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Ultra-Low Profile Backlight Driver Circuit Design



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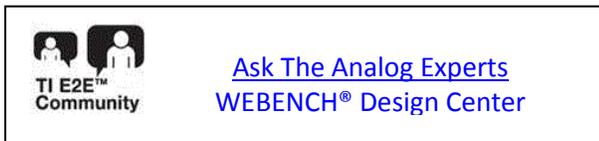
Design Resources

[TIDA-00878](#)

Design Folder

[TPS61163A](#)

Product Folder



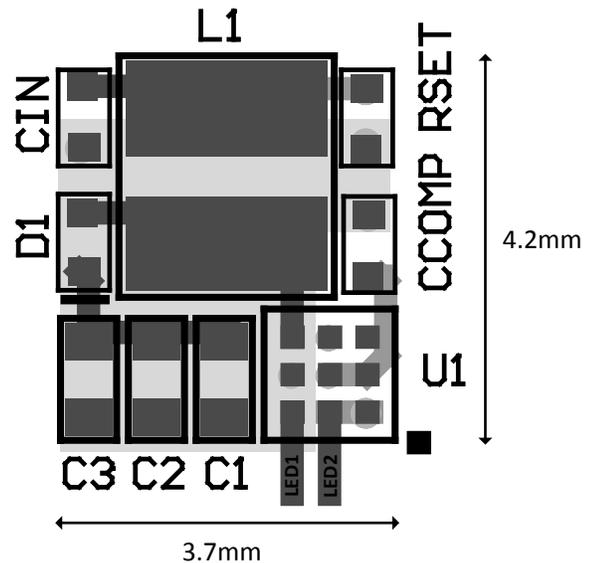
Design Features

- White LED Driver
- Displays up to 16 LEDs (2P8S)
- Total Circuit Height < 0.7mm (max)

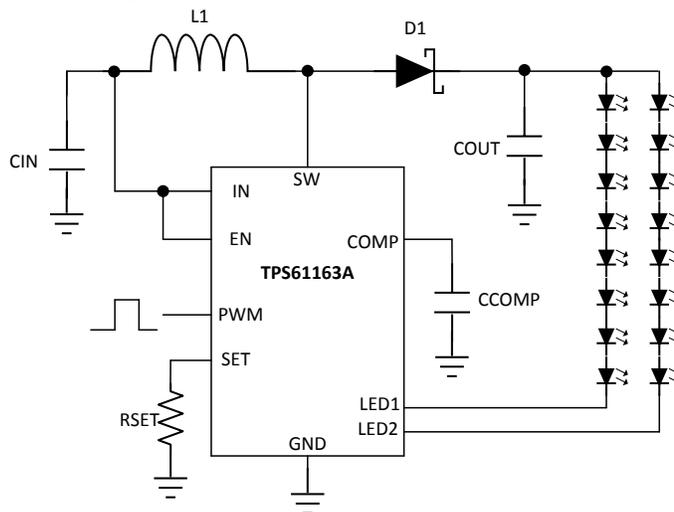
Featured Applications

- Ultra-Thin Handset/Tablets
- Wearable Devices

PCB Layout



Block Diagram



1 Introduction

Inductive power sources for driving white LEDs for LCD backlights in mobile handsets must consume very little space, be efficient, and must be no thicker than a predetermined height. Usually there can be compromises on efficiency and PCB area, but the height restriction is a hard requirement since this is dictated by the overall thickness of the handset.

Achieving good efficiency and finding usable components for these applications can be difficult since typical height restrictions are <1mm while the power requirements can be up 1W. This forces almost unrealistic constraints on a typical capacitor and inductor choices.

The objective of this reference design is to demonstrate an inductive boost white LED driver which can drive up to 2 strings of 8 LEDs (16 LEDs total) at 20mA per LED, while maintaining an overall component height of < 0.7mm (max). Data is presented for optimum circuit configuration in the 2x4, 2x5, 2x6, 2x7, and 2x8 LED configurations.

2 Key System Specifications

| Parameter | Specification and Feature | |
|---|---------------------------|---|
| Max String Current | 20mA | |
| Maximum VOUT | 28V | |
| Maximum Component Height | 0.6mm | |
| Operating Temperature Range | -40C to 85C | |
| PWM Dimming Frequency Range | 5kHz to 50kHz | |
| Dimming Duty Cycle Range | 0.5% to 100% | |
| Boost Switching Frequency | 1.2MHz | |
| Boost Efficiency (2x8 LEDs, VIN = 3.7V, TA = 25C) | 5mA/string | L = 4.7µH (81%) L = 10µH (Saturation) |
| | 20mA/string | L = 4.7µH (81.8%) L = 10µH (Saturation) |
| Boost Efficiency (2x7 LEDs, VIN = 3.7V, TA = 25C) | 5mA/string | L = 4.7µH (82%) L = 10µH (82.7%) |
| | 20mA/string | L = 4.7µH (82.6%) L = 10µH (81.2%) |
| Boost Efficiency (2x6 LEDs, VIN = 3.7V, TA = 25C) | 5mA/string | L = 4.7µH (83%) L = 10µH (83.5%) |
| | 20mA/string | L = 4.7µH (83.2%) L = 10µH (83.3%) |
| Boost Efficiency (2x5 LEDs, VIN = 3.7V, TA = 25C) | 5mA/string | L = 4.7µH (83.6%) L = 10µH (84.6%) |
| | 20mA/string | L = 4.7µH (84.3%) L = 10µH (84.9%) |
| Boost Efficiency (2x4 LEDs, VIN = 3.7V, TA = 25C) | 5mA/string | L = 4.7µH (Not Taken, 10uH is best) L = 10µH (85%) |
| | 20mA/string | L = 4.7µH (Not Taken, 10uH is best) L = 10µH (86.2%) |

3 System Description

3.1 TI Device 1

The main component in the design is the TPS61163A. This is a dual string inductive boost white LED driver with a 2.7V to 6.5V input voltage range, a 30mA max current per string, and an output which can range from VIN to 37.5V. The device operates with typical inductors in the 4.7uH to 22uH range and requires a typical 1uF output capacitor. Dimming is achieved by applying a logic level PWM signal into the PWM input with a frequency range of 5kHz to 50kHz.

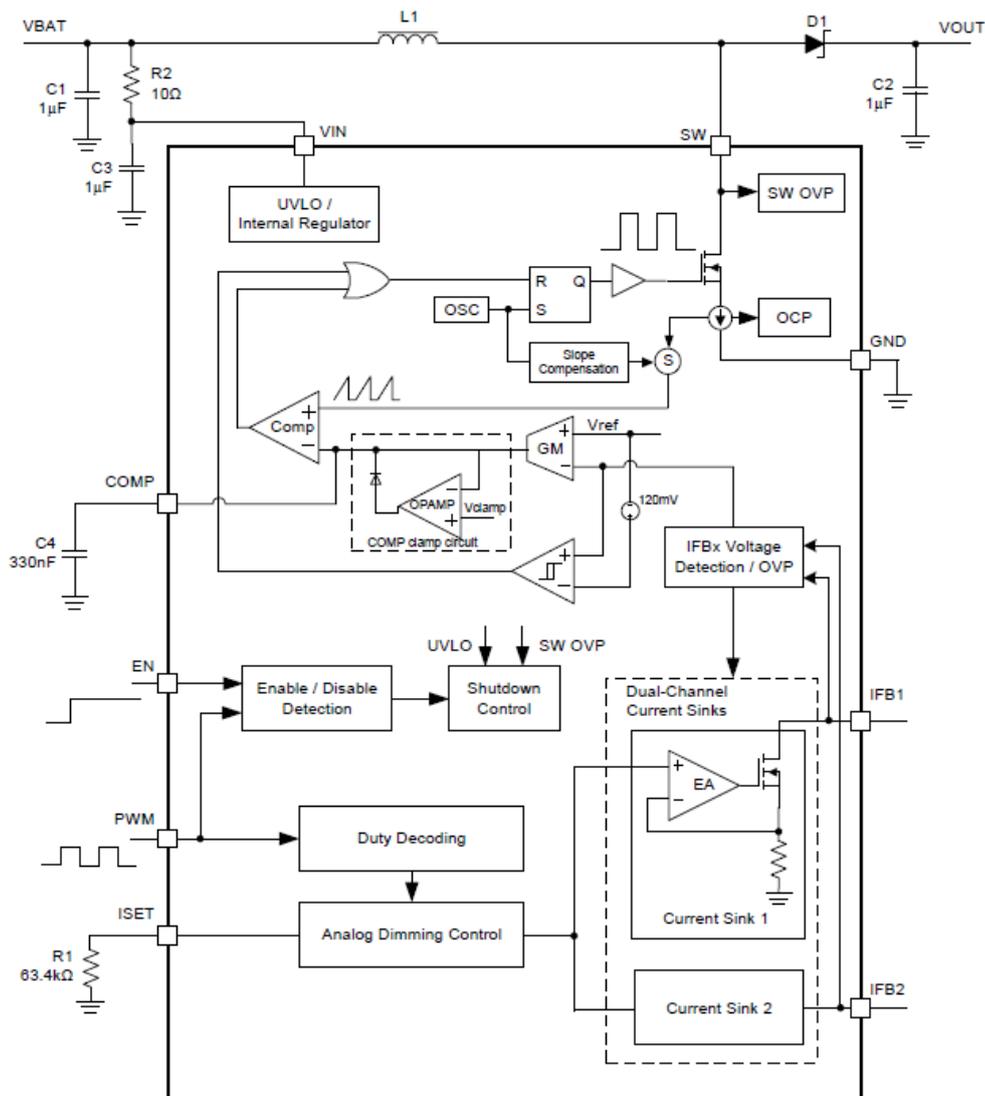


Figure 1: TPS61163A block diagram

The design of the Ultra-Low Profile circuit is all about component selection. This consists of the inductor, the output capacitor, and the Schottky diode.

Inductor Selection

The inductor selected is the XFL2006 from Coilcraft. The following options are possible selections:

Table 1. XFL2006 Inductors

| Part Number | Inductance (Nominal) | DC Resistance | IDC_MAX (20% drop from nominal) | IRMS_MAX (40°C temp rise) |
|---------------|----------------------|----------------|---------------------------------|---------------------------|
| XFL2006-472ME | 4.7 μ H | 0.665 Ω | 520mA | 660mA |
| XFL2006-103ME | 10 μ H | 1.27 Ω | 310mA | 440mA |

The 2 main concerns with inductor selection are the DC resistance (for efficiency) and the inductor saturation rating (for inductor current capability). The DC resistance will be what it is since these inductors are not chosen for their low DCR, but for their low height. The inductor saturation rating on the other hand will determine the inductor selected for the configuration (4.7uH or 10uH) and will dictate the maximum output power from the boost.

Maximum Inductor Current

The XFL2006 inductors have a gradual saturation vs current so the limiting parameter is the RMS inductor current instead of the peak inductor current. Determining the maximum RMS inductor current required by the configuration is dependent on the following:

1. Minimum VIN
2. Maximum VOUT
3. Maximum Output Current
4. Circuit Efficiency
5. Minimum Inductance
6. Minimum Switching Frequency

Generally at the maximum RMS current the circuit will be operating in continuous conduction mode (CCM). However, for higher minimum input voltages, discontinuous conduction mode operation is possible so the equations for both are given in (1) and (3) below.

For continuous conduction mode

$$I_{L_RMS_CCM} = \sqrt{\left(\frac{I_{OUT}}{1-D}\right)^2 + \frac{\left(\frac{V_{IN} \times D}{f_{sw} \times L}\right)^2}{12}} \quad (1)$$

$$I_{L_AVE_CCM} = \left(\frac{I_{OUT}}{1-D}\right) = \left(\frac{I_{OUT} \times V_{OUT}}{V_{IN} \times efficiency}\right) \quad (2)$$

$$\text{Where } D = \frac{V_{OUT} - V_{IN} \times efficiency}{V_{OUT}}$$

For discontinuous conduction mode

$$I_{L_RMS_DCM} = \frac{V_{IN} \times D}{f_{sw} \times L} \times \sqrt{\frac{(D+D_0)}{3}} \quad (3)$$

$$I_{L_AVE_DCM} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times efficiency} \quad (4)$$

$$\text{Where } D = \sqrt{\left(\frac{V_{OUT} \times I_{OUT}}{V_{IN} \times efficiency} - I_{OUT} \times 2\right) \times \frac{f_{sw} \times L}{V_{IN}}}$$

$$\text{And } D_0 = \frac{I_{OUT} \times 2 \times f_{sw} \times L}{V_{IN} \times D}$$

Table 1 list the summary of operating conditions for the different configurations (2P4S, 2P5S, 2P6S, 2P7S, and 2P8S). The green font indicates sufficient margin between the maximum operating capabilities of the inductor and the TPS61163A. The orange font indicates the operation is within typical limits allowed for either the inductor or the TPS61163A, but can be outside the limits at extremes of process, voltage, or temperature. The red font indicates the operation is outside the range of the TPS61163A or the inductor. These indications are only for the conditions listed in the table. The one line item that is in red font is possible with a more restricted input voltage range.

