The IPS315 as a Constant Current LED Driver for Battery Operated and Low Voltage Rectified AC Applications

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Introduction

This application note describes how to use the IPS315 PWM controller for LED constant current control applications.

How suitable is IPS315 for constant current LED driving?

The IPS315 was initially intended for automotive applications that required DC to DC solutions up to approximately 70W and needed to operate from as low as 8V DC battery voltage. But its 7.2V chip Vcc (shunt regulator) together with a direct feedback option makes it a perfect candidate for constant current LED driving in non-isolated applications operating from above 7.5V DC or rectified AC.
The IPS315 incorporates one voltage reference of 925mV and one amplifier for current control. This voltage reference has a comparatively low value, which allows for sensing of larger currents with acceptable efficiency.

Summary of features

The IPS315 can be seen as a precise constant current LED controller as described below:

- Operates from 7.5V DC or rectified AC
- One stage PWM LED constant current control (simple and low component count buck, boost, SEPIC and flyback topologies)
- Low current sensing threshold of 925mV for maximum efficiency
- Application power depends on selected MOSFET
- Full flexibility in LED choice 100mW, 1W, 3W, 5W and others
- Full flexibility in number of LEDs per string
- Easy intensity linear and PWM dimming

Available topologies for constant current LED control

The buck and boost topologies provide a good solution when the application requires that the input-to-output voltage change is either always an increase (boost) or decrease (buck). For applications that need the output to be both above and below the output, either a SEPIC or one-to-one turns-ratio flyback can be used. There are many similarities between the two topologies (one switch, two windings on one core). The SEPIC has an input-to-output capacitor, which adds an additional component in the power path. The tradeoff is that the flyback switch needs to tolerate an inductive voltage ‘kick’ from the transformer leakage inductance at turn-off. The SEPIC capacitor takes this energy and transfers it to the output. The flyback has higher rms current in its input and output capacitors compared to the SEPIC, but the flyback input capacitor typically has the same current requirement as the SEPIC transfer capacitor. The flyback windings will have

half the inductance of the SEPIC windings, but the size of the required core is nearly the same for the two topologies if core and winding losses are kept identical.

