

# 3.3V $V_{IN}$ , Dual 2A, 6MHz Synchronous Step-Down Regulators at 1.8V and 2.0V Outputs, in a 0.71cm<sup>2</sup> Solution

## DESCRIPTION

Demonstration Circuit DC2748A features the **LTC®3315B** dual 5V, 2A Synchronous Step-Down DC/DC regulators operating at 6MHz. One regulator provides a 1.8V output and the other provides 2.0V, both up to a 2A load. The LTC3315B supports adjustable output voltages from 0.5V to  $V_{IN}$ , operating frequencies from 3MHz up to 10MHz. The LTC3315B is a compact, high efficiency, and high speed synchronous monolithic step-down switching regulator. Fast minimum on-time of 25ns enables high  $V_{IN}$  to low  $V_{OUT}$  conversion at high frequency.

The DC2748A operating mode may be selected as Burst Mode operation, Skip mode or Forced Continuous (FC) mode. Setting JP1 to the FC/SYNC position will allow the LTC3315B to sync to a clock frequency from 3MHz to

10MHz. The LTC3315B operates in Forced Continuous mode when syncing to an external clock.

The LTC3315B data sheet gives a complete description of the device, operation and application information. The data sheet must be read in conjunction with this demo. The LTC3315B is assembled in a 2mm × 2mm LQFN package with exposed pads for low thermal resistance. The PCB Considerations section in the data sheet.

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

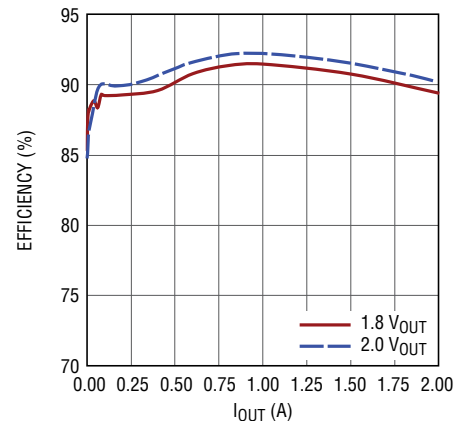
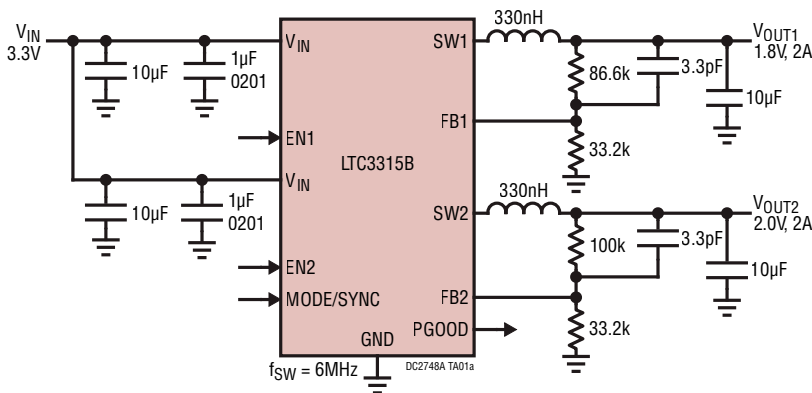
**Design files for this circuit board are available.**