Table 2. Summary Table for Inductor Operating Current

| Circuit Operating Conditions | | | | | | | Inductor Limitations | | | | | |
|------------------------------|----------------|--------|---------|-------|------------|------------------|----------------------|-----------------------------|---|-------------------------------------|-----------------|-----------------|
| Config | T _A | VOUT | IOUT | VIN | Efficiency | Boost Duty Cycle | L (-20% from nom) | IL_AVE (equation #2, or #4) | IL_RMS (assuming -20% drop in L, from equation #1, or #3) | ISAT(20% drop in L) (based on IAVE) | IRMS (20C rise) | IRMS (40C rise) |
| 2P5S | 25 | 16.03V | 39.61mA | 2.8V | 81.8% | 0.86 | 3.76uH | 277mA | 317mA | 440mA | 500mA | 660mA |
| 2P6S | 25 | 19.08V | 39.66mA | 2.8V | 80% | 0.88 | 3.76uH | 338mA | 373mA | 440mA | 500mA | 660mA |
| 2P7S | 25 | 22.15V | 39.67mA | 2.8V | 77.7% | 0.9 | 3.76uH | 404mA | 435mA | 440mA | 500mA | 660mA |
| 2P8S | 25 | 25.24V | 39.64mA | 2.8V | 74.4% | 0.92 | 3.76uH | 480mA | 507mA | 440mA | 500mA | 660mA |
| 2P5S | 85 | 15.26V | 39.6mA | 2.8V | 79.9% | 0.85 | 3.76uH | 270mA | 310mA | 440mA | 500mA | 660mA |
| 2P6S | 85 | 18.2V | 39.64mA | 2.8V | 77.3% | 0.88 | 3.76uH | 333mA | 369mA | 440mA | 500mA | 660mA |
| 2P7S | 85 | 21.14V | 39.63mA | 2.8V | 73.7% | 0.9 | 3.76uH | 405mA | 436mA | 440mA | 500mA | 660mA |
| 2P8S | 85 | 24.11V | 39.64mA | 2.8V | 67.3% | 0.92 | 3.76uH | 507mA | 533mA | 440mA | 500mA | 660mA |
| 2P8S | 85 | 24.11V | 39.63mA | 3V | 73.1% | 0.91 | 3.76uH | 435mA | 469mA | 440mA | 500mA | 660mA |
| 2P8S | 85 | 24.12V | 39.68mA | 3.3V | 76.9% | 0.89 | 3.76uH | 377mA | 421mA | 440mA | 500mA | 660mA |
| | | | | | | | | | | | | |
| 2P4S | 25 | 12.84V | 39.6mA | 2.8V | 81.4% | 0.82 | 8uH | 223mA | 234mA | 310mA | 345mA | 440mA |
| 2P5S | 25 | 15.94V | 39.61mA | 2.79V | 77.5% | 0.86 | 8uH | 292mA | 300mA | 310mA | 345mA | 440mA |
| 2P6S | 25 | 19V | 39.66mA | 2.79V | 71.6% | 0.89 | 8uH | 377mA | 385mA | 310mA | 345mA | 440mA |
| 2P7S | 25 | 22.05V | 39.67mA | 3V | 70.5% | 0.9 | 8uH | 414mA | 422mA | 310mA | 345mA | 440mA |
| 2P4S | 85 | 12.3V | 39.6mA | 2.79V | 78.9% | 0.82 | 8uH | 221mA | 231mA | 310mA | 345mA | 440mA |
| 2P5S | 85 | 15.25V | 39.61mA | 2.8V | 73.6% | 0.87 | 8uH | 294mA | 303mA | 310mA | 345mA | 440mA |
| 2P6S | 85 | 18.2V | 39.62mA | 2.78V | 70.5% | 0.89 | 8uH | 407mA | 414mA | 310mA | 345mA | 440mA |

Measured Efficiency (L = 4.7μH)

The following plots (Figures 2 through 9) show the measured (Boost) efficiency vs Duty cycle (or LED Current) and VIN for the 4.7μH configuration. Boost Efficiency is the total output power POUT divided by the input power. $V_{OUT} \times I_{OUT} / (V_{IN} \times I_{IN})$

