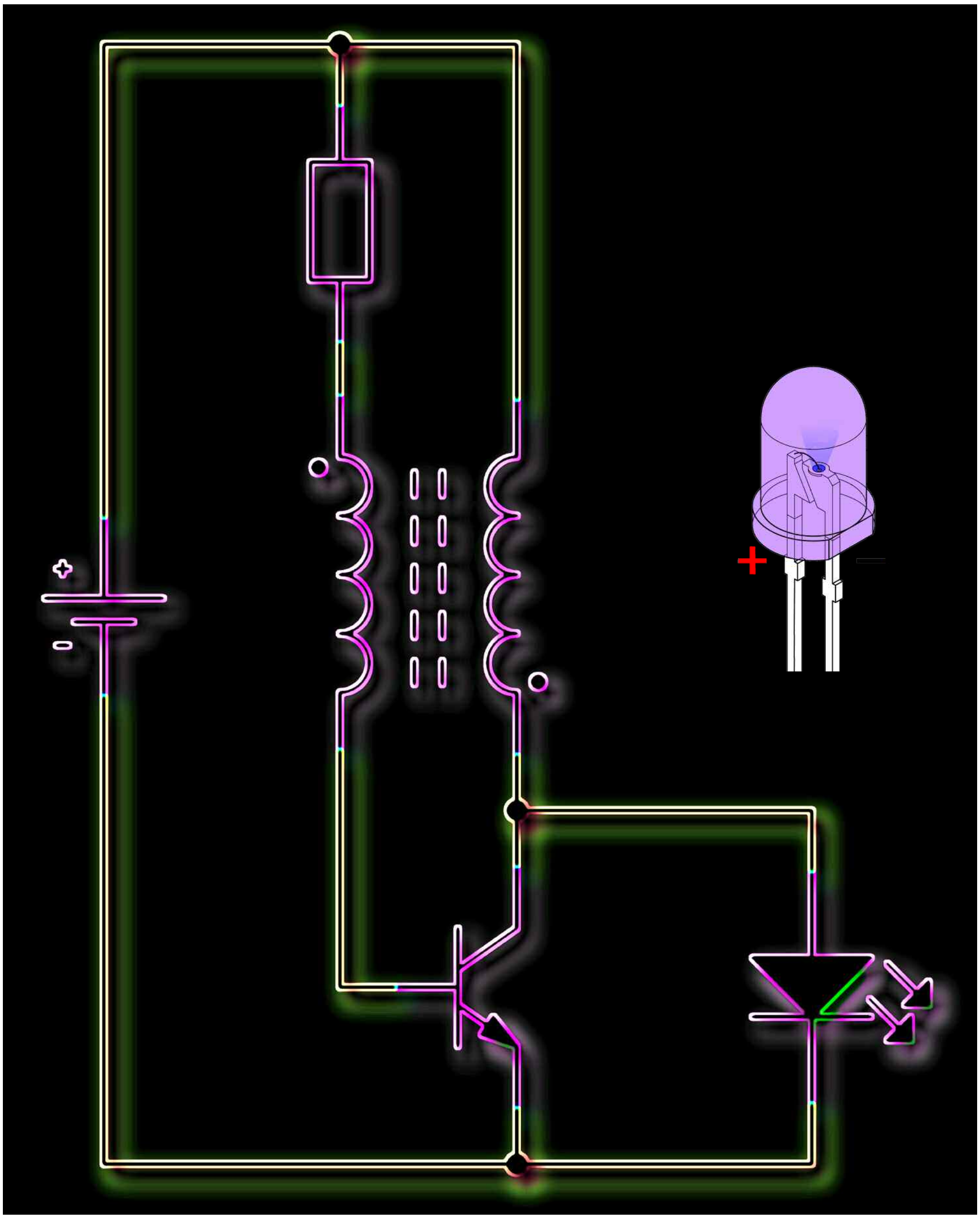
# Joule Thief
# DC-DC converters
# LED drivers
# Knipperlicht schakelingen

## deel 2

Energie besparing, verlichting, zaklantaarn, groeilamp, zonnecellen, tweede leven voor uitgeputte batterijen, Step-Up - Boost drivers, licht in het donker, tuinverlichting, LED's, Astabiele Multivibratoren, Energy Harvesting etc.



# Joule Thief uit het Pools

https://web.archive.org/web/20171030234220/http://flagiusz.republika.pl/joulethief/sim.html

START VAN VERTAALDE INTERNETPAGINA

**Joule Thief - simulations of different versions of the layout**

This part of the website devoted to the analysis of the Joule Thief system and its numerous variants is intended for more advanced people who want not only to understand how they work, but also to find out the answer to a number of naturally arising questions:

- Which layout is better?
- Which of them will have the highest efficiency, and which will we be able to obtain the highest current efficiency?
- How to choose the optimal values of the elements?

These are very good questions that can be answered by performing a series of time-consuming trials and tests on a "live" circuit. Such systems can also be subjected to computer simulation, which will tell us which way to go to achieve the intended goal.

There are many electronic circuit simulators. Not all of them cope well with oscillatory systems, as well as with the difficult problems of couplings on inductive elements - and such are the problems in the systems analyzed here.

One of the best in terms of simulation accuracy and generally available is the Spice program, known for many years.
I use the **LTspice IV** version available on the website of a market-leading electronics manufacturer, Linear Technology.

LT SPICE TV LINK
https://web.archive.org/web/20171102173425/
http://www.linear.com/designtools/software#LTspice

LINEAR TECH LINK (Analog Devices)
https://web.archive.org/web/20171031183812/
http://www.linear.com/

NIEUWE LINKS
https://www.analog.com/en/design-center/design-tools-and-calculators.html

https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html

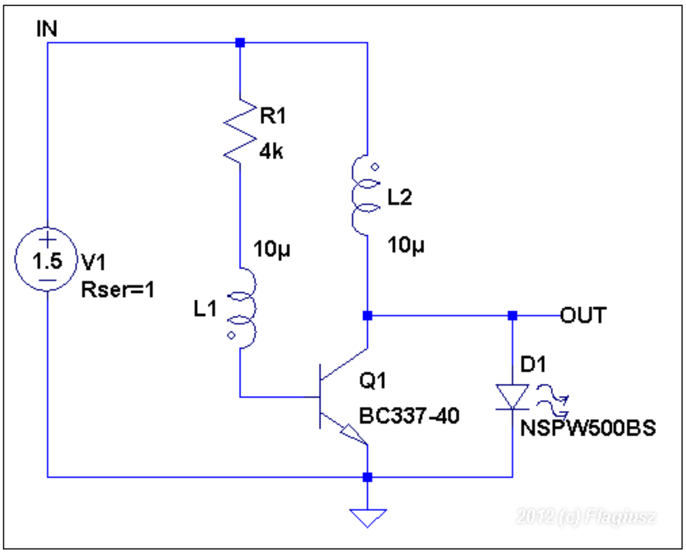
https://www.analog.com/en/index.html

This program includes everything you need. We have a schematic editor (in the past we had to describe connection graphs in a text file), we have an analyzer (the main part of the Spice engine), we have waveform visualizations, we also have a very rich collection of libraries of electronic components and circuits - so we have everything we need.

To make the simulation conditions as close to reality as possible, in all cases I used the real resistance of the supply voltage Rs = 1Ω
The values of the elements have been selected so that for all systems with a supply voltage of 1.5 V, the current flowing through the LED was about 20 mA.

“ So let's go ! “

## Joule Thief - basic layout




Schematic diagram

The first to be simulated was the basic version of the system, consisting of the minimum number of elements and the simplest transformer with the same number of turns in both windings.

Waveform diagrams: system start and stable operation.

The control of the LED diode, as shown in the attached diagram, is pulse-driven.

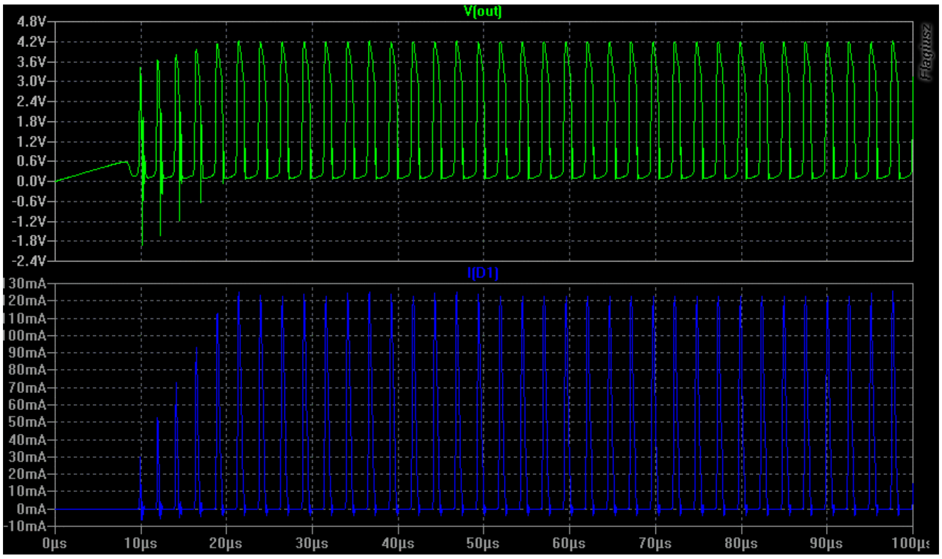
LED current average value:
~ 20mA (peak ~ 120mA)
- efficiency: ~ 63%
- for R1 = 5k6

Waveform diagrams: system start and stable operation

Vin [V]
0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 **1.5** 2.0 2.5 3.0

