# 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 ±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**



## PERFORMANCE SUMMARY

**Specifications are at $T_A$ = 25°C**

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

## QUICK START PROCEDURE

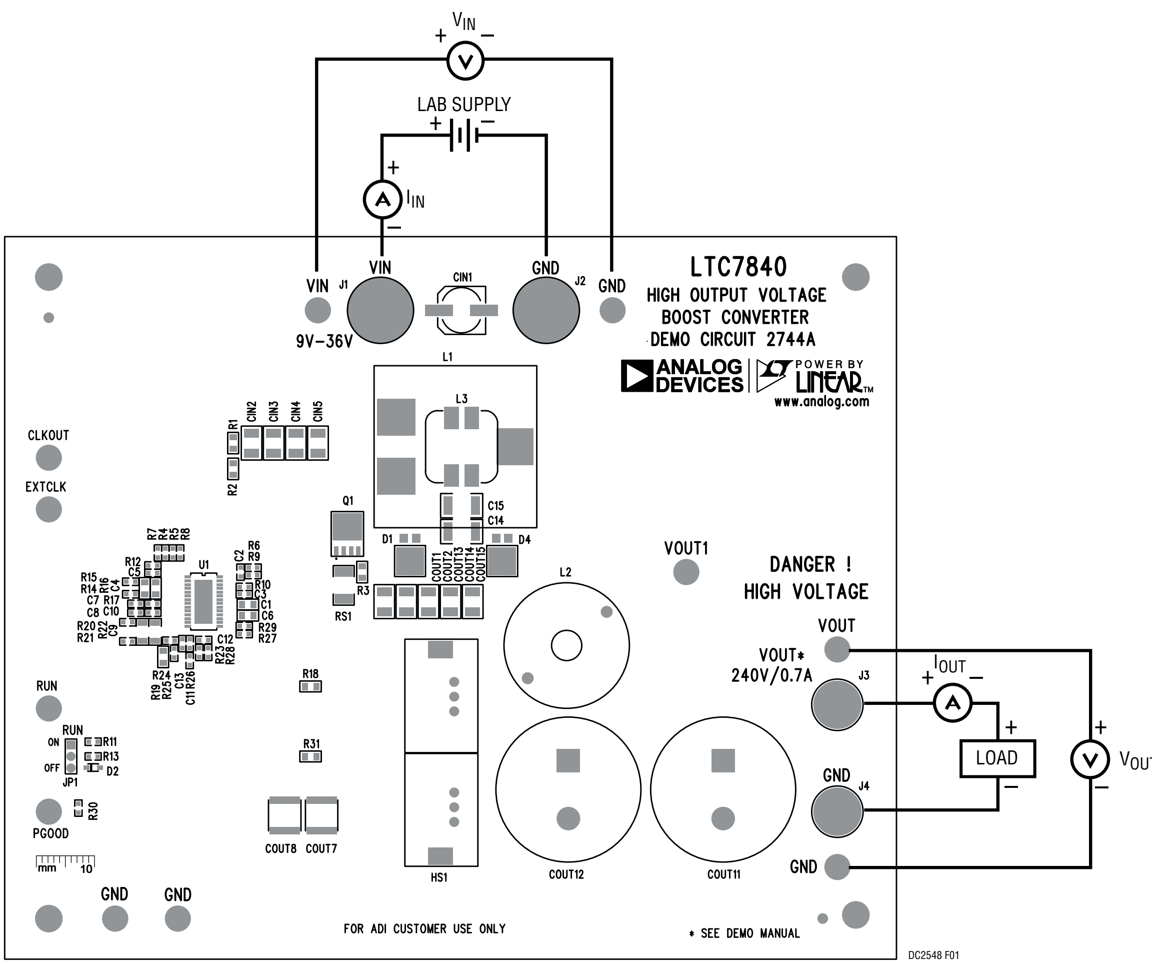
Demonstration circuit DC2744 is easy to set up to evaluate the performance of the LTC7840. For proper measurement equipment setup refer to Figure 1 and follow the procedure below:

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.

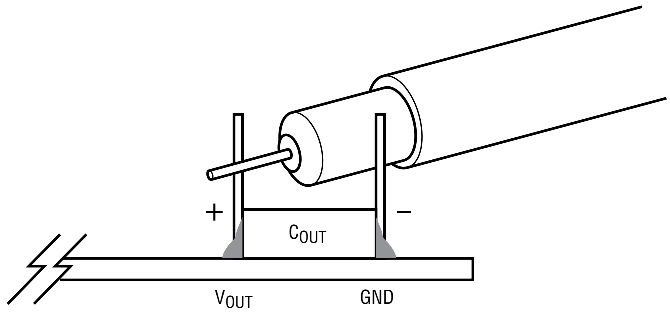
4. Set the input voltage to 12V and check for the proper output voltage of 240V. Set the output load to 0.7A. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
5. Once the proper output voltage is established, adjust the load and observe the output 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.

