

## LTC7862 140V High Efficiency Switching Surge Stopper

### DESCRIPTION

Demonstration circuit 2674A is a 140V high efficiency switching surge stopper featuring the [LTC<sup>®</sup>7862](#). The board operates from an input voltage range of 8V to 140V, and provides a 8V to 34V output from 0A to 10A. Its output voltage is programmed to be clamped at 34V (typical) with a minimum ride-through duration of 500ms to allow the load to operate through the input overvoltage events. Its output current is limited to protect against output short-circuit faults. A soft-start feature is utilized to control its output voltage slew rate at start-up and input voltage transients. This feature reduces current surge and output voltage overshoot. The demonstration board is able to achieve low insertion drop (210mV typical) by utilizing the low  $R_{DS(ON)}$  N-channel MOSFETs and low DCR inductor. This board also includes optional reverse polarity protection circuit which protects the downstream loads up to -40V. The demonstration circuit is suitable for a wide range of automotive, industrial, and telecom applications.

The LTC7862 high efficiency switching surge stopper protects loads from input high voltage transients. During an input overvoltage event, the LTC7862 controls the gate of two external N-channel MOSFETs and operate as a switching DC/DC step-down regulator. The output voltage is maintained at a safe level, allowing the loads to continue to operate through the input overvoltage events.

During normal operation, the LTC7862 turns on the top external N-channel MOSFET continuously, passing the input voltage through to the output with minimal voltage drop. The LTC7862 also limits the maximum output current to protect against overcurrent and short-circuit faults. A programmable timer limits the time that the LTC7862 can spend switching during an overvoltage, overcurrent, or startup condition. When the timer expires, the external MOSFETs are turned off for a cooldown period and then the LTC7862 restarts. The timer limits how long the LTC7862 can switch when the power loss is relatively high, the components and thermal design can be optimized for normal pass-through operation.

The LTC7862 data sheet gives a complete description of the part, operation and application information. The data sheet must be read in conjunction with this demo manual for DC2674A. Proper board layout is essential for maximum thermal and electrical performance. See the data sheet sections for details. The LTC7862 is available in 20-lead TSSOP and QFN packages and two operating junction temperature grades: industrial (-40°C to 125°C) and high temperature automotive (-40°C to 150°C).

**Design files for this circuit board are available at <http://www.analog.com/DC2674A>**

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

| SYMBOL      | PARAMETER                        | CONDITIONS            | MIN  | TYP  | MAX  | UNITS |
|-------------|----------------------------------|-----------------------|------|------|------|-------|
| $V_{IN}$    | Input Voltage                    | Normal Operation      | 8    |      | 32   | V     |
|             |                                  | 500ms Ride-Through    | 8    |      | 140  | V     |
|             |                                  | DC Survival           | 0    |      | 140  | V     |
| $V_{INRPP}$ | Reverse Polarity Protection      | DC Survival           | -40  |      |      | V     |
| $V_{OUT}$   | Output Regulation Voltage        |                       | 32.7 | 34.0 | 35.0 | V     |
| $I_{OUT}$   | Output Current Range, Continuous | Free Air              | 0    |      | 10   | A     |
| $I_{LIMIT}$ | Current Limit                    | $V_{IN} = 28\text{V}$ | 13.3 | 15.4 | 17.6 | A     |

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

| SYMBOL                | PARAMETER   | CONDITIONS   | MIN | TYP          | MAX | UNITS             |
|-----------------------|---|--|-----|--------------|-----|-------------------|
| $V_{IN} - V_{OUT}$    | Insertion Drop  | $V_{IN} = 28\text{V}, I_{OUT} = 10\text{A}$                                  |     | 210          |     | mV                |
| $V_{INRPP} - V_{OUT}$ | Insertion Drop with Reverse Polarity Protection Circuit | $V_{INRPP} = 28\text{V}, I_{OUT} = 10\text{A}$                               |     | 250          |     | mV                |
| $F_{SW}$              | Switching (Clock) Frequency                             |  |     | 535          |     | kHz               |
| $V_{OUT\ P-P}$        | Output Ripple   | $V_{IN} = 40\text{V}, V_{OUT} = 32\text{V}, I_{OUT} = 10\text{A}$ (20MHz BW) |     | 150          |     | mV <sub>P-P</sub> |
|                       | Approximate Size  | Component Area • Top Component Height  |     | 44 × 46 × 12 |     | mm                |

## QUICK START PROCEDURE

Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

**NOTE:** When measuring the output voltage during switching transitions, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the output voltage ripple by touching the probe tip and ground ring directly across the output capacitor as shown in Figure 1.