ILED [mA]
- 1.8 3.5 5.4 7.4 10 12 15 18 **20** 36 63 48

Eff. [%]
- 42 50 55 58 59 62 62 63 63 **63** 67 55

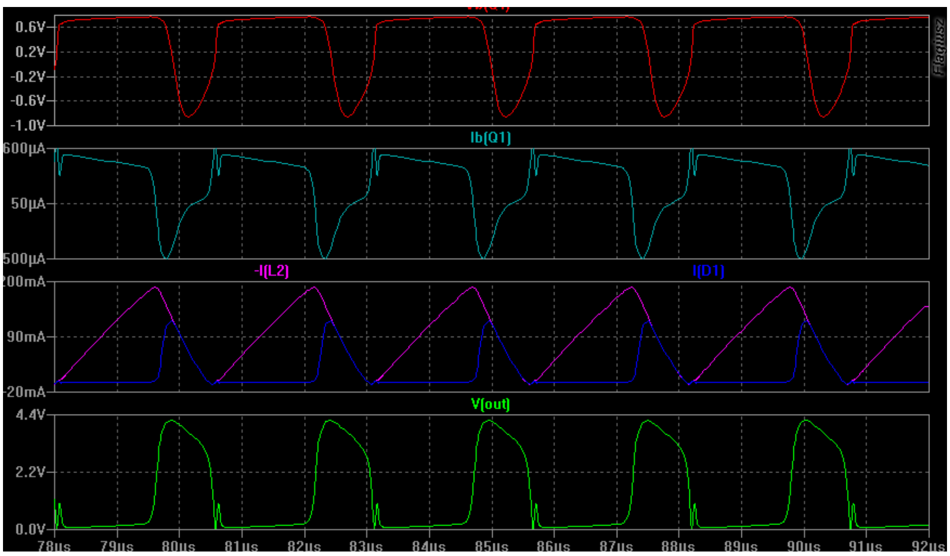


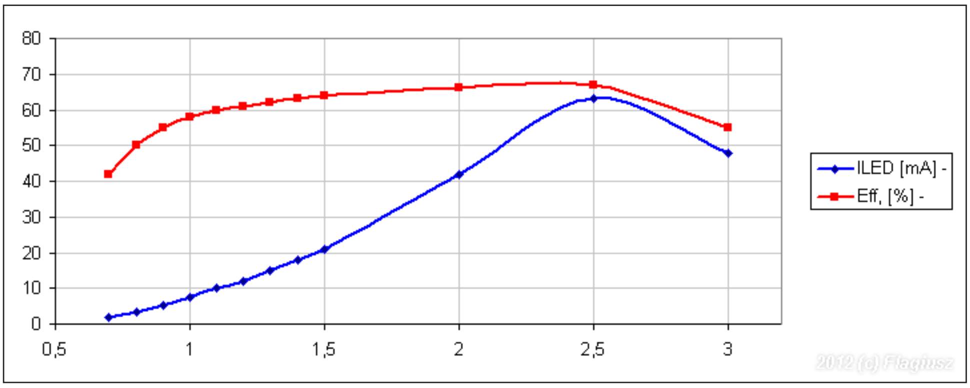

Maximum achievable LED current at Vin = 1.5V:

~ 50 mA (peak ~ 600 mA)
- efficiency: ~ 76%
- for R1 = 250 Ohm.

Download data files for simulation, version 4:

http://flagiusz.republika.pl/joulethief/JT_basic.asc



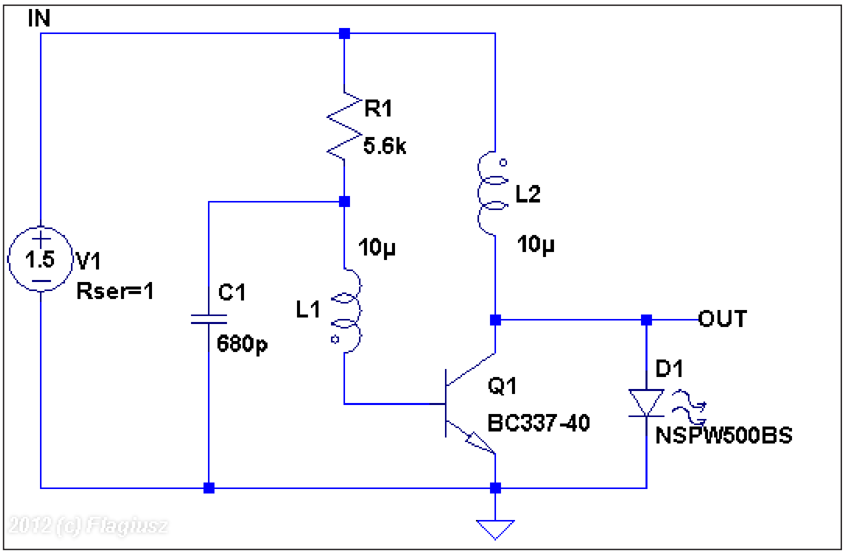



## **Fast Joule Thief - fast version** (by Flagiusz)

A capacitor C1 has been added to speed up the switching of the transistor.

Thanks to it, the dynamic impedance in the transistor's base control circuit was significantly reduced, as a result of which the transistor switching caused by the current induced in L1 changing with time was accelerated.

The faster switching transistor (from clogging to saturation and back) works less in the linear range, which results in lower losses and higher efficiency.



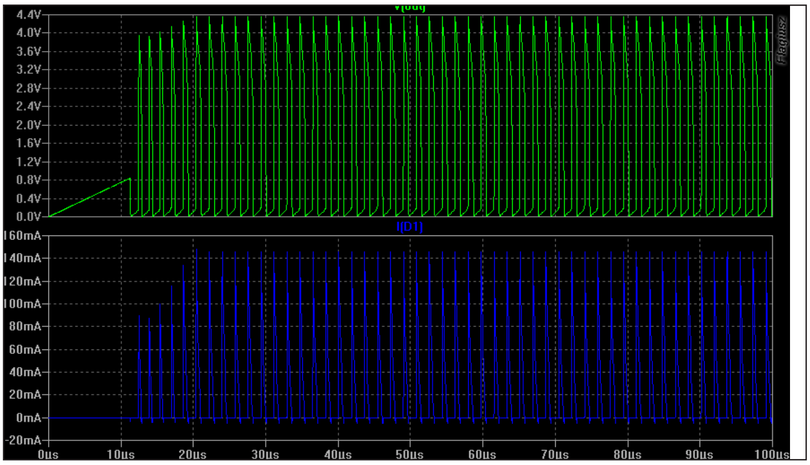

Here, too, the LED diode is impulse-controlled, and thanks to the faster switching of the transistor, the efficiency of the entire system has significantly increased.

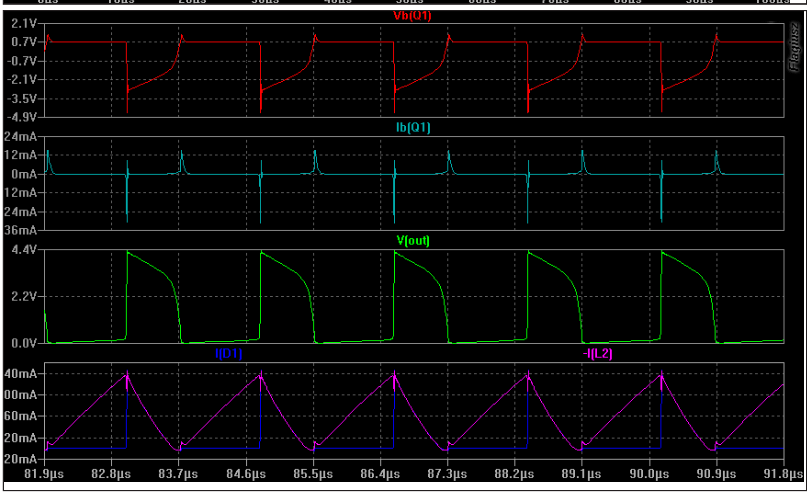
LED current average value:

~ 21mA (peak ~ 150mA)

- efficiency: ~ 92.8%

- for R1 = 5k6




Vin [V]

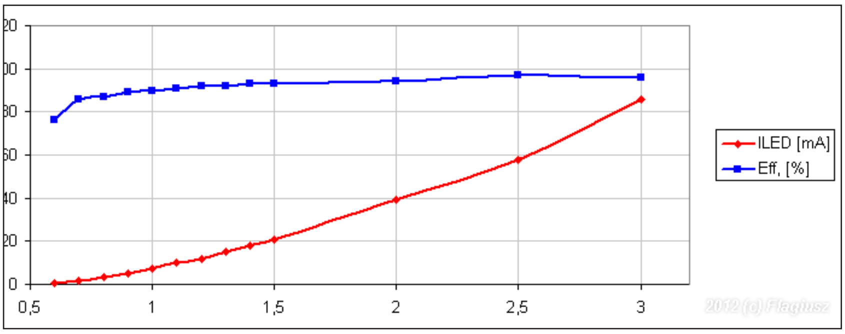
0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 2.0 2.5 3.0

ILED [mA]

0.5 1.7 3.3 5.2 7.3 10 12 15 18 21 39 58 86

Eff. [%]

76 86 87 89 90 91 92 92 93 93 94 97 96




Maximum achievable LED current at Vin = 1.5V:

~ 50mA (peak ~ 600mA)

- efficiency: ~ 81.8%
- for R1 = 250

Download data files for simulation.

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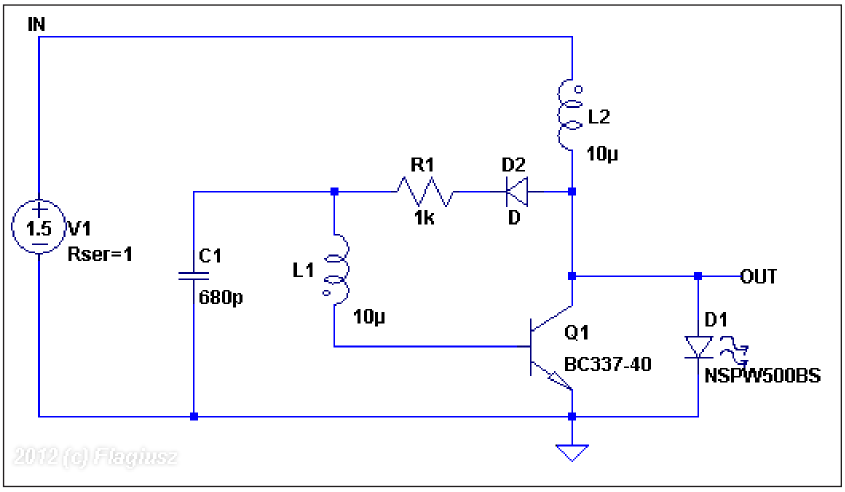
**Supercharged Joule Thief** (by A. Watson)

Schematic diagram




Another interesting modification of the basic JT system is the Supercharged Joule Thief (SJT) developed by A. Watson.

LINKS in this text:
RustyBolt.info/wordpress

https://web.archive.org/web/20160820054134/
http://rustybolt.info/wordpress/?p=221

The branch that controls the base current of the transistor Q1 has changed, and it is no longer powered directly from the positive pole, but via the D diode from the point behind the L2 coil.

