

LTC7821EUH High Density Hybrid Step-Down Synchronous Converter

DESCRIPTION

Demonstration circuit 2513A is a high efficiency, high power density hybrid converter. It can deliver 12V/20A with an input voltage from 36V to 72V. This demo board features the [LTC[®]7821](#), which uses an architecture that merges soft-switching switched-capacitor topology with a traditional step-down converter to provide superior efficiency compared to the traditional switching architectures. It offers a high efficiency/high density and cost effective solution for nonisolated intermediate bus applications in power distribution, datacom and telecom as well as emerging 48V automotive systems.

External MOSFETs switch at a 500kHz fixed frequency for this demo board and can be programmed from 200kHz to 1.5MHz. The LTC7821's powerful 1Ω N-channel MOSFET gate drivers maximize efficiency and can drive multiple MOSFETs in parallel for higher power applications. Due to its current mode control architecture, multiple LTC7821s can be operated in a parallel, multiphase configuration with excellent current sharing and low output voltage ripple to enable much higher power applications. Other benefits include low EMI emissions due to a soft-switched front end and reduced MOSFET stress.

The LTC7821 design eliminates the inrush current typically associated with switched capacitor circuits by pre-balancing the capacitors on start-up. The LTC7821 also monitors system voltage, current and temperature for faults, and uses a sense resistor for overcurrent protection. It stops switching and pulls the $\overline{\text{FAULT}}$ pin low when a fault condition occurs. An onboard timer can be set for appropriate restart/retry times.

Additional features include $\pm 1\%$ output voltage accuracy over temperature, a clock output for multiphase operation, a power good output signal, short-circuit protection, monotonic output voltage start-up, optional external reference, undervoltage lockout and internal charge balance circuitry.

The LTC7821 data sheet must be used in conjunction with this demo board manual.

Design files for this circuit board are available at <http://www.linear.com/demo/DC2513A>

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

PARAMETER	CONDITION	VALUE
Input Voltage Range		36V to 72V
Output Voltage, V_{OUT}	$V_{\text{IN}} = 36\text{V to } 72\text{V}, I_{\text{OUT}} = 0\text{A to } 20\text{A}$	12V
Maximum Output Current, I_{OUT}	$V_{\text{IN}} = 36\text{V to } 72\text{V}, V_{\text{OUT}} = 12\text{V}$	20A
Typical Efficiency	$V_{\text{IN}} = 48\text{V}, V_{\text{OUT}} = 12\text{V}, I_{\text{OUT}} = 20\text{A}$	97.3% ¹
Peak Efficiency	$V_{\text{IN}} = 48\text{V}, V_{\text{OUT}} = 12\text{V}$	97.5% ¹
Switching Frequency		500kHz

Note 1: Tested with external 8V bias.

QUICK START PROCEDURE

Demonstration circuit 2513A is easy to set up to evaluate the performance of the LTC7821. Refer to Figure 1 for the proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input power supply to V_{IN} (36V to 72V) and GND (input return).
2. Connect the output loads between V_{OUT} and GND (Initial load: no load). Refer to Figure 1.
3. Connect the DVMs to the input and output.
4. Check the default jumper/switch position: SW1 (RUN): OFF; JP2 (BIAS): ON.
5. Turn on the input power supply and adjust voltage to 48V;
NOTE. Make sure that the input voltage does not exceed 72V.
6. Turn on the switches: SW1: ON.
7. Check for the proper output voltages from VO_{SNS+} to VO_{SNS-} .
8. Once the proper output voltage is established, adjust the loads within the operating range and measure the efficiency, output ripple voltage and other parameters.
9. After completing all tests, adjust the load to 0A, power off the input power supply.

Notes:

1. When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 2 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (-) terminals of an output capacitor. The probe's ground ring needs to touch the (-) lead and the probe tip needs to touch the (+) lead.
2. When doing the load step test with the onboard dynamic load circuit, please make sure the load step-up pulse duty cycle does not exceed 2% and the pulse duration is less than 500 μ s so that the temperature of the MOSFETs Q9, Q10 in the dynamic load circuit stay in the safe region. Instead of using the onboard dynamic load circuit, an electric load can also be used for the load step test, which does not have the 2% max duty cycle limit for the load step.

