

# LTC3779

## High Voltage, High Efficiency 48V/10A Synchronous Buck-Boost Converter

### DESCRIPTION

Demonstration circuit 2456A is a high voltage, high efficiency synchronous buck-boost DC/DC converter with a 16V to 120V input voltage range. It can supply a 10A maximum load current with a 48V output. The demo board features the [LTC®3779EFE](#) controller. The constant frequency current mode architecture allows a phase-lockable frequency of up to 600kHz, while an optional output current feedback loop provides support for applications such as battery charging. With a wide input range, wide output range and seamless transfers between operation modes, the LTC3779 is ideal for Industrial, Automotive, Medical, Military and Avionics applications.

The light load operation mode of the converter is determined with the MODE pin. Use JP2 jumper to select pulse-skipping mode or forced continuous mode (CCM) operation. The switching frequency is pre-set at about 200kHz. The converter can also be externally synchronized to an external clock through the PLLIN pin (PLLIN terminal on the board). To shut down the converter, force the RUN pin below 1.2V (SW1: OFF). The power good output (PGOOD terminal) is low when the output voltage is outside of the  $\pm 10\%$  regulation window.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC2456A>**

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### PERFORMANCE SUMMARY

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

| PARAMETER                         | CONDITION                                                                    | VALUE         |
|-----------------------------------|------------------------------------------------------------------------------|---------------|
| Input Voltage Range               |                                                                              | 16V to 120V   |
| Output Voltage, $V_{OUT}$         | $V_{IN} = 21\text{V to } 120\text{V}$ , $I_{OUT} = 0\text{A to } 10\text{A}$ | 48V $\pm 2\%$ |
| Maximum Output Current, $I_{OUT}$ | $V_{IN} = 21\text{V to } 120\text{V}$ , $V_{OUT} = 48\text{V}$               | 10A           |
| Default Operating Frequency       |                                                                              | 200kHz        |
| Typical Efficiency                | 48V <sub>IN</sub> , 48V <sub>OUT</sub> , 10A                                 | 98.7%         |
|                                   | 36V <sub>IN</sub> , 48V <sub>OUT</sub> , 10A                                 | 99.0%         |
|                                   | 72V <sub>IN</sub> , 48V <sub>OUT</sub> , 10A                                 | 98.7%         |
| Typical Output Ripple             | 48V <sub>IN</sub> , 48V <sub>OUT</sub> , 10A                                 | 480mV         |

## QUICK START PROCEDURE

Demonstration circuit 2456A is easy to set up to evaluate the performance of the LTC3779. Refer to Figure 1 for the proper measurement equipment setup and follow the procedure below:

1. With power off, connect the input power supply to  $V_{IN}$  (16V to 120V) and GND (input return).
2. Connect the 48V output load between  $V_{OUT}$  and GND (Initial load: no load).
3. Connect the DVMs to the input and the output.
4. Turn on the input power supply and then check for the proper output voltages.  $V_{OUT}$  should be  $48V \pm 2\%$ .
5. Once the proper output voltages are established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage and other parameters.

Note: When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 2 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (–) terminals of an output capacitor. The probe's ground ring needs to touch the (–) lead and the probe tip needs to touch the (+) lead.

Additional Note:

R2, R3, R4 and C10 is needed for additional/constant output current limit only. If this average current loop function is not used, short R2 and remove R3, R4 and C10; and then short IAVGSNSP and IAVGSNSN pins together, and tie them to V5.

## Output Current Derating

Demonstration circuit 2456A is designed to supply 48V output with a 10A maximum load current. Figure 3 shows the full load efficiency and loss vs. the input voltage. For thermal concern, hotspot temperature is limited below  $90^{\circ}\text{C}$  for input voltage range between 21V and 120V with 200LFM air flow. Figure 4 and Figure 5 show the thermal performance of Demonstration circuit 2456A with  $21V_{IN}$ ,  $48V_{OUT}$ , 10A load current and  $120V_{IN}$ ,  $48V_{OUT}$ , 10A load current, respectively. Further decreasing the input voltage below 21V with 10A load current is not recommended. For applications with input voltage range between 16V and 21V, the output current derating curve is shown as Figure 6. For input voltage range between 36V and 72V which is popular in Telecom Industry, Demonstration circuit 2456A can handle the 10A full load current without any forced air flow. Figure 7, Figure 8 and Figure 9 show the thermal performance at  $36V_{IN}$ ,  $48V_{IN}$  and  $72V_{IN}$ , respectively.

Besides the thermal performance, another limit factor for high output power capability is the saturation current of the power inductor. To supply  $48V_{OUT}$ , 10A load current with the input voltage below 21V, 15 $\mu\text{H}$  inductor with P/N 60068 from Payton Planar Magnetics Ltd. is recommended. Please contact the manufacture for detail information. Figure 10 shows the thermal performance at  $18V_{IN}$ ,  $48V_{OUT}$ , 10A load current with 400LFM air flow. For applications with input voltage range between 16V and 18V, the output current derating curve is shown as Figure 6.