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## PERFORMANCE SUMMARY

Specifications are at  $T_A = 25^\circ\text{C}$

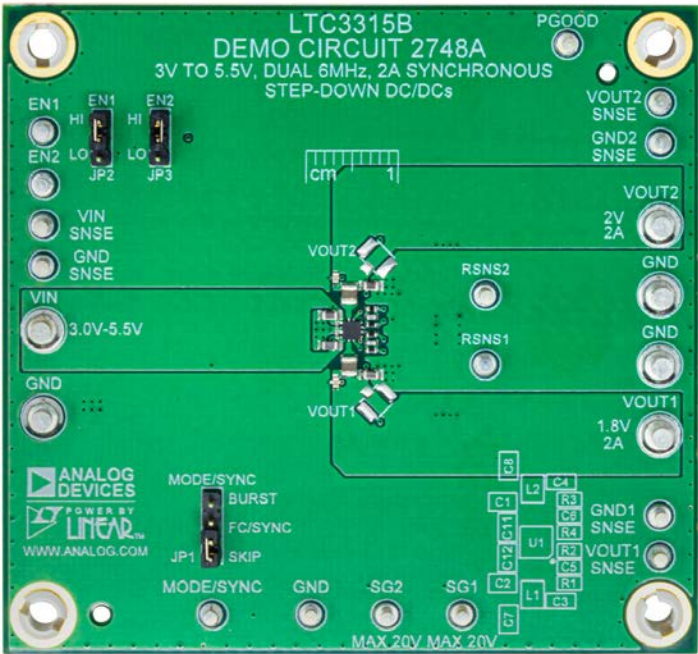
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Supply Range ( $V_{IN}$ )		2.25	3.3	5.5	V
Internal Oscillator Frequency ( $f_{SW}$ )		5.55	6	6.45	MHz
Top Switch On Time			25		ns
$V_{OUT1}$	0 to 2A		1.8		V
$V_{OUT2}$	0 to 2A		2.0		V



