LTC7815EUHF
Triple Output Synchronous Step-Up/Dual Step-Down Supply

DESCRIPTION

Demonstration circuit 2738A is a triple output synchronous step-up/dual step-down supply featuring the LTC®7815. The demonstration circuit is designed for two buck 5V/8A, 3.3V/8A outputs supplied by a boost 10V/7A output. Benefiting from this feature, the buck outputs are able to maintain regulation over a wide input voltage range of 4.5V to 36V which is suitable for automotive or other battery fed applications. Also, the demonstration circuit uses a drop-in layout that the main buck circuit components fit in an area of three-quarter inches by 1.5 inches, while the main boost circuit area is three-quarter inches by 1.75 inches. The package style for the LTC7815 is a 38-pin exposed pad QFN.

The main features of the board include rail tracking (buck channels only), an internal 5V linear regulator for bias, separated RUN pins for each output, a PGOOD signal (CH1 only), an over voltage indicator for CH3 and a mode selector that allow the converter to run in CCM, pulse-skipping or Burst Mode® operation. Synchronization to an external clock is also possible. The LT7815 data sheet gives a complete description of these parts, operation and application information. The data sheet must be read in conjunction with this quick start guide for demo circuit 2738A.

Design files for this circuit board are available at http://www.linear.com/demo/DC2738A

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

Table 1

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	Input Supply Range		4.5		36	V
V_{OUT1}	Output1 Voltage Range	V_{IN} = 4.5V – 36V, I_{OUT1} = 0A to 8A	4.9	5.0	5.1	V
V_{OUT2}	Output2 Voltage Range	V_{IN} = 4.5V – 36V, I_{OUT2} = 0A to 8A	3.2	3.3	3.4	V
V_{OUT3}	Output3 Voltage Range	I_{OUT3} = 0A to 7A*, V_{IN} = 4.5V to 10V†	9.80	10.0	10.20	V
f_{SW}	Typical Free Running Switching Frequency			2000		kHz
	Efficiency See Figures 3, 4 and 5 for Efficiency Curves	V_{IN} = 12V, V_{OUT1} = 5V, I_{OUT1} = 8A		92		%
		V_{IN} = 12V, V_{OUT2} = 3.3V, I_{OUT2} = 8A		88.5		%
		V_{IN} = 5V, V_{OUT3} = 10V, I_{OUT3} = 7A*		89.5		%

† When $V_{IN} > V_{OUT3}$ then V_{OUT3} follows V_{IN}

* Maximum output current roughly equivalent to full load from V_{OUT1} and V_{OUT2}

QUICK START PROCEDURE

Demonstration circuit 2738A is easy to set up to evaluate the performance of the LTC7815. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

NOTE: When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the V_{IN} or V_{OUT} and GND terminals or directly across relevant capacitor. See Figure 2 for proper scope probe technique.

1. Place jumpers in the following positions:

JP1	ON
JP2	ON
JP3	Burst Mode
JP4	ON

2. With power off, connect the input power supply to V_{IN} and GND.

3. Turn on the power at the input.

   NOTE: Make sure that the input voltage does not exceed 36V.

4. Check for the proper output voltages.

   V_{OUT1} = 4.9V to 5.1V

   V_{OUT2} = 3.2V to 3.4V

   V_{OUT3} = 9.800V to 10.200V (If V_{IN} is higher than 10V then V_{OUT3} equals to V_{IN}.)

   NOTE: If there is no output, temporarily disconnect the load to make sure that the load is not set too high.

