

## LTC3777 High Voltage, High Efficiency 48V/10A Synchronous Buck-Boost Converter

### DESCRIPTION

Demonstration circuit 2519A is a high voltage, high efficiency synchronous buck-boost DC/DC converter with a 16V to 120V input voltage range. It can supply a 10A maximum load current with a 48V output. The demo board features the [LTC®3777EFE](#) controller. The constant frequency current mode architecture allows a phase-lockable frequency of up to 600kHz, while an optional output current feedback loop provides support for applications such as battery charging. The 150V integrated switching bias supply is a high efficiency step-down regulator that draws only 12μA typical DC supply current with a regulated output voltage at no load. With a wide input range, wide output range and seamless transfers between operation modes, the LTC3777 is ideal for Industrial, Automotive, Medical, Military and Avionics applications.

The light load operation mode of the converter is determined with the MODE pin. Use JP2 jumper to select pulse-skipping mode or forced continuous mode (CCM) operation. The switching frequency is pre-set at about 200kHz. The converter can also be externally synchronized to an external clock through the PLLIN pin (PLLIN terminal on the board). To shut down the converter, force the RUN pin below 1.2V (SW1: OFF). The power good output (PGOOD terminal) is low when the output voltage is outside of the ±10% regulation window.

**Design files for this circuit board are available at <http://www.analog.com/DC2519A>**

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### PERFORMANCE SUMMARY Specifications are at T<sub>A</sub> = 25°C

PARAMETER	CONDITION	VALUE
Input Voltage Range		16V to 120V
Output Voltage, V <sub>OUT</sub>	V <sub>IN</sub> = 21V to 120V, I <sub>OUT</sub> = 0A to 10A	48V ±2%
Maximum Output Current, I <sub>OUT</sub>	V <sub>IN</sub> = 21V to 120V, V <sub>OUT</sub> = 48V	10A
Default Operating Frequency		200kHz
Typical Efficiency	48V <sub>IN</sub> , 48V <sub>OUT</sub> , 10A	98.7%
Typical Output Ripple	48V <sub>IN</sub> , 48V <sub>OUT</sub> , 10A	480mV

## QUICK START PROCEDURE

Demonstration circuit 2519A is easy to set up to evaluate the performance of the LTC3777. 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  $V_{IN}$  (16V to 120V) and GND (input return).
2. Connect the 48V output load between  $V_{OUT}$  and GND (Initial load: no load).
3. Connect the DVMs to the input and the output.
4. Turn on the input power supply and then check for the proper output voltages.  $V_{OUT}$  should be 48V  $\pm 2\%$ .
5. Once the proper output voltages are established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage and other parameters.

**Note:** 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.

**Additional Note:** R2, R3, R4 and C10 are needed for additional/constant output current limit only. If this average current loop function is not used, short R2 and remove R3, R4 and C10; and then short IAVGSNSP and IAVGSNSN pins together, and tie them to V5.

## Output Current Derating

DC2519A is designed to supply 48V output with a 10A maximum load current. Figure 3 shows the full load efficiency and loss vs the input voltage. For thermal concern, hot spot temperature is limited below 90°C for input voltage range between 21V and 120V with 200LFM airflow. Figure 4 and Figure 5 show the thermal performance of DC2519A with 21V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A load current and 120V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A load current, respectively. Further decreasing the input voltage below 21V with 10A load current is not recommended. For applications with input voltage range between 16V and 21V, the output current derating curve is shown as Figure 6. For input voltage range between 36V and 72V which is popular in Telecom Industry, DC2519A can handle the 10A full load current without any forced airflow. Figure 7, Figure 8 and Figure 9 show the thermal performance at 36V<sub>IN</sub>, 48V<sub>IN</sub> and 72V<sub>IN</sub>, respectively.

