Evaluating the Multiphase Operation of the LTC3313 5 V, 15 A Synchronous Step-Down Silent Switcher in 3 mm × 3 mm LQFN

FEATURES

- EVAL-LTC3313EV-MULTI-AZ evaluation board
- Transient circuit included for load transient evaluation
- RT pin pull-up option for external clock synchronization

EVALUATION KIT CONTENTS

- EVAL-LTC3313EV-MULTI-AZ evaluation board

DOCUMENTS NEEDED

- LTC3313 data sheet
- EVAL-LTC3313EV-MULTI-AZ user guide

EQUIPMENT NEEDED

- A DC voltage source
- An electronic load
- A multimeter

GENERAL DESCRIPTION

The EVAL-LTC3313EV-MULTI-AZ features the LTC3313, a 15 A, low-voltage, synchronous step-down Silent Switcher®, operating as a multiphase 2 MHz, 3.0 V to 5.5 V input, 1.2 V buck regulator. The EVAL-LTC3313EV-MULTI-AZ has three build options to provide 2-phase 30 A, 3-phase 45 A, or 4-phase 60 A output solutions. The LTC3313 supports adjustable output voltages from 0.5 V to input voltage (V_{IN}) and operating frequencies from 500 kHz up to 5 MHz in multiphase operation.

All phases of EVAL-LTC3313EV-MULTI-AZ operate in forced continuous mode at 2 MHz switching frequency (f_{SW}). The LTC3313 can also synchronize to an external clock using a MODE/SYNC turret when the RT pin of the main phase is pulled up to the V_{IN} pin.

The EVAL-LTC3313EV-MULTI-AZ also has an electromagnetic interference (EMI) filter to reduce conducted EMI. This EMI filter can be included by applying the input voltage at the V_{IN} EMI terminal.

Figure 4 shows the efficiency of the circuit with a 3.3 V input for all three build options.

An on-board transient circuit is included to measure fast transient performance.

The LTC3313 data sheet gives a complete description of the part, operation, and application information. The data sheet must be read in conjunction with this user guide. The LTC3313 is assembled in a 3 mm × 3 mm LQFN package with exposed pads for low thermal resistance. The layout recommendations for low EMI operation and maximum thermal performance are available in the LTC3313 data sheet.

EVALUATION BOARD PHOTOGRAPH

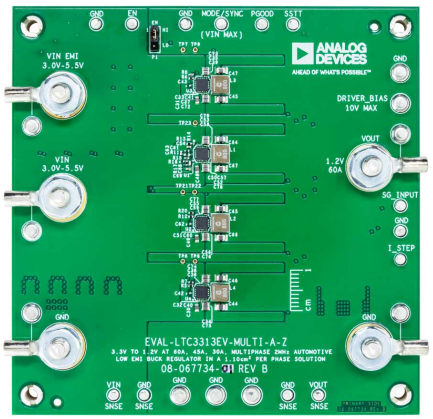

Figure 1. EVAL-LTC3313EV-MULTI-AZ Board Photograph

TABLE OF CONTENTS

REVISION HISTORY

2/2024—Revision 0: Initial Version

SPECIFICATIONS

T_A = 25°C, unless otherwise noted.

Table 1. Specifications

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
INPUT VOLTAGE (V_{IN})		3.0		5.5	V
OUTPUT VOLTAGE (V_{OUT})		1.176	1.200	1.224	V
OUTPUT CURRENT (I_{OUT})					
4-Phase				60	A
3-Phase				45	A
2-Phase				30	A
SWITCHING FREQUENCY (f_{SW})		1.8	2	2.2	MHz
EFFICIENCY, 4-PHASE	V_{IN} = 3.3 V, I_{OUT} = 20 A		92.5		%

INTRODUCTION TO THE EVAL-LTC3313EV-MULTI-AZ

The EVAL-LTC3313EV-MULTI-AZ demonstration circuit features the LTC3313, a low-voltage, synchronous step-down Silent Switcher in 2-, 3-, or 4-phase operations. The LTC3313 is a monolithic, constant frequency, current mode step-down DC-to-DC converter.

Connecting the RT pin of the main phase with a resistor to the AGND pin programs the frequency from 500 kHz to 5 MHz. With the RT resistor on the main phase, the MODE/SYNC pin becomes a clock output to drive the MODE/SYNC pins of the subordinate phases. The EVAL-LTC3313EV-MULTI-AZ can operate with an external clock by shorting the main phase RT pin to VIN pin with a 0 Ω resistor in the R14 location and applying a clock signal on the MODE/SYNC turret.

If the EN pin is low, the LTC3313 is in shutdown mode and in a low quiescent current state. When the EN pin is above the EN threshold, the switching regulator enables.