## QUICK START PROCEDURE

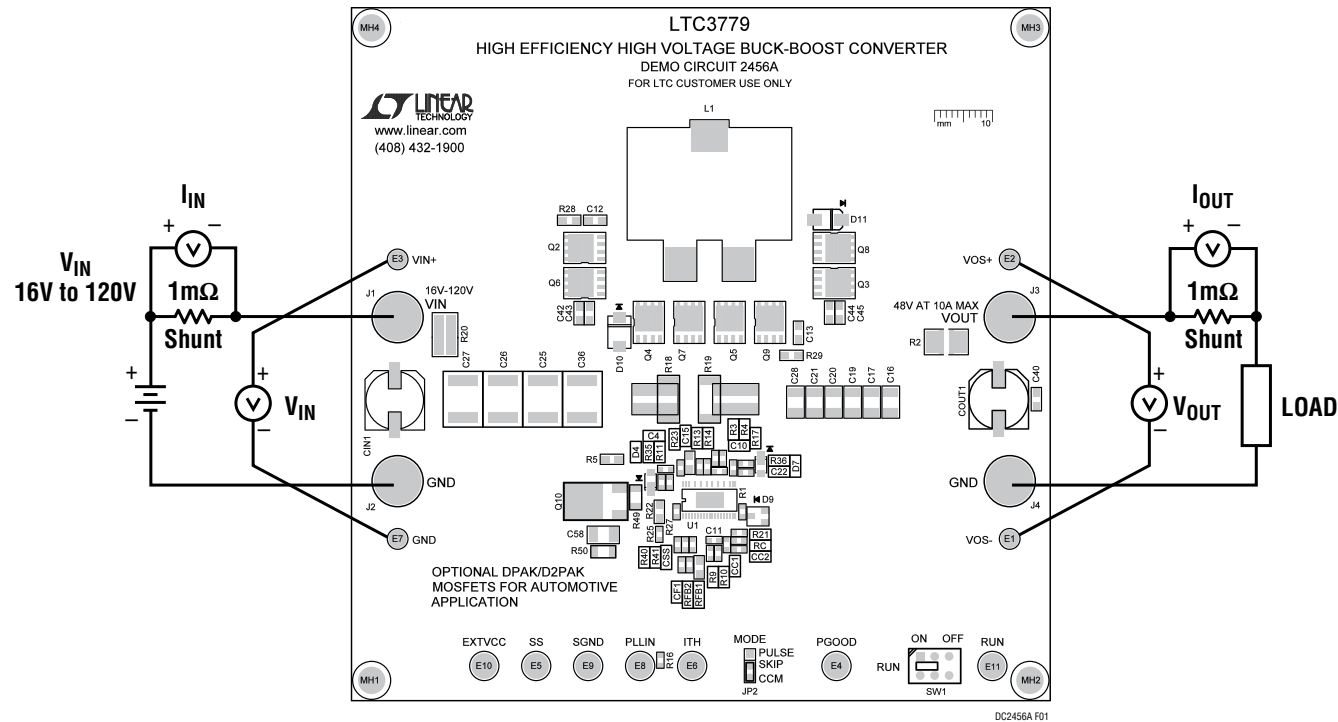


Figure 1. Proper Measurement Equipment Setup

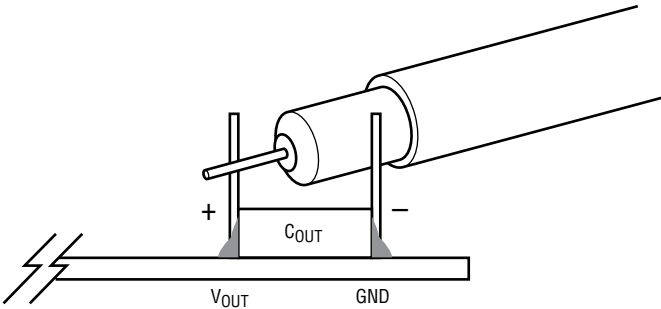


Figure 2. Measuring Output Voltage Ripple

QUICK START PROCEDURE

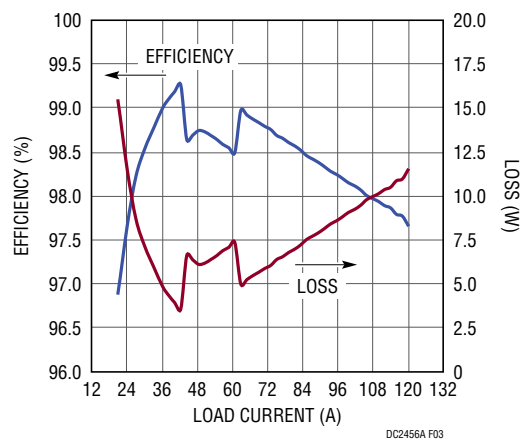


Figure 3. Efficiency and Loss vs Input Voltage ( $I_{OUT} = 10A$ )

