# LT8390
# 12$V_{OUT}$, 120W Synchronous 4-Switch Buck-Boost Regulator

## DESCRIPTION

Demonstration circuit 2825A is a 4-switch synchronous buck-boost regulator that demonstrates the medium power capability of the LT®8390. The output is 12V and the maximum output current is 10A for up to 120W power delivery. The switching frequency is 300kHz and efficiency can exceed 96%.

The steady-state operating input voltage range of DC2825A in which the temperature of the components is less than 90°C is from 9V to 22V. The transient operating input voltage range of DC2825A is from 7V to 36V. The output voltage and EN/UVLO are all programmed by resistor dividers. EN/UVLO is set so the circuit will turn off when the input voltage falls below 7V and will turn on when the input voltage rises above 8V.

DC2825A features MOSFETs that complement the 5V gate drive of the LT8390 to achieve high efficiency. 40V AEC-Q101 MOSFETs are used on the input and output side of the 4-switch topology. Ceramic capacitors are used at both the circuit input and output because of their small size and high ripple current capability. In addition to ceramic capacitors, there are hybrid polymer aluminum electrolytic capacitors at the input and output to mitigate the effects of the input and output transients.

The PCB has large copper planes and extensive vias for excellent high power thermal performance. There are four mounting holes on the board for optional heat sink and fan, which can push the output power of DC2825A up to 180W. For more details, please consult the factory for assistance.

The CTRL input is pulled up to the $V_{REF}$ pin through a 0Ω resistor to set the output current limit to its maximum; an external voltage on CTRL can be used to lower the current limit if the resistor is removed. A capacitor at the SS pin programs soft-start.

To improve the EMI performance, the LT8390 has spread spectrum frequency modulation. With the SYNC/SPRD pin tied to $INTV_{CC}$, LT8390 spreads its switching frequency ±15% around the programmed oscillator frequency.

The PGOOD status flag indicates when output voltage is within ±10% of the final regulation voltage.

The LT8390's proprietary peak current mode buck-boost architecture ensures DC2825A runs either in discontinuous conduction mode (DCM) or pulse-skipping mode (PSM) without reverse inductor current. Both modes enhance the light load efficiency.

The demo circuit is designed to be easily reconfigured to suit other applications, including the example schematics in the data sheet. Consult the factory for assistance.

High power operation, 4-switch buck-boost topology, proprietary peak current mode architecture, fault protection and output current monitoring make the LT8390 attractive for high power voltage regulator circuits and also circuits that require output current regulation such as battery chargers. The LT8390EFE is available in a thermally enhanced 28 lead TSSOP package. The LT8390 data sheet must be read in conjunction with this demo manual to properly use or modify demo circuit DC2825A.

**Design files for this circuit board are available.**

## PERFORMANCE SUMMARY

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

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| Input Voltage Range ($V_{IN}$) | $V_{OUT}$ = 12V | 7 | | 36 | V |
| Full Load (10A) Input Voltage Range ($V_{IN}$) | Component Temperature <90°C with No Airflow | 9 | | 22 | V |
| Output Voltage ($V_{OUT}$) | R7 = 110k, R8 = 10k | 11.5 | 12.0 | 12.5 | V |
| Output Voltage Ripple | $V_{IN}$ = 12V, $V_{OUT}$ = 12V, $I_{OUT}$ = 10A | | 70 | | $mV_{P-P}$ |
| Maximum Output Current | 9V ≤ $V_{IN}$ ≤ 22V, $V_{OUT}$ = 12V | 10 | | | A |
| Switching Frequency | R5 = 140k | | 300 | | kHz |
| Efficiency | $V_{IN}$ = 12V, $V_{OUT}$ = 12V, $I_{OUT}$ = 10A | | 95 | | % |
| Input EN Voltage | R9 = 374k, R10 = 78.7k | | 8 | | V |
| Input UVLO Voltage | R9 = 374k, R10 = 78.7k | | 7 | | V |
| Output Current Limit ($I_{OUT}$) | R3 = 8mΩ | | 12.5 | | A |
| Peak Switch Current Limit | R1 = 2mΩ | 17.5 | 25 | 32.5 | A |
| $V_{ISMON}$ | $V_{OUT}$ = 12V, $I_{OUT}$ = 10A | | 1.05 | | V |

## QUICK START PROCEDURE

The DC2825A is easy to set up to evaluate the performance of the LT8390EFE. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

**NOTE:** Make sure that the voltage applied to $V_{IN}$ does not exceed 40V, which is the voltage rating for the input side MOSFETs.

