LTC3789EGN
8V to 75V_{IN} Buck/Boost DC/DC Converter

DESCRIPTION

Demonstration circuit 1878A features the LTC3789EGN, a high efficiency switching step-up/down controller. The input range has been extended to 75V by using a LTC4444-5 MOSFET driver on the input side. The minimum input voltage is 8V. The output voltage is 12V. The board is capable of delivering up to 5A of output current over the input voltage range.

The LTC3789EGN is a high performance switching regulator controller designed to regulate the output using input voltages above, below or equal to the output voltage. Synchronous operation provides very high efficiency, up to 97%. Constant frequency current mode architecture allows phase-lockable frequency from 200kHz to 600kHz.

An accurate output current limit provides support for battery charging. A wide input and output range with smooth transfer function through all operating modes makes the product ideal for automotive, telecom and battery systems.

The MODE/PLLIN pin can select between pulse-skipping mode and forced continuous mode operation and allows the IC to be synchronized to an external clock. A power good output pin indicates when the output is within 7.5% of its set point.

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

PERFORMANCE SUMMARY (T_A = 25°C)

PARAMETER	CONDITIONS	VALUE
Minimum Input Voltage		8V
Maximum Input Voltage		75V
Output Voltage V_{OUT} Regulation	V_{IN} = 8V – 75V, I_{OUT} = 0A – 5A	12V ± 2%
Maximum Continuous Output Current	Some Airflow May Be Needed at High Input Voltage and Continuous Full Load	5A
Default Operating Frequency	R3 = 0Ω	200kHz
External Clock Synchronous Frequency Range		200kHz – 600kHz
Efficiency	V_{IN} = 8V to 75V, I_{OUT} = 5A	90.5% to 97%. See Figures 3 and 6
Load Transient		See Figure 5

QUICK START PROCEDURE

Demonstration circuit 1878A is easy to set up to evaluate the performance of the LTC3789EGN. Please refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input supply, load and meters as shown in Figure 1. Preset the load to 0A and V_{IN} supply to 0V.
2. Set the current limit of the input supply high enough so that the bench supply does not go into current limit mode. Figure 2 shows input current as a function of input voltage, at full load. Input current can reach 8A at 8V input voltage.
3. Place jumper in the following position:

JP1
RUN
ON

4. Turn on the power at the input. Increase V_{IN} to between 8V and 75V. The circuit will start and the output voltage will regulate at 12V ±2%. The current draw at no load is typically 18mA to 37mA depending on the input voltage.
5. Apply load and observe output voltage regulation, ripple voltage, efficiency and other parameters. Efficiency and power loss at full load is shown in Figure 3. Continuous operation with full power and high input voltage may require some airflow.

Auxiliary Supply

The demo board DC1878A has a LTC3803 based flyback converter to provide 8V/50mA bias voltage for LTC3789 and LTC4444-5. The snubber for the flyback primary winding provides a voltage that is above the input voltage. A transistor Q9 is used to provide a small current source to the top gate driver of LTC4444-5 so that 100% duty cycle is possible.

If this current source is not used, for example if the flyback auxiliary supply is replaced by an external 6V to 12V supply, it is necessary to connect BOOST1 to 3.0V (add 3V Zener diode D11, R11 = 1k, remove R16) and use a level shift circuit (add D3 = BAS16, R12 = 1k, remove R6) between TG1 and TINP (due to the 3.25V maximum threshold for TINP). By setting BOOST1 to 3.0V, the LTC3789 will issue narrow refresh pulses on BG1 which keeps the top gate driver powered also in BOOST mode.

In addition, DC1878A demo board has layout for an optional bias supply intended for a future monolithic high voltage buck regulator. Additional information will be provided when this part is released.

