LTC3307A
3.3V to 1.2V at 3A, 2MHz Low EMI Buck Regulator in a 47mm² Solution

DESCRIPTION

Demonstration circuit 3122A features the LTC®3307A 5V, 3A synchronous step-down Silent Switcher® operating as a 2MHz, 3.3V to 1.2V 3A buck regulator. The LTC3307A supports adjustable output voltages from 0.5V to V_{IN} with operating frequencies from 1MHz up to 3MHz. The LTC3307A is a compact, ultralow emission, high efficiency, and high speed synchronous monolithic step-down switching regulator. A minimum on-time of 22ns enables high V_{IN} to low V_{OUT} conversion ratios at high frequencies.

The DC3122A operating mode may be selected as Burst, Skip or forced continuous (FC) mode. Setting JP1 to the FC/SYNC position will allow the LTC3307A to sync to a clock frequency from 1MHz to 3MHz. The LTC3307A operates in forced continuous mode when syncing to an external clock. The DC3122A is set to a fixed 2MHz frequency by connecting RT to V_{IN} through a 0Ω resistor, R9. The frequency can be easily changed by removing R9 and setting an appropriate resistor in the R4 location to obtain the desired frequency. Refer to the LTC3307A data sheet for the proper RT value for a desired switching frequency.

The DC3122A also has an EMI filter to reduce conducted EMI. This EMI filter can be included by applying the input voltage at the V_{IN} EMI terminal. The EMI performance of the board is shown in the EMI Test Results section. The red lines in the EMI performance graphs illustrate the CISPR25 Class 5 peak limits for the conducted and radiated emission tests.

The LTC3307A data sheet gives a complete description of the device, operation and application information. The data sheet must be read in conjunction with this demo manual. The LTC3307A is assembled in a 1.6mm × 1.6mm WLCSP package with exposed pads for low thermal resistance. The layout recommendations for low EMI operation and maximum thermal performance are available in the data sheet section Low EMI PCB Layout.

The Efficiency vs Load graph shows the efficiency and the power loss of the circuit with a 3.3V input in Burst Mode® operation.

Design files for this circuit board are available.

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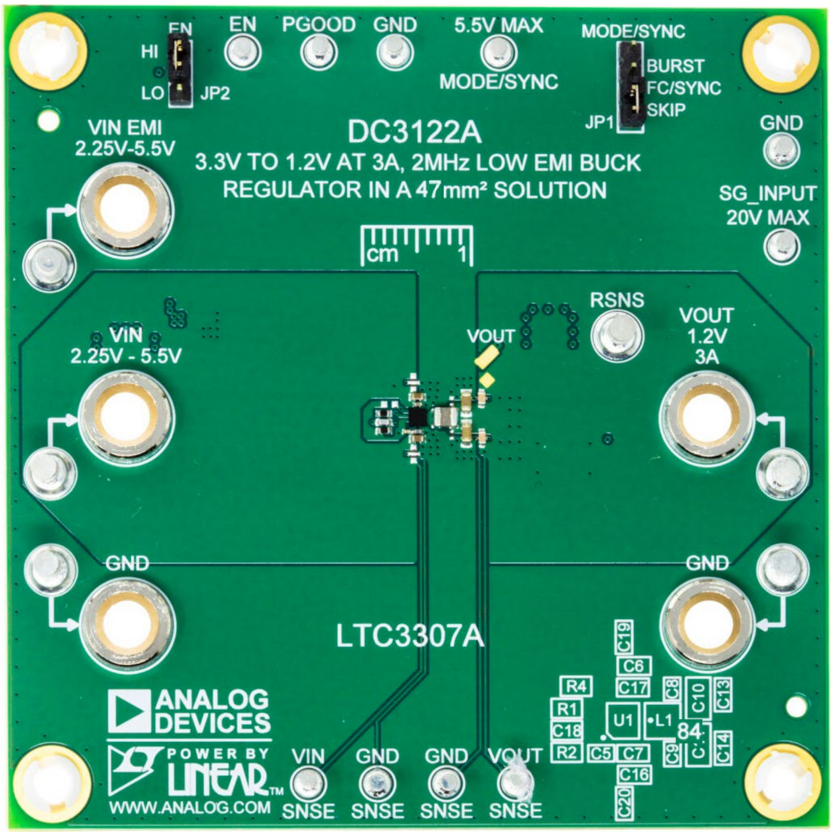
PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	Input Voltage Range		2.25		5.5	V
V_{OUT}	V_{OUT} Voltage Range*		1.183	1.2	1.217	V
I_{OUT}	Output Current				3	A
f_{SW}	Switching Frequency	V_{IN} Greater than V_{OUT}	1	2	3	MHz
t_{ON}	Top Switch Minimum On-Time			22		ns
Duty Cycle	Top Switch Duty Cycle				100	%

