

# 42V Quad Monolithic Synchronous Step-Down Regulator

## DESCRIPTION

Demonstration circuit 1949A is a quad power supply featuring the [LT<sup>®</sup>8602](#). LT8602 is a 42V quad monolithic synchronous step-down regulator. The demo circuit is designed for 5.0V, 3.3V, 1.8V, and 1.2V outputs from a nominal 12V input, with switching frequency set at 2MHz to avoid audio band. The 1.8V and 1.2V converters are powered from the 3.3V output. The 5V, 3.3V are powered from a wide range of 5.5V to 42V. The current capability is 2.5A for the 3.3V output, 1.5A for the 5V output, and 1.8A for the other outputs when running individually. Up to 1A load current can be applied to all the channels simultaneously without special cooling.

Individual soft-start, current limit, input voltage, power good for each output simplify the complex design of quad-output power converters. All regulators are synchronized to a common external clock input or a resistor programmable 250kHz to 2.2MHz internal oscillator. At all frequencies, a 180° phase shift is maintained between 1 and 3, 2 and 4 channels, reducing the input peak current and voltage ripple. Programmable frequency allows optimization between efficiency and external component

size. Each output can be independently disabled using its own TRKSS or RUN pin and be placed in a low quiescent current shutdown mode. Table 1 summarizes the performance of the demo board at room temperature. The circuit can be easily modified for different applications.

Figure 6 shows the typical thermal performance of the circuit.

The demo board has an EMI filter installed on the bottom layer. The conducted and radiated EMI performance of the board is shown on Figure 4. The limit in Figure 4 is CISPR Class 5, Peak. It shows the circuit passes the CISPR Class 5, Peak test with a wide margin.

The LT8602 data sheet gives a complete description of the part, operation and application information. The data sheet must be read in conjunction with this quick start guide for DC1949A.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC1949A>**

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## PERFORMANCE SUMMARY Specifications are at T<sub>A</sub> = 25°C

Table 1

| PARAMETER                                | CONDITIONS                                            | MIN  | TYP | MAX  | UNITS |
|------------------------------------------|-------------------------------------------------------|------|-----|------|-------|
| Input Voltage*                           |                                                       | 5.5  | 12  | 42   | V     |
| Standby Current When Switching           | I <sub>OUT1,2,3,4</sub> = 0mA, V <sub>IN</sub> = 12V  |      | 60  |      | μA    |
| Output Voltage V <sub>OUT1</sub>         | V <sub>IN</sub> = 12V, I <sub>OUT1</sub> = 1A         | 4.80 | 5   | 5.20 | V     |
| Output Voltage V <sub>OUT2</sub>         | I <sub>OUT2</sub> = 1A                                | 3.17 | 3.3 | 3.43 | V     |
| Output Voltage V <sub>OUT3</sub>         | I <sub>OUT3</sub> = 1A                                | 1.73 | 1.8 | 1.87 | V     |
| Output Voltage V <sub>OUT4</sub>         | I <sub>OUT4</sub> = 1A                                | 1.15 | 1.2 | 1.25 | V     |
| Maximum Output Current I <sub>OUT1</sub> | V <sub>IN</sub> = 12V, No Load on Other Channels      | 1.5  |     |      | A     |
| Maximum Output Current I <sub>OUT2</sub> | V <sub>IN</sub> = 12V, No Load on Other Channels      | 2.5  |     |      | A     |
| Maximum Output Current I <sub>OUT3</sub> | No Load on Other Channels                             | 1.8  |     |      | A     |
| Maximum Output Current I <sub>OUT4</sub> | No Load on Other Channels                             | 1.8  |     |      | A     |
| Switching Frequency                      | V <sub>IN</sub> = 12V, I <sub>OUT1,2,3,4</sub> = 1.0A | 1.85 | 2   | 2.15 | MHz   |
| Efficiency                               | V <sub>IN</sub> = 12V, I <sub>OUT1,2,3,4</sub> = 1.0A |      | 80  |      | %     |

Refer to Figure 6 to determine the maximum input voltage and load. If IC temperature exceeds target, reduce input voltage, output current or switching frequency.

dc1949af

## QUICK START PROCEDURE

DC1949A is easy to set up to evaluate the performance of the LT8602. Refer to Figure 1 for proper equipment setup and follow the procedure below.

