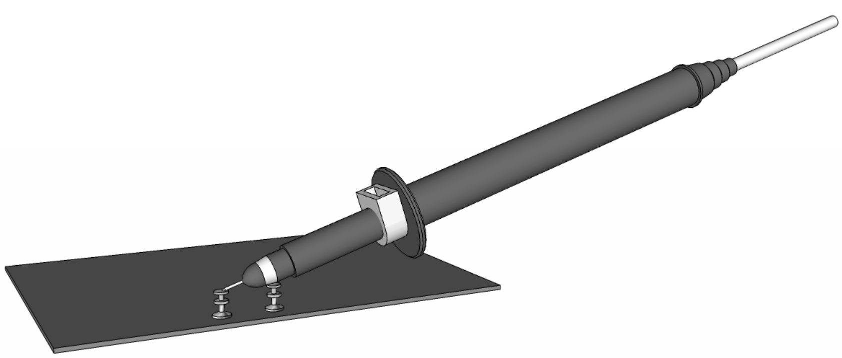


Figure 2. Measuring Input or Output Ripple

MODIFYING THE DC2311A TO OTHER POWER CONFIGURATIONS

The LTC3370 can be configured to one of eight different power configurations as shown in Table 1. To reconfigure the DC2311A to a different configuration some resistors will need to be changed, traces will need to be shorted together, and often traces will need to be cut. Follow the steps below to modify the board to a desired configuration.

1. Choose the desired configuration from Table 1.

Table 1. Master Slave Program Combinations (Each Letter Corresponds to a V_{IN} and SW Pair)

PROGRAM CODE C3C2C1	BUCK 1	BUCK 2	BUCK 3	BUCK 4
000	AB	CD	EF	GH
001	ABC	D	EF	GH
010	ABC	D	E	FGH
011	ABCH	D	E	FG
100	ABC	DE	Not Used	FGH
101	ABCD	Not Used	EF	GH
110	ABCD	Not Used	E	FGH
111	ABCD	Not Used	Not Used	EFGH

2. Set the associated C bit pins high or low as per Table 1 by opening and shorting the appropriate resistors. C1, C2, and C3 are set high by shorting R7, R11, and R14 respectively. C1, C2, and C3 are set low by shorting R9, R13, and R16 respectively. The C bit resistors are 0603 resistors located on the bottom of the board as shown in Figure 3.

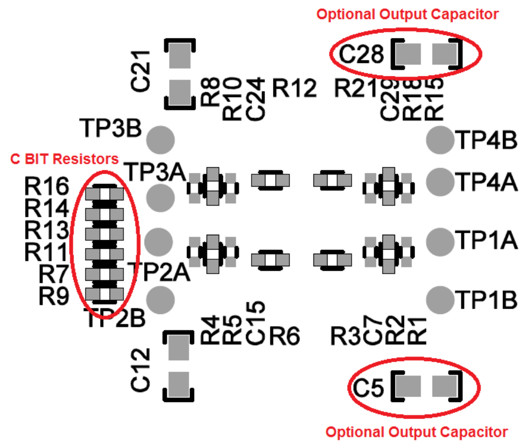


Figure 3. C Bit Resistors and Optional Output Capacitors for V_{OUT1} and V_{OUT4}

3. The DC2311A is set up with the following power stage switch nodes and V_{IN} nodes connected together; A & B, C & D, E & F, and G & H. Any configuration using 1A or 3A regulators will require one or more of the V_{IN} and switch nodes to be separated. Refer to Table 1 to determine which power stages are connected together and separated. Cut the required V_{IN} nodes by cutting the V_{IN} traces on the bottom of the board near the V_{IN} terminals as shown in Figure 4.