1. Place SW1 to ON position.
2. Choose an input power supply that is capable of 8V to 140V and 15A. Set its output voltage to 10V. Then turn off the supply.
3. With power off, connect the input power supply to the input terminals  $V_{IN}$  and GND.
4. Connect the voltmeters capable of measuring at least 150V to input terminals  $V_{IN}$  to GND and output terminals  $V_{OUT}$  to GND.
5. Turn on the input power supply.

**NOTE:** Make sure that the input voltage never exceeds 140V.

6. Check the voltage across  $V_{OUT}$  to GND. The voltage reading should be close to input voltage. Turn off the input power supply.
7. Once the proper output voltage is established, connect a variable load capable of 10A at 35V to the output terminals  $V_{OUT}$  to GND. Set the current to 0A.
8. Turn on the input power supply.

**NOTE:** If there is no output, temporarily disconnect the load to make sure that the load is not set too high.

9. Once the proper output voltage is established, adjust the load up to 10A and/or input power supply within the operating range up to 32V and observe the output voltage and other desired parameters.
10. Now apply an input voltage between 35V and 140V. Observe the output voltage and fault timer operation.
11. If desired, you may apply input transient profiles in the range of 0V to 140V and observe the output to illustrate operation of the circuit to prevent input surges from reaching the output.

**NOTE:** The input voltage range is up to 140V but hot-plugging with long leads may result in input voltages in excess of 140V.