1. With power off, connect the input power supply to the board through  $V_{IN}$  and GND terminals on the top layer. Connect the loads to the terminals  $V_{OUT1}$  and GND,  $V_{OUT2}$  and GND,  $V_{OUT3}$  and GND,  $V_{OUT4}$  and GND on the board. The default positions of the Headers are given in Table 2.

**Table 2. Default Positions of the Headers**

| NAME    |     | POSITION |
|---------|-----|----------|
| EN/UVLO | JP1 | ON       |
| TRKSS1  | JP4 | ON       |
| TRKSS2  | JP5 | ON       |
| RUN3    | JP2 | RUN      |
| RUN4    | JP3 | RUN      |

2. Turn on the power at the input. Increase  $V_{IN}$  to 12V.

**Note:** Make sure that the input voltage is always within spec. Refer to data sheet on the burst mode operation in light load and high  $V_{IN}$  condition.

3. Check for the proper output voltages. The output should be regulated at 5.0V ( $\pm 4\%$ ), 3.3V ( $\pm 4\%$ ), 1.8V ( $\pm 4\%$ ), 1.2V ( $\pm 4\%$ ).

**Note:** Do not overload unless proper thermal cooling method such as air flow or heat sink is applied.

**Note:** If there is no output, temporarily disconnect the load to make sure that the load is not set too high, and the Headers of EN/UVLO, TRKSS1, TRKSS2, RUN3, RUN4, are set in right positions.

4. Once the proper output voltage is established, adjust the input voltage and load currents within the operating range and observe the output voltage regulation, transient, ripple voltage, efficiency and other parameters.

**Note:** Refer to the thermal derating curves in LT8602 data sheet for high input voltage and/or high ambient temperature operations.

**Note:** By default, SYNC is grounded, and the circuit is set in low ripple burst mode operation. Remove R16, and add R25 of  $0\Omega$ , the circuit is set in pulse-skipping mode. The circuit runs in full frequency with lower load current. Refer to the data sheet on the input voltage and load current ranges the circuit runs in full frequency. To synchronize to an external clock, apply the external clock to the SYNC turret.

**Note:** When measuring the input or output voltage ripples, 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  $V_{OUT}$  capacitor terminals. See Figure 2 for proper scope probe technique.

**Note:** The EMI filter is assembled on the bottom layer of the demo circuit. For EMI test, connect the EMI test facility to the terminals of  $VEMI^+$ , and  $VEMI^-$  with very short wires.

