

**LTC3374EUHF**  
**8-Channel Parallelable**  
**1A Buck DC/DC**

## DESCRIPTION

Demonstration circuit 1953A is an 8-output power supply featuring the [LTC®3374](#). The LTC3374 has eight synchronous buck regulators each with an independent  $V_{IN}$  supply. Up to four buck regulators may be paralleled together to create a higher power buck regulator with a single inductor. The input range of the LTC3374 is ideal for single cell Li-Ion/Polymer battery applications.

The buck regulators can be enabled via external precision threshold enable pins to allow hardwired power up sequences.

The LTC3374 has a default operating frequency of 2MHz or it can be set between 1MHz and 3MHz using an external resistor. The LTC3374 also has a SYNC pin which allows the internal oscillator to synchronize to an external clock from 1MHz to 3MHz.

Refer to the LTC3374 data sheet for more details on the electrical and timing specifications.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC1953A>**

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## PERFORMANCE SUMMARY

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

| PARAMETER                          | CONDITIONS                                     | MIN  | TYP | MAX | UNITS |
|------------------------------------|------------------------------------------------|------|-----|-----|-------|
| Input Supply Range ( $V_{IN1-8}$ ) |                                                | 2.25 |     | 5.5 | V     |
| $V_{CC}$                           |                                                | 2.7  |     | 5.5 | V     |
| $V_{OUT1}$                         | $V_{IN1} > 3.3\text{V}$ , $I_{VOUT1}$ 0A to 1A |      | 3.3 |     | V     |
| $V_{OUT2}$                         | $V_{IN2} > 3.0\text{V}$ , $I_{VOUT2}$ 0A to 1A |      | 3.0 |     | V     |
| $V_{OUT3}$                         | $V_{IN3} > 2.5\text{V}$ , $I_{VOUT3}$ 0A to 1A |      | 2.5 |     | V     |
| $V_{OUT4}$                         | $I_{VOUT4}$ 0A to 1A                           |      | 2.0 |     | V     |
| $V_{OUT5}$                         | $I_{VOUT5}$ 0A to 1A                           |      | 1.8 |     | V     |
| $V_{OUT6}$                         | $I_{VOUT6}$ 0A to 1A                           |      | 1.5 |     | V     |
| $V_{OUT7}$                         | $I_{VOUT7}$ 0A to 1A                           |      | 1.2 |     | V     |
| $V_{OUT8}$                         | $I_{VOUT8}$ 0A to 1A                           |      | 1.0 |     | V     |

## QUICK START PROCEDURE

The DC1953A is easy to set up to evaluate the performance of the LTC3374. Refer to Figure 1 and Figure 2 for proper measurement equipment setup and follow the evaluation procedure below.

**Note:** When measuring the input or output voltage ripple, 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 VIN or VOUT and GND terminals. See Figure 2 for proper scope probe technique.

1. Set the JP1-JP8 jumpers on the DC1953A board to the OFF position.
2. Set the MODE jumper, JP9, to the BURST position.
3. With power off, connect a 0V to 6V, 100mA power supply to VCC and GND with a voltmeter as shown in Figure 1.
4. With power off, connect a 0V to 6V, 3A power supply to each VIN and GND with a series ammeter and a voltmeter as shown in Figure 1. A single 0V to 6V, 10A supply can be used instead to supply all VIN inputs simultaneously.
5. Turn on and set the VCC input power supply to 3.3V and turn on and set the VIN1 supply to 5V.

**Note:** Make sure that the input voltages do not exceed 6V.

6. Set the JP1 jumper, EN1, to the ON position and observe the VOUT1 regulator turns on and the PGOOD\_ALL LED extinguishes.

**Note:** All regulators not powered or set up as a slave must have their EN pins tied to GND to allow the PGOOD\_ALL LED to extinguish.

7. With power off, connect a 0V to 3A load to each VOUT and GND with a series ammeter and a voltmeter as shown in Figure 1.
8. Slowly increase LOAD1 from 0A to 1A and observe the output voltage. The output ripple may also be observed using an oscilloscope with the probe connected as shown in Figure 2.
9. When done evaluating VOUT1, repeat steps 5 through 8 for each regulator.
10. Refer to the LTC3374 data sheet for more details on how the LTC3374 operates.
11. When done, turn off all loads and power supplies.

