LTC3896
High Voltage, Low I_Q, Synchronous Inverting DC/DC Controller

DESCRIPTION

Demonstration circuit 2447A is a high voltage, high efficiency synchronous inverting converter featuring the LTC®3896. This demo board has a wide input voltage range from 7V to 72V and produces a –12V output voltage.

The DC2447A is capable of delivering up to 5A of output current. Note that the thermal stress increases at lower input voltages due to increased input current.

This demo board supports four operation modes consisting of fixed-frequency modulation, pulse skipping, Burst Mode® Operation (default mode) and adjustable Burst Mode operation. During a light load condition, fixed-frequency mode reduces output voltage ripple and yields the lowest noise spectrum. Burst mode operation employs a variable frequency algorithm that minimizes the no-load quiescent current and improves light load efficiency.

The DC2447A consumes less than 12µA of current in shutdown and consumes only 100µA of quiescent current when the output is in regulation, unloaded and configured for Burst Mode operation which helps extend the run-time in battery powered applications. This demo board operates at a 300kHz switching frequency and can easily be adjusted from 50kHz to 900kHz.

To prevent high on-chip power dissipation in high input voltage applications, the LTC3896 includes an onboard driver to drive the gate of an external N-channel MOSFET which acts as a linear regulator to power the IC.

The LTC3896 can support a wide output voltage range from –0.8V to –60V. However, the voltage difference between the input voltage and output voltage should not exceed the maximum voltage of the switching semiconductors (100V for DC2447A) and shown by the equation $|-V_{OUT}| + V_{IN} < V_{DS}$.

The DC2447A is set to provide a 10V gate drive voltage (DRV_{CC}) for the switching MOSFETs. It has an UVLO of 7.5V rising and 6.7V falling. However, the gate drive voltage and UVLO voltages can be adjusted lowered. See the LTC3896 data sheet for details.

The DC2447A was designed to support multiple footprints of input and output capacitors, and inductors to accommodate a variety of applications.

The LTC3896 data sheet gives a complete description of the part, contains operating and application information, and must be read in conjunction with this data sheet.

Design files for this circuit board are available at http://www.linear.com/demo/DC2447A

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	VALUE
Minimum Input Voltage		7V
Maximum Input Voltage		72V
Output Voltage VOUT– Regulation	V_{IN} = 7V – 72V	–12V ±2%
Maximum Continuous Output Current		5A
Preset Operating Frequency	R26 = 47.5kΩ	300kHz
External Clock Sync. Frequency Range		75kHz – 850Hz
Efficiency	V_{IN} = 24V, VOUT– = –12.0V, I_{OUT} = 5A	93%
Typical Output Ripple VOUT–	V_{IN} = 24V, VOUT– = –12V, I_{OUT} = 2.5A (20MHz BW)	<70mV_{P-P}
Quiescent Current at Shut-Down	V_{IN} = 24V	<12µA

QUICK START PROCEDURE

Demonstration circuit 2447A is easy to set up to evaluate the performance of the LTC3896. For proper measurement equipment configuration, set up the circuit according to the diagram in Figure 1. Before proceeding to test, insert shunt into JP1 (RUN) into OFF position, which connects the RUN pin to ground (GND) and shuts down the output. Set jumper JP2 (MODE) into the FCM (Forced Continuous Conduction Mode) position.

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 VOUT– and GND terminals. See Figure 2 for proper scope probe technique.

1. With the DC2447A set up according to the proper measurement and equipment in Figure 1, apply 16V at V_{IN}. Measure VOUT–; it should read 0V. If desired, one can measure the shutdown supply current at this point. The supply current will be approximately 12µA, or less, in shutdown.
2. Turn on VOUT– of the circuit by inserting the shunt in header JP1 (RUN) into the ON position. The output voltage should be regulating. Measure VOUT– and it should measure –12.0V ± 2% (Do not apply more than the maximum voltage of 72V to the board or the part may be damaged). Vary the VOUT– load, which should not exceed 5A. Vary the input voltage from 7V to 72V, the VOUT–, it should measure –12.0V ± 2%.
3. Set output current to zero and move jumper JP2 (MODE) into Burst Default position and measure VOUT–. It should be –12.0V ± 2%. Vary the VOUT– load, which should not exceed 5A. Vary the input voltage from 7V to 72V, the VOUT–, it should measure –12.0V ± 2%.
4. Set output current to zero and move jumper JP2 (MODE) into Pulse Skip position and measure VOUT–. It should be –12.0V ± 2%. Vary the VOUT– load, which should not exceed 5A. Vary the input voltage from 7V to 72V, the VOUT–, it should measure –12.0V ± 2%.

