# Non-Isolated, Flyback, LED Driver Demoboard with a High Step-Up Ratio

## General Description

The HV9860DB1 is a non-isolated, flyback, LED driver, which drives a 360V LED string at 120mA from a 24V input. The demoboard uses Supertex's HV9860 LED driver IC.

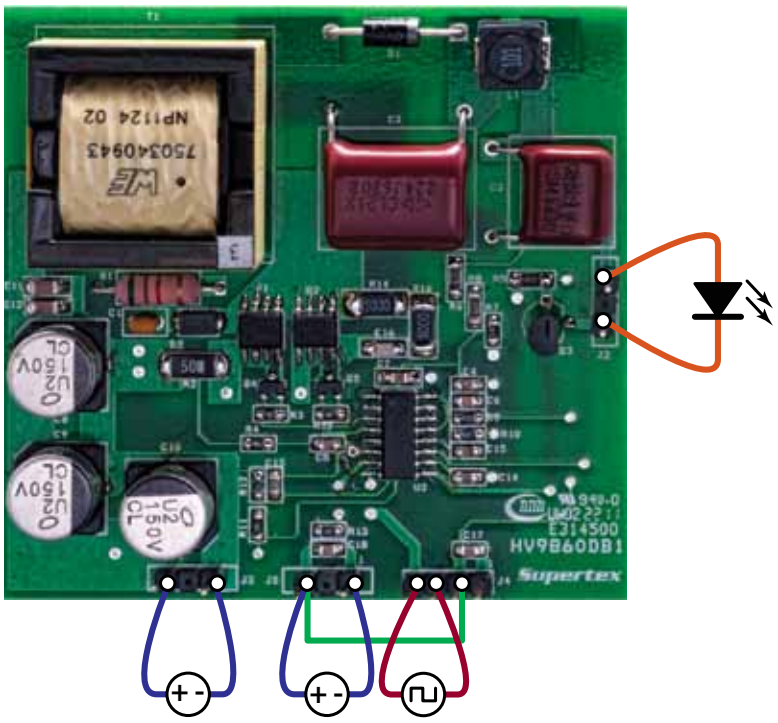
The board is designed to be restricted to a maximum thickness of 15mm, which demonstrates the usage of the HV9860 as a low profile LCD backlight driver.

The HV9860DB1 includes hiccup mode protection for both short circuit and open circuit conditions to ensure that it recovers from a momentary fault condition. In particular, it features a safe latch-off mode protection for short cathode detect. In this way, it enables the board to survive prolonged fault conditions without any damage to both the driver as well as the LEDs.

## Specifications

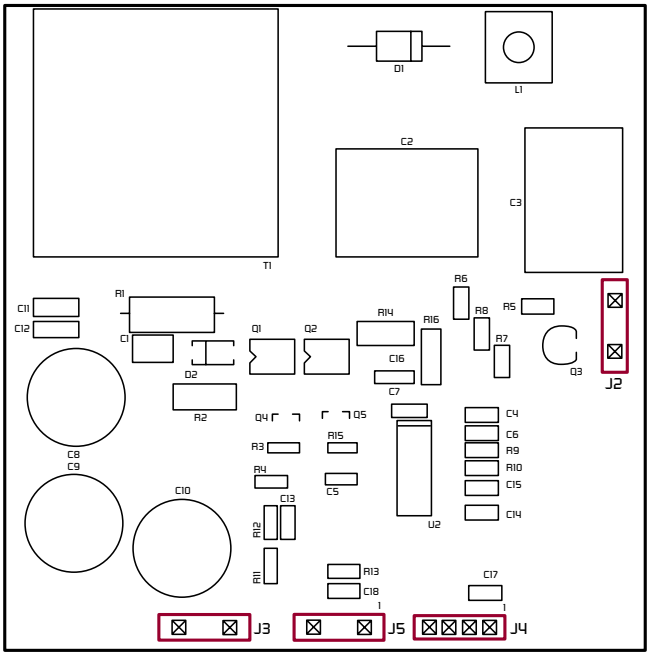
| Parameter | Value |
|---|---|
| Input voltage ($V_{IN}$) | 22 - 26V |
| Output voltage | 260 - 360V |
| Output current | 120mA +/-5% |
| Typical full load efficiency (@24V input) | 90% |
| Open LED protection | Yes |
| Output short circuit protection | Yes |
| Short cathode detect | Yes |
| Dimensions | 72.4mm X 68.4mm |

