

LTC7840 High Step-Up Voltage Ratio Boost Converter

DESCRIPTION

Demonstration circuit DC2744 is a two stage DC/DC boost converter featuring the [LTC®7840](#), a constant frequency current mode boost controller. The DC2744A operates over a 9V to 36V input voltage range. The first stage boost generates V_{OUT1} at 48V. The second stage boost takes this 48V input and provides a 240V output with 0.7A of load current as shown in Figure 3. The 150kHz constant frequency operation results in a small and efficient circuit. The converter provides high output voltage accuracy (typically $\pm 3\%$) over a wide load range with no minimum load requirement. The demonstration circuit can be easily modified to generate different output voltages.

The DC2744 has small circuit footprint. It is a high performance cost effective solution for applications that require high step-up voltage ratios and high output power.

WARNING:

THE 240V OUTPUT VOLTAGE IS LETHAL! ONLY THE PERSONNEL TRAINED IN WORKING WITH HIGH VOLTAGES SHOULD EVALUATE THE DC2744 CIRCUIT. DO NOT LEAVE THE CIRCUIT OPERATING UNATTENDED. DO NOT OPERATE THE CIRCUIT ALONE. DISCHARGE THE OUTPUT CAPACITORS WITH THE LOAD UPON TURNING THE CIRCUIT OFF!

Design files for this circuit board are available at <http://www.analog.com/DC2744A>

All registered trademarks and trademarks are the property of their respective owners.

PERFORMANCE SUMMARY

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

PARAMETER	CONDITIONS	VALUE
Minimum Input Voltage	$I_{OUT} = 0\text{A to } 0.7\text{A}$	9V
Maximum Input Voltage	$I_{OUT} = 0\text{A to } 1.2\text{A}$	36V
V_{OUT}	$V_{IN} = 9\text{V to } 36\text{V}, I_{OUT} = 0\text{A to } 0.7\text{A}$	240V $\pm 3\%$
Typical Output Ripple V_{OUT}	$V_{IN} = 9\text{V to } 36\text{V}, I_{OUT} = 0.7\text{A}$	500mV _{p-p}
Nominal Switching Frequency		150kHz
Typical Efficiency	$V_{IN} = 24\text{V}, I_{OUT} = 1.2\text{A}, V_{OUT} = 240\text{V}$	92%

DEMO MANUAL DC2744A

QUICK START PROCEDURE

Demonstration circuit DC2744 is easy to set up to evaluate the performance of the LTC7840. For proper measurement equipment setup refer to Figure 1 and follow the procedure below:

