ANALOG DEVICES e LTC3302A, 3.3 V to 1.2 V at 2 A, 2 MHz Synchronous Step-Down Regulator User Guide

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Contents

1 FEATURES
2 EVALUATION KIT CONTENTS
3 DOCUMENTS NEEDED
4 EQUIPMENT NEEDED
5 GENERAL DESCRIPTION
6 DC3251A EVALUATION BOARD PHOTOGRAPH
7 PERFORMANCE SUMMARY
8 QUICK START PROCEDURE
9 QUICK START PROCEDURE
10 QUICK START PROCEDURE
11 TYPICAL PERFORMANCE CHARACTERISTICS
12 EMI TEST RESULTS
13 EVALUATION BOARD HARDWARE
14 EVALUATION BOARD SCHEMATIC
15 ORDERING INFORMATION
16 ORDERING INFORMATION
17 Documents / Resources
17.1 References

FEATURES

- LTC3302A evaluation board
- Transient circuit included for load-transient evaluation
- EMI filter included to reduce noise in EMI emission tests

EVALUATION KIT CONTENTS

- DC3251A evaluation board

DOCUMENTS NEEDED

- LTC3302A data sheet

EQUIPMENT NEEDED

- One 5 V, 2 A, DC power supply
- One 2 A, Electronic load
- Three digital voltmeters
- Two digital ammeters

GENERAL DESCRIPTION

Demonstration Circuit DC3251A features the LTC3302A, 5 V, 2 A synchronous step-down silent switcher operating as a 2 MHz, 3.3 V to 1.2 V, 2 A buck regulator. The LTC3302A supports adjustable output voltages from 0.5 V to VIN. The LTC3302A is a compact, high efficiency, and high-speed synchronous monolithic step-down switching regulator. A minimum on-time of 27 ns enables high VIN to low VOUT conversion.

The DC3251A operating mode can be selected as Burst Mode operation, skip (PS) or forced continuous (FC) mode. Setting JP1 to the SKIP position allows the LTC3302A to sync to a clock frequency from 1.6 MHz to 2.4 MHz. The LTC3302A operates in forced continuous mode when syncing to an external clock.

The DC3251A also has an EMI filter to reduce conducted EMI. This EMI filter can be included by applying the input voltage at the VIN EMI terminal. The EMI performance of the board is shown in the EMI Test Results section. The red lines in the EMI performance graphs show the CISPR25 Class 5 peak limits for the conducted and radiated emission tests .

The LTC3302A data sheet gives a complete description of the device, operation, and application information. Full specifications on the LTC3302A are available in the LTC3302A data sheet available from Analog Devices, Inc., and must be consulted with this user guide when using the DC3251A evaluation board. The LTC3302A is assembled in a 2 mm × 2 mm FCQFN package with side settable flanks (SWF) for visual solder inspection. The layout recommendations for low EMI operation and maximum thermal performance are available in the data sheet section Low EMI PCB Layout.

Figure 7 shows the efficiency and the power loss of the circuit with a 3.3 V input in Burst Mode operation.

DC3251A EVALUATION BOARD PHOTOGRAPH

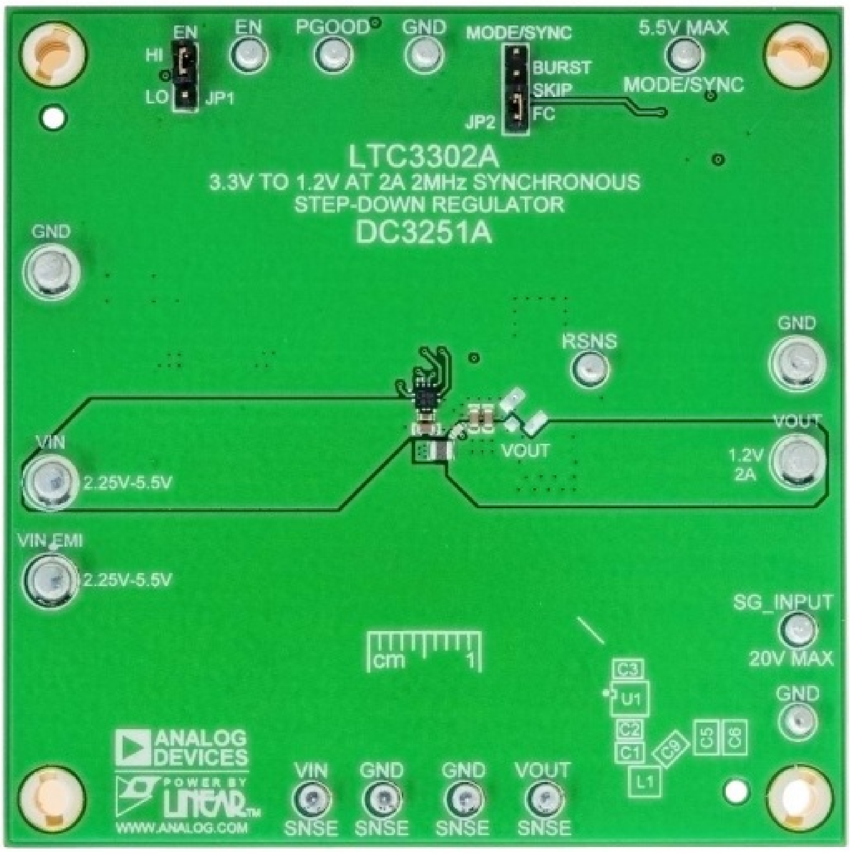


Figure 1. DC3251A Evaluation Board Photograph

PERFORMANCE SUMMARY

Specifications are at TA = 25°C, unless otherwise noted.

Table 1. Performance Summary

VOLTAGE RANG EInput Output1	VIN V OUT		2.25 1.18 3	1.2	5.51.217	V V
OUTPUT CURRENT	IOUT		2			A
SWITCHING FREQUENCY	fSW	VIN > VOUT	1.6	2.0	2.4	MHz
TOP SWITCH MINIMUM ON -TIME	tON		27			ns
TOP SWITCH DUTY CYCLE			100			%

1 With 1% resistors. Accuracy improves to within 1% using 0.1% FB resistors or a fixed voltage version of the LTC3302A.

QUICK START PROCEDURE

Demonstration circuit DC3251A is easy to set up and use to evaluate the performance of the **LTC3302A**. For the proper measurement equipment setup, see **Figure 3** and follow the procedure below:
NOTE: For accurate VIN, VOUT, and efficiency measurements, measure VIN at the VIN SNSE and GND SNSE turrets, and VOUT at the VOUT SNSE and GND SNSE turrets as shown as VM1 and VM2 in **Figure 3**. When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the output voltage ripple by touching the probe tip directly across the output turrets or to TP1 as shown in **Figure 4.** TP1 is designed for a 50 Ω coax cable to reduce any high frequency noise that might couple into the oscilloscope probes.

