LTC3314A
3.3V to 1.2V and 1.8V at 4A, 2MHz Dual Step-Down DC/DC Regulators

DESCRIPTION

Demo circuit 3204A features the LTC3314A, 5V, dual 4A/dual-phase 8A step-down DC/DC regulator IC. This demo circuit is configured as a 2MHz, 3.3V input buck regulator with dual 4A output at 1.2V and 1.8V.

The LTC®3314A features dual monolithic synchronous 4A step-down power stages in a 30-ball, 2.2mm × 2.7mm WLCSP package for space saving applications with demanding performance requirements. Both bucks achieve high efficiency and fast transient response with small external components. The LTC3314A can also be configured as a single output, dual-phase 8A step-down converter. Please refer to DC3205A as a single output dual-phase application example. The LTC3314A data sheet gives a complete description of its operation and application information. The data sheet must be read in conjunction with this demo manual when evaluating or modifying this demo circuit.

DC3204A supports three operation modes, including pulse-skipping, forced continuous and Burst Mode® operation. The clock frequency and the operation mode are shared by both regulators. User can select desired operation mode with JP3 jumper. Setting JP3 to FC/SYNC position also allows the LTC3314A to sync to a clock frequency from 1MHz to 3MHz, operating in forced continuous mode.

An EMI filter is included in this demo circuit for noise sensitive applications. To power with EMI filter, please apply input voltage via VIN EMI terminal.

Design files for this circuit board are available.

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}/V_{IN} EMI	DC3204A Input Voltage Range		2.25		5.5	V
V_{OUT1}	DC3204A Output 1 Voltage Range		1.174	1.2	1.226	V
V_{OUT2}	DC3204A Output 2 Voltage Range		1.755	1.8	1.843	V
I_{OUT}	DC3204A Output Current (Each Output)				4	A
f_{SW}	Switching Frequency		1.8		2.2	MHz
EFF1	Output1 Efficiency	V_{IN} = 3.3V, I_{OUT} = 2A, V_{OUT1} = 1.2V		92		%
EFF2	Output2 Efficiency	V_{IN} = 3.3V, I_{OUT} = 2A, V_{OUT2} = 1.8V		94		%