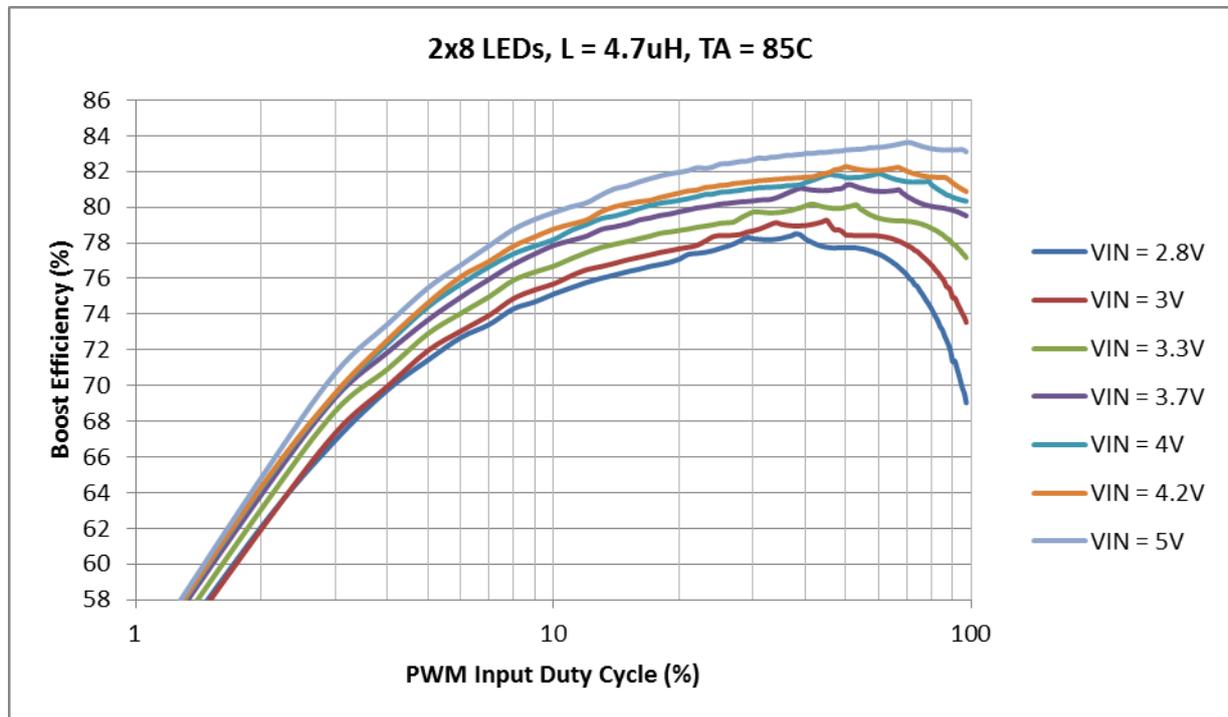


Figure 2. Boost Efficiency (2x8 LEDs), L = 4.7μH, TA = 85C

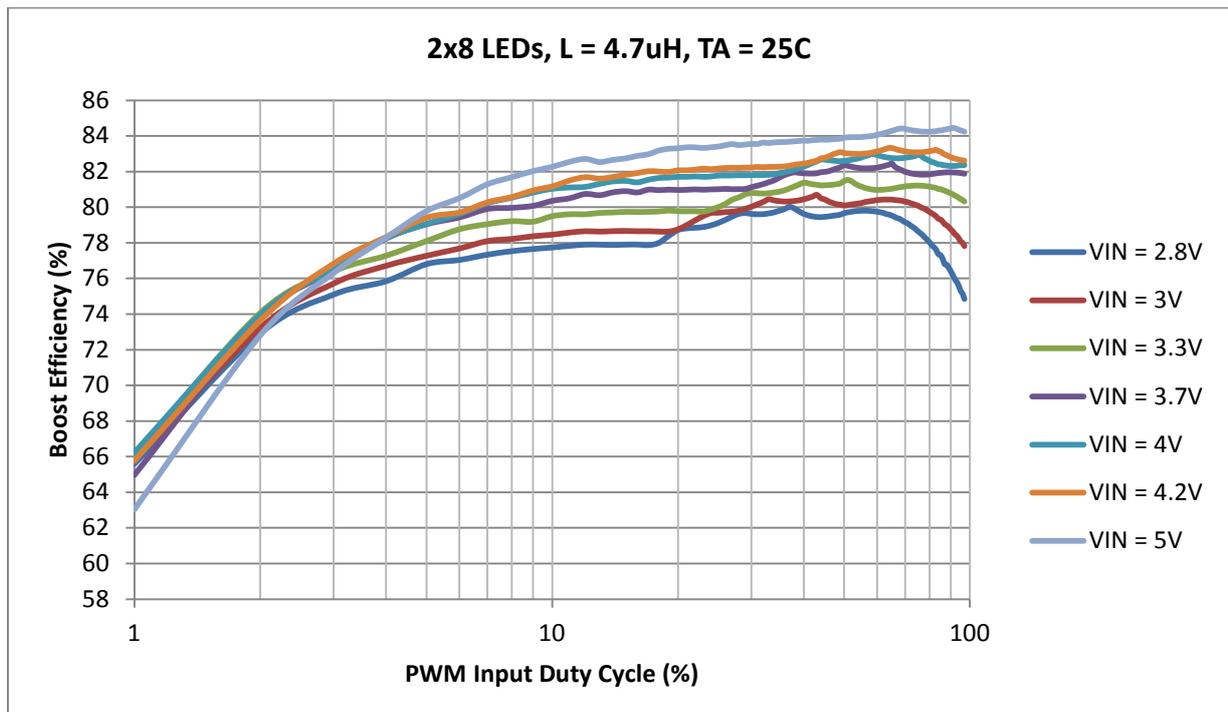


Figure 3. Boost Efficiency (2x8 LEDs), L = 4.7μH, TA = 25C

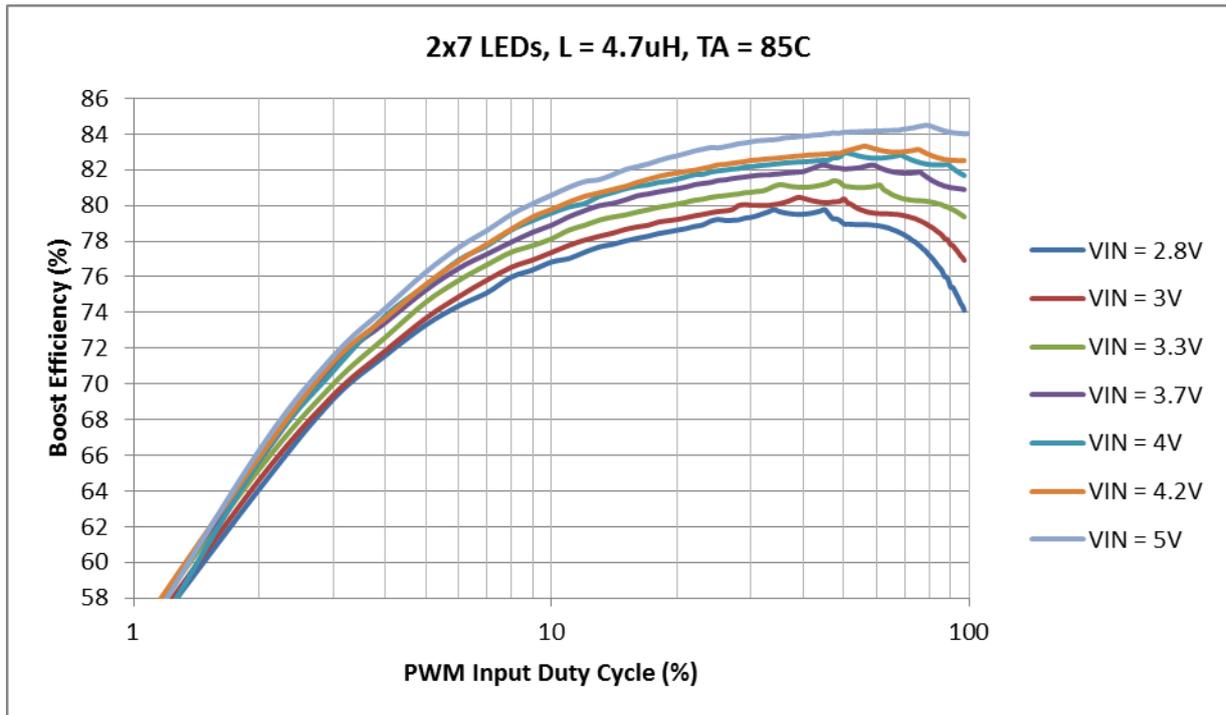


Figure 4. Boost Efficiency (2x7 LEDs), L = 4.7 μ H, TA = 85C

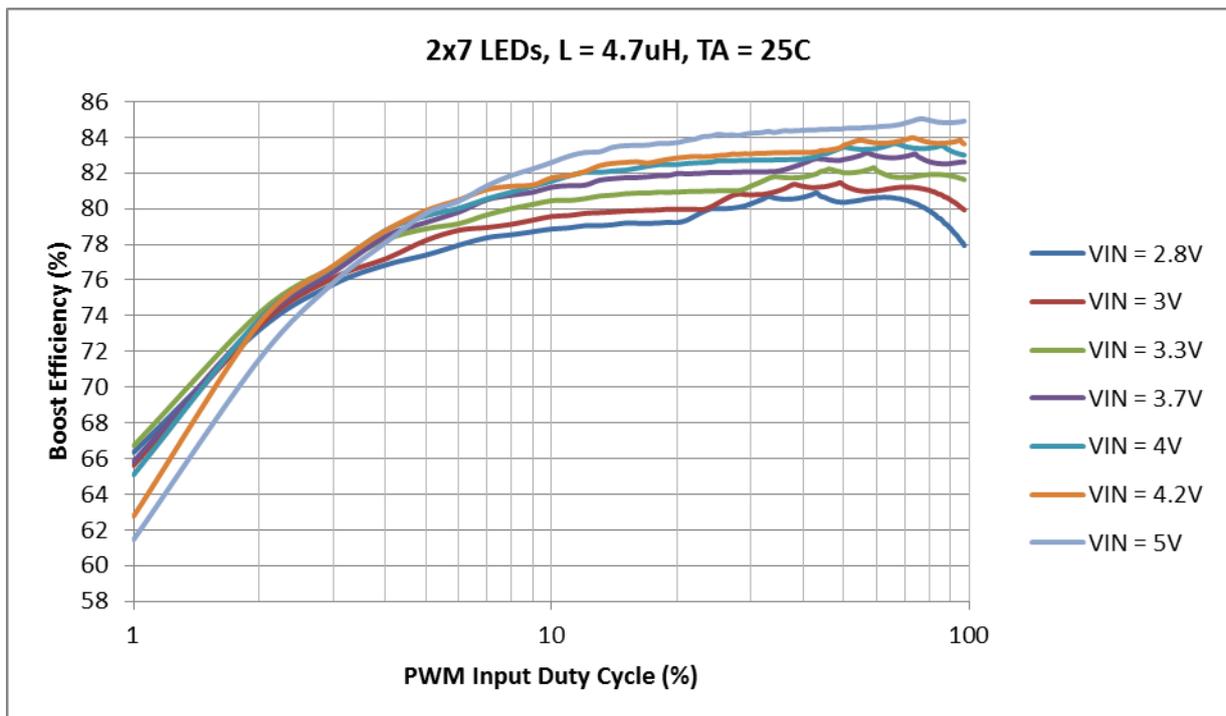


Figure 5. Boost Efficiency (2x7 LEDs), L = 4.7 μ H, TA = 25C

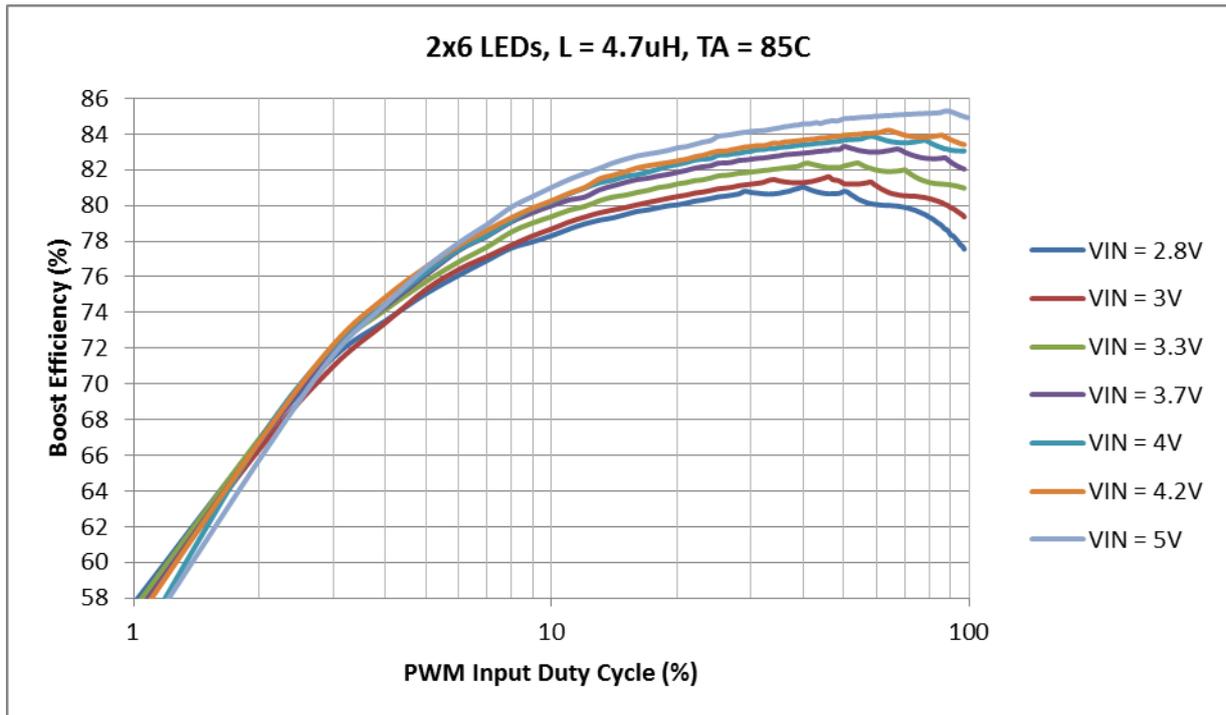


Figure 6. Boost Efficiency (2x6 LEDs), L = 4.7 μ H, TA = 85C

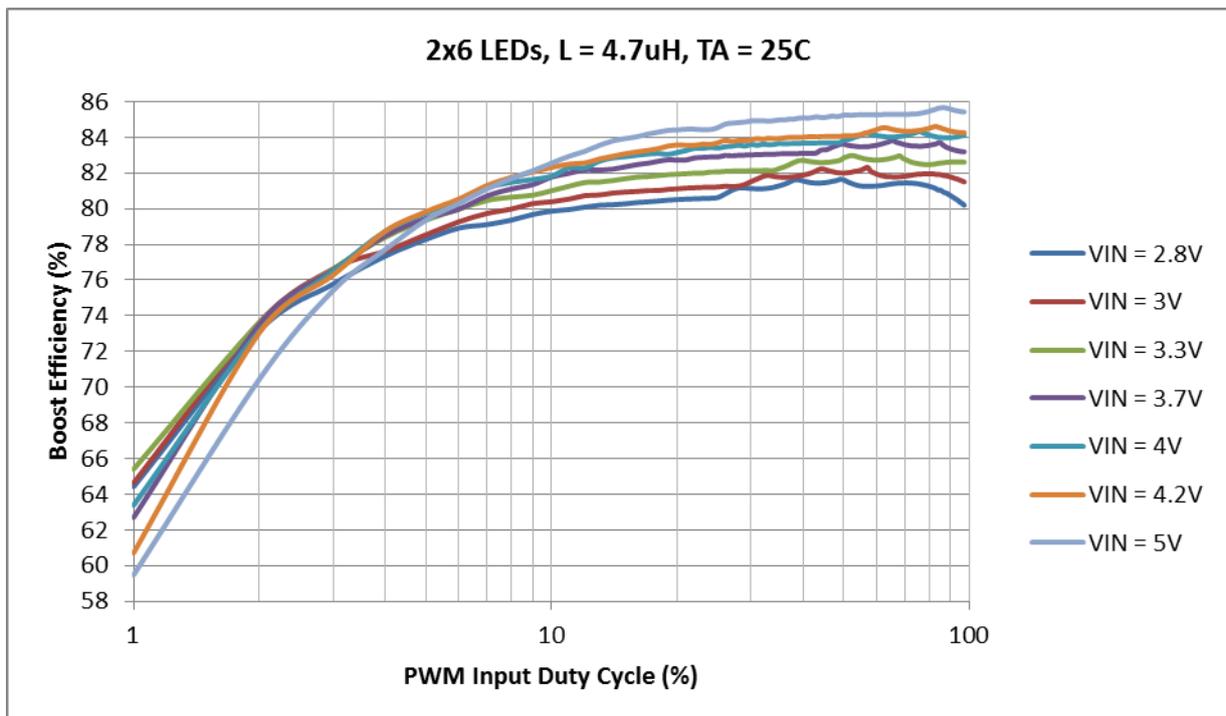


Figure 7. Boost Efficiency (2x6 LEDs), L = 4.7 μ H, TA = 25C

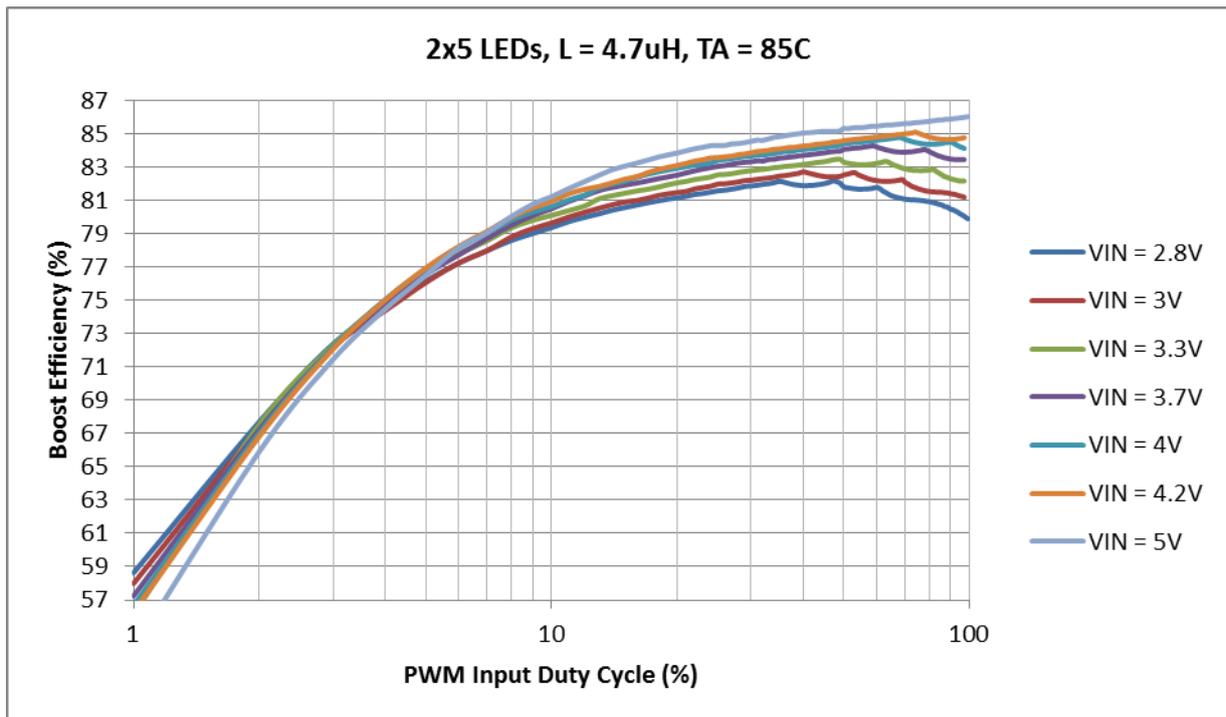


Figure 8. Boost Efficiency (2x5 LEDs), L = 4.7 μ H, TA = 85C

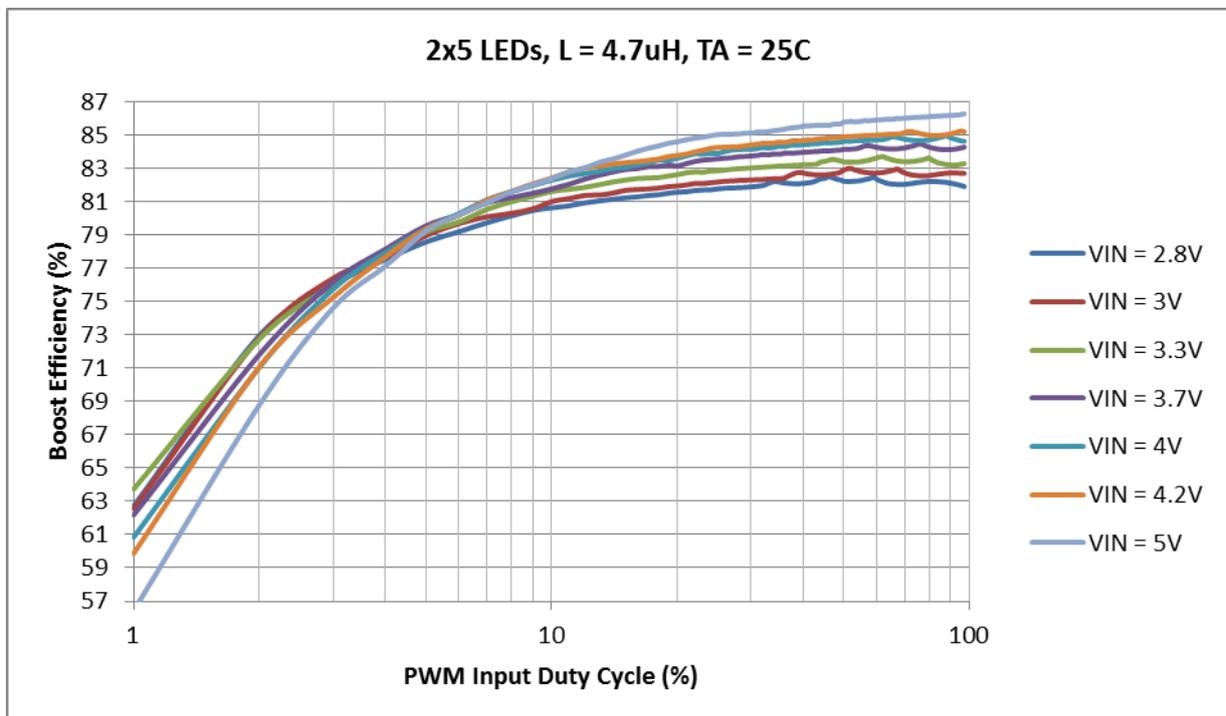


Figure 9. Boost Efficiency (2x5 LEDs), L = 4.7 μ H, TA = 25C

Inductor Current Ripple (4.7μH)

