

## LTC7000-1 Fast High Voltage Protected High Side NMOS Static Switch Driver

### DESCRIPTION

Demonstration circuit 2492A is a 135V protected, high side switch featuring the [LTC®7000-1](#). The demo board is designed to switch a 5.5A output load from input voltages from 8V to 135V. The wide input range and low shutdown current (1μA typical) make it suitable for automotive, industrial, medical instrument and telecom applications. This board offers a low 50ns (typical) propagation delay, fast switching times (<10ns) and 100% duty cycle operation.

The LTC7000-1 is a fast high voltage protected high side N-channel MOSFET driver with high voltage pin spacing (0.657mm). An internal charge pump fully enhances an external N-channel MOSFET switch, allowing it to remain on indefinitely. A powerful gate driver can drive large gate capacitance MOSFETs with very short transition times, ideal for both high frequency switching and static switch applications. The LTC7000-1 operates over a 3.5V to 135V input supply range. When an external current sense resistor and internal comparator sense that the switch current has exceeded a preset level, a fault flag is asserted and the switch is turned off after a period of time set by an external timing capacitor. After a cooldown period, the LTC7000-1 can be configured to automatically retry or remain off until the input is re-cycled.

The demo board includes input capacitors and an output diode to accommodate input and output supply inductance when switching loads. The switch can be controlled directly with external signal or using the on-board on/off switch. A single-shot pulse generator is included for evaluating switching times while limiting output power. Optional auxiliary  $V_{CC}$  input accommodates gate power associated with high frequency switching. Positions for RC delay network to control inrush current are also included.

The LTC7000-1 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 demo circuit 2492A. Proper board layout is essential for maximum thermal and electrical performance. See the data sheet sections for details. The LTC7000-1 is available in 16-lead MSOP package and three operating junction temperature grades, extended and industrial from -40°C to 125°C, high temp automotive version from -40°C to 150°C and a military grade from -55°C to 150°C.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC2492A>**

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### PERFORMANCE SUMMARY

| SYMBOL     | PARAMETER                         | CONDITIONS Specifications are at $T_A = 25^\circ\text{C}$                          | MIN | TYP | MAX | UNITS |
|------------|-----------------------------------|------------------------------------------------------------------------------------|-----|-----|-----|-------|
| $V_{IN}$   | Input Voltage                     |                                                                                    | 8.0 |     | 135 | V     |
| $I_{OUT}$  | Output Current                    |                                                                                    | 5.5 |     |     | A     |
|            | Insertion Drop                    | $V_{IN} - V_{OUT}$ , 5.5A Load, Input to Output Terminals                          |     | 150 |     | mV    |
| $V_{IN}$   | Start-Up Voltage                  | 100kΩ Load, $V_{INP} = 4\text{V}$                                                  |     | 7.0 | 8.0 | V     |
| $V_{CCUV}$ | $V_{CC}$ Undervoltage Lockout     | $V_{CC}$ Rising                                                                    | 6.5 | 7.0 | 7.5 | V     |
|            |                                   | $V_{CC}$ Falling                                                                   | 5.8 | 6.4 | 6.9 | V     |
|            |                                   | Hysteresis                                                                         |     | 0.6 |     | V     |
|            | Overcurrent to $V_{OUT}$ Low      | Turn-On into a 10A Resistive Load                                                  |     | 19  |     | μs    |
|            | Input to Output Propagation Delay | $V_{IN} = 135\text{V}$ , 50Ω Load, $INP = 2.2\text{V}$ to $V_{OUT} = 13.5\text{V}$ |     | 50  |     | ns    |
|            | Output Rise Time                  | $V_{IN} = 135\text{V}$ , 50Ω Load, 10% to 90%                                      |     | 6.5 |     | ns    |

## 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 by touching the probe tip and ground ring directly across the output capacitor as shown in Figure 2.