## QUICK START PROCEDURE

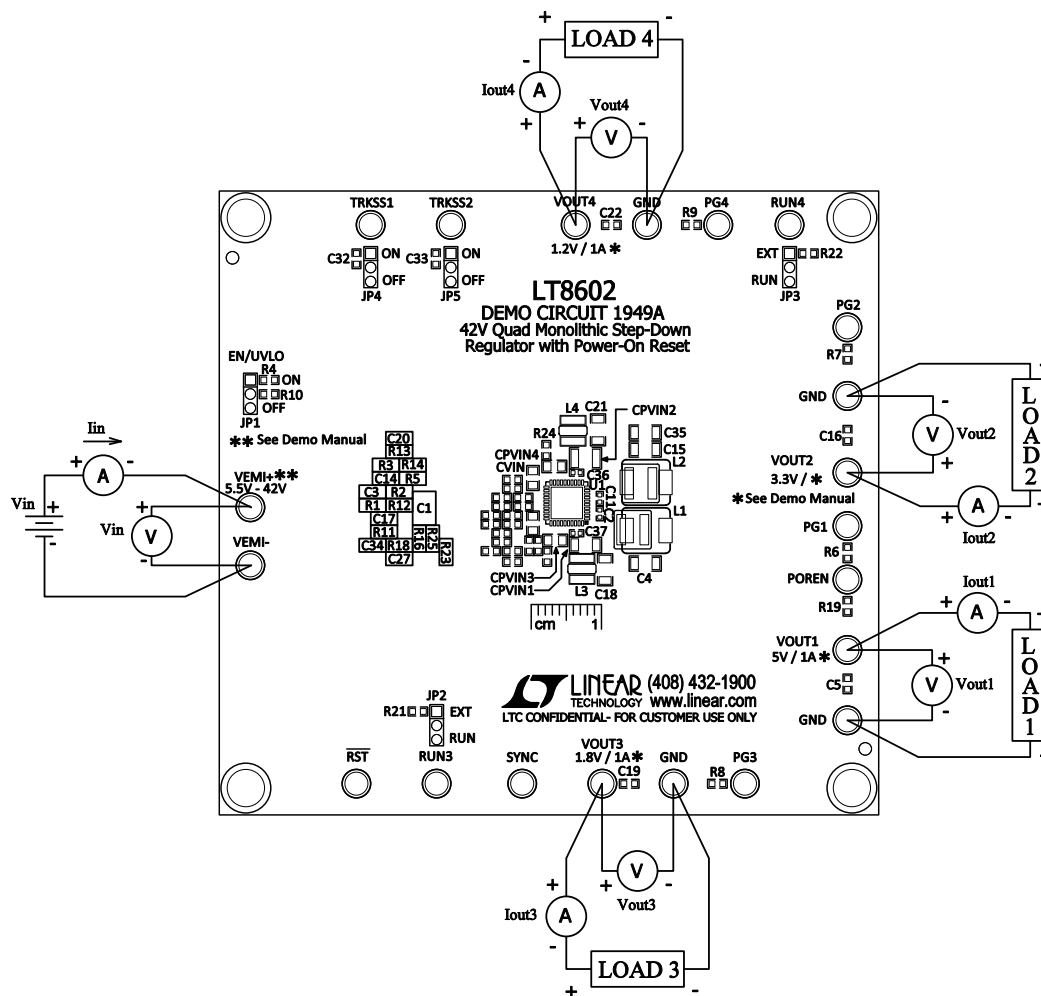


Figure 1. Proper Measurement Equipment Setup

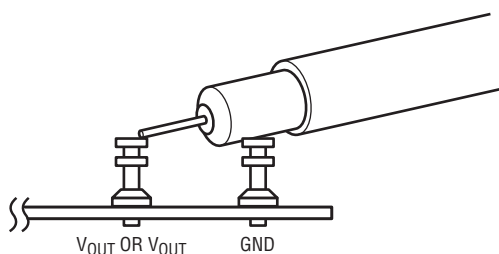


Figure 2. Proper Scope Probe Placement for Measuring Input or Output Ripple

QUICK START PROCEDURE

