

LTC7821

High Efficiency, Polyphase Hybrid Step Down Converter

DESCRIPTION

Demonstration circuit 2787A is a high efficiency, 4 phase, hybrid converter. It can deliver 12V/100A with the input voltage from 40V to 60V. The demo board features the [LTC®7821](#), which uses an architecture that merges a 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 400kHz 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 LTC7821 devices 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 prebalancing 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 **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.](#)

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

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		40		60	V
Output Voltage, V_{OUT}	$V_{IN} = 40\text{-}60\text{V}$, $I_{OUT} = 0\text{A to } 100\text{A}$		12		V
Maximum Output Current, I_{OUT}	$V_{IN} = 40\text{-}60\text{V}$, $V_{OUT} = 12\text{V}$		100		A
Typical Efficiency	$V_{IN} = 48\text{V}$, $V_{OUT} = 12\text{V}$, $I_{OUT} = 100\text{A}$		97.6		%
Peak Efficiency	$V_{IN} = 48\text{V}$, $V_{OUT} = 12\text{V}$		98		%
Switching Frequency			400		kHz

BOARD PHOTO

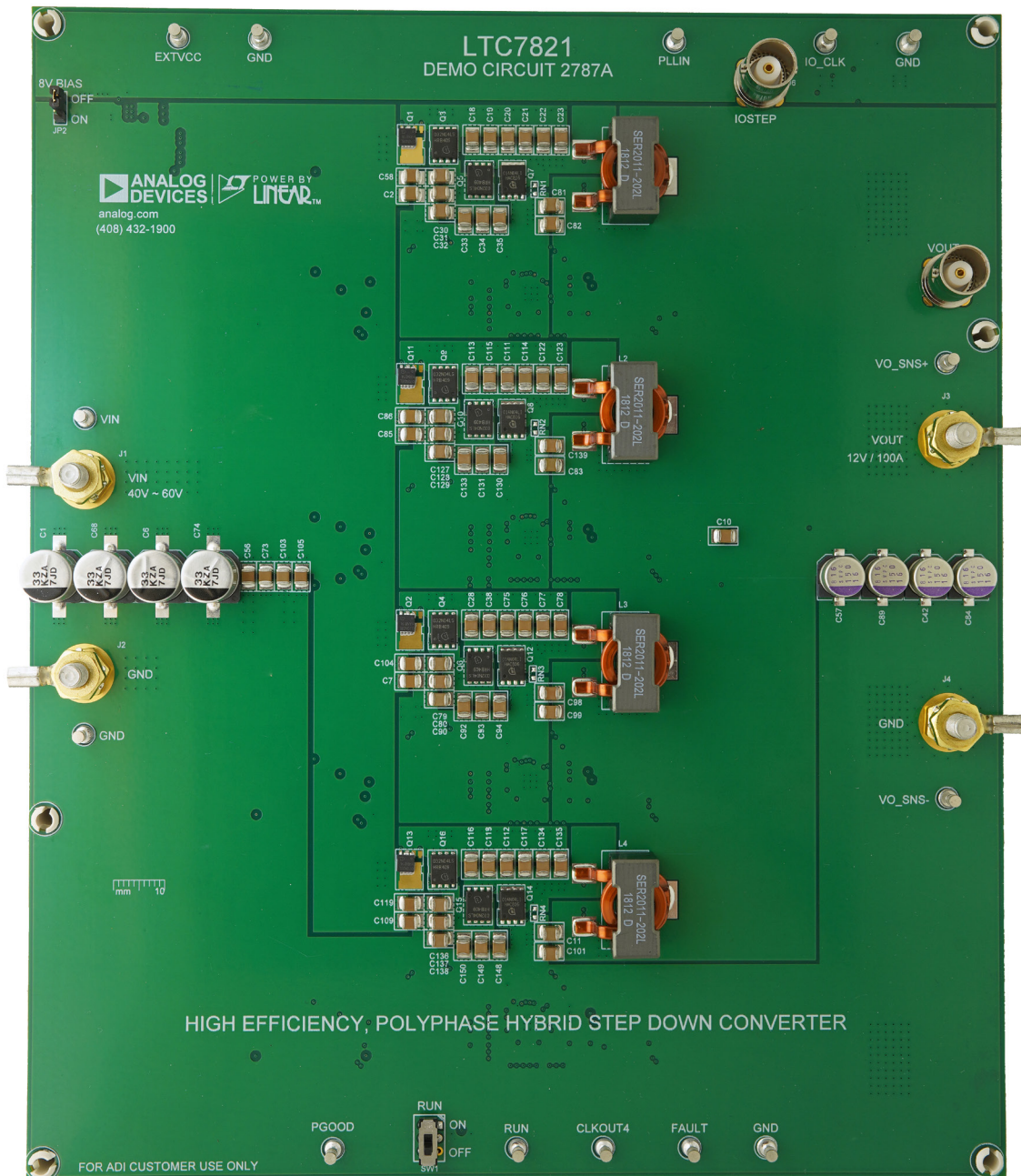


Figure 1. 4x LTC7821; 100A DC2787A Demo Circuit

QUICK START PROCEDURE

Demonstration circuit 2787A is easy to set up to evaluate the performance of the LTC7821. Refer to Figure 2 for the proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input power supply to V_{IN} (40V-60V) and GND (input return).
2. Connect the output loads between V_{OUT} and GND (**Initial load: no load**). Refer to Figure 2.
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 60V.
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 3 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 on-board 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 Q20, Q21 in the dynamic load circuit stay in the safe region. Instead of using the on-board 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.