1. Place SW1 to OFF position. Move JP1 from the PULSE (default position) to ON/OFF position (load on continuously when SW1 is ON).
  2. With input power supply set to zero volt and power off, connect the input power supply to +VIN and GND.
  3. With power off, connect load from +VOUT to GND.
  4. Turn on the input power supply and increase the input voltage slowly to 8V minimum. The input range is up to 135V but hot-plugging with long leads may result in input voltages in excess of 135V.
  5. Place SW1 to ON position.
  6. Check for the proper output voltage using a voltmeter. Output voltage should be close to input voltage.
- NOTE:** If there is no output, temporarily disconnect the load and cycle SW1 (the ON/OFF switch) or press reset pushbutton SW2. If output is good, the load may be set too high.
7. Once the proper output voltage is established, adjust the load, if desired, to test current limit.
  8. Placing SW1 to OFF position, moving JP1 to PULSE position then placing SW1 in ON position will allow pulse operation. Pushing SW2 will turn the high side switch on for 300 $\mu$ s time.
  9. Placing SW1 to OFF position, moving JP1 to INPUT position connects INPUT terminal to LTC7000-1 INP pin. An INPUT pin voltage of 2.2V or more will turn-on the high side switch.

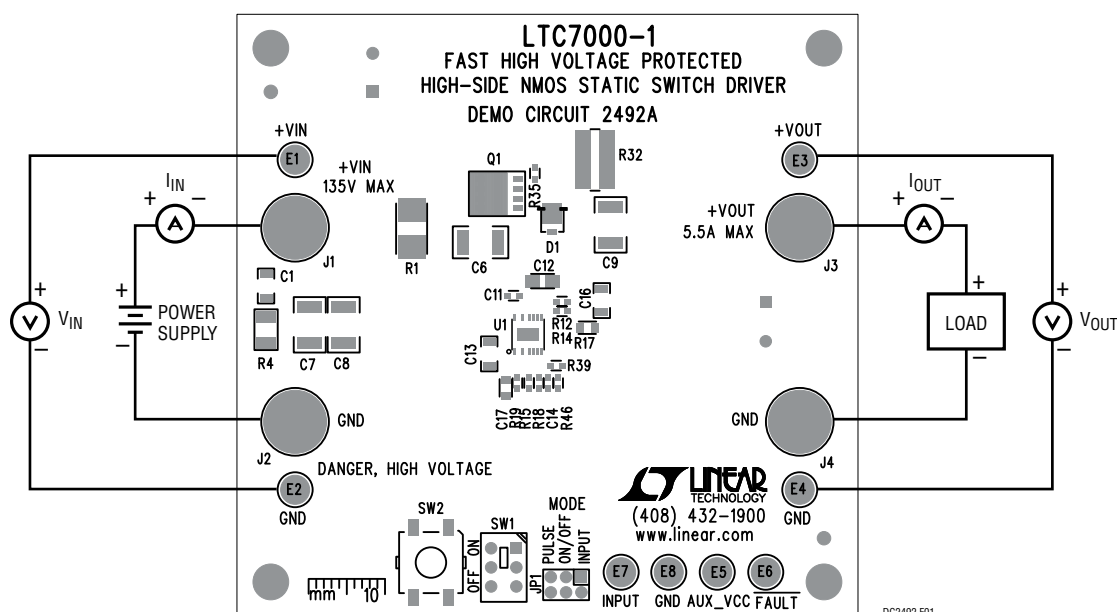


Figure 1. Proper Measurement Equipment Setup

## QUICK START PROCEDURE

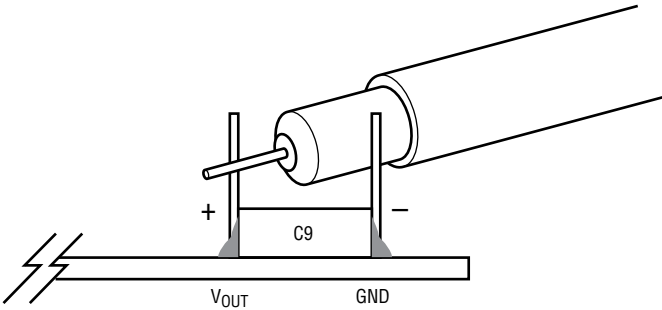


Figure 2. Measuring Output Voltage During Switching across C9. Note that C9 May Not Be Installed