5. Once the proper output voltages are established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

QUICK START PROCEDURE

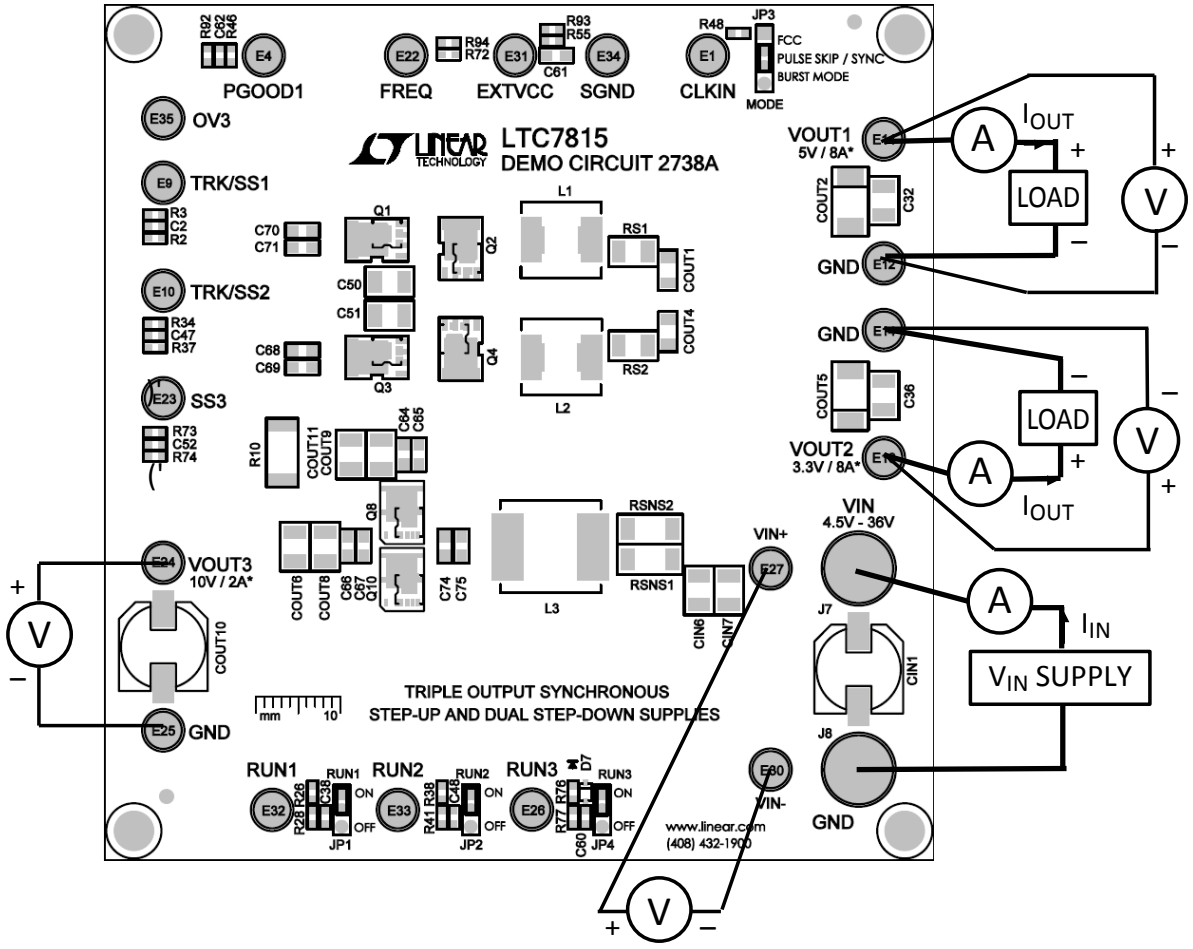


Figure 1. Proper Measurement Equipment Setup. (Please Note Polarity on V_{OUT2})

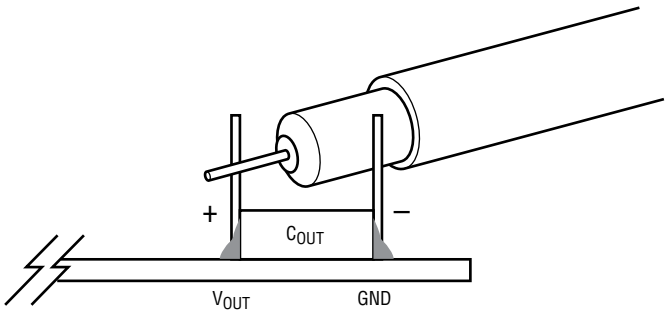


Figure 2. Measuring Input or Output Ripple Across Terminals or Directly Across Bulk Capacitor

QUICK START PROCEDURE

FREQUENCY SYNCHRONIZATION AND MODE SELECTION

The demonstration circuit 2738A's mode selector allows the converter to run in FCC operation, pulse-skipping operation, Burst Mode operation or be synchronizing to an external clock by changing the position of JP3.

For synchronizing to an external clock source, JP3 jumper needs to be removed. Apply the external clock from CLKIN turret to GND. Refer to Table 2 and to the data sheet for more details.

RAIL TRACKING

Demonstration circuit 2738A is configured for an onboard soft-start circuit. The soft-start ramp rate can beadjusted by changing the value of C2 and C47. Demonstration circuit 2738A can also be modified to track an external reference. Refer to Table 3 and Table 4 for tracking options and to the data sheet for more details.