BOARD PHOTO

Part marking is either ink mark or laser mark

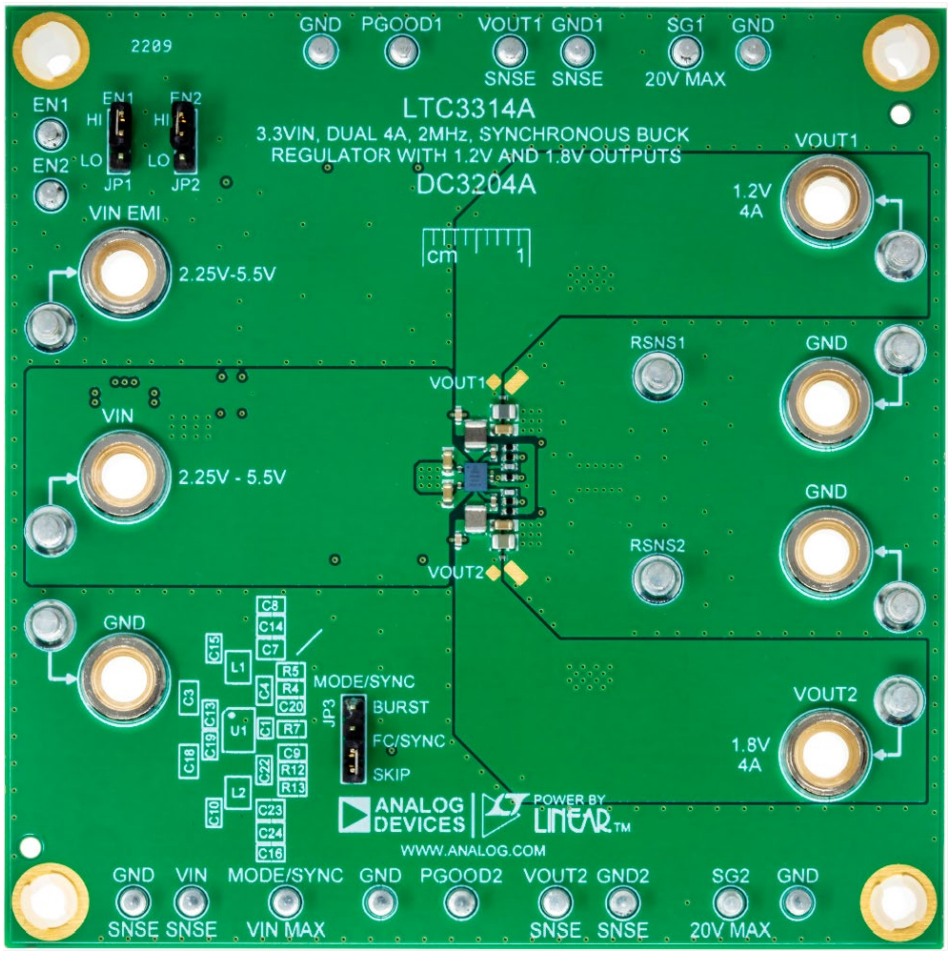


Figure 1. DC3204A Demo Board

QUICK START PROCEDURE

Refer to Figure 2 for the proper measurement equipment setup and follow the procedure below:

NOTE: For accurate V_{IN}, V_{OUT} and efficiency measurements, measure V_{IN} at the VIN SNSE and GND SNSN turrets, and measure V_{OUT} at the VOUT SNSE and GND SNSE turrets. When measuring the input or output ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. It is recommended to use technique shown in Figure 3 and Figure 4 for basic ripple measurement.

Prepare for the Test

A. Select a power supply PS1 that can handle 5V of output voltage and 10A of output current, with internal current meter. If possible, connect PS1 Kelvin Sense terminals with VIN SNSE and GND SNSE turrets.

B. Select two electronic loads LD1 and LD2 that can handle 2V of load voltage and up to 4A of load current in constant current mode.

C. Select an oscilloscope with two or more channels and two voltage probes.

Test BUCK1 (VOUT1)

1. Connect PS1, LD1, VM1, VM2 and VM3 as shown in Figure 2. If the input EMI filter is desired, connect the input power supply to VIN EMI and GND.
2. Set the JP1 to HI position. Set LD1 to 0A. Slowly increase PS1 to 1V. If PS1 current reads less than 20mA, increase PS1 to 3.3V until VM1 reads 3.3V ±10mV. VM2 should read between 1.174V to 1.226V. VM3 should read above 3V.
3. Connect an oscilloscope voltage probe as shown in Figure 3, between VOUT1 SNSE and GND1 SNSE turrets. Set channel to AC-coupled, voltage scale to 20mV, and time base to 10µs/div. Check VOUT1 ripple voltage. Output voltage ripple can also be measured with a low inductor connector on TP1, as shown in Figure 4.
4. Increase the load by 1A intervals up to 4A and observe the voltage output regulation, ripple voltage and SW behavior.
