

**LT3955EUHE**  
**60V<sub>IN</sub> 80V<sub>OUT</sub> LED Driver****DESCRIPTION**

Demonstration circuit 2020A is a 60V<sub>IN</sub>, 80V<sub>OUT</sub> LED driver. It generates its own PWMOUT waveform from its internal PWM generator for accurate PWM dimming with up to 33:1 brightness ratio. It accepts an input voltage from 5V to 60V and drives up to 67V of LEDs at 300mA (when PV<sub>IN</sub> is less than V<sub>LED</sub>). DC2020A features both PWM and analog dimming of the LED string. It has an OPENLED flag that indicates when the LED string has been removed.

DC2020A features high efficiency at 350kHz switching frequency. At high LED string voltages up to 67V and 300mA of LED current, the single switch controller has 92% efficiency. The LT3955 has an internal 80V, 3.5A switch that simplifies the schematic and layout.

Small ceramic input and output capacitors are used to save space and cost. The open LED overvoltage protection uses the IC's constant voltage regulation loop to regulate the output to approximately 75V if the LED string is opened although it may reach 79V peak during transient from running LEDs to open string.

For low input voltage operation, the CTRL pin voltage is reduced as the input voltage drops below 9V, reducing LED brightness and restraining the peak switch currents in order to limit inductor and switch size. UVLO turns the LEDs off when V<sub>IN</sub> drops below 5V.

DC2020A PWM dimming is simplified when compared with other LED drivers. The LT3955 generates its own PWMOUT dimming waveform at a frequency determined

by the capacitance on the PWM pin (C16 gives 320Hz for DC2020A). The PWMOUT duty cycle is determined by the voltage on the DIM terminal. Between 0V and 7.7V V<sub>DIM</sub> gives between 4% and 96% PWM duty cycle. Information regarding PWM dimming ratios and performance can be found in the LT3955 data sheet in the applications section. Analog dimming is also simple to use with a single voltage source on the CTRL terminal.

Modifications can be made to DC2020A in order to convert the board to power different LED strings or from an LED driver to a constant voltage regulator or battery charger. It can easily be changed from a boost topology to a SEPIC, buck mode, or buck-boost mode LED driver. Please consult the factory or the LT3955 data sheet for details. It can be modified to provide LED<sup>+</sup> to GND short-circuit protection as well.

The LT3955 data sheet gives a complete description of the part, operation and applications information. The data sheet must be read in conjunction with this demo manual for demonstration circuit DC2020A. The LT3955EUHE is assembled in a 36-lead plastic QFN package with two thermal pads underneath the IC. Proper board layout is essential for maximum thermal performance. See the data sheet section Layout Considerations.

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

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# DEMO MANUAL DC2020A

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

| PARAMETER                                          | CONDITIONS                                                                 | VALUE (TYPICAL)             |
|----------------------------------------------------|----------------------------------------------------------------------------|-----------------------------|
| Input Voltage $PV_{IN}$ Range                      | Operating                                                                  | 5V to $V_{LED}$ (up to 60V) |
| Switching Frequency                                | $R1 = 28.7k$                                                               | 350kHz                      |
| $I_{LED}$                                          | $RS1 = 0.82\Omega$ $9V < PV_{IN} < V_{LED}$ (60V)                          | 300mA                       |
| Low $PV_{IN}$ $I_{LED}$ (CTRL foldback)            | $RS1 = 0.82\Omega$ $PV_{IN} = 7.0V$<br>$RS1 = 0.82\Omega$ $PV_{IN} = 8.0V$ | 240mA<br>278mA              |
| $V_{LED}$ Range                                    | $R7 = 1M$ $R8 = 16.9k$                                                     | $PV_{IN} < V_{LED} < 67V$   |
| Open LED Voltage                                   | $R7 = 1M$ $R8 = 16.9k$                                                     | 75V                         |
| Typical Efficiency                                 | $PV_{IN} = 14V$ $V_{LED} = 67V$ $I_{LED} = 300mA$ $PWM = INTV_{CC}$        | 92.1%                       |
| $PV_{IN}$ Under Voltage Lockout (falling turn-off) | $R3 = 499k$ and $R4 = 165k$                                                | 5.0V                        |
| $PV_{IN}$ Under Voltage Lockout (rising turn-on)   | $R3 = 499k$ and $R4 = 165k$                                                | 6.1V                        |
| $INTV_{CC}$                                        | Operating                                                                  | 7.85V                       |
| Peak Switch Current Limit                          |                                                                            | 3.3A                        |
| PWMOUT Dimming Duty Cycle                          | $VDIM = 7.7V$<br>$VDIM = 4.0V$<br>$VDIM = 1.5V$<br>$VDIM = 0.4V$           | 96%<br>50%<br>10%<br>4.3%   |
| Internal PWM Dimming Frequency                     | $C16 = 0.047\mu F$ $0V < VDIM < 8V$                                        | 300Hz                       |