## TYPICAL PERFORMANCE CHARACTERISTICS

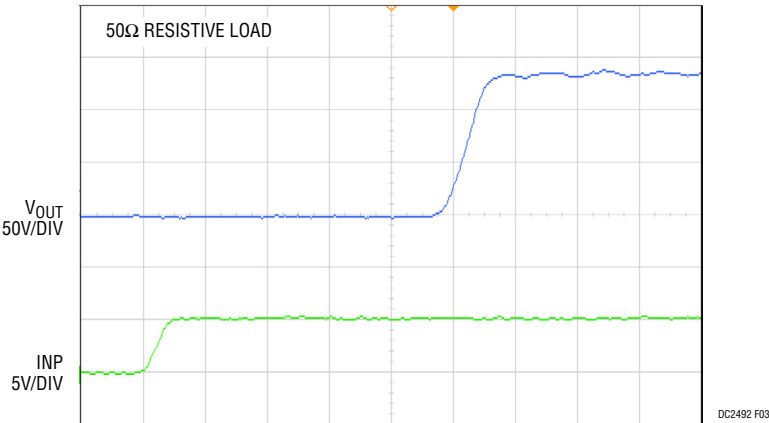


Figure 3. Rise Time into 50Ω Load ( $V_{IN} = 135V$ ,  $V_{INP} 5V/DIV$ ,  $V_{OUT} 50V/DIV$ , 10ns/DIV)