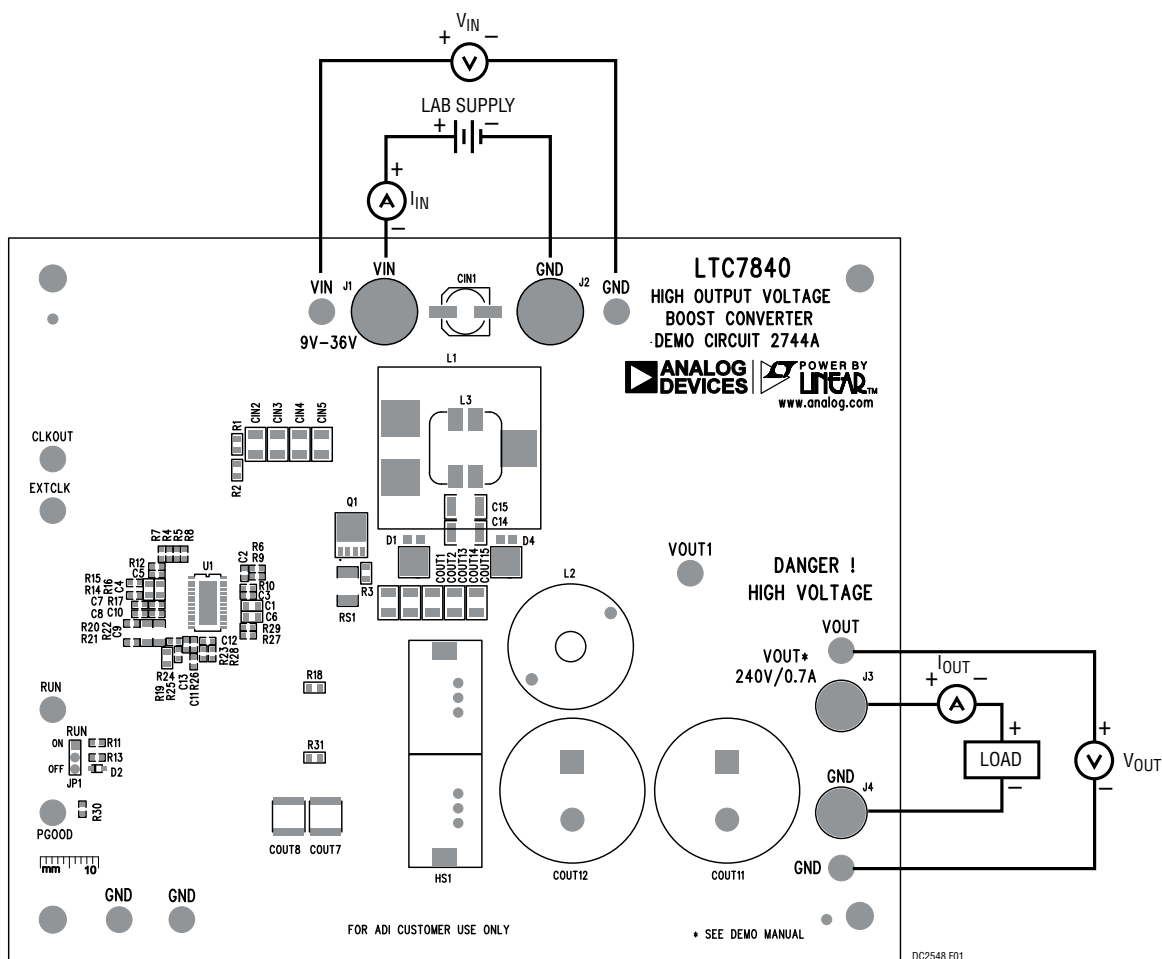
NOTE: When measuring the input or output voltage ripple, care must be taken to minimize the length of oscilloscope probe ground lead. Measure the input or output voltage ripple by connecting the probe tip directly across the V_{IN} or V_{OUT} and GND terminals as shown in Figure 2.

1. With power off, connect the input power supply to V_{IN} and GND.
2. Keep the load set to 0A or disconnected.

3. Turn the input power source on and slowly increase the input voltage. Be careful not to exceed 36V.

NOTE: Make sure that the input voltage V_{IN} does not exceed 36V.

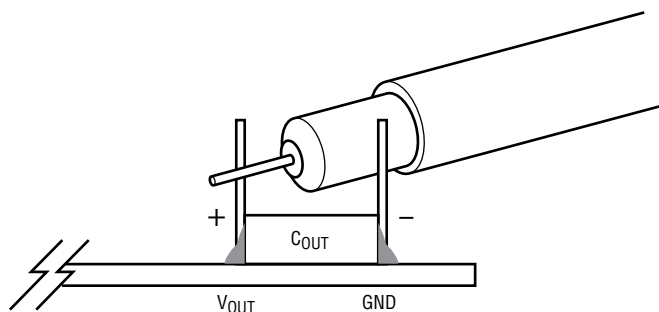
4. Set the input voltage to 12V and check for the proper output voltage of 240V. Set the output load to 0.7A. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
5. Once the proper output voltage is established, adjust the load and observe the output voltage regulation, ripple voltage, efficiency and other parameters.
6. ***Do not remove the output load before powering down in order to discharge the output capacitors!***



WARNING: HIGH VOLTAGE PRESENT!

Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE



WARNING: HIGH OUTPUT VOLTAGE

Figure 2. Measuring Input or Output Ripple

Changing the Output Voltage

To set the output voltage lower than 240V, change the bottom voltage divider resistors connected to LTC7840 FB pin (see the Schematic Diagram). To get higher than 240V output voltage, MOSFETs and capacitors with higher voltage ratings may be required.

Converter Efficiency and Output Current

The DC2744 output current capability depends on the input voltage and proper cooling. Typical performance of DC2744A is shown in Figure 3. As can be seen from Figure 3, the output current capability depends on the input voltage. The circuit may require forced air-cooling at high loads. The power MOSFETs and output diodes should not be allowed to exceed their specified operating temperature. To be on the safe side, the surface temperature of power components should be kept under 105°C.