DC2447A supports synchronization to external clock referenced to input GND; use PLLIN terminal for synchronization. PGOOD signal also referenced to input GND. To activate PGOOD functionality, connect external voltage source to terminals V_PGOOD and GND. DC2447A also supports $EXTV_{CC}$ function, however $EXTV_{CC}$ is referenced to VOUT–.

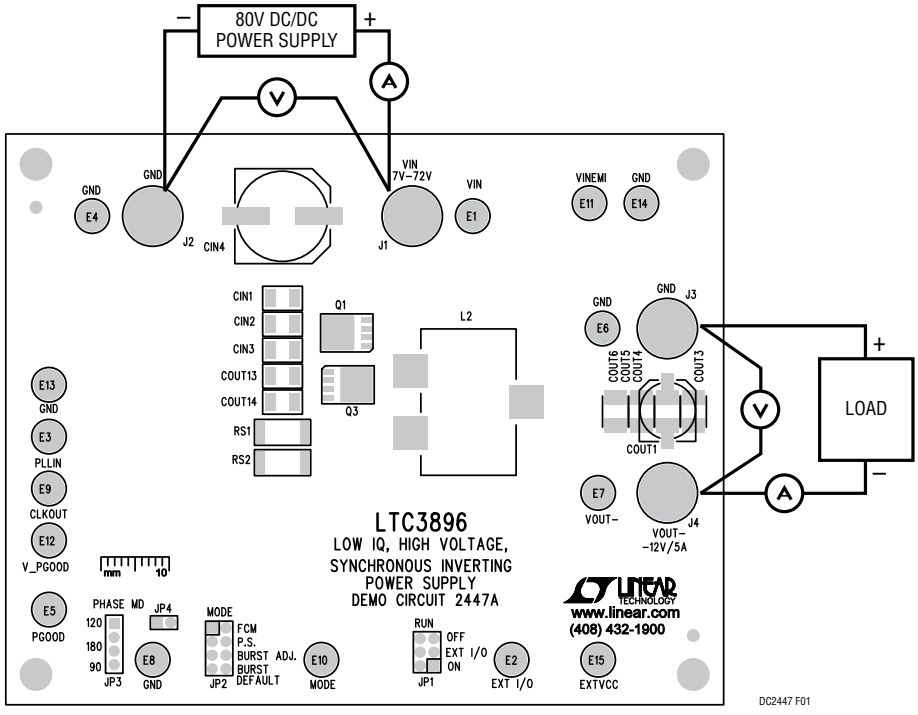


Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE

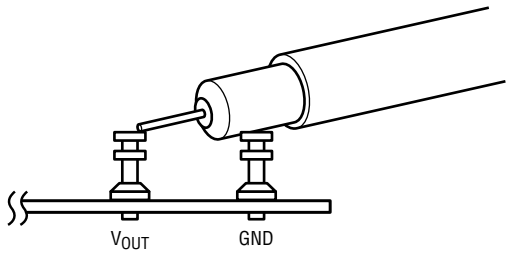