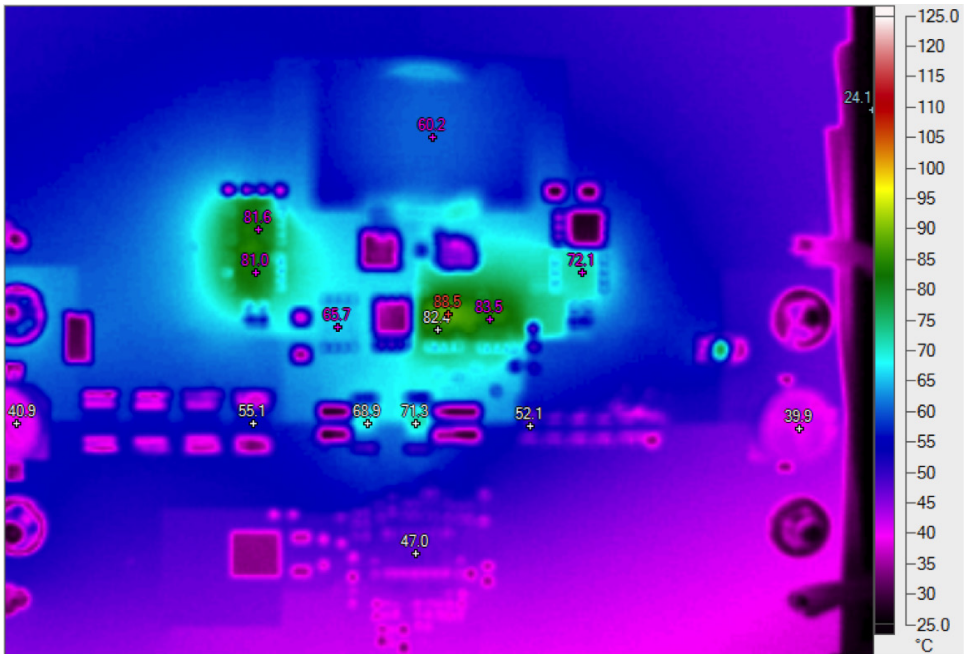


Figure 4. DC2456A Thermal Performance at 21V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A Load Current with 200LFM Air Flow

# QUICK START PROCEDURE

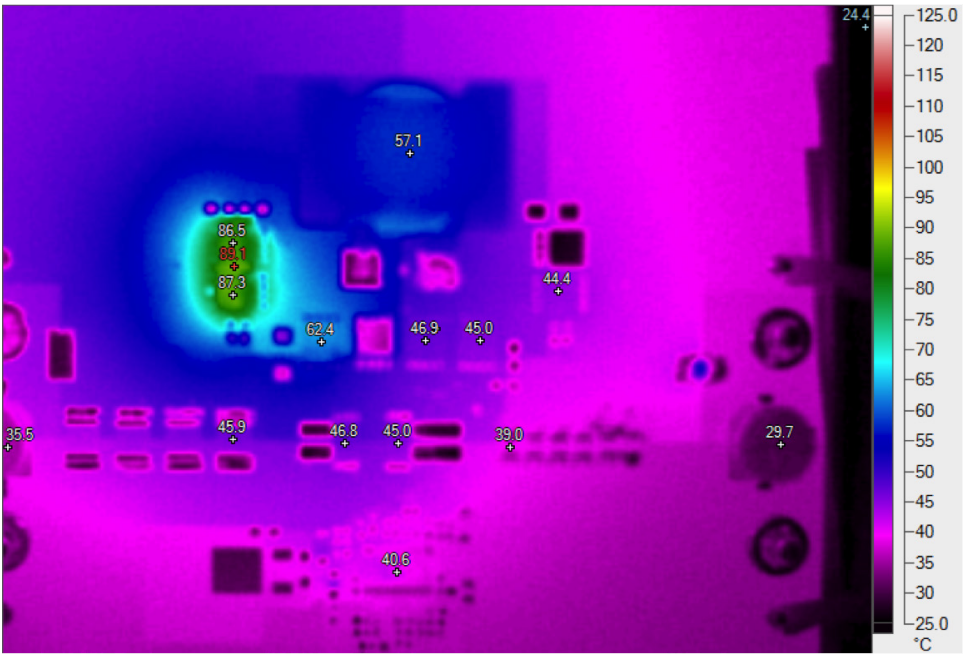


Figure 5. DC2456A Thermal Performance at 120V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A Load Current with 200LFM Air Flow

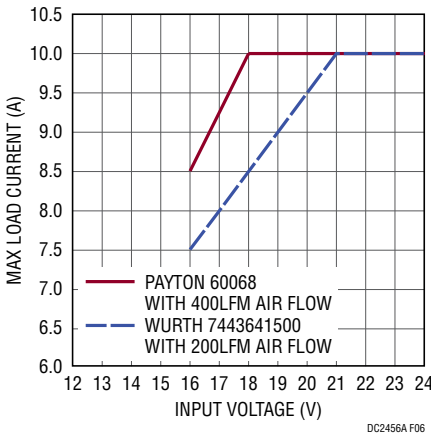


Figure 6. DC2456A Output Current Derating vs Input Voltage ( $\Delta T_{MAX} = 65^{\circ}C$ )