## Connection Diagram



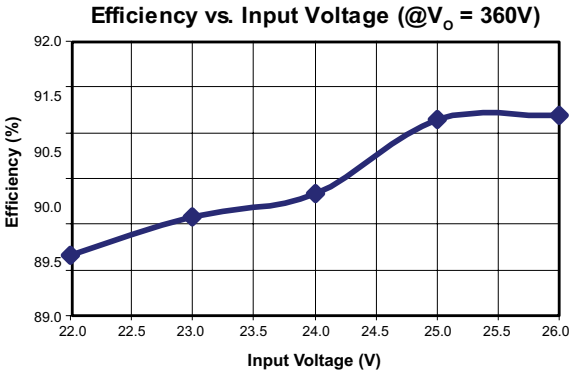

*Actual Board Size: 72.4mm x 68.4mm*

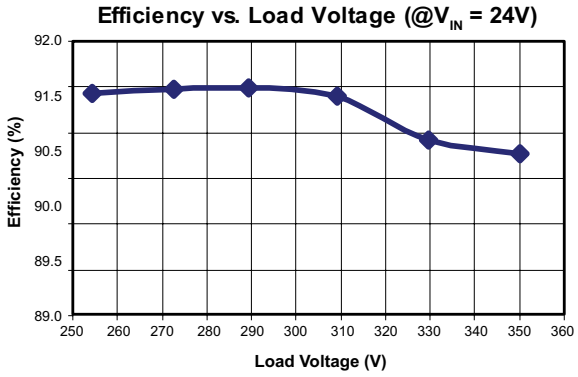
## Connections

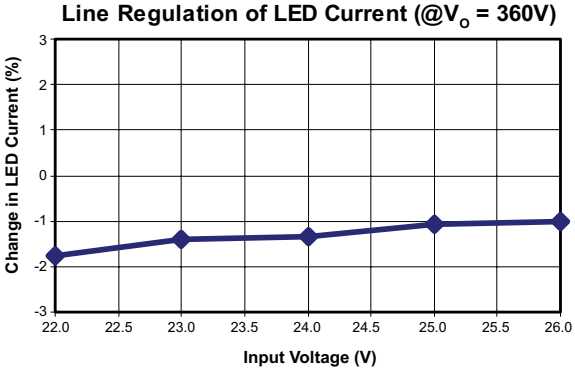


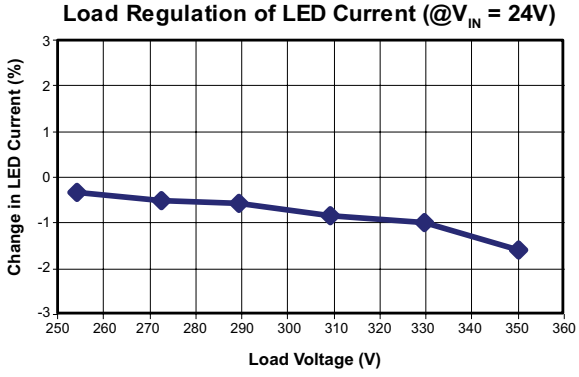

1. Connect the input DC power source between VIN and GND (terminal J3).
2. Connect the LED string between LED+ and LED- (terminal J2).
3. To enable the driver, short PWMI & LD (terminal J4) to 3.3V (terminal J5).
4. Connect the 3.3V PWM dimming pulse source between PWMI and GND. Connect the 0~3.3V linear dimming signal source between LD and GND. To achieve 100% dimming, short PWMI & LD to 3.3V.