## QUICK START PROCEDURE

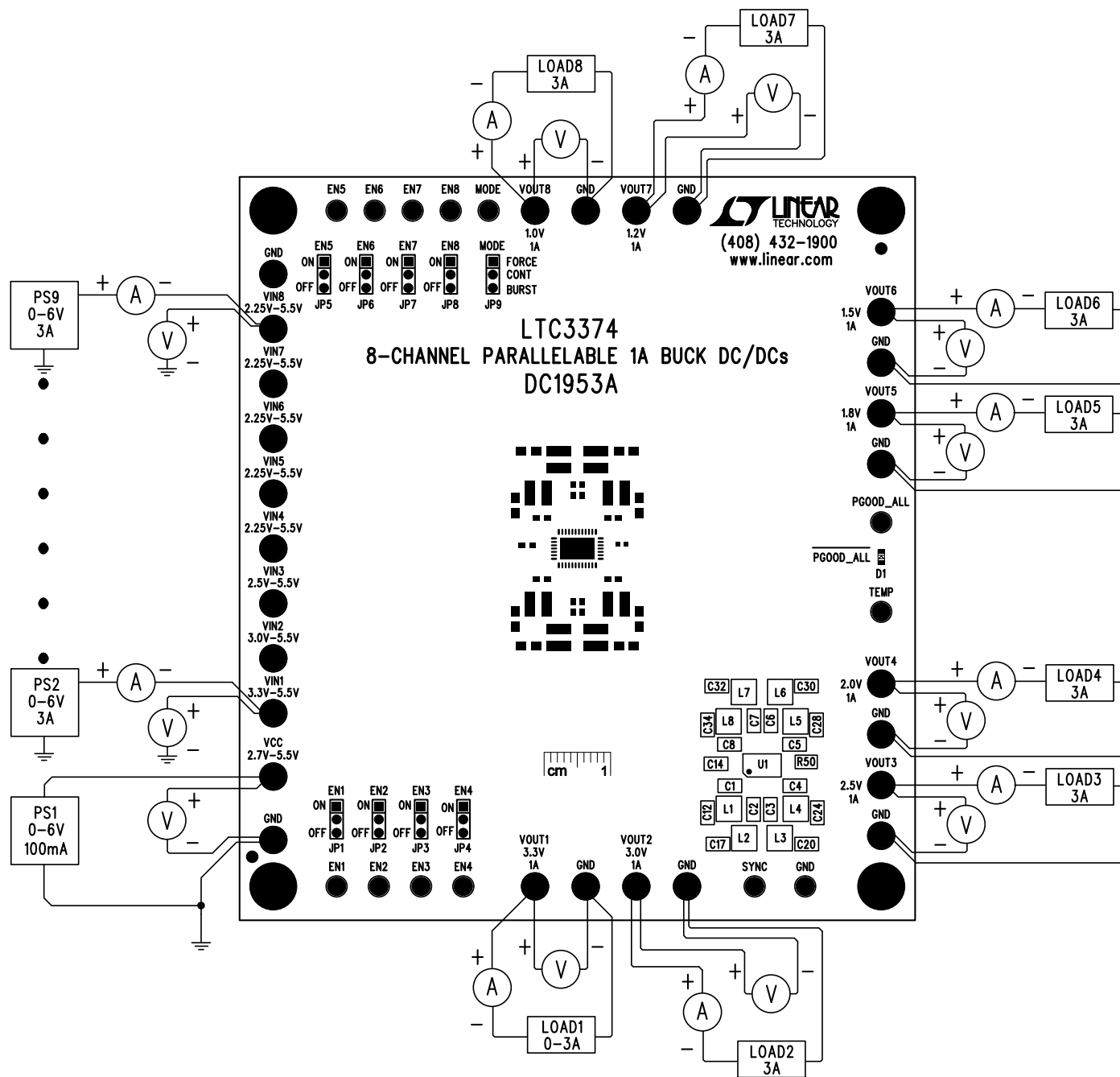


Figure 1. Proper Measurement Equipment Setup

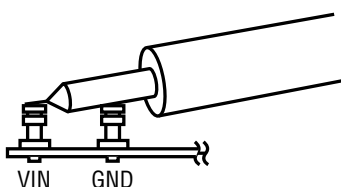


Figure 2. Measuring Input or Output Ripple

## COMBINING BUCK REGULATORS WITH MULTIPLE OUTPUT FILTERS

The LTC3374 has the ability to combine up to 4 consecutively numbered bucks to achieve output currents of 1A, 2A, 3A or 4A. The easiest way to configure the DC1953A with combined outputs is to use an output inductor and output capacitor on each switch node. While combining stages with multiple filters is not ideal for performance or minimization of components, it does provide the easiest way to prototype with the desired current levels. Follow the steps below to make an output a slave to the adjacent regulator:

1. Remove the desired slave regulator's associated FB resistors and feed forward capacitor.
2. Add the associated 0 $\Omega$  resistor to tie the FB pin to its VIN pin.
3. Connect the outputs together at the output capacitors.
4. Connect the VIN of the slave regulator to the VIN of the master regulator.

For example, to make regulator 2 a slave of regulator 1:

1. Remove R6, R7 and C16.
2. Solder a 0 $\Omega$  resistor to R5.

3. Connect VIN1 to VIN2 at the VIN terminals.
4. Connect VOUT1 to VOUT2 at the output capacitors C12 and C17.

Regulator 3 can also be combined with regulator 1 and regulator 2 to create a 3A output by:

1. Removing FB3 components, R10, R11 and C19.
2. Solder a 0 $\Omega$  resistor to R9.
3. Connect VIN3 to VIN2 and VIN1 at the VIN terminals.
4. Connect VOUT3 to VOUT2 and VOUT1 at the output capacitors.