Connecting the FB pin to VIN pin configures a phase as a subordinate. The MODE/SYNC pin becomes an input, and the voltage control loop is disabled. The current control loop in the subordinate phase is still active, and the peak current is controlled via the shared ITH node. The phasing of a subordinate phase relative to the main phase is programmed with a resistor divider on the RT pin. Refer to the LTC3313 Programming Slave Phase Angle table in the LTC3313 data sheet for more information on setting the subordinate phase angle.

In the multiphase application, the LTC3313 operates in forced continuous mode. At light loads, the subordinate phases continues to operate in forced continuous mode.

Setting the compensation for the multiphase is similar to setting the compensation to the single phase. When designing the compensation network, controlling the loop stability and transient response are the two main considerations. The LTC3313 was designed to operate at a high bandwidth for fast transient response capabilities,which reduces output capacitance required to meet the desired transient voltage range. The midband gain of the loop increases with R11, and the bandwidth of the loop increases with decreasing C63. The C68, along with the R17, provides a phase lead which improves the phase margin. The C61, C62, C43, and C42, along with the R11, provides a high-frequency pole to reduce the high-frequency gain. The C61, C62, C43, and C42 are in parallel on the ITH node. The sum of these capacitors is the total capacitance on the main phase ITH pin. Note that too much capacitance slows down the response time.

Loop stability is generally measured using the Bode Plot method of plotting loop gain in dB and phase shift in degrees. The 0 dB crossover frequency must be less than 1/6 of the operating frequency to reduce the effects of added phase shift of the modulator. The control loop phase margin goal must be 45° or greater and a gain margin goal of 8 dB or greater. Refer to the LTC3313 data sheet and LTPowerCAD for more information on choosing the required components.

The soft-start of the multiphase regulator is controlled by a single capacitor, C54, on the main phase. After the regulator is in regulation, the SSTT pin can be used to monitor the temperature of each IC. The main phase temperature can be monitored at the SSTT turret and subordinate 1, 2, and 3 can be monitored at TP21, TP7, and TP6 respectively. Calculate the die temperature with the following formula:

$$T_J(°C) = \frac{V_{SSTT}}{4\ mV} - 273 \quad (1)$$

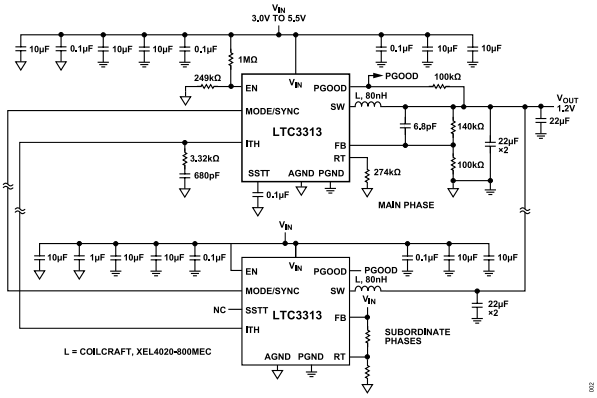

Figure 2. LTC3313, Multiphase Step-Down Converter Typical Solution

QUICK START PROCEDURE

Before following the quick start procedure, note that for accurate V_{IN}, V_{OUT}, and efficiency measurements, measure V_{IN} at the VIN SNSE and GND SNSE turrets, and measure V_{OUT} at the VOUT SNSE and GND SNSE turrets, which are illustrated as VM1 and VM2 in Figure 5. In addition, when measuring the input or output ripple, avoid a long ground lead on the oscilloscope probe.

Refer to Figure 5 for proper measurement equipment test setup and take the following steps:

1. Set the JP1 jumper to the high position.
2. With power off, connect the input power supply to VIN and GND. If the input EMI filter is desired, connect the input power supply to VIN EMI and GND.
3. Set power supply (PS1) current limit to 40 A.
4. Set the electronic load (LD1) to CC mode and 0 A current.
5. Slowly increase PS1 to 1.0 V. If PS1 output current reads less than 20 mA, increase PS1 to 3.3 V.
6. Verify that VM1 reads 3.3 V and VM2 reads 1.2 V.
7. Check VM1, VM2, VM3, PS1 output current, and LD1 input current.
8. Connect an oscilloscope voltage probe as shown in Figure 6 or Figure 7.
9. Set channel to AC-coupled, voltage scale to 20 mV, and time base to 10 µs. Check V_{OUT} ripple voltage and verify that PGOOD voltage is more than 3 V.
10. Increase the load by 1 A intervals up to full load and observe the voltage output regulation, ripple voltage.
11. To test the transient response with a base load, add the desired resistor to produce a minimum load between VOUT and I_STEP turrets (RL shown on Figure 5). Note that the total load resistance is RL plus 10 mΩ from R1 and R2. The EVAL-LTC3313EV-MULTI-AZ uses a buffered signal generator input to drive a source follower circuit and to control the slew rate and amplitude of the current transient. The source follower FET (Q1) operates in the linear region during the load step.
12. Connect a second power supply (PS2) to DRIVER BIAS and GND turrets.
13. Set PS2 to 8 V and turn on PS2.
14. Connect a signal generator (SG1) to SG_INPUT and GND turrets.
15. Set SG1 with a 10 ms period, a 10% duty cycle, and an amplitude from 0 V to 3.5 V to start.
16. Connect an oscilloscope with a time scale of 200 µs/div with one channel having a vertical scale of 2 V/div on the SG_INPUT and another with a vertical scale of 50 mV/DIV to the I_STEP turret.
17. Measure the I_STEP voltage to observe the current, V_{I_STEP} /10 mΩ. 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. Figure 4 shows a load step from 10 A to 20 A in 1 µs. Refer to the following equations:

$$I_{OUT} = \frac{V_{I\_STEP}}{10\ m\Omega} \quad (2)$$

$$V_{GS} = V_{SG\_INPUT} - V_{I\_STEP} \quad (3)$$

where VGS is the gate to source voltage of Q1.

18. When done, turn off SG1, PS1, PS2, and LD1. Remove all the connections to the EVAL-LTC3313EV-MULTI-AZ.

TYPICAL PERFORMANCE CHARACTERISTICS

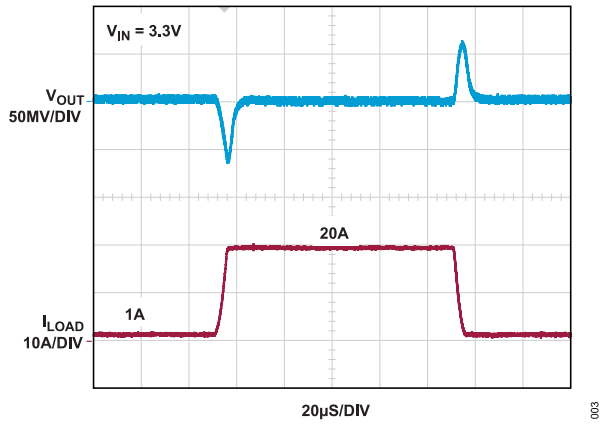

Figure 3. Load Step Response

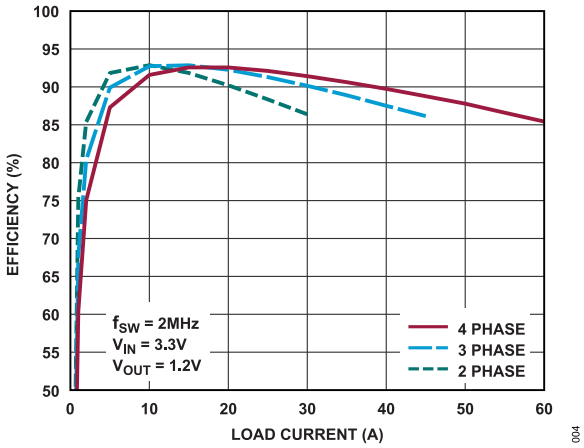

Figure 4. Efficiency vs. Load Current

TEST SETUP

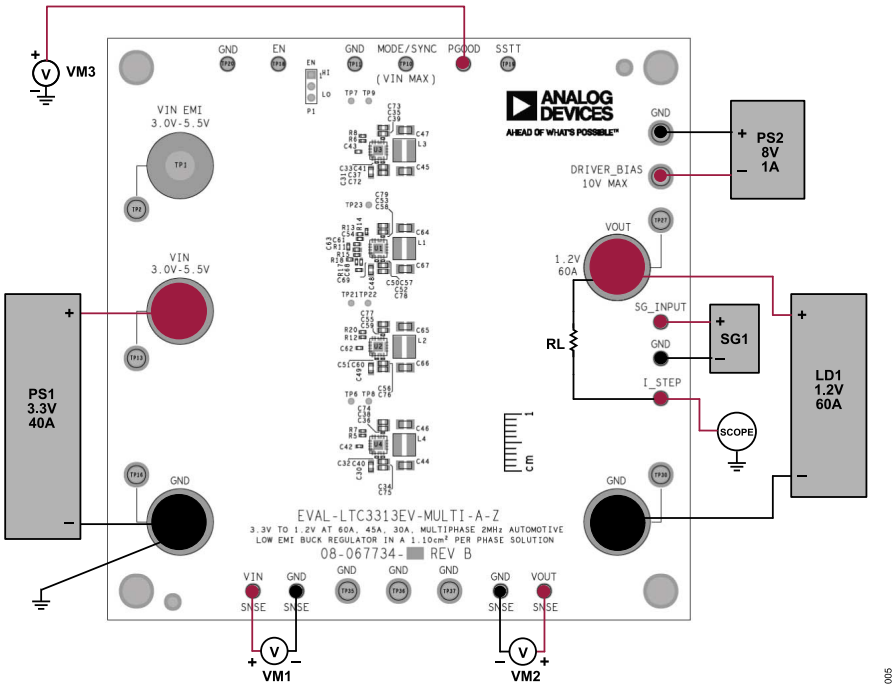

Figure 5. Test Setup for EVAL-LTC3313EV-MULTI-AZ

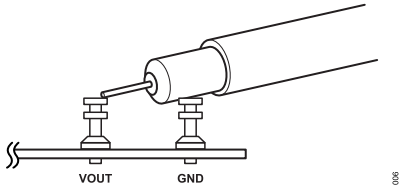

Figure 6. Technique for Measuring the Output Ripple and the Step Response with a Scope Probe

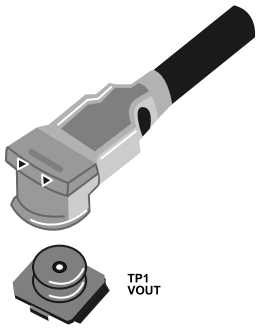

Figure 7. Technique for Measuring the Output Ripple and the Load Response with a Low Inductance Connector (Not Supplied)