This connection introduces a strong positive feedback which helps to turn on the transistor as quickly as possible, causing it to immediately go from clogged to saturated.

**The entire cycle works as follows:**

when the transistor is turned off, the current flowing in the branch from + V1 through L2, D and R1 charges C1.

when the voltage on the capacitor exceeds the value of approx. 0.7V required for the polarization of the B-E junction of the Q1 transistor, the current that opens the Q1 transistor begins to flow through L1.

As a result, the second branch is created: + V1, L2, Q1 (c-> e) through which the current increases with time this current, flowing through L2, induces the electromotive force in the magnetically coupled L1, in such a way that it maintains the current flowing through the base of Q1, compensating for the falling voltage on the discharging C1.

When the current flowing through L2 is not able to increase further (reaching the maximum current efficiency of the power source, reaching the maximum current for Q1 or saturation of the L2 / L1 core), the interaction generating the electromotive force in L1, which supported Q1 in the fully open state (saturation ).

The transistor, devoid of polarization current, begins to close.

The energy stored in the core begins to be released, as a result of which the coil L1 begins to generate current towards the collector and the anode of diode D2 and diode D1 (LED)

Disimilarly, the L1 winding tries to "suck" the current from the base of Q1, causing it to turn off immediately

The transistor's B-E junction becomes reverse biased and the current through L1 is unable to flow

The only outlet for the energy stored in the core is the current flow through the L1 branch

Until then, the D1 (LED) diode was not conducting - it was not lit because the voltage on it was too low (supply voltage 1.5 V < Vf for the LED - for blue and white Vf it is about 2.8-3.2 V )

L1 striving to return the stored energy causes an immediate increase in the potential of the point at the interface of the collector Q1 and the anodes D and D1 (LED), causing a voltage there that allows the LED to start conducting (> Vf)

So the current begins to flow through: the power source, L1, which gives off the stored energy, and the diode D1 (LED) causing it to glow.

At this time also the capacitance C1 from + V1 is charged through L2, D2 and R1, on which the voltage increases

As long as the energy stored in the core is returned, L1 blocks the base polarity of the transistor keeping it plugged

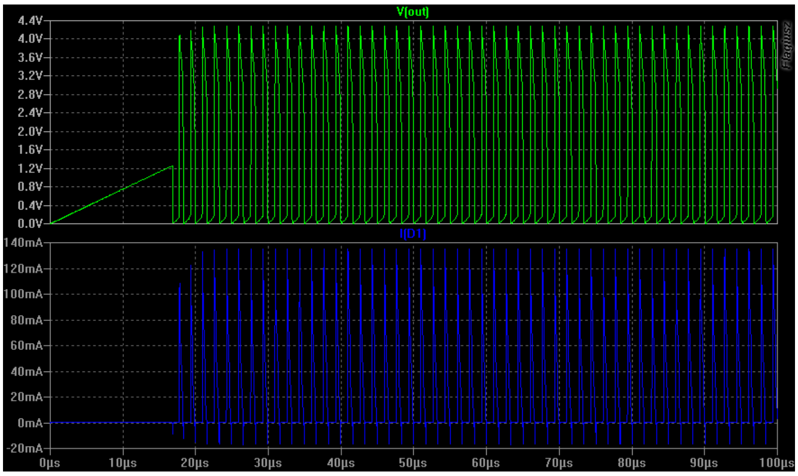
When the stored energy is exhausted, the current produced by L2 disappears, and the force that keeps the base of the transistor blocked by L1 also disappears

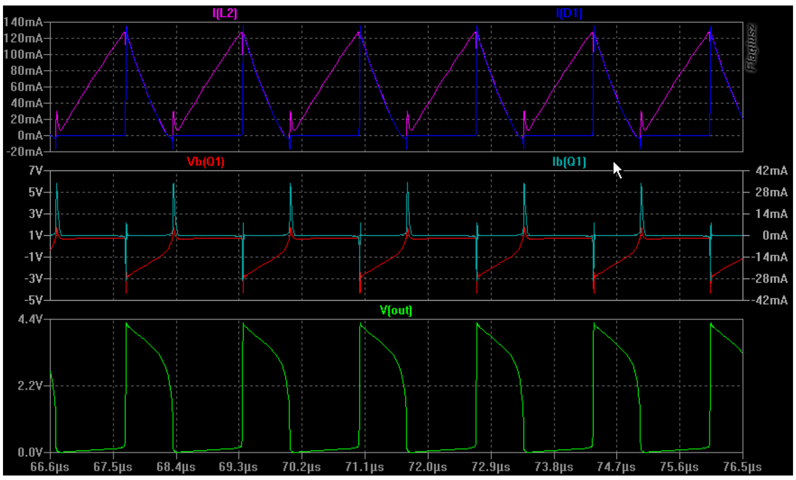
Because the newly charged capacitor C1 has sufficient voltage to polarize the BE junction of the transistor, and the braking force generated by L1 has just disappeared, the current begins to flow, which opens the Q1 transistor again and the whole fun starts from the beginning, which can be seen in detail on the waveforms below.

The optimal selection of the values of the elements enables very fast switching of the transistor and full core charging runs to the maximum value supported by the transistor (Ic). Pictures below.

**Why did I devote so much to this particular description?**

Well, because although the SJT actually works much better than the standard Joule Thief, I have never managed to get better results on it than on the much simpler, well-op-



timized, high-speed version I use.

The numerous tests and measurements performed by me, both on the physically built circuit and on the simulations carried out, did not confirm the superiority of this system over the fast version, and in terms of the maximum output current also in my DC versions.

On the contrary, due to the additional series diode D2 in the base current control circuit Q1, the minimum voltage required for the start has increased adversely.

The fast version does not have such a defect - it starts from a very low supply voltage slightly exceeding the base bias voltage ( about 0.6 V ).

Also in terms of SJT efficiency, it does not exceed the alternative solution proposed by me, although in both cases this efficiency is actually very high and difficult to achieve by other JT systems.
This slight decrease in efficiency in SJT is caused by the diode D2, through which the base current of the transistor actually flows and these additional losses are caused on it.

I corresponded with Watson on this matter, discussing the advantages and disadvantages of this solution for a long time and convincing him that the JT fast version I use is simpler, cheaper and slightly better (more effective).

The originator showed the superiority of his solution by comparing it to the classic solution.

If he had decided to leave the upper C2 pin on tap T1 just BEFORE SW1 switch, and not behind - only in "his" branch, he would certainly notice that the solution he invented does not work any better.

I am absolutely far from accusing anyone of bad intentions, especially since what he presents on his blog undoubtedly confirms that he knows his stuff. I fully respect his knowledge and appreciate his creativity - otherwise I wouldn't be spending so much time on this layout.

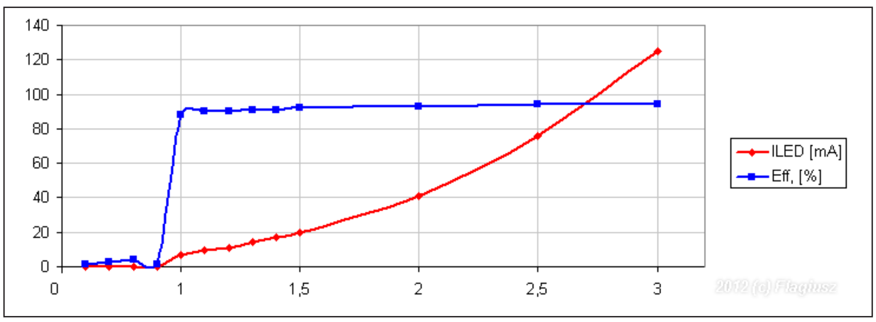
*In electronics, it is sometimes such that even a small innocent suggestion, slight differences in the values of the elements or the method of measurement, may cause divergent results and, consequently, a wrong impression. I hope it was the same this time.*

If you think otherwise - please contact me.

LED current average value:
~ 20.3 mA (peak ~ 135.2 mA)
- efficiency: ~ 92.1%
- I (in): ~ 60.2 mA (peak ~ 135.3 mA)
- for R1 = 2k2 Ohm.

| | | | | | | |
|---|---|---|---|---|---|---|
| Vin [V] | | | | | | |
| 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 |
| 1.3 | 1.4 | 1.5 | 2.0 | 2.5 | 3.0 | |
| ILED [mA] | | | | | | |
| - | - | - | - | 6.4 | 9.1 | 11 |
| 14 | 17 | 20 | 41 | 76 | 125 | |
| Eff. [%] | | | | | | |
| 1.4 | 2.3 | 3.7 | 1.4 | 88 | 90 | 90 |
| 91 | 91 | 92 | 93 | 94 | 94 | |

Maximum achievable LED current at Vin = 1.5V:
~ 54.9 mA (peak ~ 348.7mA)
- efficiency: ~ 75.6%



- I (in): ~ 346.5 mA (peak ~ 437.1 mA)
- for R1 = 40 Ohm.

Download data files for simulation.

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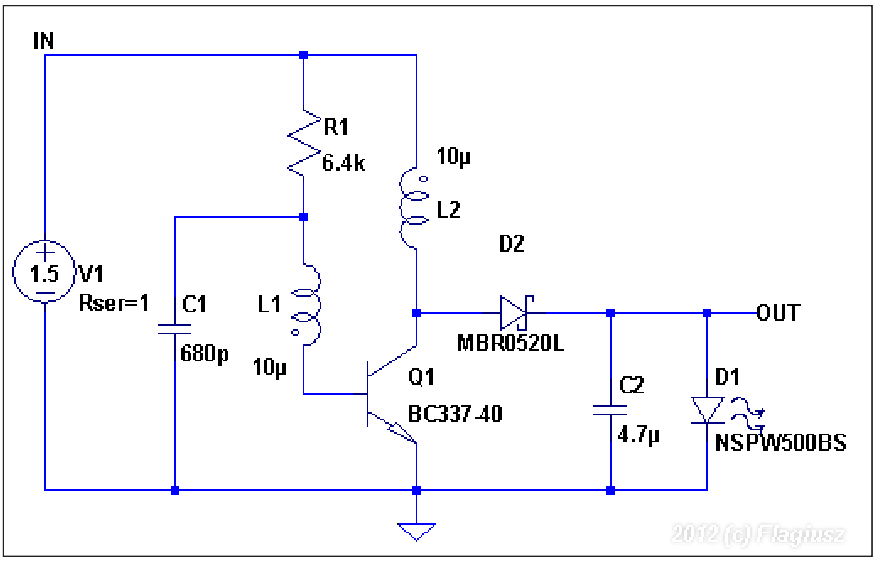
**DC version - without stabilization**