1. Set JP1 at NO SSFM/SYNC to disable SSFM, at SSFM ON to enable SSFM, or at EXT SYNC and connect an external oscillator to EXT SYNC.
2. Connect the EN/UVLO terminal to ground with a clip-on lead. Connect the power supply (with power off), load, and meters as shown.
3. After all connections are made, turn on the input power and verify that the input voltage is between 9V and 22V.
4. Remove the clip-on lead from EN/UVLO. Verify that the output voltage is 12V.

   **NOTE:** If the output voltage is low, temporarily disconnect the load to make sure that it is not set too high.
5. Once the proper output voltage is established, adjust the input voltage and load within the operating ranges and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

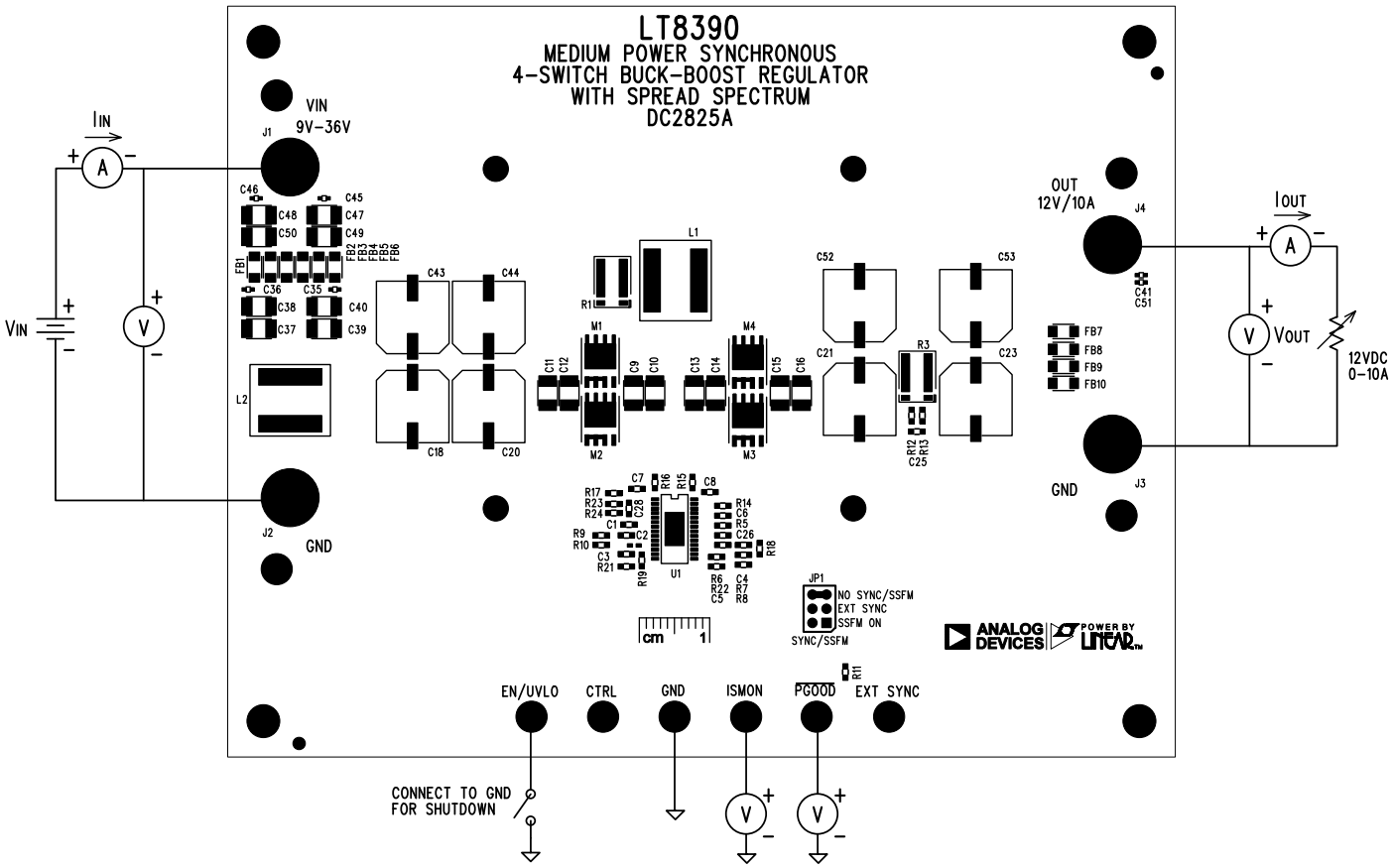



**Figure 1. Test Procedure Setup Drawing for DC2825A**

## TEST RESULTS

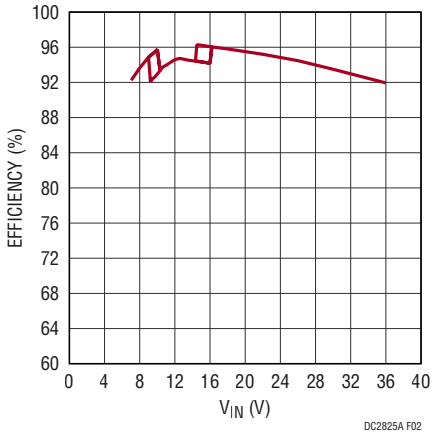



Figure 2. Efficiency vs $V_{IN}$ at Full Load ($I_{OUT}$ = 10A, SSFM OFF)

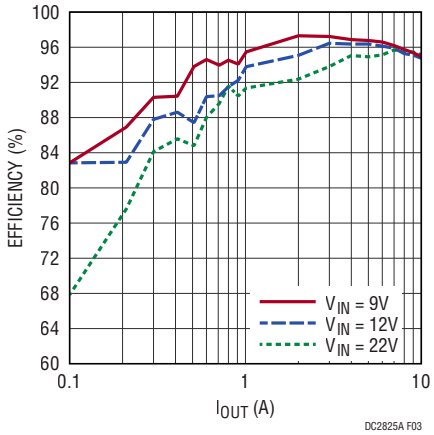



Figure 3. Efficiency vs $I_{OUT}$ at Different $V_{IN}$ (SSFM OFF)

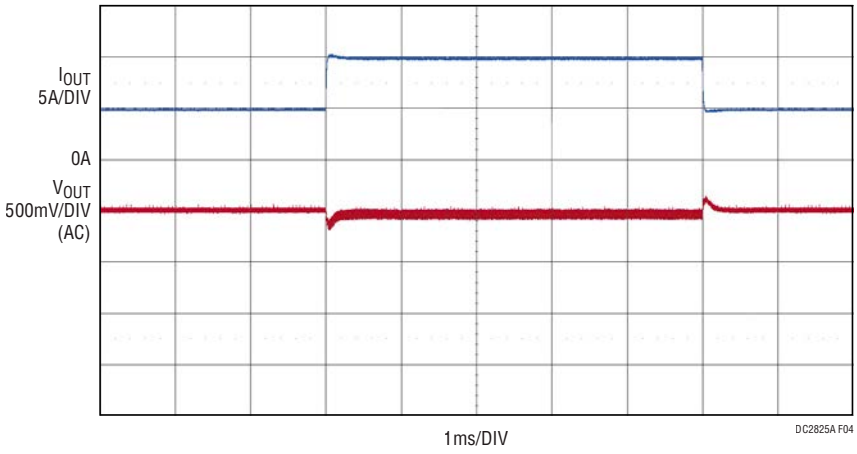



Figure 4. Output Voltage Load Transient Response ($V_{IN}$ = 12V, $V_{OUT}$ = 12V, $I_{OUT}$ = 5A to 10A to 5A)

