APPLICATION IDEAS: DRIVING LEDS USING L497X, L597X, L692X DC-DC CONVERTERS FAMILIES

by A. Maggioni, M. Merisio

1 INTRODUCTION

Light Emitting Diodes (LEDs) are becoming more and more popular in a variety of different applications:

- Mobile appliances
  - Mobile phone screen and keyboard backlight
  - PDA and digital camera backlight
- Signs and displays
  - Advertising signs
  - Traffic variable messages signs
- "Automotive applications
  - Interior application: lights for instrumental panel and dashboard
  - Exterior lighting stop/turn/tail lights
- Signals
  - Traffic signals
  - Arrows and pedestrian signals
- Illumination
  - Flashlights
  - Architectural lighting
  - Emergency lighting

Despite the different final application we can draw a line between 2 major LEDs Drivers topology: powered by AC source or by DC source.

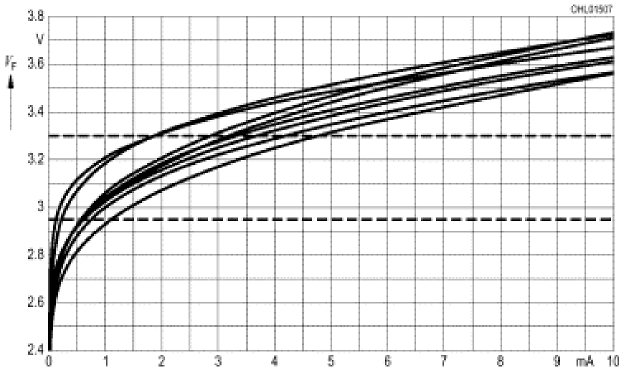
This paper will focus on the devices suitable to drive LEDs from a DC source.

We will refer mainly to white LEDs, that are characterized by a forward drop ~3-4V and currents ranging from few tenths mA to nearly 1A.

2 DRIVING LEDS

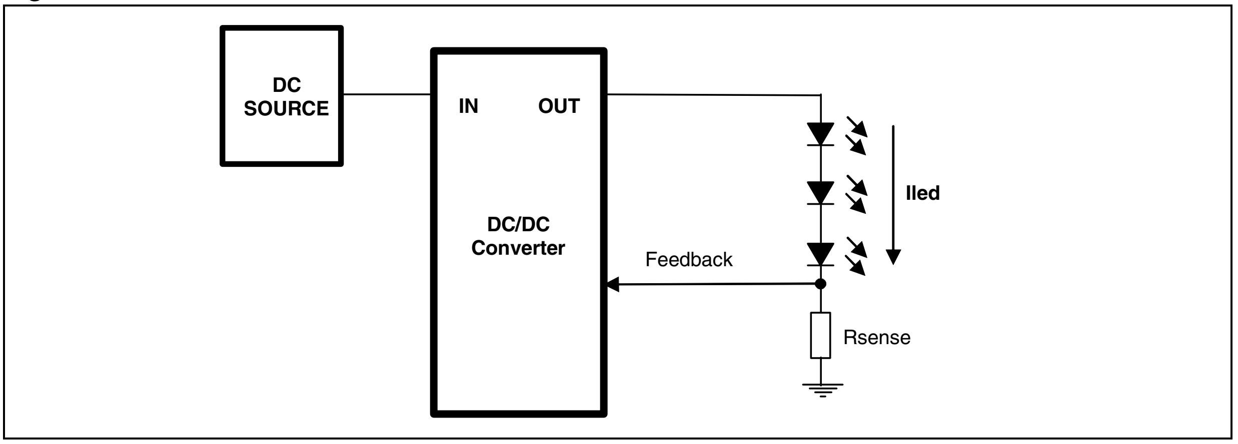
LEDs have to be current driven, because the forward voltage variance can be greater than +/-100mV given the same forward current. This can lead to poor current and brightness matching in configuration where currents are not regulated (Fig. 1)

Figure 1.



LEDs can be driven in series (see Fig. 2) or in parallel (see Fig 3).
Both solutions show advantages and disadvantages:

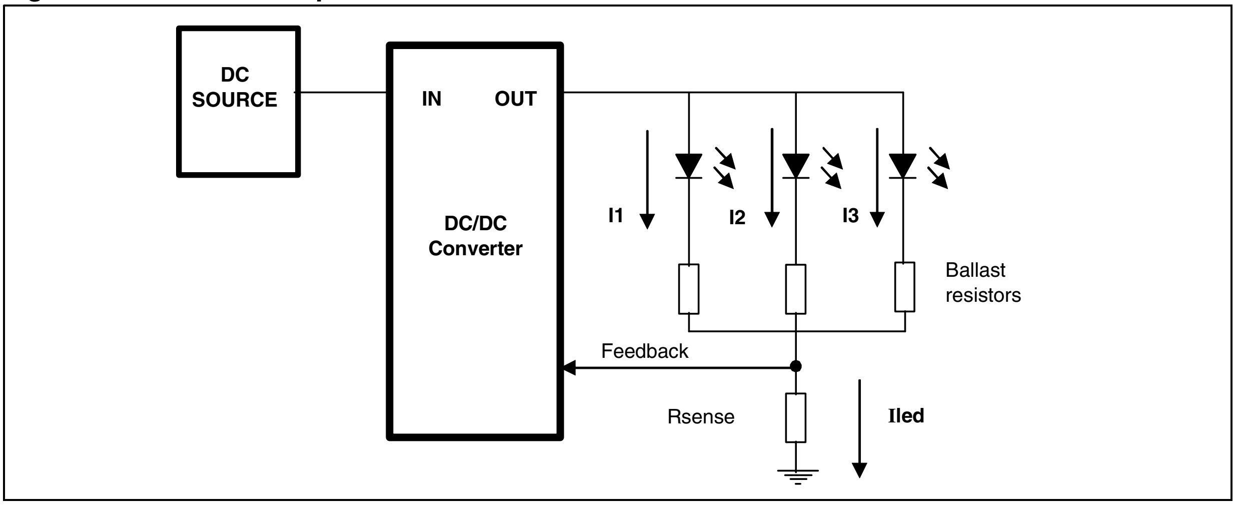
Figure 2. LEDs driven in series.



Driving in SERIES:

- We have uniform brightness since the same current flows through all the diodes
- The LEDs forward drops add together causing a high total voltage drop.

Figure 3. LEDs driven in parallel



Driving in PARALLEL:

- It requires a lower voltage (one forward drop)
- The LED - to - LED voltage drop variation can cause a variation in the brightness between the LEDs. The so called "ballast resistors" are used to match the current through all the LEDs, but affects the efficiency.

The choice of the most suitable DC-DC converter depends both on the chosen topology and on the DC source.

The main difference can be drawn between battery powered application and the applications powered by a pre-regulated DC bus.

2.1 DC BUS SUPPLY.

Most of automotive and lighting application belong to this category.
The most common input voltages are 12V, 18V, 24V and 48V .
For these application we suggest to use L497x and L597x/L6902 families of step down monolithic DC-DC converters.
Here a table summing up the devices characteristics (devices are grouped by families and sorted by output current):

Table 1.

device	Iout (A)	Vout (V)	Vin (V)	Fsw (KHz)	Features useful for LEDs	packages
L4976	1	0.5 to 50	8 to 55	Up to 300	5.1V Vref	Minidip/SO16W
L4971	1.5	3.3 to 50	8 to 55	Up to 300		Minidip/SO16W
L4978	2	3.3 to 50	8 to 55	Up to 300		Minidip/SO16W
L4973x3.3	3.5	0.5 to 50	8 to 55	Up to 300	5.1V Vref	DIP18/SO20
L4973x5.1	3.5	5.1 to 50	8 to 55	Up to 300		DIP18/SO20
L6902D	1	0.5 to 35	8 to 36	250	Constant current control, 3.3V Vref	SO8
L5970D	1	0.5 to 35	4.4 to 36	250	3.3V Vref	SO8
L5972D	1.5	1.23 to 35	4.4 to 36	250		SO8
L5973AD	1.5	0.5 to 35	4.4 to 36	500	3.3V Vref	HSOP8
L5973D	2	0.5 to 35	4.4 to 36	250	3.3V Vref	HSOP8

There are many criteria to select the most suitable device: of course input voltage range, output current capability, output voltage range (according to the number of serial LEDs) - as in standard DC-DC converter choice.
But there are characteristics that can be better exploited in LEDs driving: the first one is the presence of a voltage reference VREF (when available).
As we have to control the LEDs current L6902 with its current loop control could be the best choice - if all the other IC parameters can fit the application requirements.
Otherwise to regulate the LEDs current we can use a standard Step Down configuration, substituting the upper resistor of the output resistive divider with the LED (s). The remaining resistor will work as SENSE resistor, and it will be used to program the LEDs current :

$$I_{LED} = \frac{V_{SENSE}}{R_{SENSE}}$$

As the application efficiency is defined as:

$$\eta = \frac{V_{LED} \cdot I_{OUT}}{V_{IN} \cdot I_{IN}}$$

the smaller the losses on the R_{SENSE} the higher the efficiency. In order to decrease the losses we have to make the drop across the R_{SENSE} as small as possible.
If a device has no V_{REF} available, the drop across the R_{SENSE} will be V_{FB}.
If there is a reference voltage available, it can be connected to the R_{SENSE} via a resistive divider, and the drop across R_{SENSE} will be:

$$V_{SENSE} = V_{FB} - \frac{V_{REF} - V_{FB}}{R_1} \cdot R_2$$

We will show in the application ideas using L5970D and L4973 how this characteristic can be really useful in improving the efficiency of the application.