DEMO MANUAL DC2787A

QUICK START PROCEDURE

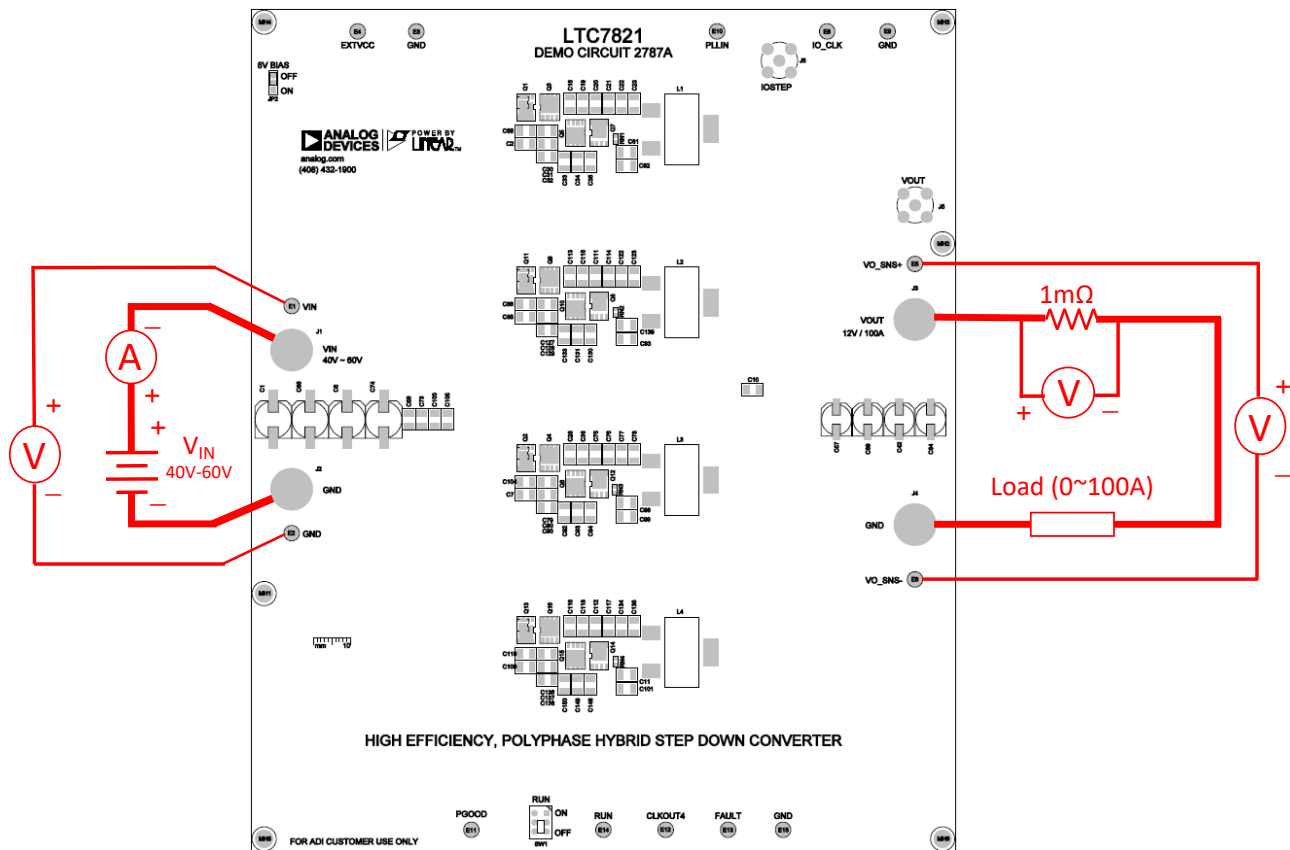


Figure 2. Proper Measurement Equipment Setup

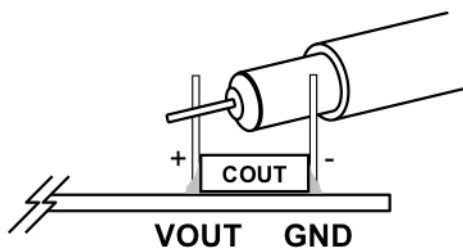


Figure 3. Measuring Output Voltage Ripple

QUICK START PROCEDURE