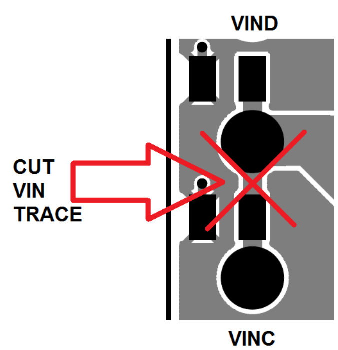


Figure 4. Separate V_{IN} Pairs by Cutting Traces at Terminals

MODIFYING THE DC2311A TO OTHER POWER CONFIGURATIONS

4. Any switch node associated with a V_{IN} trace that was cut will also need to be cut. The SWC/SWD traces and SWD/SWF traces can be cut in between to pads near the SW pins as shown in Figure 5. The SWG/SWH traces only need to be cut for the "4112" configuration. SWH needs to be cut between the SWH pin and L4 as shown in Figure 6.

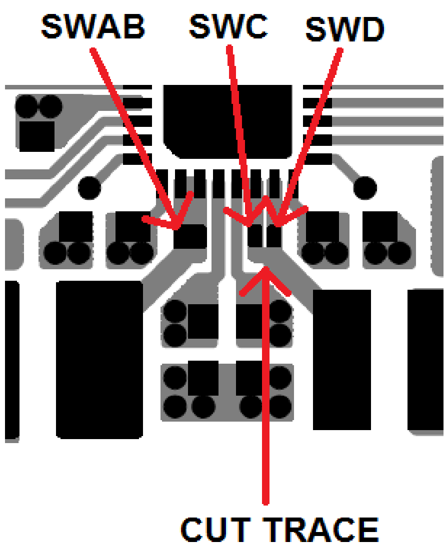


Figure 5. Cut SWC and SWD connection near pins

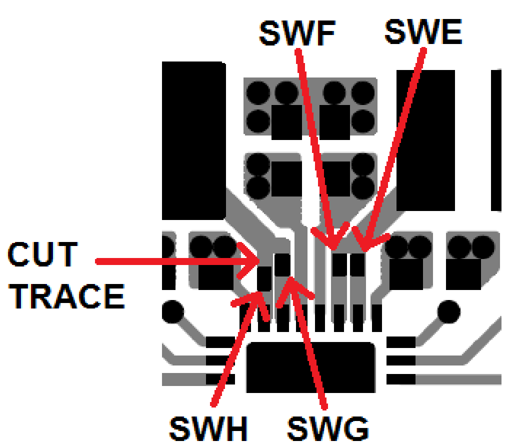


Figure 6. Cut SWH trace between L4 and SWH pin

5. For all combinations containing 3A and 4A outputs, the V_{IN} nodes of adjoining power stages will need to be connected together. Connect all V_{IN}s of adjoining power stages at the V_{IN} terminals with a 22AWG wire or larger.
6. All switch nodes of adjoining power stages will need to be connected together. Each power stage has a pad to solder a small bus wire, 28AWG. The switch node pads are also shown in Figure 5 and Figure 6. Carefully solder a bus wire as short as possible between adjoining power stages.

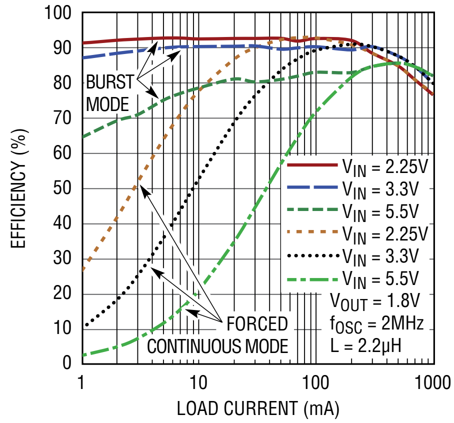
   Note: For the 4112 combination switch AB will need to connect to switch C and switch H. For the 332 combination switch D will need to connect to switch E.
7. The XAL4020-222M inductors are rated for 5.5A. This is less than the current limit of the 3A or 4A regulators. The pads for L1 and L4 as sized to accommodate a 5mm x 5mm inductor such as the Toko FDSD05xx or the Coilcraft XAL05xx series. Change inductors L1 and/or L4 to accommodate current limit conditions if needed.
8. Remove any inductors of unused regulators.