## TEST RESULTS

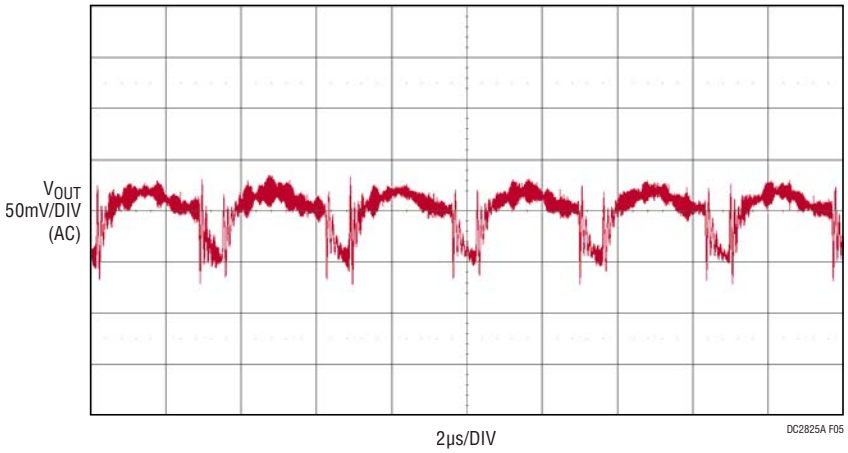



**Figure 5. Output Voltage Ripple Measured at C41 ($V_{IN}$ = 12V, $V_{OUT}$ = 12V, $I_{OUT}$ = 10A)**

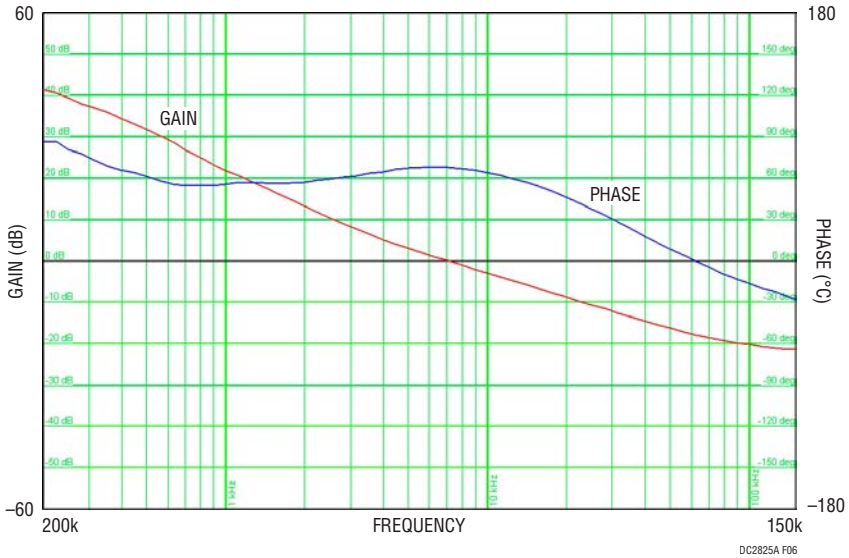



**Figure 6. Loop Gain Bode Plot ($V_{IN}$ = 12V, $V_{OUT}$ = 12V, $I_{OUT}$ = 10A)**

## THERMAL IMAGES

Two example thermal images show the temperature profile of the DC2825A. The test is done in still air at room temperature (25°C) at 10A full load current with spread spectrum frequency modulation (SSFM). Figure 7 shows a result when the input voltage is 12V; the highest temperature is lower than 70°C. Figure 8 shows a result with worst-case conditions (lowest input voltage in the 4-switch buck-boost region; the highest temperature is below 90°C, near the power MOSFET (M3).