1. Set the JP1 Jumper to the SKIP position and JP2 to the HI position.
2. With power off, connect the input power supply to VIN and GND. If the input EMI filter is required, connect the input power supply to VIN EMI.
3. Slowly increase PS1 to 1.0 V. If AM1 reads less than 20 mA, increase PS1 to 3.3 V. Verify that VM1 reads 3.3 V and VM2 reads 1.2 V.
4. Connect an oscilloscope voltage probe as shown in **Figure 4** in parallel with VM2. Set Channel to AC-coupled, voltage scale to 20 mV and time base to 10 µs. Observe the VOUT ripple voltage.
5. Verify that PGOOD turret is above 1 V.
6. Increasing the load by 1 A intervals up to 2 A and record VM1, VM2, AM1, and AM2 for each interval.
7. Repeat step 6 for PS1 set to 2.5 V and again for PS1 set to 5.0 V.
8. Set the load to a constant 1 A. Remove the oscilloscope voltage probe from VOUT. Place a ground clip on PGND terminal and set the voltage scale to 1 V and the time scale to 500 ns/ Division. Trigger on the rising edge of the voltage probe. Using
9. tip on the voltage probe, contact the SW node on the pad of L1. Observe the duty cycle and the period of the switching waveform (~500 ns).
10. Set the load current to 0.1 A and repeat step 8. Observe that the switching waveform is now operating in pulse skip mode.
11. Move the jumper on JP2 to LO. Verify that VOUT reads 0 V and verify that PGOOD is low. Return jumper on JP2 to HI and verify that VM2 is 1.2 V and verify that PGOOD is above 1 V.
12. If forced continuous or Burst Mode is required, set PS1 to 0 V. Move JP1 to FC or BURST. Repeat steps 3 through 9. In step 9, observe that the switching waveform is now operating in forced continuous or Burst Mode.
13. To test the transient response with a base load, add the required resistor to produce a minimum load between

VOUT and RSNS turrets (RL shown on **Figure 3**). Note that the total load resistance is RL plus R8 (100 mΩ).

14. Adjust a signal generator with a 10 ms period, 10% duty cycle, and an amplitude from 1 V to 2 V to start.
15. Measure the RSNS voltage to observe the current, VRSNS/100 mΩ. Adjust the amplitude of the pulse to provide the required transient. Adjust the rising and falling edge of the pulse to provide the required ramp rate. For more details, see **Figure 9** and the optional transient response circuit shown in F**igure 6**. IOUT = VRSNS/100mΩ (1)
16. When done, turn off PS1 and Load. Remove all connections to the demo board.