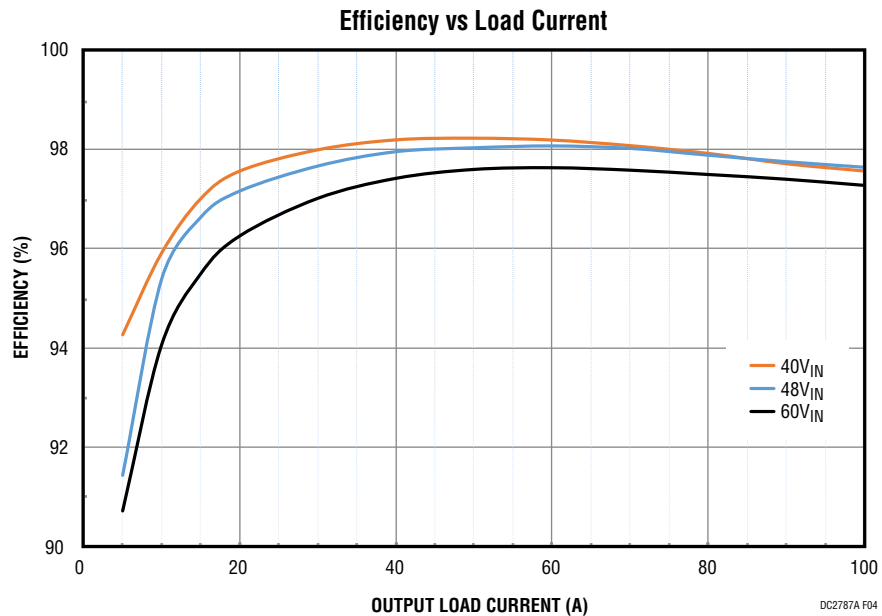


Figure 4. Efficiency vs Load Current at $V_{OUT} = 12V$, $f_{SW} = 400kHz$

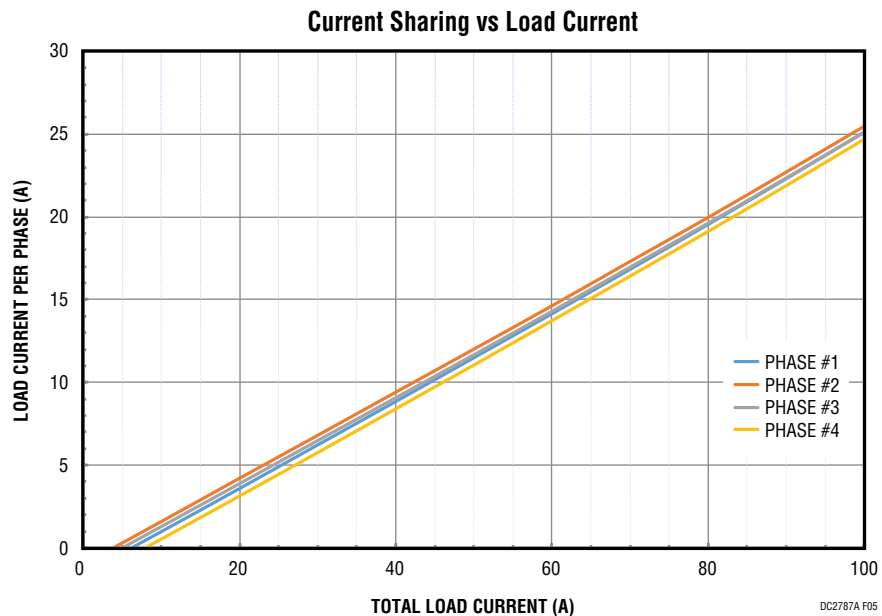


Figure 5. Current Sharing vs Load Current at $V_{IN} = 48V$, $V_{OUT} = 12V$, $f_{SW} = 400kHz$