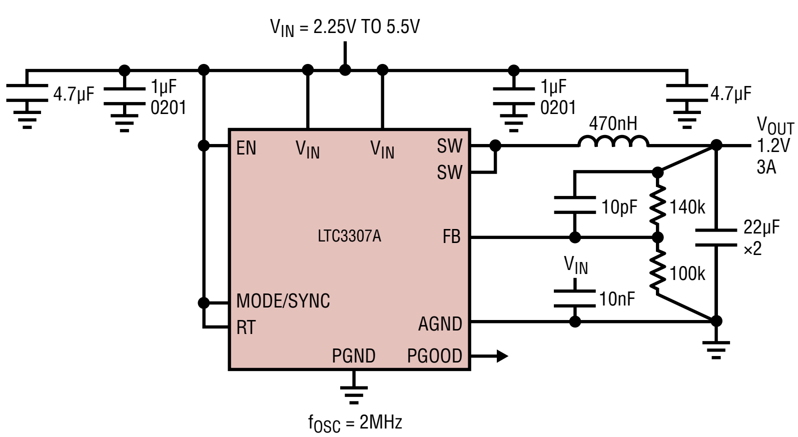
*With 1% resistors. Accuracy will improve to within 1% using 0.1% resistors.

BOARD PHOTO

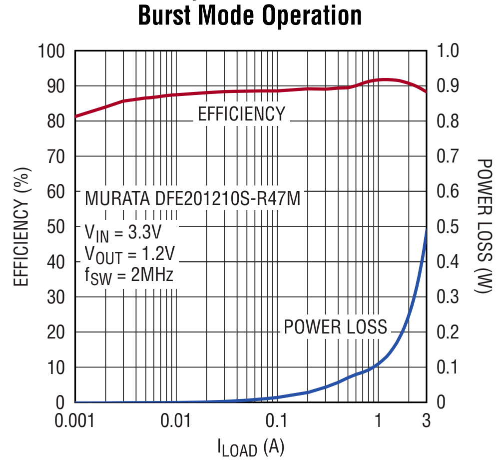


CIRCUIT SCHEMATIC

High Efficiency, 2MHz, 1.2V 3A Step-Down Converter



Efficiency and Power Loss in Burst Mode Operation



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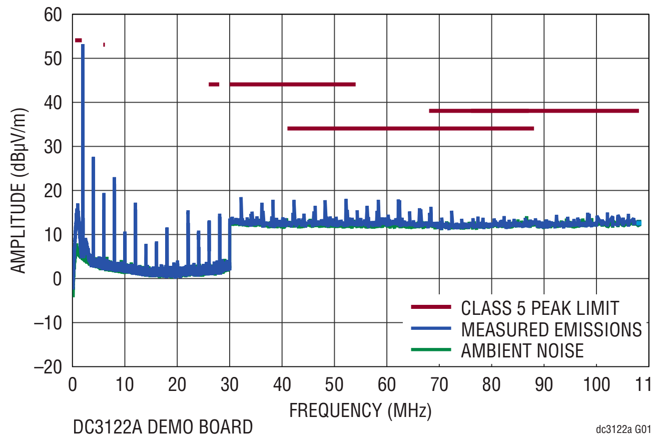
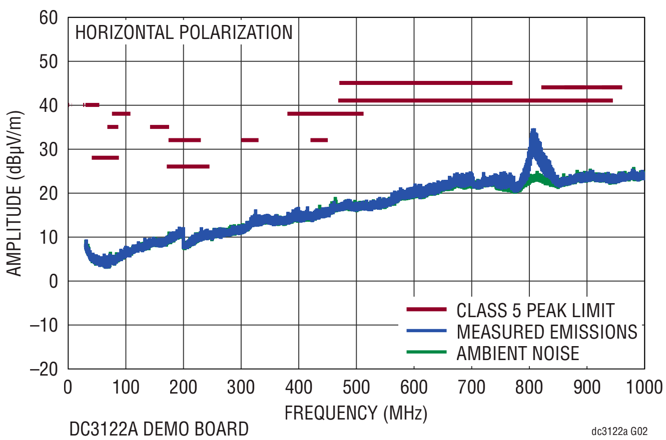
EMI TEST RESULTS