Output Load Step Response

The load step response of DC2744A was designed to prevent large input current transients and to provide acceptable output voltage load step response. The I_{IN} trace in Figure 4 shows the input current transient resulting from 0.2A to 0.7A load step. If faster load step response is required, the input power source capable of handling faster current surges may have to be used. Also, if higher load steps need to be handled, more output capacitance may be added in order to keep the voltage transients at the desired level.

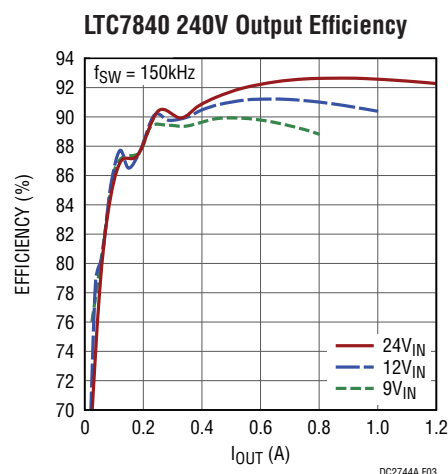


Figure 3. High Efficiency of DC2744 Allows the Board to Be Used in Thermally Critical Applications

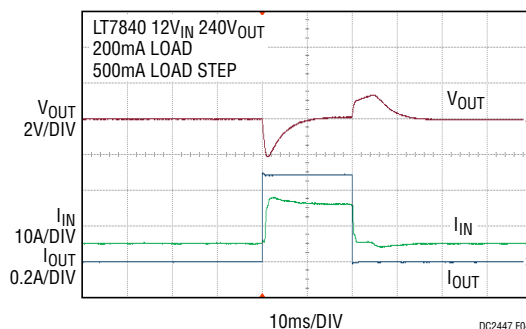


Figure 4. The Two Feedback Loops of DC2744 Circuit Are Set to Minimize Current Transients on the Input and to Provide Reasonable Output Load Step Response

QUICK START PROCEDURE

Soft-Start Function

The DC2744 features soft-start circuit that controls the inrush current and output voltage ramp at start-up. The SS pin capacitors (Schematic Diagram) control the start-up period. The start-up waveforms are shown in Figure 5. The first boost stage soft-start is fast since it is only charging the output capacitors to 48V. The second stage boost circuit soft-start is much slower and it charges the output capacitors to the nominal 240V level in 300ms.

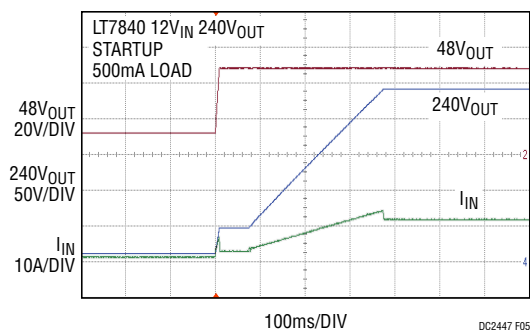


Figure 5. The DC2744 Ramps the Output Slowly at Startup Without Generating an Input Current Surge.

Intermediate Voltage Output

The output of first boost stage of DC2744 is available at VOUT1 terminal. The intermediate output voltage VOUT1 is set to 48V, which is a good input voltage for the second boost stage. This voltage level allows the first boost stage to use high current 60V power MOSFET and diode. The second boost stage input current will be under 4A, which allows the use of relatively small high voltage MOSFET and output diode. In addition to supplying the power for second boost stage, the 48V intermediate output can be used to power other 48V loads in the system if required.

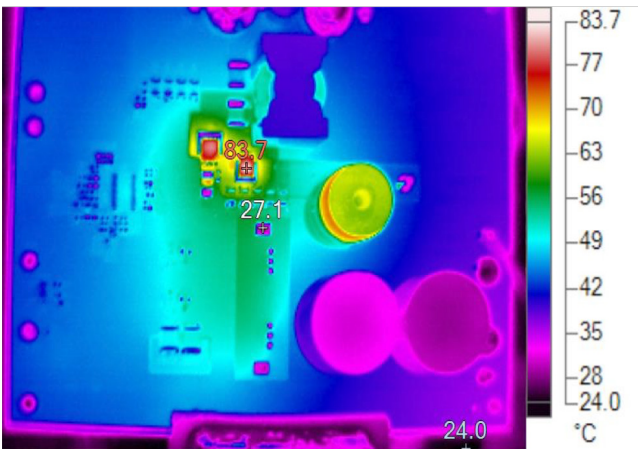


Figure 6. Thermal Image, 12V Input to 240V Output at 0.7A, No Air Flow, No Heat Sink, Top Side.