EVALUATION BOARD SCHEMATICS

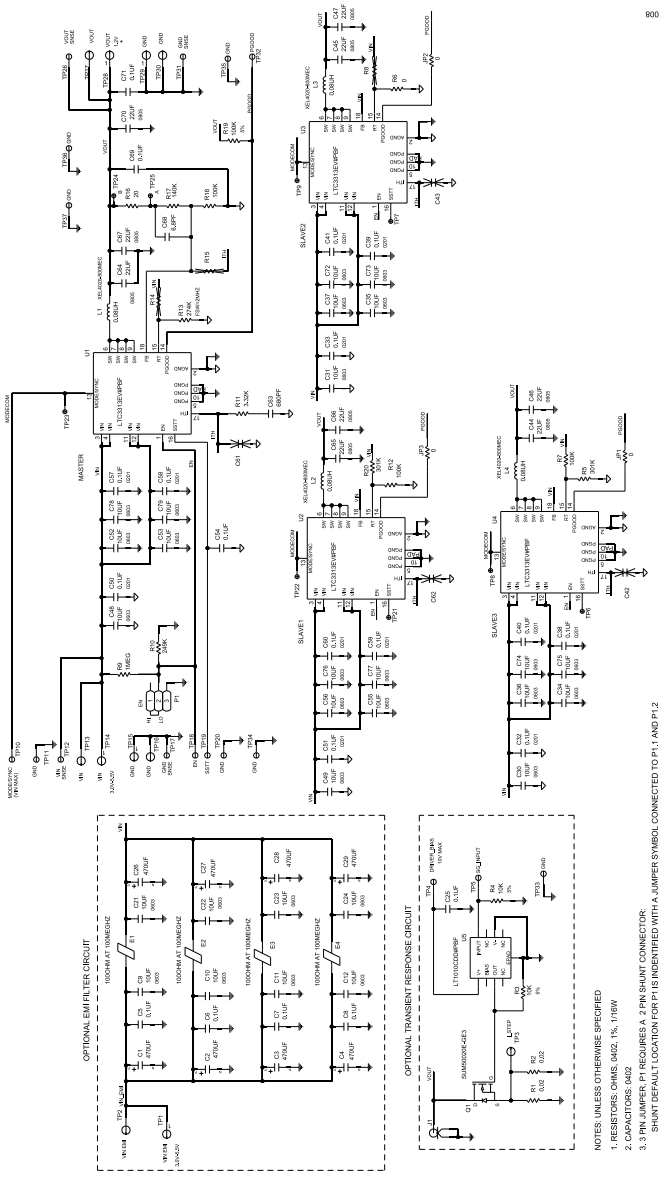

Figure 8. EVAL-LTC3313EV-MULTI-A1Z Evaluation Board Schematic

EVALUATION BOARD SCHEMATICS

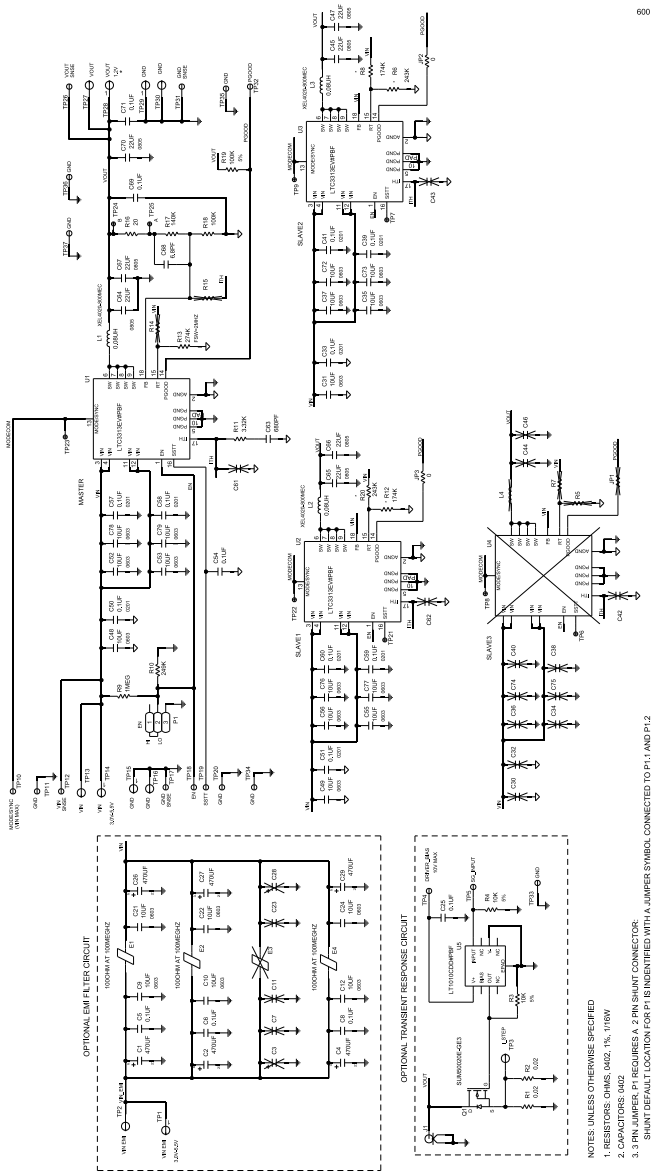

Figure 9. EVAL-LTC3313EV-MULTI-A2Z Evaluation Board Schematic

EVALUATION BOARD SCHEMATICS

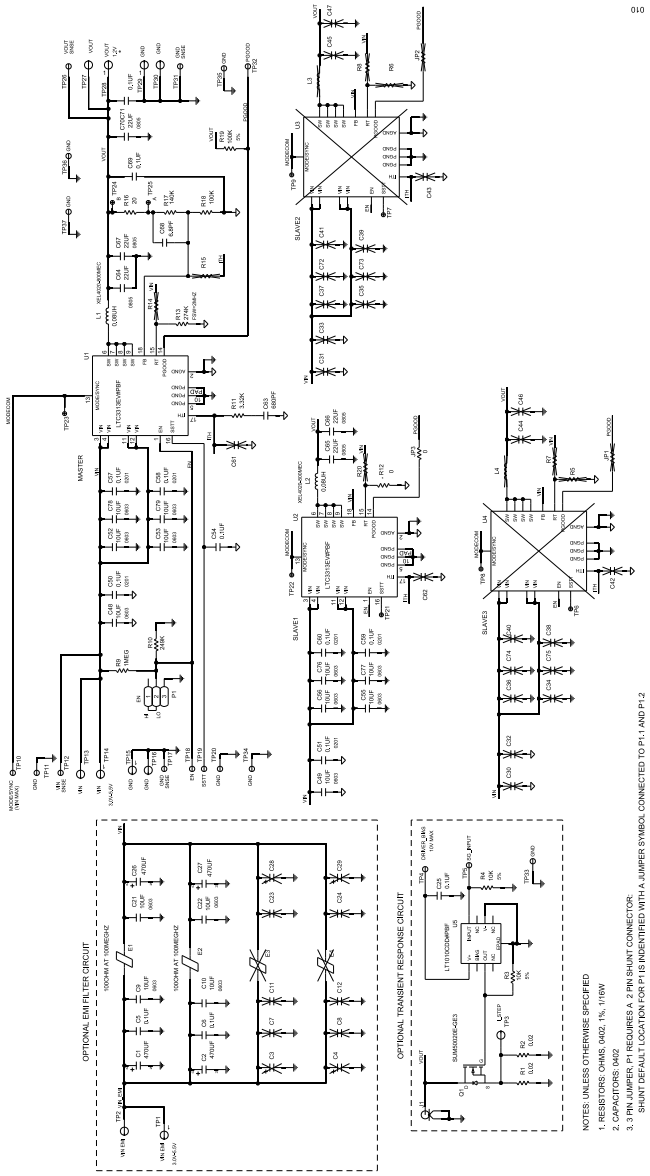

Figure 10. EVAL-LTC3313EV-MULTI-A3Z Evaluation Board Schematic

ORDERING INFORMATION

BILL OF MATERIALS

Table 2. EVAL-LTC3313EV-MULTI-A1Z Bill of Materials

Item	Qty	Reference	Part Description	Manufacturer/Part Number
Required Circuit Components				
1	20	C30, C31, C34 to C37, C48, C49, C52, C53, C55, C56, C72 to C79	Ceramic capacitors, 10 µF, 6.3 V, 20%, X7S, 0603, low equivalent series resistance (ESR)	TDK, C1608X7S0J106M080AC
2	12	C32, C33, C38 to C51, C57 to C60	Ceramic capacitors, 0.1 µF, 10 V, 10%, X7S, 0201	Murata, GRM033C71A104KE14D
3	9	C44 to C47, C64 to C67, C70	Ceramic capacitors, 22 µF, 10 V, 20%, X7S 0805, low ESR	TDK, C1608X7S0J106M080AC
4	1	C63	Ceramic capacitor, 680 pF, 50 V, 5%, C0G, 0402	Murata, GRM1555C1H681JA01D
5	1	C68	Ceramic capacitor, 6.8 pF, 50 V, 0.05 pF, C0G, 0402, AEC-Q200	Murata, GCQ1555C1H6R8WB01D
6	4	L1 to L4	Shielded power inductors, wirewound, 0.08 µH, 20%, 1 MHz, 21.4 A, 0.0018 Ω, 1515, AEC-Q200	Coilcraft, XEL4020-800MEC
7	1	R11	Surface-mount device (SMD) resistor, 3.32 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF3321X