Regulator 4 can also be added to this combination by following the same steps with regulator 4's associated components.

The higher number regulator is always a slave to the adjacent lower number regulator; therefore regulator 1 can never be a slave and regulator 8 can never be a master.

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## COMBINING BUCK REGULATORS WITH A SINGLE OUTPUT FILTER

In most applications it is more practical to use a single output filter on a combined regulator. To do this the switch nodes of the combined regulators need to be shorted together, and the output inductor and capacitor need to be sized correctly. Please refer to the Combined Buck Regulator section in the LTC3374 data sheet for more information on sizing the output capacitor and inductor.

**Note:** The DC1953A layout was optimized for eight 1A outputs. For applications with combined regulators the layout should be optimized for the components used, the lowest and equal impedance on the combined switch nodes, and the shortest AC current paths as possible.

To combine regulators 1 and 2 for a 2A output, perform the following steps and refer to Figure 3:

1. Remove L2, R6, R7 and C16.
2. Add a 0 $\Omega$  resistor to R5.
3. Replace L1 with an inductor that can handle the 2A output at current limit.
4. Replace C12 with at least a 47 $\mu$ F ceramic capacitor.
5. Short SW1 and SW2 together. To reduce the impedance on the SW node, cut the excess trace from SW2 to L2 close to the short as possible.
6. Short VIN1 and VIN2 together near the VIN terminals.