QUICK START PROCEDURE

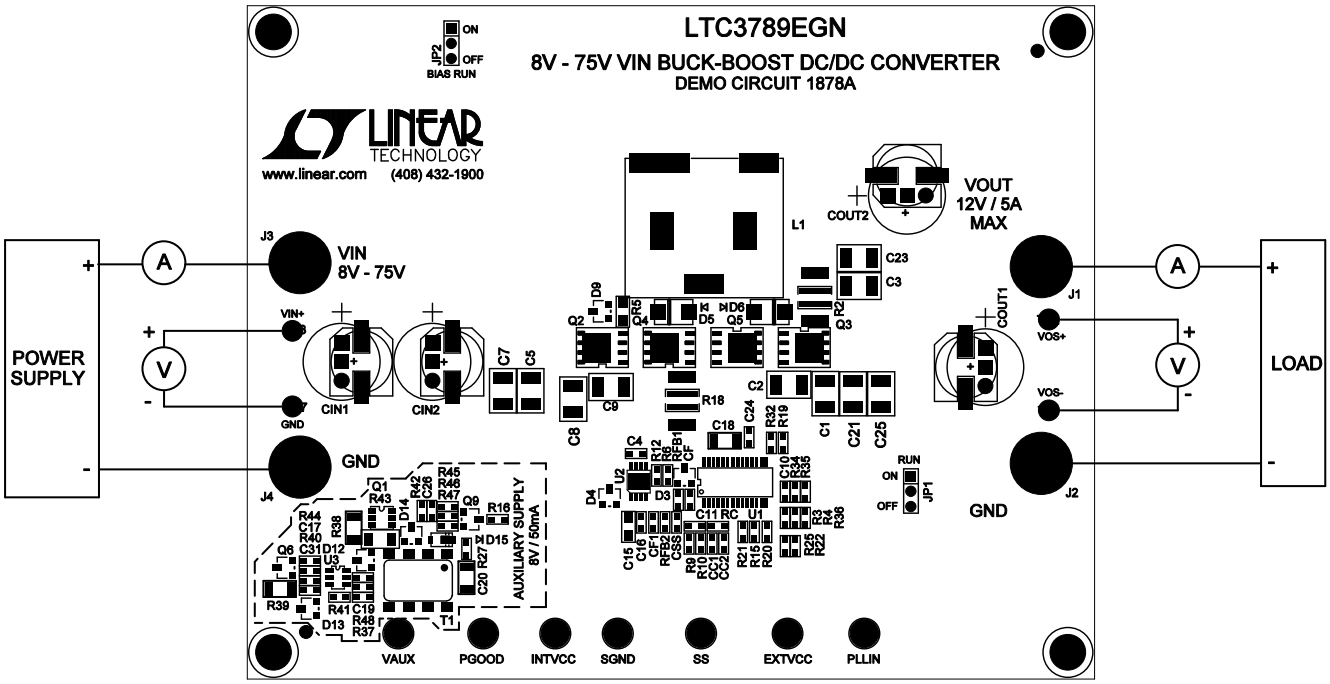


Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE

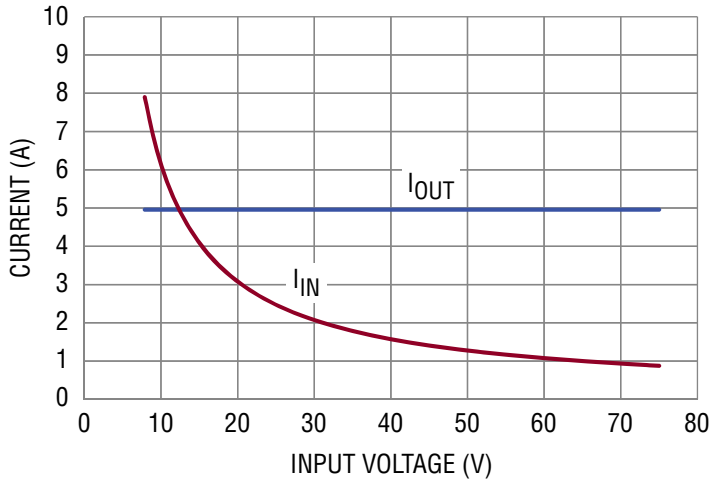


Figure 2. Input Current at Full Load (12V at 5A Output)

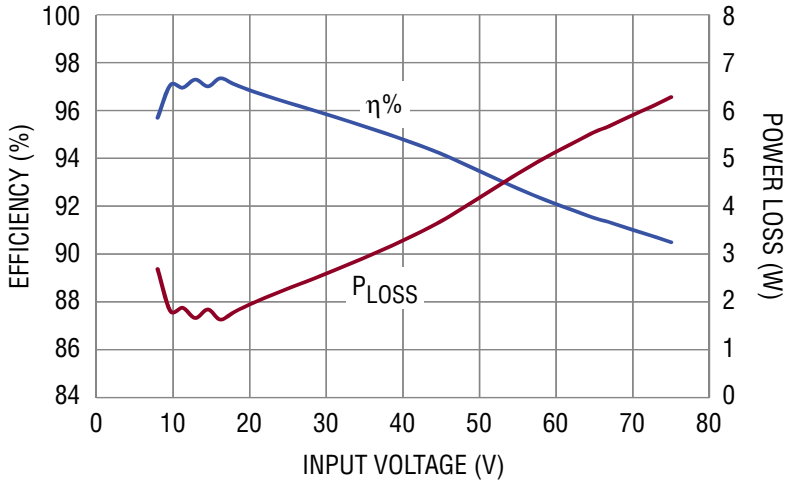


Figure 3. Efficiency and Power Loss at Full Load. The Power Loss is Highest at High Input Voltage Due to the Switching Losses and Drops as Input Voltage Decreases, Until the Inductor Current Starts to Increase as the Circuit Enters Boost Mode Below 10V Input Voltage