QUICK START PROCEDURE

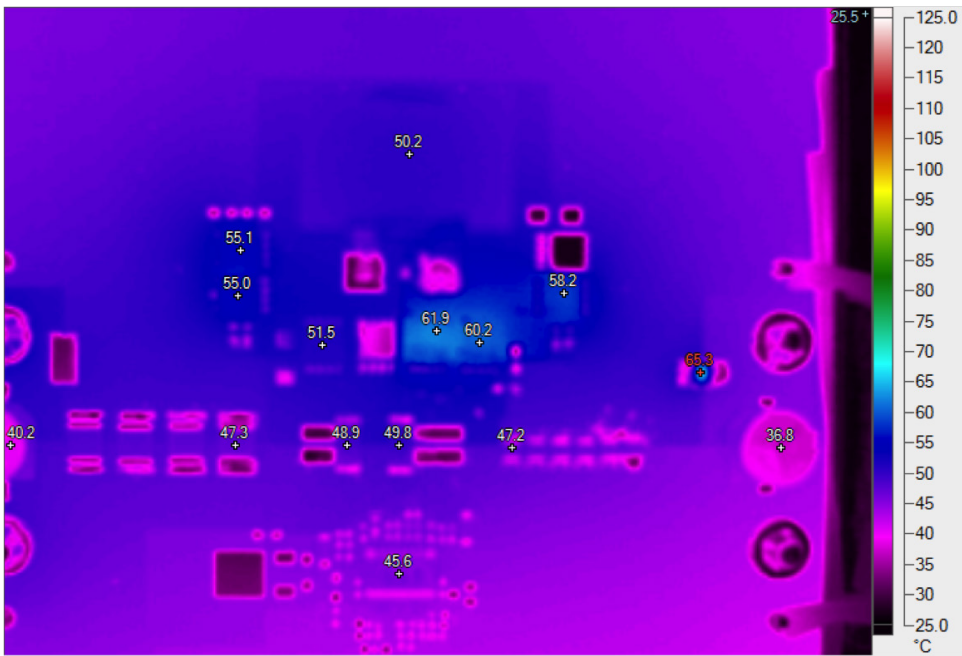


Figure 7. DC2456A Thermal Performance at 36V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A Load Current with No Forced Air Flow

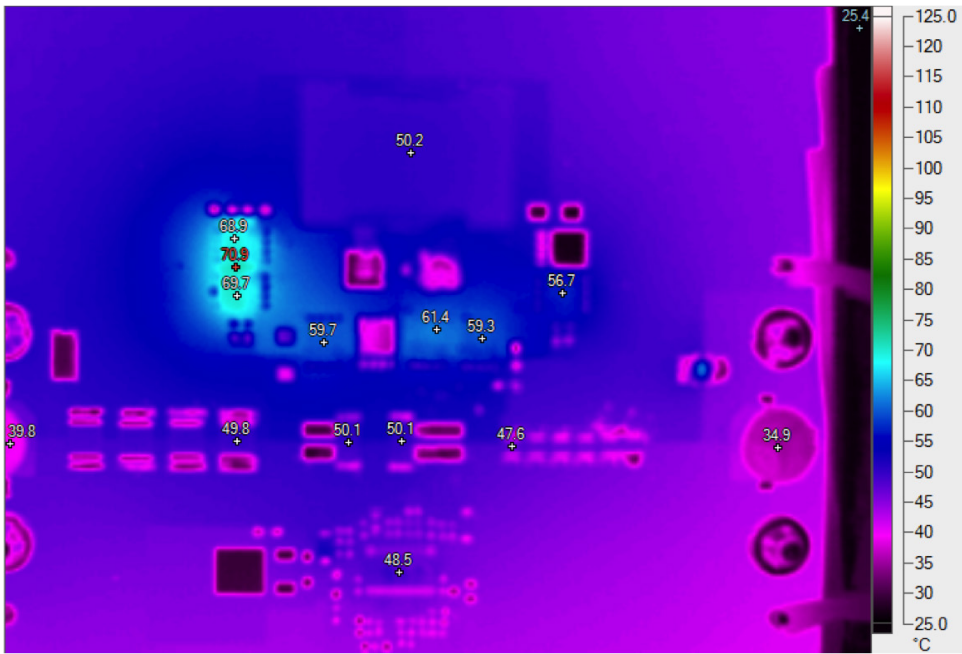


Figure 8. DC2456A Thermal Performance at 48V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A Load Current with No Forced Air Flow

QUICK START PROCEDURE

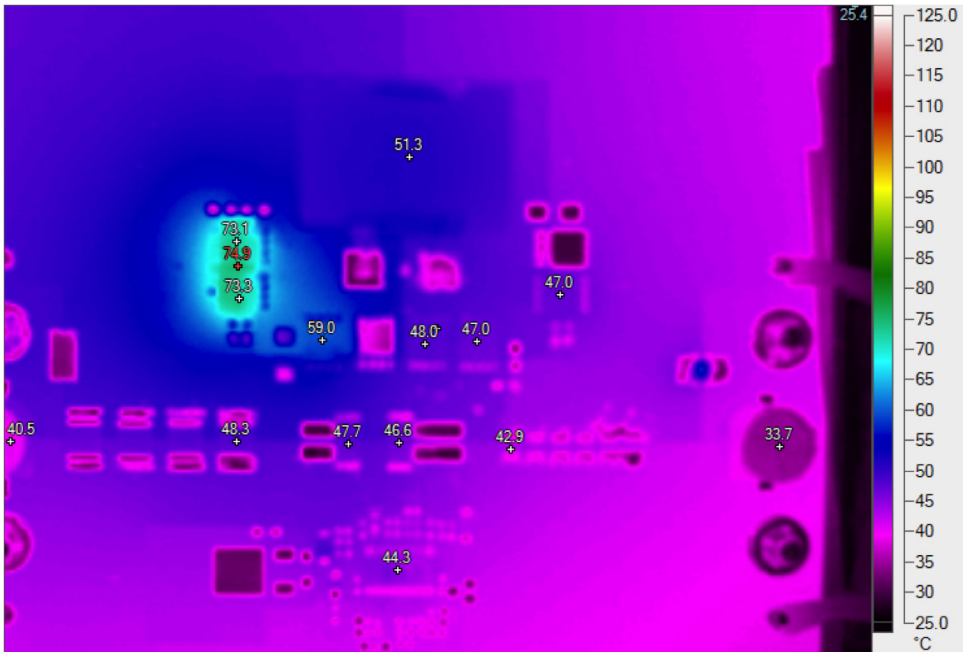


Figure 9. DC2456A Thermal Performance at 72V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A Load Current with No Forced Air Flow