   Note: For the 323 configuration, L2 needs to be populated and L3 needs to be removed to utilize the regulator 2 FB network.
9. The output capacitance requirement is a minimum of 22µF for each 1A of output current. Each output has an optional 0805 capacitor on the bottom of the board. Add the required amount of capacitance to C5 and/or C29 (shown in Figure 3) for V_{OUT1} and V_{OUT4} respectively, if needed.
10. Set the EN jumpers of any unused regulators to the OFF position.

APPLICATION INFORMATION

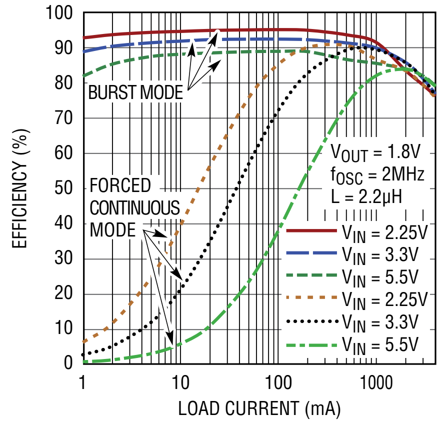
The DC2311A can be used to evaluate each of the eight configurations of the LTC3370 from 1MHz to 3MHz. The following efficiency graphs and transient response plots illustrate how a 1.8V, 1A regulator performs compared to a 1.8V, 4A regulator. Please refer to the LTC3370 data sheet for more performance information for the LTC3370.

1A Buck Efficiency vs I_{LOAD}



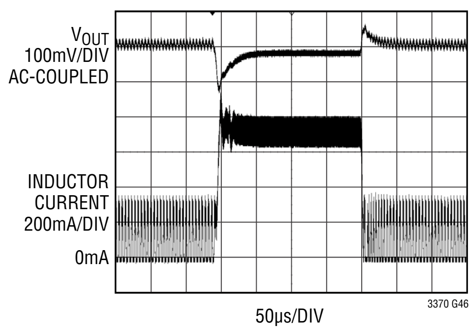
3370 G23

4A Buck Efficiency vs I_{LOAD}



3370 G33

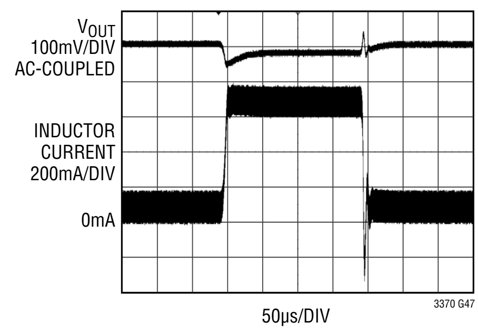
1A Buck Regulator, Transient Response (Burst Mode Operation)



3370 G46

LOAD STEP = 100mA TO 700mA
V_{IN} = 3.3V
V_{OUT} = 1.8V

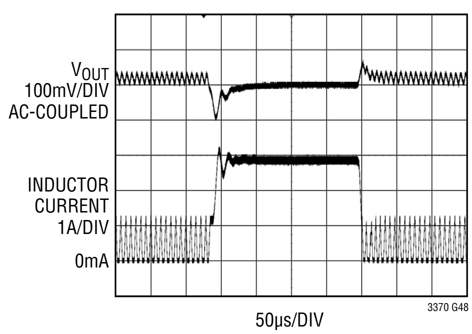
1A Buck Regulator, Transient Response (Forced Continuous Mode)



3370 G47

LOAD STEP = 100mA TO 700mA
V_{IN} = 3.3V
V_{OUT} = 1.8V

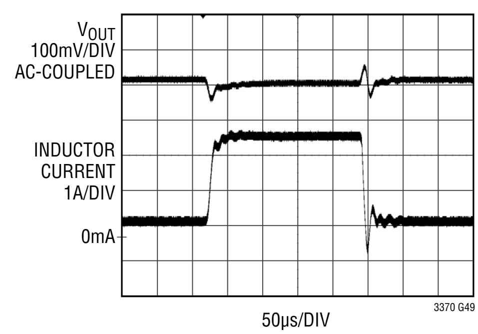
4A Buck Regulator, Transient Response (Burst Mode Operation)