Here some application ideas with key characteristic highlighted:

2.1.1 L6902D application idea

Figure 4. L6902D application idea

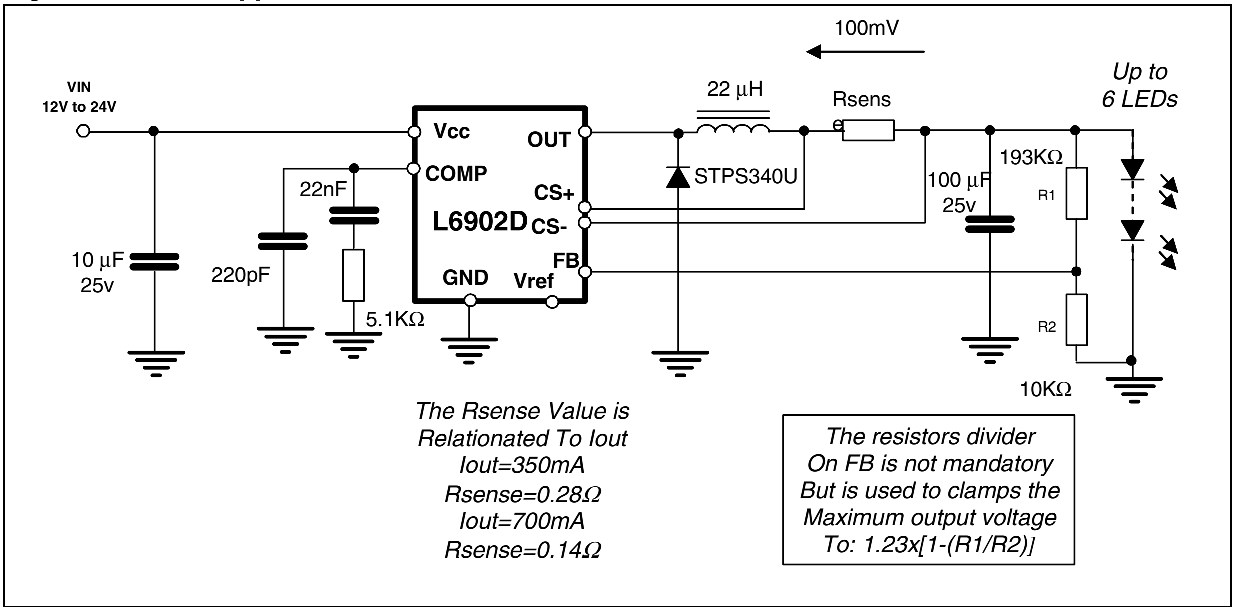


Table 2.

efficiency	1 LED	2 LEDs	3 LEDS	4 LEDs	5LEDS	6LEDs
Vin=12V						
Iout=350mA	75%	89%				
Iout=700mA	89%	90%				
Vin=18V						
Iout=350mA		86%	89%	96.5%		
Iout=700mA		88%	92.5%	94.5%		
Vin=24V						
Iout=350mA		84%	88%	90%	94%	97.5%
Iout=700mA		86%	92.5%	93.5%	95%	96.5%