External $EXTV_{CC}$ Option

By default, the $EXTV_{CC}$ pin of the LTC7821 on the DC2513A board is connected to the output of the on-board bias circuit with R24 (0 Ω). Please follow the below procedure if an external power supply is used to bias the LTC7821 $EXTV_{CC}$ pin. (Do not float this pin.)

1. Remove R24 on the board.
2. Apply a DC voltage ($7V < EXTV_{CC} < 40V$) on the $EXTV_{CC}$ pin and the GND turret after the input voltage is established/ Make sure $EXTV_{CC} < V_{IN}$.
3. Turn off the DC bias on $EXTV_{CC}$ before powering off the input power supply.

QUICK START PROCEDURE

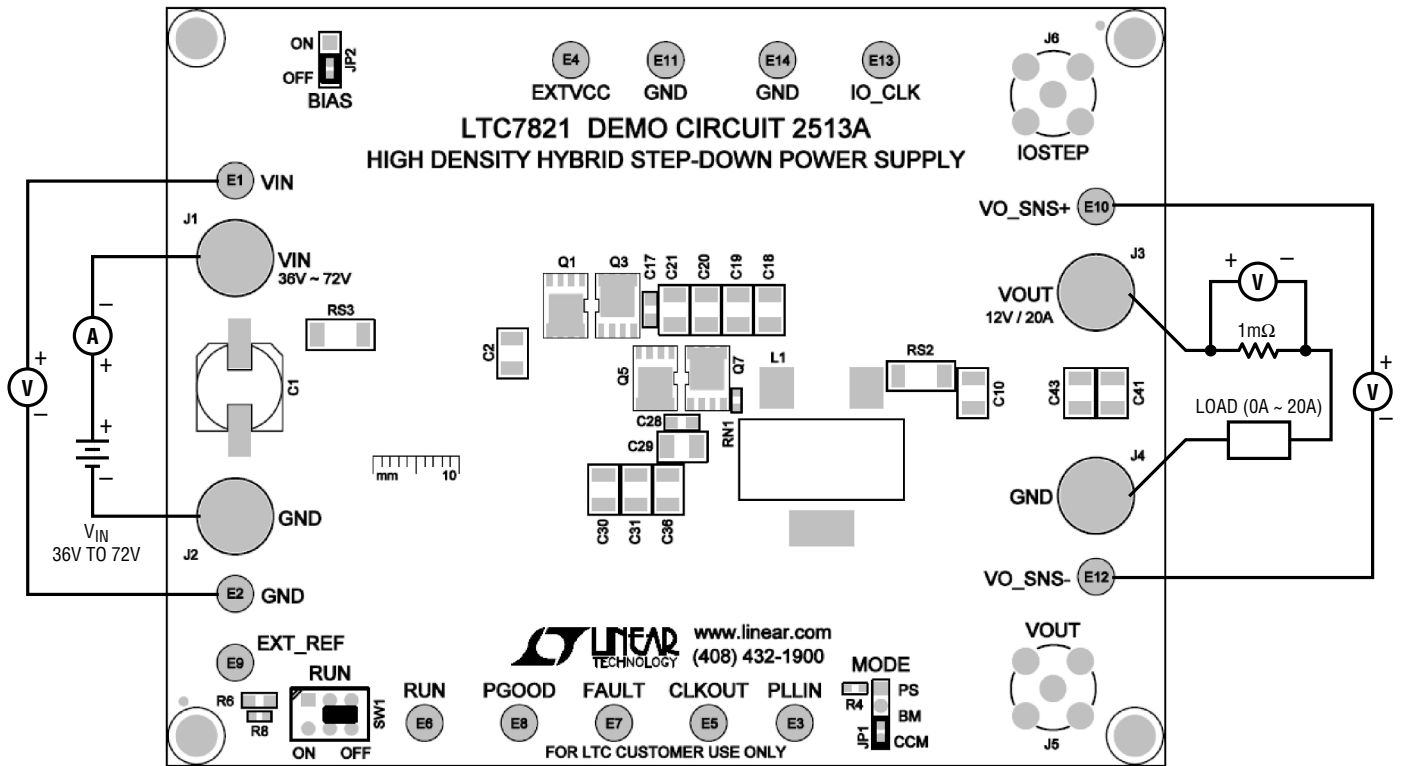


Figure 1. Proper Measurement Equipment Setup

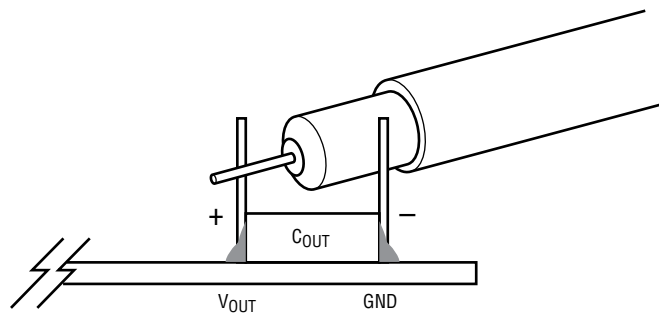
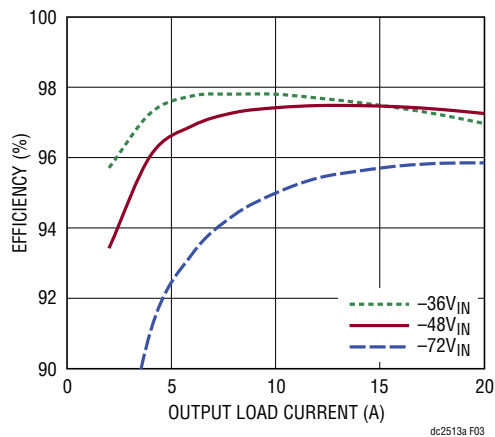


Figure 2. Measuring Output Voltage Ripple

QUICK START PROCEDURE



**Figure 3. Efficiency vs Load Current at $V_{IN} = 36V \sim 72V$, $V_{OUT} = 12V$, $f_{SW} = 500kHz$
Note: Tested with External 8V Bias**

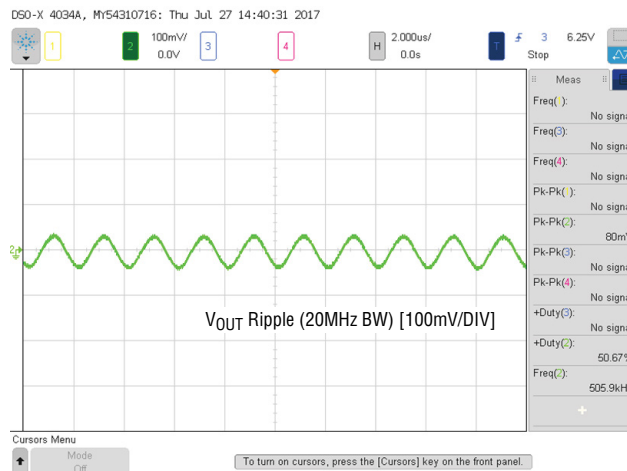
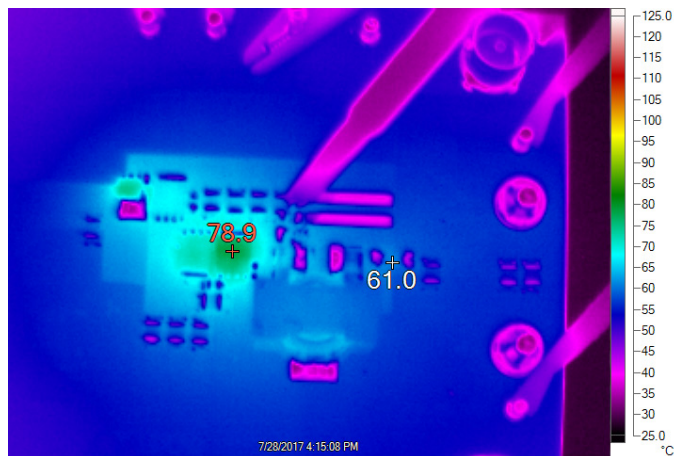