The inductor current ripple with the 4.7μH inductor is shown in Figures 10 and 11. This is with the maximum output power configuration (2x8), and at full load (40mA total output current). This shows that the nominal value of inductance is only slightly changing with the increased ambient temperature (around a 6% drop).

$$L(\text{equivalent}) = V \times \Delta t / \Delta I = 2.8V \times 776\text{ns} / 420\text{mA} = 5.17\mu\text{H}$$

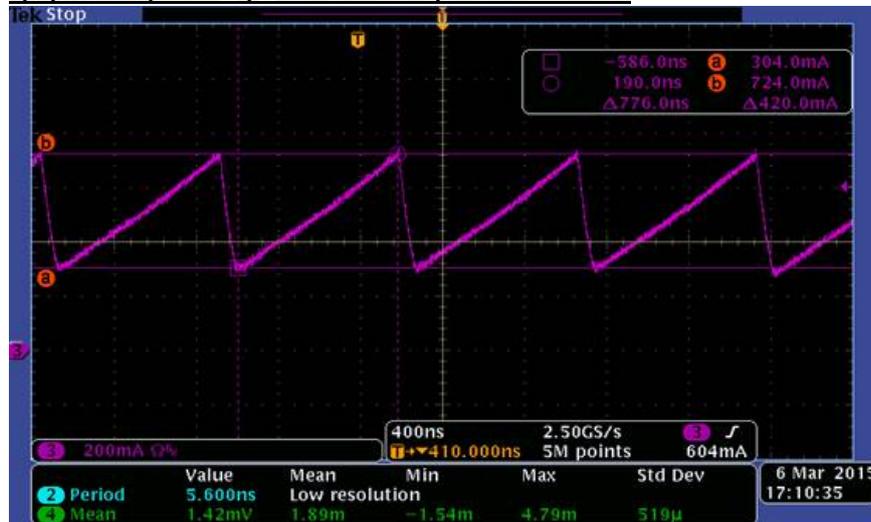


Figure 10. Inductor Current Ripple (2x8 LEDs), L = 4.7μH, TA = 85C, IOU = 40mA

$$L = V \times \Delta t / \Delta I = 2.8V \times 768\text{ns} / 392\text{mA} = 5.49\mu\text{H}$$



Figure 11. Inductor Current Ripple (2x8 LEDs), L = 4.7μH, TA = 25C, IOU = 40mA

Measured Efficiency (L = 10μH)

The following plots (Figures 12 through 17) show the measured (Boost) efficiency vs Duty cycle (or LED Current) and VIN for the 10μH configuration. Boost Efficiency is the total output power POUT divided by the input power. $V_{OUT} \times I_{OUT} / (V_{IN} \times I_{IN})$