QUICK START PROCEDURE

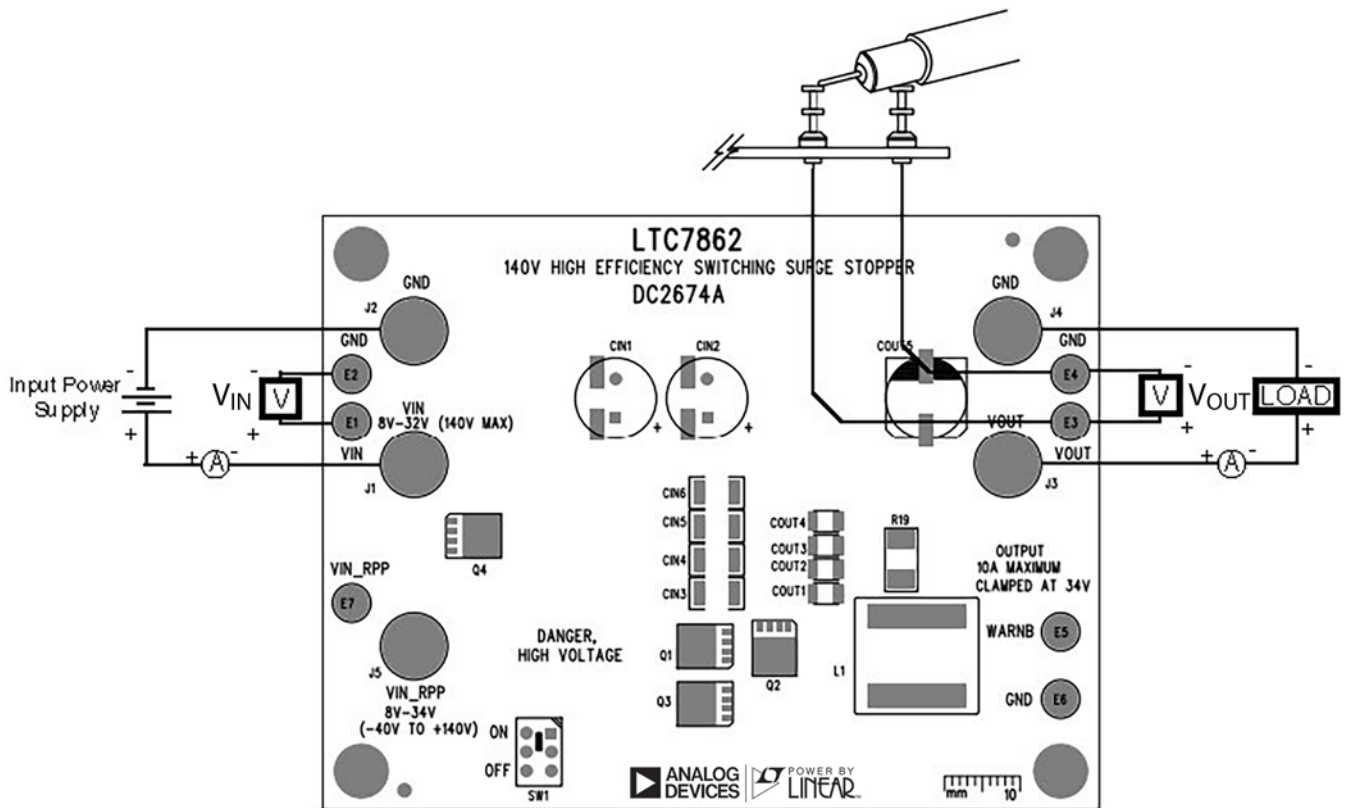


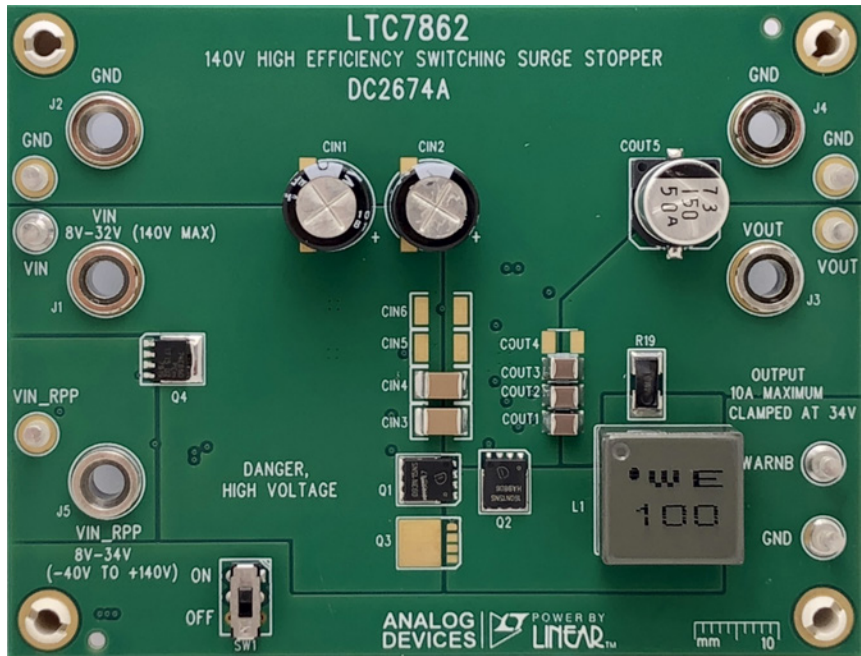
Figure 1. Proper Measurement Equipment Setup