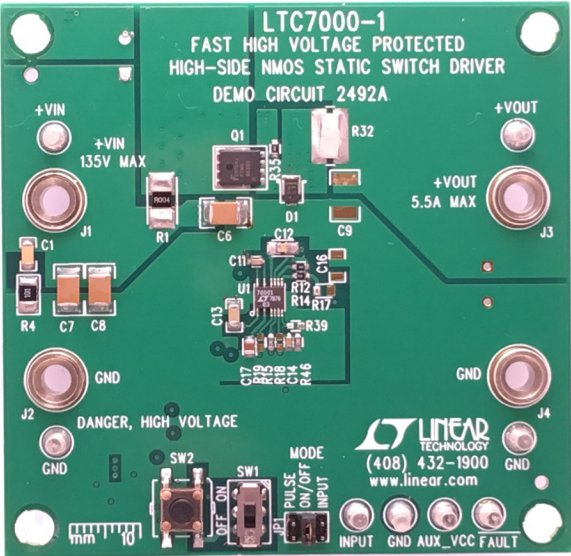


Figure 4. Board Photo

# DEMO MANUAL DC2492A

## PARTS LIST

| ITEM                                            | QTY | REFERENCE                         | PART DESCRIPTION                               | MANUFACTURER/PART NUMBER        |
|-------------------------------------------------|-----|-----------------------------------|------------------------------------------------|---------------------------------|
| <b>Required Circuit Components</b>              |     |                                   |                                                |                                 |
| 1                                               | 5   | C3, C4, C5, C7, C8                | CAP, 1 $\mu$ F, X7T, 250V, 1812                | TDK, C4532X7T2E105K250KA        |
| 2                                               | 2   | C11, C14                          | CAP, 1000pF, X7R, 25V, 10%, 0603               | MURATA, GRM188R71E102KA01D      |
| 3                                               | 1   | C12                               | CAP, 0.1 $\mu$ F, X7R, 25V, 10%, 0805          | AVX, 08053C104KAT2A             |
| 4                                               | 1   | C13                               | CAP, 0.1 $\mu$ F, X7R, 200V, 10%, 1206         | AVX, 12062C104KAT2A             |
| 5                                               | 1   | C17                               | CAP, 1 $\mu$ F, X7R, 25V, 10%, 0805            | AVX, 08053C105KAT2A             |
| 6                                               | 1   | D1                                | DIODE, ES1PD, 200V, 1A, DO-220AA               | VISHAY, ES1PD-M3/84A            |
| 7                                               | 1   | Q1                                | MOSFET, N-CH, 150V, POWERPAK-SO-8              | FAIRCHILD, FDMS86250            |
| 8                                               | 1   | R1                                | RES., SENSE, 0.004 $\Omega$ , 1W, 2%, 2512     | PANASONIC, ERJM1WTF4M0U         |
| 9                                               | 2   | R7                                | RES., 100 $\Omega$ , 1/10W, 1%, 0603           | VISHAY, CRCW0603100RFKEA        |
| 10                                              | 1   | R35                               | RES., 10 $\Omega$ , 1/10W, 1%, 0603            | VISHAY, CRCW060310R0FKEA        |
| 11                                              | 1   | U1                                | IC, LTC7000EMSE-1, MSE-16L(12)                 | LINEAR TECH., LTC7000EMSE-1#PBF |
| <b>Additional Demo Board Circuit Components</b> |     |                                   |                                                |                                 |
| 1                                               | 1   | C1                                | CAP, 10nF, X7R, 200V, 10%, 1206                | AVX, 12062C103KAZ2A             |
| 2                                               | 1   | C2                                | CAP, 22 $\mu$ F, ALUM, 160V, 20%, TH C-10X12.5 | SUN ELECT, 160ME22HPC           |
| 3                                               | 0   | C6, C9                            | CAP, OPTIONAL, 1812                            | OPTIONAL                        |
| 4                                               | 0   | C10                               | CAP, OPTIONAL, TH C-10X12                      | OPTIONAL                        |