Schematic diagram

Contrary to the previous two versions, a rectifier (Shottky diode) and a filter (C2) are used here. Waveform diagrams: system start and stable operation

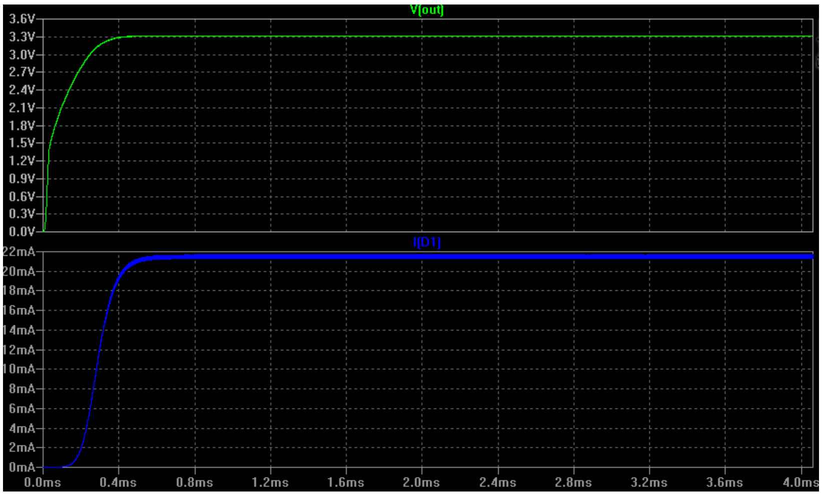
Thanks to this, the LED diode is not powered by impulse, but by a much more favorable direct current.

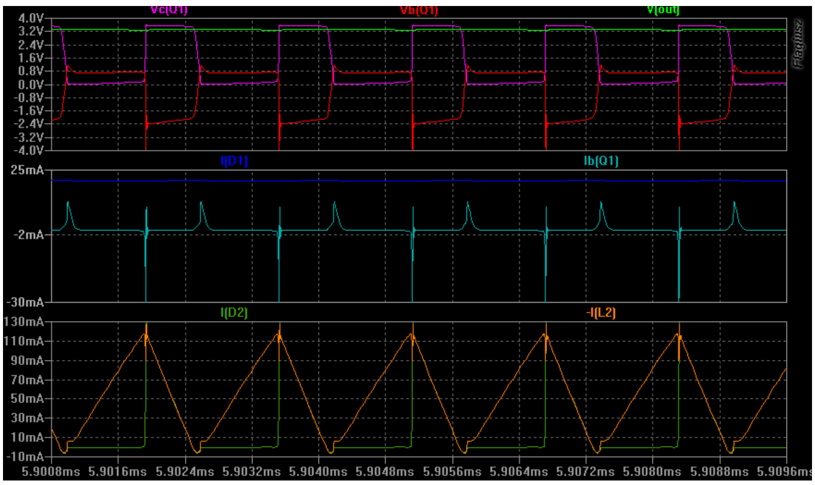
Additional elements through which the current flows (diode D2) introduce slight losses, so that the efficiency of the system is slightly lower than in the previous version.




LED current average value:

~ 20 mA (peak ~ 21 mA)
- efficiency: ~ 86%
- for R1 = 6k4 Ohm.

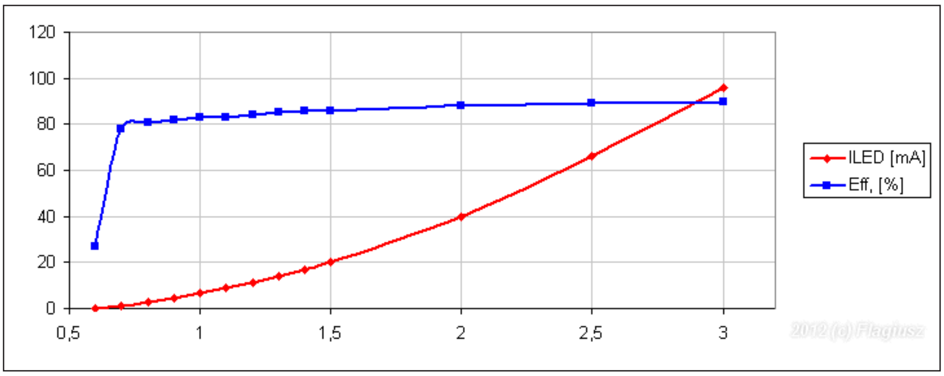


Vin [V]
0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 2.0 2.5 3.0

ILED [mA]
0.2 1.4 2.8 4.7 6.8 8.7 11 14 17 20 40 66 96

Eff. [%]
27 78 81 82 83 83 84 85 86 86 88 89 90




Maximum achievable LED current at Vin = 1.5V:
~ 72.5 mA (peak ~ 80 mA)
- efficiency: ~ 67.8%
- for R1 = 100 Ohm
- I (in): ~ 414 mA (peak ~ 711 mA)

Download data files for simulation.

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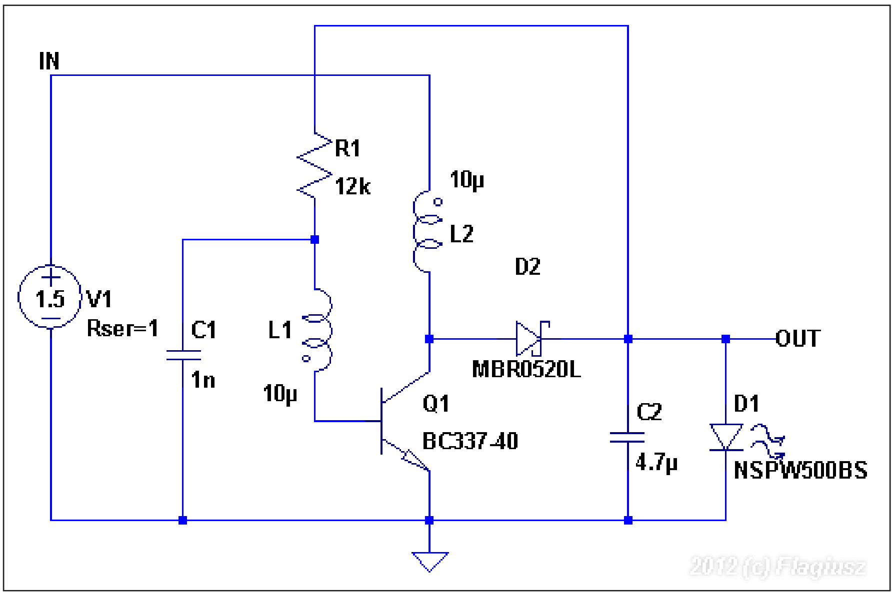
**DC version - without stabilization # 2**
(by Flagiusz)

Schematic diagram

It is the same as the previous one, with the difference that the voltage of the circuit controlling the base of the transistor does not come directly from the power supply, but from the output voltage.



Waveform diagrams: system start and stable operation

The Q1 transistor control circuit, which consists of R1, L1 and C1, operates at a constant voltage determined by Vf (D1) regardless of the value of the supply V1.
As a result, the stability of the system has been increased at lower input voltages and a better current efficiency was obtained in this range at the cost of a slightly inferior efficiency.

LED current average value:
~ 20.5 mA (peak ~ 20.6 mA)
- efficiency: ~ 85.6%
- I (in): ~ 55.7 mA (peak ~ 127.5 mA)
- for R1 = 12k Ohm.

Vin [V]

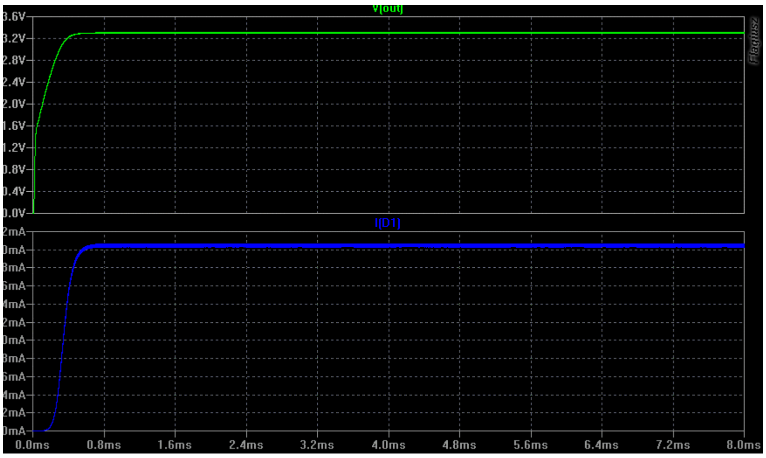
| | | | | | | |
|---|---|---|---|---|---|---|
| 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 |
| 1.3 | 1.4 | 1.5 | 2.0 | 2.5 | 3.0 | |

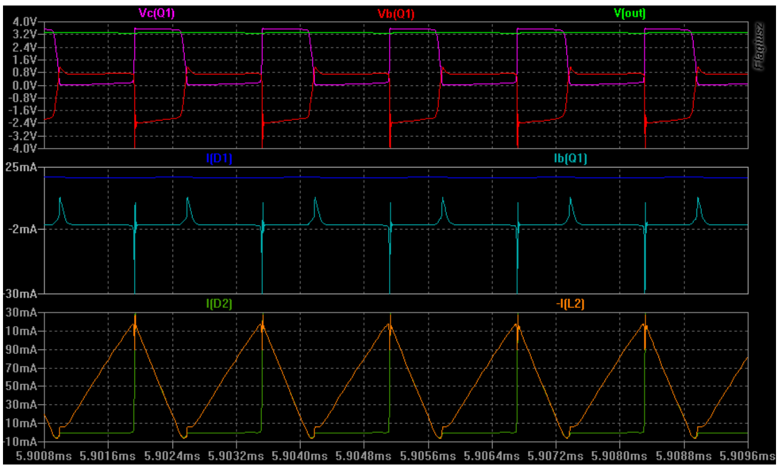
ILED [mA]