3370 G48

LOAD STEP = 400mA TO 2.8A
V_{IN} = 3.3V
V_{OUT} = 1.8V

4A Buck Regulator, Transient Response (Forced Continuous Mode)



3370 G49

LOAD STEP = 400mA TO 2.8A
V_{IN} = 3.3V
V_{OUT} = 1.8V

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	CAP, CHIP, X5R, 22µF, ±20%, 6.3V, 0805	TAIYO YUDEN, JMK212BJ226MG-T
2	9	C3, C6, C8, C10, C14, C17, C19, C23, C26	CAP, CHIP, X5R, 10µF, ±20%, 6.3V, 0603	TDK, C1608X5R0J106M
3	4	C4, C11, C20, C27	CAP, CHIP, X5R, 47µF, ±20%, 6.3V, 0805	TAIYO YUDEN, JMK212BJ476MG
4	4	C7, C15, C24, C29	CAP, CHIP, NPO, 10pF, ±5%, 50V, 0402	AVX, 04025A100JAT2A
5	4	L1–L4	IND, SMT, 2.2µH, 38mΩ, ±20%, 5.5A, 4mm × 4mm	COILCRAFT, XAL4020-222MEC
6	2	R2	RES, CHIP, 232kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603232KFKEA
7	1	R3	RES, CHIP, 464kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603464KFKEA
8	1	R5	RES, CHIP,665kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603665KFKEA
9	1	R6	RES, CHIP, 309kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603309KFKEA
10	1	R10	RES, CHIP, 806kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603806KFKEA
11	1	R12	RES, CHIP, 649kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603649KFKEA
12	1	R18	RES, CHIP, 511kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603511KFKEA
13	1	R21	RES, CHIP,162kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603162KFKEA
14	1	R30	RES, CHIP,402kΩ, ±1%, 1/10W, 0603	VISHAY, CRCW0603402KFKEA
15	1	U1	4-CHANNEL 8A CONFIGURABLE BUCK DC-DCs,TSSOP	LINEAR TECH., LTC3370EUH#PBF
Additional Demo Board Circuit Components				
16	1	C2	CAP, POSCAP, 100µF, ±20%, 6.3V, SMT	PANASONIC, 6TPG100MG
17	0	C5, C12, C21, C28 (OPT)	CAP, CHIP, 0805	
18	6	C6, C10, C14, C17, C19, C23	CAP, POSCAP, 47µF, ±20%, 6.3V, SMT	PANASONIC, 6TPC47M
19	6	C9, C13, C16, C18, C22, C25	CAP, POSCAP, 47µF, ±20%, 6.3V, SMT	PANASONIC, 6TPC47M
20	1	D1	DIODE, LED, SUPER RED DIFF, 0603 SMD	LUMEX, SML-LX0603SRW-TR
21	4	R1, R4, R8, R15	RES, CHIP, 20Ω , ±1%, 1/16W, 0402	VISHAY, CRCW040220R0FKED
22	0	R7, R11, R14 (OPT)	RES, CHIP, 1/10W, 0603	
23	3	R9, R13, R16	RES, CHIP, 0Ω JUMPER, 1/10W, 0603	VISHAY, CRCW06030000Z0EA
24	6	R17, R20, R22, R24, R26, R28	RES, CHIP, 1kΩ, ±5%, 1/16W, 0402	VISHAY, CRCW04021K00JNED
25	5	R19, R23, R25, R27, R29	RES, CHIP, 1.00MΩ, ±5%, 1/16W, 0402	VISHAY, CRCW04021M00JNED
Hardware				
26	20	E1–E18, E27, E29	TURRET, 0.09 DIA	MILL-MAX, 2501-2-00-80-00-00-07-0
27	10	E19–E26, E28, E30	TURRET, 0.061 DIA	MILL-MAX, 2308-2-00-80-00-00-07-0
28	5	JP1–JP4, JP6	2mm to HEADER 1 × 3 , 2mm	SAMTEC, TMM-103-02-L-S
29	1	JP5	2mm to HEADER 1 × 4 , 2mm	SAMTEC, TMM-104-02-L-S
30	6	JP1–JP6	SHUNT, 2mm	SAMTEC, 2SN-KB-G
31	4		STAND-OFF NYLON, 0.375" TALL (SNAP-ON)	KEYSTONE, 8832 (SNAP ON)