QUICK START PROCEDURE

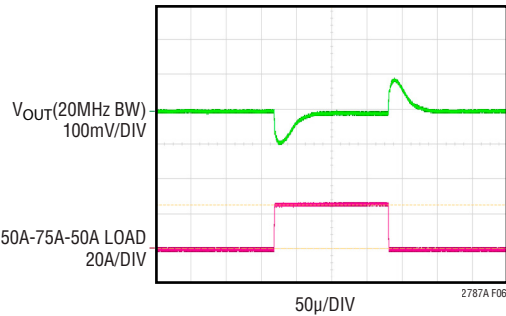


Figure 6. Load Step at V_{IN} = 48V, V_{OUT} = 12V

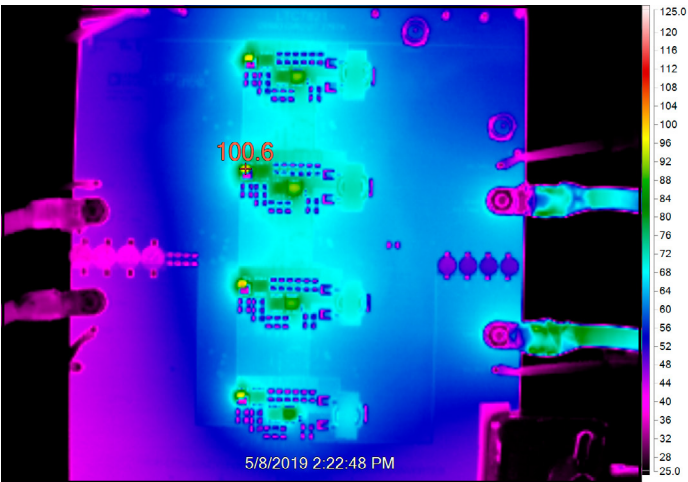


Figure 7. Thermal performance V_{IN} = 48V, V_{OUT} = 12V, I_{OUT} = 100A T_A = 23°C, No Airflow

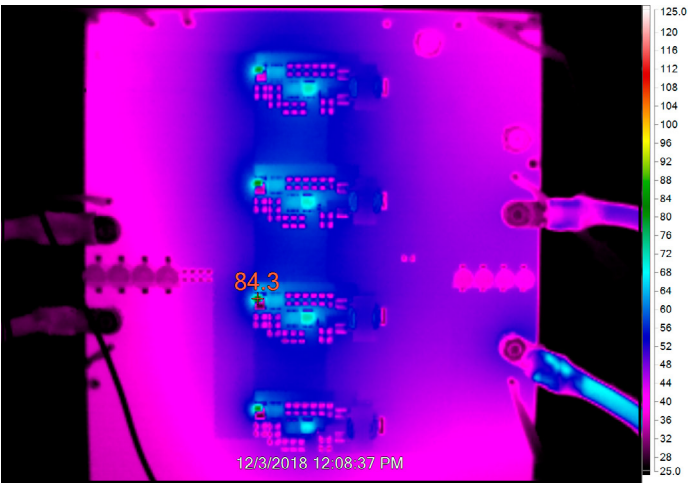


Figure 8. Thermal performance V_{IN} = 48V, V_{OUT} = 12V, I_{OUT} = 100A T_A = 23°C, 200LFM Airflow

