

LTC7878 High Efficiency Buck-Boost Converter

DESCRIPTION

Demonstration circuit 2931A is a buck-boost regulator featuring the [LTC®7878](#). The DC2931A operates from a 9V to 55V input voltage range and generates a 12V, 6A output. The LTC7878 has a precision voltage reference that can generate an output voltage with 1% tolerance over the full operating conditions. The 260kHz switching frequency operation results in a small and efficient circuit. The converter achieves over 97% efficiency with 6A load.

The demonstration circuit can be easily modified to regulate output voltages from 1V to 70V.

The DC2931A provides a high-performance, cost-effective solution for generating a 12V output. The LTC7878 data sheet gives a complete description of this part, its operation, and application information. Refer to it in conjunction with this demo manual.

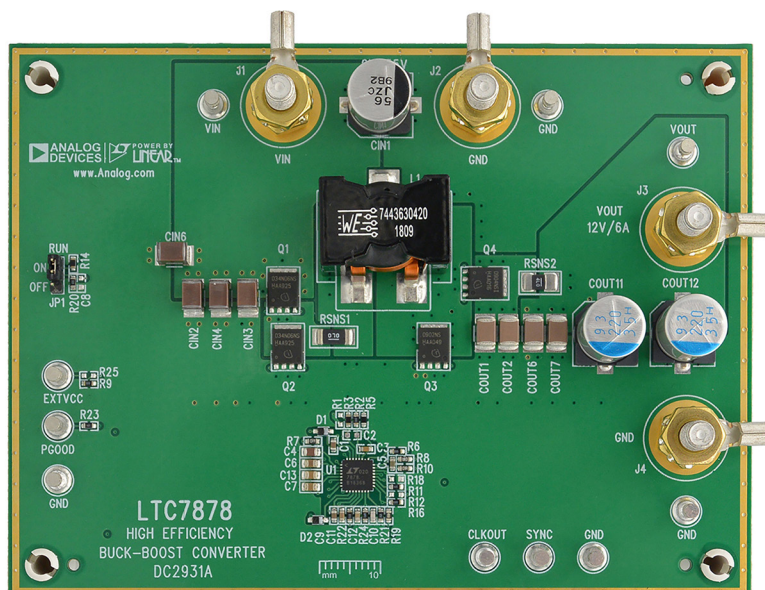
[Design files for this circuit board are available.](#)

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

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Minimum Input Voltage	$I_{OUT} = 0\text{A to }6\text{A}$		9		V
Maximum Input Voltage	$I_{OUT} = 0\text{A to }6\text{A}$		55		V
Output Voltage	$V_{IN} = 9\text{V to }55\text{V}$		$12 \pm 3\%$		V
Output Voltage Ripple	$V_{IN} = 12\text{V}, I_{OUT} = 6\text{A}$		50		mV _{p-p}
Nominal Switching Frequency			260		kHz

BOARD PHOTO Part marking is either ink mark or laser mark



QUICK START PROCEDURE

Demonstration circuit 2931A is easy to set up to evaluate the performance of the LTC7878. For proper measurement equipment setup, refer to Figure 1 and use the following procedure.

NOTE: When measuring the input or output voltage ripple, take care to minimize the length of the oscilloscope probe ground lead. Measure the input or output voltage ripple by connecting the probe tip directly across the VIN or VOUT and GND terminals as shown in Figure 2.

1. With power off, connect the input power supply to VIN and GND.
2. Keep the load set to 0A or disconnected.
3. Turn the input power source on and slowly increase the input voltage.

NOTE: Ensure that the input voltage VIN does not exceed 55V.

4. Set the input voltage to 12V and check for the proper output voltage of 12V. 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 voltage is established, adjust the load, and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.

Changing the Output Voltage

To change the output voltage from the programmed 12V, change the voltage setting resistors connected to LTC7878 V_{FB} pin (see Schematic Diagram section). Also, change all the power components required to meet the desired output voltage.

Converter Efficiency and Output Current

Typical performance of the DC2931A operating in forced continuous current mode is shown in Figure 3. The high efficiency of the LTC7878 makes the DC2931A suitable for demanding automotive, industrial, telecom, and medical applications.

Output Load Step Response

The load step response of the DC2931A is dependent on the amount and type of output caps used. For higher load steps, more output capacitance can be added to keep the voltage transients at the desired level. The 5A load step transients with 12V input are shown in Figure 4. Other types of low ESR and high-value capacitors can be used if space is available to reduce the load transients to desired level.