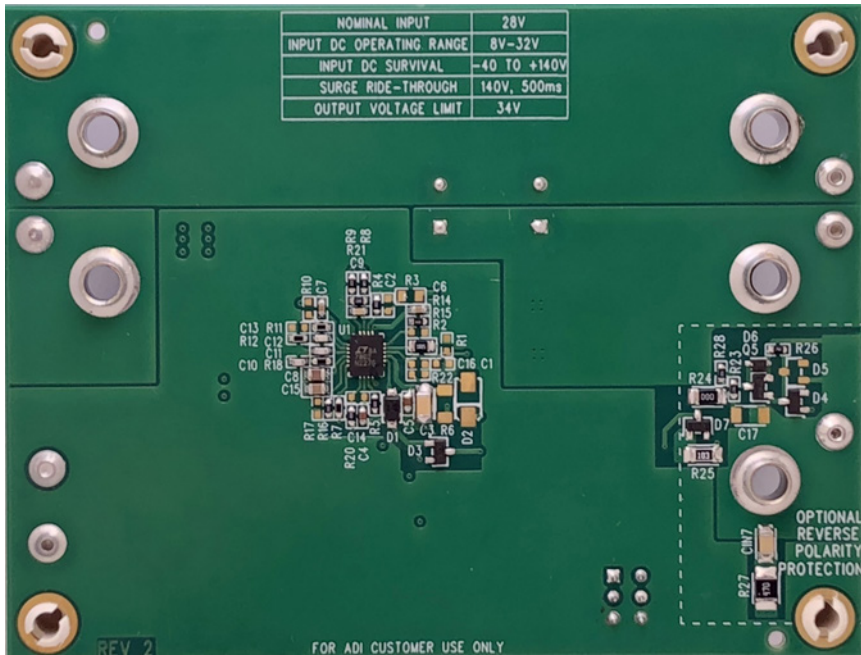
Figure 2. Output Response Waveform with 28V to 140V Input Surge (CH2  $V_{IN}$  20V/DIV, CH3  $V_{OUT}$  20V/DIV, 100ms/DIV)

# DEMO MANUAL DC2674A

## QUICK START PROCEDURE



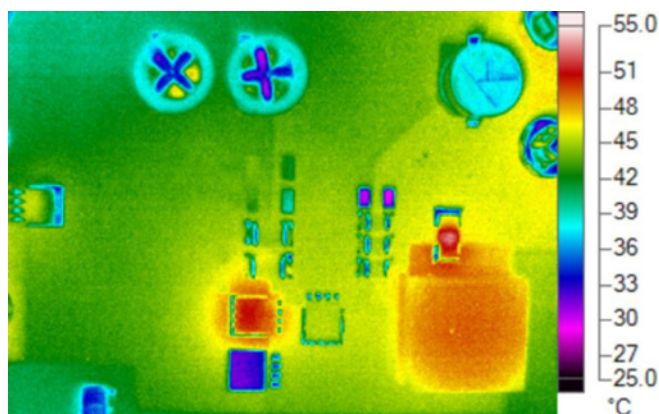
(a) Top View



(b) Bottom View

Figure 3. Board Photos

## QUICK START PROCEDURE



Top View

Figure 4. Thermal Plot, Test Conditions:  $V_{IN\_RPP} = 28.0V$ ,  $V_{OUT} = 27.7V$ , Load = 10.0A,  $T_{AMBIENT} = 27.4^{\circ}C$