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

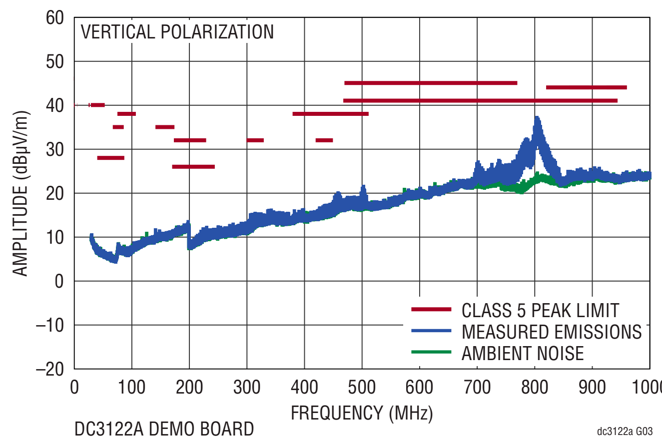


DC3122A DEMO BOARD
(WITH EMI FILTER INSTALLED)
3.3V INPUT TO 1.2V OUTPUT AT 2.4A, f_{SW} = 2MHz

Radiated EMI Performance (CISPR25 Radiated Emission Test with Class 5 Peak Limits)

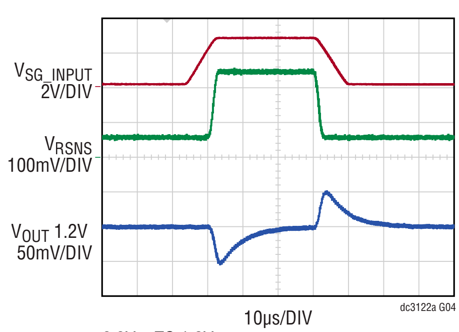


DC3122A DEMO BOARD
(WITH EMI FILTER INSTALLED)
3.3V INPUT TO 1.2V OUTPUT AT 2.4A, f_{SW} = 2MHz



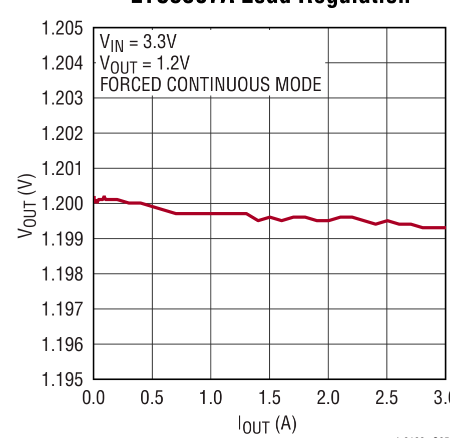
DC3122A DEMO BOARD
(WITH EMI FILTER INSTALLED)
3.3V INPUT TO 1.2V OUTPUT AT 2.4A, f_{SW} = 2MHz

Load Transient Response Forced Continuous Mode



$3.3V_{IN}$ TO $1.2V_{OUT}$
LOADSTEP 0.6A TO 2.4A 1A/μs

LTC3307A Load Regulation



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QUICK START PROCEDURE

Demonstration circuit 3122A is easy to set up and evaluate the performance of the LTC3307A. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

NOTE: For accurate V_{IN}, V_{OUT} and efficiency measurements, measure V_{IN} at the V_{IN} SNSE and GND SNSE turrets and V_{OUT} at the V_{OUT} SNSE and GND SNSE turrets as illustrated as VM1 and VM2 in Figure 1. When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe.