## Typical Results



## Typical Waveforms *(All waveforms are at 24V input and 360V LED voltage unless otherwise noted)*

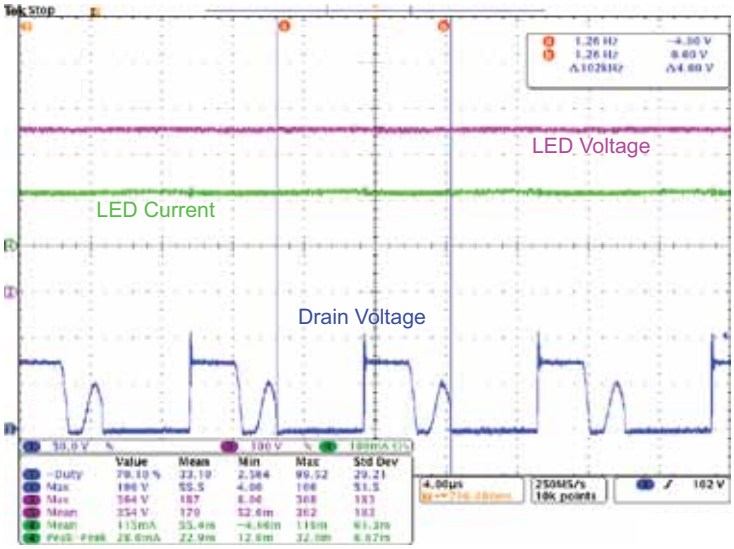



**Figure 1. Steady State Waveforms**

| | | |
|---|---|---|
| C1 (Blue) | : | Drain Voltage (50V/div) |
| C3 (Purple) | : | LED Voltage (100V/div) |
| C4 (Green) | : | LED Current (100mA/div) |
| Time Base | : | 4µs/div |

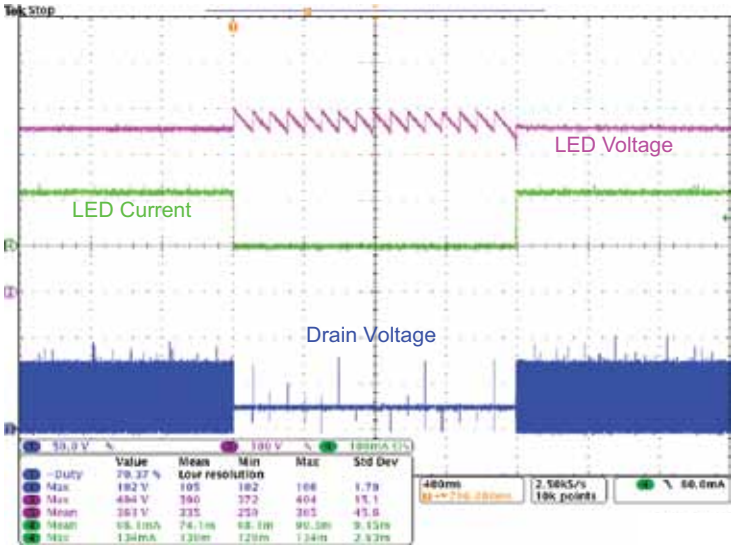



**Figure 2. Open Circuit Waveforms**

| | | |
|---|---|---|
| C1 (Blue) | : | Drain Voltage (50V/div) |
| C3 (Purple) | : | LED Voltage (100V/div) |
| C4 (Green) | : | LED Current (100mA/div) |
| Time Base | : | 400ms/div |

## Typical Waveforms *(cont.)*

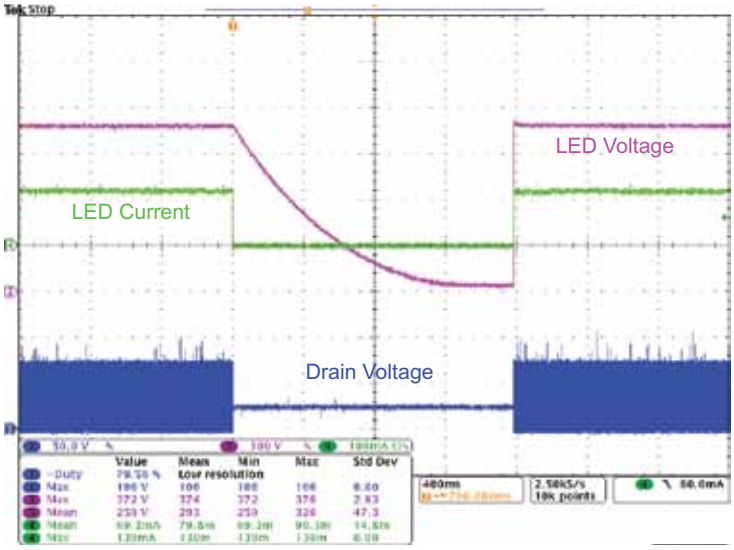



**Figure 3. Short Circuit Waveforms**

| | | |
|---|---|---|
| C1 (Blue) | : | Drain Voltage (50V/div) |
| C3 (Purple) | : | LED Voltage (100V/div) |
| C4 (Green) | : | LED Current (100mA/div) |
| Time Base | : | 400ms/div |