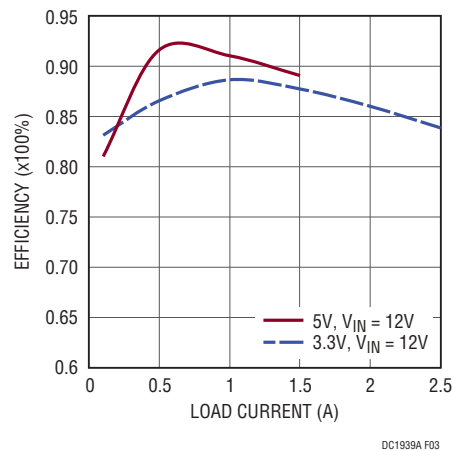
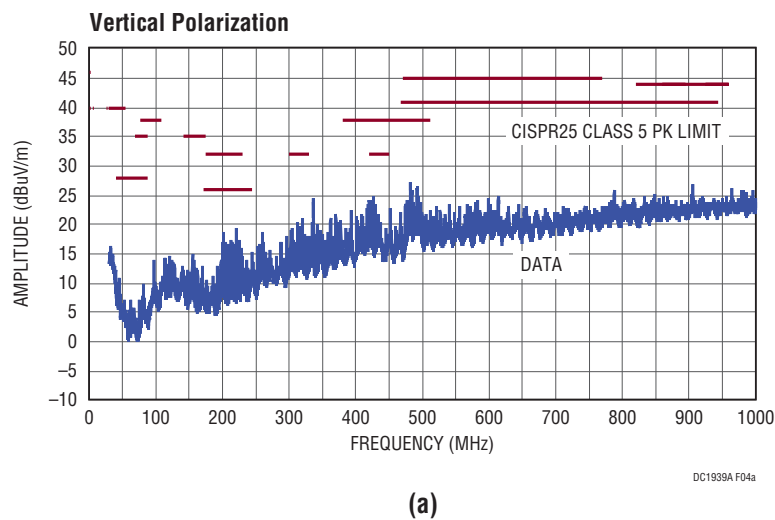
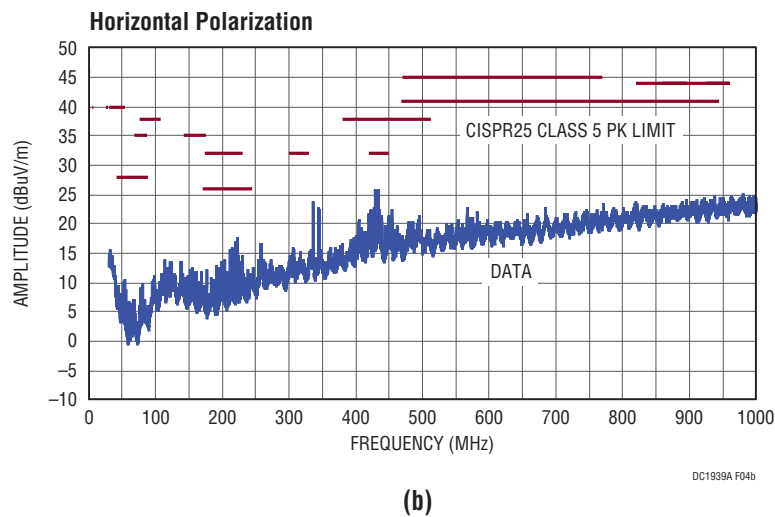


Figure 3. Typical Efficiency Curves of HV Bucks, at  $V_{IN} = 12V$



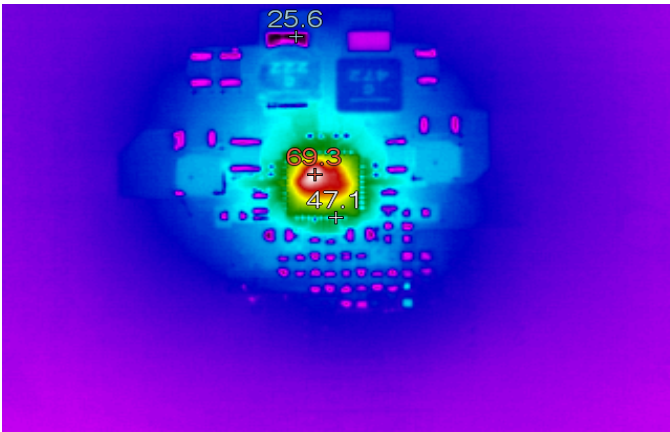
(a)



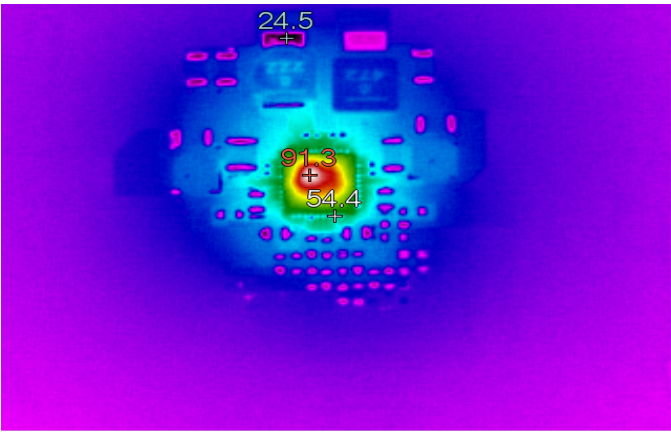
(b)