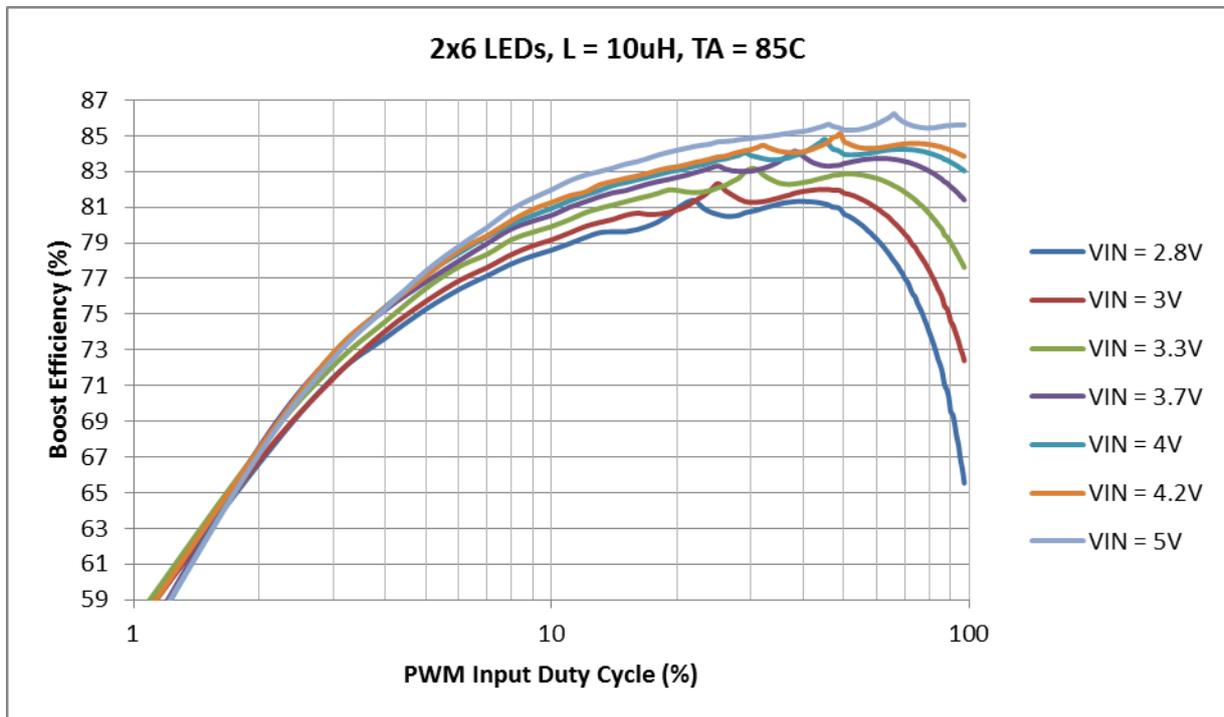


Figure 12. Boost Efficiency (2x6 LEDs), L = 10μH, TA = 85C

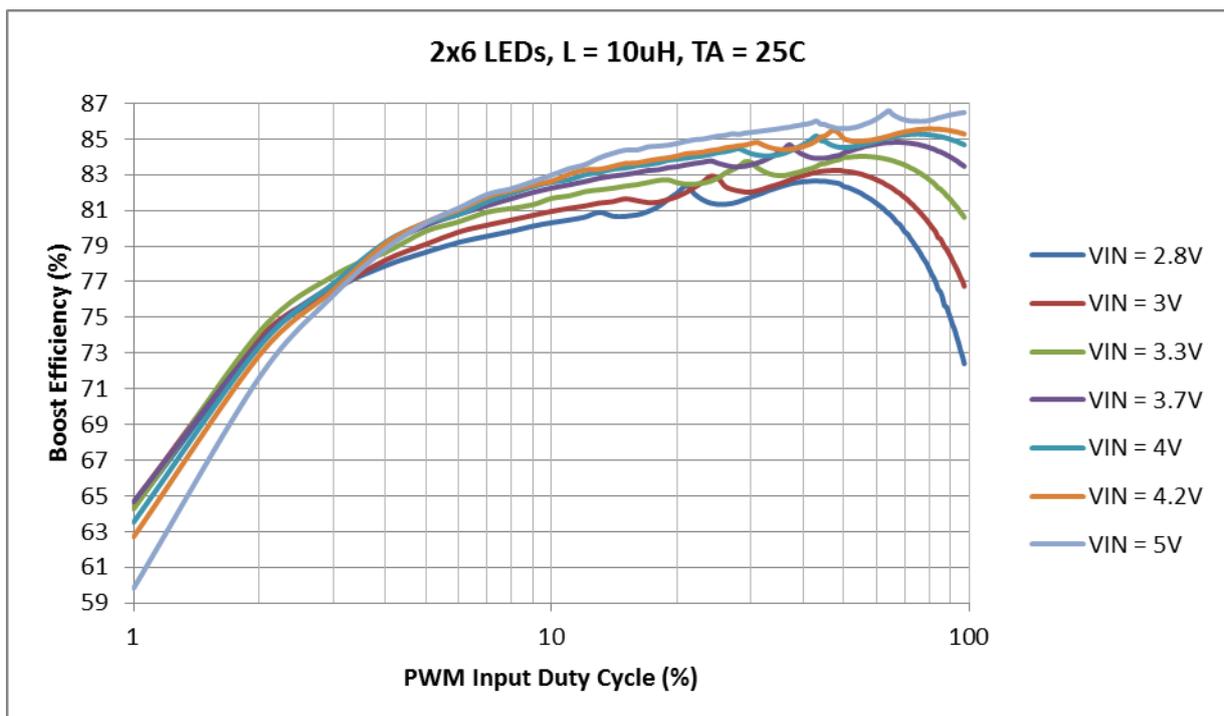


Figure 13. Boost Efficiency (2x6 LEDs), L = 10μH, TA = 25C

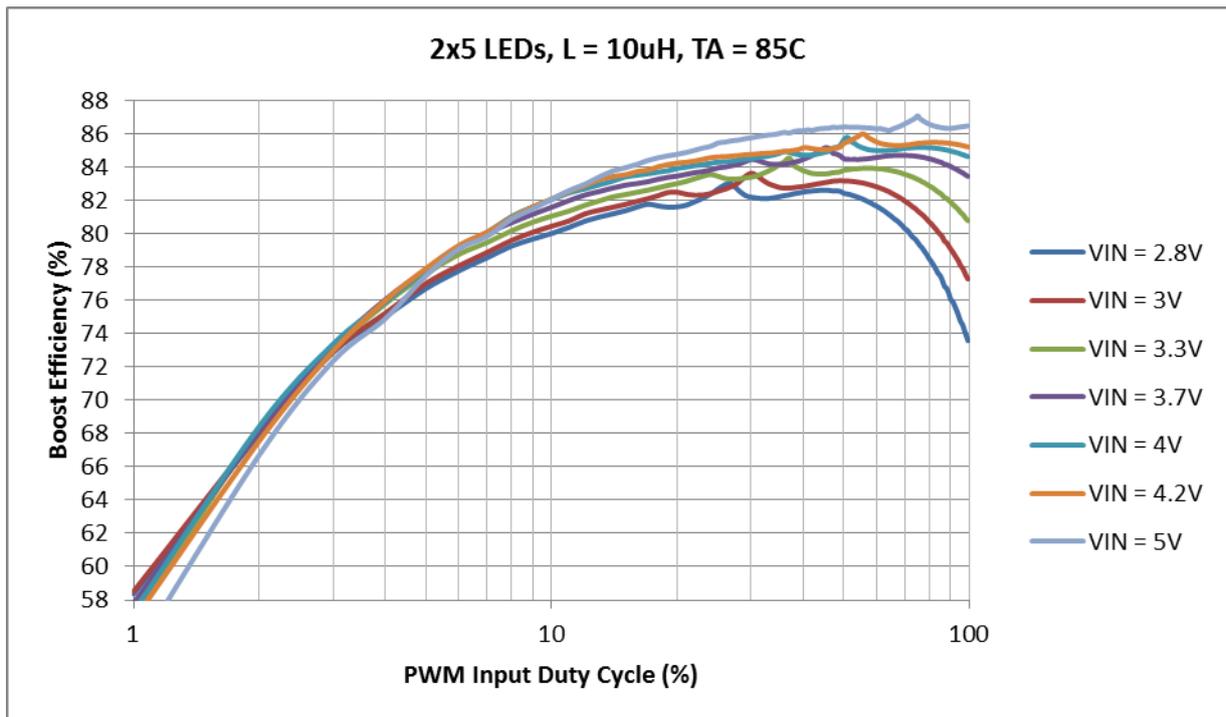


Figure 14. Boost Efficiency (2x5 LEDs), L = 10 μ H, TA = 85C

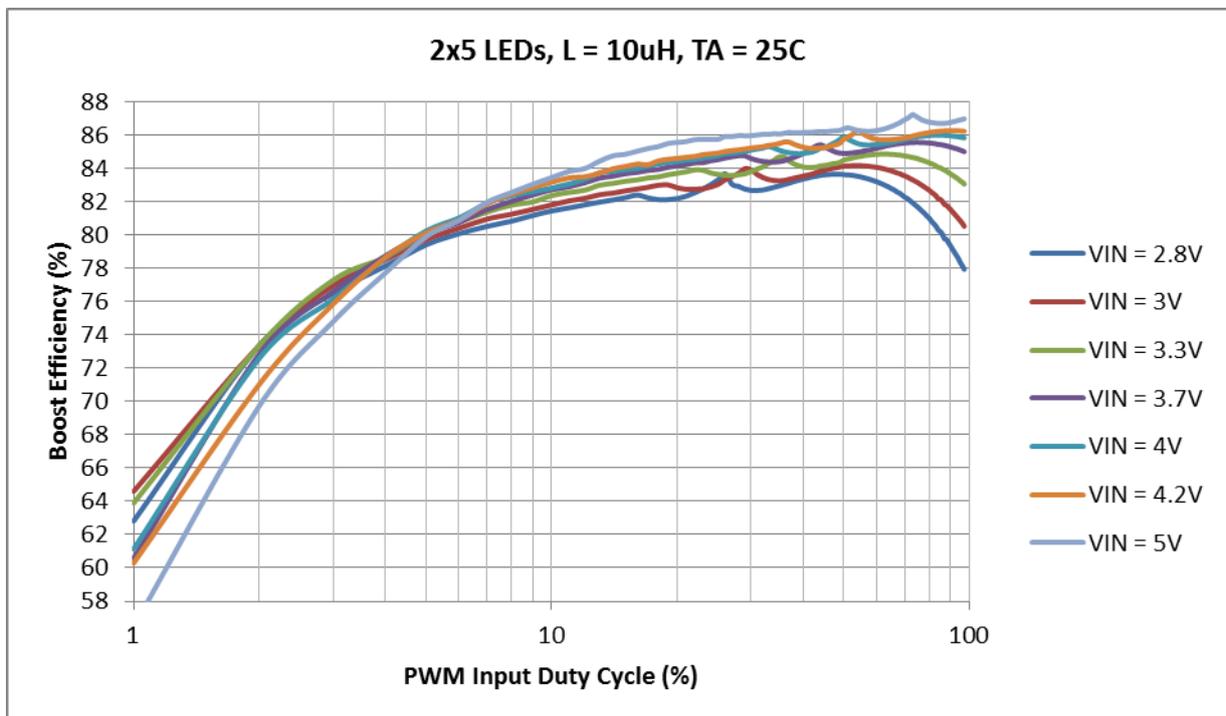


Figure 15. Boost Efficiency (2x5 LEDs), L = 10 μ H, TA = 25C

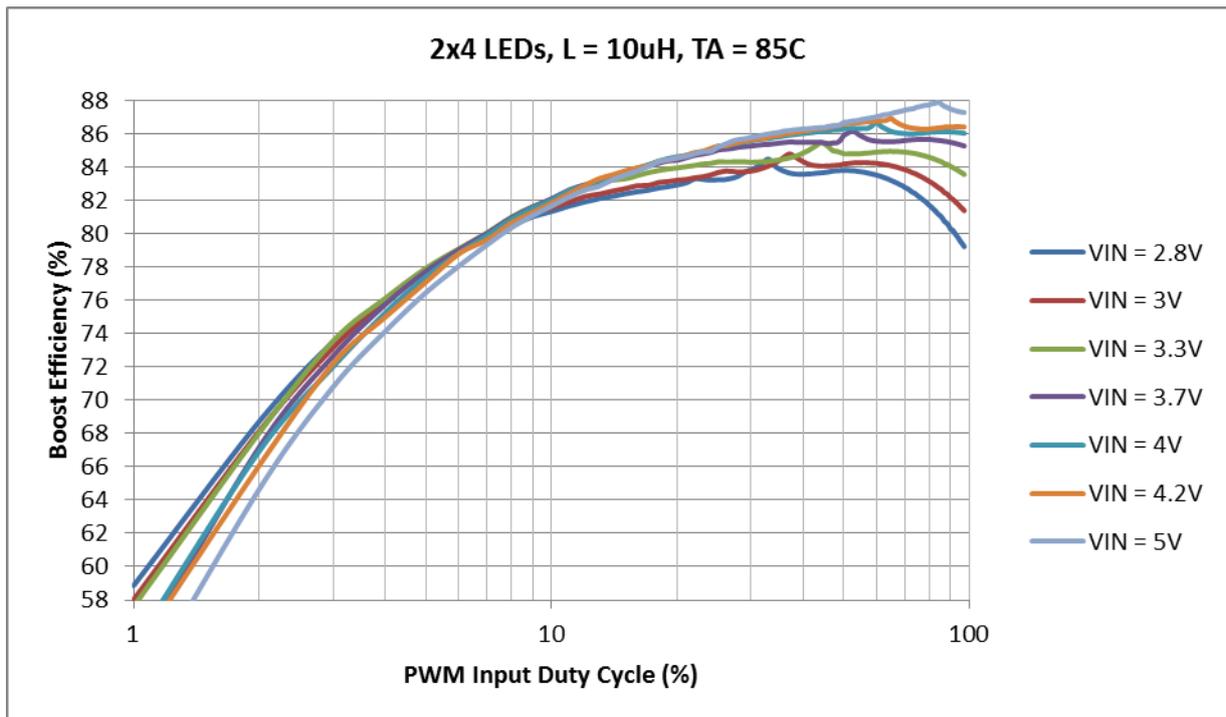


Figure 16. Boost Efficiency (2x4 LEDs), L = 10 μ H, TA = 85C

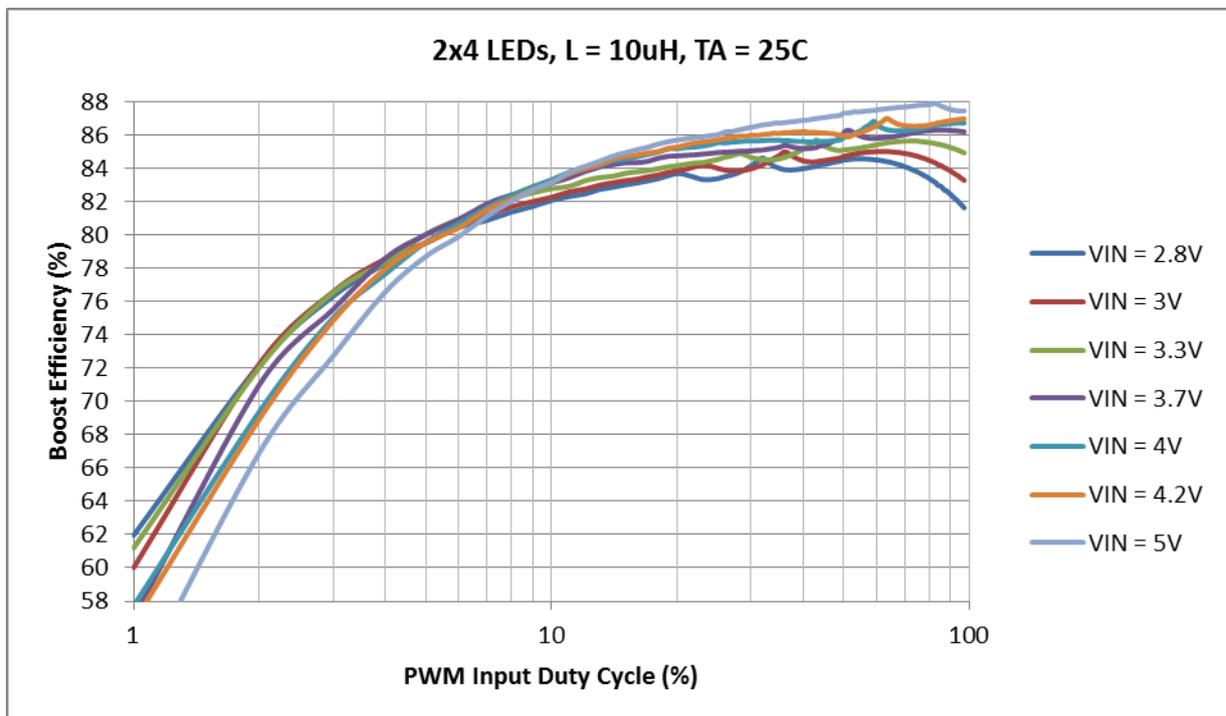


Figure 17. Boost Efficiency (2x4 LEDs), L = 10 μ H, TA = 25C

Inductor Current Ripple (10μH)

The inductor current ripple for the 10μH is shown in Figures 18 and 19. This is with the maximum output power configuration (2x6), and at full load (40mA total output current). The plots show the operating inductance at 25C and 85C. This shows that the nominal value of inductance is changing with the increased ambient temperature (around a 14% drop).

$$L = V \times \Delta t / \Delta I = 2.8V \times 768ns / 256mA = 8.4\mu H$$

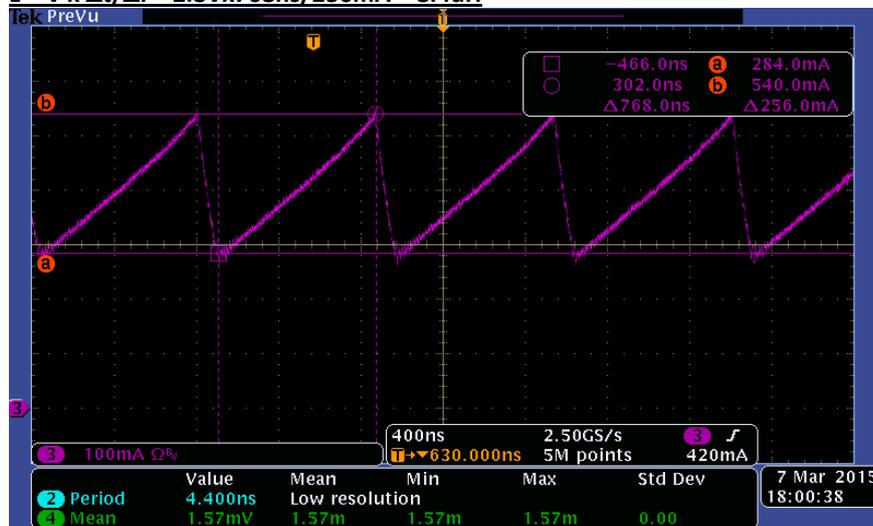


Figure 18. Inductor Current Ripple (2x6 LEDs), L = 10μH, TA = 85C, IOU_T = 40mA

$$L = V \times \Delta t / \Delta I = 2.8V \times 736ns / 212mA = 9.72\mu H$$

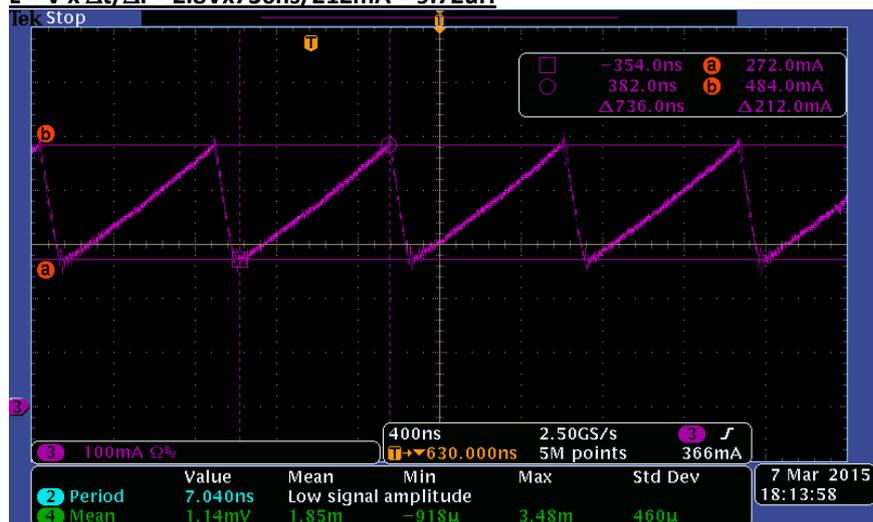


Figure 19. Inductor Current Ripple (2x6 LEDs), L = 10μH, TA = 25C, IOU_T = 40mA

Boost Output Voltage

The operating boost output voltage for the different configurations is shown in the following figures.