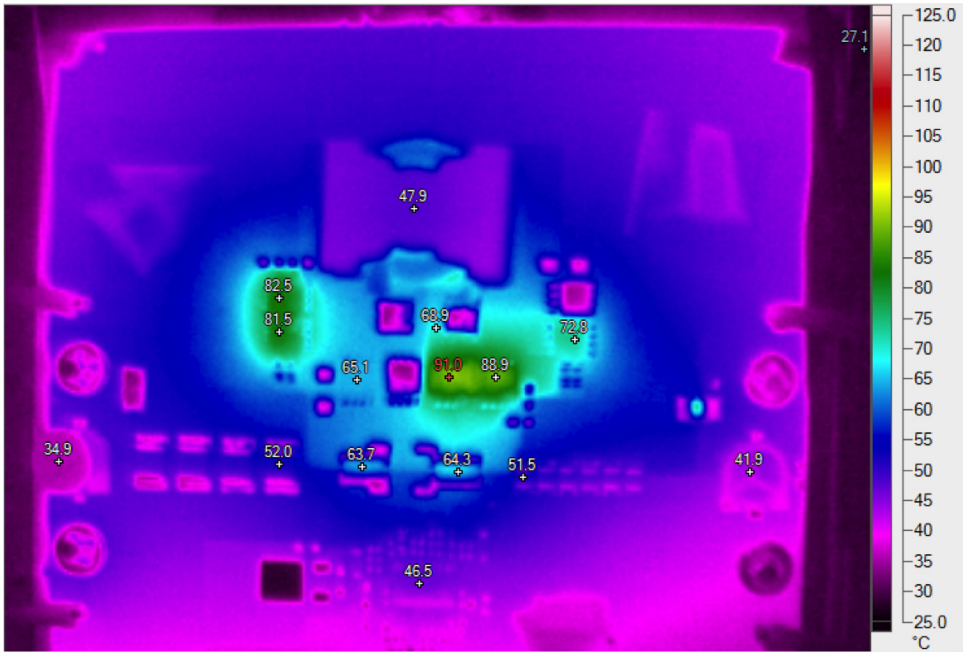


Figure 10. DC2456A Thermal Performance at 18V<sub>IN</sub>, 48V<sub>OUT</sub>, 10A Load Current with 400LFM Air Flow