Figure 2. Measuring Input or Output Ripple

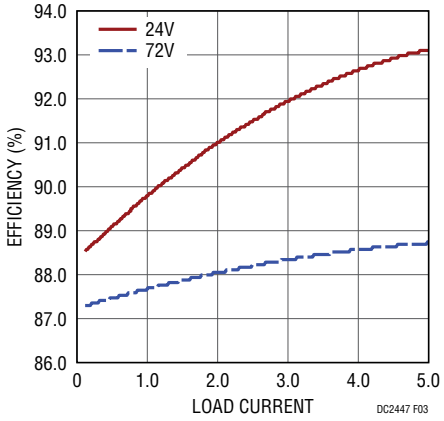
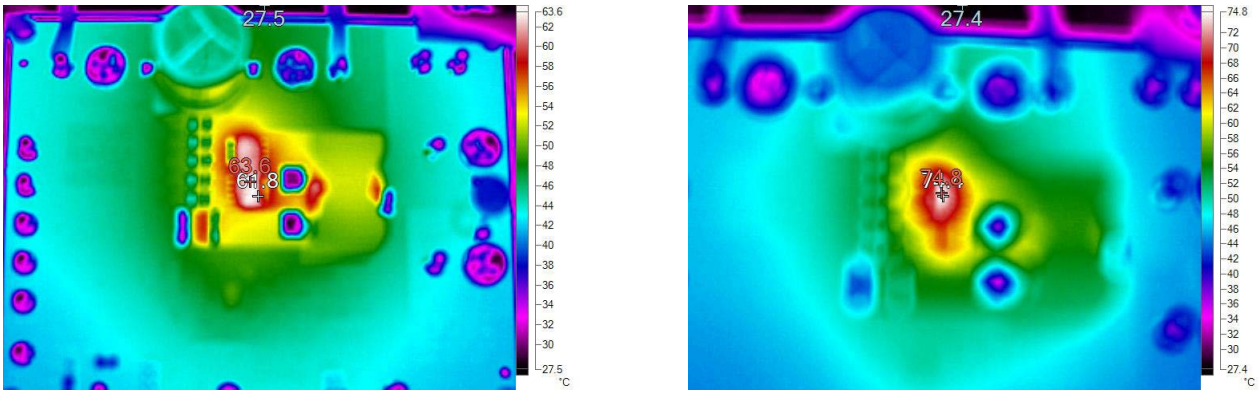


Figure 3. Efficiency vs Load Current for Different Input Voltages



a) V_{IN} = 12V **b) V_{IN} = 48V**

Figure 4. Thermal Map, V_{IN} 12V and 48V (Left to Right) VOUT– is –12V at 5.0A. No Air Flow, T_A = 25°C

QUICK START PROCEDURE

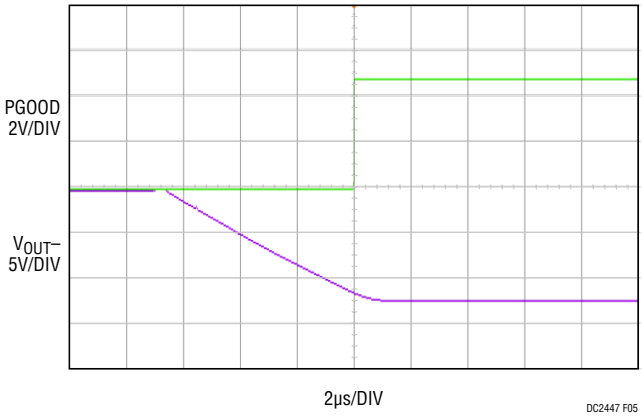


Figure 5. Start-UP to Full Load. V_PGOOD Connected to External +5V. As VOUT– Approaches –12V, PGOOD Signal Changes State