Figure 4. Output Voltage Ripple at $V_{IN} = 48V$, $V_{OUT} = 12V$, $I_{OUT} = 20A$, $f_{SW} = 500kHz$



Figure 5. Load Step at $V_{IN} = 48V$, $V_{OUT} = 12V$



**Figure 6. Thermal Performance $V_{IN} = 48V$, $V_{OUT} = 12V$, $I_{OUT} = 20A$, $T_A = 23^\circ C$, No Airflow
Note: Tested with External 8V Bias**

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	CAP, 33µF 20% 80V POLYMER HYBRID ALUM ELEC	PANASONIC EEHA1K330P
2	8	C2, C3, C47, C49, C56, C57, C58, C59	CAP, 1210 2.2µF 10% 100V X7R	MURATA GRM32DR72A225KA12K
3	4	C4, C5, C15, C37	CAP, 0603 0.1µF 10% 100V X7R	MURATA GRM188R72A104KA35D
4	1	C6	CAP, 0805 4.7µF 10% 16V X7R	MURATA GRM21BR71C475KA73K
5	1	C7	CAP, 0805 4.7µF 10% 25V X7R	MURATA GRM21BR71E475KA73L
6	2	C8, C40	CAP, 0603 0.22µF 10% 25V X7R	MURATA GRM188R71E224KA88D
7	1	C9	CAP, 0603 0.47µF 10% 25V X7R	MURATA GRM188R71E474KA12D
8	19	C10, C18, C19, C20, C21, C22, C23, C24, C25, C29, C30, C31, C32, C33, C34, C35, C36, C41, C43	CAP, 1210 10µF 10% 50V X7R	MURATA GRM32ER71H106KA12L
9	2	C17, C28	CAP, 0805 2.2µF 10% 50V X7R	TDK C2012X7R1H225K125AC
10	3	C26, C27, C50	CAP, 0603 1µF 20% 25V X5R	AVX 06033D105MAT2A
11	1	C39	CAP, 6800pF, X7R, 50V, 10%, 0603	AVX 06035C682KAT2A
12	2	C42, C44	CAP, 150µF 20% 16V	PANASONIC 16SVPC150M
13	1	C45	CAP, 56pF, COG, 25V, 5%, 0603	MURATA GRM1885C1H560JA01D
14	2	C52, C53	CAP, 1210 22µF 10% 25V X5R	AVX 12103D226KAT2A
15	1	C54	CAP, 0603 47nF 10% 25V X7R	AVX 06033C473KAT2A
16	1	C55	CAP, 0603 220pF 10% 50V X7R	AVX 06035C221KAT2A
17	3	D1, D2, D3	DIODE, SCHOTTKY	CENTRAL SEMI. CMDSH-4E-TR LEAD-FREE
18	1	L1	IND, 2µH 20%	COILCRAFT SER2011-202MLD
19	1	L2	IND, 68µH	COILCRAFT LPS6225-683MRB
20	1	Q1	XSTR, N-CHANNEL MOSFET	INFINEON BSZ070N08LS5ATMA1
21	2	Q3, Q5	XSTR, N-CHANNEL MOSFET	INFINEON BSC032N04LS
22	1	Q7	XSTR, N-CHANNEL MOSFET	INFINEON BSC014N04LSI
23	2	Q9, Q10	XSTR, MOSFET N-CHANNEL 40V TO-252	VISHAY SILICONIX SUD50N04-8M8P-4GE3
24	4	RS1, RS2, RS3, RS4	RES, 2010 0.001Ω 1% 2W	PANASONIC ERJ-MP3PF1M0U
25	2	R1, R7	RES, 0603 1kΩ 1% 0.1W	VISHAY CRCW06031K00FKEA
26	1	R2	RES, 0603 2.2Ω 5% 0.1W	VISHAY CRCW06032R20JNEA
27	1	R4	RES, 0603 20kΩ 1% 0.1W	VISHAY CRCW060320K0FKEA
28	7	R5, R10, R12, R19, R20, R24, R32	RES, 0603 0Ω JUMPER	VISHAY CRCW06030000Z0EA
29	1	R6	RES, 0805 1MΩ 1% 0.125W	VISHAY CRCW08051M00FKEA
30	1	R8	RES, 0603 39.2kΩ 1% 1/10W	VISHAY CRCW060339K2FKEA
31	3	R9, R13, R28	RES, 0603 10kΩ 1% 0.1W	VISHAY CRCW060310K0FKEA
32	1	R15	RES, 0603 100kΩ 1% 0.1W	VISHAY CRCW0603100K0FKEA
33	1	R16	RES, 0603 68kΩ 1% 0.1W	VISHAY CRCW060368K0FKEA
34	1	R17	RES, 0805 6.81kΩ 1% 0.1W	VISHAY CRCW08056K81FKEA
35	1	R18	RES, 0603 29.4kΩ 1% 1/10W	VISHAY CRCW060329K4FKEA
36	1	R23	RES, 0805 60.4kΩ 1% 0.125W	VISHAY CRCW080560K4FKEA