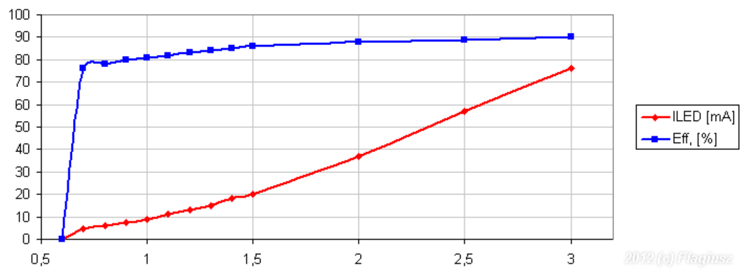
| | | | | | | |
|---|---|---|---|---|---|---|
| - | 4.5 | 5.9 | 7.4 | 9.1 | 11 | 13 |
| 15 | 18 | 20 | 37 | 57 | 76 | |

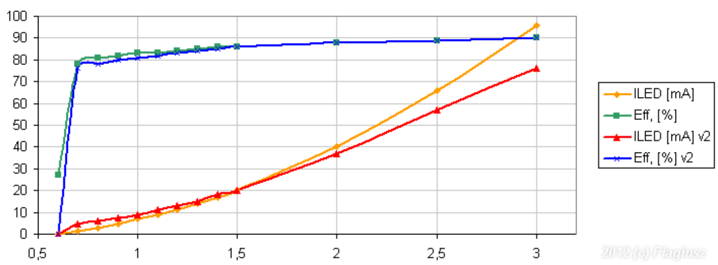
Eff. [%]

| | | | | | | |
|---|---|---|---|---|---|---|
| - | 76 | 78 | 80 | 81 | 82 | 83 |
| 84 | 85 | 86 | 88 | 89 | 90 | |

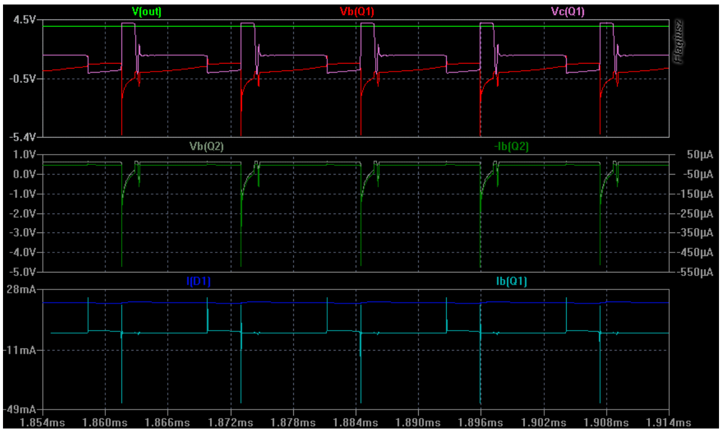


Characteristics of the output current and efficiency in the function of supply voltage, comparison of both versions of the system
Maximum achievable LED current at Vin = 1.5V:
~ 73.7mA (peak ~ 81.4mA)
- efficiency: ~ 65.1%
- for R1 = 100
- I (in): ~ 435 mA (peak ~ 706 mA)




Download data files for simulation.

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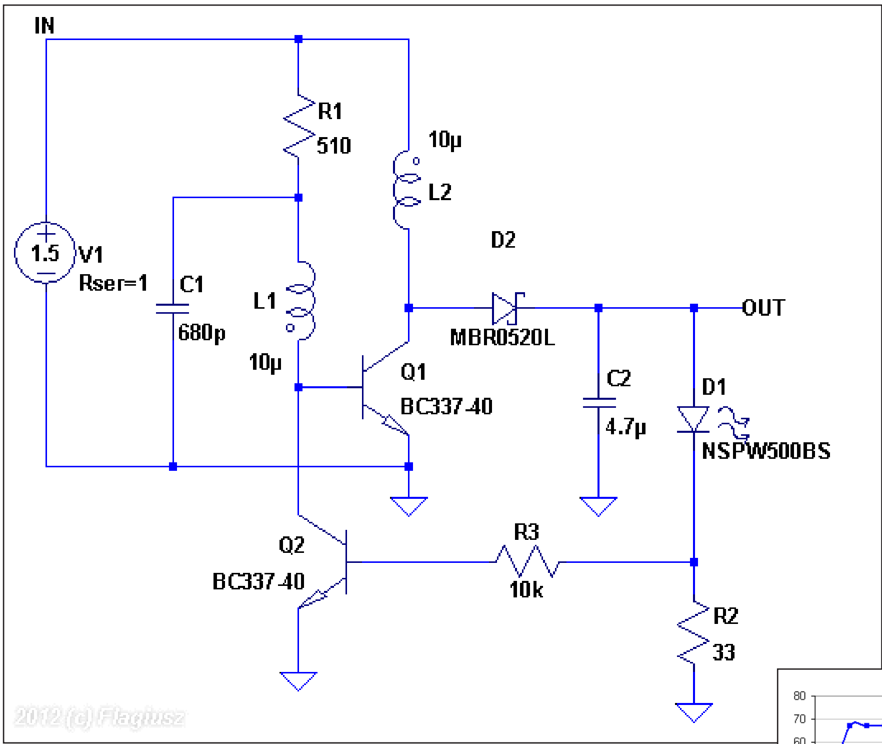
**JT with current stabilization**

LED current average value:
~ 19.6 mA (peak ~ 20.0 mA)
- efficiency: ~ 67.4%
- I (in): ~ 79.7 mA (peak ~ 399.1 mA)
- for R1 = 510 Ohm.

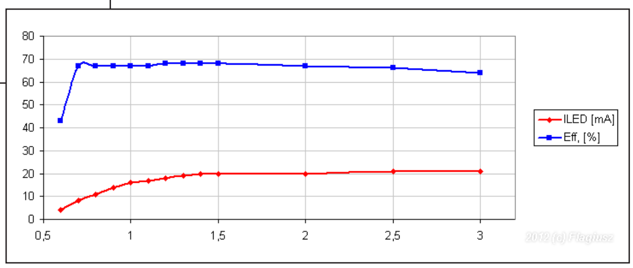


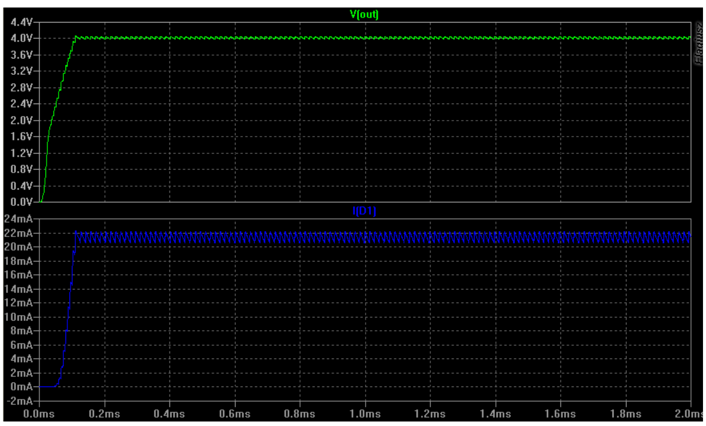

Vin [V]
0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 2.0 2.5 3.0

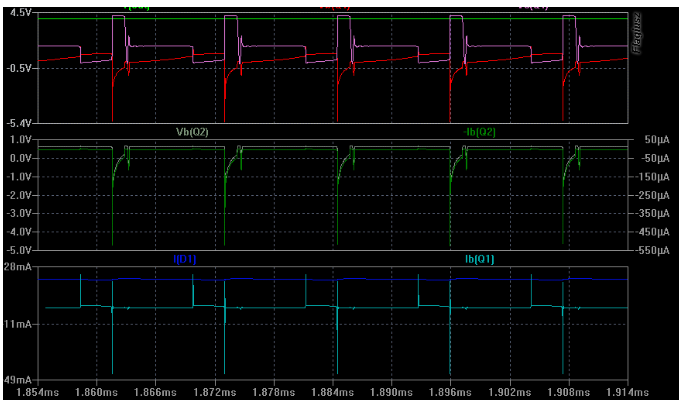
ILED [mA]
4.0 8.3 11 14 16 17 18 19 20 20 20 21 21

Eff. [%]
43 67 67 67 67 67 68 68 68 68 67 66 64

Download data files for simulation.

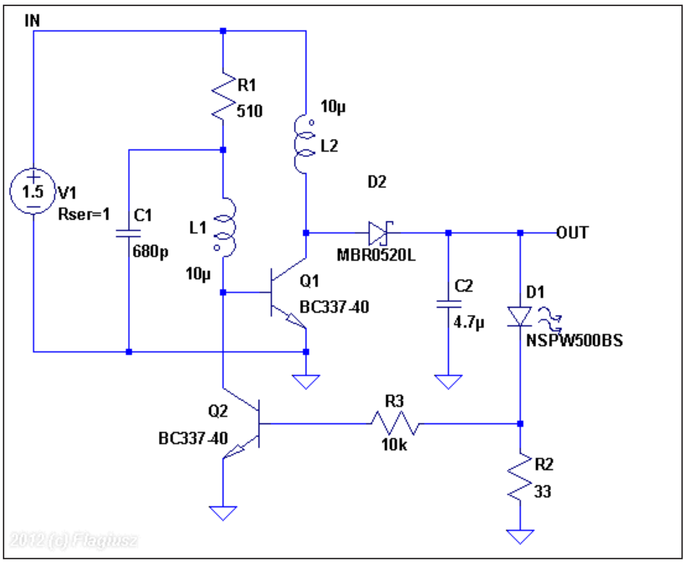


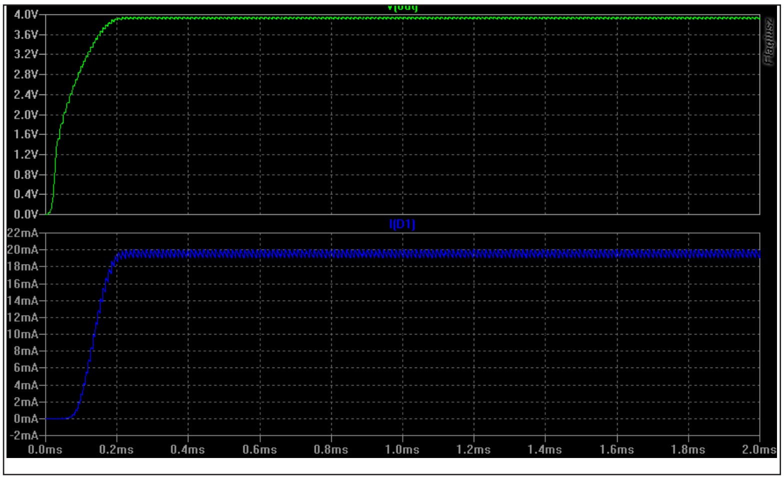



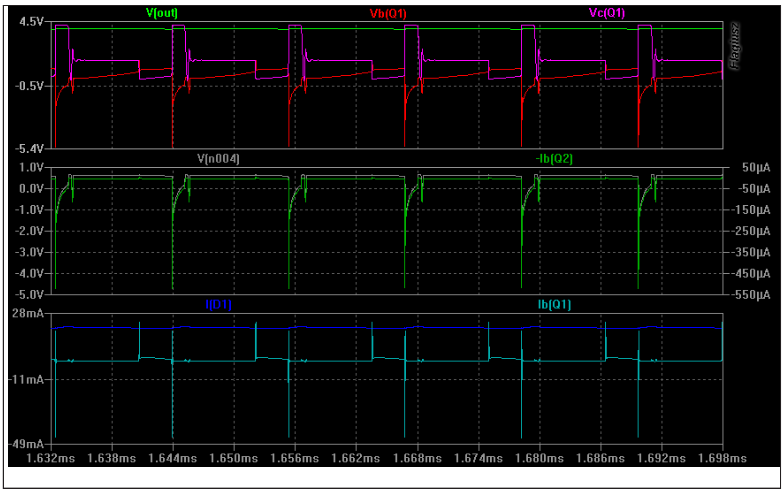



## JT with current stabilization # 2

(by Flagiusz)