Figure 4. Radiated EMI (Vertical/Horizontal),  $V_{IN} = 12V, I_{OUT1,2,3,4} = 1A$

# QUICK START PROCEDURE



$V_{IN} = 12V$



$V_{IN} = 24V$

Figure 5. Thermal Image Top View,  $I_{OUT1,2,3,4} = 1A$ ,  $T_A = 25^{\circ}C$ ,  $f_{SW} = 2MHz$

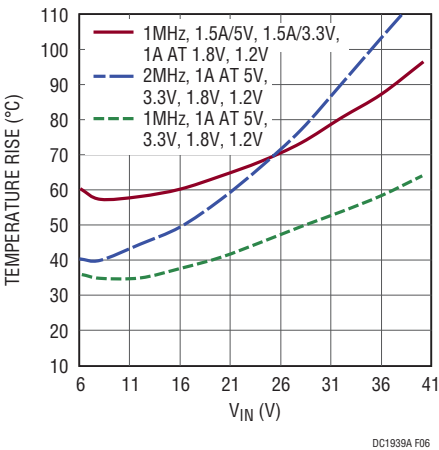


Figure 6. LT8602 Case Temperature Rise,  $T_A = 25^{\circ}C$

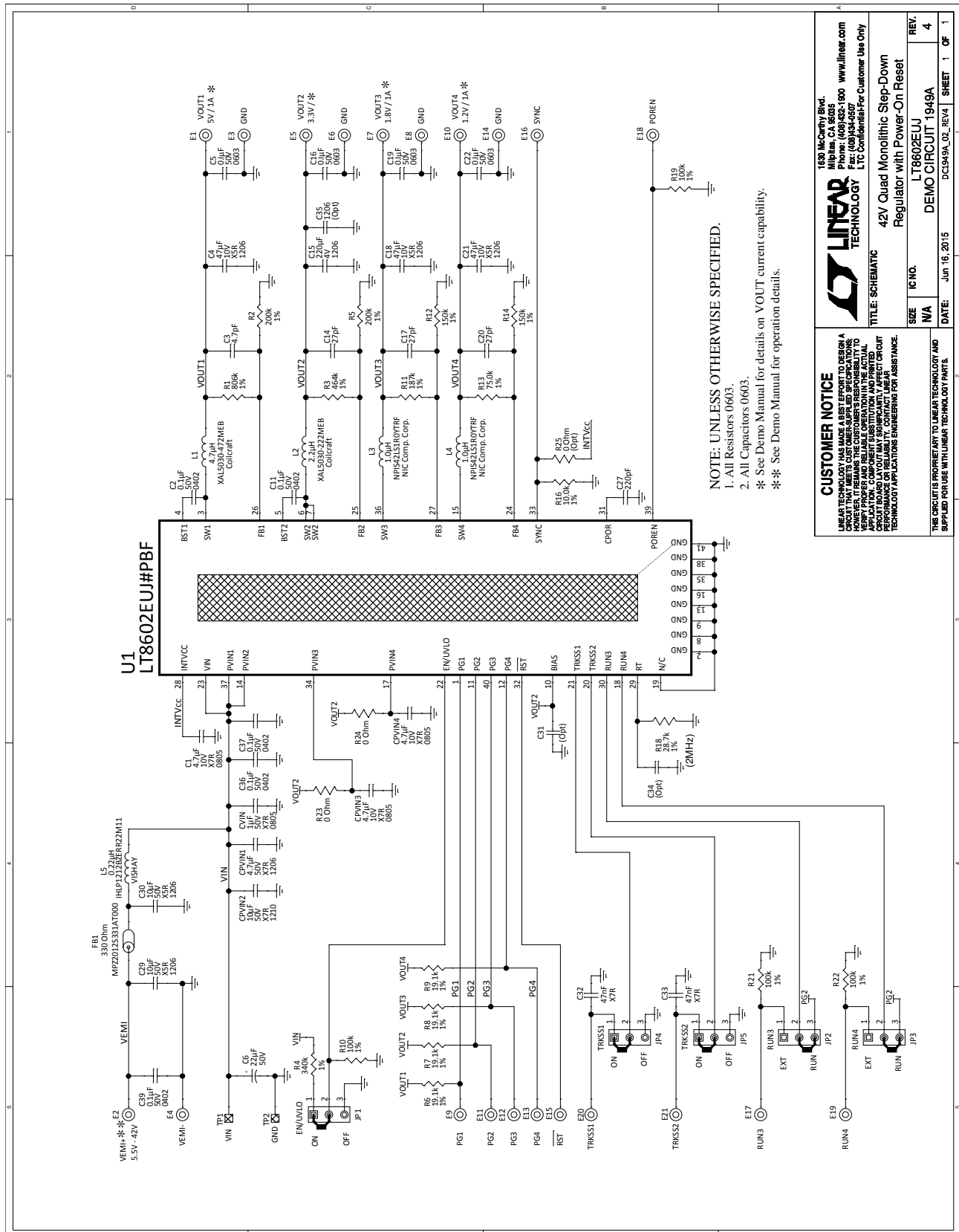
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## PARTS LIST