# COMBINING BUCK REGULATORS WITH A SINGLE OUTPUT FILTER

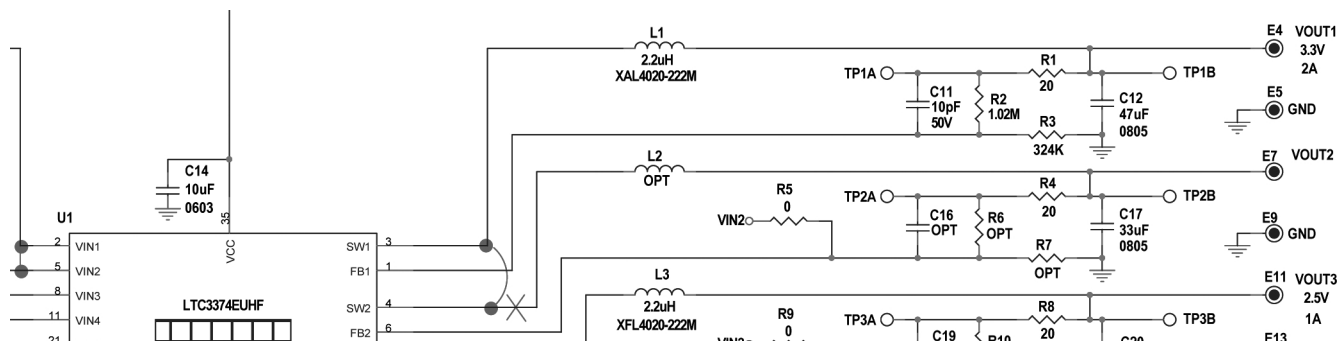


Figure 3. Combined 2A Output Regulators 1 and 2

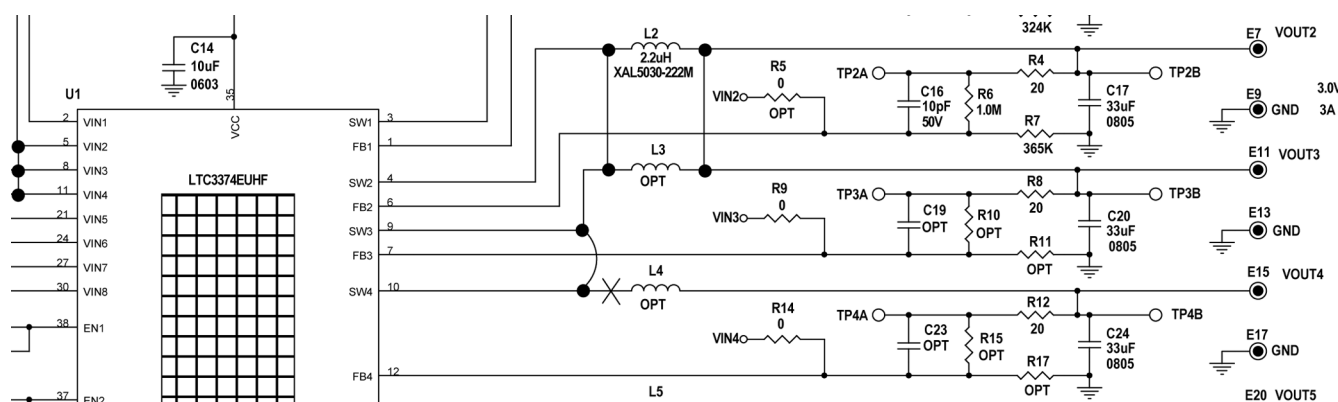
To combine regulators 2, 3 and 4 for a 3A output, perform the following steps and refer to Figure 4:

1. Remove L2, L3 and L4.
2. Add copper foil between the L2 and L3 SW node pads. Refer to Figure 5 for steps 2 thru 5.

**Note:** Copper foil does not provide as low thermal or electrical impedance as PCB copper traces. An optimized layout should be fabricated to accurately evaluate a 3A output.

3. Add copper foil between VOUT2 and VOUT3 nodes at the location needed for the inductor pad. The solder mask may need to be scraped away to do this.

4. Short SW3 and SW4 together.
5. Cut excess SW4 node between short and the L4 pad.
6. Remove R10, R11, R15, R17, C19 and C23.
7. Add 0Ω resistors to R9 and R14.
8. C17 and C20 must have at least 33µF ceramic capacitors.
9. Connect VIN2, VIN3 and VIN4 together at the VIN terminals.