5. If other operation modes are desired. Turn off PS1, set LD1 to 0A and set JP3 to FC/SYNC or BURST position. Turn on PS1, slowly increase LD1 and observe the change in PS1 output current, SW behavior and output ripple.
6. Optional: To change the frequency, remove R7. Install the desired R_T resistor in the R8 location. Size the inductor, output capacitors and compensation components to provide the desired inductor ripple and a stable output. Refer to the LTC3314A data sheet and LTPowerCAD for more information on choosing the required components.
7. Optional: To SYNC to a specific frequency, set JP3 to FC/SYNC position. Connect a waveform generator to MODE/SYNC turret. Please refer to LTC3314A data sheet for synchronization signal requirements.
8. To test the transient response with a base load, add the desired resistor to produce a minimum load between VOUT and RSNS1 turrets (RL1 shown on Figure 2). Note that the total load resistance will be RL1 plus R18 (100mΩ). Adjust a signal generator with a 10ms period, 10% duty cycle and an amplitude from 1V to 2V to start.
9. Measure the R_{SNS1} voltage to observe the current, $V_{RSNS1}/100m\Omega$. Adjust the amplitude of the pulse to provide the desired transient. Connect signal generator SG1 between SG_INPUT and GND turrets. Adjust the rising and falling edge of the pulse to provide the desired ramp rate. Refer to the following equation for output current measurement:

$$I_{OUT} = \frac{V_{RSNS1}}{100m\Omega} \quad (1)$$

10. When done, turn off SG1, PS1 and Load.

Test BUCK2 (VOUT2)

11. Follow similar steps for BUCK1 tests. Change the setup to LD2, VM4, VM5, SG2, RL2. VOUT2 should read between 1.755V to 1.843V when powered.
12. When done, turn off all the supplies and loads. Disconnect all the cables.