Start-Up and Soft-Start Function

The DC2931A features a soft-start circuit that ramps the output voltage up in monotonic fashion as shown in Figure 5. The soft-start circuit also prevents output voltage overshoot when output voltage ramp reaches regulation.

When the RUN pin is enabled, the output voltage starts ramping up after 2ms delay, which is required for the INTV_{CC} pin to reach the internal UVLO level.

Thermal Performance

The LTC7878 features excellent thermal performance due to high efficiency of synchronous buck-boost circuit operation. The temperature rises of LTC7878 with 55V input and 6A load are shown in Figure 6. Note that the temperature rises at lower input voltages are lower than the temperature rises with 55V input.

The six-layer PCB layout features solid copper planes that provide heat spreading across the whole board.

QUICK START PROCEDURE

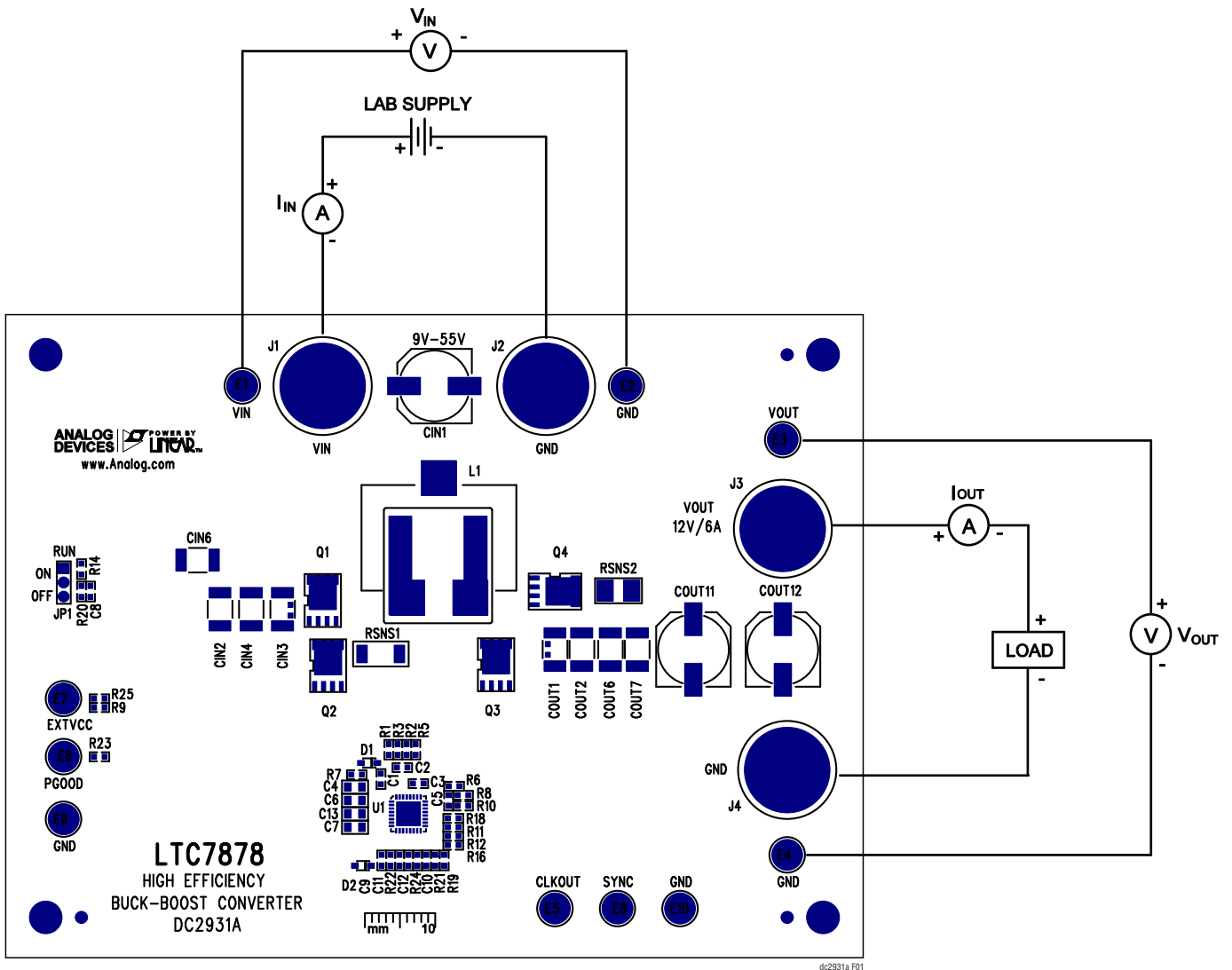


Figure 1. Proper Measurement Equipment Setup

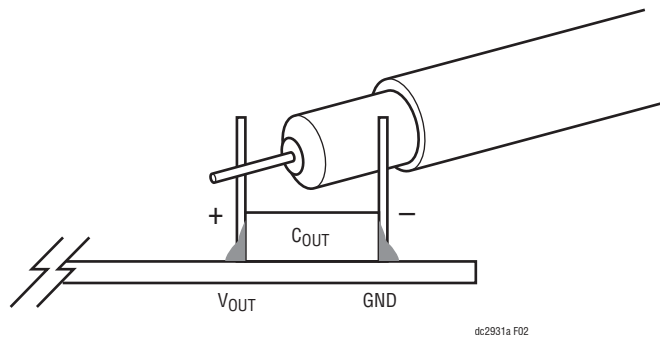


Figure 2. Measuring Input or Output Ripple Voltage

TEST RESULTS

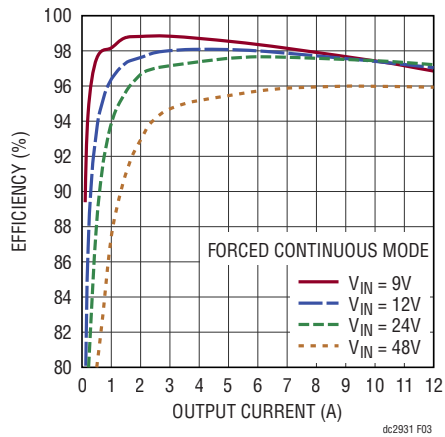


Figure 3. The 12V Input Efficiency is 97% with 12A Load

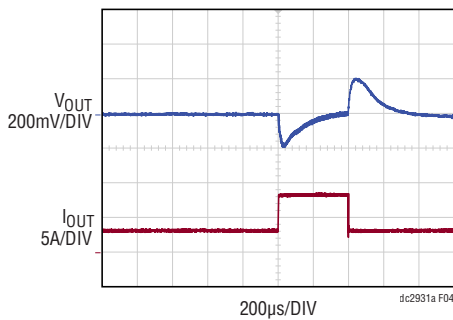


Figure 4. The LTC7878 Has Good Load Step Response with Small Output Capacitors

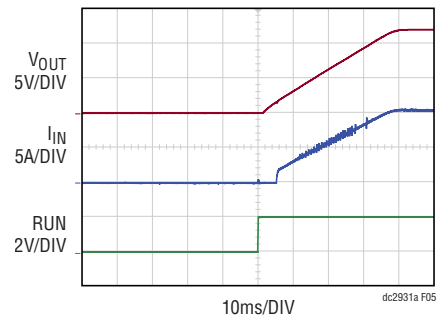


Figure 5. The DC2931A Ramps the Output Slowly at Start-Up without Output Voltage Overshoot

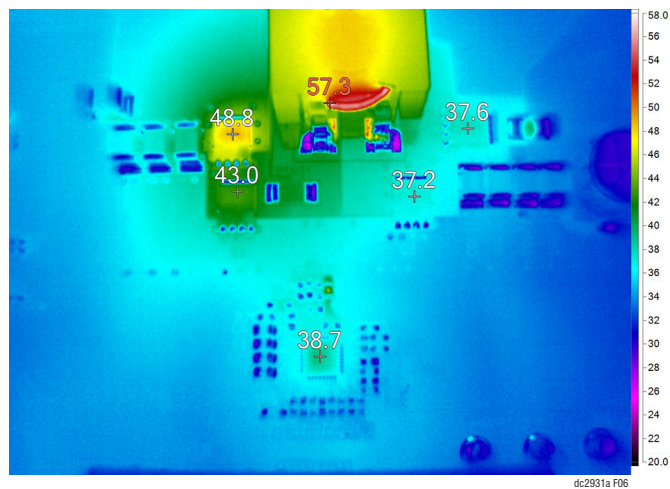


Figure 6. The LTC7878 Has Only 32.3°C Temperature Rise with 55V Input, 12V Output and 6A Load ($T_A = 25^\circ\text{C}$, No Cooling Fan)