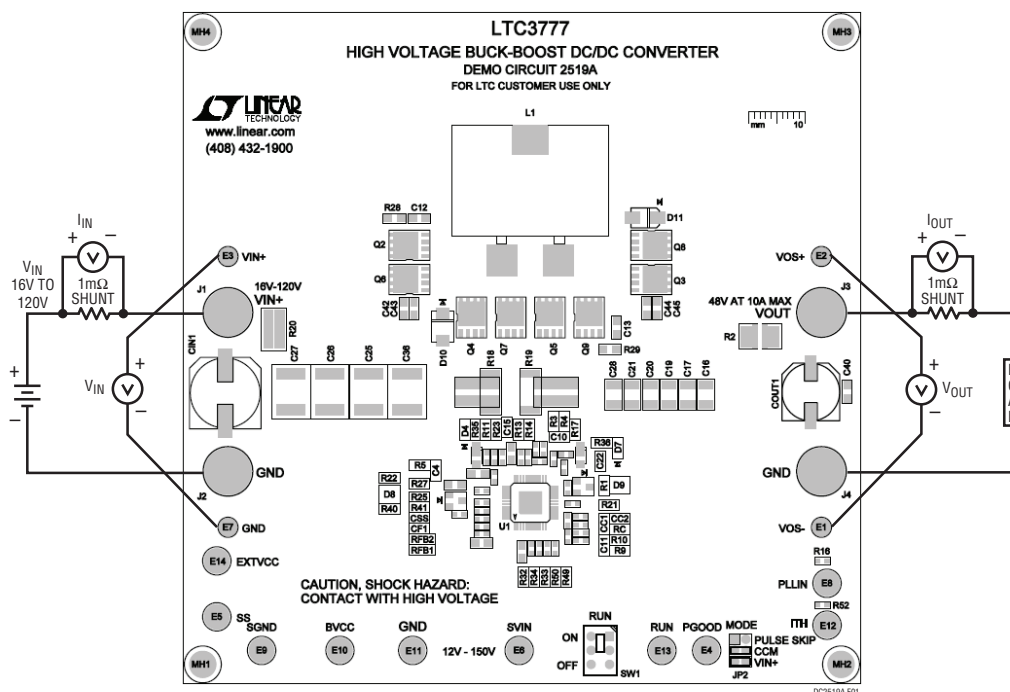


Figure 1. Proper Measurement Equipment Setup

## QUICK START PROCEDURE

Besides the thermal performance, another limit factor for high output power capability is the saturation current of the power inductor. To supply 48V<sub>OUT</sub>, 10A load current with the input voltage below 21V, 15μH inductor with P/N 60068 from Payton Planar Magnetics Ltd. is recommended. Please contact the manufacture for detail information. Figure 10 shows the thermal performance at 18V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A load current with 400LFM airflow. For applications with input voltage range between 16V and 18V, the output current derating curve is shown as Figure 6.

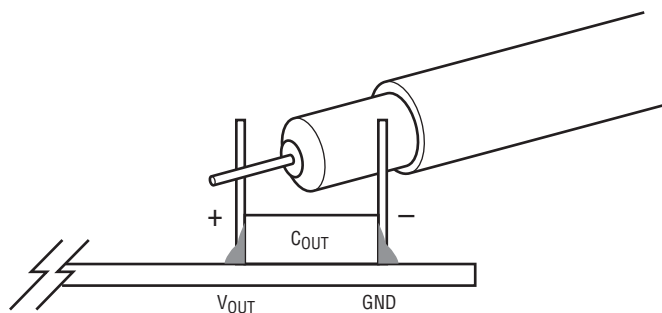


Figure 2. Measuring Output Voltage Ripple

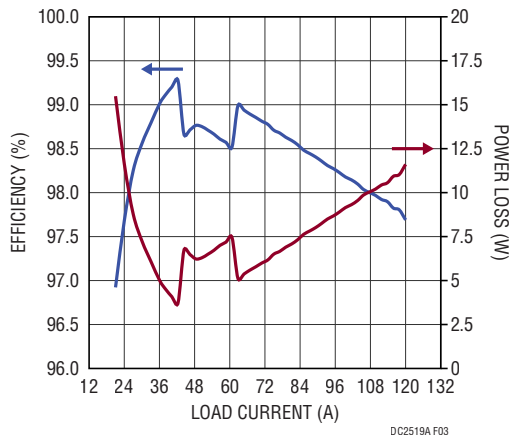


Figure 3. Efficiency and Loss vs Input Voltage ( $I_{OUT} = 10A$ )

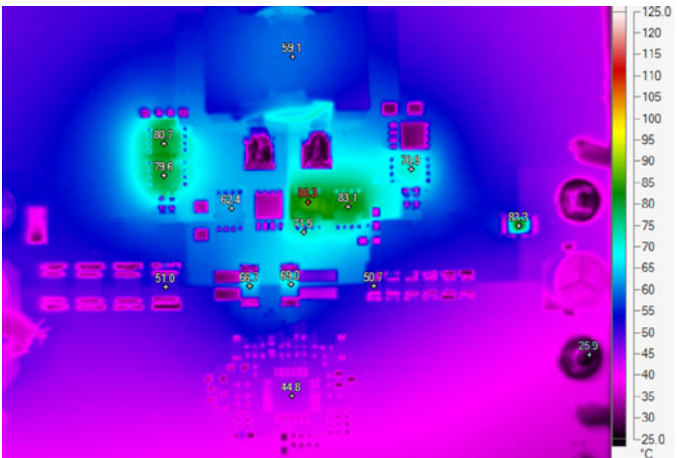


Figure 4. DC2519A Thermal Performance at 21V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A Load Current with 200LFM Airflow