TEST SETUP

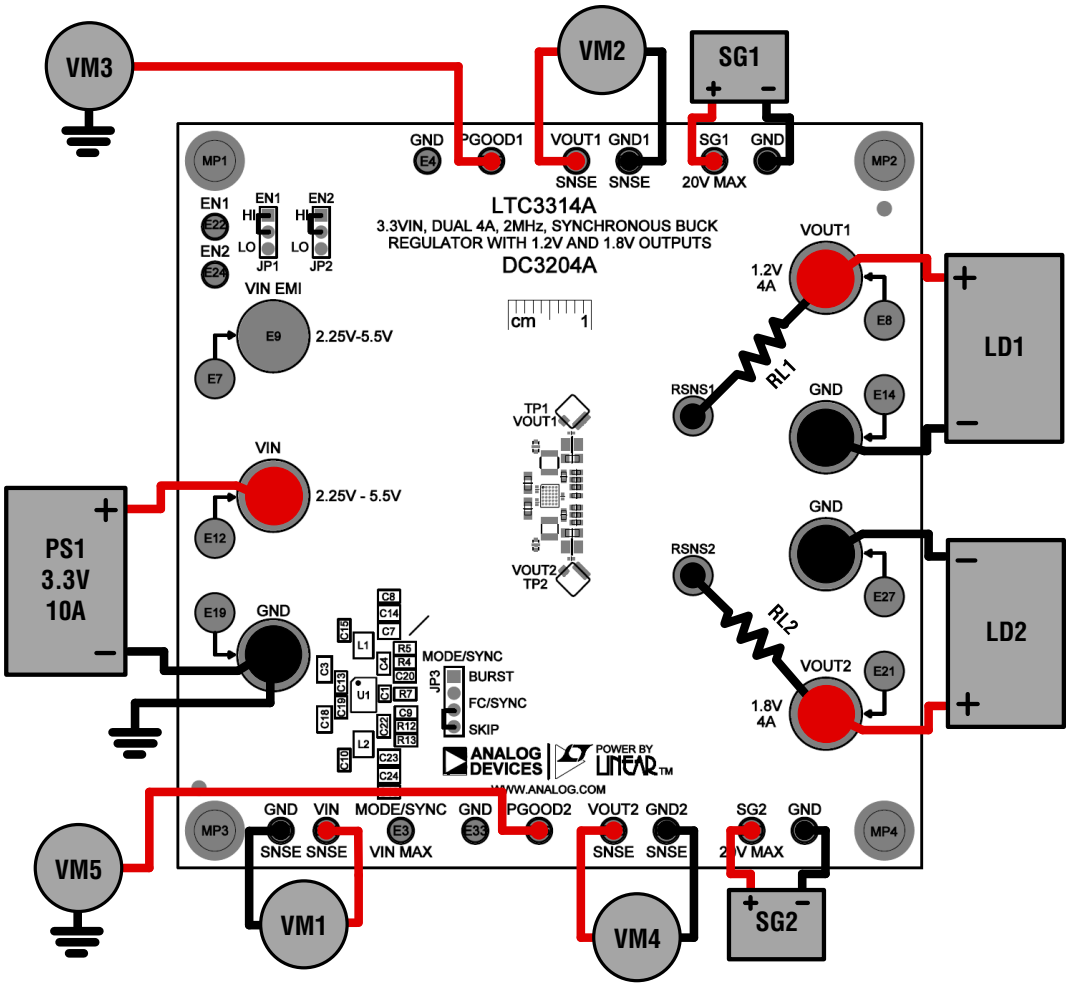


Figure 2. Test Setup for DC3204A Demo Board

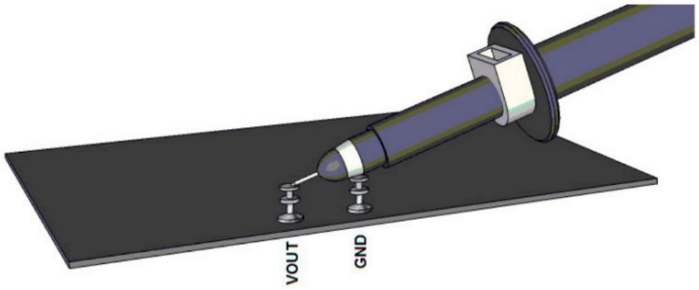


Figure 3. Technique for Measuring Output Ripple and Step Response

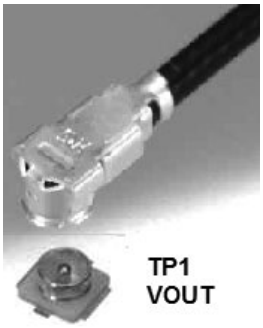


Figure 4. Technique for Measuring Output Ripple and Step Response with a Low Inductance Connector (Not Supplied)

THEORY OF OPERATION

Introduction to the DC3204A

The DC3204A demonstration circuit features the LTC3314A, 5V, Dual 4A/Dual-Phase 8A Step-Down DC/DC Regulator. The LTC3314A contains two monolithic, constant frequency, current mode step-down DC/DC converters. An oscillator, shared by two converters, with frequency set by a resistor on the RT pin, turns on the internal top power switch at the beginning of each clock cycle. The beginning of each clock cycle of the two converters are 180-degree out of phase. Current in the inductor then increases until the top switch comparator trips and turns off the top power switch. The peak inductor current, at which the top switch turns off, is controlled by the voltage on the internal V_C node, which is the output of the error amplifier. The internal V_C node is connected with internal compensator to stabilize the control loop. The error amplifier servos the V_C node by comparing the voltage on the FB pin with an internal 500mV reference. When the load current increases, it causes a reduction in the feedback voltage relative to the reference leading the error amplifier to raise the V_C voltage until the average inductor current matches the new load current. When the top switch turns off, the synchronous bottom power switch turns on until the next clock cycle begins. In pulse-skipping mode and Burst Mode, the bottom switch also turns off when inductor current falls to zero. If overload conditions result in excessive current flowing through the bottom switch, the next clock cycle will be delayed until the switch current returns to a safe level. In Burst Mode, the error amplifier and most part of the internal circuitry can be turned off until output voltage trips an output low comparator, during extreme light load condition, to improve light load efficiency.