## PARTS LIST

| ITEM                               | QTY | REFERENCE                                     | PART DESCRIPTION  | MANUFACTURER/PART NUMBER     |
|------------------------------------|-----|---|---|------------------------------|
| <b>Required Circuit Components</b> |     |   |   |                              |
| 1                                  | 3   | COUT1, COUT2, COUT3                           | CAP., X7S, 10 $\mu$ F, 50V, 20%, 1210                   | TDK, C3225X7S1H106K250AB     |
| 2                                  | 1   | COUT5   | CAP., 150 $\mu$ F, ALUM, 50V, 20%, 10mm $\times$ 10.5mm | SUN ELEC, 50CE150AX          |
| 3                                  | 1   | C3  | CAP., X7R, 0.1 $\mu$ F, 200V, 10%, 1206                 | AVX, 12062C104KAT2A          |
| 4                                  | 1   | C4  | CAP., X7R, 0.33 $\mu$ F, 50V, 10%, 0603                 | TDK, C3225X7S1H106K250AB     |
| 5                                  | 1   | C5  | CAP., 10 $\mu$ F, X5R, 10V, 20%, 0603                   | AVX, 12062C104KAT2A          |
| 6                                  | 2   | C6, C7  | CAP., 0.1 $\mu$ F, X7R, 50V, 10%, 0603                  | AVX, 06035C104KAT2A          |
| 7                                  | 1   | C8  | CAP., 10 $\mu$ F, X7S, 16V, 10%, 0805                   | MURATA, GCM21BC71C106KE36    |
| 8                                  | 1   | C9  | CAP., X7R, 1000pF, 50V, 10%, 0603                       | AVX, 06035C102KAT2A          |
| 9                                  | 1   | C10   | CAP., COG, 2200pF, 50V, 5%, 0603                        | MURATA, GCM1885C1H222JA16D   |
| 10                                 | 1   | C11   | CAP., COG, 470pF, 50V, 5%, 0603                         | AVX, 06035A471JAT2A          |
| 11                                 | 1   | C12   | CAP., COG, 10pF, 50V, 5%, 0603                          | AVX, 06035A100JAT2A          |
| 12                                 | 1   | C15   | CAP., 2.2 $\mu$ F, X7R, 16V, 10%, 0805                  | MURATA, GCM21BR71C225KA64    |
| 13                                 | 1   | C17   | CAP., 0.01 $\mu$ F, U2J, 250V, 5%, 1206                 | MURATA, GCM31B7U2E103JX01L   |
| 14                                 | 2   | CIN1, CIN2                                    | CAP., 22 $\mu$ F, ALUM, 160V, 20%, 10mm $\times$ 12mm   | NICHICON, UVY2C220MPD1TD     |
| 15                                 | 2   | CIN3, CIN4                                    | CAP., X7T, 1 $\mu$ F, 250V, 10%, 1812                   | TDK, CGA8P3X7T2E105M250KA    |
| 16                                 | 1   | Q1  | XSTR., MOSFET, N-CH, 150V, 87A, PG-TDSON-8              | INFINEON, BSC093N15NS5ATMA1  |
| 17                                 | 1   | Q2  | XSTR., MOSFET, N-CH, 150V, 56A, PG-TDSON-8              | INFINEON, BSC160N15NS5GATMA1 |
| 18                                 | 1   | D1  | DIODE, 200V, 1A   | NEXPERIA, ES1DRX             |
| 19                                 | 1   | R2  | RES., 10MEG, 1/8W, 1%, 0805                             | VISHAY, CRCW080510M0FKEA     |
| 20                                 | 10  | R4, R5, R9, R14, R16, R20, R22, R28, R29, R30 | RES., 0 $\Omega$ , 1/16W, 0603                          | VISHAY, CRCW06030000Z0EA     |
| 21                                 | 1   | R6  | RES., 2.2 $\Omega$ , 5%, 3/4W, 1206                     | VISHAY, CRCW12062R20JNEAHP   |



# DEMO MANUAL DC2674A

## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION                       | MANUFACTURER/PART NUMBER       |
|------|-----|-----------|--|--------------------------------|
| 22   | 1   | R7        | RES., 100k $\Omega$ , 1/16W, 1%, 0603  | VISHAY, CRCW0603100KFKEA       |
| 23   | 1   | R8        | RES., 5.11 $\Omega$ , 1/10W, 1%, 0603  | VISHAY, CRCW06035R11FKEA       |
| 24   | 1   | R10       | RES., 10 $\Omega$ 1/10W 1%, 0603       | VISHAY, CRCW060310R0FKEA       |
| 25   | 1   | R11       | RES., 162k $\Omega$ , 1/10W, 1%, 0603  | VISHAY, CRCW0603162KFKEA       |
| 26   | 1   | R12       | RES., 3.92k $\Omega$ , 1/16W, 1%, 0603 | VISHAY, CRCW06033K92FKEA       |
| 27   | 1   | R18       | RES., 21.5k $\Omega$ , 1/16W, 1%, 0603 | VISHAY, CRCW060321K5FKEA       |
| 28   | 1   | R19       | RES., 0.004 $\Omega$ , 3W, 1%, 2512    | PANASONIC, ERJ-MS4SF4M0U       |
| 29   | 1   | R21       | RES., 20 $\Omega$ , 1/10W, 1%, 0603    | VISHAY, CRCW060320R0FKEA       |
| 30   | 1   | L1        | INDUCTOR, 10 $\mu$ H                   | WURTH, 74439370100             |
| 31   | 1   | U1        | IC, LTC7862EUF                         | ANALOG DEVICES, LTC7862EUFDPBF |