DEMO MANUAL DC2513A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
37	1	R25	RES, 0603 4.32k Ω 1% 0.1W	VISHAY CRCW06034K32FKEA
38	1	R26	RES, 0603 182k 1% 0.1W	VISHAY CRCW0603182KFKEA
39	1	R27	RES, 0603 20k Ω 5% 0.1W	VISHAY CRCW060320K0JNEA
40	1	R29	RES, 0603 80.6k Ω 1% 0.1W	VISHAY CRCW060380K6FKEA
41	1	R30	RES. 2010 0.1 Ω 1% 1W	VISHAY WSL2010R1000FEA18
42	1	U1	IC	LINEAR TECH. LTC7821EUH#PBF
43	1	U2	IC, SYNCHRONOUS STEP-DOWN CONVERTER	LINEAR TECH. LTC3630EMSE#PBF

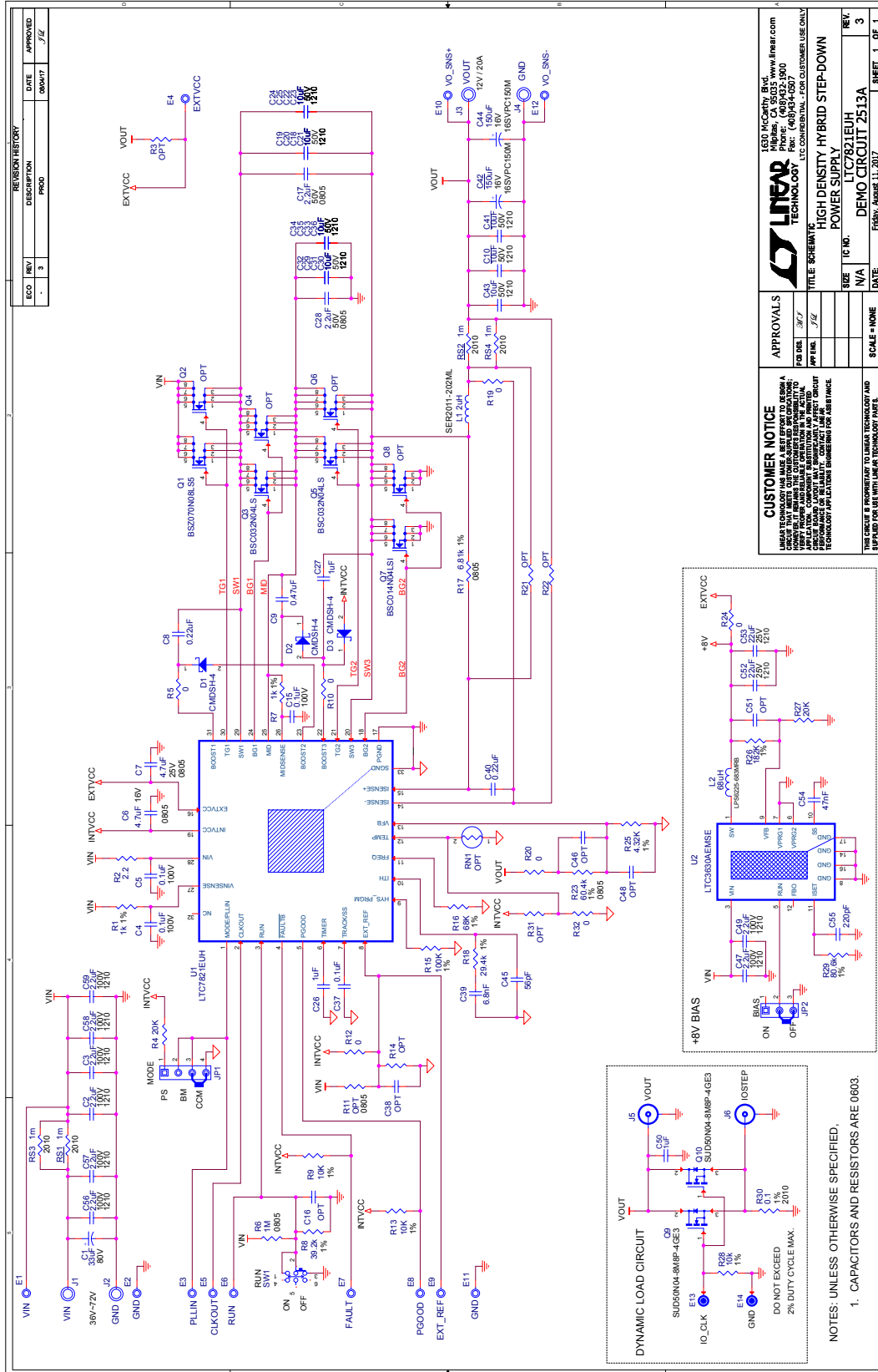
Required Circuit Components

1	0	C16, C38, C46, C48, C51	CAP, 0603 OPTION	OPTION
2	0	R3, R11, R14, R21, R22, R31	RES, 0603 OPTION	OPTION
3	0	Q2, Q4, Q6, Q8	XSTR, N-CHANNEL MOSFET OPTION	OPTION

Additional Demo Board Circuit Components

1	14	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14	TURRET	MILL-MAX 2501-2-00-80-00-00-07-0
2	1	JP1	HEADER, 4-PIN, 2mm	WURTH ELEKTRONIK 62000411121