# DEMO MANUAL DC2456A

## PARTS LIST

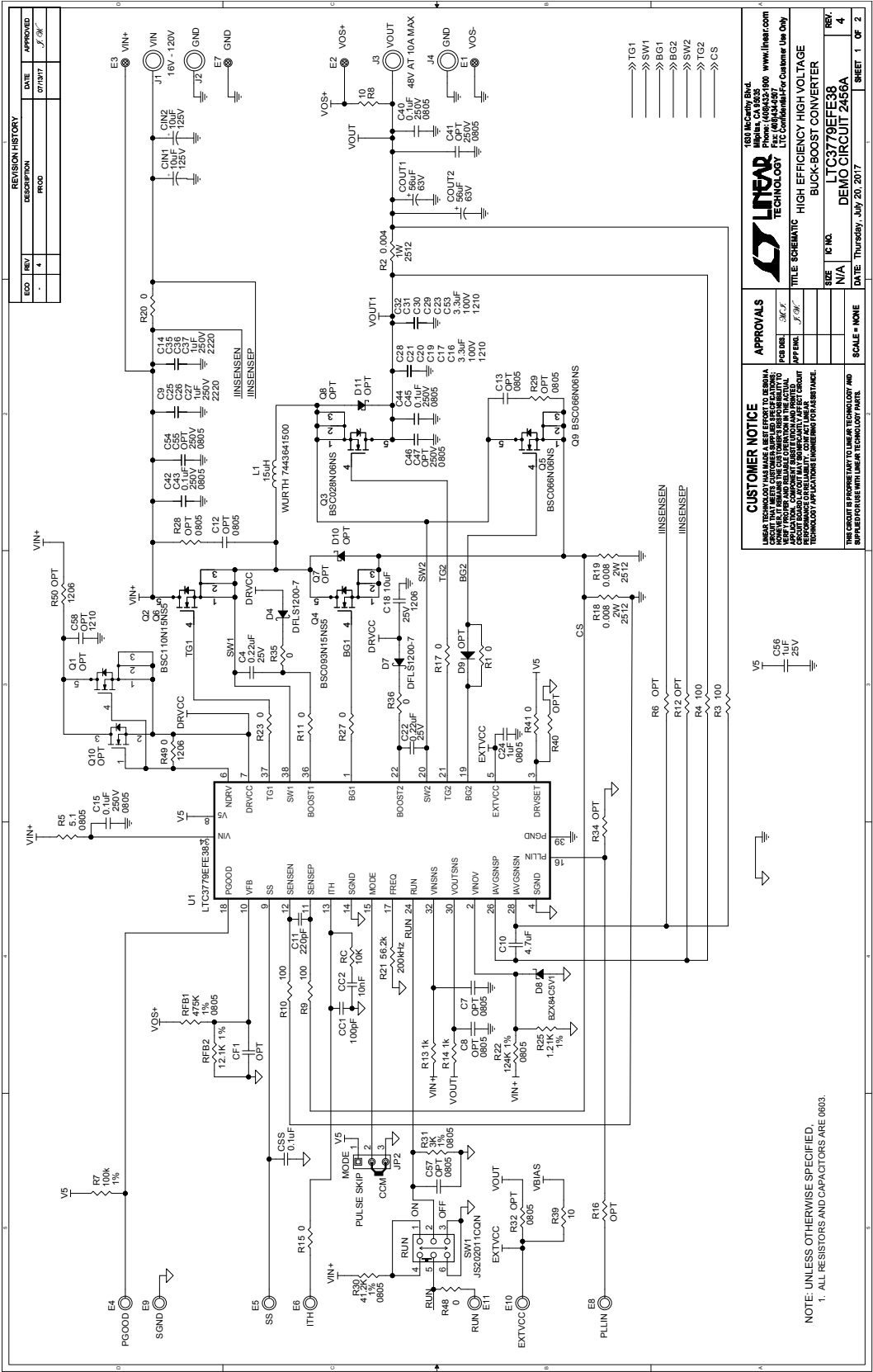
| ITEM | QTY | REFERENCE                                                  | PART DESCRIPTION                    | MANUFACTURER/PART NUMBER           |
|------|-----|------------------------------------------------------------|-------------------------------------|------------------------------------|
| 1    | 1   | CC1                                                        | CAP, 0603 100pF 10% 50V C0G         | AVX 06035A101KAT2A                 |
| 2    | 1   | CC2                                                        | CAP, 0603 10nF 10% 50V X7R          | AVX 06035C103KAT2A                 |
| 3    | 0   | CF1                                                        | CAP, 0603 OPTION                    | OPTION                             |
| 4    | 2   | CIN1, CIN2                                                 | CAP, 10µF 20% 125V ELEC             | SUNCON 125HVH10M                   |
| 5    | 2   | COUT1, COUT2                                               | CAP, 56µF 20% 63V HYB POLYMER       | UNITED CHEMI-CON HHXA630ARA560MJA0 |
| 6    | 2   | C52, CSS                                                   | CAP, 0603 0.1µF 10% 50V X7R         | AVX 06035C104KAT2A                 |
| 7    | 2   | C4, C22                                                    | CAP, 0603 0.22µF 20% 16V X7R        | AVX 0603YC224MAT2A                 |
| 8    | 0   | C7, C8, C12, C13, C57                                      | CAP, 0805 OPTION                    | OPTION                             |
| 9    | 9   | C9, C14, C25, C26, C27, C35, C36, C37, C48                 | CAP, 2220 1µF 10% 250V X7R          | MURATA GRM55DR72E105KW01L          |
| 10   | 1   | C10                                                        | CAP, 0603 4.7µF 10% 10V X5R         | MURATA GRM188R61A475KE15D          |
| 11   | 1   | C11                                                        | CAP, 0603 220pF 5% 100V C0G         | MURATA GRM1885C2A221JA01D          |
| 12   | 6   | C15, C40, C42, C43, C44, C45                               | CAP, 0805 0.1µF 10% 250V X7T        | TDK CGA4J3X7T2E104K125AE           |
| 13   | 12  | C16, C17, C19, C20, C21, C23, C28, C29, C30, C31, C32, C53 | CAP, 1210 3.3µF 10% 50V X7R         | AVX 12105C335K4T2A                 |
| 14   | 1   | C18                                                        | CAP, 1206 10µF 20% 6.3V X5R         | AVX 12066D106MAT2A                 |
| 15   | 1   | C24                                                        | CAP, 0805 1µF 10% 50V X7R           | AVX 08055C105KAT2A                 |
| 16   | 0   | C41, C46, C47, C54, C55                                    | CAP, 0805 0.1µF 10% 250V X7T OPTION | TDK CGA4J3X7T2E104K125AE OPTION    |
| 17   | 1   | C49                                                        | CAP, 0603 47nF 10% 50V X7R          | MURATA GRM188R71H473KA61D          |
| 18   | 2   | C50, C51                                                   | CAP, 1210 22µF 20% 16V X5R          | AVX 1210YD226MAT2A                 |