SCHEMATIC DIAGRAM

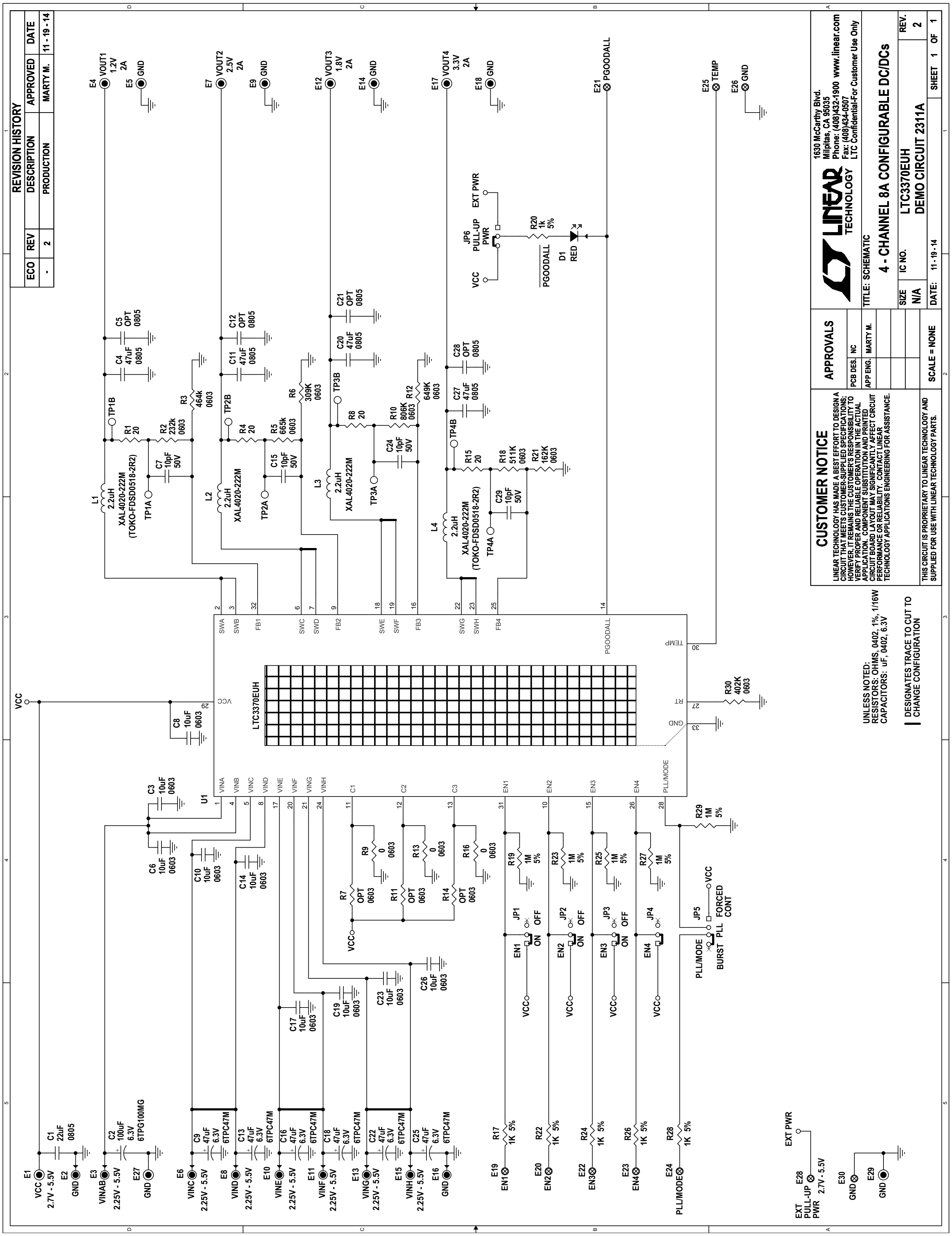


Figure 7. DC2311A Demo Circuit Schematic

dc2311af

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