OPTIONAL INDUCTOR DCR CURRENT SENSING

Demonstration circuit 2738A provides an optional circuit for inductor DCR current sensing. Inductor DCR current sensing uses the DCR of the inductor to sense the inductor current instead of discrete sense resistors. The advantages of DCR sensing are lower cost, reduced board space and higher efficiency, but the disadvantage is a less accurate current limit. If DCR sensing is used, be sure to select an inductor current with a sufficiently high saturation current or use an iron powder type material.

Table 2. Mode Selection and Synchronizing Operation Options

CONFIGURATION	MODE/PLLIN JUMPER
Forced CCM Mode Operation	FCC
Pulse-Skipping Mode Operation	PULSE SKIP/SYNC
Burst Mode Operation	BURST MODE
Synchronize to Ext. Clock (Ext. Clock Apply to CLKIN Turret)	Remove Jumper

Table 3. V_{OUT1} Tracking Options

CONFIGURATION	R2	R3	R4	TRK/SS1 CAP
Soft-Start Without Tracking (Default)	OPEN	OPEN	0.1µF	OPEN
V_{OUT1} Tracking Scaled V_{OUT2}	Resistor	Divider	OPEN	OPEN

Table 4. V_{OUT2} Tracking Options

CONFIGURATION	R34	R37	R47	TRK/SS2 CAP
Soft-Start Without Tracking (Default)	0Ω	OPEN	0.1µF	OPEN
V_{OUT2} Equals External Ramp	0Ω	OPEN	OPEN	External Ramp
Vout2 Tracking Scaled External Ramp	Resistor	Divider	OPEN	External Ramp

QUICK START PROCEDURE

Refer to Table 5 for optional inductor DCR current sensing setup and to the data sheet for more details.

LOW QUIESCENT CURRENT APPLICATIONS AND MEASUREMENT

The typical quiescent current (I_Q) of the LTC7815 controller is 28µA in sleep mode as specified in the LTC7815 data sheet. However, the input current of the DC2738A board can be higher than this value because of additional circuit outside of the IC. To reduce the total input current, large value FB divider resistors should be used. In addition, some of the optional pull-up resistors should be removed from the board. Refer to Table 6 for the low input quiescent current setup.

MINIMUM ON-TIME CAUSES CHANNEL 2 TO SKIP PULSES

The typical minimum on-time $T_{ON(MIN)}$ of the LTC7815 is 40ns for the buck channels as specified in the data sheet. Therefore, when the input voltage is higher than 24V the SW2 may start to skip pulses at no load worst-case condition.

THERMAL DERATING OF THE BUCK CHANNELS

The maximum DC output current of each buck channel is specified at the nominal input voltage, which is 12V. At higher input voltage, because of the increased power losses, the output currents should be derated. The power devices (power MOSFETs, inductors) surface temperature must be monitored to ensure safe steady-state operation at higher input voltages.

$EXTV_{CC}$ SUPPLY

With the high switching frequency, the power losses imposed on the LTC7815 onboard gate drivers and LDO become a concern. For example: when V_{IN} equals to 36V and the gate drive current is 20mA, the LTC7815 dissipates 720mW power. If the steady-state input voltage is high, then apply an external supply voltage between 6V and 10V to the $EXTV_{CC}$ turret. Therefore, the power loss of the V_{IN} LDO can be eliminated. Ensure that the LTC7815 VBIAS pin voltage is higher than $EXTV_{CC}$ under all circumstances.

Table 5. Optional Inductor DCR Current Sensing

CONFIGURATION	CHANNEL1	RS1	R29	R30	C14	R45	R47	R61
	CHANNEL2	RS2	R39	R40	C15	R51	R53	R62
	CHANNEL3	RSNS1, 2	R80	R81	C56	R89	R90	R91
Current Sense Resistor (Default)		Ref. Sch.	Ref. Sch.	Ref. Sch.	Ref. Sch.	OPEN	OPEN	OPEN
Inductor DCR Current Sensing		0Ω Copper	OPEN	OPEN	Calculated Value from Data Sheet			0Ω

Table 6. Low Input Quiescent Current Configuration

Reference Designator	R46	R48	R92
Function	PGOOD1	MODE	OV3
Stuffing Option	OPEN	OPEN	OPEN