## QUICK START PROCEDURE

Demonstration circuit DC2020A is easy to set up to evaluate the performance of the LT3955EUHE. Follow the procedure below:

1. Connect a string of LEDs that will run with forward voltage less than or equal to 67V, but greater than the intended  $PV_{IN}$ , to the  $LED^+$  and  $LED^-$  terminals on the PCB as shown in Figure 1.
2. Connect the EN/UVLO terminal to GND.
3. With power off, connect the input power supply to the  $PV_{IN}$  and GND terminals. Make sure that the  $PV_{IN}$  DC input voltage will not exceed 60V (or  $V_{LED}$ ).
4. Connect the DIM terminal to a voltage between 0V and 8V to set the internal PWMOUT dimming duty cycle. If this terminal is left floating the converter will run with approximately 12% PWMOUT dimming duty cycle. Pull the PWM terminal high to  $INTV_{CC}$  to set the converter at 100% duty cycle.
5. Turn the input power supply on and make sure the voltage is between 6.1V and 60V (or  $V_{LED}$ ) to start.
6. Release the EN/UVLO-to-GND connection.
7. Observe the LED string running at the programmed LED current and brightness related to the programmed PWMOUT duty cycle.
8. To change the brightness with PWM dimming, simply vary the VDIM voltage between 0V and 8V with the PWM terminal floating.
9. To change the brightness with analog dimming, simply attach a voltage source on the CTRL terminal and reduce the voltage below 1.2V.
10. Observe the reduction of brightness in the LED string when PWM or analog dimming.