| ITEM                                            | QTY | REFERENCE                                                                                      | PART DESCRIPTION                     | MANUFACTURER/PART NUMBER         |
|-------------------------------------------------|-----|------------------------------------------------------------------------------------------------|--------------------------------------|----------------------------------|
| <b>Required Circuit Components</b>              |     |                                                                                                |                                      |                                  |
| 1                                               | 1   | CPVIN1                                                                                         | Cap., X7R 4.7µF 50V 10% 1206         | Murata GRM31CR71H475KA12L        |
| 2                                               | 1   | CPVIN2                                                                                         | Cap., X7R 10µF 50V 10% 1210          | Murata ERIE GRM32ER71H106KA12L   |
| 3                                               | 3   | C1, CPVIN3, CPVIN4                                                                             | Cap., X7R 4.7µF 10V 10% 0805         | Murata GRM21BR71A475KA73L        |
| 4                                               | 1   | CVIN                                                                                           | Cap., X7R 1µF 50V 10% 0805           | TDK C2012X7R1H105KT              |
| 5                                               | 5   | C2, C11, C36, C37, C39                                                                         | Cap., X7R 0.1µF 50V 10% 0402         | TDK CGA2B3X7R1H104K050BB         |
| 6                                               | 1   | C3                                                                                             | Cap., NPO 4.7pF 25V 5% 0603          | AVX 06033A4R7JAT2A               |
| 7                                               | 3   | C14, C17, C20                                                                                  | Cap., NPO 27pF 25V 5% 0603           | AVX 06033A270JAT2A               |
| 8                                               | 3   | C4, C18, C21                                                                                   | Cap., X5R 47µF 10V 20% 1206          | Murata GRM31CR61A476ME15L        |
| 9                                               | 4   | C5, C16, C19, C22                                                                              | Cap., X7R 0.1µF 50V 10% 0603         | Murata GRM188R71H104KA93D        |
| 10                                              | 1   | C6                                                                                             | Cap., Alum 22µF 50V 10%              | Sun Elect. 50CE22BSS             |
| 11                                              | 1   | C15                                                                                            | Cap., X5R 220µF 4V 20% 1206          | Murata GRM31CR60G227ME11L        |
| 12                                              | 1   | C27                                                                                            | Cap., X7R 220pF 25V 10% 0603         | AVX 06033C221MAT2A               |
| 13                                              | 2   | C29, C30                                                                                       | Cap., X5R 10µF 50V 10% 1206          | Murata CGA5L3X5R1H106K160AB      |
| 14                                              | 2   | C32, C33                                                                                       | Cap., X7R 47nF 25V 20% 0603          | AVX 06033C473MAT2A               |
| 15                                              | 1   | FB1                                                                                            | Ferrite Bead, 330Ω                   | TDK Corp. MPZ2012S331AT000       |
| 16                                              | 1   | L1                                                                                             | Inductor, 4.7µH                      | Coilcraft XAL5030-472MEB         |
| 17                                              | 1   | L2                                                                                             | Inductor, 2.2µH                      | Coilcraft XAL5030-222MEB         |
| 18                                              | 2   | L3, L4                                                                                         | Inductor, 1.0µH ±30%                 | NIC Comp. Corp. NPIS42LS1R0YTRF  |
| 19                                              | 1   | L5                                                                                             | Inductor, 0.22µH                     | Vishay, IHLP1212BZERR22M11       |