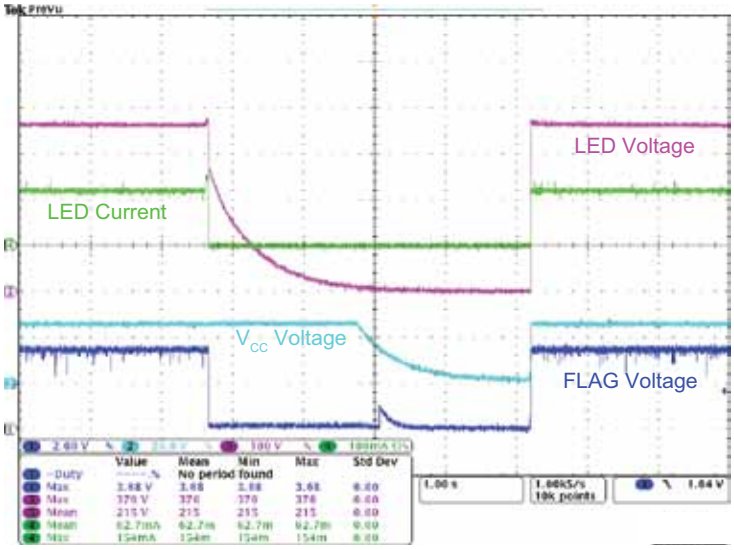
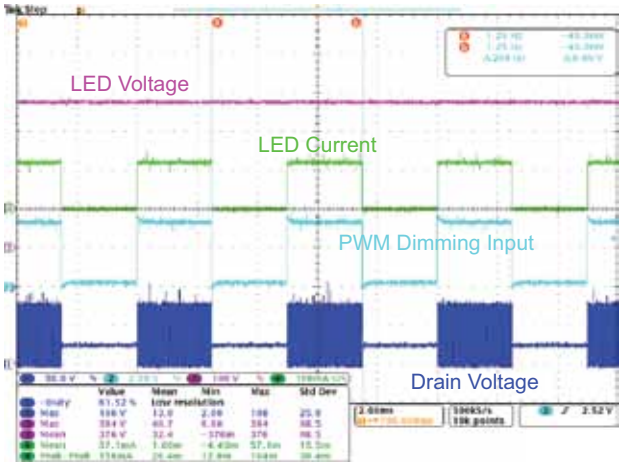



**Figure 4. Short Cathode Waveforms**

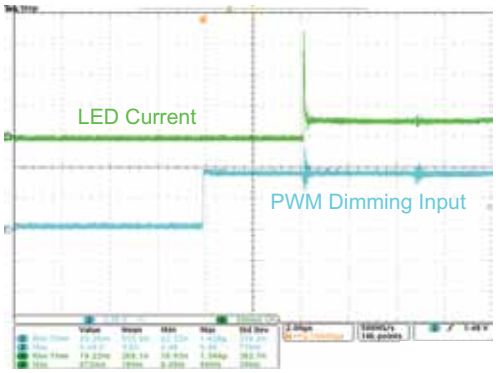
| | | |
|---|---|---|
| C1 (Blue) | : | FLAG Voltage (2V/div) |
| C2 (Sky-blue) | : | $V_{CC}$ Voltage (20V/div) |
| C3 (Purple) | : | LED Voltage (100V/div) |
| C4 (Green) | : | LED Current (100mA/div) |
| Time Base | : | 1s/div |

## Typical Waveforms *(cont.)*

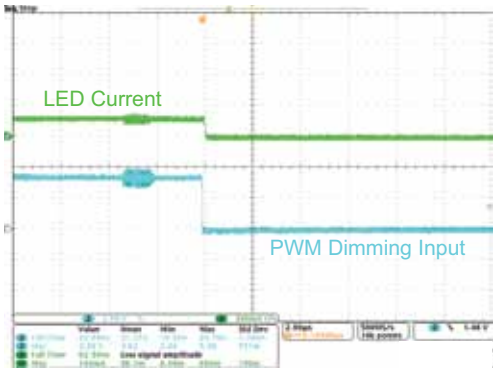



**(a) PWM Dimming Performance**

C1 (Blue) : Drain Voltage (50V/div)
C2 (Sky-blue) : PWMI Input Voltage (2V/div)
C3 (Purple) : LED Voltage (100V/div)
C4 (Green) : LED Current (100mA/div)
Time Scale : 2ms/div