## QUICK START PROCEDURE

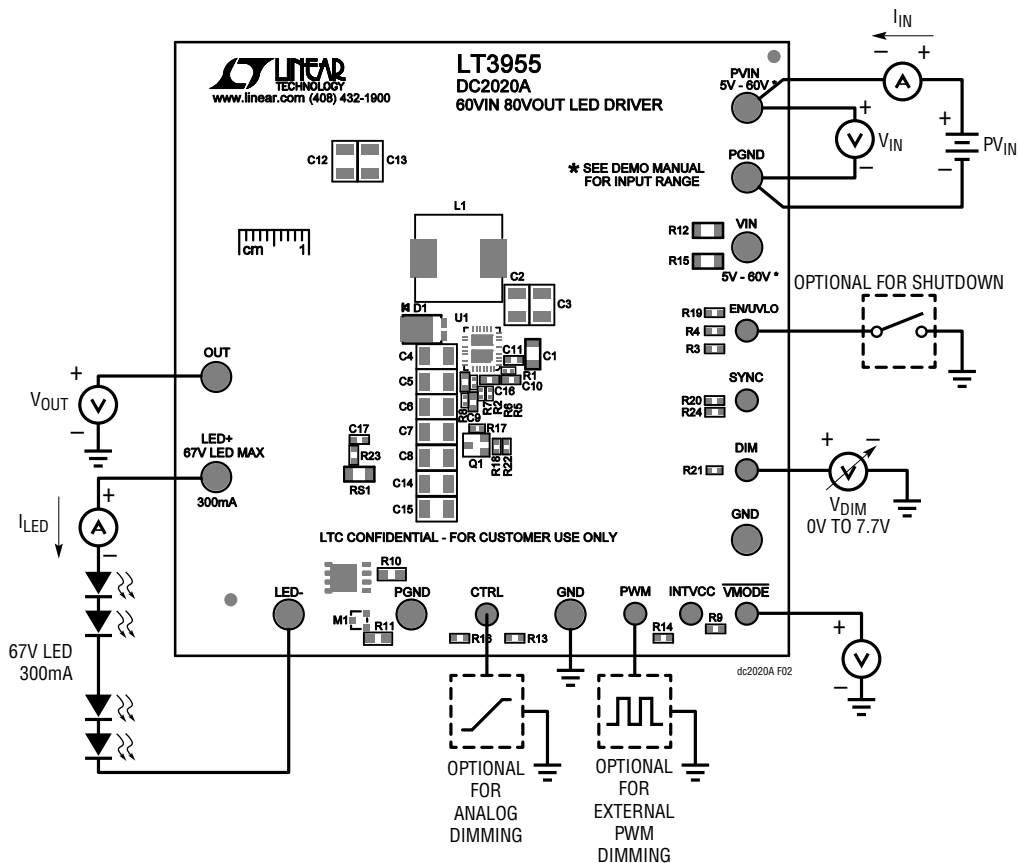


Figure 1. Test Procedure Setup Drawing for DC2020A

QUICK START PROCEDURE

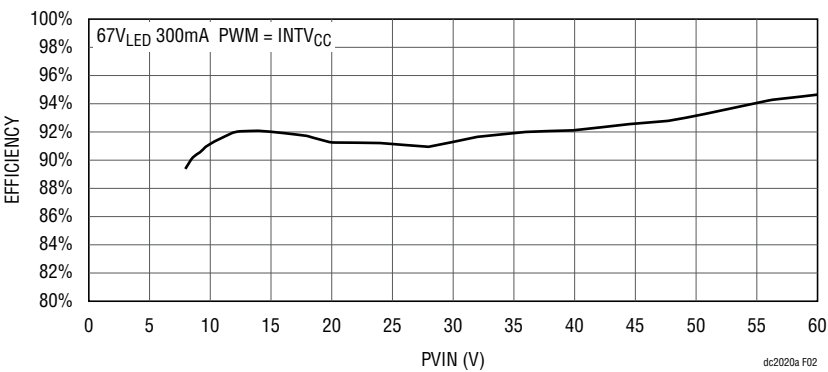


Figure 2. DC2020A Efficiency with 67V LEDs at 300mA and 100% PWMOUT Duty Cycle

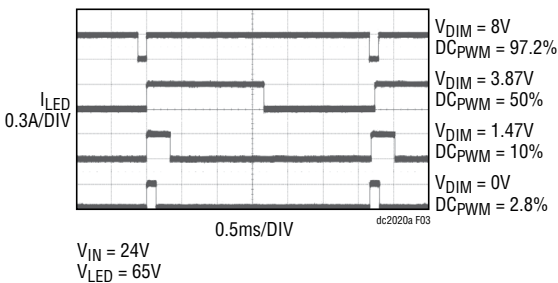


Figure 3. DC2020A 300Hz PWM Dimming Waveforms at Different PWMOUT Duty Cycles

## QUICK START PROCEDURE

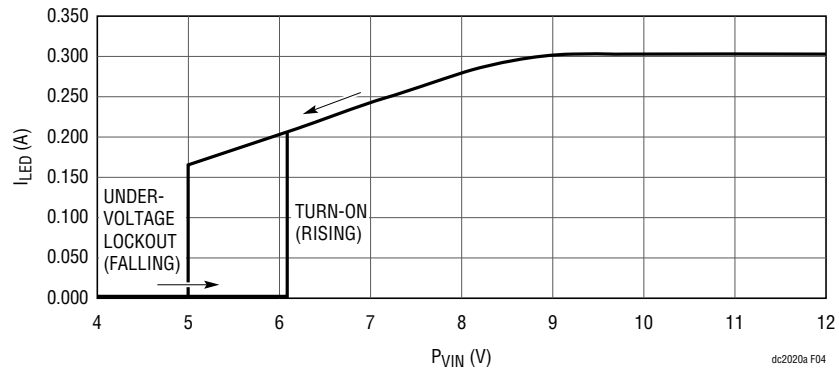
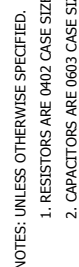


Figure 4. DC2020A CTRL LED Current Foldback at Low  $P_{VIN}$  with UVLO (Falling and Rising)