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	8	C1, C6, C68-C70, C74, C153, C154	CAP,33uF,ALUM. ELECT.,80V,20%,10x10.2mm SMD, RADIAL,AEC-Q200	PANASONIC, EEHZA1K330P
2	26	C2, C3, C7, C47, C49, C56, C58, C59, C71-C73, C85-C88, C103-C105, C109, C119, C203, C206-C210	CAP,2.2uFX7R,100V,10%,1210	AVX, 12101C225KAT2A
3	16	C4, C5, C12, C13, C15, C17, C37, C91, C95, C107, C166, C169, C174, C175, C287, C288	CAP,0.1uFX7S,100V,10%,0603	TAIYO YUDEN, HMK107C7104KA-T
4	8	C8, C14, C40, C106, C108, C165, C167, C170	CAP,0.22uFX7R,25V,10%,0603	YAGEO, CC0603KRX7R8BB224
5	4	C9, C102, C164, C173	CAP,0.47uFX7R,25V,10%,0603	AVX, 06033C474KAT2A
6	113	C10, C11, C18-C25, C28-C36, C38, C41, C43, C60-C67, C75-C83, C90, C92-C94, C98-C101, C111-C118, C121-C150, C176-C202, C216	CAP,10uFX7S,100V,10%,1210	MURATA, GRM32EC72A106KE05L
7	4	C26, C120, C157, C158	CAP,2.2uFX5R,25V,10%,0603	MURATA, GRM188R61E225KA12D
8	5	C27, C50, C96, C159, C162	CAP,1uFX7R,25V,10%,0603,AEC-Q200	MURATA, GCM188R71E105KA64D
9	1	C39	CAP,4.7nF,X7R,25V,10%,0603	AVX, 06033C472KAT2A
10	8	C42, C44, C57, C84, C89, C97, C152, C155	CAP,150uF,ALUM./OS-CON,16V,20%,8x6.9mm SMD, RADIAL	PANASONIC, 16SVPC150M
11	4	C45, C110, C156, C215	CAP,27pF,C0G,250V,5%,0603	MURATA, GQM1875C2E270JB12D
12	2	C52, C53	CAP,22uFX5R,25V,10%,1210	MURATA, GRM32ER61E226KE15K
13	1	C54	CAP,0.047uFX7R,25V,10%,0603	AVX, 06033C473KAT2A
14	1	C55	CAP,220pF,C0G,50V,5%,0603	AVX, 06035A221JAT2A
15	4	C255, C257, C259, C261	CAP,4.7uFX5R,16V,10%,0603	MURATA, GRM188R61C475KE11D
16	4	C256, C258, C260, C262	CAP,4.7uFX5R,50V,10%,0805	MURATA, GRM21BR61H475KE51L
17	12	D1-D6, D11-D16	DIODE,SCHOTTKY,40V,250mW,SOD-323	CENTRAL SEMI., CMDSH-4E TR Lead Free
18	4	L1-L4	IND.,2uH,PWR, SHIELDED,20%,40A,1.34mOhms,19.69x19.55x10.67mm, SMD,AEC-Q200	COILCRAFT, SER2011-202MLB
19	1	L5	IND.,68uH,PWR, SHIELDED,20%,0.74A,0.42 OHM,2424, LPS6225	COILCRAFT, LPS6225-683MRB
20	4	Q1, Q2, Q11, Q13	XSTR.,MOSFET, N-CH,80V,40A,TSDSON-8 FL	INFINEON, BSZ070N08LS5
21	8	Q3-Q6, Q9, Q10, Q15, Q16	XSTR.,MOSFET, N-CH,40V,98A,TDSON-8	INFINEON, BSC032N04LS
22	4	Q7, Q8, Q12, Q14	XSTR.,MOSFET, N-CH,40V,100A,TDSON-8 FL	INFINEON, BSC014N04LSI
23	2	Q20, Q21	XSTR.,MOSFET, N-CH,40V,TO-252 (DPAK)	VISHAY, SUD50N04-8M8P-4GE3
24	8	R1, R7, R19, R38, R42, R58, R59, R61	RES.,1k OHM,1%,1/10W,0603	VISHAY, CRCW06031K00FKEA