QUICK START PROCEDURE

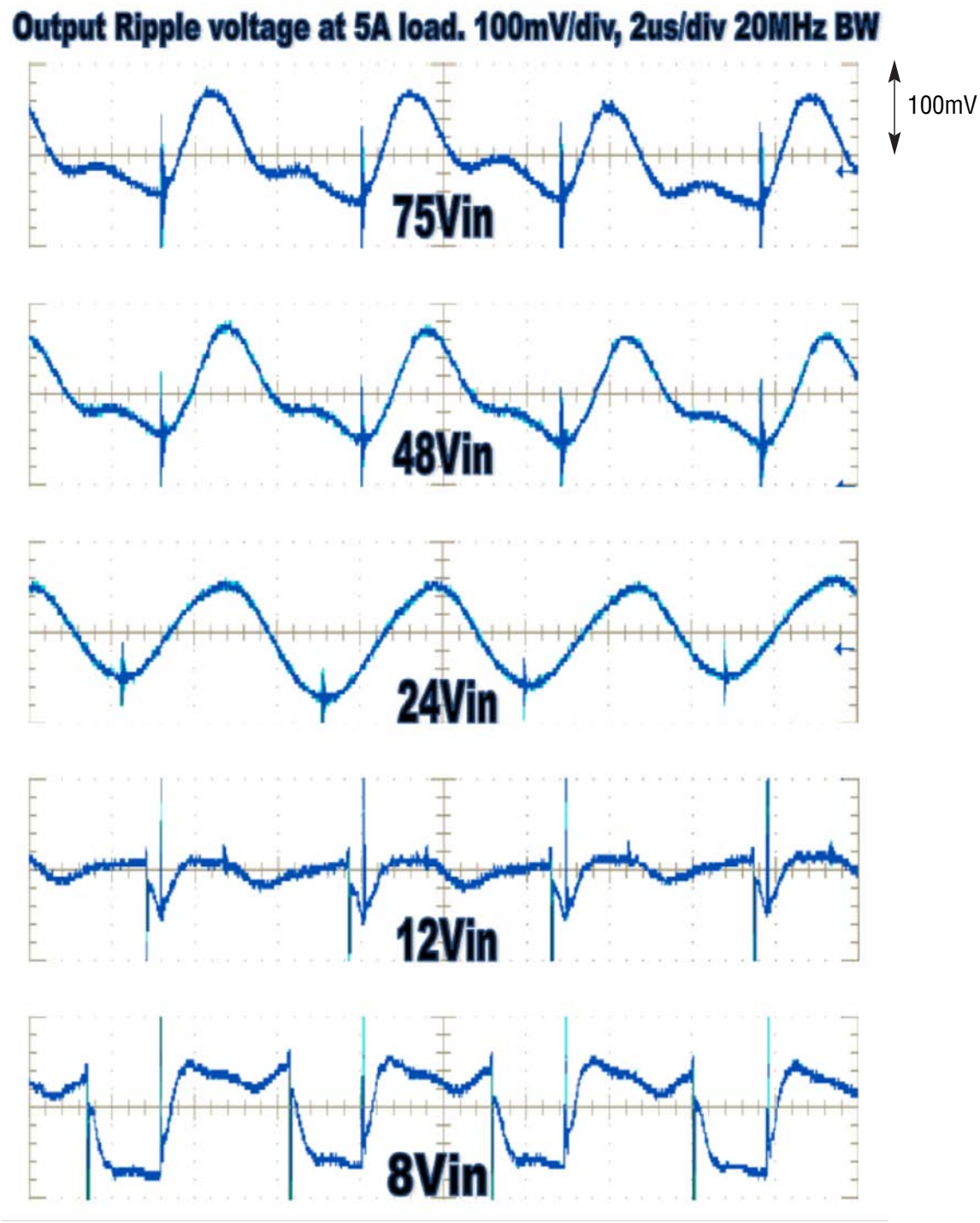


Figure 4. Output Ripple Voltage Measured Across C_{OUT1}

QUICK START PROCEDURE

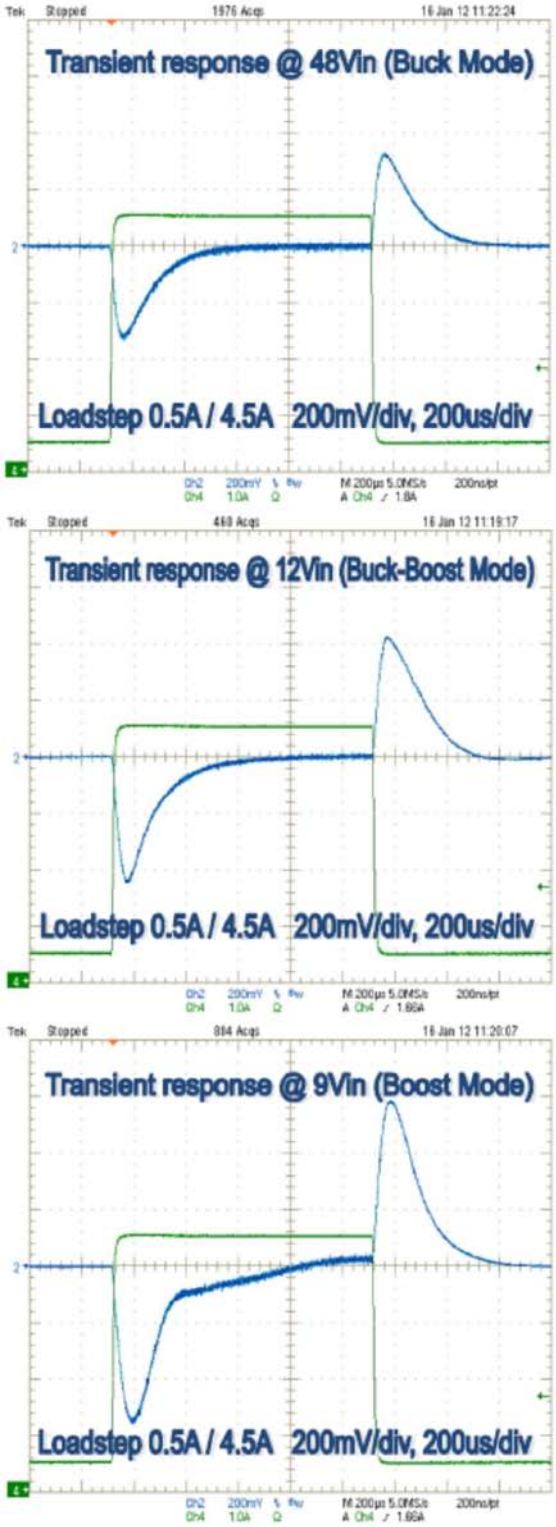


Figure 5. Load Transient Response