8	3	R7, R12, R18	SMD resistors, 100 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF1003X
9	1	R13	SMD resistor, 274 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW0402274KFKED
10	1	R17	SMD resistor, 140 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW0402140KFKED
11	1	R18	SMD resistor, 100 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF1003X
12	1	R19	SMD resistor, 100 kΩ, 5%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW0402100KJNED
13	2	R5, R20	SMD resistors, 301 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF3013X
14	1	R6	SMD resistor, 0 Ω jumper, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2GE0R00X
15	4	U1 to U4	5 V, 15 A synchronous step-down Silent Switchers	Analog Devices, Inc. LTC3313EV#PBF
Additional Demo Board Circuit Components				
1	8	C1 to C4, C26 to C29	Tantalum capacitors, 470 µF, 6.3 V, 20%, 7343-40, very low ESR 0.005 Ω	KEMET, T530Y477M006ATE005
2	8	C5 to C8, C25, C54, C69, C71	Ceramic capacitors, 0.1 µF, 16 V, 10%, X7R, 0402, AEC-Q200	Murata, GCM155R71C104KA55D
3	8	C9 to C12, C21 to C24	Ceramic capacitors, 10 µF, 6.3 V, 20%, X7S, 0603, low ESR	TDK, C1608X7S0J106M080AC
4	4	E1 to E4	Inductors electromagnetic interference multilayer power suppression ferrite bead, 0.006 Ω maximum DCR, 8 A	Würth Elektronik, 74279226101
5	3	JP1 to JP3	SMD resistors, 0 Ω jumper, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2GE0R00X