## COMBINING BUCK REGULATORS WITH A SINGLE OUTPUT FILTER

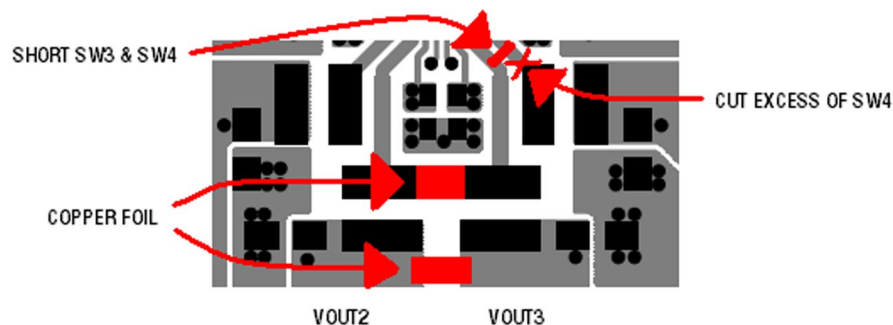


Figure 5. Copper Foil Between L2 and L3, Modified SW4 Trace

To combine regulators 1, 2, 3, and 4 for a 4A output perform the following steps and refer to Figure 6:

1. Remove L1, L2, L3 and L4.
2. Add copper foil between the L2 and L3 SW node pads. Refer to Figure 7 for steps 2 thru 5.
- Note:** An optimized layout should be fabricated to accurately evaluate a 4A output.
3. Add copper foil between VOUT2 and VOUT3 nodes at the location needed for the inductor pad. The solder mask may need to be scraped away to do this.
4. Short SW1 and SW2 together then short SW3 and SW4 together.
5. Cut excess SW1 node between the short and the L1 pad then cut the excess SW4 node between the short and the L4 pad.

6. Remove R6, R7, R10, R11, R15, R17, C16, C19 and C23.
7. Add 0Ω resistors to R5, R9 and R14.
8. Replace C17 and C20 with at least 47μF ceramic capacitors.
9. Connect TP1B with TP2B with a 26 AWG wire. This connects the 4A output voltage to the FB1 network.
- Note:** Do not connect the load on the VOUT1 terminal. The 4A OUTPUT will be observed on the VOUT1 terminal, however it is only connected via the 26AWG wire and 10 mil FB traces. Connect the load to the VOUT2 and/or VOUT3 terminals instead.
10. Connect VIN1, VIN2, VIN3 and VIN4 together at the VIN terminals.