DC2748A TA01b

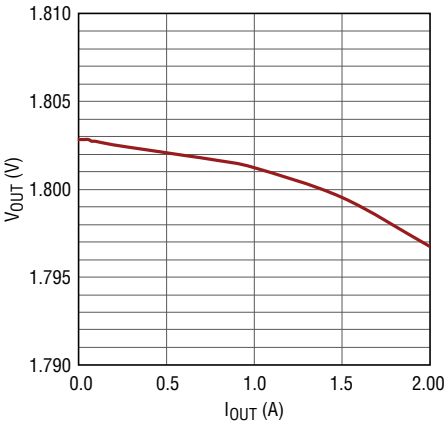
# DEMO MANUAL DC2748A

## BOARD PHOTO



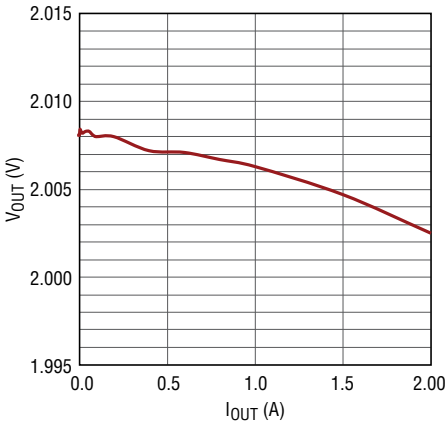
## BOARD PERFORMANCE

LTC3315B 1.8V FC MODE  
LOAD REGULATION  
 $V_{IN} = 3.3V$



DC2748A G01

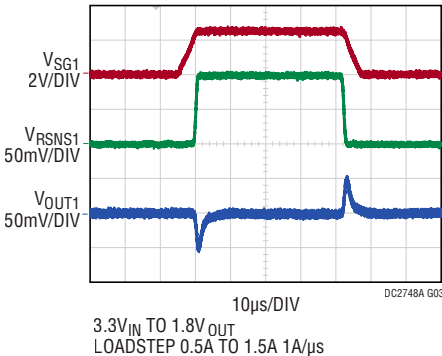
LTC3315B 2.0V FC MODE  
LOAD REGULATION  
 $V_{IN} = 3.3V$



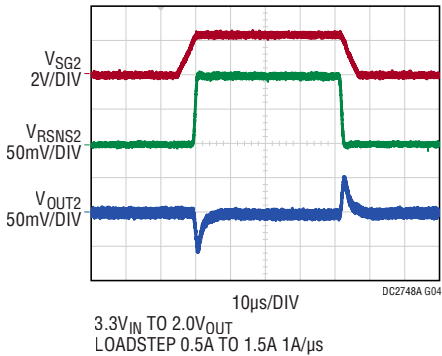
DC2748A G02

# BOARD PERFORMANCE

## 1.8V Load Transient Response Forced Continuous Mode



## 2.0V Load Transient Forced Continuous ModeMode



## QUICK START PROCEDURE

The DC2748A is easy to set up to evaluate the performance of the LTC3315B. Refer to Figure 1 and Figure 2 for proper measurement equipment setup and follow the evaluation 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, VM2 and VM3 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 JP2 and JP3 jumpers on the DC2748A board to the HI position.
2. Set the JP1 jumper on the DC2748A board to the desired position, BURST for best efficiency, FC/SYNC for lowest ripple, and PS for a compromise between the two.
3. With power off, connect 0V to 6V, 5A power supply, PS1, between  $V_{IN}$  and GND with a series ammeter and a voltmeter as shown in Figure 1.
4. Turn on and set the PS1 input power supply to 3.3V and observe that  $V_{OUT1}$  regulates to 1.8V and  $V_{OUT2}$  regulates to 2.0V.

NOTE: Make sure that the input voltage does not exceed 6V.

5. 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.
6. Turn on LOAD1 and slowly increase 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.

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 50 $\Omega$  coax cable to reduce any high frequency noise that might couple into the oscilloscope probes.

7. Set LOAD1 to 500mA.
8. With power off, connect a second 0A to 2A load to  $V_{OUT2}$  and GND with a series ammeter and a voltmeter as shown in Figure 1.

9. Turn on LOAD2 and slowly increase the 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.
10. Momentarily short  $V_{OUT1}$  to ground with a clip lead and observe that the voltage on PGOOD drops to 0V.
11. To change the operating frequency of the LTC3315B, an external clock must be used. To do this set the JP1 jumper on the DC2748A board to the FC/SYNC position.
12. Set a pulse generator to output a 0V to 3.3V pulse at 6MHz, 50% duty cycle and connect it to the MODE/ SYNC terminal and GND.
13. Change the frequency of the pulse generator from 6MHz to 7MHz and observe how observe how the frequency of SW1 follows the pulse generator.
14. Set LOAD1 greater than 1.0A. With an oscilloscope probe on SW1, remove the pulse signal to the MODE/ SYNC terminal and observe how the switch frequency settles from 7MHz back to 6MHz.
15. To test the transient response with a base load, turn off LOADx (LOAD1 or LOAD2) and add the desired resistor to produce a minimum load between  $V_{OUTx}$  and RSNSx turrets (RL shown on Figure 1). Note that the total load resistance will be RL plus RSNSx (100m $\Omega$ ).
16. Adjust a signal generator with a 10ms period, 10% duty cycle and an amplitude from 1V to 2V to start.

Measure the RSNSx voltage to observe the current,  $V_{RSNSx}/100m\Omega$ . 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, the LTC3315B DC2748A transient plots and Figure 3.

$$17. I_{OUTx} = V_{RSNSx}/100m\Omega$$

$$V_{RSNSx} = V_{SGx} - V_{GSx}$$

Observe load transient effect on  $V_{OUTx}$

18. Refer to the LTC3315B data sheet for more details on how the LTC3315B operates.
19. When done, turn off all loads, signal generator and power supplies.