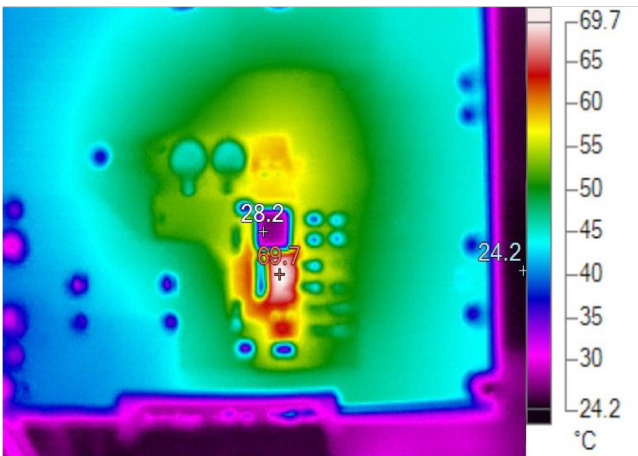


Figure 7. Thermal Image, 12V Input to 240V Output at 0.7A, No Air Flow, No Heat Sink, Bottom Side.

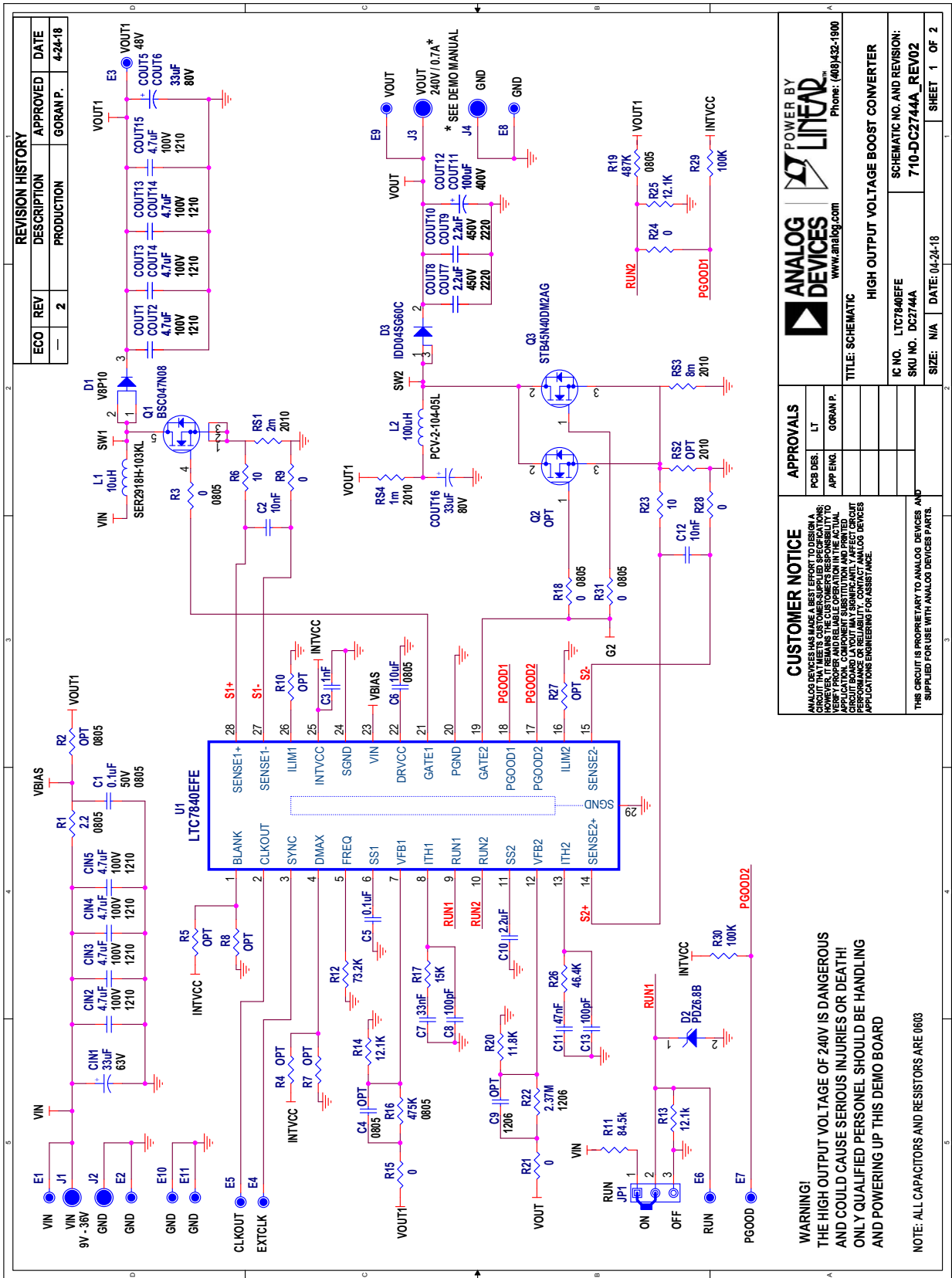
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	CIN1	CAP, ALUM, 33μF, 63V, CAP8X10	PANASONIC, EEHZA1J330P
2	11	COUT1, COUT2, CIN2, COUT3, CIN3, COUT4, CIN4, CIN5, COUT13, COUT14, COUT15	CAP, X7S, 4.7μF, 100V, 20%, 1210	TDK, C3225X7S2A475M
3	3	COUT5, COUT6, COUT16	CAP, ALUM, 33μF, 80V, CAP-10X10	PANASONIC, EEHZA1K330P
4	4	COUT7, COUT8, COUT9, COUT10	CAP, X6S, 2.2μF, 450V, 2220	TDK, C5750X6S2W225K250KA
5	2	COUT11, COUT12	CAP, ALUM, 100μF, 400V, 20%, CAP-TH-25X25	KEMET, ELH107M400AR1AA
6	1	C1	CAP, X7R 0.1μF, 50V, 10%, 0805	AVX, 08053C104K4T2A
7	2	C2, C12	CAP, X7R 10nF, 25V, 10%, 0603	AVX, 06033C103JAT2A
8	1	C3	CAP, X7R 1nF, 25V, 5%, 0603	AVX, 06033A102JAT2A
9	1	C5	CAP, X7R 0.1μF, 25V, 10%, 0603	AVX, 06033C104KAT2A
10	1	C6	CAP, X5R, 10μF, 10V, 10%, 0805	AVX, 0805ZD106KAT2A
11	1	C7	CAP, X7R, 33nF, 25V, 10%, 0603	AVX, 06033C333JAT2A
12	2	C8, C13	CAP, NPO, 100pF, 50V, 5%, 0603	KEMET, C0603C101J5GACTU
13	1	C5	CAP, X7R 0.1μF, 25V, 10%, 0603	AVX, 06033C104KAT2A
14	1	C10	CAP, X5R 2.2μF, 25V, 10%, 0603	MURATA GRM188R61E225KA12D
15	1	C11	CAP, X7R, 47nF, 25V, 10%, 0603	AVX, 06033C473JAT2A
16	1	D1	DIODE SCHOTTKY, 8Amp 100V, TO-277A	VISHAY, V8P10-M3 / 86A