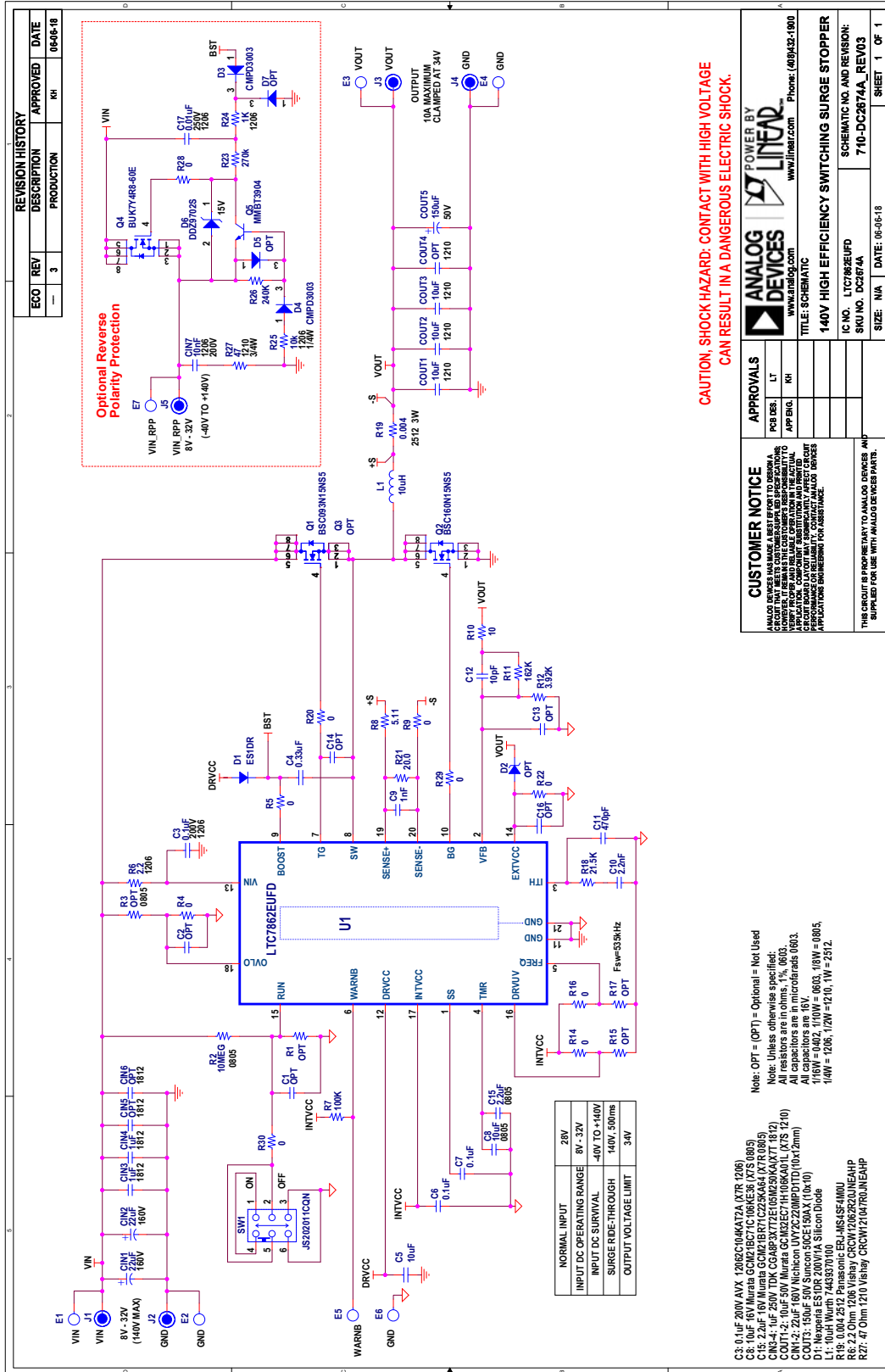
### Additional Demo Board Circuit Components