QUICK START PROCEDURE

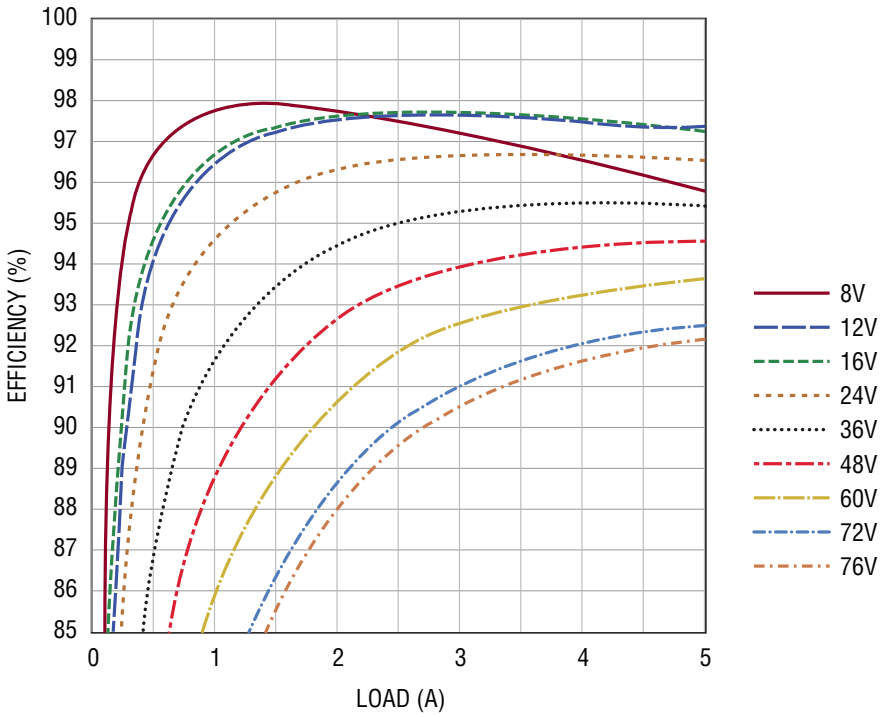


Figure 6. Efficiency at Various Input Voltages

QUICK START PROCEDURE

Figure 7. Output Current Limit (The Easiest Way to Do This Test Is with an Active Load in Voltage Mode)