| 19   | 1   | C56                                                        | CAP, 0603 1F 10% 50V X5R            | TDK C1608X5R1H105K080AB            |
| 20   | 0   | C58                                                        | CAP, 1210 OPTION                    | OPTION                             |
| 21   | 2   | D4, D7                                                     | DIODE, SCHOTTKY 1A 200V POWERDI123  | DIODES INC. DFSL1200-7             |
| 22   | 1   | D8                                                         | DIODE, ZENER 5.1V 350mW SOT23-3     | DIODES INV. BZX84C5V1-7-F          |
| 23   | 0   | D9                                                         | DIODE, OPTION                       | DIODES INC. BAS16-7-F OPTION       |
| 24   | 0   | D10                                                        | DIODE, SCHOTTKY OPTION SMB          | OPTION                             |
| 25   | 0   | D11                                                        | DIODE, SCHOTTKY OPTION SMA          | OPTION                             |
| 26   | 0   | D12, D13                                                   | DIODE, SCHOTTKY OPTION POWERDI5     | OPTION                             |
| 27   | 4   | E1, E2, E3, E7                                             | TURRET                              | MILL-MAX 2308-2-00-80-00-00-07-0   |
| 28   | 7   | E4, E5, E6, E8, E9, E10, E11                               | TURRET                              | MILL-MAX 2501-2-00-80-00-00-07-0   |
| 29   | 1   | JP2                                                        | HEADER, 3PIN 2mm                    | SAMTEC TMM-103-02-L-S              |
| 30   | 4   | J1, J2, J3, J4                                             | JACK, BANANA                        | KEYSTONE 575-4                     |
| 31   | 1   | L1                                                         | IND, 15µH                           | WURTH 7443641500                   |
| 32   | 0   | L2                                                         | IND, OPTION                         | OPTION                             |
| 33   | 1   | L3                                                         | IND, 220µH                          | SUMIDA CDRH105RNP-221NC            |
| 34   | 4   | MH1, MH2, MH3, MH4                                         | STANDOFF, SNAP ON 9.525mm           | KEYSTONE 8834                      |
| 35   | 0   | Q1, Q7, Q8                                                 | XSTR, OPTION                        | OPTION                             |
| 36   | 2   | Q2, Q6                                                     | XSTR, N-CHANNEL POWER MOSFET        | INFINEON BSC110N15NS5              |
| 37   | 1   | Q3                                                         | XSTR, N-CHANNEL POWER MOSFET        | INFINEON BSC028N06NS               |
| 38   | 1   | Q4                                                         | XSTR, N-CHANNEL POWER MOSFET        | INFINEON BSC093N15NS5              |
| 39   | 2   | Q5, Q9                                                     | XSTR, N-CHANNEL POWER MOSFET        | INFINEON BSC066N06NS               |