| 5                                               | 0   | C16                               | CAP, OPTIONAL, 1206                            | OPTIONAL                        |
| 6                                               | 2   | C18, C19                          | CAP, 0.1 $\mu$ F, X7R, 25V, 10%, 0603          | AVX, 06033C104KAT2A             |
| 7                                               | 0   | C23                               | CAP, OPTIONAL, 0603                            | OPTIONAL                        |
| 8                                               | 0   | D2, D3, D4                        | DIODE, OPTIONAL, SOT23                         | OPTIONAL                        |
| 9                                               | 1   | D5                                | DIODE, MMSZ5V1T1, SOD-123                      | ON SEMICONDUCTOR, MMSZ5V1T1G    |
| 10                                              | 1   | D6                                | DIODE, MMBD4148, SOT23                         | DIODES INC., MMBD4148-7-F       |
| 11                                              | 0   | D7                                | DIODE OPTION, PDS4150, POWERDI5                | OPTIONAL                        |
| 12                                              | 0   | D8                                | DIODE, OPTION, BAS21, SOT23                    | OPTIONAL                        |
| 13                                              | 0   | D9                                | DIODE., OPTION, CMMR1U, SOD-123F               | OPTIONAL                        |
| 14                                              | 0   | Q2                                | MOSFET, N-CH, 80V, PSOF08A                     | FAIRCHILD, FDBL86361_F085       |
| 15                                              | 1   | Q4                                | XSTR, PNP, 0.2A, MMBT3906, SOT23               | FAIRCHILD, MMBT3906             |
| 16                                              | 1   | Q5                                | MOSFET, P-CH, -200V, SOT23                     | DIODES INC., ZXMP2120FFTA       |
| 17                                              | 1   | R2                                | RES., 0 $\Omega$ , 1/10W, 1%, 0805             | VISHAY CRCW08050000Z0EA         |
| 18                                              | 1   | R4                                | RES., 100 $\Omega$ , 1/2W, 5%, 1210            | NIC, NRCP25J101TRF              |
| 19                                              | 7   | R6, R12, R14, R22, R25, R45, R47  | RES., 0 $\Omega$ , 1/10W, 0603                 | VISHAY, CRCW06030000Z0EA        |
| 20                                              | 0   | R9, R17                           | RES., OPTIONAL, 0805                           | OPTIONAL                        |
| 21                                              | 0   | R13, R18, R19, R33, R34, R36, R39 | RES., OPTIONAL, 0603                           | OPTIONAL                        |
| 22                                              | 5   | R15, R21, R37, R38, R46           | RES., 100k, 1/10W, 1%, 0603                    | VISHAY, CRCW0603100KFKEA        |
| 23                                              | 1   | R23                               | RES., 787 $\Omega$ , 1/10W, 1%, 0603           | VISHAY, CRCW0603787RFKEA        |