If the ENx pin is low, the corresponding converter in LTC3314A is in shutdown and in a low quiescent current state. When the ENx pin is above its threshold, the corresponding switching converter will be enabled.

The MODE/SYNC pin synchronizes the switching frequency to an external clock. It also sets the PWM mode. The PWM modes of operation are Burst, pulse-skipping and forced continuous. See the LTC3314A data sheet for more detailed information.

The maximum allowable operating frequency is influenced by the minimum on time of the top switch, the ratio of V_{OUT} to V_{IN} and the available inductor values. The maximum allowable operating frequency may be calculated in the formula below.

$$f_{SW(MAX)} = \frac{V_{OUT}}{V_{IN(MAX)} \bullet t_{ON(MIN)}} \quad (2)$$

Select an operating switching frequency below $f_{SW(MAX)}$. Typically, it is desired to obtain an inductor current of 30% of the maximum LTC3314A operating load, 4A. Use the formulas below to calculate the inductor value to obtain a 30% (1.2A) inductor ripple for the operating frequency.

$$L \geq \frac{V_{OUT}}{1.2A \bullet f_{SW}} \bullet \left(1 - \frac{V_{OUT}}{V_{IN(MAX)}}\right) \text{ for } \frac{V_{OUT}}{V_{IN(MAX)}} \leq 0.5 \quad (3)$$

$$L \geq \frac{0.25 \bullet V_{IN(MAX)}}{1.2A \bullet f_{SW}} \text{ for } \frac{V_{OUT}}{V_{IN(MAX)}} > 0.5 \quad (4)$$

The overall control loop of the converter can be tuned by output capacitors and feedforward capacitors. The LTC3314A has been designed to operate at a high bandwidth for fast transient response capabilities. This reduces required output capacitance to meet the desired transient voltage range. C20 along with R4, or C9 along with R12, provides a phase lead which will improve the phase margin.