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	1	CC1	CAP, 0603 470pF 10% 50V NPO	AVX 06035A471KAT
2	1	CC2	CAP, 0603 0.01µF 10% 50V X7R	AVX 06035C103KAT2A
3	0	CF1, C31, C32, C37, CF	CAP, 0603 OPTION	OPTION
4	0	CIN1, COUT11, CIN11, COUT21, CIN21	CAP, OPTION	OPTION
5	1	CIN2	CAP, 150µF 100V ELEC	SUN ELEC. 100ME150AX
6	1	COUT1	CAP, 330µF 20% 16V OSCON	SUN ELECT. 16SEP330M+T
7	0	COUT2	CAP, 330µF 20% 16V OSCON OPTION	SUN ELECT. 16SEP330M+T OPTION
8	1	CSS	CAP, 0603 4700pF 10% 50V X7R	AVX 06035C472KAT2A
9	2	C1,C2	CAP, 1210 22µF 10% 25V X5R	MURATA GRM32ER61E226KE15L
10	0	C3, C21, C23, C25, C27, C28	CAP, 1210 OPTION	OPTION
11	1	C4	CAP, 0603 0.22µF 10% 25V X7R	AVX 06033C224KAT2A
12	3	C5, C6, C9	CAP, 1210 2.2µF 10% 100V X7R	MURATA GRM32ER72A225KA35L
13	0	C7, C8, C29, C30, C33	CAP, 1210 2.2µF 10% 100V X7R OPTION	MURATA GRM32ER72A225KA35L OPTION
14	1	C10	CAP, 0603 4.7µF 20% 6.3V X5R	TAIYO YUDEN JMK 107 BJ457MA-T
15	1	C11	CAP, 0603 33pF 10% 50V NPO	AVX 06035A330KAT2A
16	0	C12, C13	CAP, 1206 OPTION	OPTION
17	3	C14, C16, C26	CAP, 0603 0.1µF 10% 50V X7R	AVX 06035C104KAT2A
18	1	C15	CAP, 0805 1µF 20% 16V X5R	AVX 0805YD105MAT2A
19	1	C17	CAP, 0603 1nF 10% 50V COG	AVX 06035A102KAT2A
20	2	C18, C20	CAP, 1206 10µF 20% 10V X7R	AVX 1206ZC106MAT2A
21	2	C19, C24	CAP, 0603 1µF 20% 16V X7R	AVX 0603YC105MAT2A
22	1	C22	CAP, 0603 0.22µF 20% 16V X7R	TAIYO YUDEN EMK107BJ224MA
23	0	C34	CAP, 0603 0.1µF 10% 50V X7R OPTION	AVX 06035C104KAT2A OPTION
24	0	C35	CAP, 0603 47nF 10% 25V X7R OPTION	AVX 06033C473KAT2A OPTION
25	0	C36	CAP, 1210 47µF 10% 10V X7R OPTION	MURATA GRM32ER71A476KE15L OPTION
26	3	D2, D9, D12	DIODE, SWITCHING, 200mW, SOT23	DIODES INC. BAS16
27	0	D3, D10, D11	DIODE, OPTION SOT-23	OPTION
28	2	D4, D14	DIODE, SWITCHING, 350mW, SOT23	DIODES INC. BAS21
29	1	D5	DIODE, SCHOTTKY	DIODES INC. B1100
30	1	D6	DIODE, SCHOTTKY, SMA	DIODES INC. B240A-13-F
31	1	D7	DIODE, SCHOTTKY	DIODES INC. DFLS160
32	1	D8	DIODE, ZENER, 5.1V, SOT23	DIODES INC. BZX84C5V1-7-F
33	1	D13	DIODE, ZENER, 6.8V, SOT23	DIODES INC. BZX84C6V8
34	1	D15	DIODE, 1.0A HIGH VOLTAGE SCHOTTKY BARRIER RECTIFIER	DIODES INC. DFLS1100
35	1	JP1	HEADER, SINGLE ROW, 3 PIN, 2mm	SAMTEC TMM103-02-L-S
36	0	JP2	HEADER, SINGLE ROW, 3 PIN, 2mm OPTION	SAMTEC TMM103-02-L-S OPTION
37	4	J1, J2, J3, J4	JACK, BANANA	KEYSTONE 575-4
38	1	L1	IND, 19µH	PULSE PA2050.193NL
39	0	L2	IND, 22µH OPTION	TDK VLF10040T-220M2R5 OPTION
40	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE_8834