QUICK START PROCEDURE

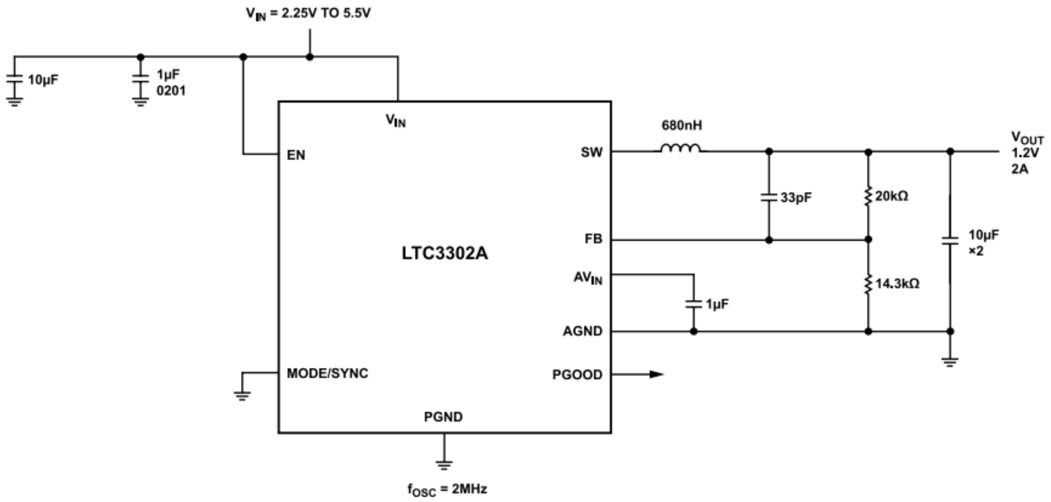


Figure 2. DC3251A Simplified Schematic

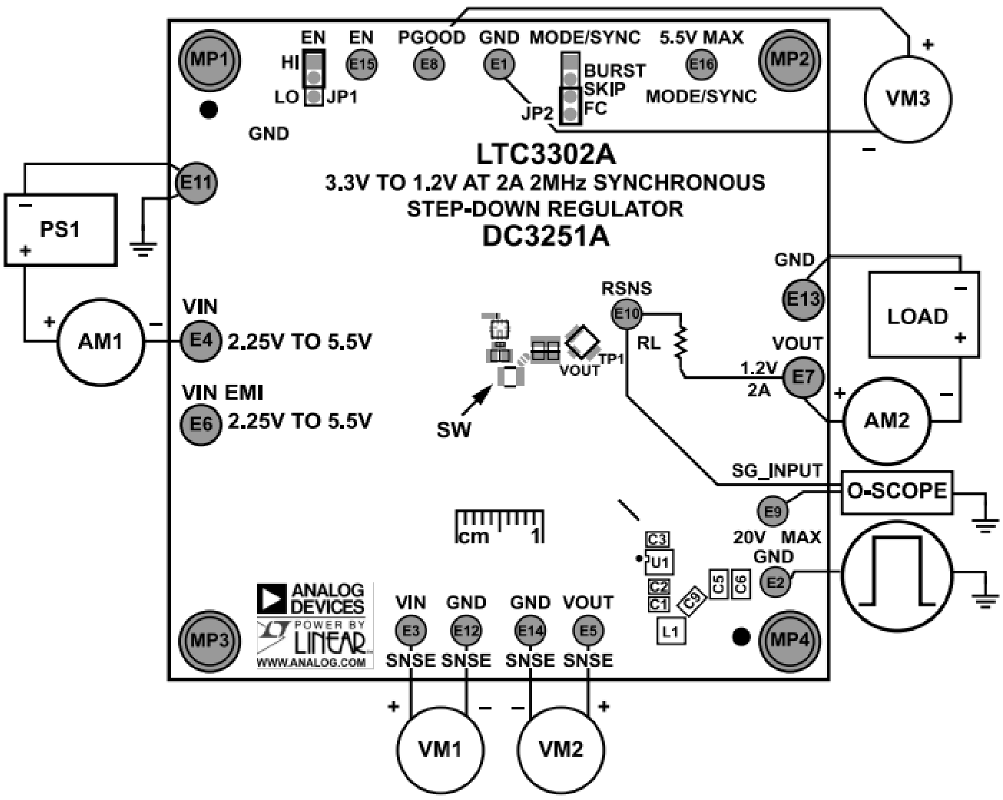


Figure 3. Test Setup for the DC3251A Demo Board

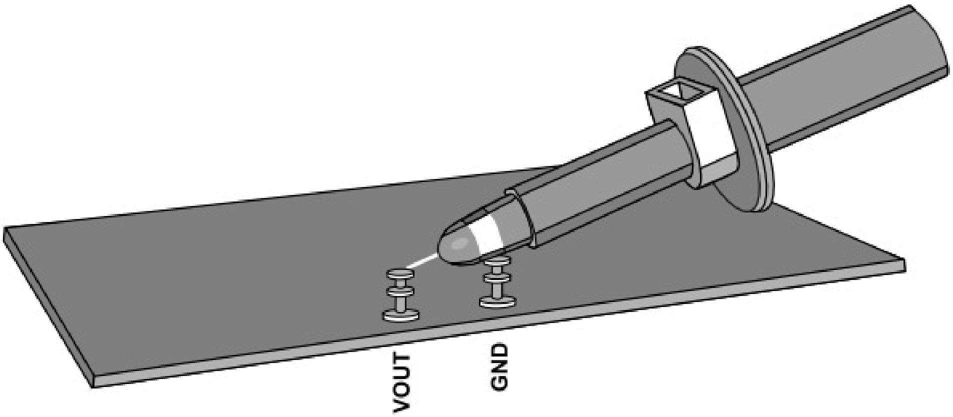


Figure 4. Technique for Measuring Output Ripple and Step Response with a Scope Probe

QUICK START PROCEDURE

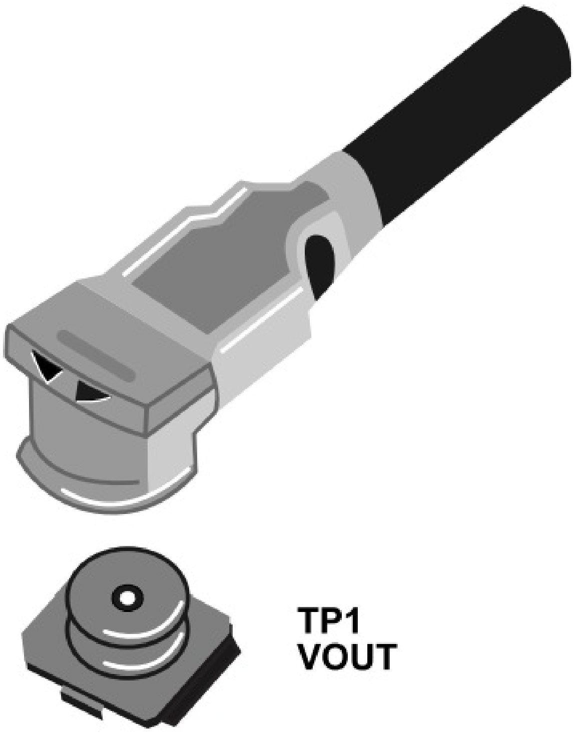


Figure 5. Technique for Measuring Output Ripple and Step Response with a Low Inductance Connector (Not Supplied)