6	1	Q1	Metal-oxide semiconductor field effect (MOSFET) transistor, N-CH, 60 V, 120 A, 3LD D2PAK	Vishay, SUM50020E-GE3
7	2	R1, R2	SMD resistors 0.02 Ω, 1%, 10 W, 2818, AEC-Q200	Vishay, WSHP2818R0200FEA
8	1	R10	SMD resistor 249 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Stackpole Electronics, RMCF0402FT249K
9	1	R16	SMD resistor 20 Ω, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF20R0X
10	2	R3, R4	SMD resistors 10 kΩ, 5%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW040210K0JNED
11	1	R9	SMD resistor 1 MΩ, 1%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW04021M00FKED
12	1	U5	Fast, ±150 mA power buffer	Analog Devices, LT1010CDD#PBF
Hardware: For Demo Board Only				
1	1	J1	PCB connector, ultra miniature coaxial (UMC), straight jack, 50 Ω, SMD	Hirose Electric, U.FL-R-SMT-1(01)
2	1	P1	PCB connector, three position male header, unshrouded single row, straight, 2 mm PITCH, 2.70 mm solder tail	Würth Elektronik, 62000311121
3	5	TP1, TP14, TP15, TP28, TP29	PCB connectors, threaded broaching stud 10-32, fastener 0.625, use ALT_SYMBOL for C450D200 PAD	Captive Fastener, CKFH1032-10
4	13	TP3, TP5, TP10 to TP12, TP17 to TP20, TP26, TP31, TP32, TP34	PCB connectors, solder terminal turrets for clip leads	Mill-Max, 2308-2-00-80-00-00-07-0
5	10	TP2, TP4, TP13, TP16, TP27, TP30, TP33, TP35 to TP37	PCB connectors, solder terminal turrets	Mill-Max, 2501-2-00-80-00-00-07-0