2.1.2 L5970D application idea

Figure 5. L5970D application idea

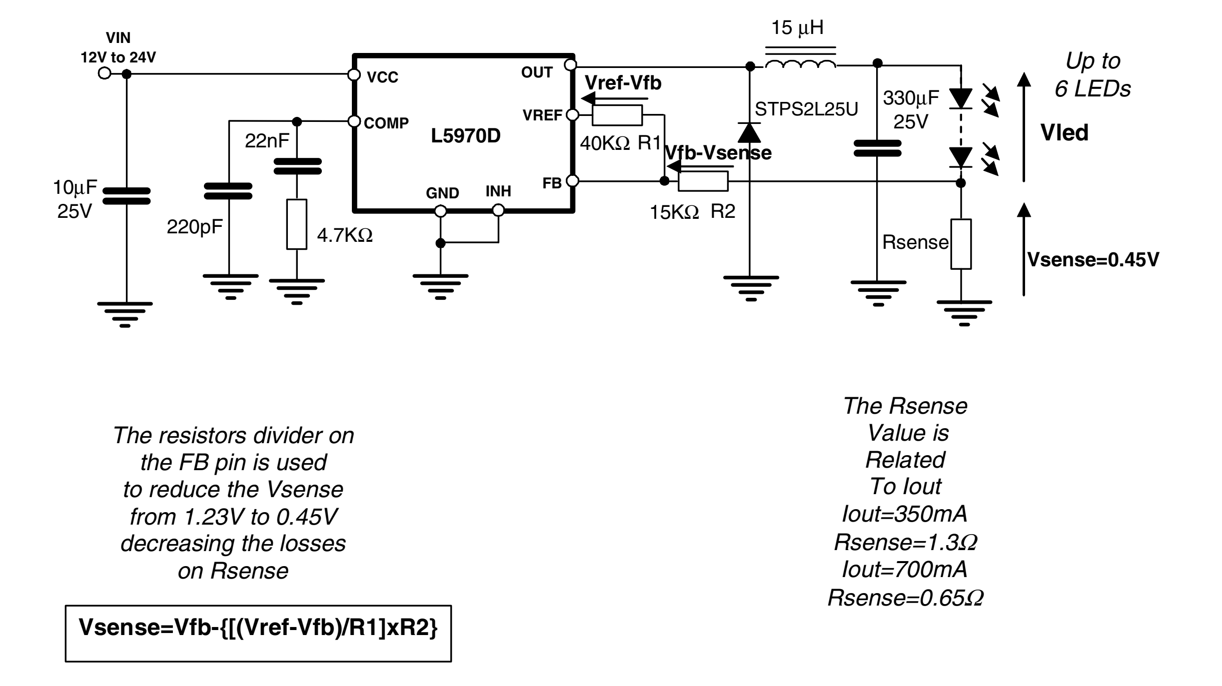


Table 3.

efficiency	1 LED	2 LEDs	3 LEDS	4 LEDs	5LEDS	6LEDs
Vin=12V						
Iout=350mA	76%	89%	93.5%			
Iout=700mA	77%	88%	90.5%			
Vin=18V						
Iout=350mA		83.5%	90%	95%	90%	
Vin=24V						
Iout=350mA			86.5%	90%	94.5%	97.5%
Iout=700mA			87%	90%	93.5%	96%

2.1.3 L4973 application idea

Figure 6. L4973 application idea

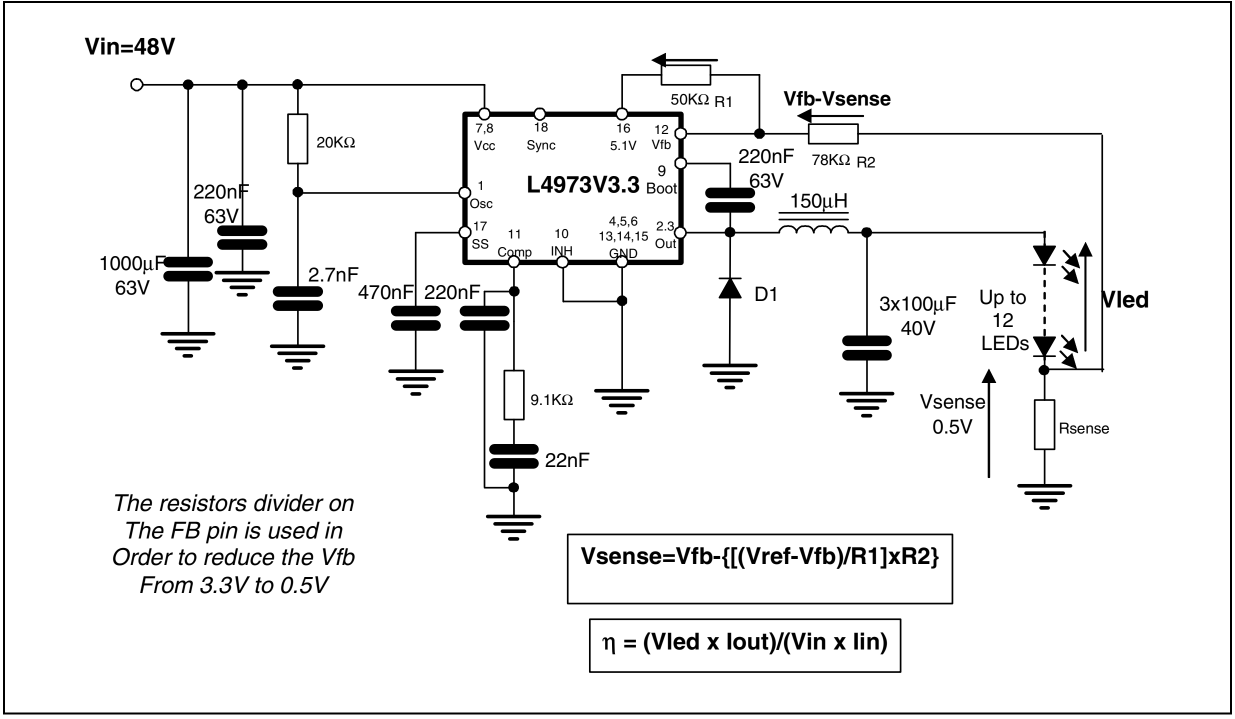


Table 4.