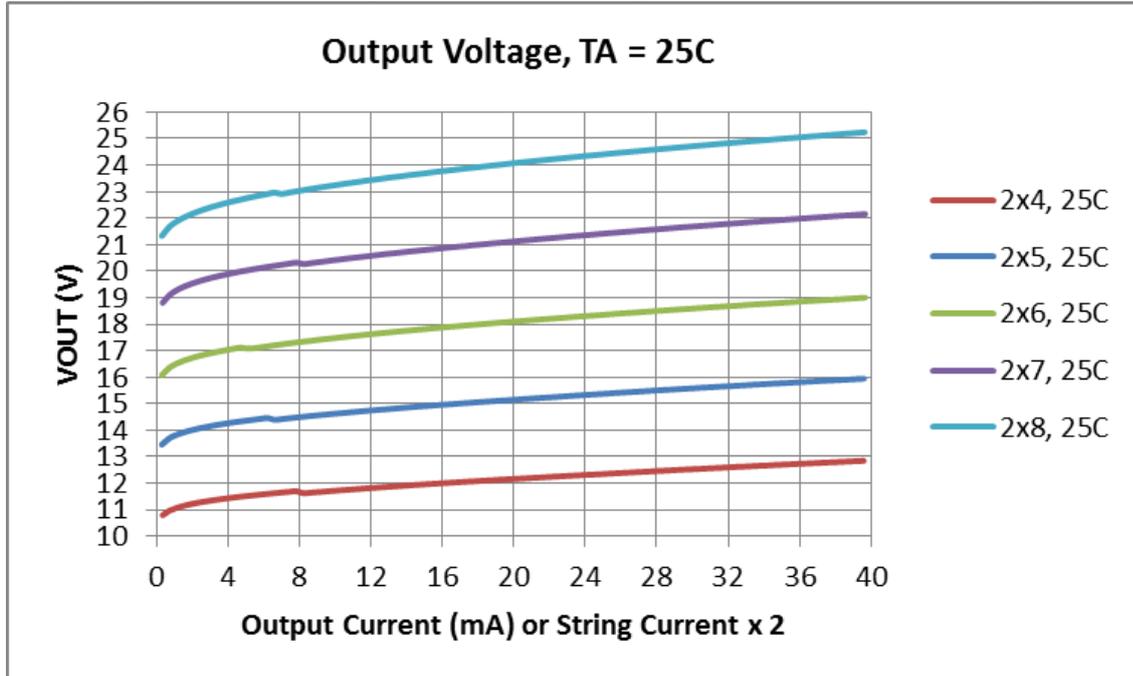


Figure 20. Boost Output Voltage (TA = 25C)

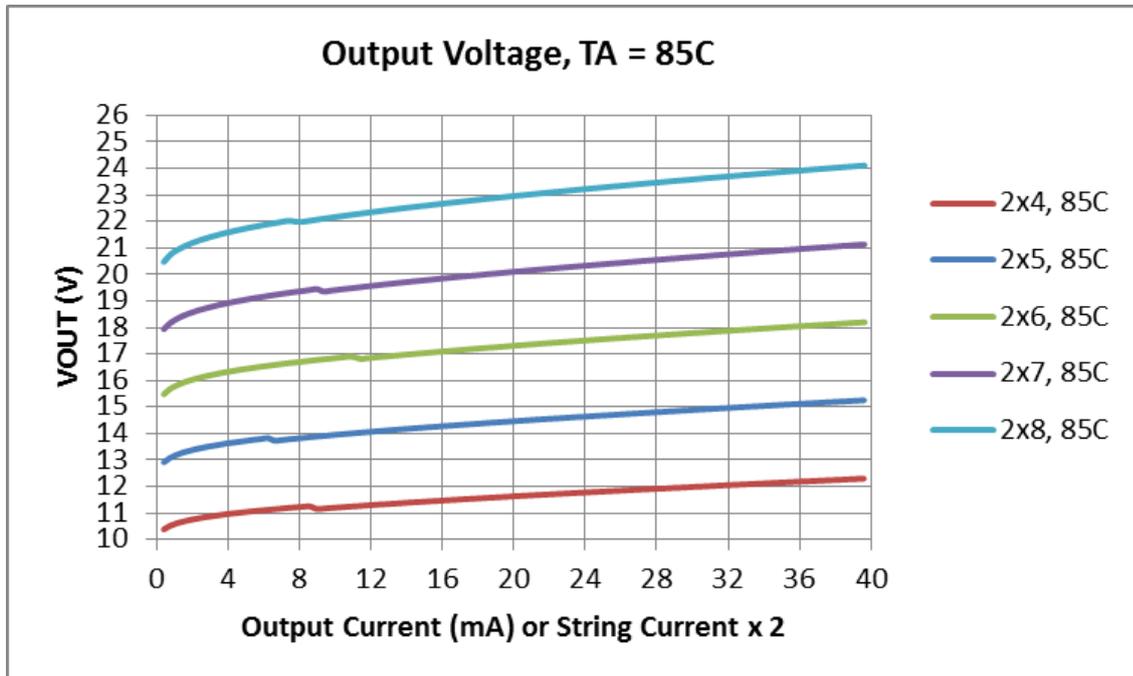


Figure 21. Boost Output Voltage (TA = 85C)

Output Capacitor

To keep the circuit height < 0.7mm (max), the output capacitor will have to be an 0402 case size. However, due to the requirement that the output capacitance be at least 0.4 μ F at the operating voltage, there will have to be multiple 0402 capacitors in parallel.

The choice of capacitor is a 25V, 2.2 μ F, 0402 from Murata, part number (GRM155R61E225KE11J). The typical curve of capacitance vs DC bias for a single capacitor is given in Figure 22. The blue line is the measured capacitance for a typical device at 25C. The red line is the same curve with the -15% reduction due to temperature and the -10% reduction in tolerance (i.e. Red = Blue x 0.85 x 0.9). The target is to have at least 0.4 μ F of total capacitance at the output. With the max operating voltage of around 25V, a single capacitor can be as low as 0.187 μ F. Because of this the design requires 3 of these capacitors in parallel.

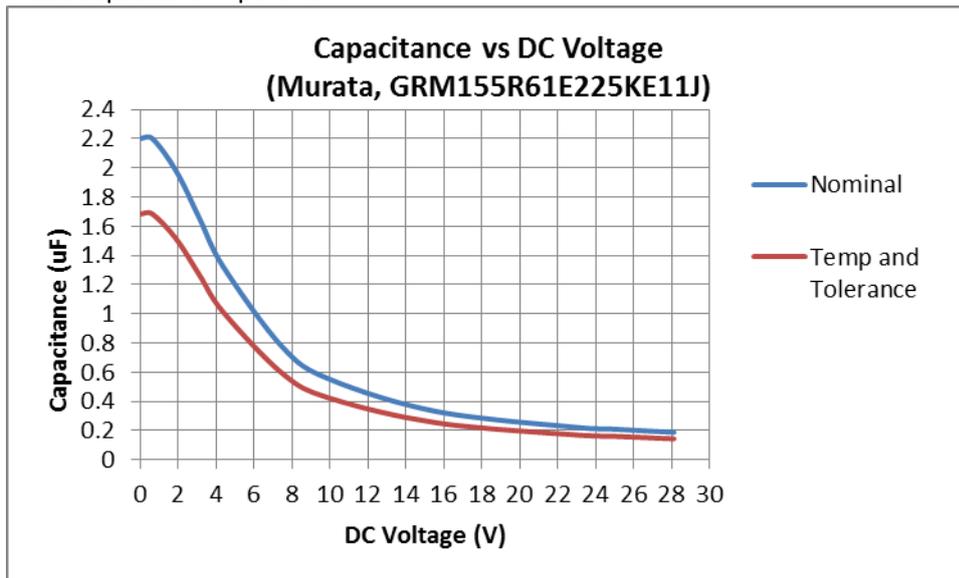


Figure 22. Output Capacitor Derating Curve

Output Capacitor Stability Verification

To verify the design is stable with the recommended capacitance, line steps are shown below over temperature (Figures 23 through 28) . The plots (at max load current), show normal behavior (i.e. no instability, or marginal instability).



Figure 23. Line Voltage Steps (3.3V to 2.8V), L = 10uH, IOUT = 40mA



Figure 24. Line Voltage Steps (3.7V to 3.2V), L = 10uH, IOUT = 40mA

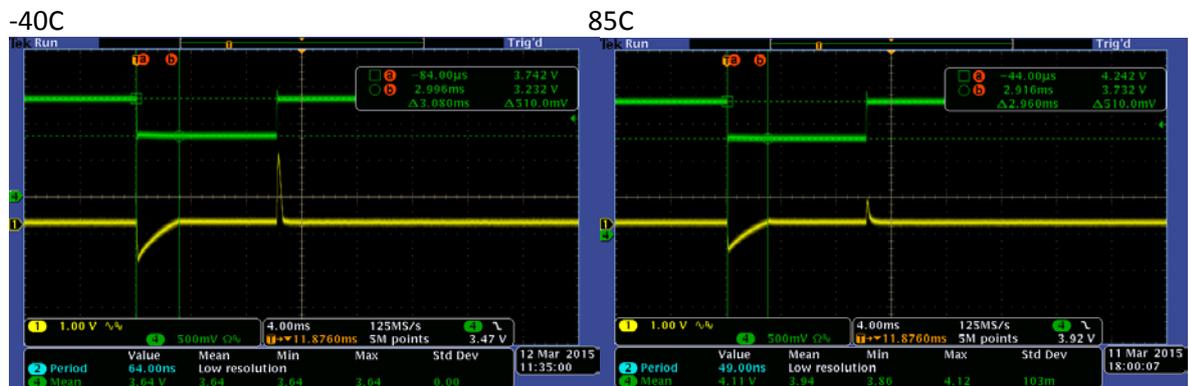


Figure 25. Line Voltage Steps (4.2V to 3.7V), L = 10uH, IOUT = 40mA

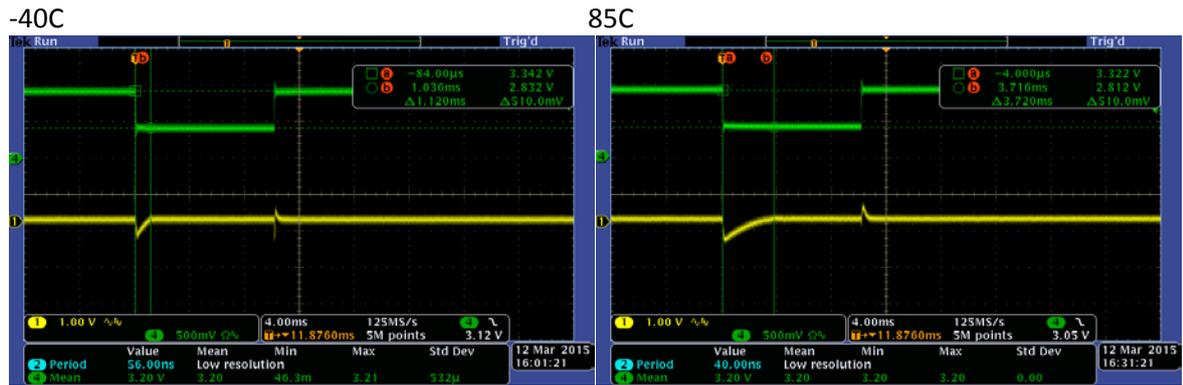


Figure 26. Line Voltage Steps (3.3V to 2.8V), L = 4.7uH, IOU_T = 40mA



Figure 27. Line Voltage Steps (3.7V to 3.2V), L = 4.7uH, IOU_T = 40mA



Figure 28. Line Voltage Steps (4.2V to 3.7V), L = 4.7uH, IOU_T = 40mA

Measuring Active Output Capacitance in a Boost

Another method to verify the output capacitance is to measure it directly by observing the output capacitors voltage ripple. In a boost, during the on time of the switch, the output capacitor is the only source of the load current. Because of this, VOUT will discharge ($I = C \times \Delta V / \Delta t$), or ($C = I \times \Delta t / \Delta V$), where ΔV is the voltage ripple, Δt is the switch on-time, and I is the output current. In the case in figure TBD, COUT is measured across 3 of the GRM155R61E225KE11's in parallel.

$$C = 39.7\text{mA} \times 776\text{ns} / 44.4\text{mV} = 0.693\mu\text{F}$$

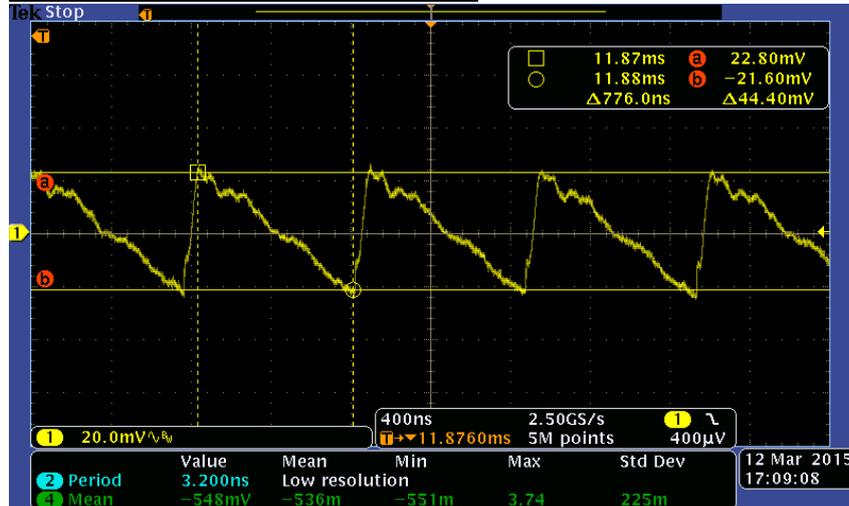


Figure 29. Typical COUT at 2x8 LEDs, IOUT = 39.7mA, TA = 25C, VOUT = 25.4V)

Schottky Diode Selection

The Schottky diode is chosen for small size and a height < 0.7mm. A good fit device is the NSR02F30NXT5G from On-Semiconductor. This is in a 0201 case size with a max height of 0.3mm. The Schottky diode must be selected such that it has a maximum reverse voltage which is greater than the maximum VOUT in the application, a maximum DC current that is greater than the total LED current, and a peak surge current which is greater than the peak inductor current seen in the application.