ORDERING INFORMATION

Table 3. EVAL-LTC3313EV-MULTI-A2Z Bill of Materials

Item	Qty	Reference	Part Description	Manufacturer/Part Number
Required Circuit Components				
1	15	C31, C35, C37, C48, C49, C52, C53, C55, C56, C72, C73, C76 to C79	Ceramic capacitors, 10 µF, 6.3 V, 20%, X7S, 0603, low ESR	TDK, C1608X7S0J106M080AC
2	9	C33, C39, C41, C50, C51, C57 to C60	Ceramic capacitors, 0.1 µF, 10 V, 10%, X7S, 0201	Murata, GRM033C71A104KE14D
3	7	C45, C47, C64 to C67, C70	Ceramic capacitors, 22 µF, 10 V, 20%, X7S, 0805, low ESR	TDK, C1608X7S0J106M080AC
4	1	C63	Ceramic capacitor, 680 pF, 50 V, 5%, C0G, 0402	Murata, GRM1555C1H681JA01D
5	1	C68	Ceramic capacitor, 6.8 pF, 50 V, 0.05 pF, C0G, 0402, AEC-Q200	Murata, GCQ1555C1H6R8WB01D
6	3	L1 to L3	Shielded power inductors, wirewound, 0.08 µH, 20%, 1 MHz, 21.4 A, 0.0018 Ω, 1515, AEC-Q200	Coilcraft, XEL4020-800MEC
7	1	R11	SMD resistor, 3.32 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF3321X
8	2	R8, R12	SMD resistors, 174 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF1743X
9	1	R13	SMD resistor, 274 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW0402274KFKED
10	1	R17	SMD resistor, 140 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW0402140KFKED
11	1	R18	SMD resistor, 100 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF1003X
12	1	R19	SMD resistor, 100 kΩ, 5%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW0402100KJNED
13	2	R6, R20	SMD resistors, 243 kΩ, 1%, 1/16 W, 0402	YAGEO, RC0402FR-07243KL
14	3	U1 to U3	5 V, 15 A synchronous step-down Silent Switchers	Analog Devices, LTC3313EV#PBF
Additional Demo Board Circuit Components				
1	6	C1, C2, C4, C26, C27, C29	Tantalum capacitors, 470 µF, 6.3 V, 20%, 7343-40, very low ESR, 0.005 Ω	KEMET, T530Y477M006ATE005
2	7	C5, C6, C8, C25, C54, C69, C71	Ceramic capacitors, 0.1 µF, 16 V, 10%, X7R, 0402, AEC-Q200	Murata, GCM155R71C104KA55D
3	6	C9, C10, C12, C21, C22, C24	Ceramic capacitors, 10 µF, 6.3 V, 20%, X7S, 0603, low ESR	TDK, C1608X7S0J106M080AC
4	3	E1, E2, E4	Inductors, EMI suppression ferrite bead, 0.006 Ω maximum DC receiver, 8 A	Würth Elektronik, 74279226101
5	2	JP2, JP3	SMD resistors, 0 Ω, jumper, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2GE0R00X
6	1	Q1	Transistor, MOSFET, n-channel, 60 V, 120 A, 3LD D2PAK	Vishay, SUM50020E-GE3
7	2	R1, R2	SMD resistors, 0.02 Ω, 1%, 10 W, 2818, AEC-Q200	Vishay, WSHP2818R0200FEA
8	1	R10	SMD resistor, 249 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Stackpole Electronics, RMCF0402FT249K
9	1	R16	SMD resistor, 20 Ω, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF20R0X
10	2	R3, R4	SMD resistors, 10kΩ, 5%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW040210K0JNED
11	1	R9	SMD resistor, 1 MΩ, 1%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW04021M00FKED
12	1	U5	Fast ±150 mA power buffer	Analog Devices, LT1010CDD#PBF
Hardware: For Demo Board Only				
1	1	J1	PCB connector, UMC jack straight, 50 Ω SMD	Hirose Electric, U.FL-R-SMT-1(01)
2	1	P1	PCB connector, three position male header, unshrouded, single row, straight, 2 mm pitch, 2.70 mm solder tail	Würth Elektronik, 62000311121
3	5	TP1, TP14, TP15, TP28, TP29	PCB connectors, threaded broaching stud 10-32 fastener 0.625, use ALT_SYMBOL for C450D200 PAD	Captive Fastener, CKFH1032-10
4	13	TP3, TP5, TP10 to TP12, TP17 to TP20, TP26, TP31, TP32, TP34	PCB connectors solder terminal turrets for clip leads	Mill-Max, 2308-2-00-80-00-00-07-0
5	10	TP2, TP4, TP13, TP16, TP27, TP30, TP33, TP35 to TP37	PCB connectors solder terminal turrets	Mill-Max, 2501-2-00-80-00-00-07-0