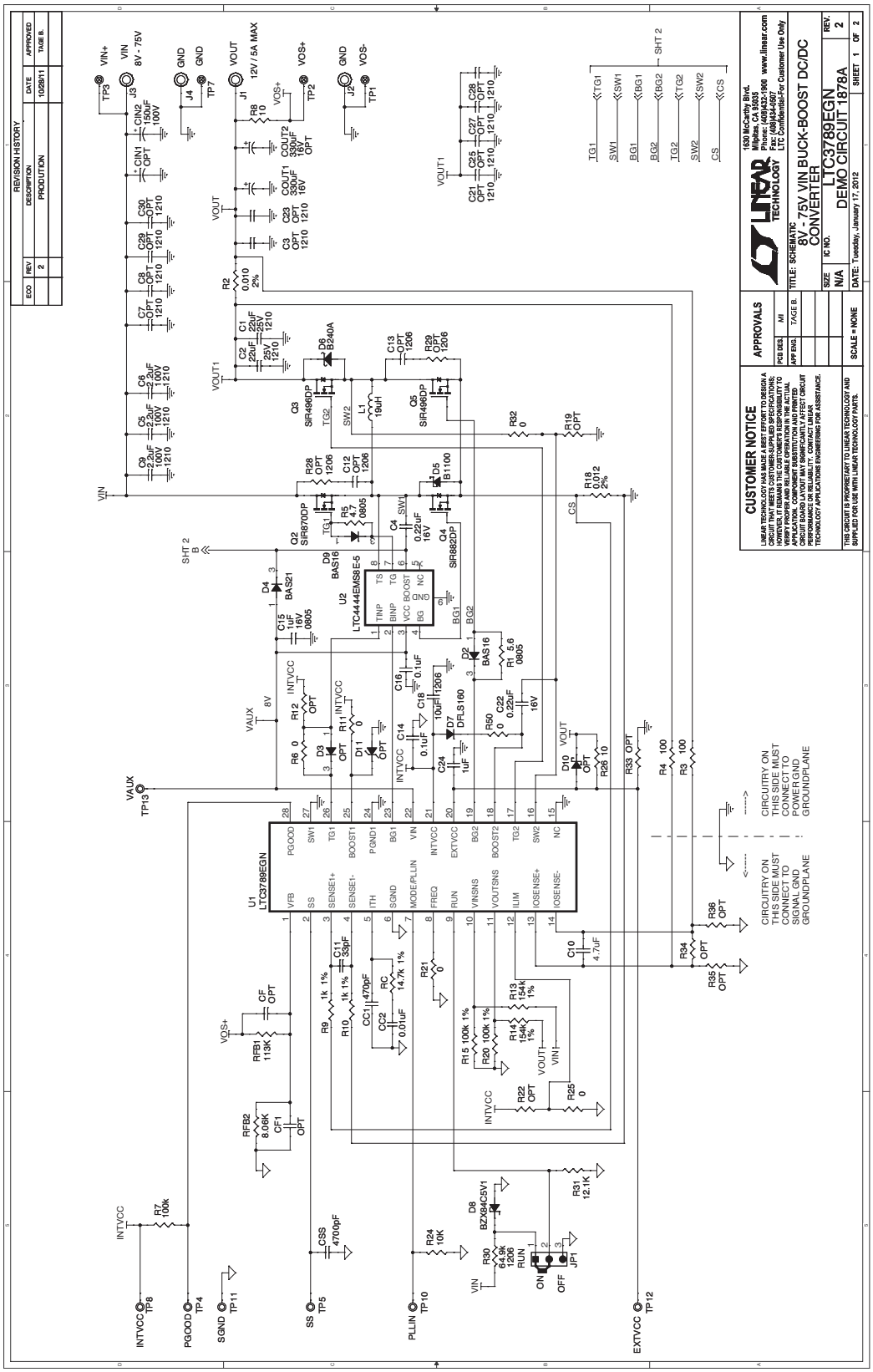
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
41	1	Q1	XSTR, FDC2512 N-CHANNEL MOSFET	FAIRCHILD FDC2512
42	1	Q2	XSTR, MOSFET N-CHANNEL 100V	VISHAY SiR870DP
43	2	Q3, Q5	XSTR, MOSFET N-CHANNEL 20V	VISHAY SiR496DP-T1-GE3
44	1	Q4	XSTR, MOSFET N-CHANNEL 100V	VISHAY SiR882DP
45	1	Q6	XSTR, SMALL SIGNAL NPN SOT-23	DIODES INC. MMBTA42-7
46	0	Q8, Q13	XSTR, MOSFET N-CHANNEL 20V OPTION	VISHAY SiR496DP-T1-GE3 OPTION
47	1	Q9	XSTR, SMALL SIGNAL PNP SOT-23	DIODES INC. MMBTA92-7
48	0	Q14, Q15	XSTR, MOSFET N-CHANNEL 100V OPTION	VISHAY SiR882DP OPTION
49	1	RC	RES, 0603 14.7kΩ 1% 1/10W	VISHAY CRCW060314K7FKEA
50	1	RFB1	RES, 0603 113kΩ 1% 1/10W	VISHAY CRCW0603113KFKEA
51	1	RFB2	RES, 0603 8.06kΩ 1% 1/10W	VISHAY CRCW06038K06FKEA
52	1	R1	RES, 0805 5.6Ω 1% 1/10W	VISHAY CRCW08055R60FKNEA
53	1	R2	RES, 3720 0.01Ω 2% 1W	THIN FILM RECH. RL3720WT-R010-F
54	3	R3, R4, R44	RES, 0603 100Ω 5% 1/10W	VISHAY CRCW0603100RJNEA
55	1	R5	RES, 0805 4.7Ω 1% 1/10W	VISHAY CRCW08054R70FKNEA
56	8	R6, R11, R16, R21, R25, R27, R32, R50	RES, 0603 0Ω JUMPER	VISHAY CRCW06030000Z0EA
57	3	R7, R15, R20	RES, 0603 100kΩ 1% 1/10W	VISHAY CRCW0603100KFKEA
58	2	R8, R26	RES, 0603 10Ω 5% 1/10W	VISHAY CRCW060310R0JNEA
59	2	R9, R10	RES, 0603 1kΩ 1% 1/10W	VISHAY CRCW06031K00FKEA
60	0	R12, R19, R22, R23, R33-R36, R51	RES, 0603 OPTION	OPTION