The NSR02F30NXT5G diode has the following ratings:

1. Maximum peak current (4A)
2. Maximum DC forward current (200mA)
3. Maximum reverse voltage (30V)

The maximum VOUT in the application for the 2x8 LED configuration forces the need for a 30V Schottky. The max IOUT is 40mA, therefore the diodes average current must be > 40mA. The peak current can be calculated from the following:

$$I_{PEAK} = \frac{V_{OUT_MAX} \times I_{OUT_MAX}}{V_{IN_MIN} \times efficiency} + \frac{V_{IN_MIN} \times (V_{OUT_MAX} - V_{IN_MIN} \times efficiency)}{V_{OUT_MAX} \times (f_{sw} \times L_{MIN} \times 2)}$$

This assumes continuous conduction mode. The equation for discontinuous conduction mode is not given since it is more complicated and the maximum peak current will not occur when the boost is in DCM in this application. For the maximum output power application (2x8 LEDs, L_MIN = 3.76uH,

VIN_MIN = 2.8V, VOUT_MIN = 25.24V, IOUT_MAX = 40mA, fsw = 1.2MHz, efficiency = 74.4%), IPEAK is 770mA.

Other things to consider when selecting the Schottky are:

1. Diode reverse leakage current
2. Total Capacitance
3. Forward Voltage Drop

Reverse Leakage Current

Reverse leakage current (IR) is the current from VOUT through the diode and into the SW node when the diode is reverse biased. Since this is leakage from VOUT it is the same as adding extra output current during the switch on time that does not go through the LEDs. In the selected diode, IR is typically 1uA at VR = 25V. This will have only a small effect on efficiency and compared to other diodes available, is on the low side.

However, typical specifications on leakage current can be misleading since IR increases drastically with diode temperature. This is enhanced further since the thermal resistance of a small device such as the (NSR02F30NXT5G) can be very high (>500°C/W), especially when mounted on the small PCB area used in mobile handsets. This can result in large diode self-heating and a much higher than expected reverse current. If reverse current over temperature becomes too high the diode can go into thermal runaway. Thermal runaway happens when the added power from the reverse current self-heats the diode causing a positive feedback between temperature and current. This eventually forces the reverse current high enough such that either the backlight boost goes into current limit or the diode fails. A conservative estimate is to assume the diode is operating at 125°C and to ensure the IR number at 125°C is still relatively low. In the case of the NSR02F30NXT5G, the IR at 125°C is only 500uA, so this would not cause any thermal issues. Figure 30 shows the reverse current plot taken from the NSR02F30NXT5G datasheet.

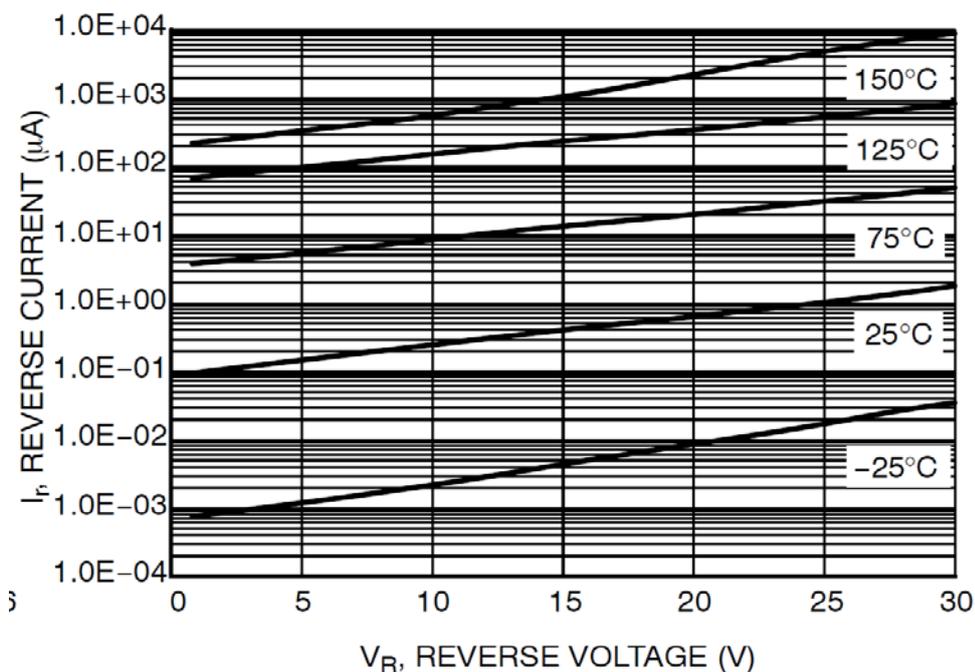


Figure 30. NSR02F30NXT5G Reverse Current (IR) vs Reverse Voltage and Temp

Total Capacitance

Total capacitance is related to the amount of charge that is stored across the diodes junction when reverse biased. This total charge is shown in the diode capacitance vs reverse voltage curve (see Figure 31, taken from the NSR02F30NXT5G datasheet). The total charge is the area under the curve from the peak reverse voltage down to 0. At a reverse voltage of 25V we see approximately 150pC. This equates to 180uA of average current per switching cycle from VOUT ($150\text{pC} \times 1.2\text{MHz} = 180\mu\text{A}$). This is OK since it has only a slight effect on efficiency. For example, with 180μA of extra output current the efficiency loss for the 2x8 LED application at VIN = 3.7V equates to approximately:

$$180\mu\text{A} \times \text{VOUT}/\text{Input Power} = 0.38\%$$

Some diodes have 10X the amount of junction capacitance which can obviously have drastic effects on efficiency especially at light loads.

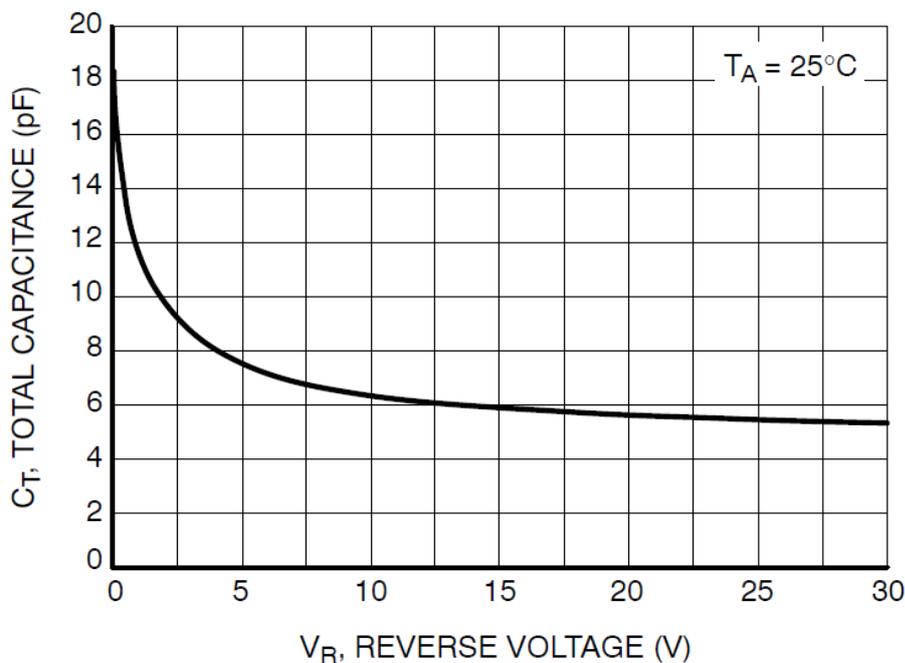


Figure 31. NSR02F30NXT5G Diode Capacitance vs Reverse Voltage and Temp

4 Test Setup

The test set-up was basically the EVM for the TPS61163 with the following changes:

1. The typical inductor was replaced with the XFL2006 (from Coilcraft), L1
2. Two extra pads were added for the 3x output capacitors (GRM155R61E225KE11J from Murata), C1, C2, C3.
3. A new footprint for the Schottky Diode (NSR02F30NXT5G) from On-Semi was added (D1).
4. The bypass capacitor used for CIN was a 2.2uF, 6.3V, X5R, 0201 case size. This device provides local filtering for the TPS61163's IN pin
5. The capacitor used for CCOMP was a 220nF, 6.3V, X5R, 0201 case size.
6. The resistor used for RSET was a 64kΩ, 1%, 0201 case size. This sets the maximum string current to

$$I_{STRING} = V_{SET}/R_{SET} \times K = 1.229V/64k\Omega \times 1030 = 19.8mA$$

The core layout for the circuit is shown in Figure 32.

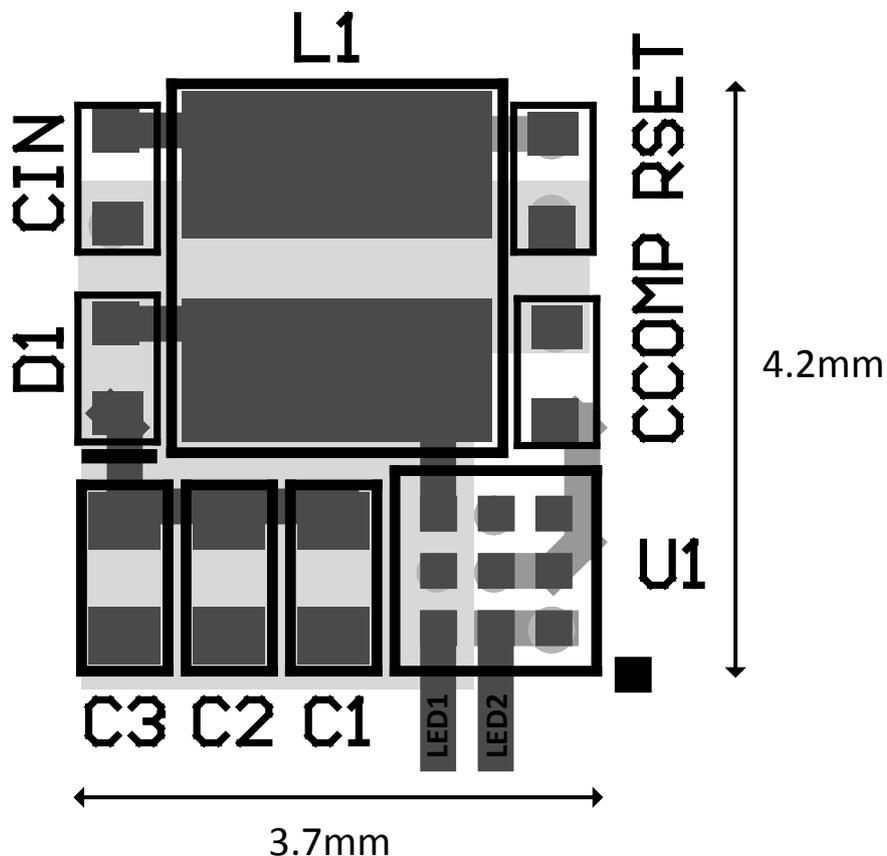


Figure 32. Ultra-Low Profile Backlight Circuit

5 Design Files

5.1 Schematics

To download the Schematics for each board, see the design files at <http://www.ti.com/tool/TIDA=-00878>