	I_{OUT}=0.35 A	I_{OUT}=0.7 A	I_{OUT}=1 A	I_{OUT}=2 A
12 LEDs	98%	96.5%	97%	96.5%
10 LEDs	94.3%	96%	96.5%	96%
8 LEDs	95%	96.5%	96.5%	95%

2.2 BATTERY POWERED APPLICATIONS

Battery powered application are characterized by lower input voltages compared to the applications shown in the previous pages.

As a consequence buck topology is not the commonest topology - boost or buck/boost topologies are often required.

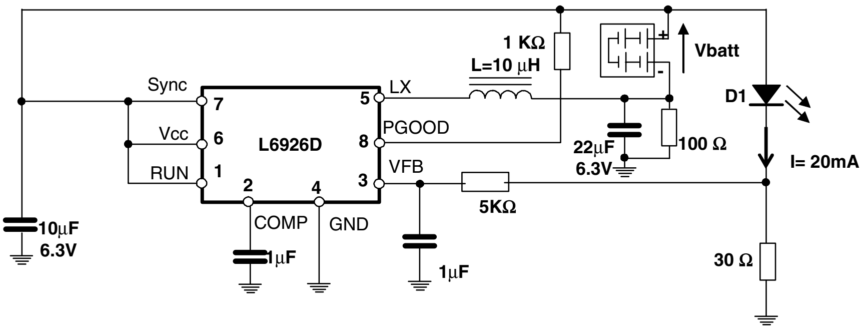
We will focus our application examples on L692x family, including a step up converter (L6920D) and step down converters (L6925D/L6926D) that can be used in both boost and in buck/boost topology.

We will go through application ideas showing how to use this devices in applications with 1 to 10 LEDs, using external references, true shutdown , and dimming.

- Application Ideas using L6926D in boost topology
- Application Ideas using L6926D in Positive Buck Boost Topology
- Application Ideas using L6920D