## PARTS LIST

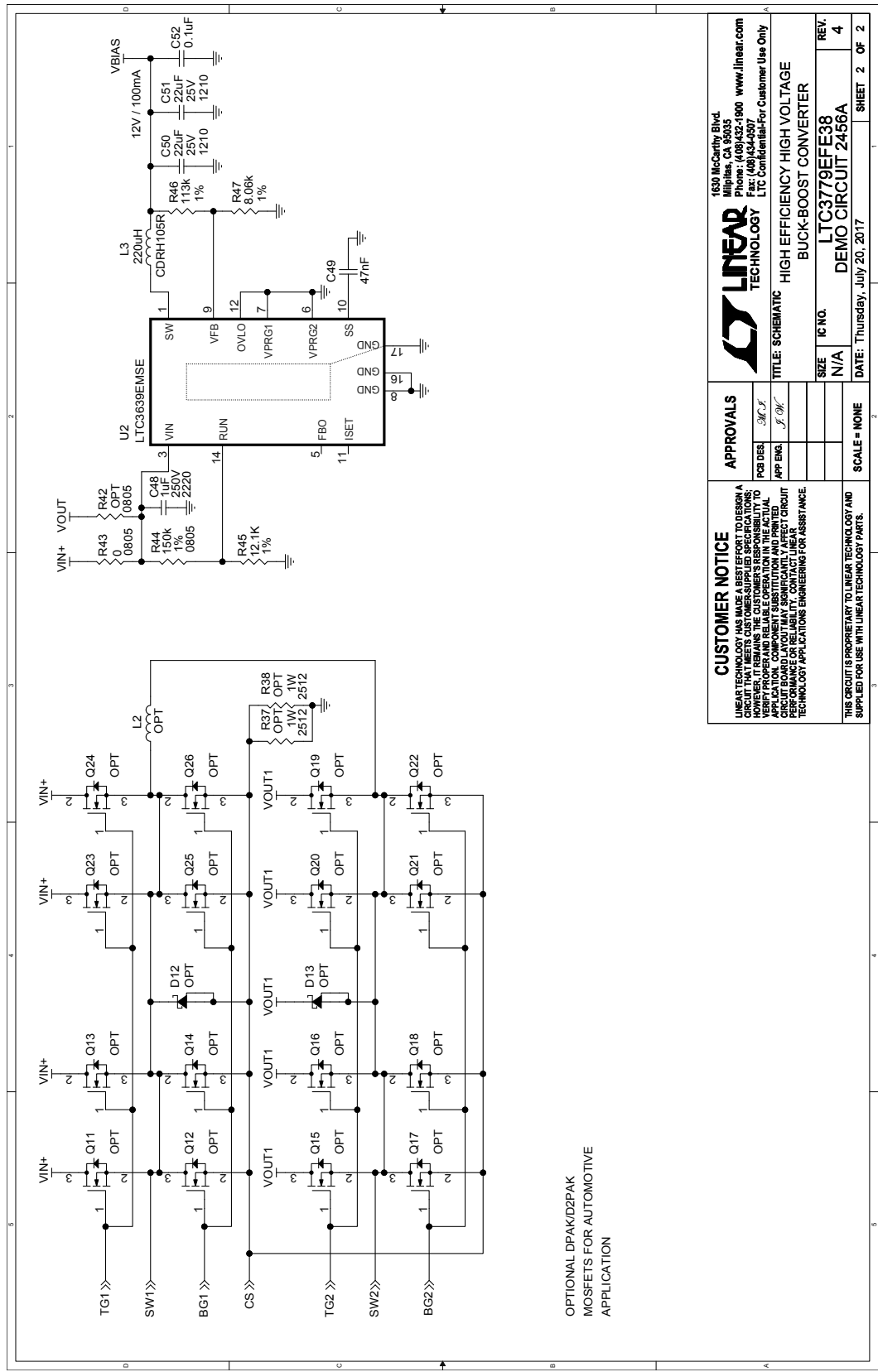
| ITEM | QTY | REFERENCE                                                                      | PART DESCRIPTION                     | MANUFACTURER/PART NUMBER      |
|------|-----|--------------------------------------------------------------------------------|--------------------------------------|-------------------------------|
| 40   | 0   | Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26 | AUTOMOTIVE MOSFET OPTION             | OPTION                        |
| 41   | 0   | Q10                                                                            | XSTR, OPTION TO-252                  | OPTION                        |
| 42   | 1   | RC                                                                             | RES, 0603 10k $\Omega$ 5% 0.1W       | VISHAY CRCW060310K0JNEA       |
| 43   | 1   | RFB1                                                                           | RES, 0805 475k $\Omega$ 1% 0.125W    | VISHAY CRCW0805475KFKEA       |
| 44   | 2   | RFB2, R45                                                                      | RES, 0603 12.1k $\Omega$ 1% 0.1W     | VISHAY CRCW060312K1FKEA       |
| 45   | 10  | R1, R11, R15, R17, R23, R27, R35, R36, R41, R48                                | RES, 0 $\Omega$ JUMPER               | VISHAY CRCW06030000Z0EA       |
| 46   | 1   | R2                                                                             | RES, 2512 0.004 $\Omega$ 1% 1W       | PANASONIC ERJ-M1WSF4M0U       |
| 47   | 4   | R3, R4, R9, R10                                                                | RES, 0603 100 $\Omega$ 1% 0.1W       | VISHAY CRCW0603100RFKEA       |
| 48   | 1   | R5                                                                             | RE, 0805 5.1 $\Omega$ 5% 0.125W      | VISHAY CRCW08055R10JNEA       |
| 49   | 0   | R6, R12, R16, R34, R40                                                         | RES, 0603 OPTION                     | OPTION                        |
| 50   | 1   | R7                                                                             | RES, 0603 100k $\Omega$ 1% 0.1W      | VISHAY CRCW0603100KFKEA       |
| 51   | 2   | R8, R39                                                                        | RES, 0603 10 $\Omega$ 5% 0.1W        | VISHAY CRCW060310R0JNEA       |
| 52   | 2   | R13, R14                                                                       | RES, 0603 1k $\Omega$ 1% 0.1W        | VISHAY CRCW06031K00FKEA       |
| 53   | 2   | R18, R19                                                                       | RES, 2512 0.008 $\Omega$ 1% 2W       | BOURNS CRE2512-FZ-R008E-2     |
| 54   | 1   | R20                                                                            | RES, 2512 0 $\Omega$ JUMPER          | TEPRO RN5326                  |
| 55   | 1   | R21                                                                            | RES, 0603 56.2k $\Omega$ 1% 0.1W     | VISHAY CRCW060356K2FKEA       |
| 56   | 1   | R22                                                                            | RES, 0805 124k $\Omega$ 1% 0.125W    | VISHAY CRCW0805124KFKEA       |
| 57   | 1   | R25                                                                            | RES, 0603 1.21k $\Omega$ 1% 0.1W     | VISHAY CRCW06031K21FKEA       |
| 58   | 0   | R28, R29, R32, R42                                                             | RES, 0805 OPTION                     | OPTION                        |
| 59   | 1   | R30                                                                            | RES, 0805 41.2k $\Omega$ 1% 0.125W   | VISHAY CRCW080541K2FKEA       |
| 60   | 1   | R31                                                                            | RES, 0805 3k $\Omega$ 1% 0.125W      | VISHAY CRCW08053K00FKEA       |
| 61   | 0   | R37, R38                                                                       | RES, 2512 0.01 $\Omega$ 1% 1W OPTION | VISHAY WSL2512R0100FEA OPTION |
| 62   | 1   | R43                                                                            | RES, 0805 0 $\Omega$ JUMPER          | VISHAY CRCW08050000Z0EA       |
| 63   | 1   | R44                                                                            | RES, 0805 150k $\Omega$ 1% 0.125W    | VISHAY CRCW0805150KFKEA       |
| 64   | 1   | R46                                                                            | RES, 0603 113k $\Omega$ 1% 0.1W      | VISHAY CRCW0603113KFKEA       |
| 65   | 1   | R47                                                                            | RES, 0603 8.06k $\Omega$ 1% 0.1W     | VISHAY CRCW06038K06FKEA       |
| 66   | 1   | R49                                                                            | RES, 1206 0 $\Omega$ JUMPER          | VISHAY CRCW12060000Z0EA       |
| 67   | 0   | R50                                                                            | RES, 1206 OPT                        | OPTION                        |
| 68   | 1   | SW1                                                                            | SWITCH, SUB-MINIATURE SLIDE 300mA 6V | C&K JS202011CQN               |
| 69   | 1   | U1                                                                             | IC, BUCK-BOOST CONVERTER             | LINEAR TECH. LTC3779EFE38     |
| 70   | 1   | U2                                                                             | IC, SYNCHRONOUS STEP-DOWN REGULATOR  | LINEAR TECH. LTC3639EMSE      |
| 71   | 1   | XJP2                                                                           | SHUNT 2mm                            | SAMTEC 2SN-BK-G               |

# DEMO MANUAL DC2456A

## SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



# DEMO MANUAL DC2456A

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**Please read the DEMO BOARD manual prior to handling the product.** Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged.**

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

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