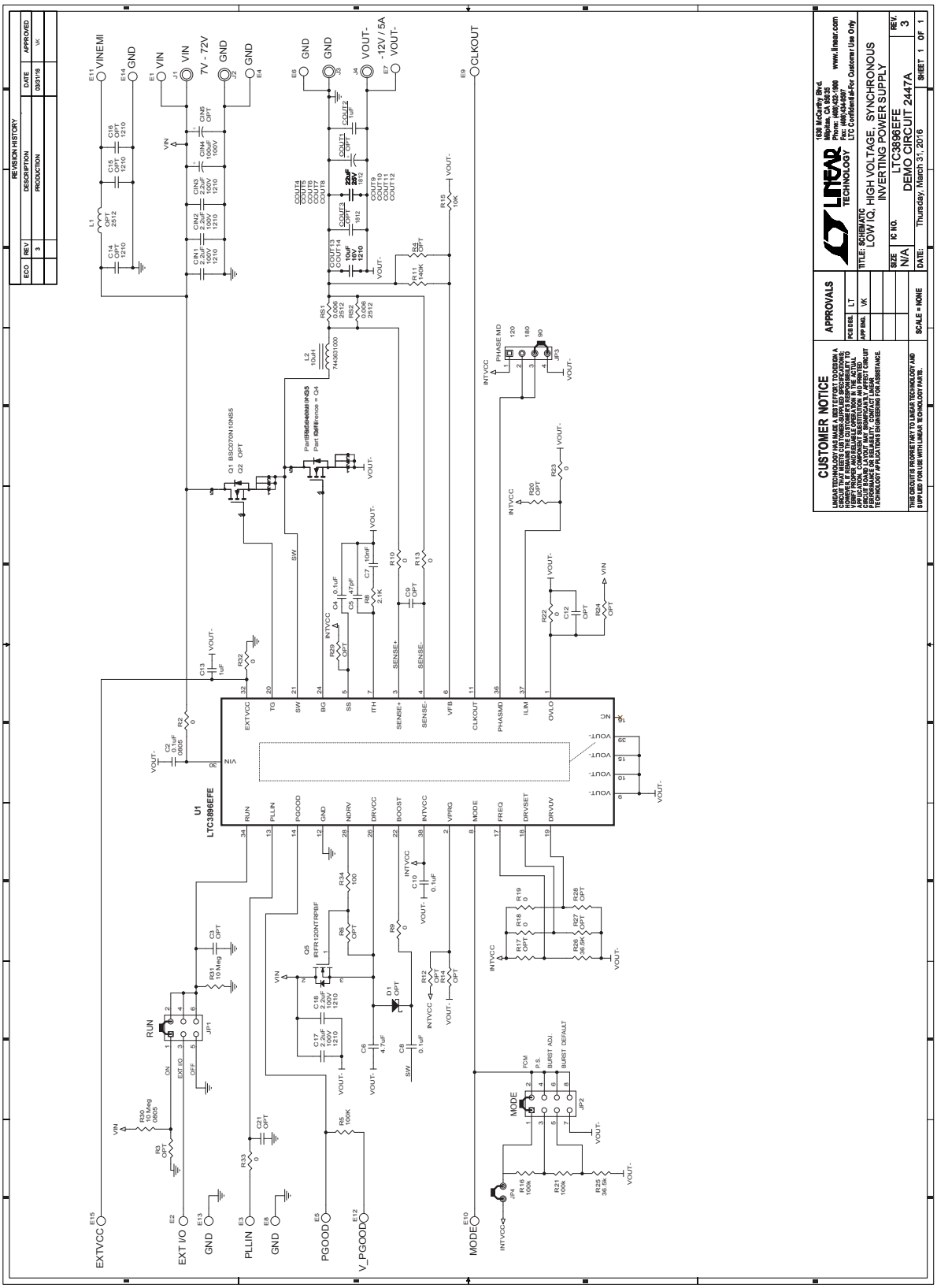
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	5	CIN1, CIN2, CIN3, C17, C18	CAP, X7R, 2.2µF, 100V, 10%, 1210	AVX, 12101C225KAT2A
2	1	CIN4	CAP., 100µF, 100V, 20%	UNITED CHEMI-CON, EMVY101ARA101MKE0S
3	8	COUT3–COUT10	CAP, X7R, 22µF, 25V, 1812	TDK, C4532X7R1E226M250KC
4	1	COUT2	CAP., X7R, 1µF, 50V, 10%, 1210	TDK, C3225X7R1H105K
5	2	COUT13, COUT14	CAP., X5R, 10µF, 16V, 10%, 1210	AVX, 1210YD106KAT2A
6	1	C2	CAP., X7T, 0.1µF, 200V, 10%, 0805	TDK, CGJ4J3X7T2D104K125AA
7	3	C4, C8, C10	CAP., X7R, 0.1µF, 25V, 10%, 0603	TDK, C1608X7R1E104K
8	1	C5	CAP., X7R, 47pF, 50V, 10%, 0603	KEMET, C0603X470K5RACTU
9	1	C6	CAP., X5R , 4.7µF, 16V, 10%, 0603	TDK, C1608X5R1C475K080AC
10	1	C7	CAP., X7R, 10nF, 50V, 10%, 0603	KEMET, C0603C103K5RACTU
11	1	C13	CAP., X7R, 1µF, 50V, 10%, 0603	TAIYO YUDEN, UMK107AB7105KA-T
12	1	L2	INDUCTOR, POWER, 10µH	WURTH ELEKTRONIK, 7443631000
13	1	Q1	XSTR, N-CHANNEL, DMOS FET, LFPAK	INFINEON, BSC070N10NS5
14	1	Q3	XSTR, N-CHANNEL, DMOS FET, LFPAK	INFINEON, BSC040N10NS5
15	1	Q5	MOSFET, N-CHANNEL, 100V, TO252	INFINEON, IRFR120NTRPBF
16	2	RS1, RS2	RES, 0.006Ω 1% 1/4W, 2512	VISHAY, WSL25126L000FEA
17	10	R2, R9, R10, R13, R18, R19	RES., 0Ω, 1/16W, 0603	VISHAY, CRCW06030000Z0EA
18		R22, R23, R32, R33		
19	3	R5, R16, R21	RES., 100k, 1/16W, 1% , 0603	VISHAY, CRCW0603100KFKEA
20	1	R8	RES., 2.1k, 1/16W, 1% , 0603	VISHAY, CRCW06032K1FKEA