Loop stability is generally measured using the Bode Plot method of plotting loop gain in dB and phase shift in degrees. The 0dB crossover frequency should be less the 1/6 of the operating frequency to reduce the effects of added phase shift of the modulator. The control loop phase margin goal should be 45° or greater and a gain margin goal of 8dB or greater.

TYPICAL PERFORMANCE CHARACTERISTICS

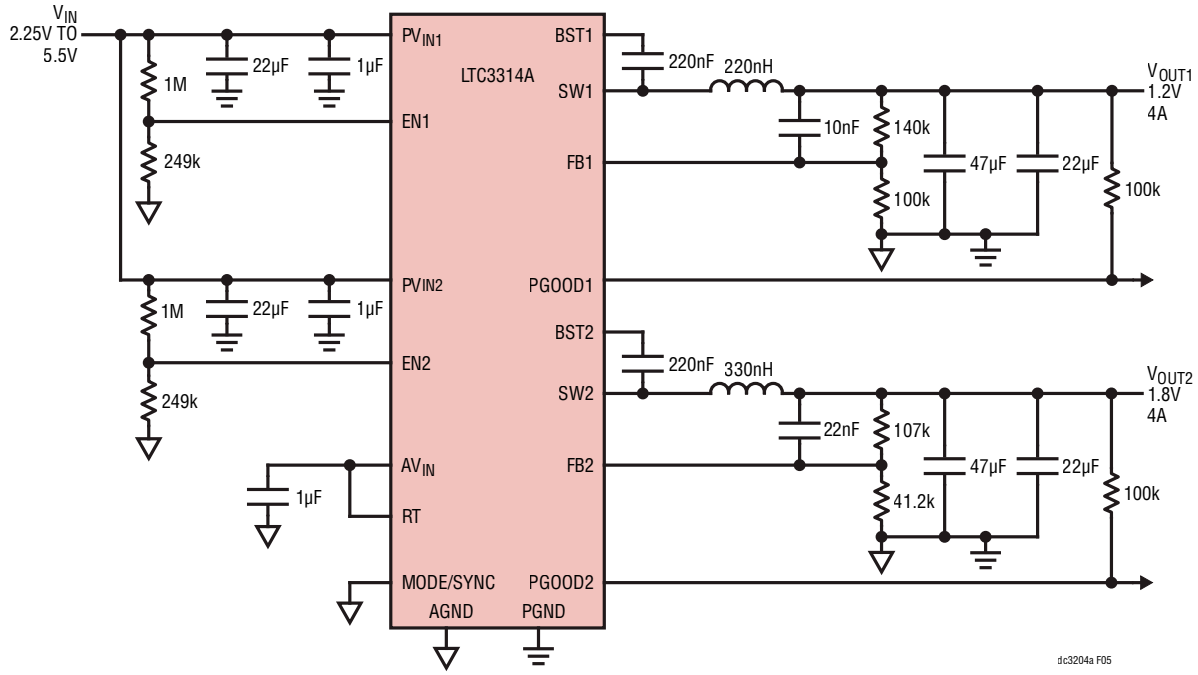


Figure 5. LTC3314A Dual 4A Buck Typical Application Schematic

Efficiency, V_{IN} = 3.3V, V_{OUT} = 1.2V All Modes

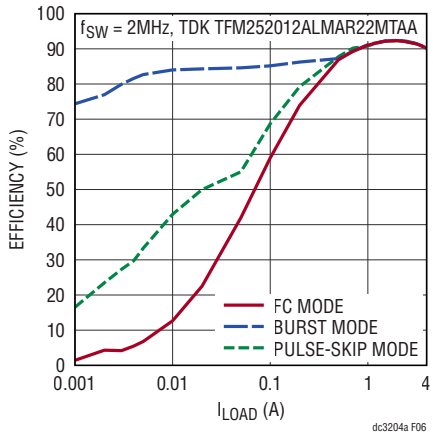


Figure 6. Output1 Efficiency vs Load

Efficiency, V_{IN} = 3.3V, V_{OUT} = 1.8V All Modes

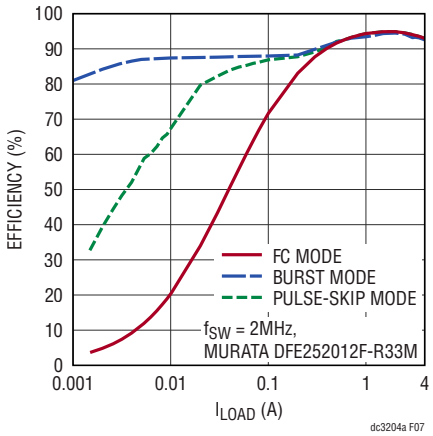


Figure 7. Output2 Efficiency vs Load

TYPICAL PERFORMANCE CHARACTERISTICS

V_{OUT1} Load Transient Response, Forced Continuous Mode

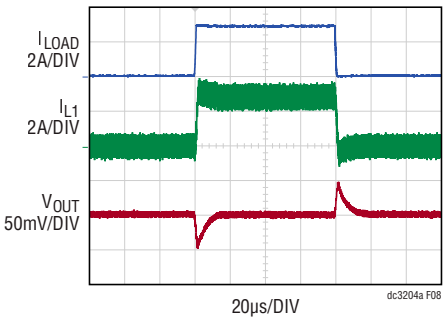


Figure 8. Output1 Load Step Response in Forced Continuous Mode with V_{IN} = 3.3V

V_{OUT2} Load Transient Response, Forced Continuous Mode

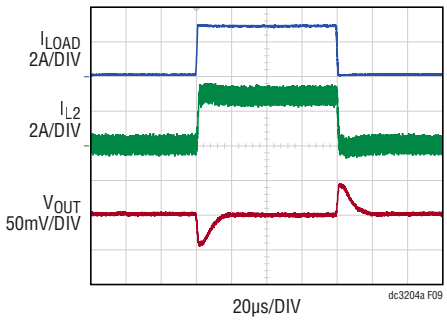


Figure 9. Output2 Load Step Response in Forced Continuous Mode with V_{IN} = 3.3V