| 20                                              | 1   | R1                                                                                             | Res., Chip 806k 0.06W 1% 0603        | Vishay CRCW0603806KFKEA          |
| 21                                              | 2   | R2, R5                                                                                         | Res., Chip 200k 0.06W 1% 0603        | Vishay CRCW0603200KFKEA          |
| 22                                              | 1   | R3                                                                                             | Res., Chip 464k 0.06W 1% 0603        | Vishay CRCW0603464KFKEA          |
| 23                                              | 1   | R4                                                                                             | Res., Chip 340k 0.06W 1% 0603        | Vishay CRCW0603340KFKEA          |
| 24                                              | 4   | R6, R7, R8, R9                                                                                 | Res., Chip 19.1k 0.06W 1% 0603       | Vishay CRCW060319K1FKEA          |
| 25                                              | 4   | R10, R19, R21, R22                                                                             | Res., Chip 100k 0.06W 1% 0603        | Vishay CRCW0603100KFKEA          |
| 26                                              | 1   | R11                                                                                            | Res., Chip 187k 0.06W 1% 0603        | Vishay CRCW0603187KFKEA          |
| 27                                              | 2   | R12, R14                                                                                       | Res., Chip 150k 0.06W 1% 0603        | Vishay CRCW0603150KFKEA          |
| 28                                              | 1   | R13                                                                                            | Res., Chip 75.0k 0.06W 1% 0603       | Vishay CRCW060375K0FKEA          |
| 29                                              | 1   | R16                                                                                            | Res., Chip 10.0k 0.06W 1% 0603       | Vishay CRCW060310K0FKEA          |
| 30                                              | 1   | R18                                                                                            | Res., Chip 28.7k 0.06W 1% 0603       | Vishay CRCW060328K7FKEA          |
| 31                                              | 2   | R23, R24                                                                                       | Res, Chip 0Ω 0.25W 5A 0603           | Vishay CRCW06030000Z0EA          |
| 32                                              | 1   | U1                                                                                             | Buck Regulator QFN(40)(UJ) 6mm × 6mm | Linear Tech. Corp. LT8602EUJ#PBF |
| <b>Additional Demo Board Circuit Components</b> |     |                                                                                                |                                      |                                  |
| 1                                               | 0   | R25 (Opt)                                                                                      | Res, Chip 0Ω 0.25W 5A 0603           | Vishay CRCW06030000Z0EA          |
| 2                                               | 0   | C31, C34 (Opt)                                                                                 | Cap., 0603                           |                                  |
| 3                                               | 0   | C35 (Opt)                                                                                      | Cap., 1206                           |                                  |
| <b>Hardware: For Demo Board Only</b>            |     |                                                                                                |                                      |                                  |
| 1                                               | 5   | XJP1, XJP2, XJP3, XJP4, XJP5                                                                   | Shunt, 2mm Ctrs.                     | Samtec 2SN-BK-G                  |
| 2                                               | 4   | MH1-MH4                                                                                        | Stand-Off, Nylon 0.25" Tall          | Keystone, 8831 (Snap On)         |
| 3                                               | 21  | E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19, E20, E21 | Turret, Testpoint                    | Mill Max 2501-2-00-80-00-00-07-0 |
| 4                                               | 5   | JP1, JP2, JP3, JP4, JP5                                                                        | Headers, 3 Pins 2mm Ctrs.            | Samtec TMM-103-02-L-S            |

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## SCHEMATIC DIAGRAM



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