**(b) PWM Dimming Rise Time**




**(c) PWM Dimming Fall Time**

**Figure 5. PWM Dimming Using the PWMI Input**

C2 (Sky-blue) : PWMI Input Voltage (2V/div)
C4 (Green) : LED Current (200mA/div)
Time Scale : 2µs/div

## Typical Waveforms *(cont.)*

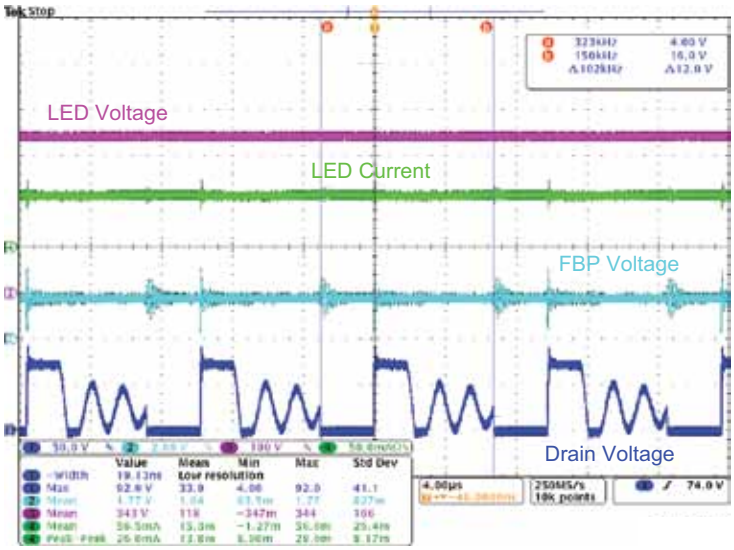


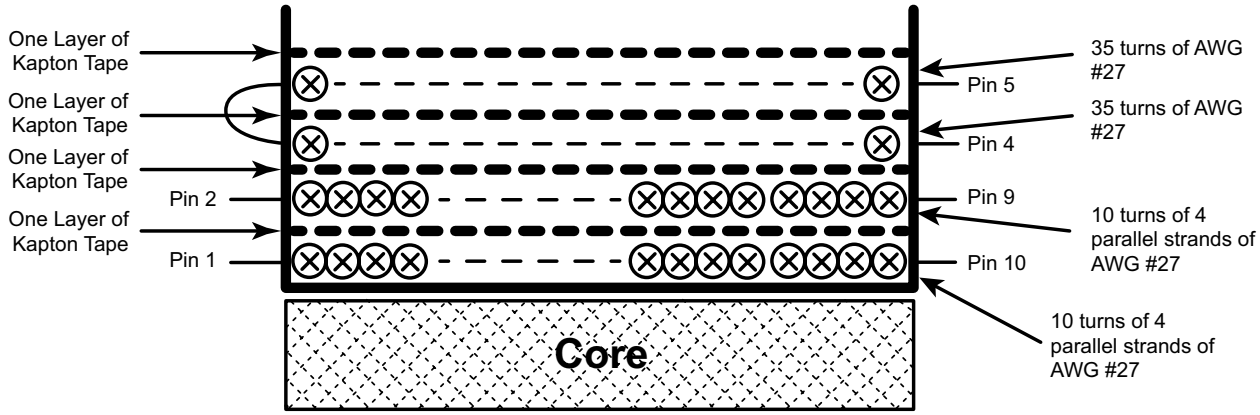

**Figure 6. Linear Dimming Using the FBP Pin**

| | | |
|---|---|---|
| C1 (Blue) | : | Drain Voltage (50V/div) |
| C2 (Sky-blue) | : | FBP Voltage (2V/div) |
| C3 (Purple) | : | LED Voltage (100V/div) |
| C4 (Green) | : | LED Current (50mA/div) |
| Time Base | : | 4µs/div |