# DEMO MANUAL DC2020A

## PARTS LIST

| ITEM                                  | QTY | REFERENCE                            | PART DESCRIPTION                               | MANUFACTURER/PART NUMBER         |
|---------------------------------------|-----|--------------------------------------|------------------------------------------------|----------------------------------|
| <b>Required Circuit Components</b>    |     |                                      |                                                |                                  |
| 1                                     | 1   | C1                                   | CAP, 1206, 1 $\mu$ F, 20%, 100V, X7R           | TDK C3216X7R2A105MT              |
| 2                                     | 2   | C2, C3                               | CAP, 1210, 4.7 $\mu$ F, 10%, 100V, X7S         | TDK C3225X7S2A475K               |
| 3                                     | 4   | C4, C5, C6, C7                       | CAP, 1210, 2.2 $\mu$ F, 20%, 100V, X7R         | TDK C3225X7R2A225M               |
| 4                                     | 0   | C8, C14, C15                         | CAP, 1210, 2.2 $\mu$ F, 20%, 100V, X7R, OPTION | TDK C3225X7R2A225M OPTION        |
| 5                                     | 1   | C9                                   | CAP, 0603, 4.7nF, 20%, 25V, X7R                | AVX 06033C472MAT2A               |
| 6                                     | 1   | C10                                  | CAP, 0603, 0.01 $\mu$ F, 10%, 25V, X7R         | AVX 06033C103KAT2A               |
| 7                                     | 1   | C11                                  | CAP, 0603, 1 $\mu$ F, 10%, 10V, X7R            | Taiyo Yuden LMK107BJ105KA        |
| 8                                     | 1   | C16                                  | CAP, 0603, 47nF, 20%, 16V, X7R                 | Taiyo Yuden EMK107BJ473MA        |
| 9                                     | 1   | D1                                   | DIODE, SCHOTTKY                                | DIODES INC. PDS3100-13           |
| 10                                    | 1   | L1                                   | IND, 22 $\mu$ H, 20%                           | COOPER COILTRONICS DR125-220     |
| 11                                    | 1   | M1                                   | MOSFET N-CHANNEL 100V                          | VISHAY SILICONIX Si2328DS        |
| 12                                    | 1   | RS1                                  | RES, 1206, 0.82 $\Omega$ , 1%, 1/4W            | IRC LR1206LF-01-R820FT           |
| 13                                    | 1   | R1                                   | RES, 0402, 28.7k $\Omega$ , 1%, 1/16W          | VISHAY CRCW040228K7FKED          |
| 14                                    | 1   | R2                                   | RES, 0402, 5.1k $\Omega$ , 5%, 1/16W           | VISHAY CRCW04025K10JNED          |
| 15                                    | 1   | R3                                   | RES, 0603, 499k $\Omega$ , 1%, 1/16W           | VISHAY CRCW0603499KFKEA          |
| 16                                    | 1   | R4                                   | RES, 0402, 165k $\Omega$ , 1%, 1/16W           | VISHAY CRCW0402165KFKEA          |
| 17                                    | 1   | R5                                   | RES, 0402, 1M $\Omega$ , 1%, 1/16W             | VISHAY CRCW04021M00FKED          |
| 18                                    | 1   | R6                                   | RES, 0603, 147k $\Omega$ , 1%, 1/16W           | VISHAY CRCW0603147KFKEA          |
| 19                                    | 1   | R7                                   | RES, 0603, 1M $\Omega$ , 1%, 1/16W             | VISHAY CRCW06031M00FKEA          |
| 20                                    | 1   | R8                                   | RES, 0402, 16.9k $\Omega$ , 1%, 1/16W          | VISHAY CRCW040216K9FKED          |
| 21                                    | 1   | R9                                   | RES, 0603, 100k $\Omega$ , 5%, 1/16W           | VISHAY CRCW0603100KJNED          |
| 22                                    | 1   | R21                                  | RES, 0402 124k $\Omega$ , 1% 1/16W             | VISHAY CRCW0402124KFKEA          |
| 23                                    | 1   | U1                                   | IC, 60VIN/80VOUT LED DRIVER                    | LINEAR TECH. LT3955EUHE          |
| <b>Optional Electrical Components</b> |     |                                      |                                                |                                  |
| 1                                     | 0   | C12, C13                             | CAP, 1210 OPTION                               | OPTION                           |
| 2                                     | 0   | C17                                  | CAP., 0603 OPTION                              |                                  |
| 3                                     | 0   | Q1                                   | XSTR, OPTION                                   | OPTION                           |
| 4                                     | 0   | R10                                  | RES, 0805, OPTION                              | OPTION                           |
| 5                                     | 1   | R11                                  | RES, 0805, 0 $\Omega$ , JUMPER                 | VISHAY CRCW08050000Z0EA          |
| 6                                     | 1   | R12                                  | RES, 1206, 0 $\Omega$ , JUMPER                 | VISHAY CRCW1206000Z              |
| 7                                     | 0   | R13, R14, R16, R19, R20, R23         | RES, 0603 OPTION                               | OPTION                           |
| 8                                     | 0   | R15                                  | RES, 1206 OPTION                               | OPTION                           |
| 9                                     | 0   | R17, R18, R22                        | RES, 0402 OPTION                               | OPTION                           |
| 10                                    | 1   | R24                                  | RES, 0603, 0 $\Omega$ JUMPER                   | VISHAY CRCW06030000Z0EA          |
| <b>Optional Hardware</b>              |     |                                      |                                                |                                  |
| 1                                     | 9   | E1, E2, E3, E4, E5, E7, E8, E12, E13 | TURRET                                         | MILL MAX 2501-2-00-80-00-00-07-0 |
| 2                                     | 7   | E6, E9, E10, E11, E14, E15, E16      | TURRET                                         | MILL MAX 2308-2-00-80-00-00-07-0 |



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