# COMBINING BUCK REGULATORS WITH A SINGLE OUTPUT FILTER

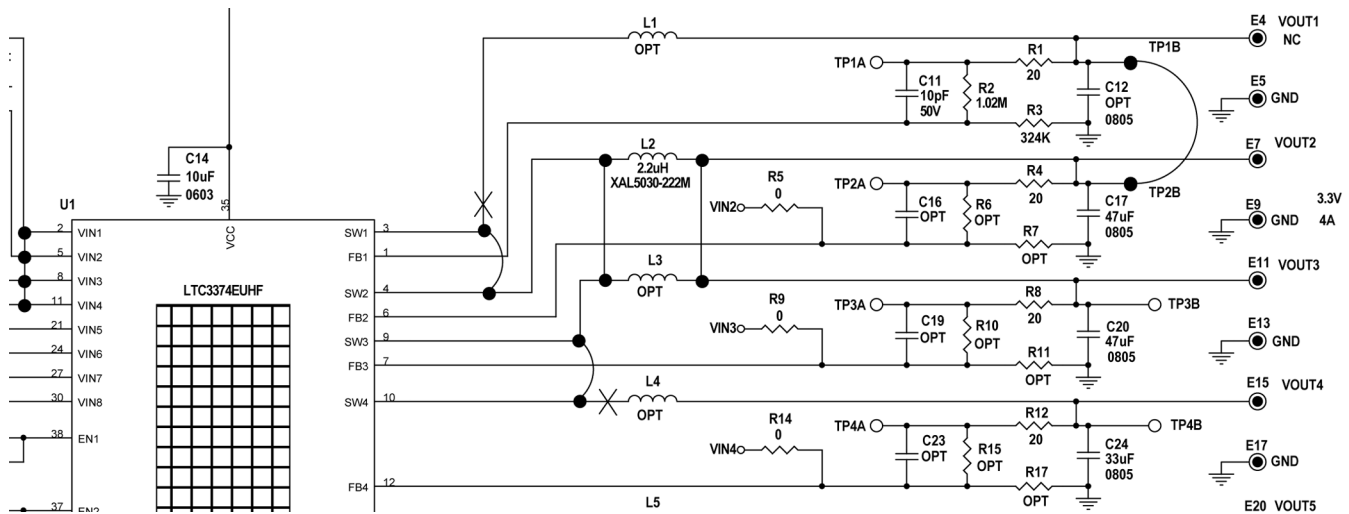


Figure 6. Combined 4A Output, Regulators 1, 2, 3 and 4