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 V_{IN} and GND. If the input EMI filter is desired, connect the input power supply to V_{IN} EMI.
3. Slowly increase PS1 to 1V. If AM1 reads less than 20mA, increase PS1 to 3.3V. Verify that VM1 reads 3.3V and VM2 reads 1.2V.
4. Connect an oscilloscope voltage probe as shown in Figure 2 in parallel with VM2. Set channel to AC-coupled, voltage scale to 20mV and time base to 10µs. Observe the V_{OUT} ripple voltage.

   NOTE: Measure the output voltage ripple by touching the probe tip directly across the output turrets or to TP1 as shown in Figure 2. TP1 is designed for a 50Ω coax cable to reduce any high frequency noise that might couple into the oscilloscope probes.
5. Verify that PGOOD turret is high.
6. Increasing the load by 1A intervals up to 4A and record VM1, VM2, AM1 and AM2 for each interval.
7. Repeat Step 6 for PS1 set to 2.5V and again for PS1 set to 5V.
8. Set the load to a constant 1.5A. Remove the oscilloscope voltage probe from V_{OUT}. Place a ground clip on PGND terminal and set the voltage scale to 1V and the time scale to 500ns/division. Trigger on the rising edge of the voltage probe. Using a 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 (~500ns).
9. Set the load current to 0.2A and repeat Step 8. Observe that the switching waveform is now operating in pulse-skippping mode.
10. Move the jumper on JP2 to LO. Verify that V_{OUT} reads 0V and verify that PGOOD is low. Return jumper on JP2 to HI and verify VM2 is 1.2V and verify PGOOD2 is high.
11. If forced continuous or Burst Mode operation is desired, set PS1 to 0V. Move JP1 to FC/SYNC or BURST. Repeat Steps 3 through 9. In Step 9 observe that the switching waveform is now operating in forced continuous or Burst Mode operation.
12. To change the frequency, remove R9 if installed. Install the desired R_T resistor in the R4 location. Size the inductor and output capacitors to provide the desired inductor ripple and a stable output. Refer to the LTC3307A data sheet and LTpowerCAD for more information on choosing the required components.
13. To test the transient response with a base load, add the desired resistor to produce a minimum load between V_{OUT} and RSNS turrets (RL shown on Figure 1). Note that the total load resistance will be RL plus R11 (100mΩ).
14. Adjust a signal generator with a 10ms period, 10% duty cycle and an amplitude from 1V to 2V to start.
15. Measure the RSNS voltage to observe the current, RSNS/100mΩ. Adjust the amplitude of the pulse to provide the desired transient. Adjust the rising and falling edge of the pulse to provide the desired ramp rate. Refer to the following equations and the optional transient response circuit.

    $I_{OUT} = V_{RSNS}/100m\Omega$

Where:

$V_{RSNS} = V_{SG\_INPUT} - V_{GS}$

16. When done, turn off PS1 and Load. Remove all connections to the demo board.

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QUICK START PROCEDURE

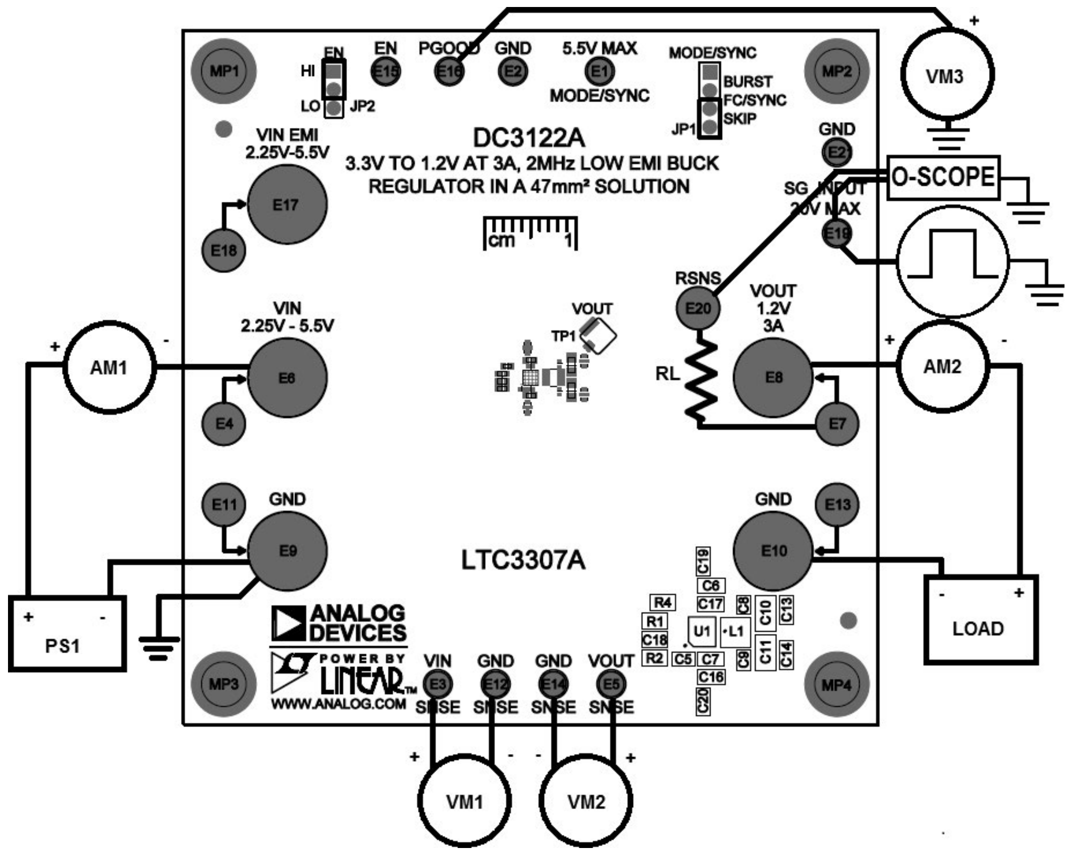


Figure 1. Test Setup for the DC3122A Demo Board

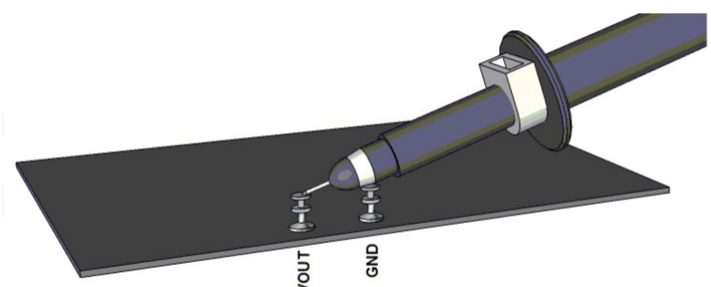


Figure 2. Technique for Measuring Output Ripple and Step Response with a Scope Probe

Figure 3. Technique for Measuring Output Ripple and Step Response with a Low Inductance Connector (Not Supplied)