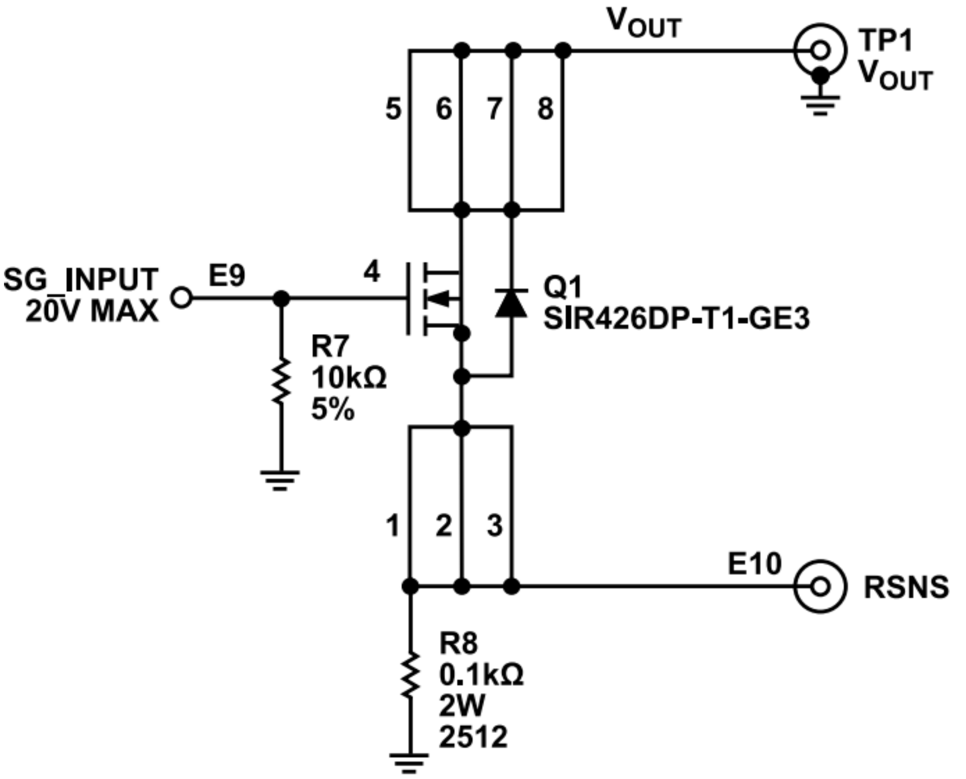


Figure 6. Optional Transient Response Circuit

TYPICAL PERFORMANCE CHARACTERISTICS

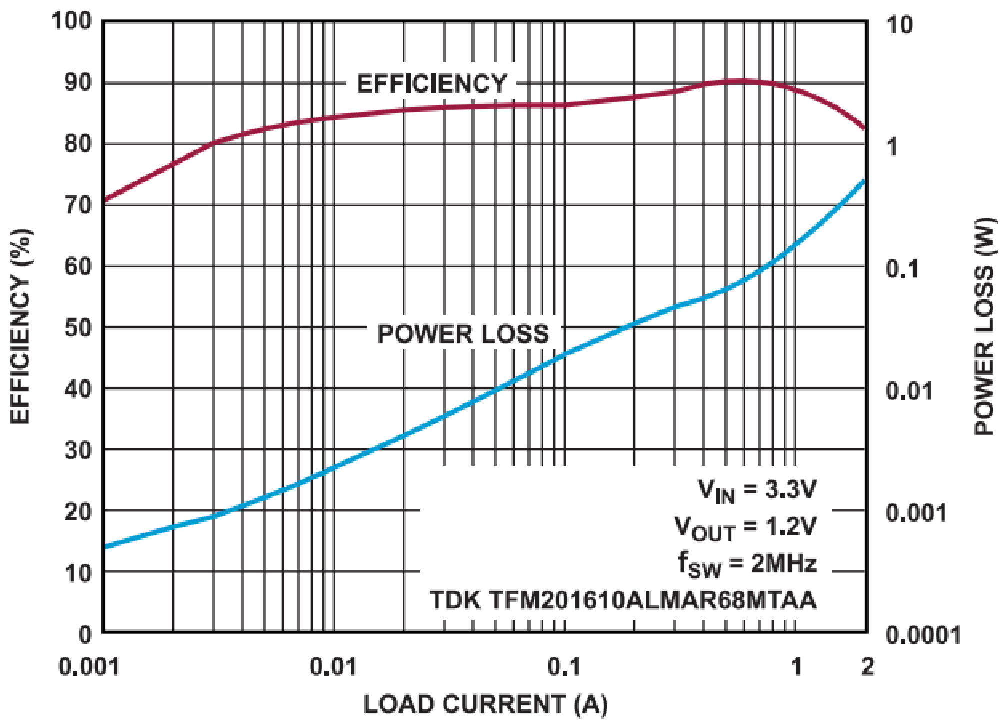


Figure 7. Efficiency and Power Loss in Burst Mode Operation

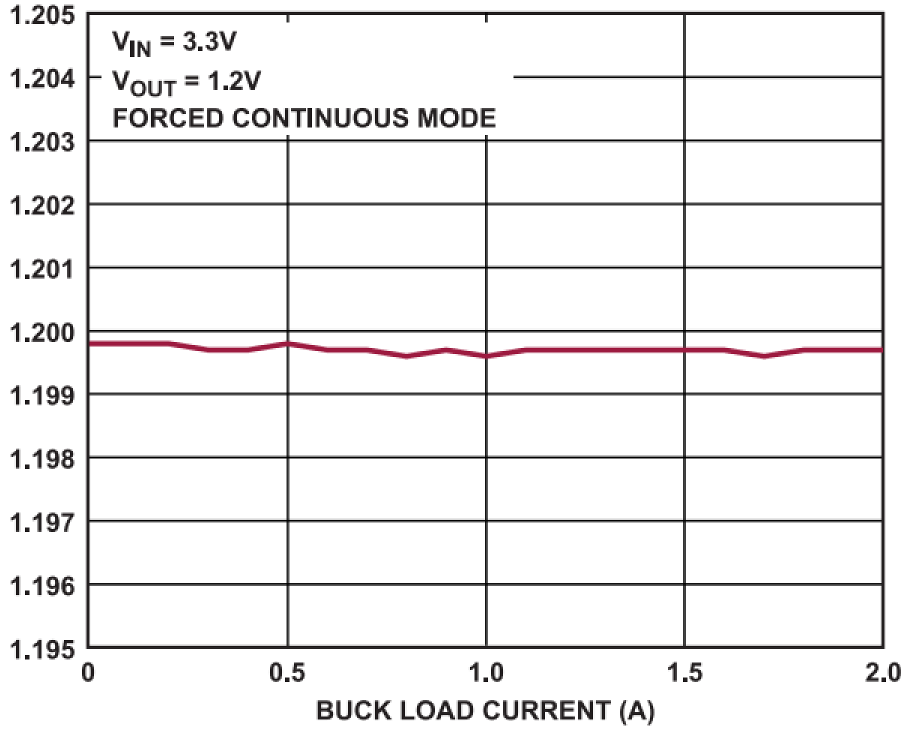


Figure 8. Buck Load Regulation

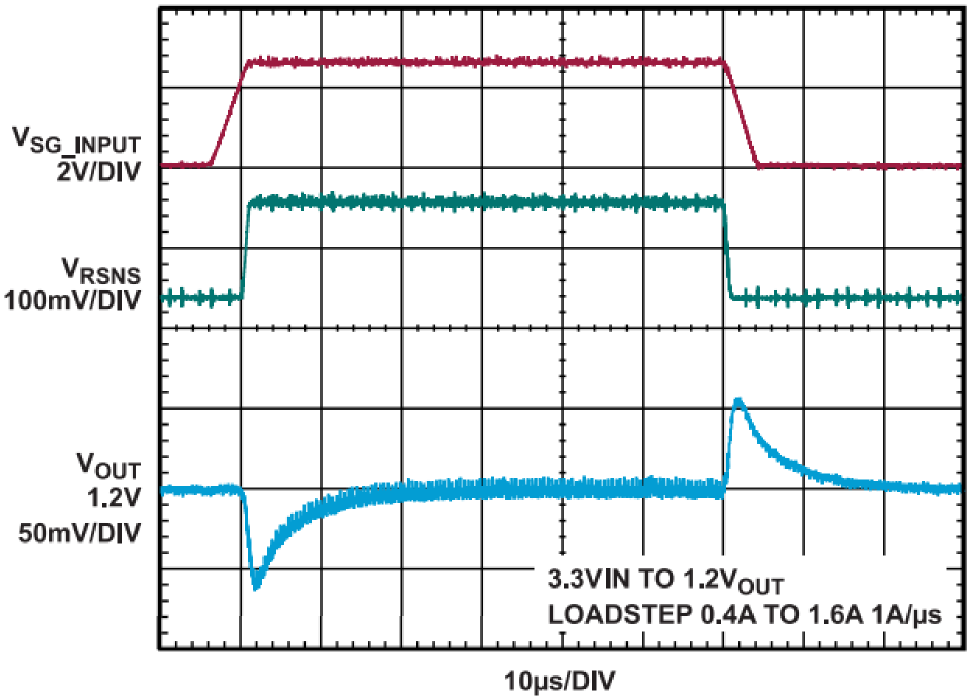
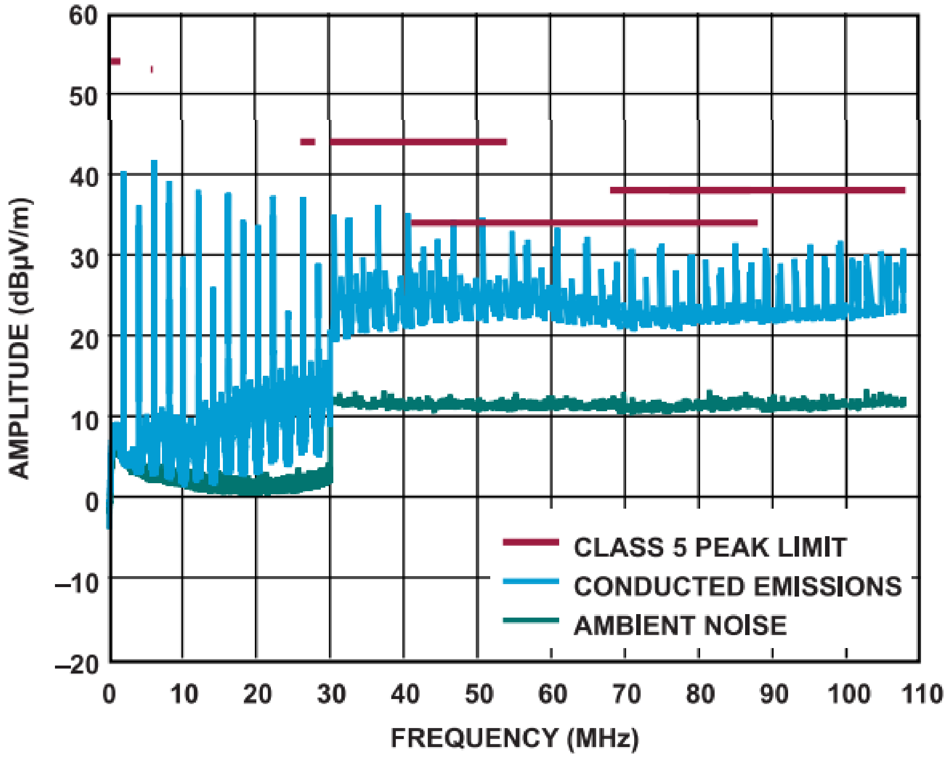


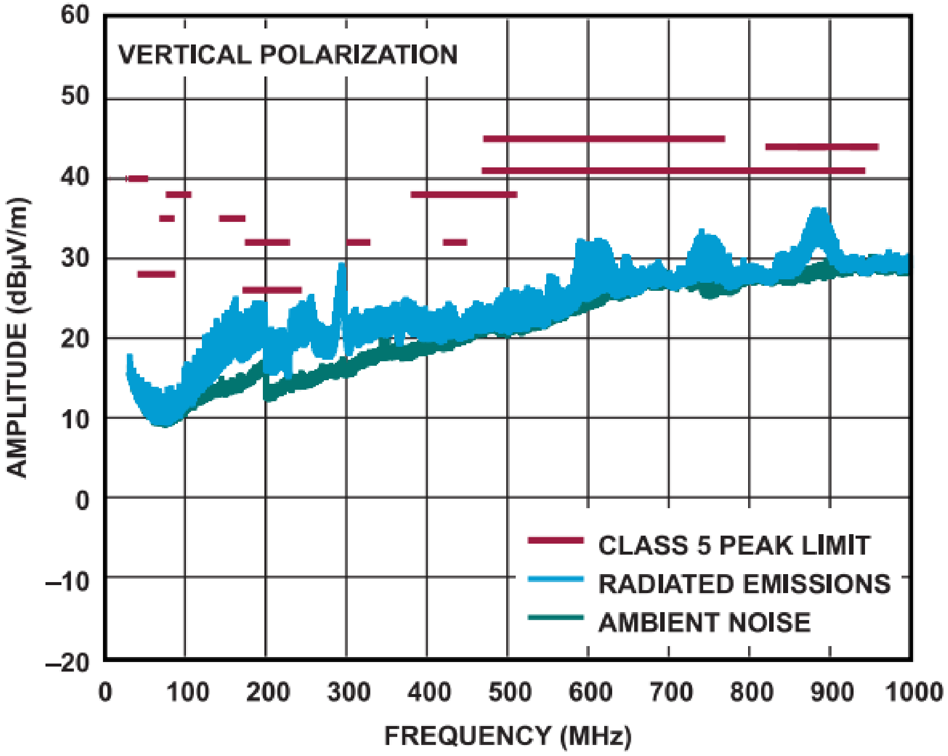
Figure 9. Load Transient Response Forced Continuous Mode

EMI TEST RESULTS



DC3251A DEMO BOARD
(WITH EMI FILTER INSTALLED)
3.3V INPUT TO 1.2V OUTPUT AT 1.6A, f_{SW} = 2MHz

Figure 10. Conducted EMI Performance (CISPR25 Conducted Emission Test with Class 5 Peak Limits)



DC3251A DEMO BOARD
(WITH EMI FILTER INSTALLED)
3.3V INPUT TO 1.2V OUTPUT AT 1.6A, f_{SW} = 2MHz

Figure 11. Radiated EMI Performance (CISPR25 Radiated Emission Test with Class 5 Peak Limits, Vertical)