21	1	R15	RES., 10k, 1/16W, 1% , 0603	VISHAY, CRCW060310K0FKEA
22	1	R11	RES., 140k, 1/16W, 1%, 0603	VISHAY, CRCW0603140KFKEA
23	2	R25, R26	RES., 36.5k, 1/16W, 1% , 0603	VISHAY, CRCW060336K5FKEA
24	1	R30	RES., 10M, 1/8W, 5%, 0805	VISHAY, CRCW080510M0JNEA
25	1	R31	RES., 10M, 1/10W, 5%, 0603	VISHAY, CRCW060310M0JNEA
26	1	R34	RES., 100, 1/10W, 1%, 0603	VISHAY, CRCW0603100RFKEA
27	1	U1	IC, LTC3896EFE	LINEAR TECH. LTC3896EFE#PBF
Additional Demo Board Circuit Components				
		C3, C9, C11, C12, C21	CAP., OPT, 0603	OPT
		CIN5	CAP., ALUM	OPT
		C14, C15, C16	CAP., OPT, 1210	OPT
		COUT1	CAP., ALUM	OPT
		COUT11, COUT12	CAP, OPT, 1812	OPT
		D1	DIODE, OPT, SOD123	OPT
		L1	INDUCTOR, OPT, 2512	OPT
		Q2, Q4	XSTR, OPT, LFPAK	OPT
		R3, R6, R12, R14, R17, R20, R24, R27, R28, R29	RES., OPT 0603	OPT

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Hardware: For Demo Board Only				
	15	E1-E15	TESTPOINT, TURRET, 0.095"	MILL-MAX, 2501-2-00-80-00-00-07-0
	1	JP1	CONN., HEADER, 2X3, 2mm	WURTH ELEKTRONIK, 620 006 211 21
	1	JP2	CONN., HEADER, 2X4, 2mm	WURTH ELEKTRONIK, 620 008 211 21
	1	JP3	CONN., HEADER, 1X4, 2mm	WURTH ELEKTRONIK, 620 004 111 21
	1	JP4	CONN., HEADER, 1X2, 2mm	WURTH ELEKTRONIK, 620 002 111 21
	4	XJP1, XJP2, XJP3, XJP4	SHUNT, 2mm	WURTH ELEKTRONIK, 608 002 134 21
	4	J1, J2, J3, J4	JACK, BANANA	KEYSTONE, 575-4

SCHEMATIC DIAGRAM



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