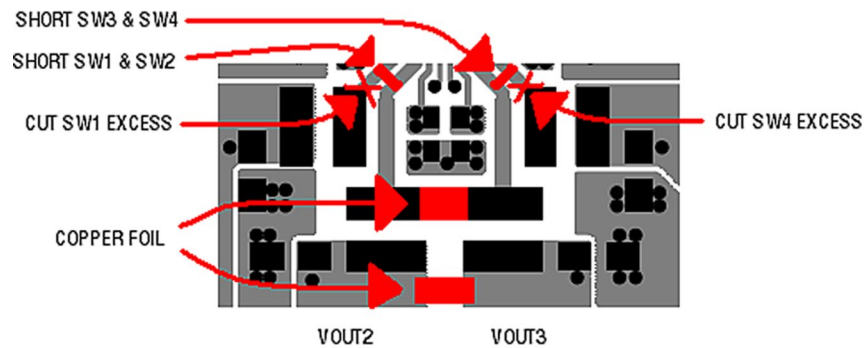


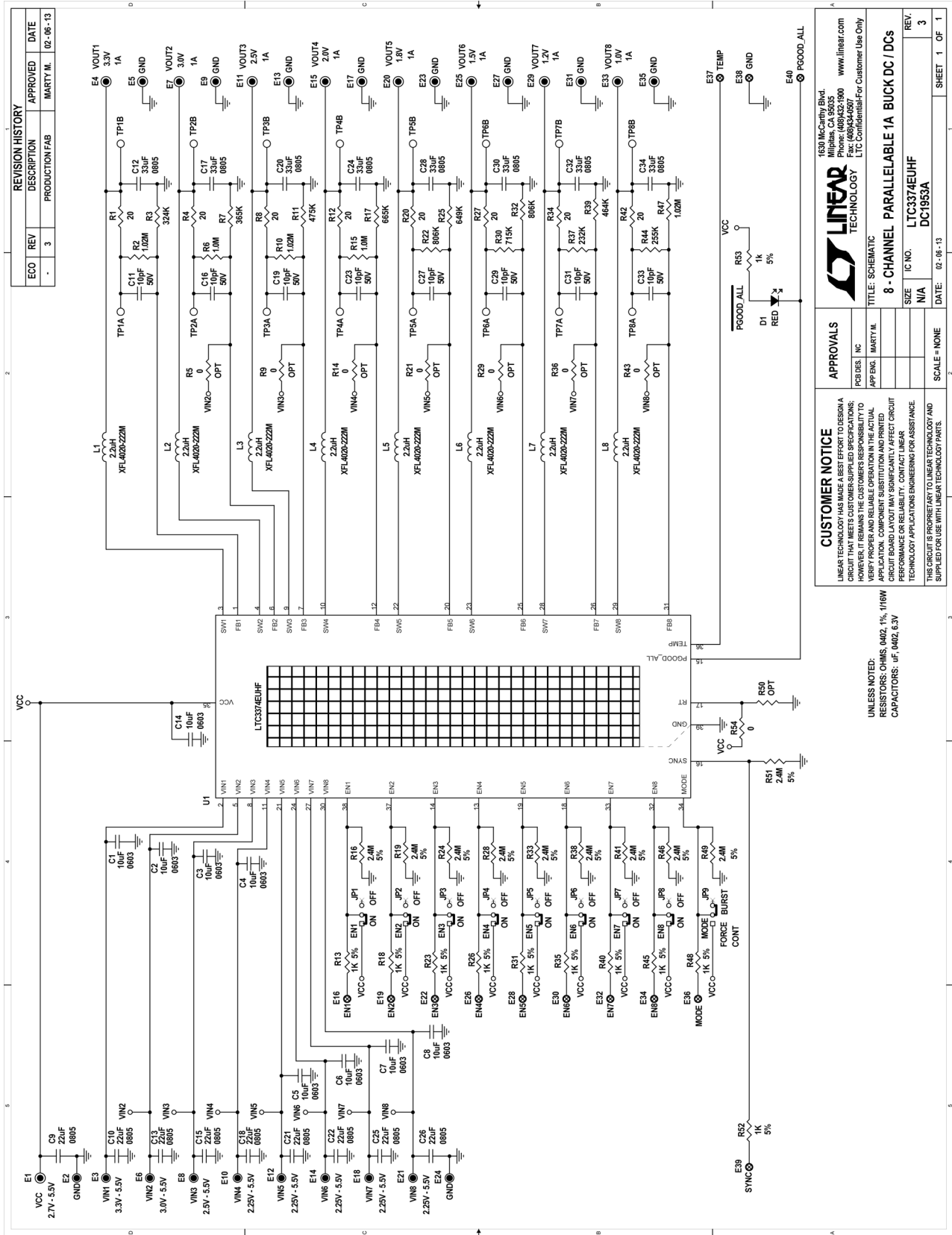
Figure 7. Copper foil between L2 and L3, Modified SW1 & SW4 Traces