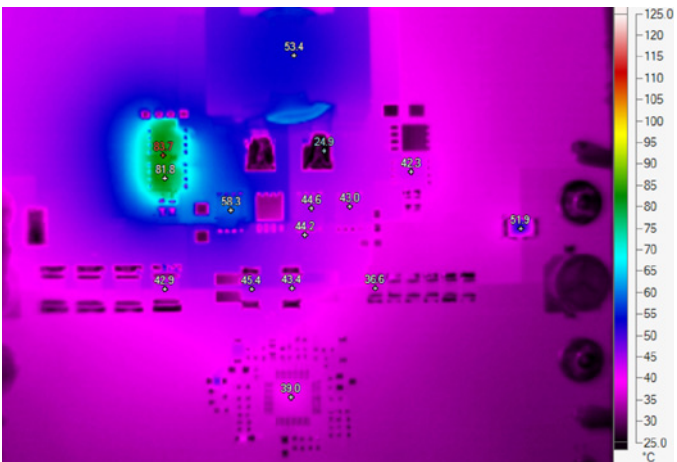


Figure 5. DC519A Thermal Performance at 120V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A Load Current with 200LFM Airflow

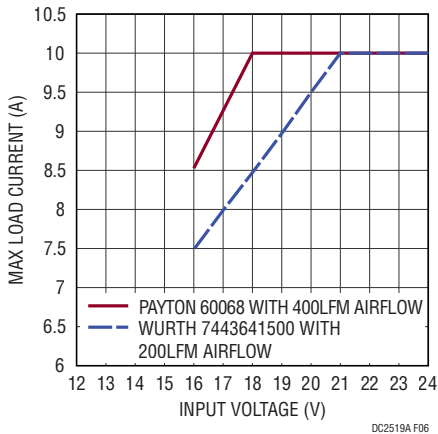


Figure 6. DC519A Output Current Derating vs Input Voltage



## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	1	CC1	CAP, 0603 100pF 10% 50V C0G	AVX 06035A101KAT2A
2	1	CC2	CAP, 0603 10nF 10% 50V X7R	AVX 06035C103KAT2A
3	0	CF1, C64	CAP, 0603 OPTION	OPTION
4	2	CIN1, CIN2	CAP, 10μF 20% 125V ALUN ELEC	SUN ELEC. IND. CORP. 5HVH10M
5	2	COUT1, COUT2	CAP, 56μF 20% 63V HYB POLYMER	UNITED CHEMI-CON HHXA630ARA560MJA0G
6	3	C59, C62, CSS	CAP, 0603 0.1μF 10% 50V X7R	AVX 06035C104KAT2A
7	2	C4, C22	CAP, 0603 0.22μF 10% 25V X7R	AVX 06033C224KAT2A
8	0	C7, C8, C12, C13, C63	CAP, 0805 OPTION	OPTION
9	9	C9, C14, C25, C26, C27, C35, C36, C37, C58	CAP, 2220 1μF 10% 250V X7R	MURATA GRM55DR72E105KW01L
10	1	C10	CAP, 0603 4.7μF 10% 6.3V X5R	AVX 06036D475KAT2A
11	1	C11	CAP, 0603 220pF 5% 100V C0G	MURATA GRM1885C2A221JA01D
12	6	C15, C40, C42, C43, C44, C45	CAP, 0805 0.1μF 10% 250V X7T	TDK CGA4J3X7T2E104K125AE
13	12	C16, C17, C19, C20, C21, C23, C28, C29, C30, C31, C32, C53	CAP, 1210 3.3μF 10% 100V X7S	AVX 12101C335K4Z2A
14	1	C18	CAP, 1206 10μF 10% 25V X5R	MURATA GRM31CR61E106KA12L
15	1	C24	CAP, 0603 1μF 10% 50V X5R	TDK C1608X5R1H105K080AB
16	0	C41, C46, C47, C54, C55	CAP, 0805 0.1μF 10% 250V X7T OPTION	TDK CGA4J3X7T2E104K125AE OPTION
17	1	C56	CAP, 0805 10μF 10% 25V X5R	MURATA GRM21BR61E106KA73L
18	1	C57	CAP 10μF 20% 200V ELEC	NICHICON UUB2D100MNL1GS
19	2	C60, C61	CAP 1210 22μF 10% 25V X5R	AVX 12103D226KAT2A
20	2	D4, D7	DIODE, SCHOTTKY 1A 200V POWERDI123	DIODES INC. DFLS1200-7
21	1	D8	DIODE, ZENER 5.1V 350mW SOT23-3	DIODES INV. BZX84C5V1-7-F
22	0	D9	DIODE, OPTION	DIODES INC. BAS16-7-F OPTION
23	0	D10	DIODE, SCHOTTKY OPTION SMB	OPTION
24	0	D11	DIODE, SCHOTTKY OPTION SMA	OPTION
25	0	D12, D13	DIODE, SCHOTTKY OPTION POWERDI5	OPTION
26	4	E1, E2, E3, E7	TURRET	MILL-MAX 2308-2-00-80-00-00-07-0
27	10	E4, E5, E6, E8, E9, E10, E11, E12, E13, E14	TURRET	MILL-MAX 2501-2-00-80-00-00-07-0
28	1	JP2	HEADER, 3-PIN, DBL ROW 2mm	SAMTEC TMM 103-02-L-D
29	4	J1, J2, J3, J4	JACK, BANANA	KEYSTONE 575-4
30	1	L1	IND, 15μH	WURTH ELECTRONIK 7443641500
31	0	L2	IND, OPTION	OPTION
32	1	L3	IND, 220μH 30%	SUMIDA CDRH105RNP-221NC
33	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE 8834
34	2	Q2, Q6	XSTR, N-CHANNEL POWER MOSFET	INFINEON BSC110N15NS5
35	1	Q3	XSTR, N-CHANNEL POWER MOSFET	INFINEON BSC028N06NS
36	1	Q4	XSTR, N-CHANNEL POWER MOSFET	INFINEON BSC093N15NS5
37	2	Q5, Q9	XSTR, N-CHANNEL POWER MOSFET	INFINEON BSC066N06NS
38	0	Q7, Q8	XSTR, N-CHANNEL POWER MOSFET OPTION	OPTION