QUICK START PROCEDURE

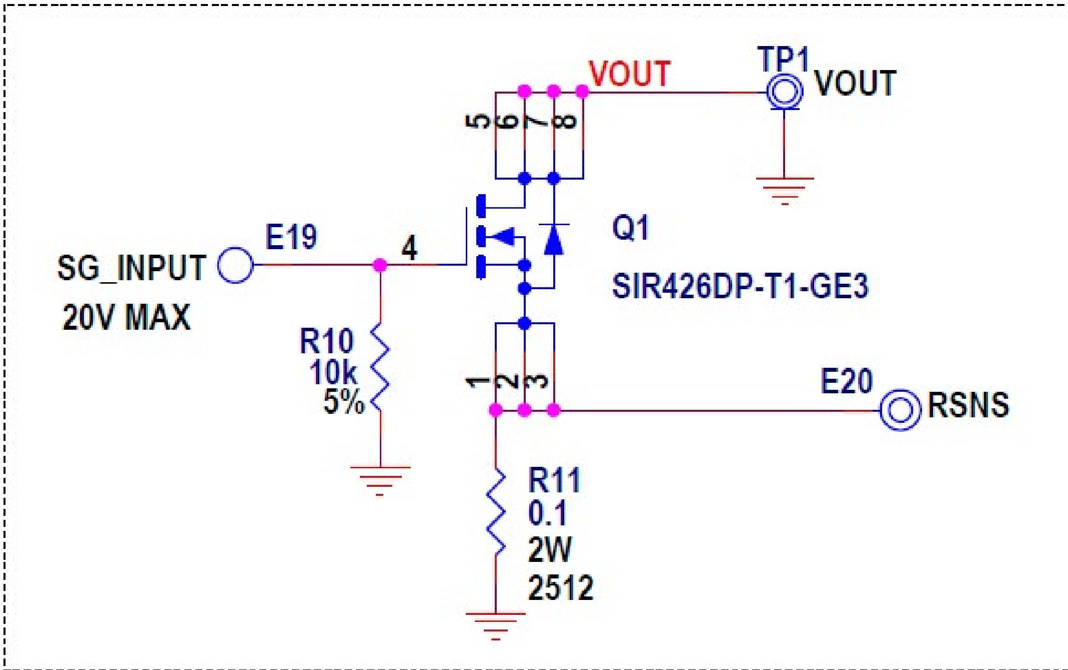


Figure 4. Optional Transient Response Circuit

THEORY OF OPERATION

Introduction to the DC3122A

The DC3122A features the LTC3307A, a low voltage synchronous step-down Silent Switcher. The LTC3307A is a monolithic, constant frequency, current mode step-down DC/DC converter. An oscillator, with frequency set using a resistor on the RT pin, 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 LTC3307A is in shutdown and in a low quiescent current state. When the EN pin is above its threshold, the switching regulator will be enabled.

The MODE/SYNC pin sets the switching mode to pulse-skipping, forced continuous, or Burst Mode operation. If an external 1MHz to 3MHz clock is connected to the MODE/SYNC turret while the JP1 is set to the FC/SYNC position, the LTC3307A switching frequency will sync to the external clock while operating in forced continuous mode. See the LTC3307A 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 using a minimum t_{ON} of 42ns in Equation 1.

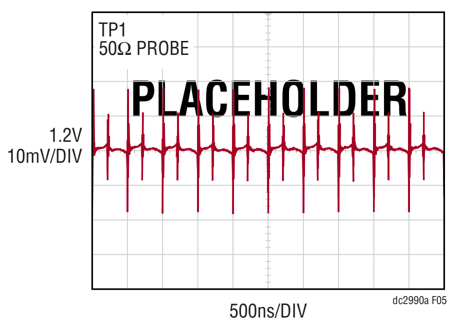
$$f_{SW(MAX)} = \frac{V_{OUT}}{V_{IN(MAX)} \bullet t_{ON(MIN)}} \quad (1)$$

Select an operating switching frequency below $f_{SW(MAX)}$. The recommended ripple current in the output inductor is 0.9A peak-to-peak for the LTC3307A. This determines the recommended inductor value for the application.

THEORY OF OPERATION

Accurately Measuring Output Ripple of the LTC3307A

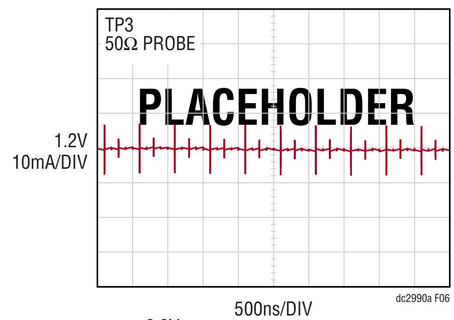
With the fast edge rates of the circuit, high frequency noise can be observed when measuring the output voltage with 1MΩ terminated oscilloscope probes. To better view the output ripple with oscilloscopes of 400MHz bandwidth and above a 50Ω coax cable connected as close to the output capacitor as possible should be used with the oscilloscope channel terminated to 50Ω at the scope. This will help 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, 0Hz to 6GHz 50Ω connector (TP1) near the output capacitor C13. These pads can also be used to solder a coax cable or other oscilloscope probe connector if desired.



V_{IN} = 3.3V
V_{OUT} = 1.2V
I_{OUT} = 3A

Figure 5.

The high frequency spikes are partially attributed to the interwinding 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 5 shows the output ripple with only the 0603 output capacitors using 500MHz scope, 50Ω probe on TP1. Figure 6 shows the output ripple with the added C13 and C14 1nF X2Y capacitors using a 500MHz scope, 50Ω probe on TP1. The 0201 capacitors, C8 and C9, made little improvement on the ripple with this layout.