17	1	D2	DIODE, VOLTAGE REGULATOR, 6.8V, 400MW, SOD-323	NEXPERIA, PDZ6.8B
18	1	D3	DIODE SCHOTTKY, 600V, 5.6A, TO252-3	INFINEON, IDD04SG60C
19	1	L1	IND., 10μH	COILCRAFT, SER2918H-103KL
20	1	L2	IND., VERT. PWR CHOKES, 100μH, 5.6A	COILCRAFT, PCV-2-104-05L
21	1	Q1	MOSFET, N-CH, 80V, 100A, LPAK	INFINEON, BSC047N08NS3-G
22	1	Q3	MOSFET, N-CH, 400V, 38A, TO-263AB	STMICRO., STB45N40DM2AG
23	1	RS1	RES., 0.002 OHM, 1/2W 1% 2010	VISHAY, WSL20102L000FEA
24	1	RS3	RES., 0.008 OHM, 1/2W 1% 2010	VISHAY, WSL20108L000FEA
25	1	RS4	RES., 0.001 OHM, 1/2W 1% 2010	VISHAY, WSL20101L000FEA
26	1	R1	RES., 2.2 OHM, 1/10W, 1%, 0805	VISHAY, CRCW08052R20FKEA
27	2	R6, R23	RES., 10 OHMS, 1/10W, 1%, 0603	VISHAY, CRCW060310R0FKEA
28	1	R11	RES., 84.5K, 1/10W, 1%, 0603	VISHAY, CRCW060384K5FKEA
29	2	R29, R30	RES., 100K, 1/10W, 1%, 0603	VISHAY, CRCW0603100KFKEA
30	1	R12	RES., 73.2K, 1/10W, 1%, 0603	VISHAY, CRCW060373K2FKEA
31	3	R13, R14, R25	RES., 12.1K, 1/10W, 1%, 0603	VISHAY, CRCW060312K1FKEA
32	1	R16	RES., 475K, 1/10W, 1%, 0603	VISHAY, CRCW0603475KFKEA
33	1	R17	RES., 15K, 1/10W, 1%, 0603	VISHAY, CRCW060315KFKEA
34	1	R19	RES., 487K, 1/10W, 1%, 0805	VISHAY, CRCW0805487KFKEA
35	1	R20	RES., 11.8K, 1/10W, 1%, 0603	VISHAY, CRCW060311K8FKEA
36	1	R22	RES., 2.37MEG, 1/10W, 1%, 1206	VISHAY, CRCW12062M37FKEA
37	1	R26	RES., 46.4K, 1/10W, 1%, 0603	VISHAY, CRCW060346K4FKEA
38	1	U1	IC, LTC7840EFE, SSOP28G	LINEAR TECH., LTC7840EFE#PBF