PARTS LIST

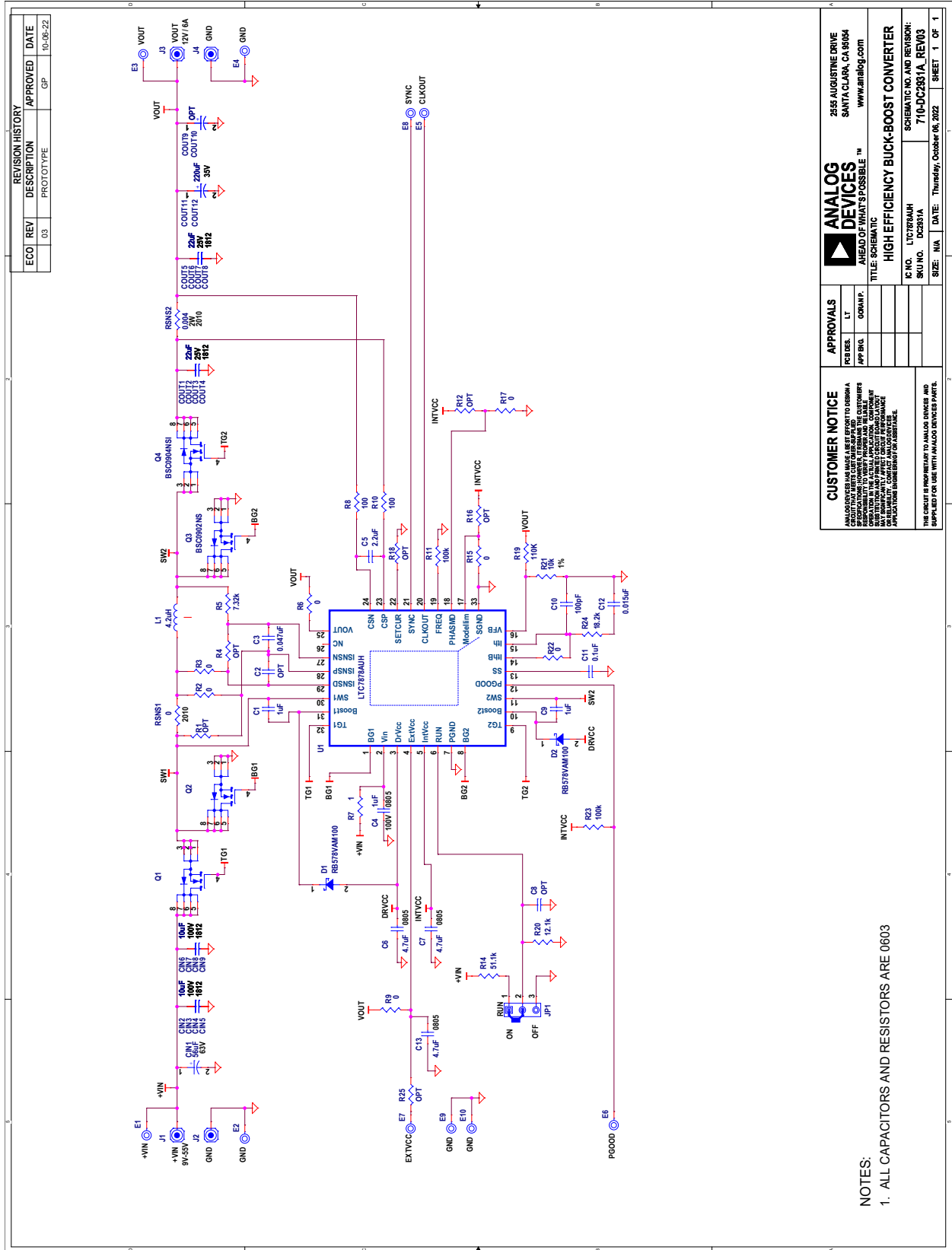
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	C1, C9	CAP, 1 μ F, X7R, 16V, 10%, 0603	KEMET, C0603C105K4RAC7867
2	1	C3	CAP, 0.047 μ F, X7R, 16V, 10%, 0603	AVX, 0603YC473KAT2A
3	1	C4	CAP, 1 μ F, X7S, 100V, 20%, 0805	MURATA, GRJ21BC72A105ME11L
4	1	C5	CAP, 2.2 μ F, X5R, 16V, 10%, 0603	KEMET, C0603C225K4PAC7867
5	3	C6, C7, C13	CAP, 4.7 μ F, X5R, 50V, 10%, 0805	MURATA, GRM21BR61H475KE51L
6	1	C10	CAP, 100pF, X7R, 25V, 5%, 0603	AVX, 06033C101JAT2A
7	1	C11	CAP, 0.1 μ F, X7R, 16V, 10%, 0603	WURTH ELEKTRONIK, 885012206046
8	1	C12	CAP, 0.015 μ F, X7R, 25V, 10%, 0603	AVX, 06033C153KAT2A
9	1	CIN1	CAP, 56 μ F, ALUM.ELECT., 63V, 20%, 10mm x10.2mm SMD, RADIAL, AEC-Q200	PANASONIC, EEHZC1J560P
10	8	CIN2-CIN9	CAP, 10 μ F, X7S, 100V, 20%, 1812	TDK, CKG45NX7S2A106M500JH
11	8	COU1-COU8	CAP, 22 μ F, X5R, 25V, 20%, 1812	TDK, C4532X5R1E226M250KA
12	2	COU11, COU12	CAP, 220 μ F, ALUM POLY HYB, 35V, 20%, 10mm x12.5mm, SMD, RADIAL, HVH SERIES, AEC-Q200	SUN ELECTRONIC INDUSTRIES CORP, 35HVH220M+P
13	2	D1, D2	DIODE, SCHOTTKY, 100V, 0.7A, SOD-323HE	ROHM, RB578VAM100TR
14	4	J1-J4	STUD, FASTENER, #10-32	PENN ENGINEERING
15	1	L1	IND., 4.2 μ H, POWER CHOKE SHEILDED, 15%, 24A, 3.04m Ω , 2013	WURTH ELEKTRONIK, 7443630420
16	2	Q1, Q2	XSTR., MOSFET N-CHAN, 60V, 112A, 8-PIN TDSON	INFINEON, BSC034N06NS
17	1	Q3	XSTR., MOSFET, N-CH, 30V, 106A, PG-TDSON-8	INFINEON, BSC0902NS
18	1	Q4	XSTR., MOSFET, N-CH, 30V, 78A, PG-TDSON-8	INFINEON, BSC0904NSI
20	1	R5	RES., 7.32k, 1%, 1/10W, 0603	PANASONIC, ERJ3EKF7321V
21	1	R7	RES., 1 Ω , 1%, 1/10W, 0603	YAGEO, RC0603FR-071RL
22	2	R8, R10	RES., 100 Ω , 1%, 1/10W, 0603	YAGEO, RC0603FR-07100RL
23	2	R11, R23	RES., 100k, 5%, 1/10W, 0603, AEC-Q200	NIC, NRC06J104TRF
24	1	R14	RES., 51.1k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF5112V
25	1	R19	RES., 110k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1103V
26	1	R20	RES., 12.1k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1212V
27	1	R21	RES., 10k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060310K0FKEA
28	1	R24	RES., 18.2k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1822
29	1	RSNS2	RES., 0.004 Ω , 1%, 1/2W, 2010	VISHAY, WSL20104L000FEA
30	1	U1	IC, 70V PARALLELABLE 4-SWITCH BUCK-BOOST CONTROLLER QFN-32	ANALOG DEVICES, LTC7878AUH#PBF
Additional Demo Board Circuit Components				
1	0	C2, C8	CAP, OPTION, 0603	
2	0	COU9, COU10	CAP, OPTION, ALUM. ELECT., SMD	
3	0	R1, R4, R12, R16, R18, R25	RES., OPTION, 0603	
4	7	R2, R3, R6, R9, R15, R17, R22	RES., 0 Ω , 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EA
5	1	RSNS1	RES., 0 Ω , JUMPER, 75A, 2010, COPPER, SENSE	VISHAY, WSL201000000ZEA9