3	1	JP2	HEADER, 3-PIN 2mm	WURTH ELEKTRONIK 62000311121
4	4	J1, J2, J3, J4	JACK, BANANA	KEYSTONE 575-4
5	2	J5, J6	CON, BNC, 5 PINS	CONNEX 112404
6	1	SW1	SWITCH, SUBMINATURE SLIDE	C&K COMPONENTS, JS202011CQN
7	2	XJP1, XJP2	SHUNT 2mm	WURTH ELEKTRONIK 60800213421
8	4		STANDOFF, SNAP ON	KEYSTONE 8834

SCHEMATIC DIAGRAM



REVISION HISTORY			
ECO	REV	DESCRIPTION	DATE
	3		08/04/17
	3		JEL

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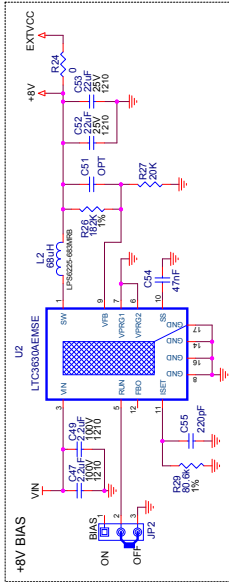
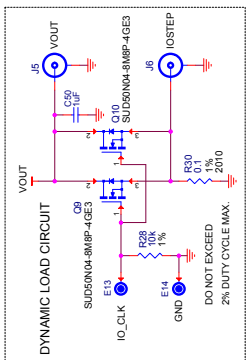
APPROVALS

DESIGNER	JEL
APP'G	JEL
SCALE	NONE

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POWER SUPPLY
 HIGH DENSITY HYBRID STEP-DOWN
 LTC831EUH
 DEMO CIRCUIT 2513A

DATE: Friday, August 11, 2017
 SHEET 1 OF 1



NOTES: UNLESS OTHERWISE SPECIFIED,
 1. CAPACITORS AND RESISTORS ARE 0603.



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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