2.2.1 L6926D in Boost Topology:

Figure 7. Application Idea : driving one white LED



Vbatt (V)	2.8	3	3.2	3.4	3.6	3.8
Eff(%)	64.6	68.4	71.3	73.7	73.5	72.8

Figure 8. Application Idea: dimming control using an analog voltage

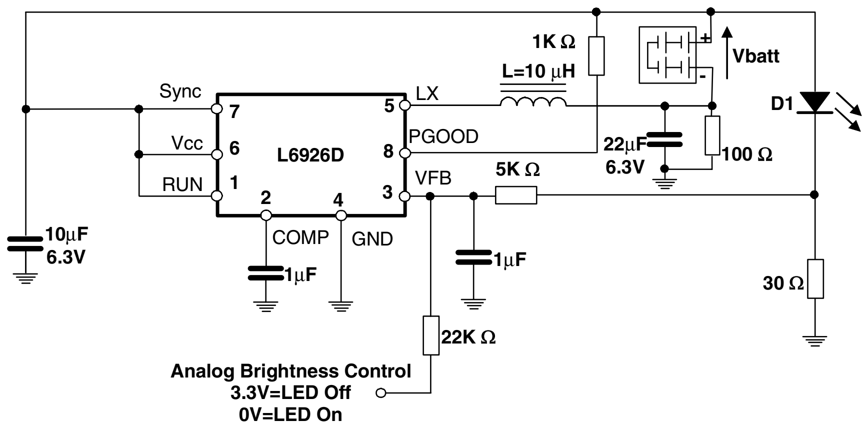
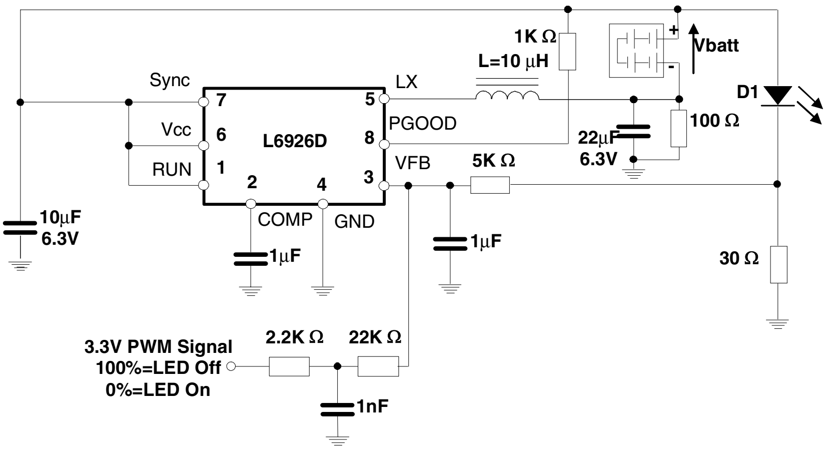
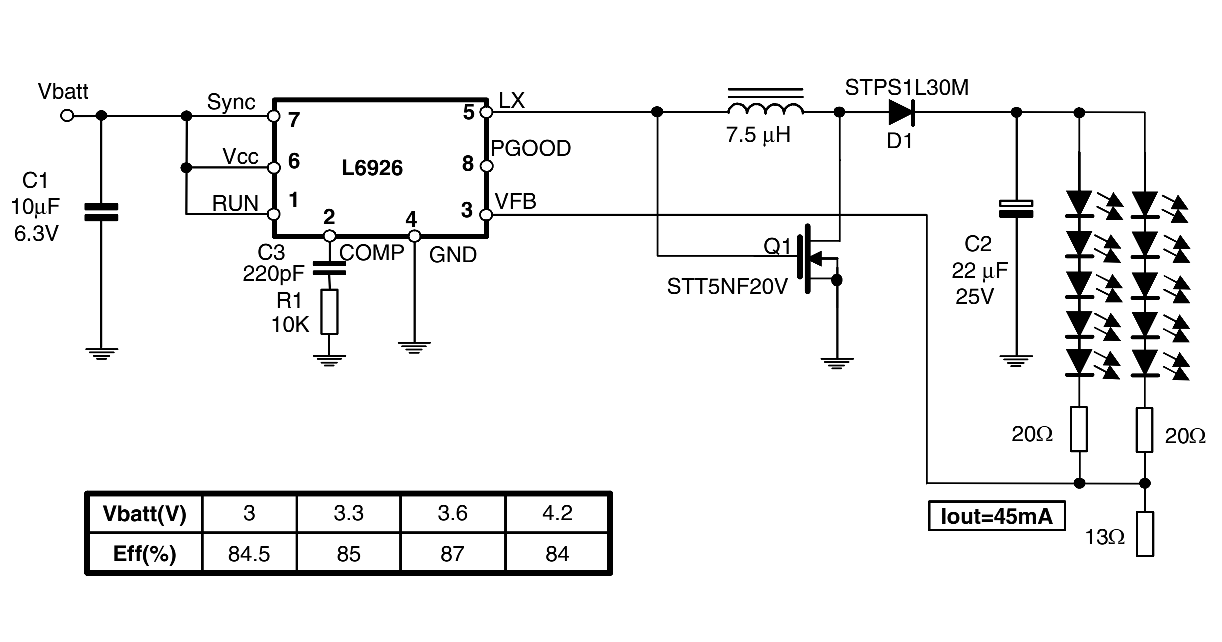


Figure 9. Application Idea: dimming control using PWM signal



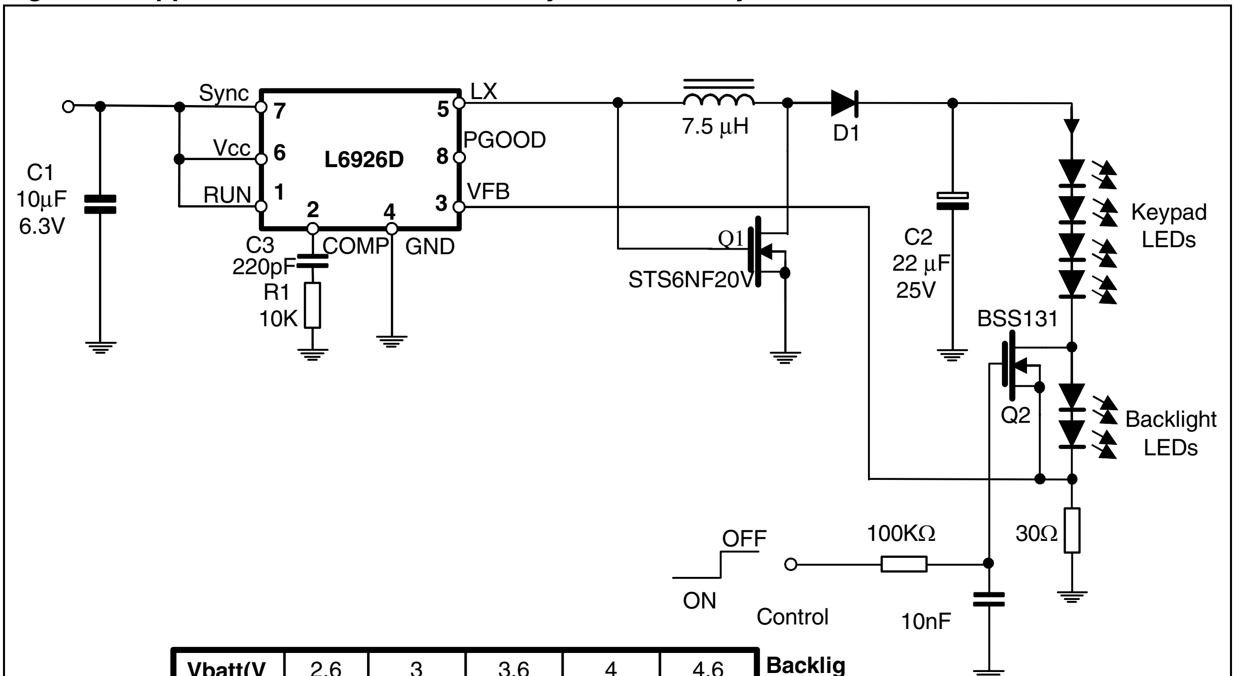
2.2.2 L6926D in Positive Buck Boost Topology