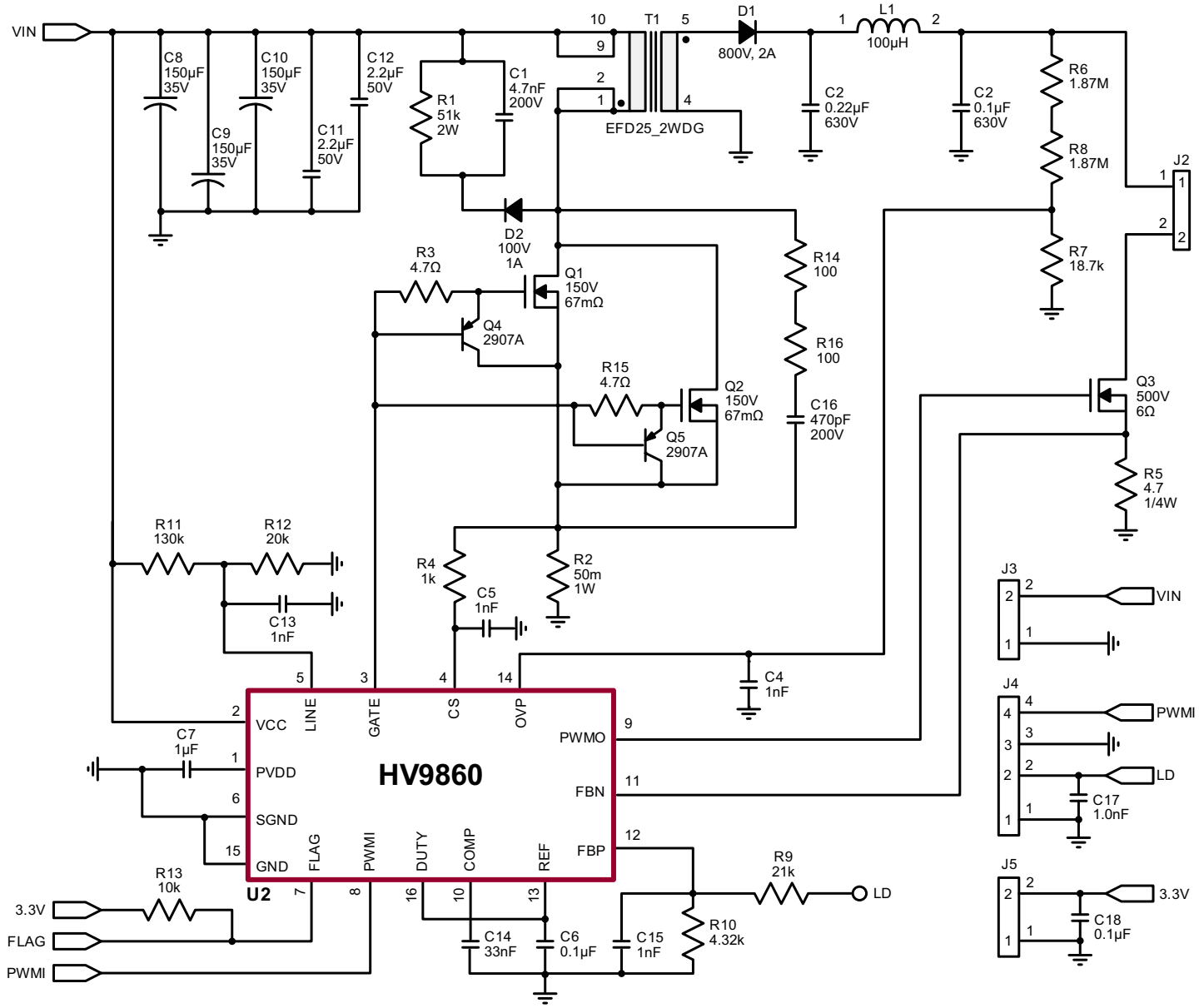
## Transformer Specifications

| Core | Bobbin | Primary | Secondary |
|---|---|---|---|
| EFD25/13/9-3C90 | CSH-EFD25-1S-10P | 10 turns of 8 parallel strands of AWG #27 | 70 turns of 27AWG |