### Figure 2. Measuring Input or Output Ripple

## QUICK START PROCEDURE

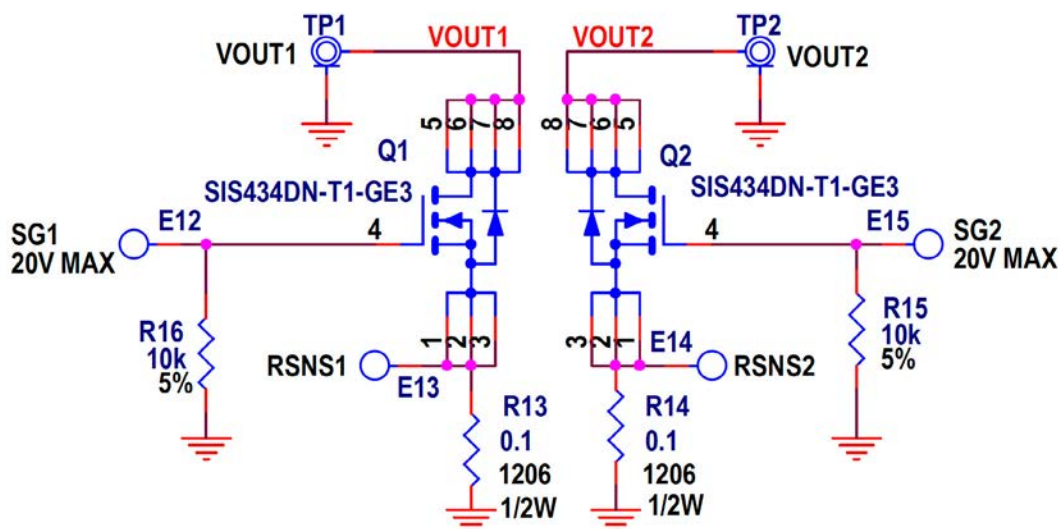


Figure 3. Optional Transient Response Circuit

## THEORY OF OPERATION

### Introduction to the DC2748A

The DC2748A demonstration circuit features the LTC3315B, a 5V Dual 2A Low voltage Synchronous Step-Down regulator. The LTC3315B is a monolithic, constant frequency, current mode step-down DC/DC converter. An internal 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 LTC3315B is in shutdown and in a low quiescent current state. When the EN pin is above its threshold, the switching regulator will be enabled. Buck 1 and Buck 2 are 180° out of phase with each other.

The MODE/SYNC pin sets the switching mode to pulse skip, forced continuous, or burst mode. If an external 3MHz to 10MHz clock is connected to the MODE/SYNC turret while the JP1 is set to the FC/SYNC position, the LTC3315B switching frequency will sync to the external clock while operating in forced continuous mode. See the LTC3315B 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 45ns in the formula below.

$$f_{SWMAX} = \frac{V_{OUT}}{V_{INMAX} \cdot T_{onMIN}}$$

Select an operating switching frequency below  $f_{SWMAX}$ . The LTC3315B has a requirement that the magnitude of the ripple current in the output inductor be greater than 0.6A peak to peak. This will determine the maximum inductor value for the application.

### Accurately Measuring Output Ripple of the LTC3315B

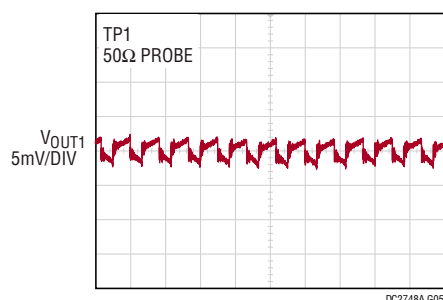
With the fast edge rates of the circuit, high frequency noise can be observed when measuring the output voltage with 1MΩ terminated oscilloscope probes. To better view the output ripple with oscilloscopes of 400MHz bandwidth and above a 50Ω coax cable connected as close to the output caps as possible should be used with the

## THEORY OF OPERATION

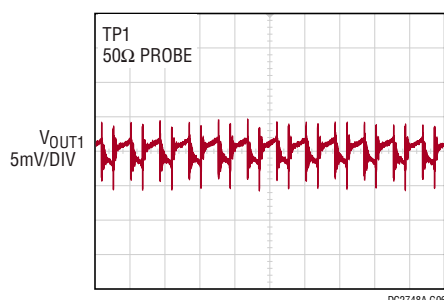
oscilloscope channel terminated to  $50\Omega$  at the scope. This will help to reduce the noise coupling onto and displaying on the scope. The demo board is set up to solder an U.FL,RECEPT,ST SMD,0Hz to 6GHz  $50\Omega$  connector (TP1) near the output cap C3 & C4. These pads can also be used to solder a coax cable or other oscilloscope probe connector if desired.

The DC2748A uses 3-terminal capacitors, C7 and C8, on the output to reduce the high frequency spikes that can be observed with high bandwidth oscilloscopes.