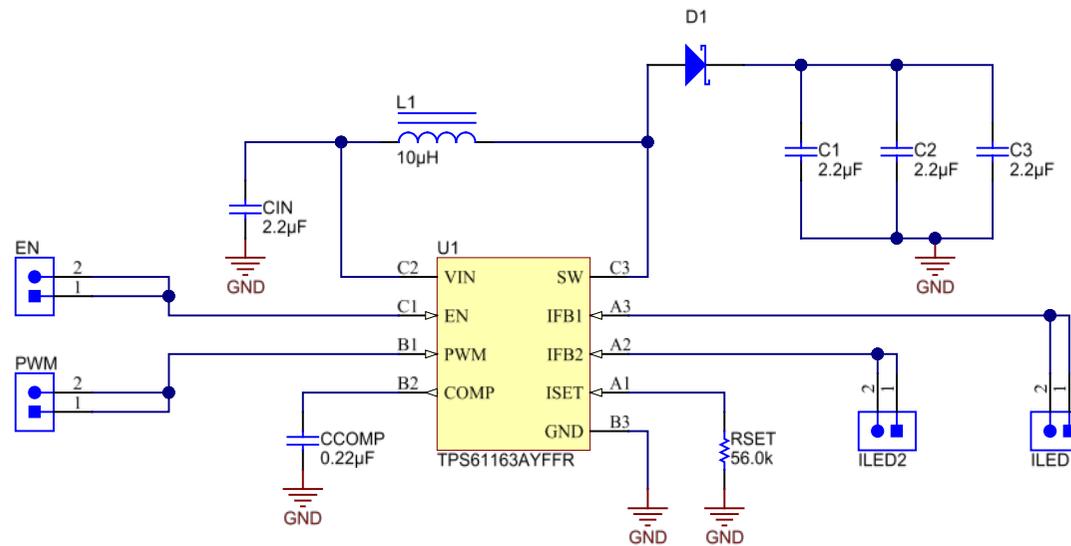
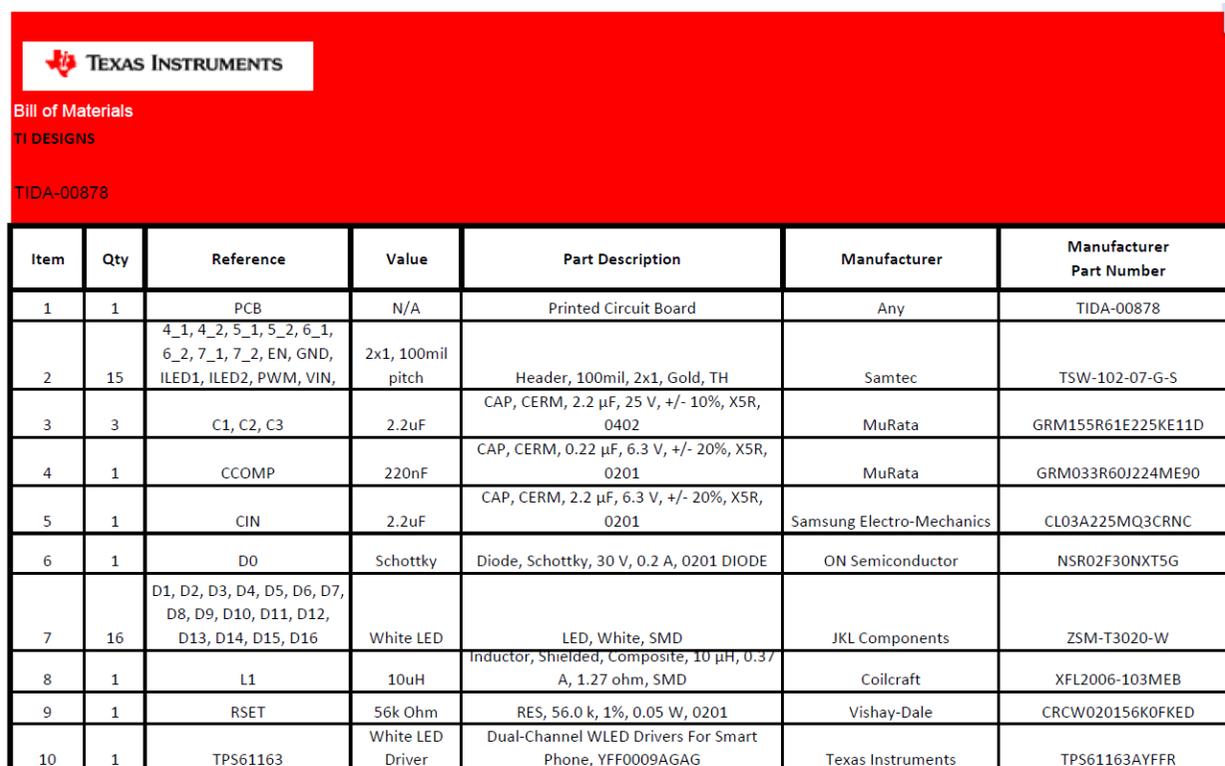


Figure 33: Board Schematic

5.2 Bill of Materials

To download the Bill of Materials for each board, see the design files at <http://www.ti.com/tool/TIDA-00878>



The screenshot shows the Bill of Materials for TIDA-00878. It includes the Texas Instruments logo, the title 'Bill of Materials', the design name 'TI DESIGNS', and the part number 'TIDA-00878'. Below this is a table with 7 columns: Item, Qty, Reference, Value, Part Description, Manufacturer, and Manufacturer Part Number. The table lists 10 items, including a PCB, headers, capacitors, a diode, LEDs, an inductor, a resistor, and a LED driver.

| Item | Qty | Reference | Value | Part Description | Manufacturer | Manufacturer Part Number |
|------|-----|--|-------------------|--|---------------------------|--------------------------|
| 1 | 1 | PCB | N/A | Printed Circuit Board | Any | TIDA-00878 |
| 2 | 15 | 4_1, 4_2, 5_1, 5_2, 6_1, 6_2, 7_1, 7_2, EN, GND, ILED1, ILED2, PWM, VIN, | 2x1, 100mil pitch | Header, 100mil, 2x1, Gold, TH | Samtec | TSW-102-07-G-S |
| 3 | 3 | C1, C2, C3 | 2.2uF | CAP, CERM, 2.2 μ F, 25 V, +/- 10%, X5R, 0402 | MuRata | GRM155R61E225KE11D |
| 4 | 1 | CCOMP | 220nF | CAP, CERM, 0.22 μ F, 6.3 V, +/- 20%, X5R, 0201 | MuRata | GRM033R60J224ME90 |
| 5 | 1 | CIN | 2.2uF | CAP, CERM, 2.2 μ F, 6.3 V, +/- 20%, X5R, 0201 | Samsung Electro-Mechanics | CL03A225MQ3CRNC |
| 6 | 1 | D0 | Schottky | Diode, Schottky, 30 V, 0.2 A, 0201 DIODE | ON Semiconductor | NSR02F30NXT5G |
| 7 | 16 | D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16 | White LED | LED, White, SMD | JKL Components | ZSM-T3020-W |
| 8 | 1 | L1 | 10uH | Inductor, Shielded, Composite, 10 μ H, 0.37 A, 1.27 ohm, SMD | Coilcraft | XFL2006-103MEB |
| 9 | 1 | RSET | 56k Ohm | RES, 56.0 k, 1%, 0.05 W, 0201 | Vishay-Dale | CRCW020156K0FKED |
| 10 | 1 | TPS61163 | White LED Driver | Dual-Channel WLED Drivers For Smart Phone, YFF009AGAG | Texas Instruments | TPS61163AYFFR |

5.2.1 Layout Prints

To download the Layout Prints for each board, see the design files at <http://www.ti.com/tool/TIDA-00878>

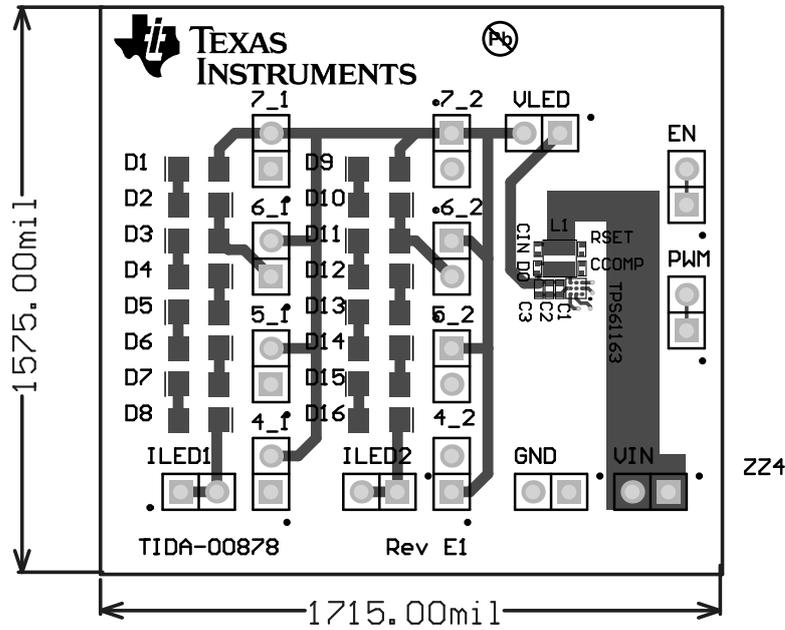


Figure 24: Top Layer

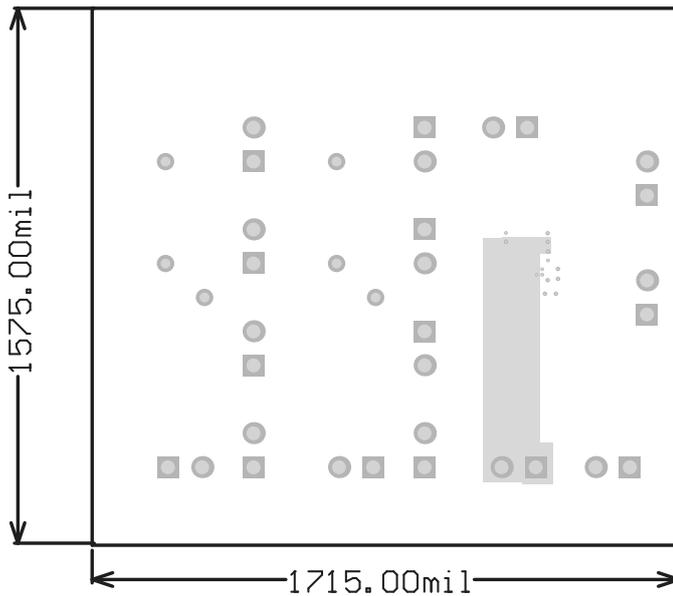


Figure 35: Mid Layer 1

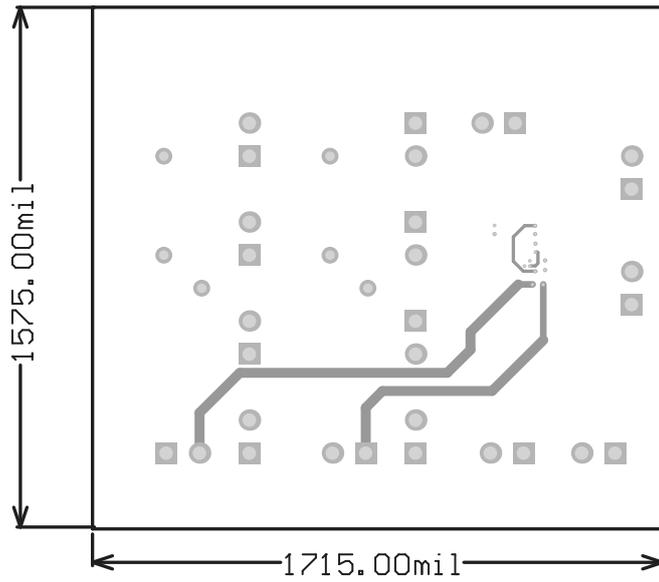


Figure 36: Mid Layer 2

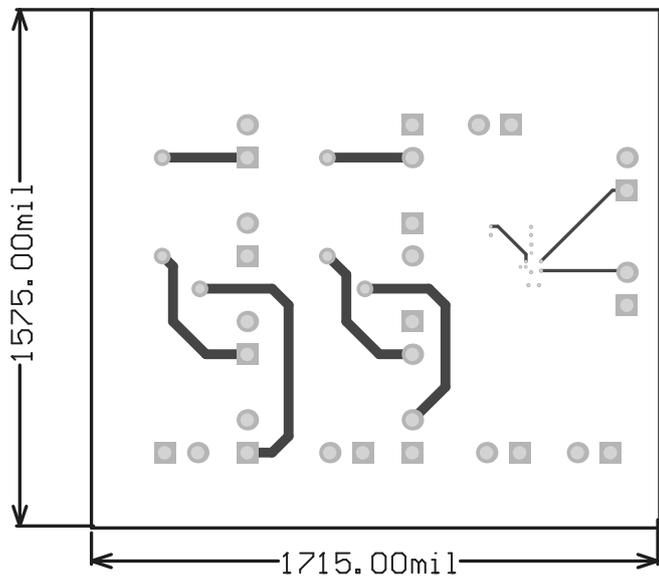


Figure 37: Bottom Layer

6 Software Files

[None](#)

7 References

1. TPS61163A Datasheet
<http://www.ti.com/lit/ds/symlink/tps61163a.pdf>
2. XFL2006 Datasheet
<http://www.coilcraft.com/pdfs/xfl2006.pdf>
3. NSR02F30NXT5G Datasheet
<http://www.onsemi.com/pub link/Collateral/NSR02F30-D.PDF>
4. GRM155R61E225KE11J Datasheet
<http://psearch.en.murata.com/capacitor/product/GRM155R61E225KE11%23.pdf>

8 Terminology

None

9 About the Author

Travis Eichhorn is a Systems Engineer at Texas Instruments, where he is responsible for low to medium power LED power products.

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