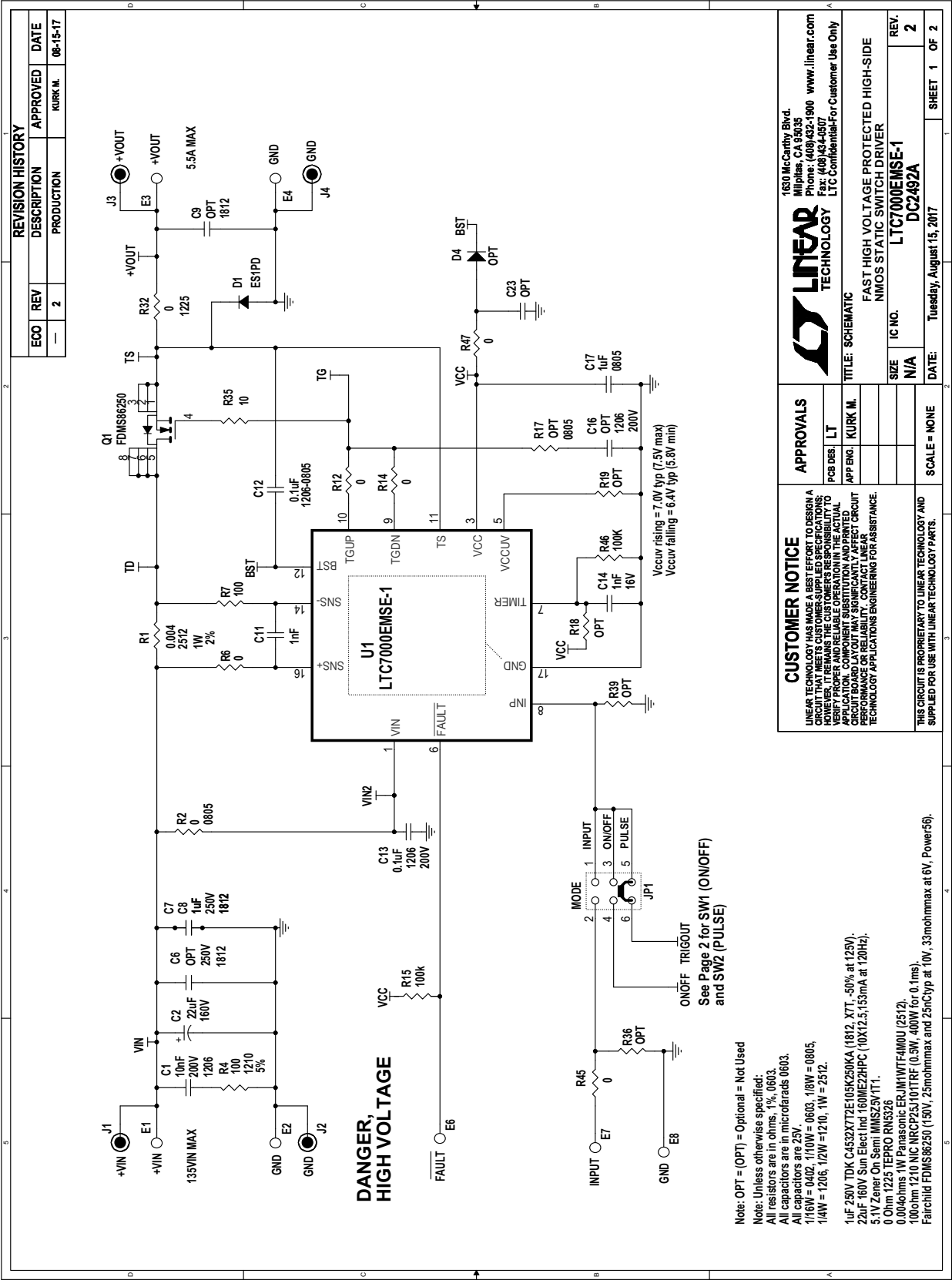
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION                         | MANUFACTURER/PART NUMBER       |
|------|-----|-----------|------------------------------------------|--------------------------------|
| 24   | 2   | R27, R31  | RES., 240k, 1/10W, 1%, 0805              | VISHAY, CRCW0805240KFKEA       |
| 25   | 1   | R28       | RES., 976k, 1/10W, 1%, 0603              | VISHAY, CRCW0603976KFKEA       |
| 26   | 1   | R29       | RES., 232k, 1/10W, 1%, 0603              | VISHAY, CRCW0603232KFKEA       |
| 27   | 1   | R30       | RES., 182k, 1/10W, 1%, 0603              | VISHAY, CRCW0603182KFKEA       |
| 28   | 1   | R32       | RES., SENSE, 0 $\Omega$ , 1/2W, 1%, 1225 | TEPRO, RN5326                  |
| 29   | 1   | SW1       | SWITCH, SUB MINIATURE SLIDE              | C&K COMPONENTS, JS202011CQN    |
| 30   | 1   | SW2       | SWITCH, MICRO MINIATURE PUSHBUTTON       | TE CONNECTIVITY, FSM4JSMA      |
| 31   | 1   | U2        | IC, LTC6993CS6-3, TSOT23-6               | LINEAR TECH., LTC6993CS6-3#PBF |