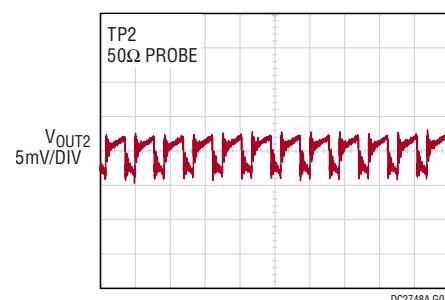
The high frequency spikes are partially attributed to the interwinding capacitance of the inductor and the voltage step is partially attributed to the inductance in the output capacitors. The step can be reduced by choosing low ESL capacitors as close to the inductor as possible. The high frequency spikes are reduced with using a small low ESL 3-terminal capacitor with the self-resonant frequency close to the high frequency spikes. Below is the output ripple using a 500MHz scope,  $50\Omega$  probe measured at TP1 on without the 3-terminal capacitor populated in C7.



$V_{IN} = 3.3V$   
 $V_{OUT1} = 1.8V$   
 $I_{OUT} = 2A$   
 C7 = 1nF 3-Terminal Cap



$V_{IN} = 3.3V$   
 $V_{OUT1} = 1.8V$   
 $I_{OUT1} = 2A$   
 C7 = OPEN



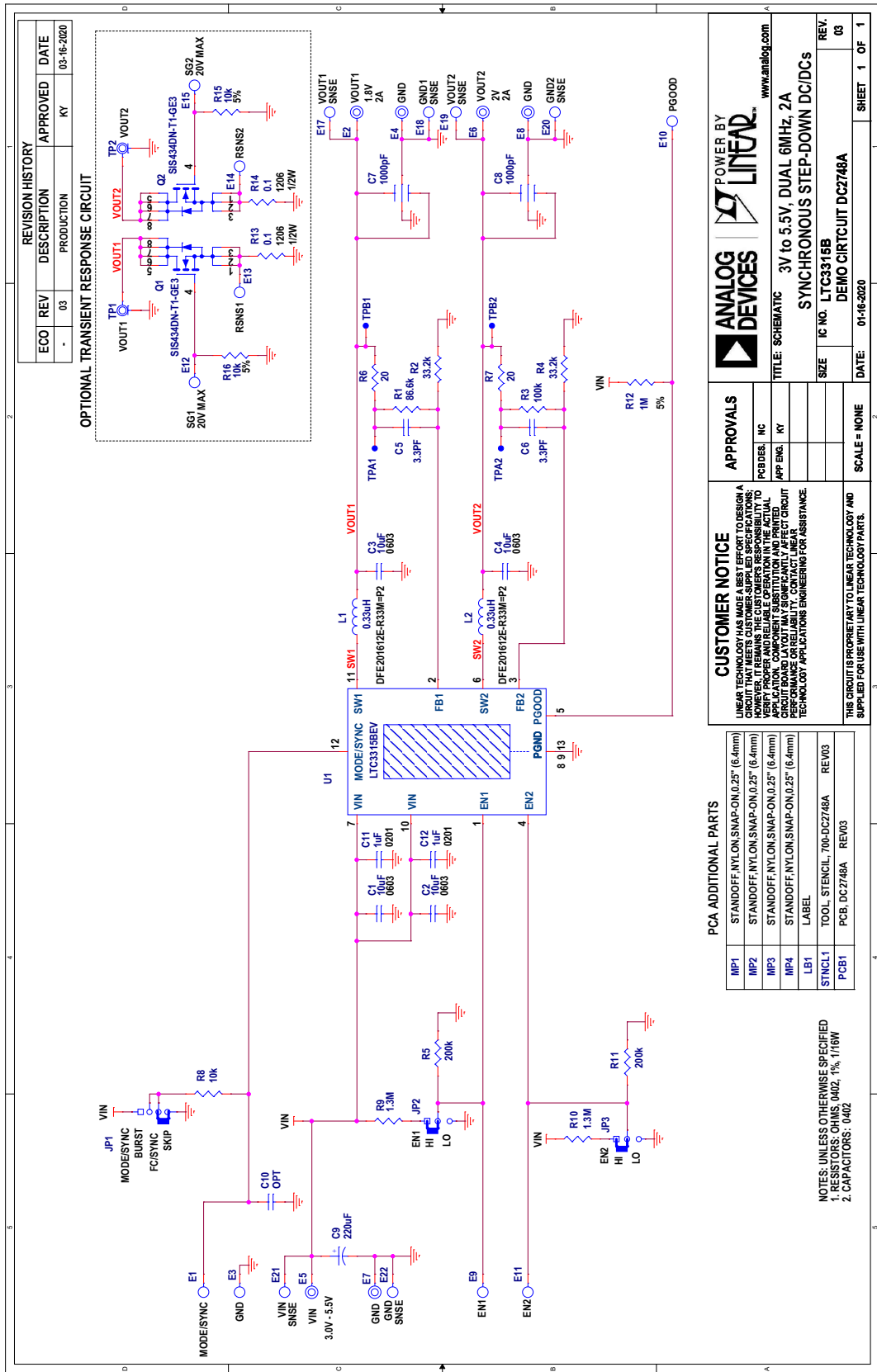
$V_{IN} = 3.3V$   
 $V_{OUT2} = 2.0V$   
 $I_{OUT2} = 2A$   
 C8 = 1nF 3-Terminal Cap