# DEMO MANUAL DC2519A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
39	0	Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26	XSTR, AUTOMOTIVE MOSFET OPTION	OPTION
40	1	RC	RES, 0603 10k $\Omega$ 5% 0.1W	VISHAY CRCW060310K0JNEA
41	1	RFB1	RES, 0805 47.5k $\Omega$ 1% 0.125W	VISHAY CRCW080547K5FKEA
42	2	RFB2, R25	RES, 0603 1.21k $\Omega$ 1% 0.1W	VISHAY CRCW06031K21FKEA
43	11	R1, R11, R16, R17, R23, R33, R35, R36, R52	RES, 0 $\Omega$ JUMPER	VISHAY CRCW06030000Z0EA
44	1	R2	RES, 2512 0.004 $\Omega$ 1% 1W	PANASONIC ERJ-M1WSF4M0U
45	4	R3, R4, R9, R10	RES, 0603 100 $\Omega$ 1% 0.1W	VISHAY CRCW0603100RFKEA
46	1	R5	RE, 0805 5.1 $\Omega$ 5% 0.125W	VISHAY CRCW08055R10JNEA
47	0	R6, R12, R15, R34, R40, R41, R48, R51	RES, 0603 OPTION	OPTION
48	1	R7	RES, 0603 100k $\Omega$ 1% 0.1W	VISHAY CRCW0603100KFKEA
49	2	R8, R27, R53	RES, 0603 10 $\Omega$ 5% 0.1W	VISHAY CRCW060310R0JNEA
50	2	R13, R14	RES, 0603 1k $\Omega$ 1% 0.1W	VISHAY CRCW06031K00FKEA
51	2	R18, R19	RES, 2512 0.008 $\Omega$ 1% 2W	BOURNS CRE2512-FZ-R008E-2
52	1	R20	RES, 2512 0 $\Omega$ JUMPER	TEPRO RN5326
53	1	R21	RES, 0603 56.2k $\Omega$ 1% 0.1W	VISHAY CRCW060356K2FKEA
54	1	R22	RES, 0805 124k $\Omega$ 1% 0.125W	VISHAY CRCW0805124KFKEA
55	0	R28, R29, R54	RES, 0805 OPTION	OPTION
56	1	R31	RES, 0805 3k $\Omega$ 1% 0.125W	VISHAY CRCW08053K00FKEA
57	1	R32	RES., AEC-Q200, 2M $\Omega$ , 1%, 1/10W, 0603	VISHAY CRCW06032M00FKEA
58	0	R37, R38	RES, 2512 0.01 $\Omega$ 1% 1W OPTION	VISHAY WSL2512R0100FEA OPTION
59	1	R39	RES, 0805 41.2k $\Omega$ 1% 0.125W	VISHAY CRCW080541K2FKEA
60	1	R49	RES, 0603 715k $\Omega$ 1% 0.1W	VISHAY CRCW0603715KFKEA
61	1	R50	RES, 0603 51.1k $\Omega$ 1% 0.1W	VISHAY CRCW060351K1FKEA
62	1	SW1	SWITCH, SUB-MINIATURE SLIDE 300mA 6V	C&K JS202011CQN
63	1	U1	IC, BUCK-BOOST CONVERTER	ANALOG DEVICES, INC. LTC3777
64	2	XJP2, XJP3	SHUNT 2mm	WURTH ELEKTRONIK 60800213421



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# DEMO MANUAL DC2519A

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## 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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