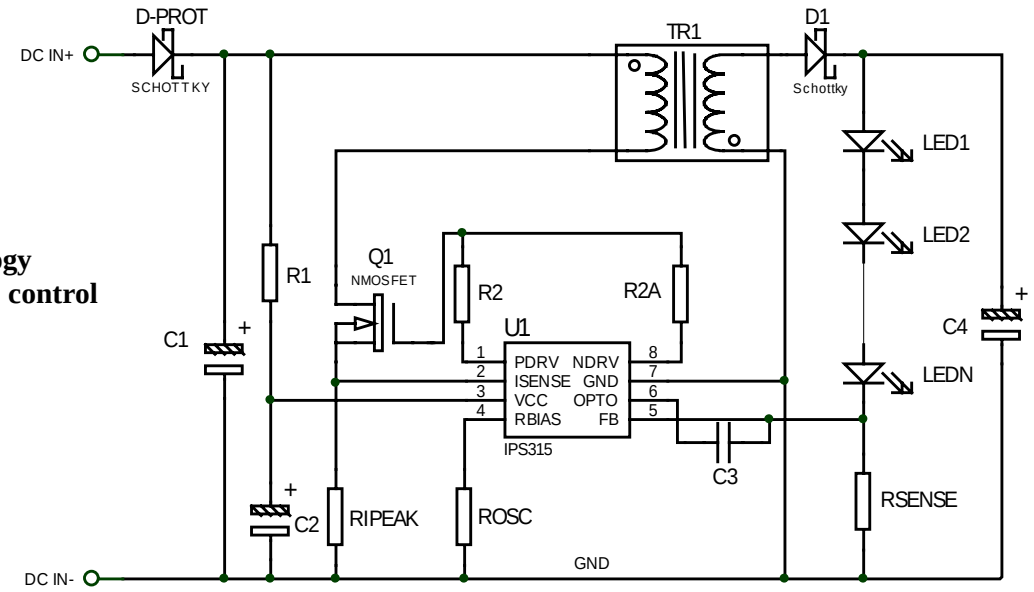


Fig.1: Flyback topology with IPS315 for LED control

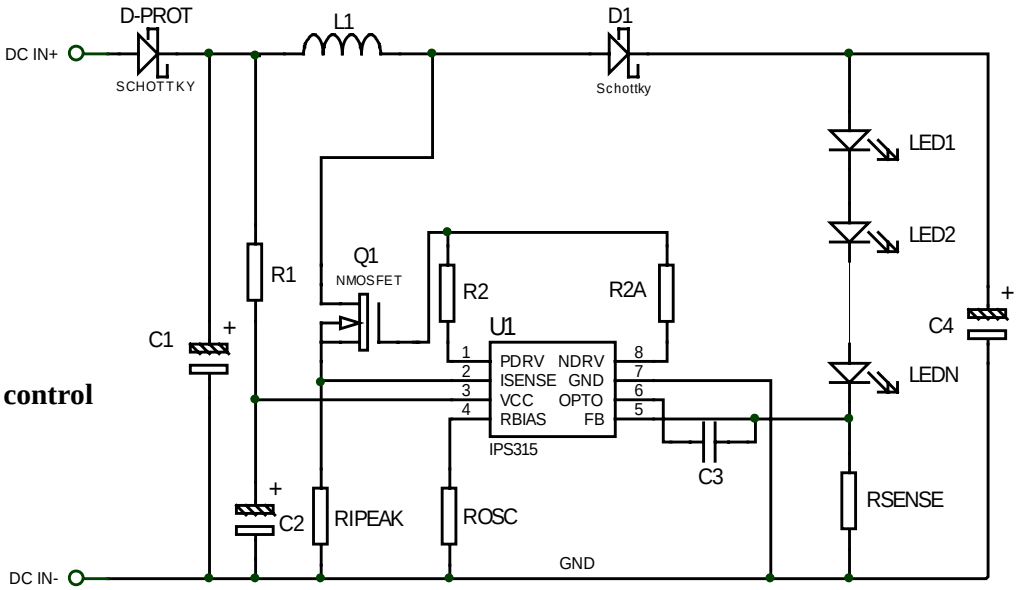


Fig.2: Boost topology with IPS315 for LED control

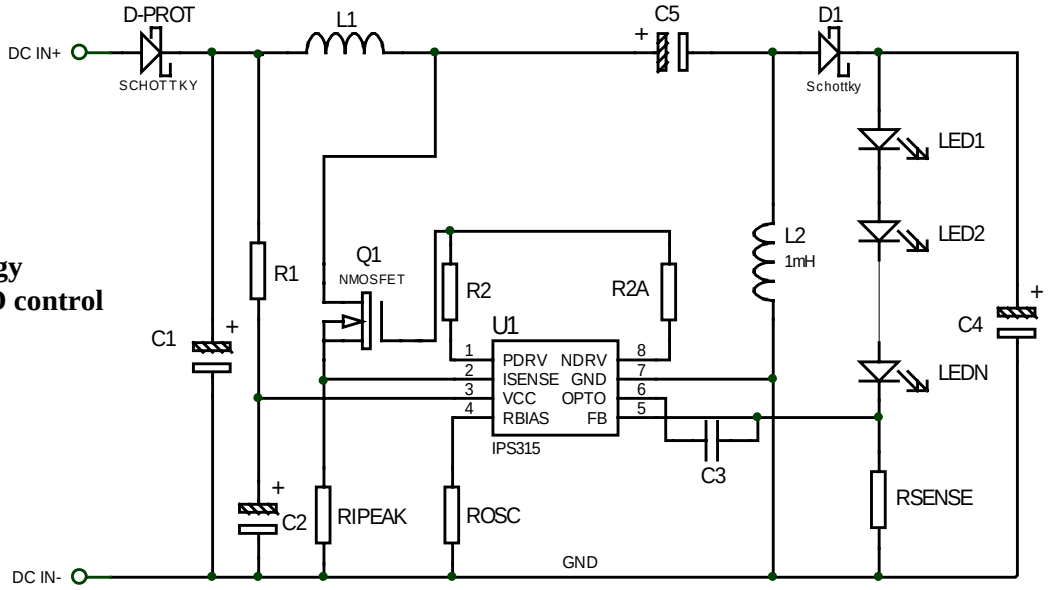


Fig.3: SEPIC topology with IPS315 for LED control

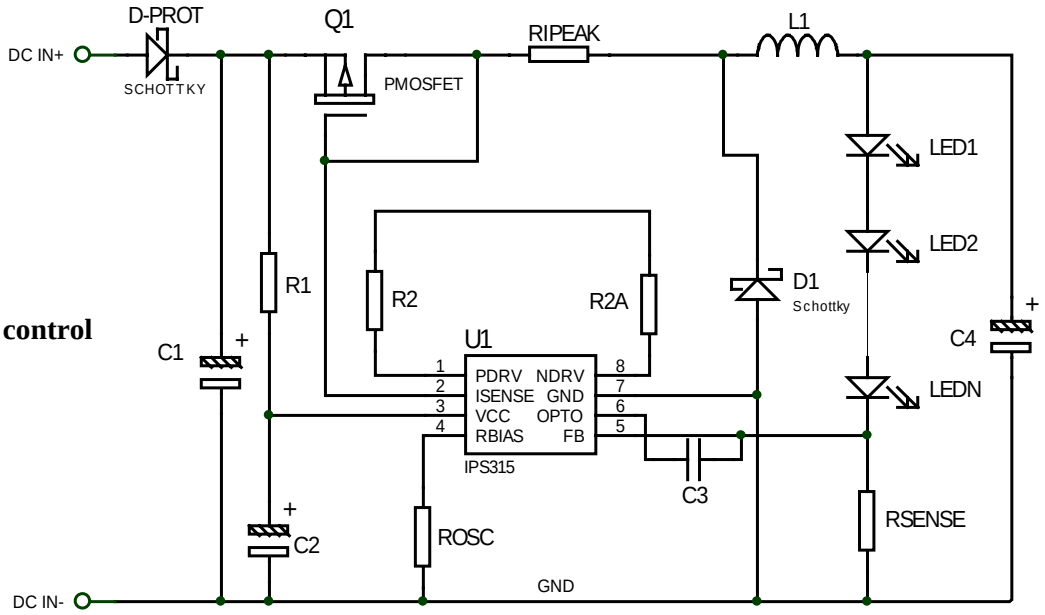


Fig.4: Buck topology with IPS315 for LED control

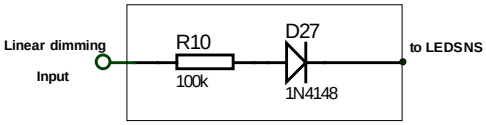
See http://www.in-plug.com/autoICs.htm to access product datasheet

Dimming

This section describes the dimming options and the components included in the associated 'Dimming" block .

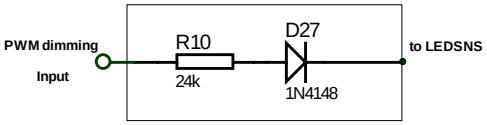
Linear dimming

A DC power supply connected through a 1N4148 diode and 100k resistor to the FB pin and ramped from 0 to 10 volts will provide a fairly good dimming function. There is no effect until the voltage is above 1 volt, but it is gradual after that. An improvement would be to add a buffer operational amplifier with an offset, running off VCC. This would allow for a 0 to 5 volt linear control with low offset. The series resistor value needs to be chosen with more scrutiny to get full utilization of the voltage control range.



PWM dimming

Changing the resistor to 24k ohms allows for fairly good PWM input control. The resistor is smaller since the PWM only goes to 5V. Tuning the series resistor value here would also be necessary for full range control.