QUICK START PROCEDURE

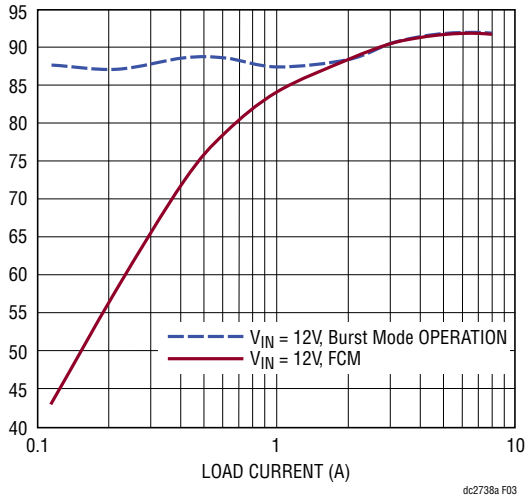


Figure 3. Channel 1 Typical Efficiency vs Load Current

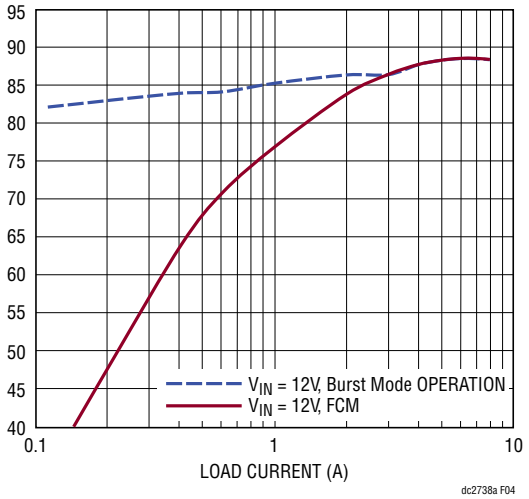


Figure 4. Channel 2 Typical Efficiency vs Load Current

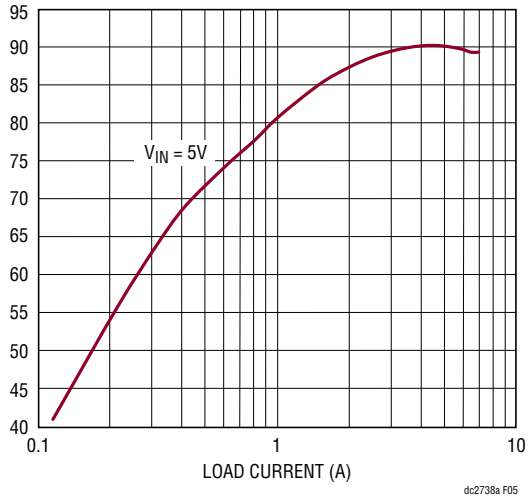


Figure 5. Channel 3 Typical Efficiency vs Load Current

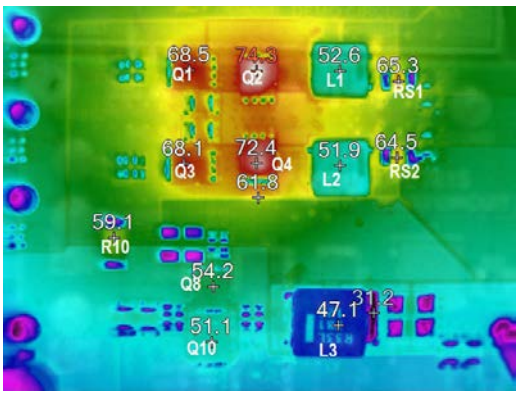


Figure 6. Thermal Image V_{IN} 12V, Vo1 5V at 8A, Vo2 3.3V at 8A, No Air Flow, T_A = 25°C