Waveform diagrams: system start and stable operation

Vin [V]

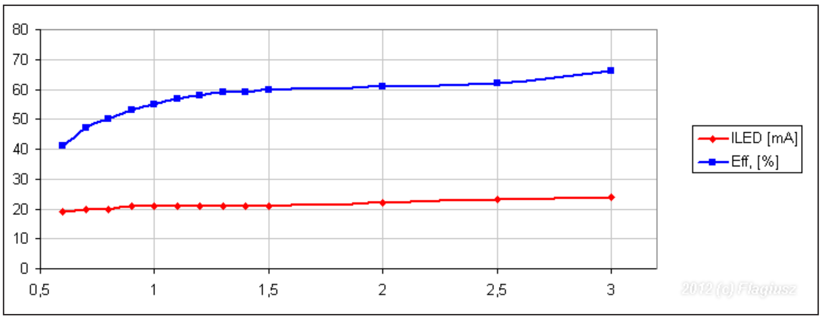
| | | | | | | |
|---|---|---|---|---|---|---|
| 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 |
| 1.3 | 1.4 | 1.5 | 2.0 | 2.5 | 3.0 | |

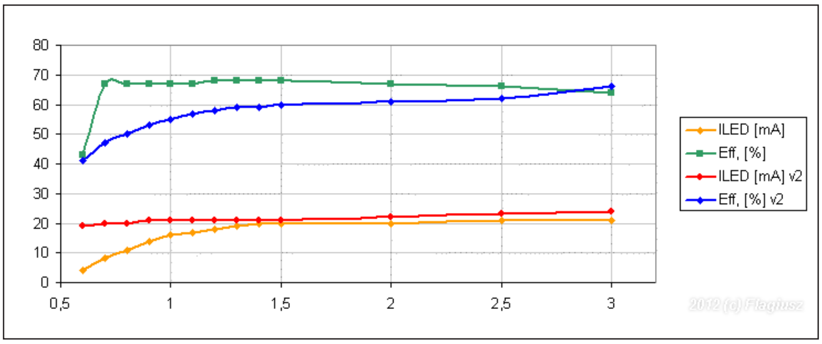
ILED [mA]

| | | | | | |
|---|---|---|---|---|---|
| 19 | 20 | 20 | 21 | 21 | 21 |
| 21 | 21 | 21 | 21 | 22 | 23 |
| 24 | | | | | |

Eff. [%]

| | | | | | |
|---|---|---|---|---|---|
| 41 | 47 | 50 | 53 | 55 | 56 |
| 58 | 58 | 59 | 60 | 61 | 62 |
| 66 | | | | | |




Characteristics of the output current and efficiency in the function of supply voltage, comparison of both versions of the system.

Download data files for simulation.

Therefore, to each of the above systems I added the maximum values of the output current (LED) achieved during the simulation, giving the corresponding values of the elements.

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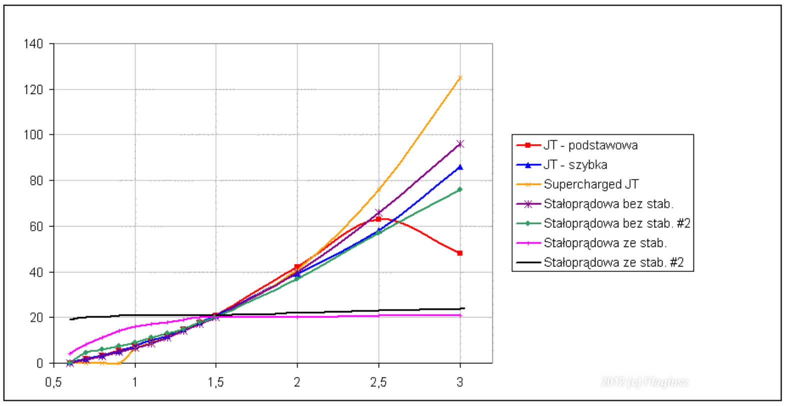
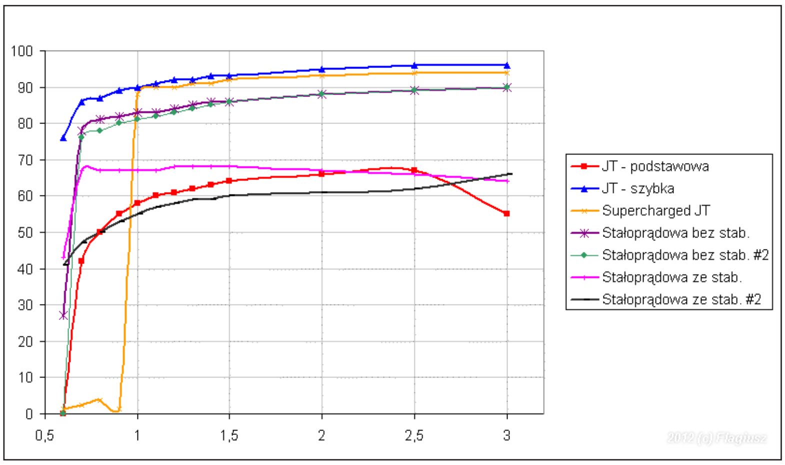
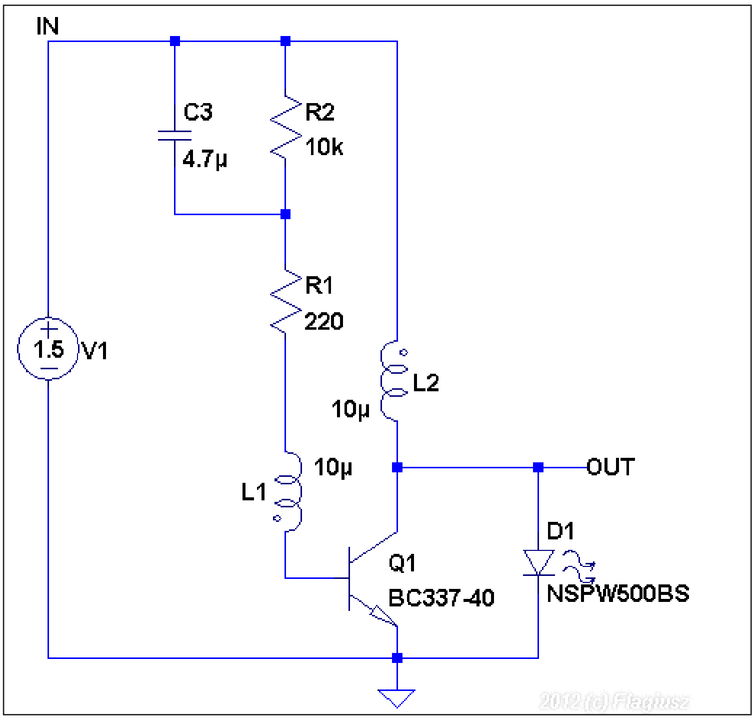
## Compare all versions of Joule Thief



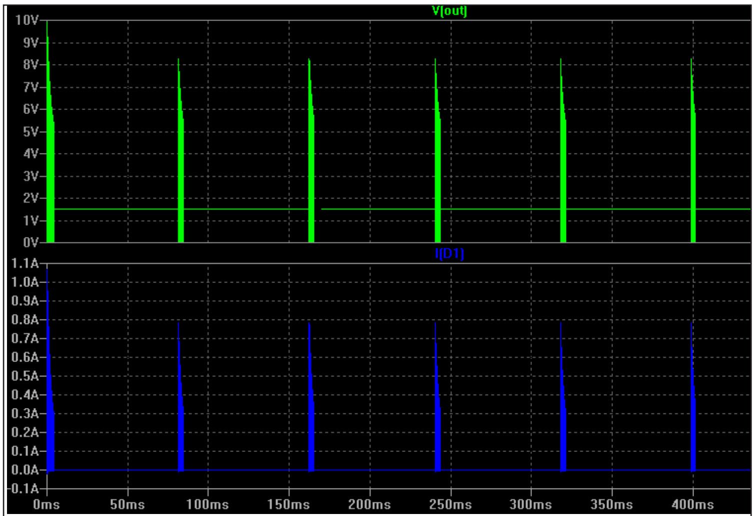

Collective summary of the output current characteristics and efficiency in the function of supply voltage
It is very important that the simulations attached here and the diagrams derived from them were carried out for specific input criteria, namely for the comparison of the systems, the values of the elements were adopted, which for the supply voltage equal to 1.5V gave the LED current as close as possible to 20 mA at the maximum possible efficiency.
The fact that the attached diagrams may show that at different supply voltages some solutions may achieve higher current (e.g. SJT), does not mean that other systems are not able to obtain the same high or even higher current. They are able, but for a different value of the elements.