ORDERING INFORMATION

Table 4. EVAL-LTC3313EV-MULTI-A3Z Bill of Materials

Item	Qty	Reference	Part Description	Manufacturer/Part Number
Required Circuit Components				
1	10	C48, C49, C52, C53, C55, C56, C76 to C79	Ceramic capacitors, 10 µF, 6.3 V, 20%, X7S, 0603, low ESR	TDK, C1608X7S0J106M080AC
2	6	C50, C51, C57 to C60	Ceramic capacitors, 0.1 µF, 10 V, 10%, X7S, 0201	Murata, GRM033C71A104KE14D
3	5	C64 to C67, C70	Ceramic capacitors, 22µF, 10 V, 20%, X7S, 0805, low ESR	TDK, C1608X7S0J106M080AC
4	1	C63	Ceramic capacitor, 680 pF, 50 V, 5%, C0G, 0402	Murata, GRM1555C1H681JA01D
5	1	C68	Ceramic capacitor, 6.8 pF, 50 V, 0.05 pF, C0G, 0402, AEC-Q200	Murata, GCQ1555C1H6R8WB01D
6	2	L1, L2	Shielded power inductors, wirewound, 0.08 µH, 20%, 1 MHz, 21.4 A, 0.0018 Ω, 1515, AEC-Q200	Coilcraft, XEL4020-800MEC
7	1	R11	SMD resistor, 3.32 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF3321X
8	1	R12	SMD resistor, 0 Ω jumper, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2GE0R00X
9	1	R17	SMD resistor, 140 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW0402140KFKED
10	1	R18	SMD resistor, 100 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF1003X
11	1	R19	SMD resistor, 100 kΩ 5%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW0402100KJNED
12	2	R6, R20	SMD resistor, 243 kΩ, 1%, 1/16 W, 0402	YAGEO, RC0402FR-07243KL
13	2	U1, U2	5 V, 15 A synchronous step-down Silent Switchers	Analog Devices, LTC3313EV#PBF
Additional Demo Board Circuit Components				
1	4	C1, C2, C26, C27	Tantalum capacitors, 470 µF, 6.3 V, 20%, 7343-40, very low ESR, 0.005 Ω	KEMET, T530Y477M006ATE005
2	6	C5, C6, C25, C54, C69, C71	Ceramic capacitors 0.1 µF, 16 V, 10%, X7R, 0402, AEC-Q200	Murata, GCM155R71C104KA55D
3	4	C9, C10, C21, C22	Ceramic capacitors 10 µF, 6.3 V, 20%, X7S, 0603, low ESR	TDK, C1608X7S0J106M080AC
4	2	E1, E2	Inductors, EMI suppression ferrite bead, 0.006 Ω maximum DC resistance, 8 A	Würth Elektronik, 74279226101
5	1	JP3	SMD resistor 0 Ω jumper, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2GE0R00X
6	1	Q1	Transistor, MOSFET n-channel, 60 V, 120 A, 3LD D2PAK	Vishay, SUM50020E-GE3
7	2	R1, R2	SMD resistors, 0.02 Ω, 1%, 10 W, 2818, AEC-Q200	Vishay, WSHP2818R0200FEA
8	1	R10	SMD resistor, 249 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Stackpole Electronics, RMCF0402FT249K
9	1	R16	SMD resistor, 20 Ω, 1%, 1/10 W, 0402, AEC-Q200	Panasonic, ERJ-2RKF20R0X
10	2	R3, R4	SMD resistors, 10 kΩ, 5% 1/16 W, 0402, AEC-Q200	Vishay, CRCW040210K0JNED
12	1	R9	SMD resistor, 1 MΩ, 1%, 1/16 W, 0402, AEC-Q200	Vishay, CRCW04021M00FKED
12	1	U5	Fast ±150 mA power buffer	Analog Devices, LT1010CDD#PBF
Hardware: For Demo Board Only				
1	1	J1	PCB connector, UMC straight jack, 50 Ω SMD	Hirose Electric, U.FL-R-SMT-1(01)
2	1	P1	PCB connector, three position male header, unshrouded, single row straight, 2 mm pitch, 2.70 mm solder tail	Würth Elektronik, 62000311121
3	5	TP1, TP14, TP15, TP28, TP29	PCB connectors, threaded broaching stud 10-32, fastener 0.625, use ALT_SYMBOL for C450D200 PAD	Captive Fastener, CKFH1032-10
4	13	TP3, TP5, TP10 to TP12, TP17 to TP20, TP26, TP31, TP32, TP34	PCB connectors, solder terminal turrets for clip leads	Mill-Max, 2308-2-00-80-00-00-07-0
5	10	TP2, TP4, TP13, TP16, TP27, TP30, TP33, TP35 to TP37	PCB connectors, solder terminal turrets	Mill-Max, 2501-2-00-80-00-00-07-0

ORDERING INFORMATION

NOTES

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.