61	2	R13, R14	RES, 0603 154kΩ 1% 1/10W	VISHAY CRCW0603154KFKEA
62	0	R17	RES, 0805 0Ω JUMPER OPTION	VISHAY CRCW08050000Z0EA OPTION
63	1	R18	RES, 3720 0.012Ω 2% 1W	THIN FILM TECH. RL3720WT-R012-F
64	1	R24	RES, 0603 10kΩ 1% 1/10W	VISHAY CRCW060310K0FKEA
65	0	R28, R29	RES, 1206 OPTION	OPTION
66	1	R30	RES, 1206 64.9kΩ 1% 1/10W	VISHAY CRCW120664K9FKEA
67	1	R31	RES, 0603 12.1kΩ 1% 1/10W	VISHAY CRCW060312K1FKEA
68	1	R37	RES, 0603 14kΩ 1% 1/10W	VISHAY CRCW060314K0FKEA
69	1	R38	RES, 1206 220kΩ 5% 1/4W	VISHAY CRCW1206220KJNEA
70	1	R39	RES, 1206 100kΩ 1% 1/10W	VISHAY CRCW1206100KFKEA
71	1	R40	RES, 0603 22.1kΩ 1% 1/10W	YAGEO RC0603FR-0722KIL
72	1	R41	RES, 0603 1.58kΩ 1% 1/10W	VISHAY CRCW06031K58FKEA
73	1	R42	RES, 0603 10Ω 1% 1/8W	VISHAY CRCW060310R0FKEA
74	1	R43	RES, 1206 0.30Ω 1% 1/8W	IRC LR1206LF-01-R300-F
75	1	R45	RES, 0603 24.9kΩ 1% 1/10W	NIC NRC06F2492TRF
76	2	R46, R47	RES, 0603 33.2kΩ 1% 1/10W	VISHAY CRCW060333K2FKEA
77	1	R48	RES, 0603 5.6kΩ 1% 1/10W	VISHAY CRCW06035K49FKEA
78	0	R49, R55, R56	RES, 0603 0Ω JUMPER OPTION	VISHAY CRCW06030000Z0EA OPTION
79	0	R52	RES, 0603 2MΩ 1% 1/10W OPTION	VISHAY CRCW06032M00FKEA OPTION
80	0	R53	RES, 0603 102kΩ 1% 1/10W OPTION	VISHAY CRCW0603102KFKEA OPTION
81	0	R54	RES, 0603 11.3kΩ 1% 1/10W OPTION	VISHAY CRCW060311K3FKEA OPTION
82	4	TP1, TP2, TP3, TP7	TURRET	MILL-MAX 2308-2-00-80-00-00-07-0