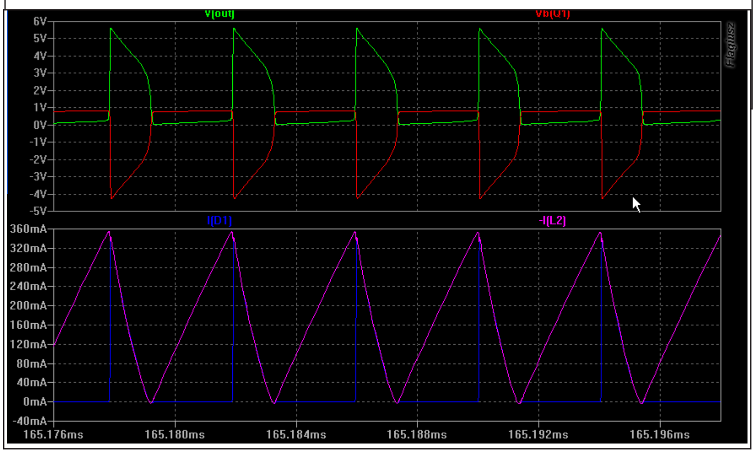


## Flashing version

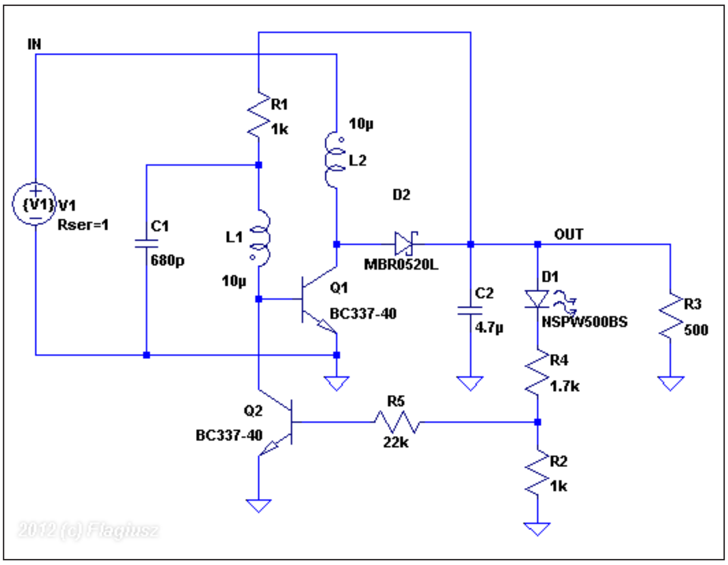


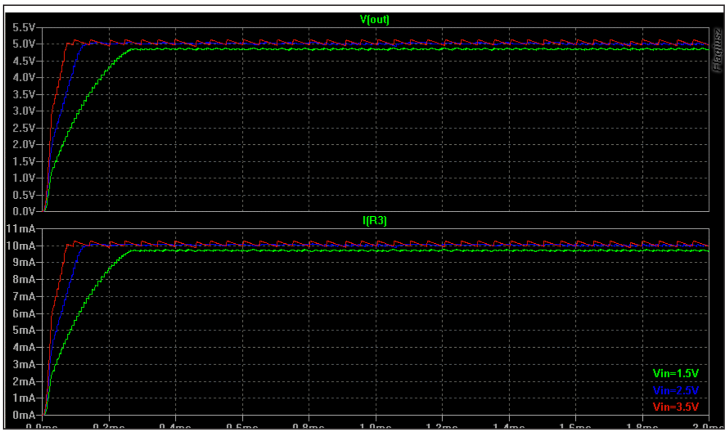

Schematic diagram

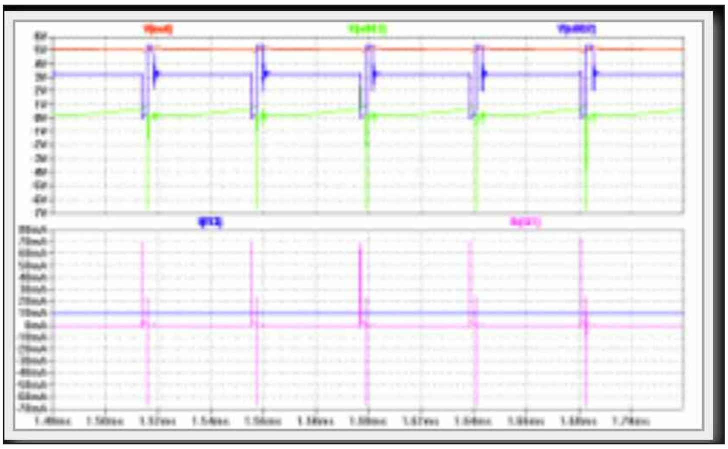


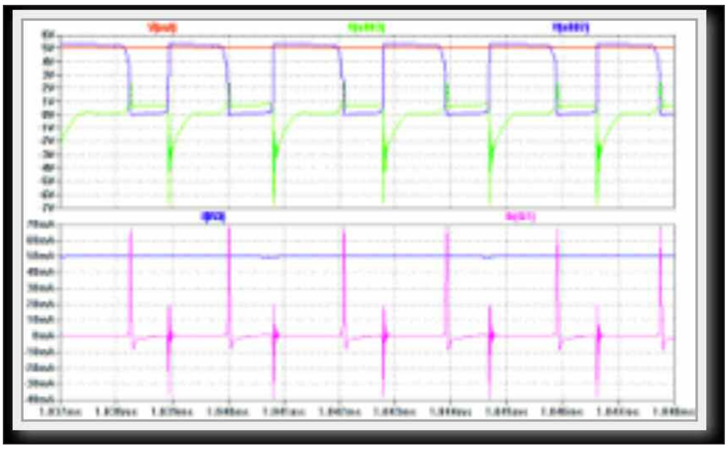




Waveform diagrams: system start and stable operation
Download data files for simulation.





## Step-up converter + 5V

Schematic diagram

Waveform diagrams: system start and stable operation under low and high load
The values of the elements were selected to obtain a voltage stabilization value of 5.0 V.

Vin [V]

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 |
| 1.3 | 1.4 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 |
| 4.0 | 4.5 | | | | | |

**Iout= 1 mA**

Vout [V]

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.5 | 0.6 | 2.6 | 3.0 | 3.5 | 4.9 | 4.9 |
| 4.9 | 4.9 | 4.9 | 5.0 | 5.0 | 5.0 | 5.0 |
| 5.1 | 5.2 | | | | | |

Eff. [%]

| | | | | | | |
|---|---|---|---|---|---|---|
| - | - | 0.9 | 1.0 | 9.7 | 9.7 | 9.7 |
| 9.7 | 9.7 | 9.7 | 9.9 | 10.2 | 12.5 | |
| 12.9 | 15.1 | 12.7 | | | | |

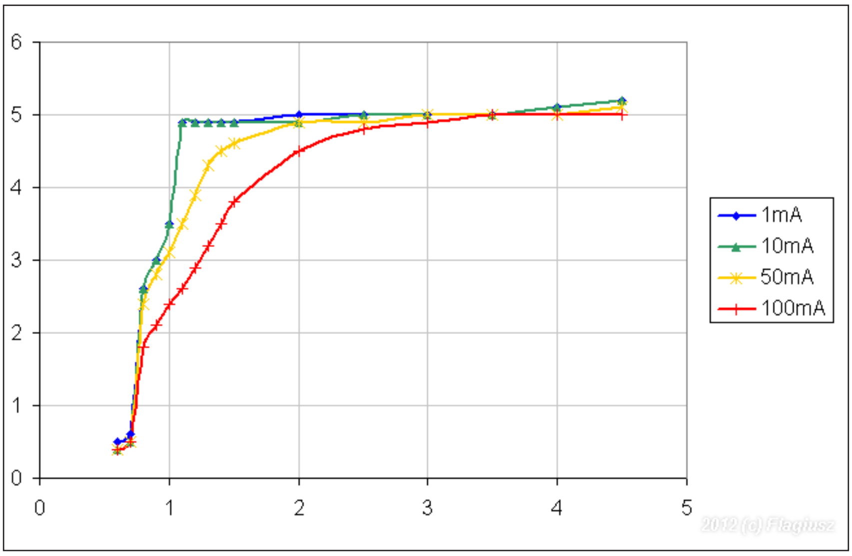
**Iout= 10 mA**

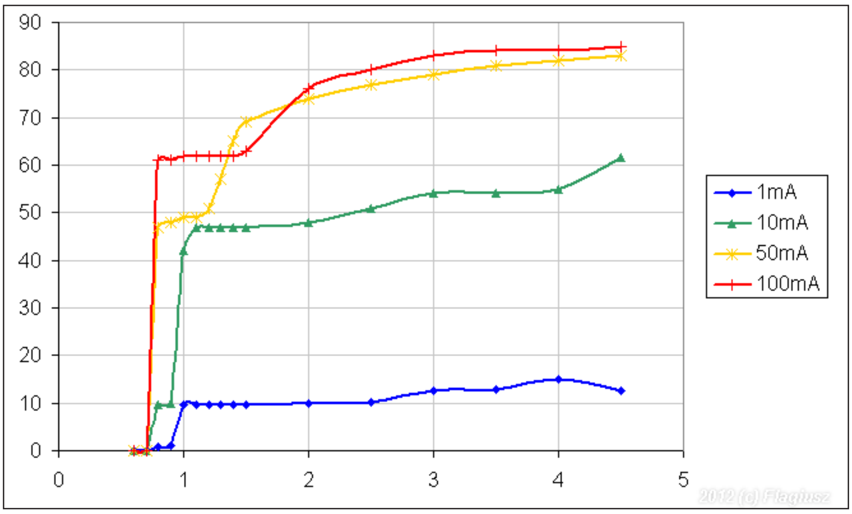
Vout [V]

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.4 | 0.5 | 2.6 | 3.0 | 3.5 | 4.9 | 4.9 |
| 4.9 | 4.9 | 4.9 | 4.9 | 5.0 | 5.0 | 5.0 |
| 5.1 | 5.2 | | | | | |

Eff. [%]

| | | | | | | |
|---|---|---|---|---|---|---|
| | - | - | 9.7 | 10 | 42 | 47 |
| 47 | 47 | 47 | 47 | 48 | 51 | 54 |
| 54 | 55 | 61.7 | | | | |




**Iout= 50 mA**

Vout [V]

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.4 | 0.5 | 2.4 | 2.8 | 3.1 | 3.5 | 3.9 |
| 4.3 | 4.5 | 4.6 | 4.9 | 4.9 | 5.0 | 5.0 |
| 5.0 | 5.1 | | | | | |
| Eff. [%] - | | - | 47 | 48 | 49 | 49 |
| 51 | 57 | 65 | 69 | 74 | 77 | 79 |
| 81 | 82 | 83 | | | | |

**Iout= 100 mA**

Vout [V]