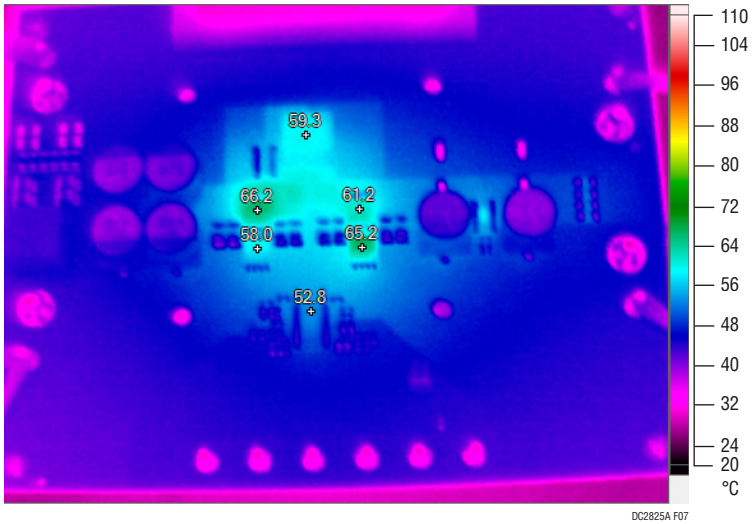



**Figure 7. Temperature at Normal Case ($V_{IN}$ = 12V, $V_{OUT}$ = 12V, $I_{OUT}$ = 10A, SSFM ON)**

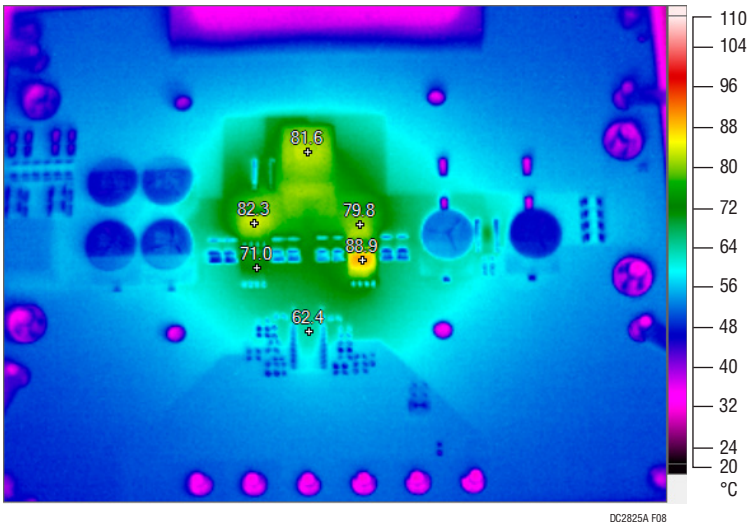



**Figure 8. Temperature at Worst-Case ($V_{IN}$ = 9.25V, $V_{OUT}$ = 12V, $I_{OUT}$ = 10A, SSFM ON)**

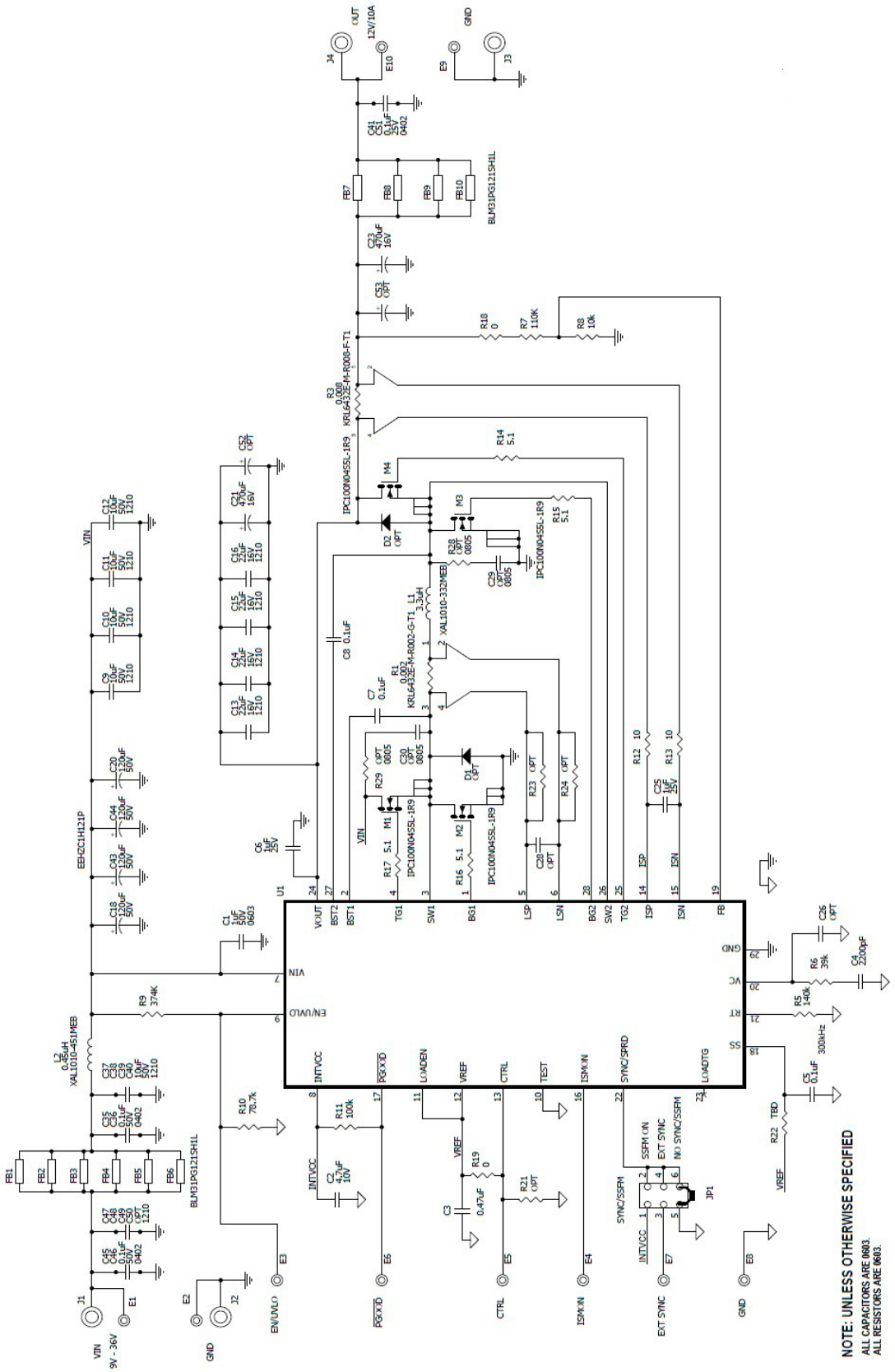
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components** | | | | |
| 1 | 1 | C1 | CAP, 1µF, X7R, 50V, 10%, 0603 | AVX, 06035C105KAT2A |
| 2 | 1 | C2 | CAP, 4.7µF, X5R, 10V, 10%, 0603 | AVX, 0603ZD475KAT2A |
| 3 | 1 | C3 | CAP, 0.47µF, X7R, 16V, 10%, 0603, AEC-Q200 | MURATA, GCM188R71C474KA55D |
| 4 | 1 | C4 | CAP, 2200pF, X7R, 25V, 10%, 0603 | AVX, 06033C222KAT2A |
| 5 | 3 | C5, C7, C8 | CAP, 0.1µF, X7R, 16V, 10%, 0603, AEC-Q200 | KEMET, C0603C104K4RACAUTO |
| 6 | 2 | C6, C25 | CAP, 1µF, X7R, 25V, 10%, 0603, AEC-Q200 | MURATA, GCM188R71E105KA64D |
| 7 | 8 | C9 TO C12, C37 TO C40 | CAP, 10µF, X7R, 50V, 10%, 1210 | MURATA, GRM32ER71H106KA12L |
| 8 | 4 | C13 TO C16 | CAP, 22µF, X7R, 16V, 20%, 1210, AEC-Q200 | MURATA, GCM32ER71C226ME19L |
| 9 | 4 | C18, C20, C43, C44 | CAP, 120µF, ALUM ELECT, 50V, 20%, 10mm × 0.2mm SMD, RADIAL, AEC-Q200 | PANASONIC, EEHZC1H121P |
| 10 | 2 | C21, C23 | CAP, 470µF, ALUM ELECT, 16V, 20%, 10mm × 10mm, RADIAL, AEC-Q200 | NIPPON CHEMI-CON, HHXB160ARA471MJA0G |
| 11 | 4 | C35, C36, C45, C46 | CAP, 0.1µF, X7R, 50V, 10%, 0402, AEC-Q200 | MURATA, GCM155R71H104KE02D |
| 12 | 2 | C41, C51 | CAP, 0.1µF, X7R, 25V, 10%, 0402 | AVX, 04023C104KAT2A |
| 13 | 10 | FB1 TO FB10 | IND, 120Ω AT 100MHz, FERRITE BEAD, 25%, 3.5A, 20mΩ, 1206, AEC-Q200 | MURATA, BLM31PG121SH1L |