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
83	7	TP4, TP5, TP8, TP10, TP11-TP13	TURRET	MILL-MAX 2501-2-00-80-00-00-07-0
84	1	T1	XFMR, LOW POWER FLYBACK TRANS	PULSE PA0648NL
85	1	U1	IC, VOLT REG.	LINEAR TECH. LTC3789EGN
86	1	U2	IC, HIGH VOLTAGE SYNCHRONOUS N-CHANNEL MOSFET DRIVER	LINEAR TECH. LTC4444EMS8E-5
87	1	U3	IC, CONSTANT FREQ. CURRENT MODE FLYBACK DC/DC CONTROLLER	LINEAR TECH. LTC3803ES6-5
88	0	U4	IC, STEP-DOWN CONVERTER, MSE16(12), 4mm × 3mm OPTION	LINEAR TECH. FUTURE PRODUCT
89	1	XJP1	SHUNT	SAMTEC 2SN-BK-G
90	0	XJP2	SHUNT OPTION	SAMTEC 2SN-BK-G OPTION

SCHEMATIC DIAGRAM



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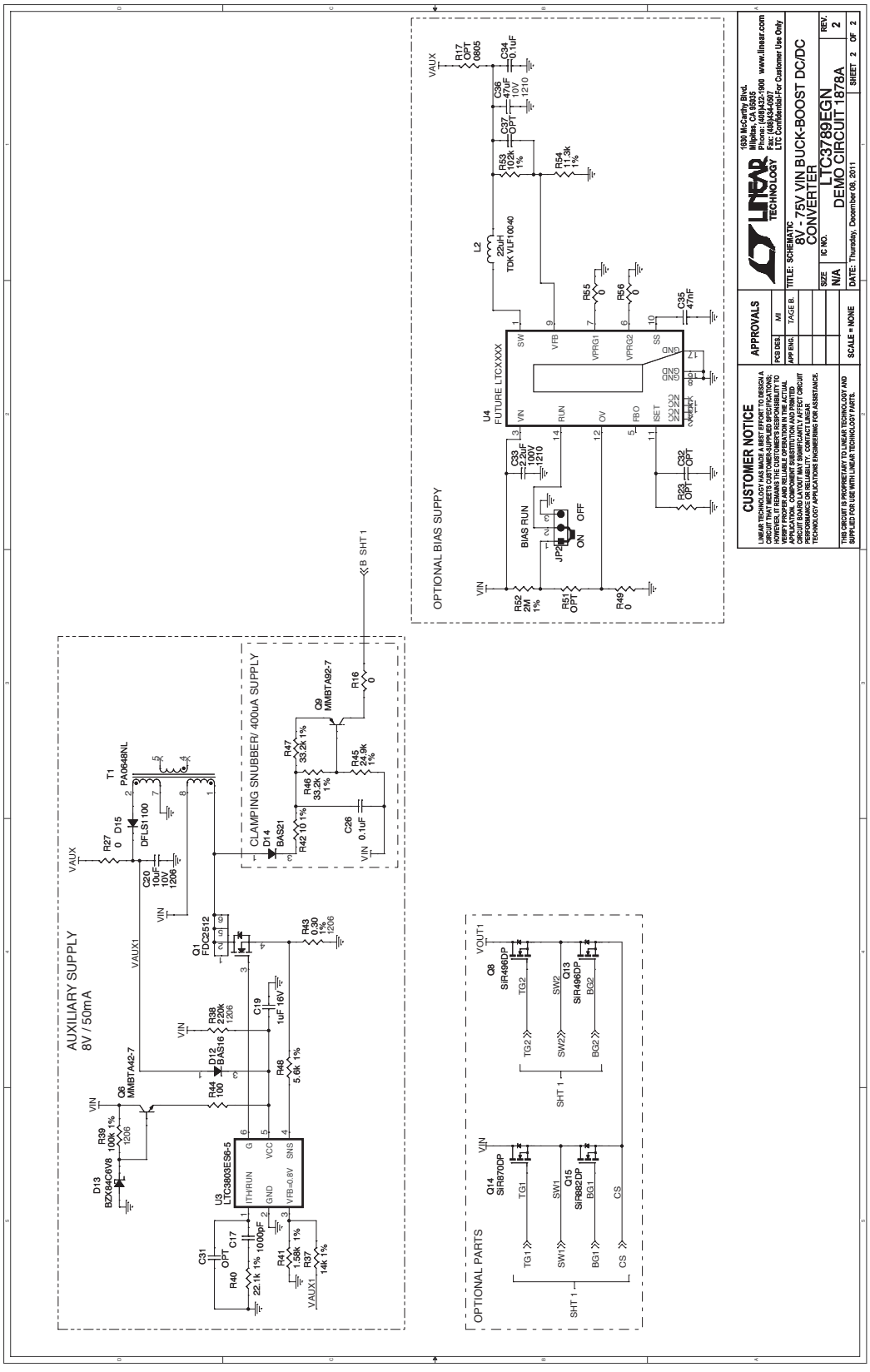

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