DEMO MANUAL DC2744A

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Circuit Components				
1	0	C4	CAP, OPT, 0805	OPT
2	0	C9	CAP, OPT, 1206	OPT
3	0	C14, C15	CAP, OPT, 1812	OPT
4	0	D4	DIODE SCHOTTKY, OPT, TO-277A	OPT
5	0	L3	IND., OPT, WURTH ELEKTRONIK 744873004	OPT
6	0	Q2	MOSFET, OPT, TO-263AB	OPT
7	0	RS2	RES., OPT, 2010	OPT
8	0	R2	RES., OPT, 0805	OPT
9	3	R3, R18, R31	RES., 0 OHM, 1/10W, 0805	VISHAY, CRCW08050000Z0EA
10	0	R4, R5, R7, R8, R10, R27	RES., OPT, 0603	OPT
11	5	R9, R15, R21, R24, R28	RES., 0Ω, 1/10W, 0603	VISHAY, CRCW06030000Z0EA
Hardware				
1	11	E1-E11	TEST POINT, TURRET, 0.094", MTG. HOLE	MILL MAX 2501-2-00-80-00-00-07-0
2	1	JP1	CONN., HDR., MALE, 1x3, 2mm, THT, STR	WURTH ELEKTRONIK, 62000311121
3	1	XJP1	CONN., SHUNT, FEMALE, 2 POS, 2mm	WURTH ELEKTRONIK, 60800213421
4	2	J1, J2	STUD, FASTENER, #10-32	PennEngineering, KFH-032-10ET
5	4	J1, J2 (X2)	NUT, HEX, STEEL, ZINC PLATE, 10-32	KEYSTONE, 4705
6	2	J1, J2	RING, LUG, CRIMP, #10, NON-INSULATED, SOLDERLESS TERMINALS	KEYSTONE, 8205
7	2	J1, J2	WASHER, FLAT, STEEL, ZINC PLATE, OD: 0.436 [11.1]	KEYSTONE, 4703
8	2	J3, J4	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
9	1	HS1	HEAT SINK	AAVID TECH., 578622B03200G
10		MTH1-MTH4	STAND-OFF, NYLON 0.625" tall	KEYSTONE, 8834(SNAP ON)

SCHEMATIC DIAGRAM



**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.

Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. **CONFIDENTIALITY.** This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. **ADDITIONAL RESTRICTIONS.** Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. **TERMINATION.** ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. **LIMITATION OF LIABILITY.** THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). **EXPORT.** Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. **GOVERNING LAW.** This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.