*Gapped to get a primary inductance of 15uH +/-10%*



## Circuit Schematic



## Bill of Materials

| Item # | Quan | RefDes | Description | Package | Manufac-turer | Manufacturer's Part Number |
|---|---|---|---|---|---|---|
| 1 | 1 | C1 | 4.7nF, 200V, 10% X7R ceramic capacitor | Radial | Kemet | C320C472K2R5TA |
| 2 | 1 | C2 | 0.22µF, 630V, 10% film capacitor | Radial | C&C | CMES224J630RB150 |
| 3 | 1 | C3 | 0.1µF, 630V, 5% film capacitor | Radial | C&C | CMES104J630RB100 |
| 4 | 5 | C4, C5, C13, C15, C17 | 1nF, 50V, 10% C0G ceramic chip capacitor | SMD0805 | - | - |
| 5 | 2 | C6, C18 | 0.1µF, 16V, 10% X7R ceramic chip capacitor | SMD0805 | - | - |
| 6 | 1 | C7 | 1µF, 16V, X7R ceramic chip capacitor | SMD1206 | - | - |
| 7 | 3 | C8, C9, C10 | 150µF, 35V, 850mA electrolytic capacitor | SMT | Nichicon | UCL1V151MCL6GS |
| 8 | 2 | C11, C12 | 2.2µF, 50V, 10% X7R ceramic chip capacitor | SMD1206 | - | - |
| 9 | 1 | C14 | 33nF, 50V, 5% C0G ceramic chip capacitor | SMD0805 | - | - |
| 10 | 1 | C16 | 470pF, 200V, 5% NPO ceramic capacitor | SMD1206 | AVX | 12062A471JAT2A |
| 11 | 1 | D1 | 800V, 2A ultra fast diode | DO-15 | Diodes Inc | UF2006-T |
| 12 | 1 | D2 | 100V, 1A ultra fast diode | SMA | Diodes Inc | US1B-13 |
| 13 | 3 | J2, J3, J5 | 2 pin connector | - | - | - |
| 14 | 1 | J4 | 4 pin connector | - | - | - |
| 15 | 1 | L1 | 100µH, 0.79A rms, 0.75A sat inductor | WE-PD size 7345 | Würth | 744 777 920 |
| 16 | 2 | Q1, Q2 | 150V, 67mΩ, N channel MOSFET | SO-8 | Fairchild Semi | FDS86242 |
| 17 | 1 | Q3 | 500V, 6Ω, N channel MOSFET | TO-92 | Fairchild Semi | FQN1N50CTA |
| 18 | 2 | Q4, Q5 | -60V, 600mA, PNP transistor | SOT-23 | ST | MMBT2907A |
| 19 | 1 | R1 | 5.1kΩ, 2W, 5% resistor | Axial | Yageo | FMP200JR-52-5K1 |
| 20 | 1 | R2 | 50mΩ, 1W, 1% chip resistor | SMD2010 | Vishay/Dale | WSL2010R0500FEA18 |
| 21 | 2 | R3, R15 | 4.7Ω, 1/8W, 5% chip resistor | SMD0805 | - | - |
| 22 | 1 | R4 | 1kΩ, 1/8W, 1% chip resistor | SMD0805 | - | - |
| 23 | 1 | R5 | 4.7Ω, 1/4W, 1% chip resistor | SMD1206 | - | - |
| 24 | 2 | R6, R8 | 1.87MΩ, 1/4W, 1% chip resistor | SMD1206 | Rohm Semi | MCR18EZHF1874 |
| 25 | 1 | R7 | 18.7kΩ, 1/8W, 1% chip resistor | SMD0805 | Rohm Semi | MCR10EZPF1872 |
| 26 | 1 | R9 | 21kΩ, 1/8W, 1% chip resistor | SMD0805 | - | - |
| 27 | 1 | R10 | 4.32kΩ, 1/8W, 1% chip resistor | SMD0805 | - | - |
| 28 | 1 | R11 | 130kΩ, 1/8W, 1% chip resistor | SMD0805 | - | - |
| 29 | 1 | R12 | 20kΩ, 1/8W, 1% chip resistor | SMD0805 | - | - |
| 30 | 1 | R13 | 10kΩ, 1/8W, 1% chip resistor | SMD0805 | - | - |
| 31 | 2 | R14, R16 | 100Ω, 1W, 5% chip resistor | SMD2010 | Vishay/Dale | CRCW2010100RJNEFHP |
| 32 | 1 | T1 | Two winding coupled inductor | Thru-Hole | Würth | 750340943 |
| 33 | 1 | U2 | Boost / Flyback LED driver with open loop detection | SO-16 | Supertex | HV9860NG-G |



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