A Low-Cost LED Driver Module, 0.5 A/33 V

For general use, with efficiency above 90%

This article describes a simple constant current driver module with fast PWM input that can be used for driving mid and high power LEDs.

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This module operates from 8V to 33V and the output current can be configured from 0.1 to 0.5A in several steps. Component selection is presented for design implementation.

Specification:
Topology: Buck
Regulation, Hysteretic
Input voltage: 8-33 VDC
Output current: 100-500 mA
Switching frequency: 1 MHz max
Current ratio: 0.13 Ohm / 1 A
Dimensions: 16 x 16 x 5.5 mm
(0.63 x 0.63 x 0.22 in)
Weight: 1.6 g
-Thermal shutdown
-Current protection
Dimming:
-PWM up to 20kHz

Short description
The LED driver module (Figure 1) utilizes the buck driver IC, TS19376 in the SOT89-5 package, as produced by Taiwan Semiconductor. This buck driver involves hysteretic regulation, thus it reach relatively high efficiencies, above 90%, without need for compensation. Output current is set by a combination of parallel R1-R3 (Figure1) with the ratio 0.13 Ohm/1 A.

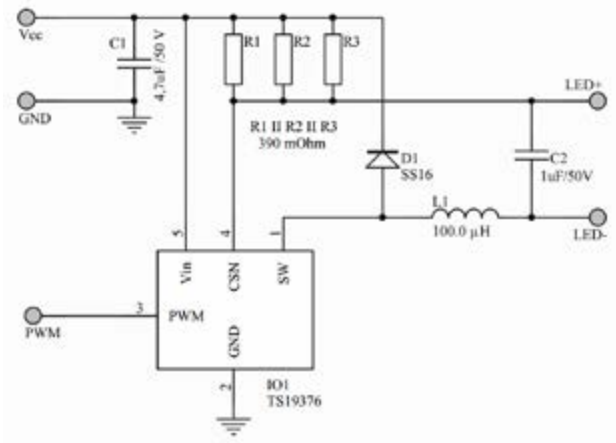

Figure 1: LED driver schematic

Hysteretic regulation, as outlined in [1] is summarized as: the internal switch of the TS19376 driver connects the input voltage to the load through inductor L1. Current through the inductor linearly increases and is monitored as the voltage drop on (R1 II R2 II R3). Once the voltage drop reaches 149.5 mV (130 mV + Vcsn_hys (15% = 19.5 mV)), the integrated switch turns off and current flowing through inductor and D1 linearly decreases until it drops down to 110.5 mV (130mV – Vcsn_hys (15% = 19.5 mV)), when the switch turns on again. This process repeats in cycle as shown in Figure 2.

The switching frequency is given by output current (ILED), input voltage (Vcc), output voltage and L1 value.

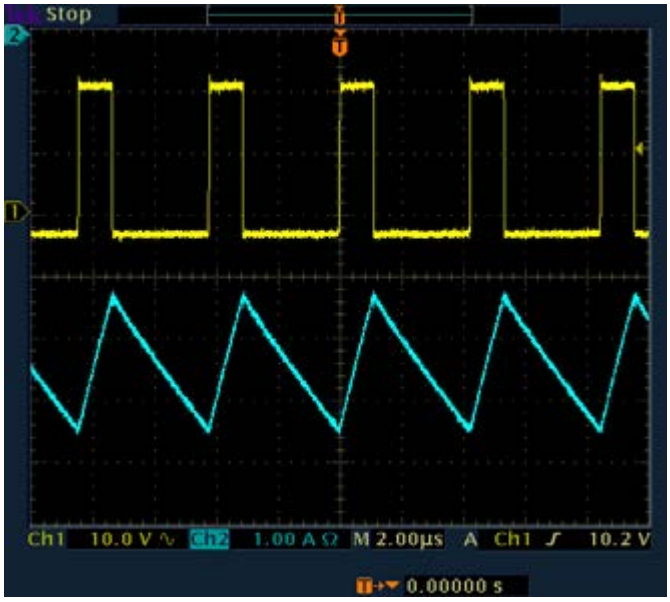

Figure 2: Current and voltage waveform at switching node (oscilloscope GND connected to Vcc)

PWM dimming

The average LED current can be controlled by the PWM signal. This type is popular and easily implemented through the MCU or by other techniques, such as a 555 timer. A PWM signal is connected to the PWM input of the module and accepts logical values Lo <0.3 V, Hi > 2 V (CMOS). The TS19376 accepts relatively high PWM frequencies and therefore it is not a problem to realize fast PWM dimming with more than 8 bit resolution.