DEMO MANUAL DC2931A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Hardware: For Demo Board Only				
1	10	E1-E10	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	1	JP1	CONN., HDR, MALE, 1x3, 2mm, VERT, ST, THT, NO SUBS. ALLOWED	WURTH ELEKTRONIK, 62000311121
3	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.625" (5/8), 15.9mm	KEYSTONE, 8834
4	1	MP5-MP8	RING, LUG, #10, CRIMP, 16/14 AWG, NON-INSULATED, SOLDERLESS TERMINALS	KEYSTONE, 8205
5	1	MP9-MP16	WASHER, FLAT, STEEL, ZINC PLATE, OD: 0.436 [11.1]	KEYSTONE, 4703
6	1	MP17-MP24	NUT, HEX, #10-32, STEEL, ZINC PLATE	KEYSTONE, 4705
7	1	XJP1	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



ECO	REV	DESCRIPTION	APPROVED	DATE
	03	PROTOTYPE	GP	10-06-22

ANALOG DEVICES
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APPROVALS

PCB DES.	LT
APP SWG.	000A.P.

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IC NO. LTC7884H
SKU NO. DC2931A
DATE: Thursday, October 06, 2022

SCHEMATIC NO. AND REVISION: 710-DJ2931A_REV03
SIZE: N/A
SHEET: 1 OF 1

NOTES:
 1. ALL 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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