|    |   |                       |   |                             |
|----|---|-----------------------|---|-----------------------------|
| 1  | 0 | COUT4                 | CAP, OPTION, 1210   | OPTION                      |
| 2  | 0 | C1, C2, C13, C14, C16 | CAP, OPTION, 0603   | OPTION                      |
| 3  | 0 | C17                   | CAP, OPTION, 1206   | OPTION                      |
| 4  | 0 | CIN5, CIN6            | CAP, OPTION, 1812   | OPTION                      |
| 5  | 1 | CIN7                  | CAP, 0.01 $\mu$ F, X7R, 200V, 10%, 1206                         | AVX, 12062C103KAT2A         |
| 6  | 0 | Q3                    | MOSFET N-CHAN, OPTION, S08-POWERPAK                             | OPTION                      |
| 7  | 1 | Q4                    | XSTR., MOSFET, N-CH, 60V, 100A, PG-TDSON-8                      | NEXPERIA, BUK7Y4R8-60E      |
| 8  | 1 | Q5                    | XSTR., MOSFET NPN, 40V, SOT23                                   | ON SEMI, MMBT3904           |
| 9  | 0 | D2                    | DIODE., OPTION, SMA   | OPTION                      |
| 10 | 2 | D3, D4                | DIODE, 180V, 200mA, SOT23                                       | CENTRAL, CMPD3003           |
| 11 | 1 | D6                    | DIODE, ZENER 15V, SOD323  | DIODES INC, DDZ9702S        |
| 12 | 0 | D7                    | DIODE, 180V, 200mA, SOT23                                       | OPTION                      |
| 13 | 0 | D5                    | DIODE, OPTION, SOT23  | OPTION                      |
| 14 | 0 | R3                    | RES., OPTION, 0805  | OPTION                      |
| 15 | 0 | R1, R15, R17, R22     | RES., OPTION, 0603  | OPTION                      |
| 16 | 1 | R23                   | RES., 270k $\Omega$ , 1%, 1/10W, 0603                           | VISHAY, CRCW0603270KFKEA    |
| 17 | 1 | R24                   | RES., 1k $\Omega$ , 1/4W, 1206                                  | VISHAY, CRCW12061K00JNEAC   |
| 18 | 1 | R25                   | RES., 10k $\Omega$ , 5%, 1/4W, 1206                             | VISHAY, CRCW120610K0JNEA    |
| 19 | 1 | R26                   | RES., 240k $\Omega$ , 1%, 1/10W, 0603                           | VISHAY, CRCW0603240KFKEA    |
| 20 | 1 | R27                   | RES., 47 $\Omega$ , 1%, 3/4W, 1210, AEC-Q200                    | VISHAY, CRCW121047R0JNEAHP  |
| 21 | 2 | R28, R30              | RES., 0 $\Omega$ , 1/16W, 0603                                  | VISHAY, CRCW06030000Z0EA    |
| 22 | 1 | SW1                   | SWITCH, SUB-MINIATURE SLIDE, DPDT, 0.3A, 6V <sub>DC</sub> , THT | C&K COMPONENTS, JS202011CQN |

### Hardware: For Demo Board Only

|   |   |                            |                                |                                   |
|---|---|----------------------------|--------------------------------|-----------------------------------|
| 1 | 7 | E1, E2, E3, E4, E5, E6, E7 | TESTPOINT, TURRET, 0.094"      | MILL MAX, 2501-2-00-80-00-00-07-0 |
| 2 | 5 | J1, J2, J3, J4, J5         | CONN, BANANA JACK              | KEYSTONE, 575-4                   |
| 3 | 4 | MH1, MH2, MH3, MH4         | STAND-OFF, SNAP ON NYLON 0.50" | KEYSTONE, 8833                    |
| 4 | 1 |                            | FAB, PRINTED CIRCUIT BOARD     | DEMO BOARD, 2674A                 |

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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