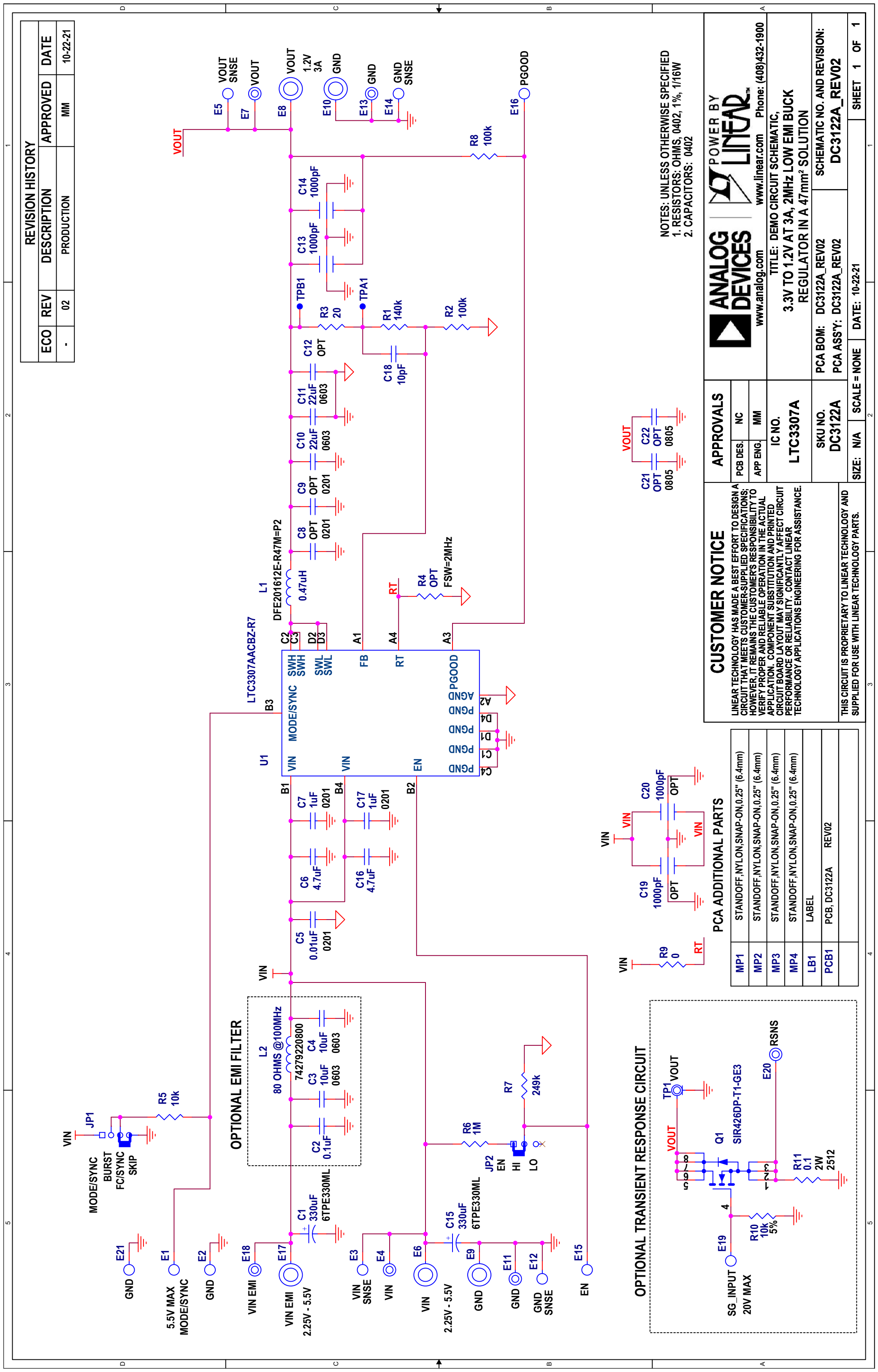
V_{IN} = 3.3V
V_{OUT} = 1.2V
I_{OUT} = 3A
C4, C5 = 22µF 0603
C17 = 1µF
C18, SC19 = 10µF 0603

Figure 6.