DEMO MANUAL DC2787A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
25	4	R2, R36, R53, R56	RES.,AEC-Q200,1 OHM,5%,1/10W,0603	VISHAY, CRCW06031R00JNEA
26	43	R5, R10-R12, R14, R20, R24, R32, R33, R35, R40, R41, R45, R47, R50, R51, R76, R226-R231, R240, R241, R246, R252, R254-R256, R258, R264, R266-R268, R270, R271, R273-R276, R278, R279	RES.,0 OHM,1/10W,0603	VISHAY, CRCW06030000Z0EA
27	1	R6	RES.,AEC-Q200,1M OHM,1%,1/8W,0805	PANASONIC, ERJ6ENF1004V
28	1	R8	RES.,34k OHMS,1%,1/10W,0603	NIC, NRC06F3402T
29	9	R9, R13, R22, R28, R49, R60, R62, R272, R277	RES.,AEC-Q200,10k OHMS,1%,1/10W,0603	VISHAY, CRCW060310K0FKEA
30	4	R15, R37, R52, R57	RES.,100k OHMS,1%,1/10W,0603	VISHAY, CRCW0603100KFKEA
31	4	R16, R48, R64, R68	RES.,53.6k OHMS,1%,1/10W,0603,AEC-Q200	VISHAY, CRCW060353K6FKEA
32	4	R17, R43, R70, R71	RES.,AEC-Q200,6.81k OHMS,1%,1/8W,0805	VISHAY, CRCW08056K81FKEA
33	1	R18	RES.,3.74k OHMS,1%,1/10W,0603	PANASONIC, ERJ3EKF3741V
34	4	R23, R75, R244, R259	RES.,AEC-Q200,60.4k OHMS,1%,1/10W,0603	VISHAY, CRCW060360K4FKEA
35	4	R25, R66, R245, R248	RES.,AEC-Q200,4.32k OHMS,1%,1/10W,0603	VISHAY, CRCW06034K32FKEA
36	1	R26	RES.,182k OHMS,1%,1/10W,0603,AEC-Q200	PANASONIC, ERJ3EKF1823V
37	1	R27	RES.,20k OHMS,5%,1/10W,0603,AEC-Q200	NIC, NRC06J203TRF
38	1	R29	RES.,80.6k OHMS,1%,1/10W,0603	VISHAY, CRCW060380K6FKEA
39	2	R30, R247	RES.,0.2 OHM,1%,1/2W,2010,SENSE, AEC-Q200	VISHAY, WSL2010R2000FEA
40	1	SW1	SWITCH,SLIDE,DPDT,0.3A,6VDC,PTH	C&K, JS202011CQN
41	4	U1-U4	IC, Hybrid Step-Down Synchronous Controller QFN-32	ANALOG DEVICES, LTC7821EUH#PBF
42	1	U7	IC, SYNCHRONOUS STEP-DOWN CONVERTER	ANALOG DEVICES, LTC3630AEMSE#PBF

Additional Demo Board Circuit Components

1	0	C16, C46, C48, C51, C160, C171, C172, C290-C295	CAP, OPTION, 0603	
2	0	Q1A, Q1A1, Q11A, Q11A1, Q22, Q22A, Q22A1-Q22A3, Q25, Q26, Q29, Q30, Q33, Q34, Q37	XSTR., OPTION, MOSFET N-CH, PPAK SO-8	
3	0	Q23, Q24, Q27, Q28, Q31, Q32, Q35, Q36	XSTR., OPTION, MOSFET N-CH, PG-TDSON-8	
4	0	R3, R31, R34, R44, R46, R65, R74, R234, R235, R250, R251, R253, R262, R263, R265	RES., OPTION, 0603	
5	0	RN1-RN4	THERMISTOR, OPTION, 0603	