Typical dimming frequency range 50Hz – 500Hz

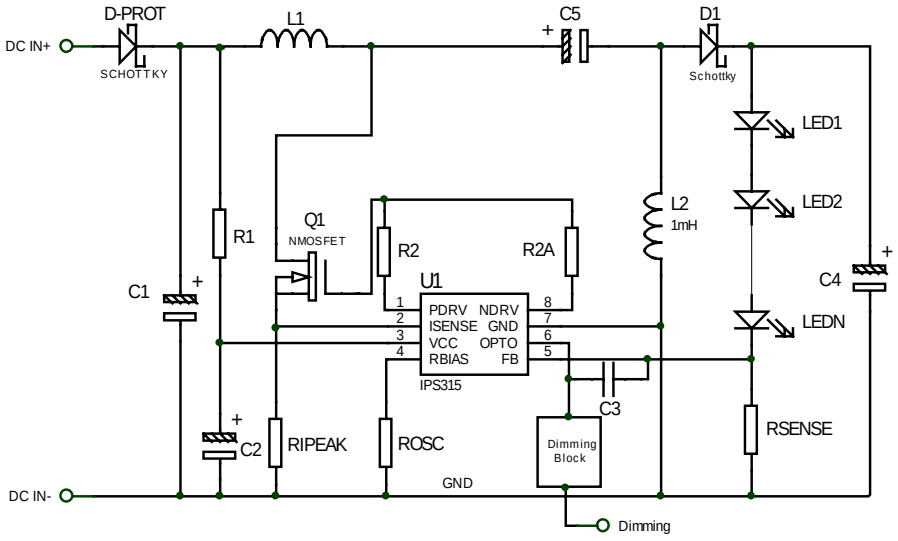


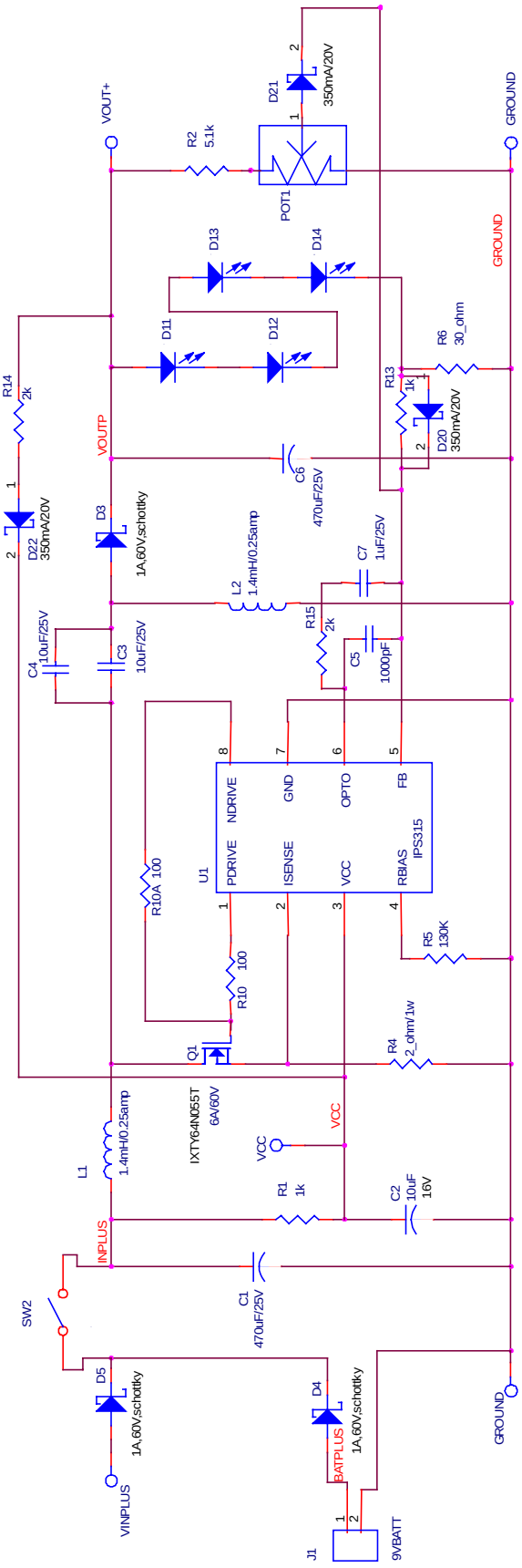
Fig.3: IPS315 SEPIC topology with dimming option

How to implement IPS315-based LED solutions

A list of topics for consideration for a typical implementation of an IPS315-based LED controller is:

- The IPS315 has a 0.925 volt nominal internal voltage reference. This is what is used for direct sensing of the current in the LED string. The FB pin is at this voltage in normal operation. The current sense resistor value is computed using this value: for example, for a string of LEDs operating at 30 milliamps, the sense resistor value should be 0.925V/0.03A = 31 ohms.
- The IPS315 has a shunt regulator for VCC, typically implemented using a series resistor off of the input voltage. Because we are referring to non-isolated applications, the VCC resistor off of the input voltage only needs to provide startup current if an additional diode/resistor is used off the output to provide the power for continuous operation. There is a need for a diode in order to prevent the output load from sinking the startup current. The shunt regulator acts like a 7.5 volt zener.
- If the input voltage range is very wide while using a single startup resistor, the current in the internal shunt regulator can become excessive. Adding a constant current source made from two bipolar transistors and two resistors can overcome this. Contact AAI Marketing for example schematics that show how this circuit is built.
- If VCC operating power is taken from the output, the input voltage can drop to lower values after startup and still have the power supply continue running. The demo board, for example, needs about 7.5 volts to start, but once operating will continue to function down to about 5.5 volts. In some applications, this could be a problem because an input battery is potentially being discharged to a very low level (completely drained). Some battery chemistries are more tolerant of this type of use than others.
- The amplifier in the IPS315 has a lot of gain at low-to-audio frequencies. Constant-current power conversion can have stability problems under these conditions. A 1uF cap may need to be added between the OPTO pin and the FB pin to slow the loop response. The OPTO pin is the output point for the amplifier inside the IPS315.
- Because of the high input impedance of the PB pin, dimming can be implemented at low power levels by sourcing a small amount of current into a net that connects the FB pin to a resistor added between the LED current sense resistor and the FB. A typical value for this resistor would be 1k (which is the value used on the IPS315 demo board). The demo board has two strings and uses the 1k resistors to provide an 'averaging' function (along with some diodes to provide a some protection against shorted LEDs. Because there are two strings, the demo board has an added diode/resistor from the switched LED string to try to provide a smoother dimming transition between one string and two string operation).
- Like the members of AAI's flyback IPS1x series, there is a pin for sensing the current in the main FET switch. The correct value of this switch current resistor is dependent on the power that the application is providing and the topology selected. The internal threshold voltage for this protection function is 700 millivolts.

Example of application: IPS315 SEPIC topology used in the IN-PLUG® DK315 Demokit



Application:
IPS315 SEPIC topology 1Watt application
VIN 7.5V DC to 18V DC
OUTPUT 14V DC / 60mA

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