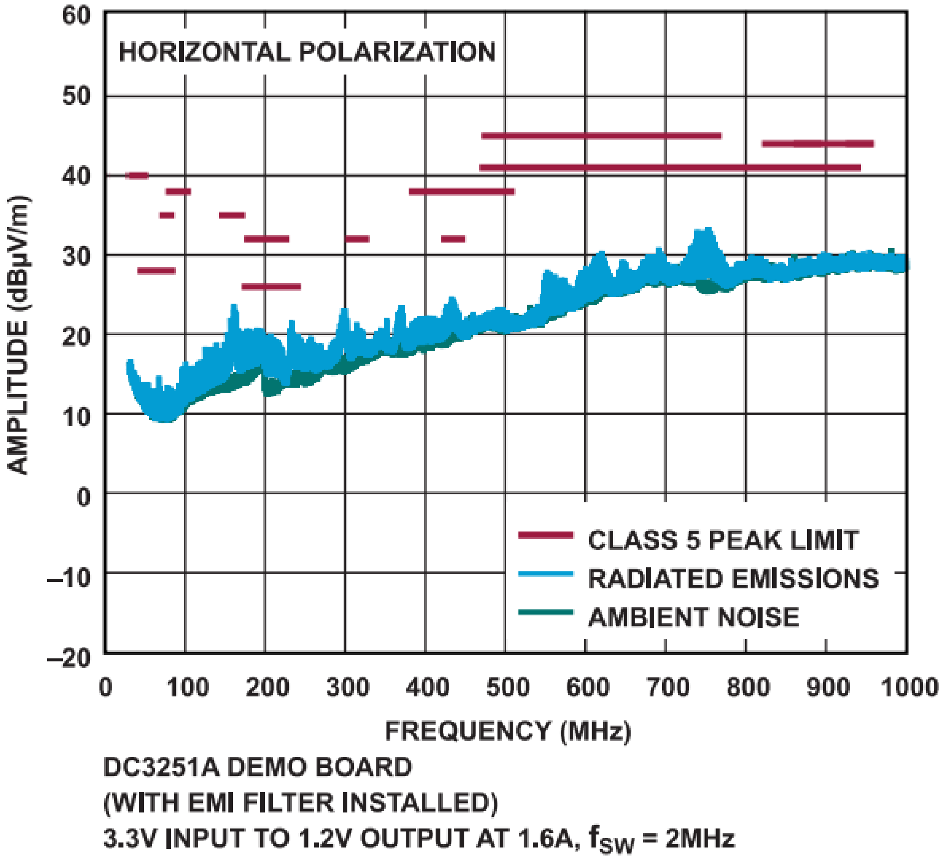


Figure 12. Radiated EMI Performance (CISPR25 Radiated Emission Test with Class 5 Peak Limits, Horizontal

EVALUATION BOARD HARDWARE

INTRODUCTION TO THE DC3251A

The DC3251A demonstration circuit features the LTC3302A, a low voltage synchronous step-down regulator. The LTC3302A is a monolithic, constant frequency, current mode step-down DC-DC converter. A 2 MHz oscillator turns on the internal top power switch at the beginning of each clock cycle. Current in the inductor then increases until the top switch comparator trips and turns off the top power switch. If the EN pin is low, the LTC3302A is in shutdown and in a low quiescent current state. When the EN pin is above its threshold, the switching regulator is enabled.

The MODE/SYNC pin sets the switching mode to pulse skip, forced continuous, or Burst Mode. If an external 1.6 MHz to 2.4 MHz clock is connected to the MODE/SYNC turret while the JP1 is set to the SKIP position, the LTC3302A switching frequency sync to the external clock. The LTC3302A operates in forced continuous mode while syncing. For more detailed information, refer to the LTC3302A data sheet.

ACCURATELY MEASURING OUTPUT RIPPLE OF THE LTC3302A

With the fast edge rates of the circuit, high frequency noise can be observed when measuring the output voltage with 1 MΩ terminated oscilloscope probes. To better view the output ripple with oscilloscopes of 400 MHz bandwidth and above a 50 Ω coax cable connected as close to the output caps as possible should be used with the oscilloscope channel terminated to 50 Ω at the scope. This helps to reduce the noise coupling onto and displaying on the scope. The demo board is set up to solder an U.FL, RECEPT, ST SMD, 0 Hz to 6 GHz, 50 Ω connector (TP1) near the output cap C6. These pads can also be used to solder a coax cable or other oscilloscope probe connector if required.

The high frequency spikes are partially attributed to the inter-winding capacitance of the inductor and the voltage step is partially attributed to the inductance in the output capacitors. This can be reduced by choosing low ESL capacitors or adding small low ESL capacitors in parallel to the output capacitors as close to the inductor as possible. **Figure 13** and **Figure 14** show the output ripple using a 500 MHz scope, 50 Ω probe with an added low ESL X2Y capacitor added, C9, close to the inductor and GND return to the input capacitors to reduce the inductance of the return path and better filter the high frequency spikes.