The PWM input has a pull-up resistor, therefore once the PWM input of the module is unconnected, ILED reaches the maximum current value. Recommended PWM frequency is above 100Hz, because of visible flickering.

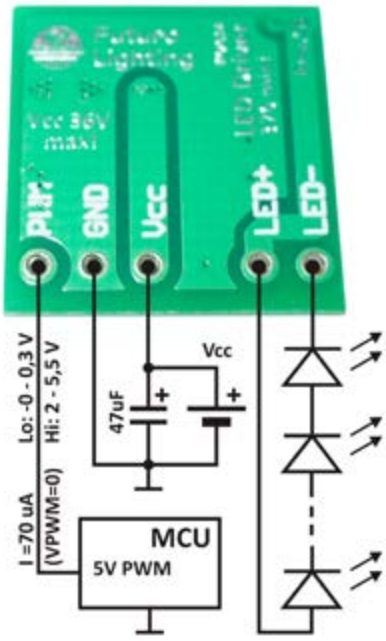

Figure 3 LED Driver module connection diagram

Practical realization

The TS19376 requires a cooling, such as is formed by the cooper layer on the back side of the PCB, thermally connected with top side through vias. A low ESR input capacitor is required to suppress current spikes during driver switching. The recommended value for C1 is 4.7 to 100 uF and dielectric material should be chosen from X7R, X5R or better. C1 must be placed as close as possible to the IO1 supply pads.

The optimal range of the L1 inductance is 47 -120 uH, where lower inductance is more appropriate for higher currents and higher inductances are more appropriate for lower currents, in order to eliminate switching delay. Placement of the components should follow normal design rules to obtain the lowest switching loop, in order to minimize EMI. The start of the inductor winding should be connected to switching node (SW pad of IO1) as well.

D1 was selected to keep leakage current low at the highest expected operational temperature, and a low trr. D1 Forward voltage influences efficiency and a lower Vf results in higher efficiency and lower heat dissipation.

It is recommended to use a 30% margin for maximum forward diode current as compared to ILED. In this case, SS16 (1A / 60V), from Taiwan Semiconductor, was selected.

C2 capacitor suppress output current ripple, where its higher capacity results in lower ripple and lower PWM frequency. It should be noted that the value of C2 influences maximum PWM frequency.

The TS19376 includes thermal shutdown. Once die temperature reaches 150°C, the driver is disabled until temperature drops below 115°C. This protection is useful to prevent burning of the module PCB. The driver module can be attached to a heat-sink by two-sided thermo-conductive tape (e.g. Bergquist Bond Ply). It is possible to extend the driver module with an EMI filter and reverse protection (e.g. a P-MOS switch), but this depends on specific application requirements. The Driver module is populated on double-sided FR4 PCB, with 1 mm thickness and dimensions of 16x16 mm.

Conclusion

Dhis LED driver has numerous applications, from driving of mid and high power LEDs, through battery charging and others where a constant current source is required. The number of LEDs in a serial string is determined from minimum allowed input voltage (Vcc). As can be seen from Fig.4, close VLED string to Vcc offers higher efficiency. For example for Vcc=12V, 3xLED in series is a good choice (VLEDF~3V). All measurements were acquired on an automatized measurement equipment at room temperature.

This LED driver module, with selectable output current from 0.1 to 0.5 A, is available for purchase through the FuturoLighting store [2]. The TS19376 and diode SS16 can be purchased in MOQ from Microdis Electronics [3], authorized distributor of Taiwan Semiconductor.

At conclusion, I would like to thank Mr. Bilik from Wurth Elektronik and Mr. Reguli from Microdis Electronics for their great support on this project.

BOM

IO1	TS19376,Taiwan semi
C1	4u7/50V (X7R, SMD 1210)
C2	1uF/50V (X7R, SMD1206)
D1	SS16, Taiwan semi
L1	Wurth 74404064101
R1	0.39 Ohm (SMD 0805)
PCB	FuturoLighting 376, Rev.O

Literature

[1] www.taiwansemi.com
[2] www.fulit.eu/store
[3] http://www.microdis.net/