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C5	CAP., 0.01µF, X7R, 6.3V, 10%, 0201	MURATA, GRM033R70J103KA01D
2	2	C6, C16	CAP., 4.7µF, X6S, 6.3V, 20%, 0402	MURATA, GRM155C80J475MEAAD
3	2	C7, C17	CAP., 1µF, X7T, 6.3V, 20%, 0201	MURATA, GRM033D70J105ME01D
4	2	C10, C11	CAP., 22µF, X6S, 6.3V, 20%, 0603	MURATA, GRM188C80J226ME15D
5	1	C18	CAP., 10pF, C0G, 50V, 5%, 0402, AEC-Q200	MURATA, GCM1555C1H100JA16D
6	1	L1	IND., 0.47µH, PWR, METAL ALLOY, 20%, 4.5A, 26mΩ, 0806	MURATA, DFE201612E-R47M=P2
7	1	R1	RES., 140k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402140KFKED
8	1	R2	RES., 100k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KFKED
9	1	U1	IC, 5V, 3A SYNCHRONOUS STEP-DOWN Silent Switcher IN WLCSP 16-PIN LQFN	ANALOG DEVICES, LTC3307AACBZ-R7
Additional Demo Board Circuit Components				
1	2	C1, C15	CAP., 330µF, TANT, POSCAP, 6.3V, 20%, 7343, 25mΩ, TPE	PANASONIC, 6TPE330ML
2	1	C2	CAP., 0.1µF, X7R, 16V, 10%, 0402, AEC-Q200	MURATA, GCM155R71C104KA55D
3	2	C3, C4	CAP., 10µF, X7S, 6.3V, 20%, 0603	TDK, C1608X7S0J106M080AC
4	0	C8, C9	CAP., 1µF, X7T, 6.3V, 20%, 0201	MURATA, GRM033D70J105ME01D
5	0	C12	CAP., 0.1µF, X5R, 25V, 10%, 0402	SAMSUNG, CL05A104KA5NNNC
6	2	C13, C14	CAP., 1000pF, X7R, 50V, 20%, 0402, 3-TERM, X2Y EMI FILTER	JOHANSON DIELECTRICS, 500X07W102MV4T
7	0	C19, C20	CAP., 1000pF, X7R, 50V, 20%, 0402, 3-TERM, X2Y EMI FILTER	JOHANSON DIELECTRICS, 500X07W102MV4T
8	0	C21, C22	CAP., OPTION, 0805	
9	1	L2	IND., 80Ω AT 100MHz, FERRITE BEAD, 25%, 4000mA, 18mΩ, 0805	WURTH ELEKTRONIK, 74279220800
10	1	Q1	XSTR., MOSFET, N-CH, 40V, 15.9A, PPAK SO-8	VISHAY, SIR426DP-T1-GE3
11	1	R3	RES., 20Ω, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040220R0FKED
12	0	R4	RES., OPTION, 0402	
13	1	R5	RES., 10k, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040210K0JNED
14	1	R6	RES., 1M, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04021M00FKED
15	1	R7	RES., 249k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402249KFKED
16	1	R8	RES., 100k, 5%, 1/16W, 0402	YAGEO, RC0402JR-07100KL
17	1	R9	RES., 0Ω, 1/16W, 0402	VISHAY, CRCW04020000Z0ED
18	1	R10	RES., 10k, 5%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2GEJ103X
19	1	R11	RES., 0.1Ω, 1%, 2W, 2512, SENSE, AEC-Q200	TT ELECTRONICS, LRC-LR2512LF-01-R100-F
20	0	TP1	CONN., U.FL, RECEPT, ST SMD, 0Hz TO 6GHz 50Ω	HIROSE ELECTRIC, U.FL-R-SMT-1(10)
Hardware: For Demo Board Only				
1	10	E1-E3, E5, E12, E14-E16, E19, E21	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
2	6	E4, E7, E11, E13, E18, E20	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
3	5	E6, E8-E10, E17	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
4	1	JP1	CONN., HDR, MALE, 1×4, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000411121
5	1	JP2	CONN., HDR, MALE, 1×3, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000311121
6	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.50"	WURTH ELEKTRONIK, 702935000
7	2	XJP1, XJP2	CONN., SHUNT, FEMALE, 2 POS, 2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



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