V_{OUT1} Load Transient Response, Pulse-Skipping Mode

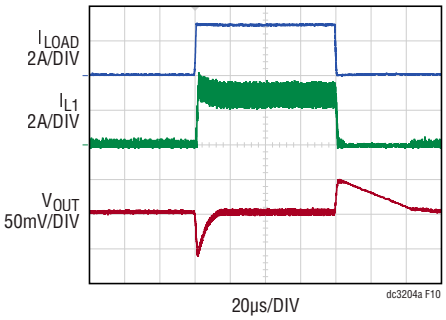


Figure 10. Output1 Load Step Response in Pulse-Skipping Mode with V_{IN} = 3.3V

V_{OUT2} Load Transient Response, Pulse-Skipping Mode

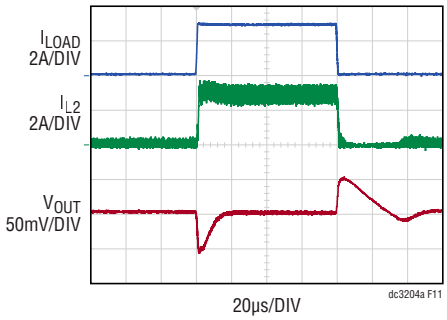


Figure 11. Output2 Load Step Response in Pulse-Skipping Mode with V_{IN} = 3.3V

V_{OUT1} Load Transient Response, Burst Mode Operation

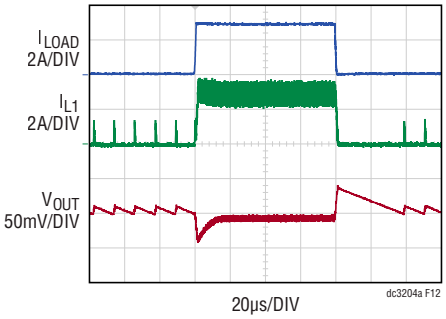


Figure 12. Output1 Load Step Response in Burst Mode with V_{IN} = 3.3V

V_{OUT2} Load Transient Response, Burst Mode Operation

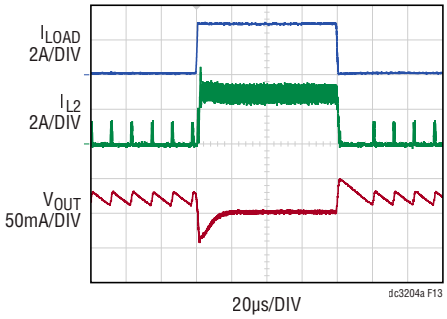
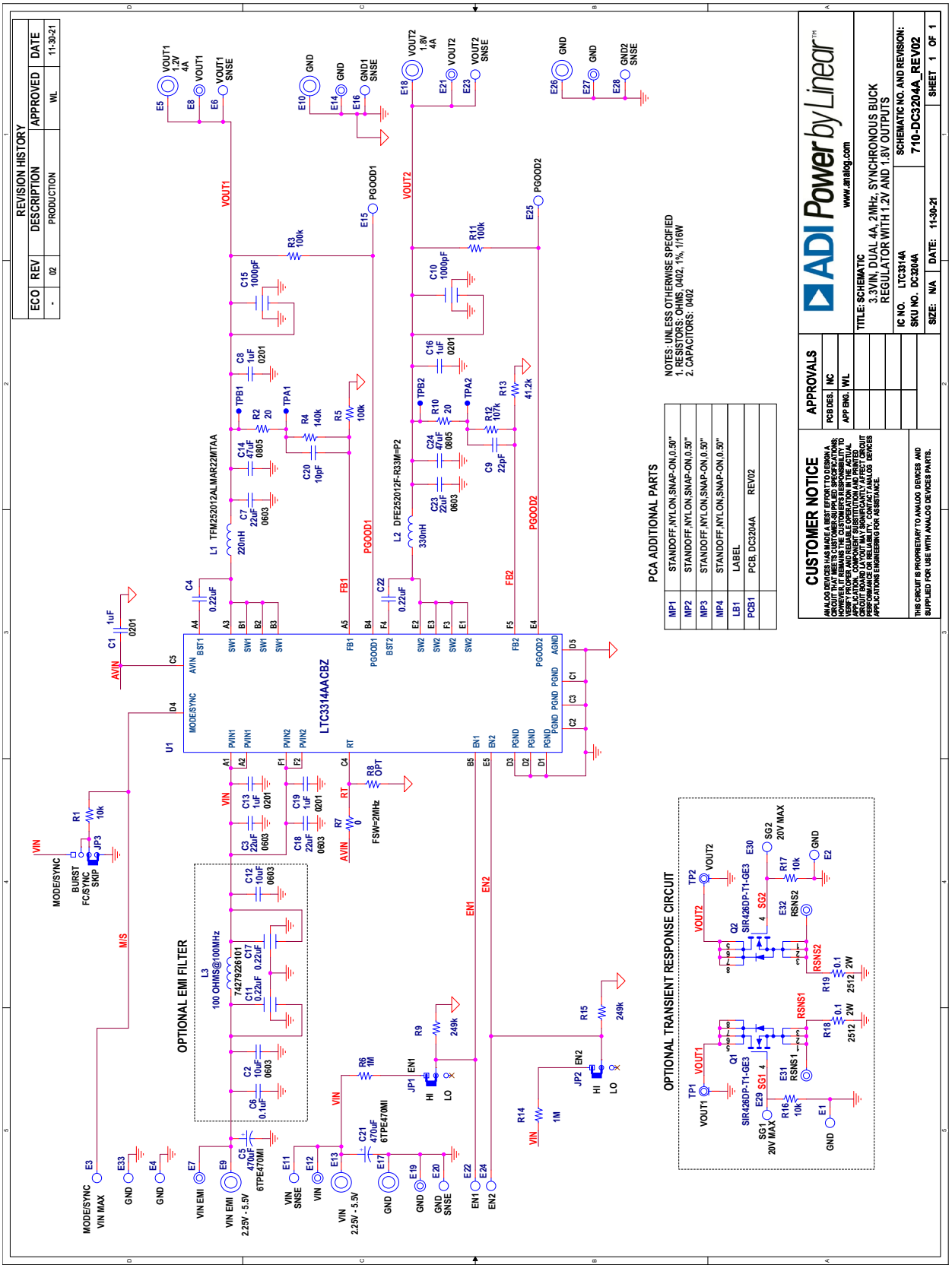