# DEMO MANUAL DC2748A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	4	C1-C4	CAP., 10uF, X7S, 6.3V, 20%, 0603	TDK, C1608X7S0J106M080AC
2	2	C5, C6	CAP., 3.3PF, C0G, 50V, 0.25pF, 0402	AVX, 04025A3R3CAT2A
3	2	C11, C12	CAP., 1uF, X7T, 6.3V, 20%, 0201	MURATA, GRM033D70J105ME01D
4	2	L1, L2	IND., 0.33uH, PWR, FIXED, 20%, 6.3A, 21mOHMS, 0806	MURATA, DFE201612E-R33M=P2
5	1	R1	RES., 86.6k OHMS, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F8662TRF
6	2	R2, R4	RES., 33.2k OHMS, 1%, 1/16W, 0402	VISHAY, CRCW040233K2FKED
7	1	R3	RES., 100k OHMS, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KFKED
8	1	U1	IC, DUAL 5V, 2A SYNCHRONOUS STEP-DOWN DC/DC, LQFN	ANALOG DEVICES, LTC3315BEV#PBF
<b>Additional Demo Board Circuit Components</b>				
1	2	C7, C8	CAP., 1000pF, X7R, 50V, 20%, 0402, 3-TERM, X2Y EMI FILTER	JOHANSON DIELECTRICS, 500X07W102MV4T
2	1	C9	CAP., 220uF, TANT. POSCAP, 6.3V, 20%, 7343, 18mOHMS, TPE, NO SUBS. ALLOWED	PANASONIC, 6TPE220MI
3	0	C10	CAP., OPTION, 0402	
4	2	Q1, Q2	XSTR., MOSFET, N-CH, 40V, 35A, PowerPAK 1212-8	VISHAY, SIS434DN-T1-GE3
5	2	R5, R11	RES., 200k OHMS, 1%, 1/16W, 0402	NIC, NRC04F2003TRF
6	2	R6, R7	RES., 20 OHMS, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F20R0TRF
7	1	R8	RES., 10k OHMS, 5%, 1/16W, 0402, AEC-Q200	NIC, NRC04J103TRF
8	2	R9, R10	RES., 1.3M OHMS, 1%, 1/16W, 0402	VISHAY, CRCW04021M30FKED
9	1	R12	RES., 1M OHM, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04021M00JNED
10	2	R13, R14	RES., 0.1 OHM, 1%, 1/2W, 1206, SENSE, AEC-Q200	IRC, LRC-LR1206LF-01-R100-F
11	2	R15, R16	RES., 10k OHMS, 5%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2GEJ103X
<b>Hardware: For Demo Board Only</b>				
1	15	E1, E3, E9-E15, E17-E22	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
2	6	E2, E4-E8	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
3	1	JP1	CONN., HDR, MALE, 1x4, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000411121
4	2	JP2, JP3	CONN., HDR, MALE, 1x3, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000311121
5	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.25" (6.4mm)	KEYSTONE, 8831
6	2	TP1, TP2	CONN., U.FL, RECEPT, ST SMD, 0Hz to 6GHz 500hm	HIROSE ELECTRIC, U.FL-R-SMT-1(10)
7	3	XJP1-XJP3	CONN., SHUNT, FEMALE, 2 POS, 2mm	WURTH ELEKTRONIK, 60800213421

## 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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