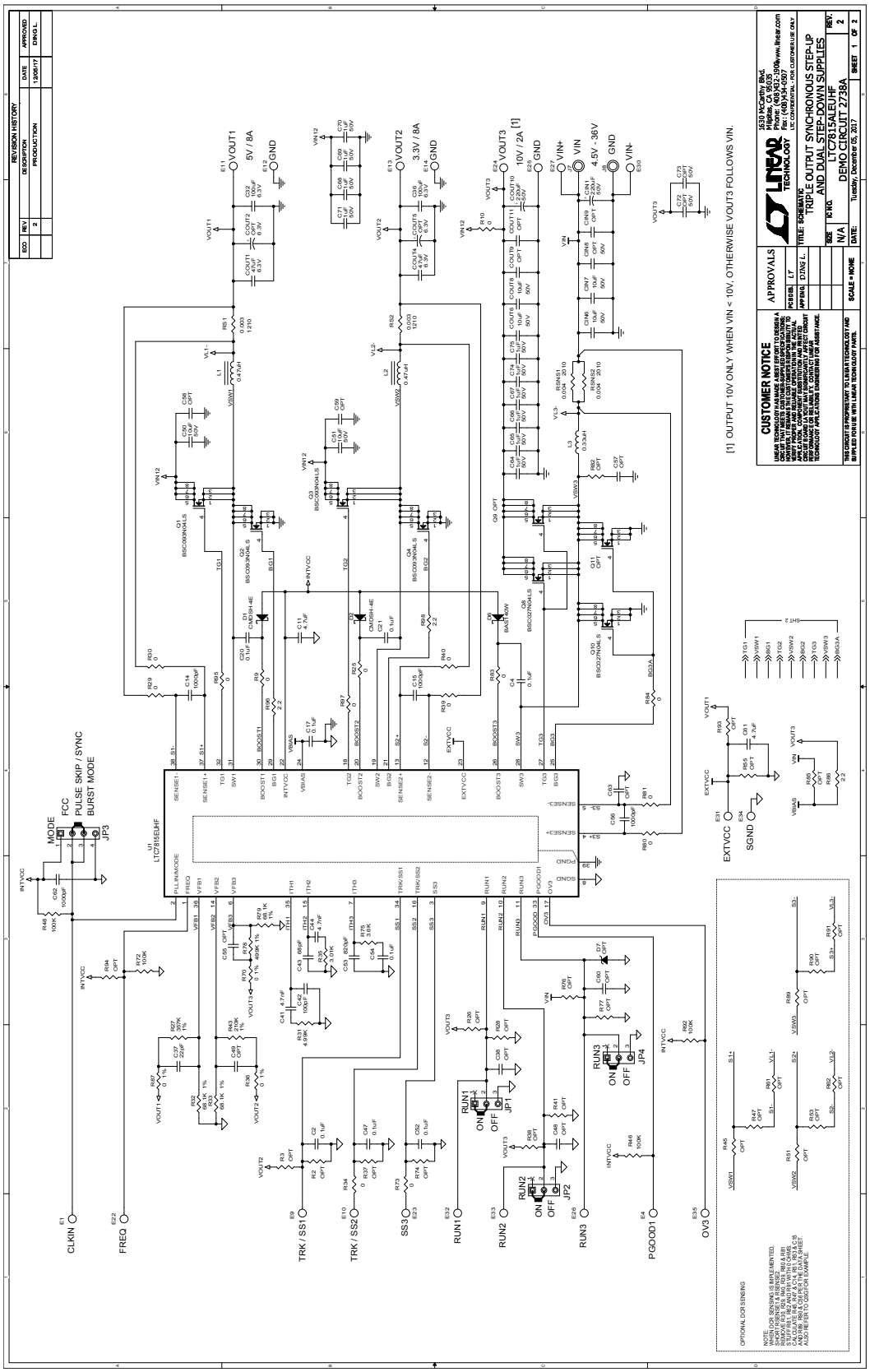
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	CIN1, COUT10	CAP, 220µF 20% 50V ELEC	SUN ELECTRONIC INDUSTRIES CORP, 50EC220LX
2	6	COUT6, CIN6, CIN7, COUT8, C50, C51	CAP, 1210 10µF 10% 50V X7S	TDK C3225X7S1H106K250AB
3	2	COUT1, COUT4	CAP, 1206 47µF 20% 10V X7R	AVX 1206ZD476KAT2A
4	8	C2, C4, C17, C20, C21, C47, C52, C54	CAP, 0603 0.1µF 10% 25V X7R	TDK C1608X7R1E104K
5	2	C11, C61	CAP, 0805 4.7µF 10% 6.3V X5R	AVX 08056D475KAT2A
6	4	C14, C15, C56, C62	CAP, 0603 1nF 10% 50V X7R	AVX 06035C102KAT2A
7	2	C32, C36	CAP, 1210 100µF 20% 6.3V X5R	TDK C3225X5R0J107M160AB
8	1	C37	CAP, 0603 22pF 10% 50V NPO	AVX 06035A220KAT2A
9	2	C41, C44	CAP, 0603 4.7nF 10% 50V X7R	AVX 06035C472KAT2A
10	1	C42	CAP, 0603 100pF 5% 50V NPO	AVX 06035A101JAT2A
11	1	C43	CAP, 0603 68pF 10% 50V NPO	AVX 06035A680KAT2A
12	1	C53	CAP, 0603 820pF 5% 50V X7R	AVX 06035A821JAT2A
13	10	C64, C65, C66, C67, C68, C69, C70, C71, C74, C75	CAP, 0805 1µF 10% 50V X7R	MURATA GRM21BR71H105KA12L
14	2	D1, D2	DIODE, SCHOTTKY SOD323	CENTRAL SEMI CMDSH-4E
15	1	D6	DIODE, SCHOTTKY 40V 0.12A SOT323-3	INFINEON BAS140W
16	2	L1, L2	IND, POWER 0.47µH	PANASONIC, ETQP4MR47KVK
17	1	L3	IND, POWER 0.33µH	PANASONIC, ETQP5MR33YLC
18	4	Q1, Q2, Q3, Q4	XSTR, N-CHANNEL MOSFET 40V 100A	INFINEON BSC093N04LS
19	2	Q8, Q10	XSTR, N-CHANNEL MOSFET 40V 100A	INFINEON BSC027N04LS
20	2	RSNS1, RSNS2	RES, 2010 0.004Ω 1% 1/2W	VISHAY WSL20104L000FEA
21	2	RS1, RS2	RES, 1210 0.003Ω 5% 1/4W	VISHAY WSL12103L000FEA
22	1	R10	RES, 2512 0Ω JUMPER	VISHAY CRCW25120000Z0EH
23	1	R27	RES, 0603 357kΩ 1% 1/10W	VISHAY CRCW0603357KFKEA
24	1	R31	RES, 0603 4.99kΩ 1% 1/10W	VISHAY CRCW06034K99FKEA
25	3	R32, R33, R79	RES, 0603 68.1kΩ 1% 1/10W	VISHAY CRCW060368K1FKEA
26	1	R35	RES, 0603 3.01kΩ 1% 1/10W	VISHAY CRCW06033K01FKEA
27	1	R43	RES, 0603 210kΩ 1% 1/10W	VISHAY CRCW0603210KFKEA
28	4	R46, R48, R72, R92	RES, 0603 100kΩ 5% 1/10W	VISHAY CRCW0603100KJNEA
29	1	R75	RES, 0603 3.6kΩ 1% 1/10W	VISHAY CRCW06033K60FKEA
30	1	R78	RES, 0603 499kΩ 1% 1/10W	VISHAY CRCW0603499KFKEA
31	3	R86, R96, R98	RES, 0603 2.2Ω 5% 1/10W	VISHAY CRCW06032R20JNEA
32	1	U1	IC, SYNCHRONOUS BOOST CONVERTER AND DUAL BUCK CONVERTER	LINEAR TECH LTC7815EUHF