Figure 10. Application Idea: Powering 10 LEDs



Vbatt(V)	3	3.3	3.6	4.2
Eff(%)	84.5	85	87	84

Figure 11. Application Idea: Two LEDs arrays controlled by an external switch



Vbatt(V	2.6	3	3.6	4	4.6
Eff(%)	68.4	68.4	67	67	66,7

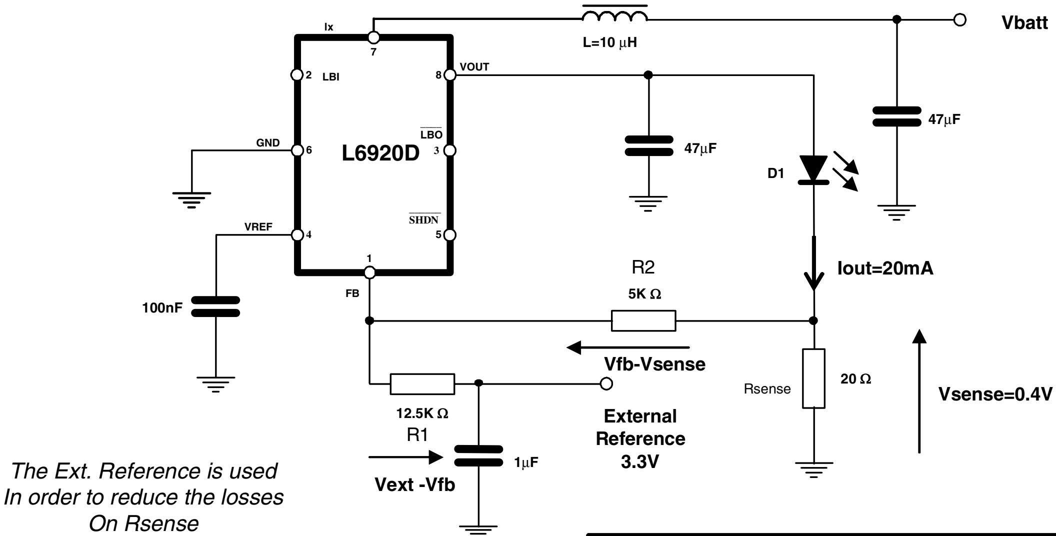
Backlight OFF

Vbatt(V	2.6	3	3.6	4	4.6
Eff(%)	67.8	70	68.4	68.2	73.5

Backlight ON

2.2.3 L6920D Application Ideas

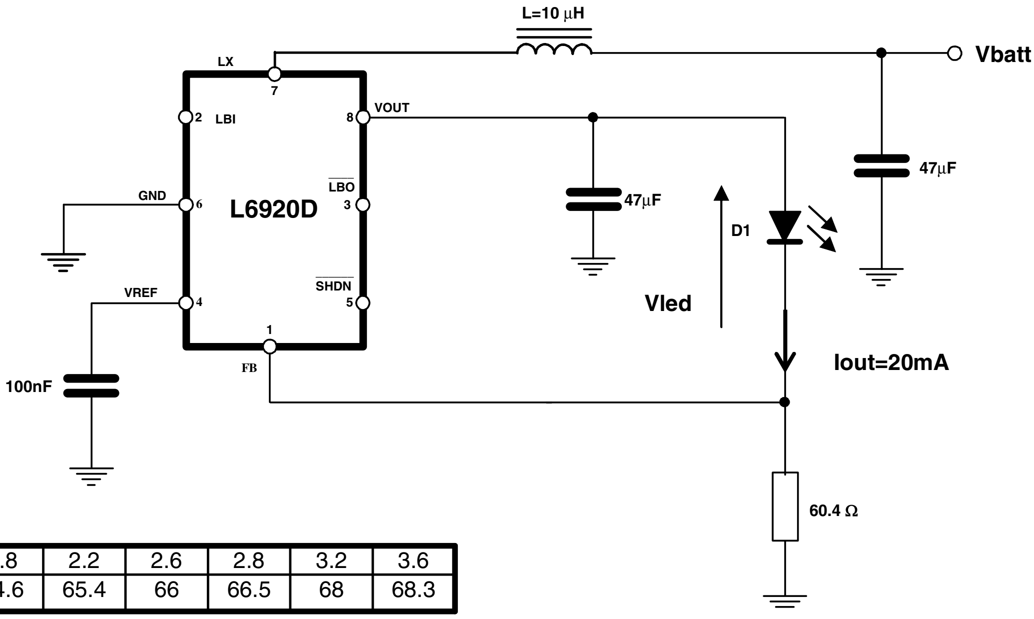
Figure 12. ApplicationIdea: driving one white LED with external reference