PARTS LIST

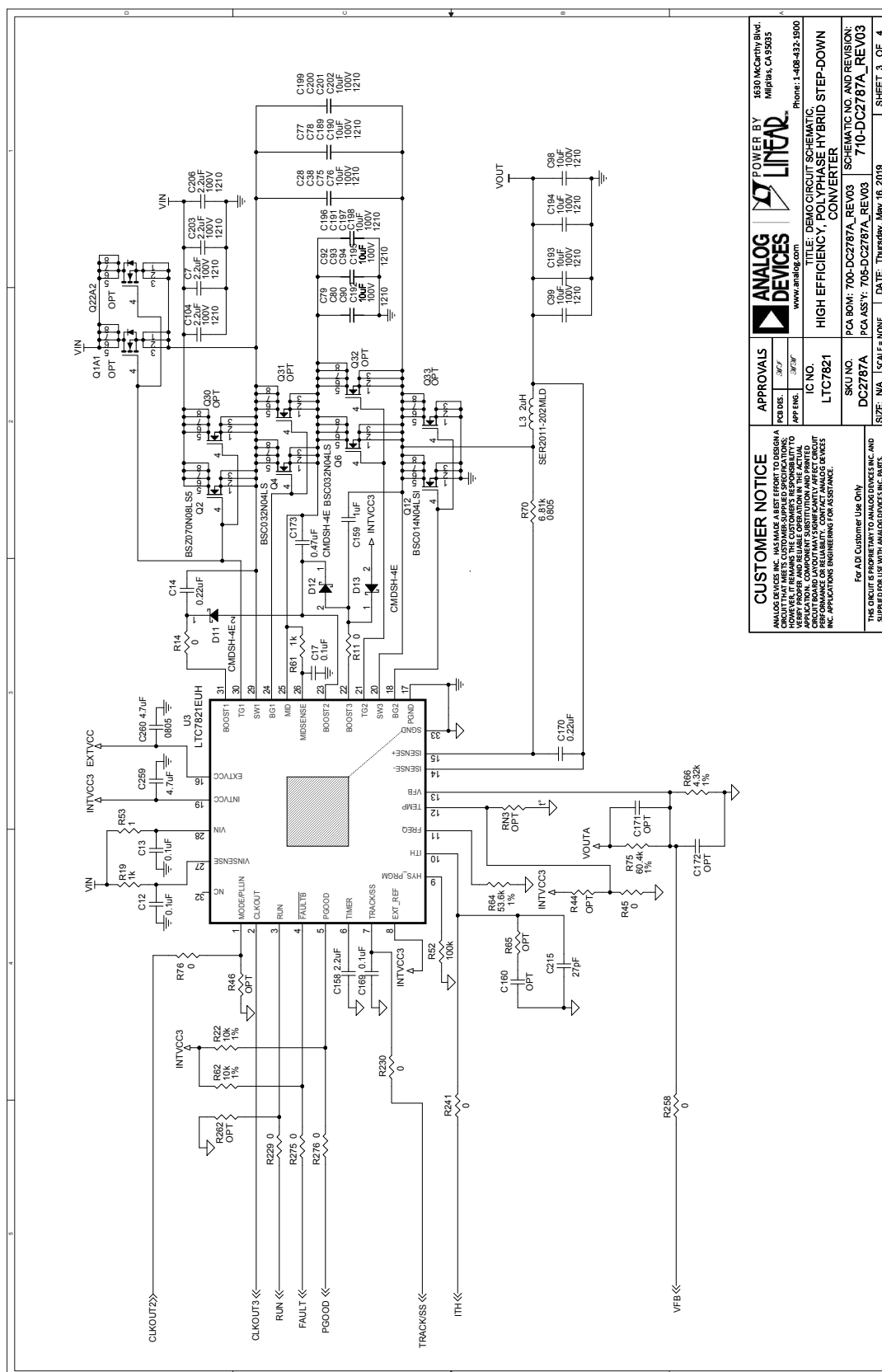
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Hardware				
1	14	E1-E6, E8-E15	TEST POINT,TURRET,0.094",MTG. HOLE	MILL-MAX, 2501-2-00-80-00-00-07-0
2	4	J1-J4	STUD, FASTENER, #10-32	PENNEENGINEERING, KFH-032-10ET
3	2	J5, J6	CONN.,RF, BNC,RCPT JACK,5-PIN,STR, THT,50 Ohms	AMPHENOL RF, 112404
4	4	J1-J4	RING, LUG, CRIMP,#10,NON-INSULATED,SOLDERLESS TERMINALS	KEYSTONE, 8205
5	8	J1-J4	NUT,HEX,#10-32,BRASS	PENCOM, NU1132
6	1	JP2	CONN.,HDR,MALE,1x3,2mm,STR, THT,NO SUBS. ALLOWED	Wurth Elektronik, 62000311121
7	4	J1-J4	WASHER,#10,LOCK,EXT,TIN FINISH	PENCOM, WA4526
8	6	MH1-MH6	STANDOFF,NYLON,SNAP-ON,0.625"	KEYSTONE, 8834
9	1	XJP2	CONN.,SHUNT,FEMALE,2 POS,2mm	Wurth Elektronik, 60800213421



SCHEMATIC DIAGRAM





SCHEMATIC DIAGRAM



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IC NO. T7C7821		TITLE: DEMO CIRCUIT SCHEMATIC EFFICIENCY: POLYPHASE HYBRID STEP DOWN CONVERTER		POWER BY LINEAR	
SKU NO 700-DC2787A REV03		PCB BOM: 700-DC2787A REV03 PCB ASSY: 705-DC2787A REV03		SCHEMATIC NO. AND REVISION: 710-DC2787A REV03	
SIZE: N/A SCALE: A		DATE: Thursday, Mar 27, 1997		SHEET: 3 OF 4	



**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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