| 14 | 1 | L1 | IND, 3.3µH, PWR, 20%, 25A, 4.10mΩ, 11.8mm×10.5mm, XAL1010, AEC-Q200 | COILCRAFT, XAL1010-332MEB |
| 15 | 1 | L2 | IND, 0.45µH, PWR, 20%, 52A, 0.72mΩ, 11.8mm×10.5mm, XAL1010, AEC-Q200 | COILCRAFT, XAL1010-451MEB |
| 16 | 4 | M1 TO M4 | XSTR, MOSFET, N-CH, 40V, 100A, TDSON-8, AEC-Q101 | INFINEON, IPC100N04S5L-1R9 |
| 17 | 1 | R1 | RES, 0.002Ω, 2%, 3W, 2512, LONG-SIDE TERM, METAL, SENSE, AEC-Q200 | SUSUMU, KRL6432E-M-R002-G-T1 |
| 18 | 1 | R3 | RES, 0.008Ω, 1%, 3W, 2512, LONG-SIDE TERM, METAL, SENSE, AEC-Q200 | SUSUMU, KRL6432E-M-R008-F-T1 |
| 19 | 1 | R5 | RES, 140kΩ, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF1403V |
| 20 | 1 | R6 | RES, 39kΩ, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF3902V |
| 21 | 1 | R7 | RES, 110kΩ, 1%,1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF1103V |
| 22 | 1 | R8 | RES, 10kΩ, 1%, 1/10W, 0603, AEC-Q200 | VISHAY, CRCW060310K0FKEA |
| 23 | 1 | R9 | RES, 374kΩ, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF3743V |
| 24 | 1 | R10 | RES, 78.7kΩ, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF7872V |
| 25 | 1 | R11 | RES, 100kΩ, 1%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3EKF1003V |
| 26 | 2 | R12, R13 | RES, 10Ω, 5%, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3GEYJ100V |
| 27 | 4 | R14 TO R17 | RES, 5.1Ω, 1%, 1/10W, 0603, AEC-Q200 | VISHAY, CRCW06035R10FKEA |
| 28 | 2 | R18, R19 | RES, 0Ω, 1/10W, 0603, AEC-Q200 | PANASONIC, ERJ3GEY0R00V |
| 29 | 1 | U1 | IC, 4-SWITCH BUCK BOOST CTRLR, TSSOP-28 | ANALOG DEVICES INC, LT8390EFE#PBF |

## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Additional Demo Board Circuit Components** | | | | |
| 30 | 0 | C26, C28 | CAP, OPTION, 0603 | |
| 31 | 0 | C29, C30 | CAP, OPTION, 0805 | |
| 32 | 0 | C47 TO C50 | CAP, OPTION, 1210 | |
| 33 | 0 | C52, C53 | CAP, OPTION, ALUM ELECT, SMD | |
| 34 | 0 | D1, D2 | DIODE, OPTION, SMB | |
| 35 | 0 | R21 TO R24 | RES, OPTION, 0603 | |
| 36 | 0 | R28, R29 | RES, OPTION, 0805 | |
| **Hardware: For Demo Board Only** | | | | |
| 37 | 10 | E1 TO E10 | TEST POINT, TURRET, 0.094" MTG HOLE, PCB 0.062" THICK | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 38 | 4 | J1 TO J4 | CONN, BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218" | KEYSTONE, 575-4 |
| 39 | 1 | JP1 | CONN, HDR, MALE, 2×3, 2mm, VERT, STR, THT | WURTH ELEKTRONIK, 62000621121 |
| 40 | 4 | MH1 TO MH4 | STANDOFF, NYLON, SNAP-ON, 0.375" | WURTH ELEKTRONIK, 702933000 |
| 41 | 1 | XJP1 | CONN, SHUNT, FEMALE, 2 POS, 2mm | WURTH ELEKTRONIK, 60800213421 |

## SCHEMATIC DIAGRAM



**ESD Caution**
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