Figure 13. Output2 Load Step Response in Burst Mode with V_{IN} = 3.3V

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	3	C1, C13, C19	CAP., 1µF, X7T, 6.3V, 20%, 0201	MURATA, GRM033D70J105ME01D
2	4	C3, C7, C18, C23	CAP., 22µF, X5R, 10V, 20%, 0603	AVX, 0603ZD226MAT2A
3	2	C4, C22	CAP., 0.22µF, X7R, 16V, 10%, 0402, AEC-Q200	MURATA, GCM155R71C224KE02D
4	1	C9	CAP., 22pF, C0G, 50V, 10%, 0402	AVX, 04025A220KAT2A
5	2	C11, C17	CAP., 0.22µF, X7R, 6.3V, 20%, 0603	JOHANSON DIELECTRICS, 6R3X14W224MV4T
6	2	C14, C24	CAP., 47µF, X6S, 6.3V, 20%, 0805	TAIYO YUDEN, JMK212BC6476MG-T
7	1	C20	CAP., 10pF, C0G/NP0, 50V, ±0.5pF, 0402	AVX, 04025A100DAT2A
8	1	L1	IND., 220nH, 20%, 6.7A, 13mΩ, AEC-Q200	TDK, TFM252012ALMAR22MTAA
9	1	L2	IND., 330nH, 20%, 5.1A, 19mΩ, 1008	MURATA, DFE252012F-R33M=P2
10	1	R4	RES., 140k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F1403TRF
11	1	R5	RES., 100k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KFKED
12	1	R12	RES., 107k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F1073TRF
13	1	R13	RES., 41.2k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040241K2FKED
14	2	R18, R19	RES., 0.1Ω, 1%, 2W, 2512, SENSE, AEC-Q200	TT ELECTRONICS, LRC-LR2512LF-01-R100-F
15	1	U1	IC, DUAL 2MHz, 4A STEP-DOWN DC/DC REGULATOR	ANALOG DEVICES INC., LTC3314AACBZ-R7#PBF
Additional Demo Board Circuit Components				
1	2	C2, C12	CAP., 10µF, X7S, 6.3V, 20%, 0603	TDK, C1608X7S0J106M080AC
2	2	C5, C21	CAP., 470µF, TANT, POSCAP, 6.3V, 20%, 7343, 18mΩ, TPE	PANASONIC, 6TPE470MI
3	1	C6	CAP., 0.1µF, X7R, 25V, 10%, 0402, AEC-Q200	MURATA, GCM155R71E104KE02D
4	2	C8, C16	CAP., 1µF, X7T, 6.3V, 20%, 0201	MURATA, GRM033D70J105ME01D
5	2	C10, C15	CAP., 1000pF, X7R, 50V, 20%, 0402, 3-TERM, X2Y EMI FILTER	JOHANSON DIELECTRICS, 500X07W102MV4T
6	1	L3	IND., 100Ω AT 100MHz, FERRITE BEAD, 25%, 8A, 6mΩ, 1812	WURTH ELEKTRONIK, 74279226101
7	2	Q1, Q2	XSTR., MOSFET, N-CH, 40V, 15.9A, PPAK SO-8	VISHAY, SIR426DP-T1-GE3
8	3	R1, R16, R17	RES., 10k, 5%, 1/16W, 0402, AEC-Q200	NIC, NRC04J103TRF
9	2	R2, R10	RES., 20Ω, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F20R0TRF
10	2	R3, R11	RES., 100k, 5%, 1/16W, 0402	YAGEO, RC0402JR-07100KL
11	2	R6, R14	RES., 1M, 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCF0402FT1M00
12	1	R7	RES., 0Ω, 1/16W, 0402	VISHAY, CRCW04020000Z0ED
13	2	R9, R15	RES., 249k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F2493TRF
14	2	R18, R19	RES., 0.1Ω, 1%, 2W, 2512, SENSE, AEC-Q200	TT ELECTRONICS, LRC-LR2512LF-01-R100-F
15	0	TP1, TP2	CONN., U.FL, RECEPT, ST SMD, 0Hz to 6GHz 50Ω	HIROSE ELECTRIC, U.FL-R-SMT-1(10)
Hardware: For Demo Board Only				
1	17	E1-E4, E6, E11, E15, E16, E20, E22-E25, E28-E30, E33	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
2	7	E5, E9, E10, E13, E17, E18, E26	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
3	9	E7, E8, E12, E14, E19, E21, E27, E31, E32	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
4	2	JP1, JP2	CONN., HDR, MALE, 1×3, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000311121
5	1	JP3	CONN., HDR, MALE, 1×4, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000411121
6	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.50"	WURTH ELEKTRONIK, 702935000
7	3	XJP1-XJP3	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



Rev. 0

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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