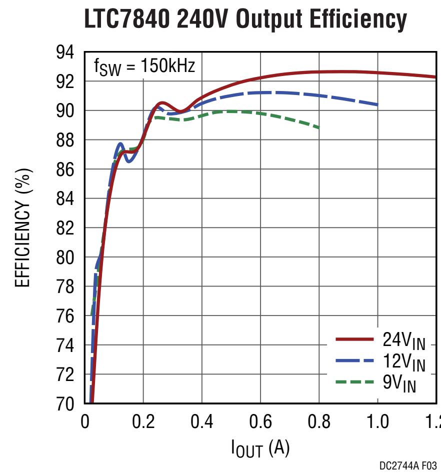



**Figure 3. High Efficiency of DC2744 Allows the Board to Be Used in Thermally Critical Applications**

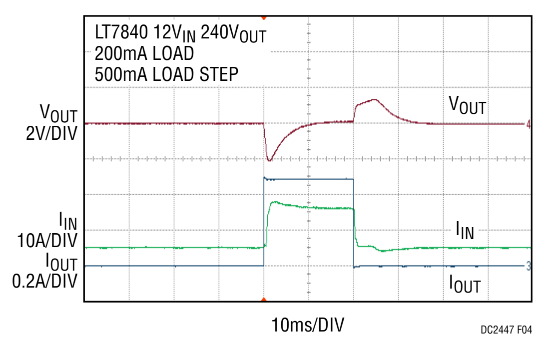



**Figure 4. The Two Feedback Loops of DC2744 Circuit Are Set to Minimize Current Transients on the Input and to Provide Reasonable Output Load Step Response**