Vsense=Vfb-{[(Vext-Vfb)/R1]xR2}

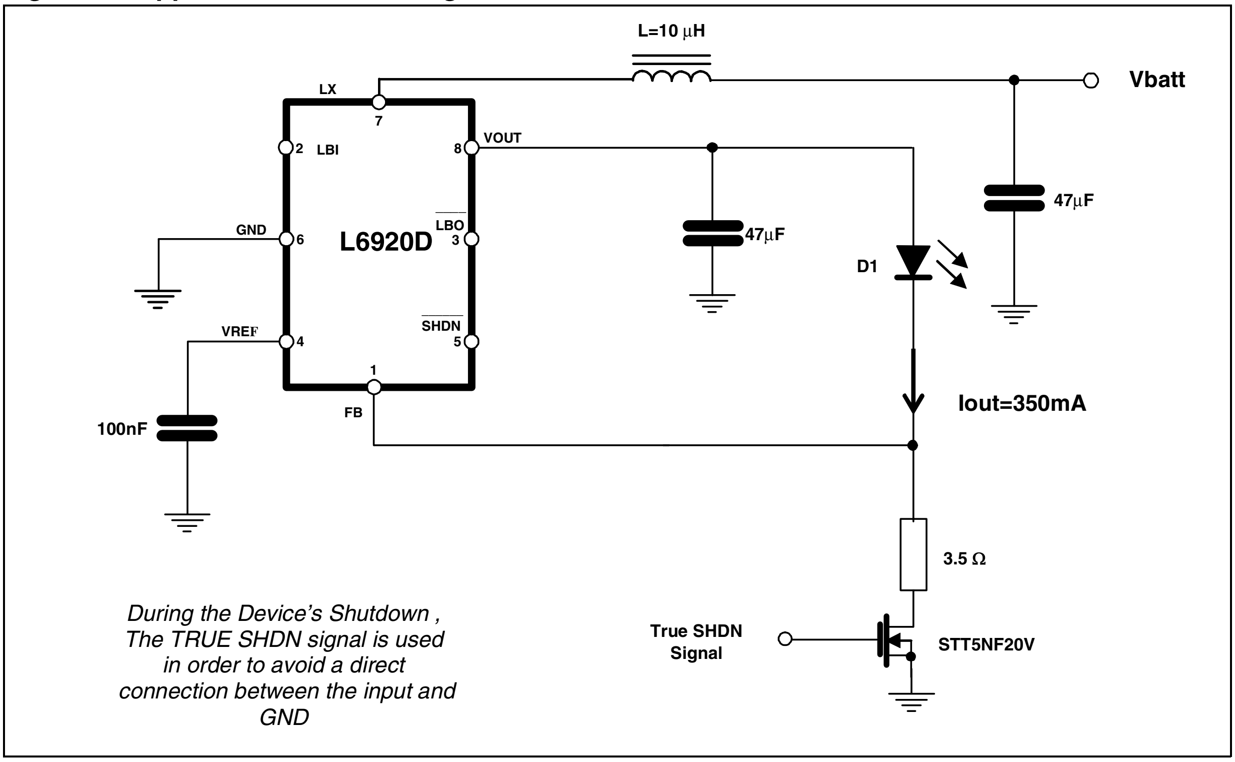
Vbatt (V)	1.8	2.2	2.6	3
Eff (%)	79	79.7	79.8	81

Figure 13. Application Idea: driving one LED



Vin (V)	1.8	2.2	2.6	2.8	3.2	3.6
Eff (%)	64.6	65.4	66	66.5	68	68.3

Figure 14. Application Idea : Driving one LED with True Shutdown



3 CONCLUSION

The aim of this paper is to show how monolithic DC-DC converters can be used to drive LEDs.

The right choice between all the ICs belonging to L497x, L597x and L692x families depends on the final application requirements: (power source, number of LEDs, additional functions….)

This paper shows only few application ideas about LEDs driving: you may find much more details on the specific ICs in the dedicated Datasheet and Application Notes available on ST web site.

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