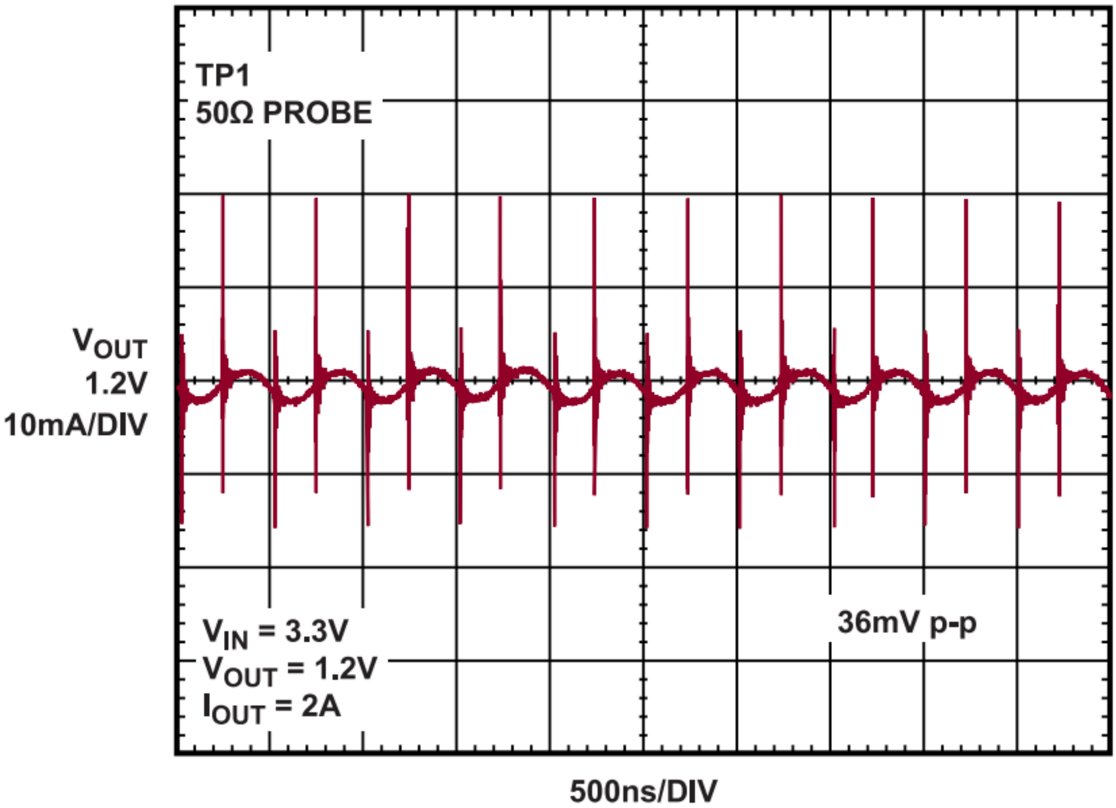


Figure 13. VOUT Ripple Without C9 X2Y Capacitor

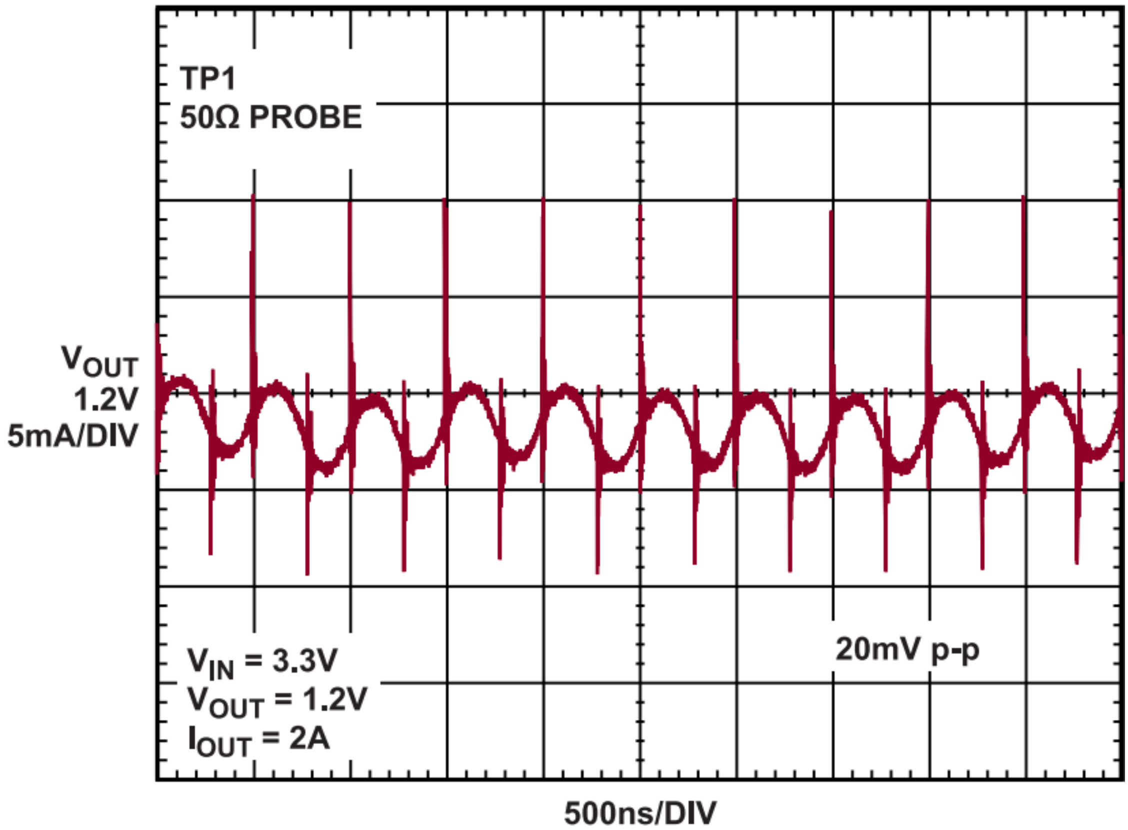


Figure 14. VOUT Ripple with C9 X2Y Capacitor

EVALUATION BOARD SCHEMATIC

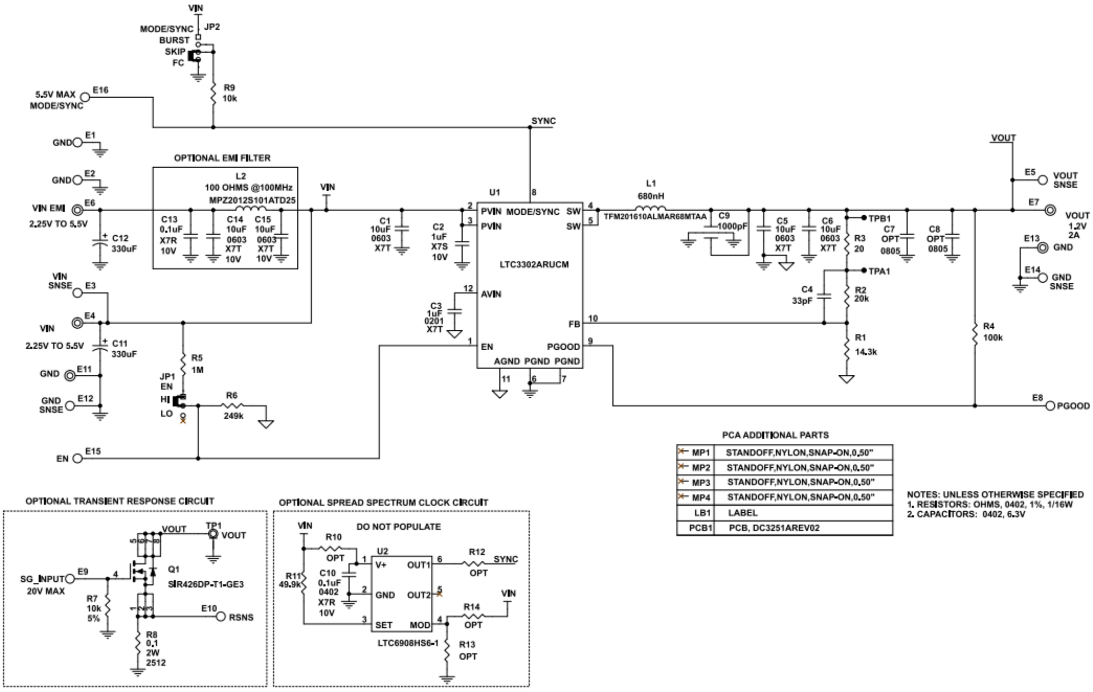


Figure 15. DC3251A Schematic Diagram

ORDERING INFORMATION

BILL OF MATERIALS

Table 2. DC3251A Bill of Materials

Item	Quantity	Reference Designator	Part Description	Manufacturer, Part Number
1	3	C1, C5, C6	Capacitors, 10 µF , X7T, 10 V, 20%, 0603, AEC-Q200	Murata, GRT188D71A106ME13D
2	1	C2	Capacitor, 1 µF, X 7S, 10 V, 10%, 04 02, AEC-Q200, n o substitutes allo wed	Murata, GCM155C71A105KE38D
3	1	C3	Capacitor, 1 µF, X 7T, 6.3 V, 20%, 0 201, AEC-Q200	Murata, GRT033D70J105ME13D
4	1	C4	Capacitor, 33 pF, C0G, 50 V, 5%, 0 402	AVX, 04025A330JAT2A
5	1	L1	Inductor, 680 nH, power, 20%, 4.3 A, 53 mΩ, 0806, AEC-Q200	TDK, TFM201610ALMAR68MTAA
		L1 (Alternate)	Inductor, 680 nH, power, 20%, 2 A, 65 mΩ, 0806, AE C-Q200	Wurth, 744383430068

6	1	Q1	Transistor, N-MO SFET, 40 V, 15.9 A, PPAK SO-8	Vishay, SIR426DP-T1-GE3
7	1	R1	Resistor, 14.3 kΩ, 1%, 1/16 W, 0402	Vishay, CRCW040214K3FKED
8	1	R2	Resistor, 20 kΩ, 1 %, 1/16 W, 0402, AECQ200	NIC, NRC04F2002TRF
9	1	U1	IC, 5 V, 2 A, 2 MH z, synchronous st epdown regulator	Analog Devices Inc., LTC3302ARUC M#TRPBF
Additional Demo Board Circuit Components				
1	0	C7, C8	Capacitors, optio n, 0805	Not applicable
2	1	C9	Capacitor, 1000 p F, X7R, 50 V, 20 %, 0402, 3-Term, X2Y EMI filter	Johansson Dielectrics, 500X07W102 MV4T
3	0	C10	Capacitor, 0.1 µF, X7R, 10 V, 10%, 0402, AEC-Q200	Murata, GCM155R71A104KA55D
4	2	C11, C12	Capacitors, 330 µ F, Tantalum, POS CAP TPE, 6.3 V, 20%, 7343, 25 m Ω	Panasonic, 6TPE330ML
5	1	C13	Capacitor, 0.1 µF, X7R, 10 V, 10%, 0402, AEC-Q200	Murata, GCM155R71A104KA55D
6	2	C14, C15	Capacitors, 10 µF , X7T, 10 V, 20%, 0603, AEC-Q200	Murata, GRT188D71A106ME13D
7	1	L2	Inductor, ferrite b ead, 100 Ω at 100 MHz, 25%, 4 A, 20 mΩ, 0805, AEC-Q200	TDK, MPZ2012S101ATD25
8	1	R3	Resistor, 20 Ω, 1 %, 1/16 W, 0402, AECQ200	NIC, NRC04F20R0TRF
9	1	R4	Resistor, 100 kΩ, 5%, 1/16 W, 0402	Yage, RC0402JR-07100KL
10	1	R5	Resistor, 1 mΩ, 1 %, 1/16 W, 0402, AECQ200	Stack pole Electronics Inc., RMCF04 02FT1M00

11	1	R6	Resistor, 249 kΩ, 1%, 1/16 W, 0402 , AECQ200	Q200 NIC, NRC04F2493TRF
12	1	R7	Resistor, 10 kΩ, 5 %, 1/10 W, 0402, AECQ200	Panasonic, ERJ2GEJ103X