# DEMO MANUAL DC1953A

## PARTS LIST

| ITEM                                            | QTY | REFERENCE                                                    | PART DESCRIPTION                                               | MANUFACTURER/PART NUMBER          |
|-------------------------------------------------|-----|--------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------|
| <b>Required Circuit Components</b>              |     |                                                              |                                                                |                                   |
| 1                                               | 9   | C1, C2, C3, C4, C5, C6, C7, C8, C14                          | CAP, CHIP, X5R, 10 $\mu$ F, $\pm$ 20%, 6.3V, 0603              | TDK, C1608X5R0J106M               |
| 2                                               | 8   | C12, C17, C20, C24, C28, C30, C32, C34                       | CAP, CHIP, X5R, 33 $\mu$ F, $\pm$ 20%, 6.3V, 0805              | TDK, C2012X5R0J336Mt              |
| 3                                               | 8   | L1-L8                                                        | IND, SMT, 2.2 $\mu$ H, 21m $\Omega$ , $\pm$ 20%, 3.7A, 4mmX4mm | COILCRAFT, XFL4020-222M           |
| 4                                               | 3   | R2, R10, R47                                                 | RES, CHIP, 1.02M, $\pm$ 1%, 1/16W, 0402                        | VISHAY, CRCW04021M02FKED          |
| 5                                               | 1   | R3                                                           | RES, CHIP, 324k, $\pm$ 1%, 1/16W, 0402                         | VISHAY, CRCW0402324KFKED          |
| 6                                               | 2   | R6, R15                                                      | RES, CHIP, 1.00M, $\pm$ 1%, 1/16W, 0402                        | VISHAY, CRCW04021M00FKED          |
| 7                                               | 1   | R7                                                           | RES, CHIP, 365k, $\pm$ 1%, 1/16W, 0402                         | VISHAY, CRCW0402365KFKED          |
| 8                                               | 1   | R11                                                          | RES, CHIP, 475k, $\pm$ 1%, 1/16W, 0402                         | VISHAY, CRCW0402475KFKED          |
| 9                                               | 1   | R17                                                          | RES, CHIP, 665k, $\pm$ 1%, 1/16W, 0402                         | VISHAY, CRCW0402665KFKED          |
| 10                                              | 2   | R22, R32                                                     | RES, CHIP, 806k, $\pm$ 1%, 1/10W, 0402                         | VISHAY, CRCW0402806KFKED          |
| 11                                              | 1   | R25                                                          | RES, CHIP, 649k, $\pm$ 1%, 1/10W, 0402                         | VISHAY, CRCW0402649KFKED          |
| 12                                              | 1   | R30                                                          | RES, CHIP, 715k, $\pm$ 1%, 1/10W, 0402                         | VISHAY, CRCW0402715KFKED          |
| 13                                              | 1   | R37                                                          | RES, CHIP, 232k, $\pm$ 1%, 1/16W, 0402                         | VISHAY, CRCW0402232KFKED          |
| 14                                              | 1   | R39                                                          | RES, CHIP, 464k, $\pm$ 1%, 1/16W, 0402                         | VISHAY, CRCW0402464KFKED          |
| 15                                              | 1   | R44                                                          | RES, CHIP, 255k, $\pm$ 1%, 1/16W, 0402                         | VISHAY, CRCW0402255KFKED          |
| 16                                              | 1   | U1                                                           | 8-CHANNEL PARALLELABLE 1A BUCK DC/DCs                          | LINEAR TECH., LTC3374EUHF         |
| <b>Additional Demo Board Circuit Components</b> |     |                                                              |                                                                |                                   |
| 17                                              | 9   | C9, C10, C13, C15, C18, C21, C22, C25, C26                   | CAP, CHIP, X5R, 22 $\mu$ F, $\pm$ 20%, 6.3V, 0805              | TAIYO YUDEN, JMK212ABJ226MG       |
| 18                                              | 8   | C11, C16, C19, C23, C27, C29, C31, C33                       | CAP, CHIP, NPO, 10pF, $\pm$ 5%, 50V, 0402                      | AVX, 04025A100JAT                 |
| 19                                              | 1   | D1                                                           | DIODE, LED, SUPER RED DIFF, 0603 SMD                           | LUMEX, SML-LX0603SRW-TR           |
| 20                                              | 8   | R1, R4, R8, R12, R20, R27, R34, R42                          | RES, CHIP, 20 $\Omega$ , $\pm$ 1%, 1/16W, 0402                 | VISHAY, CRCW040220R0FKED          |
| 21                                              | 11  | R13, R18, R23, R26, R31, R35, R40, R45, R48, R52, R53        | RES, CHIP, 1k, $\pm$ 5%, 1/16W, 0402                           | VISHAY, CRCW04021K00JNED          |
| 22                                              | 0   | R5, R9, R14, R21, R29, R36, R43                              | RES, CHIP, 0 $\Omega$ JUMPER, 1/10W, 0603 (OPT)                | VISHAY, CRCW06030000Z0ED          |
| 23                                              | 10  | R16, R19, R24, R28, R33, R38, R41, R46, R49, R51             | RES, CHIP, 2.40M, $\pm$ 5%, 1/16W, 0402                        | VISHAY, CRCW04022M40JNED          |
| 24                                              | 0   | R50                                                          | RES, CHIP, 402k, $\pm$ 1%, 1/16W, 0402 (OPT)                   | VISHAY, CRCW0402402KFKED          |
| 25                                              | 1   | R52                                                          | RES, CHIP, 470 $\Omega$ , $\pm$ 5%, 1/16W, 0402                | VISHAY, CRCW0402470RJNED          |
| 26                                              | 1   | R54                                                          | RES, CHIP, 0 $\Omega$ JUMPER, 1/16W, 0402                      | VISHAY, CRCW04020000Z0ED          |
| <b>Hardware-For Demo Board Only</b>             |     |                                                              |                                                                |                                   |
| 27                                              | 27  | E1-E15, E17, E18, E20, E21, E23-E25, E27, E29, E31, E33, E35 | TURRET, 0.09" DIA                                              | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 28                                              | 13  | E16, E19, E22, E26, E28, E30, E32, E34, E36-E40              | TURRET, 0.061" DIA                                             | MILL-MAX, 2308-2-00-80-00-00-07-0 |
| 29                                              | 9   | JP1-JP9                                                      | 2mm to HEADER 1x3, 2mm                                         | SAMTEC, TMM-103-02-L-S            |
| 30                                              | 9   | JP1-JP9                                                      | SHUNT, 2mm                                                     | SAMTEC, 2SN-KB-G                  |
| 31                                              | 4   |                                                              | STAND-OFF NYLON, 0.375" TALL (SNAP-ON)                         | KEYSTONE, 8832 (SNAP ON)          |
| 32                                              | 1   |                                                              | FAB, PRINTED CIRCUIT BOARD                                     | DC1953A-3                         |

SCHEMATIC DIAGRAM



# DEMO MANUAL DC1953A

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