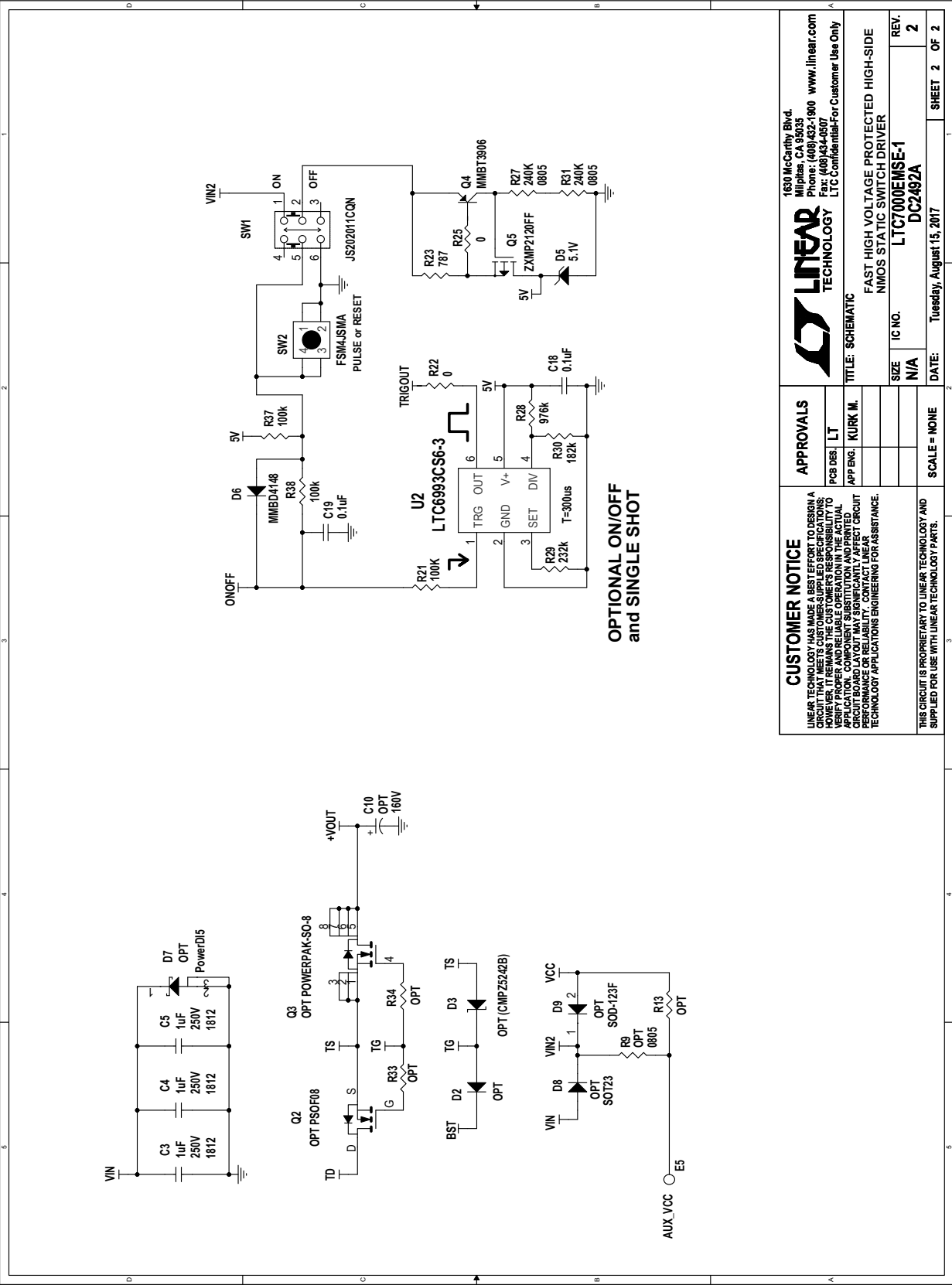
### Hardware: For Demo Board Only

|   |   |                    |                              |                                  |
|---|---|--------------------|------------------------------|----------------------------------|
| 1 | 8 | E1-E8              | TESTPOINT, TURRET 0.094"     | MILL MAX 2501-2-00-80-00-00-07-0 |
| 2 | 1 | JP1                | CONN., HEADER, 2X3, 2mm      | WURTH ELEKTRONIK, 62000621121    |
| 3 | 4 | J1, J2, J3, J4     | CONN, BANANA JACK            | KEYSTONE, 575-4                  |
| 4 | 1 | XJP1               | SHUNT, 2mm                   | WURTH ELEKTRONIK, 60800213421    |
| 5 | 4 | MH1, MH2, MH3, MH4 | STAND-OFF, NYLON 0.559" tall | WURTH ELEKTRONIK, 702935500      |

SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



|                                                                                                                                                                                                                                                                                                                                                                                              |  |                                                                                     |  |                                                                                                                                                  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------------------------------------------------------------------------------|--|
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| THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SUPPLIED FOR USE WITH LINEAR TECHNOLOGY PARTS.                                                                                                                                                                                                                                                                                          |  | TITLE: SCHEMATIC<br>FAST HIGH VOLTAGE PROTECTED HIGH-SIDE NMOS STATIC SWITCH DRIVER |  | REV. 2                                                                                                                                           |  |
| SCALE = NONE                                                                                                                                                                                                                                                                                                                                                                                 |  | SIZE IC NO. N/A                                                                     |  | REV. 2                                                                                                                                           |  |
| DATE: Tuesday, August 15, 2017                                                                                                                                                                                                                                                                                                                                                               |  | LTC7000EMSE-1                                                                       |  | DC2492A                                                                                                                                          |  |
| SHEET 2                                                                                                                                                                                                                                                                                                                                                                                      |  | OF 2                                                                                |  | REV. 2                                                                                                                                           |  |

# DEMO MANUAL DC2492A

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