13	1	R8	Resistor, 0.1 Ω, 1 %, 2 W, 2512, se nse, AEC-Q200	TT Electronics, LRC-LR2512LF-01-R 100-F
14	1	R9	Resistor, 10 kΩ, 5 %, 1/16 W, 0402, AECQ200	NIC, NRC04J103TRF
15	0	R10, R12 to R1 4	Resistors, option, 0402	Not applicable
16	0	R11	Resistor, 49.9 kΩ, 1%, 1/16 W, 0402 , AEC-Q200	NIC, NRC04F4992TRF
17	0	TP1	Connector, U.FL, RCPT, male, ST, 3.0 mm × 3.1 mm , SMD, 50 Ω	Hirose Electric, U.FL-R-SMT-1(10)

ORDERING INFORMATION

Table 2. DC3251A Bill of Materials (Continued)

18	0	U2	IC, oscillator silicon programmable, TSOT-23-6	Analog Devices Inc., LTC6908HS6-1#TRMPBF
Hardware				
1	11	E1 to E3, E5, E8 to E10,	Test points, turret, 0.064″ mounting hole	Mill-Max, 2308-2-00-80-00-00-07-0
		E12, E14 to E16	diameter, PCB 0.062″ thickness	
2	5	E4, E6, E7, E11, E13	Test points, turret, 0.094″ mounting hole	Mill-Max, 2501-2-00-80-00-00-07-0
			diameter, PCB 0.062″ thickness	
3	1	JP1	Connector, HDR, male, 1 × 3, 2 mm,	Wurth Electronic, 62000311121
			vertical, straight, THT	
4	1	JP2	Connector, HDR, male, 1 × 4, 2 mm,	Wurth Electronic, 62000411121
			vertical, straight, THT	
5	4	MP1 to MP4	Standoff, nylon, snap on, 0.50″	Keystone, 8833
6	2	XJP1, XJP2	Connectors, shunt, female, 2 position, 2	Wurth Electronic, 60800213421
			mm	

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.

Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the “Evaluation Board”), you are agreeing to be bound by the terms and conditions set forth below (“Agreement”) unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you (“Customer”) and Analog Devices, Inc. (“ADI”), with its principal place of business at Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY.

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Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.

ANALOG DEVICES

Documents / Resources

	ANALOG DEVICES e LTC3302A, 3.3 V to 1.2 V at 2 A, 2 MHz Synchronous Step-Down Regulator [pdf] User Guide e LTC3302A 3.3 V to 1.2 V at 2 A 2 MHz Synchronous Step-Down Regulator, e LTC3302A, 3.3 V to 1.2 V at 2 A 2 MHz Synchronous Step-Down Regulator, Synchronous Step-Down Regulator, Step-Down Regulator

References

- ▶ Mixed-signal and digital signal processing ICs | Analog Devices
- ▶ Mixed-signal and digital signal processing ICs | Analog Devices
- ▶ Search | Analog Devices
- User Manual