## 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.

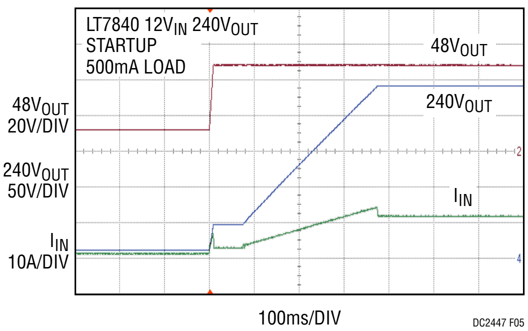



**Figure 5. The DC2744 Ramps the Output Slowly at Startup Without Generating an Input Current Surge.**

### 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.

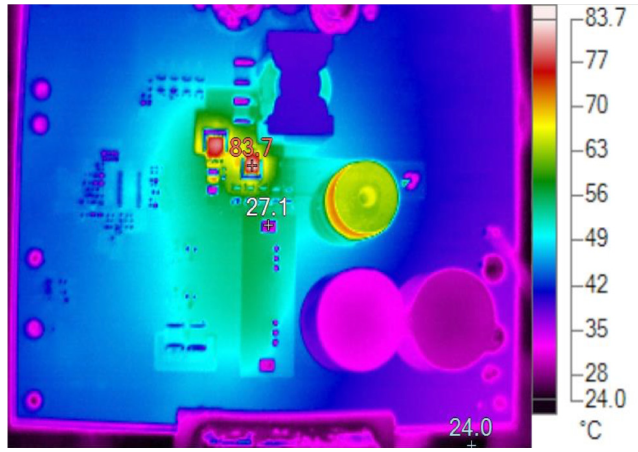



**Figure 6. Thermal Image, 12V Input to 240V Output at 0.7A, No Air Flow, No Heat Sink, Top Side.**

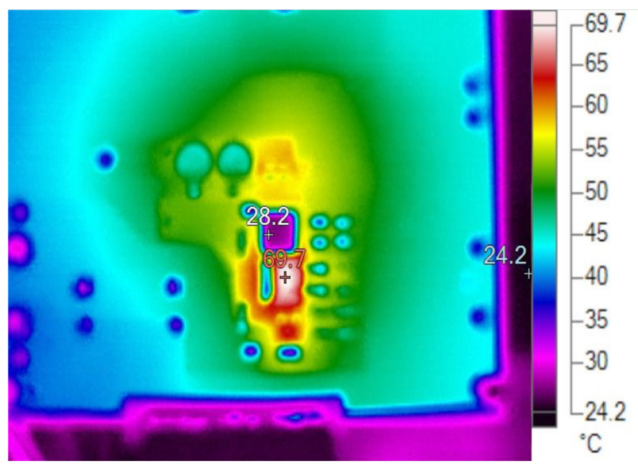


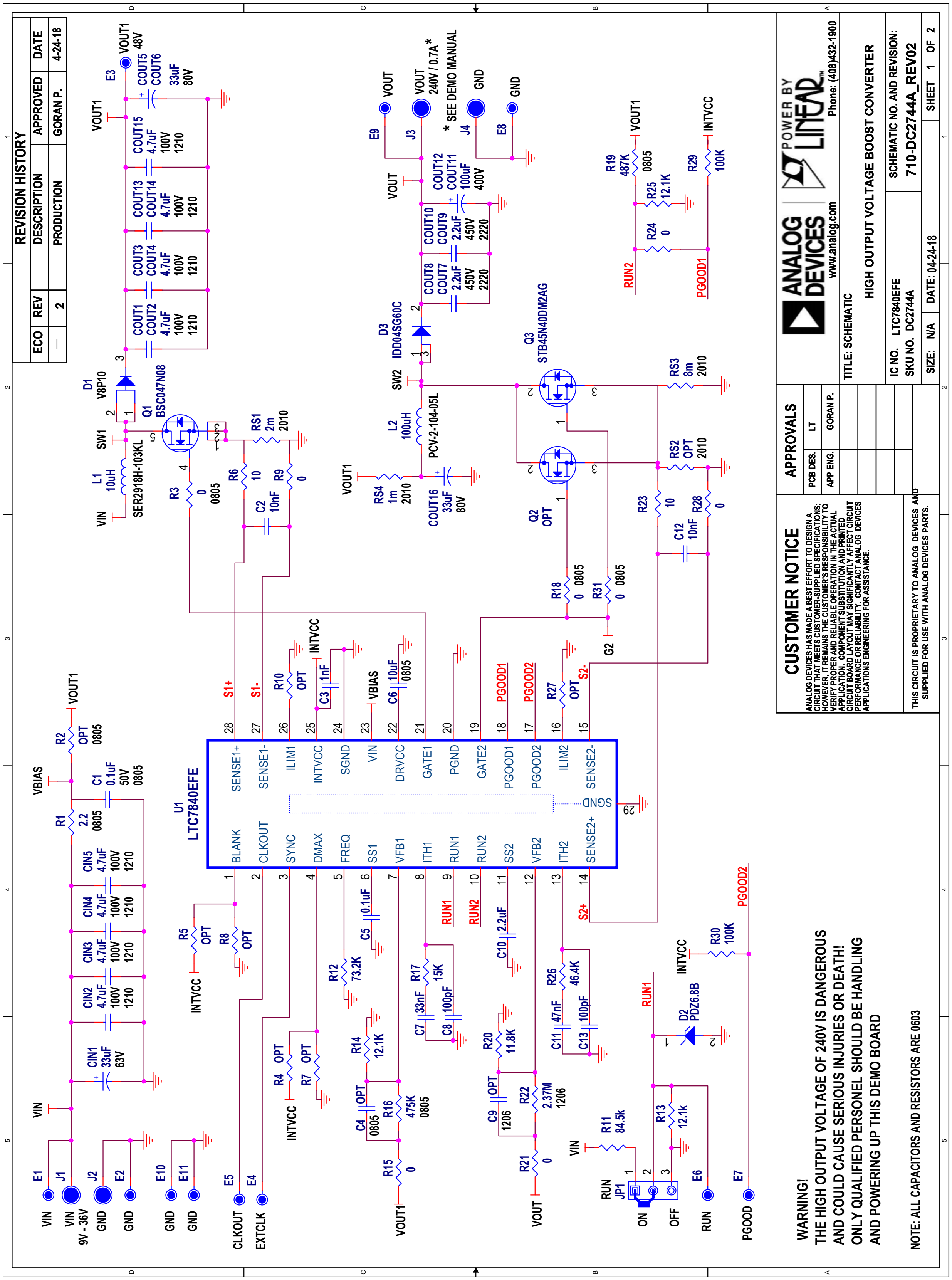

**Figure 7. Thermal Image, 12V Input to 240V Output at 0.7A, No Air Flow, No Heat Sink, Bottom Side.**

# 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, LFPAK | 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 |

| 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.



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