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Circuit Components				
1	0	CIN8, COUT9, CIN9, COUT11, C58, C59	CAP, 1210 OPTION	OPTION
2	0	COUT2, COUT5	CAP, 7343 OPT	OPTION
3	0	C38, C48, C49, C55, C57, C60, C63	CAP, 0603 OPTION	OPTION
4	0	C72, C73	CAP, 0805 OPTION	OPTION
5	0	D7	DIODE, ZENER OPTION SOD323	OPTION
6	0	Q9, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q19, Q20, Q21, Q22, Q23	XSTR, OPTION	OPTION
7	0	R2, R3, R26, R28, R37, R38, R41, R45, R47, R51, R53, R55, R61, R62, R74, R76, R77, R85, R89, R90, R91, R93, R94	RES, 0603 OPTION	OPTION
8	17	R9, R25, R29, R30, R34, R36, R39, R40, R70, R73, R80, R81, R83, R84, R87, R95, R97	RES, 0603 0Ω JUMPER	VISHAY CRCW06030000Z0EA
9	0	R82	RES, 1206 OPTION	OPTION
Hardware: For Demo Board Only				
1	20	E1, E4, E9, E10, E11, E12, E13, E14, E22, E23, E24, E25, E26, E27, E30, E31, E32, E33, E34, E35	TESTPOINT, TURRET, 0.094'	MILL-MAX 2501-2-00-80-00-00-07-0
2	3	JP1, JP2, JP4	HEADER, 3PIN, 2mm	Wurth Elektronik, 620 003 111 21
3	1	JP3	HEADER, 4PIN	Wurth Elektronik, 620 004 111 21
4	2	J7, J8	JACK, BANANA	KEYSTONE 575-4
5	4	XJP1, XJP2, XJP3, XJP4	SHUNT, 2mm	Wurth Elektronik, 608 002 134 21
6	4		STANDOFF, SNAP ON	Wurth Elektronik, 702 935 000

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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