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.4 | 0.5 | 1.8 | 2.1 | 2.4 | 2.6 | 2.9 |
| 3.2 | 3.5 | 3.8 | 4.5 | 4.8 | 4.9 | 5.0 |
| 5.0 | 5.0 | | | | | |

Eff. [%]

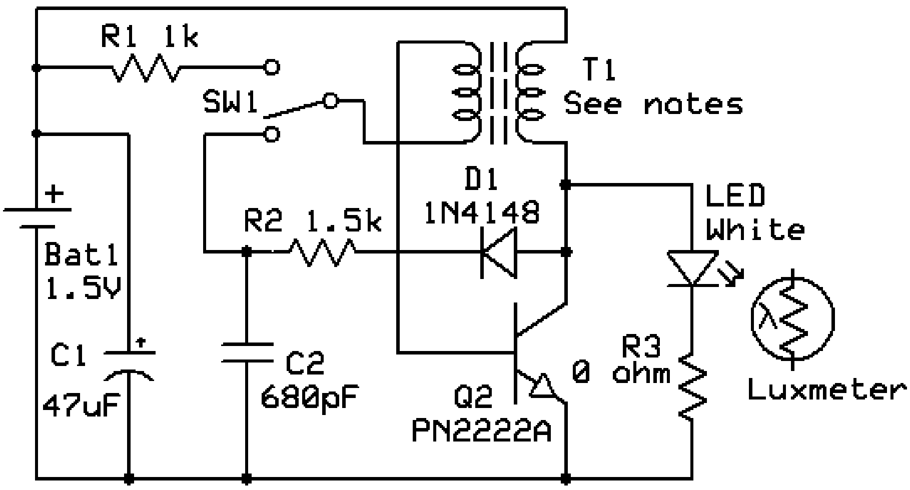
| | | | | | | |
|---|---|---|---|---|---|---|
| - | - | 61 | 61 | 62 | 62 | 62 |
| 62 | 62 | 63 | 76 | 80 | 83 | 84 |
| 84 | 85 | | | | | |

Schematic diagram

Download data files for simulation.

Following page Joule Thief from Watson.

Fig.1 Joule Thief, Switches between conventional & Supercharged. Built 2011 Oct 9




Notes: T1: core = Fair-Rite 2643002402 Quadrifilar wound with four 18 inch lengths of 30 AWG enameled magnet wire, three windings connected together for the primary winding, one winding for the feedback.

Switching between conventional & Supercharged allows one to compare light output and current using the same transistor, LED and coil, which eliminates any differences in those components.

Results:
With mA meter in series with supply:
Conven - Vsup = 1.483V, I sup = 75.2 mA, 1286 Lux
Supchg - Vsup = 1.483V, I sup = 44.5 mA, 1115 Lux

Without mA meter in series with supply:
Conven - Vsup = 1.511V, I sup = ??.? mA, 1358 Lux
Supchg - Vsup = 1.510V, I sup = ??.? mA, 1307 Lux

The above measurements show that compared to the conventional JT, the Supercharged JT draws much less supply current (about 59%), yet puts out almost as much light (87% in the first case, 96% in the 2nd case).

LEGEND: No Connection where wires cross.
All resistors 5% 1/4W unless otherwise specified

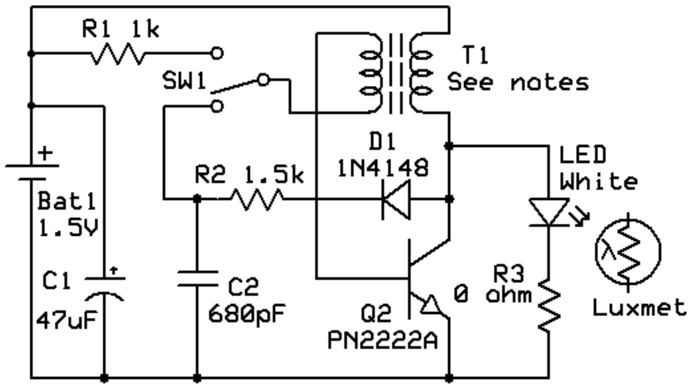
| www.rustybolt.info | | |
|---|---|---|
| Joule Thief - Conv & Supercharged | | |
| Watson aName | Rev 1.0 111009<br>10/09/2011 | Page 1 of 1 |

http://rustybolt.info/wordpress/?p=221

With original GIF
links and reactions

**RUSTY**

## 2011-12-04 Joule Thief Conventional & Supercharged




Joule Thief SMPS DC-DC
LED

Meters and Test Equipment
on December 4th, 2011 by admin - No Comments

**Clarification:**
People have asked if the three windings explained in the schematic are in series or parallel. The three are in parallel, in other words, solder three of them together on each end. But make sure you use an ohmmeter to find and separate the other (4th or feedback) winding from the three.

In Jan, 2009 I designed a circuit that removed the Schottky and capacitor from between the collector and LED and instead used it (or a regular 1N4148 diode) only to rectify and filter the coil output only for the transistor base bias. My reasoning was that the losses in the diode would be reduced – much less current through the diode – and more power would then go to the LED. I found out that when I used a 560 pF to 1000 pF capacitor for the filter cap, the circuit was much more efficient than when the capacitor was larger. I called this a Supercharged Joule Thief.

In October 2011 I added a switch to a JT to allow switching between conventional Joule Thief and Supercharged. I used a luxmeter to measure the actual light output of the LED. There was no measuring of the current through the LED, so there was no question of if or how the ammeter or voltmeter might influence the reading because of the pulses from the JT.

As I show in the schematic, the performance difference is significant between the two types. My Supercharged Joule Thief has much less power consumption for almost the same amount of light. In other words, it is much more efficient, greener and wastes less energy than a conventional JT.

The switch allows me to switch between the conventional Joule Thief and the Supercharged Joule Thief. Since the LED and most of the rest of the circuit is the same for both measurements, there is no difference in the measurements caused by a difference in the circuit or the LED's light output. This "apples to apples" comparison is important: it narrows down the efficiency difference to the changed components and only the changed components.

I used a 1 ohm resistor in series with the LED to measure the LED current. I assumed the voltage across the LED was 3.3 volts. When I calculated the SJT efficiency, I sometimes came up with a figure above 90 percent, but typically it was in the high 80s. This compared to 40 to 60 percent for a conventional JT.

I have corresponded with others and some have insisted that using this resistor in series with the LED to measure the LED current is not accurate. The problem seems to be with the way that the digital voltmeter measures the rectified pulses. I decided that the way to end this controversy is to measure the LED light output. I bought an inexpensive luxmeter for about $40 (USD). I glued the LED to a hole in the end of a small cardboard box which holds the LED a fixed distance from the luxmeter sensor, and blocks all ambient light. The LED is a white 10mm that can handle a watt for a short period – long enough to make a lux measurement.

My Supercharged JT was published on my late, great watsonseblog since 2009. I sometimes wonder if anyone considered adopting it to replace the conventional JT. It is well worth the very few changes and parts needed and almost no difference in cost.

If my SJT is compared to a conventional JT with a Schottky diode and filter capacitor on the output, I can't see how the Schottky/filter capacitor JT could come close to the efficiency of the SJT, because of the losses in the voltage drop across the Schottky diode.

Previously in my blog I measured the efficiency of a conventional JT and my SJT. I used the supply voltage times the supply current to get input power. I measured the voltage across a 1 ohm current sense resistor in series with the LED. I multiplied this current times 3.3V for the LED forward voltage to get the output power. Then I divided the output power by the input power to get the efficiency.

I have to go by my memory (my blog is now gone). I was getting around 50% to 55% efficiency for a conventional JT, and my SJT was getting 80% to 90% efficiency. The difference was very significant. But some, including myself, doubted the measurements, so that's why I bought the luxmeter – I could make a comparison of the actual light output. And as I showed above, this agrees with the earlier efficiency measurements I made.

Back to experimenting…

**Tags:**

conventional joule thief
https://rustybolt.info/wordpress/?tag=conventional-joule-thief

light output
https://rustybolt.info/wordpress/?tag=light-output

luxmeter
https://rustybolt.info/wordpress/?tag=luxmeter

supercharged joule thief
https://rustybolt.info/wordpress/?tag=supercharged-joule-thief

Share on Facebook Share on Twitter Share on Reddit Share on LinkedIn

https://rustybolt.info/wordpress/?p=221

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**2020-12-15 False Advertising For Sterilizing UV LED Lights**

https://rustybolt.info/wordpress/?p=14728

December 15th, 2020
From my comment to al-Ghaili post

https://www.facebook.com/ScienceNaturePage/videos/223929302517497/?app=fbl

https://www.sciencedirect.com/science/article/pii/S1011134420304942?via%3Dihub

Highlights

• Corona virus HCoV-43 was found sensitive to **UV-LED** irradiation.
• Sensitivity was wavelength dependent with 267 nm ~ 279 nm > 286 nm > 297 nm.
• Similar wavelength sensitivity was found for other viruses.
• UV-LEDs could probably be used in the fight against SARS-CoV-2 and COVID19.

The flaw is that the UV must be UV-C light about 265 to 285 nm wavelength. This wavelength is not emitted by almost all UV LEDs. The plastic lenses in cheap LEDs do not allow UV-C to pass through. The LED window must be **glass** that passes UV-C.
If you want to find out if your UV LED puts out UV-C, do the green banana test. Search for green banana uv test on YouTube. Big Clive has a video on how it's done.

If your UV light uses LEDs it is very doubtful that it will put out UV-C. *Don't be fooled by false advertising for LED lights that will sterilize! They don't!*

---

**Product aantallen per plaats**

| | |
|---|---|
| Yangzhou | 21,964 |
| Shenzhen | 13,879 |
| Guangzhou | 3,966 |
| Zhongshan | 2,978 |
| Yantai | 1,987 |
| Ningbo | 1,656 |
| Foshan | 1,326 |
| Jinhua | 1,250 |
| Nanjing | 1,213 |
| Zhengzhou | 1,005 |

---

**In China gemaakt:**
LED, verlichting en aansturing en onderdelen
https://www.made-in-china.com/productdirectory.do?word=led+component&file=&subaction=hunt&style=b&mode=and&code=0&comProvince=nolimit&order=0&isOpenCorrection=1

---

**Giving batteries a second life**

Battery university
Cadex C7400ER Battery analyzer
RigidArm for ceelular batteries.

https://batteryuniversity.com/learn/article/giving_batteries_a_second_life

---

**Fabrikanten van LED gerelateerde producten in China**

### Small batteries

https://batteryuniversity.com/learn/article/
primary_
batteries
9 V
AAA
AA
C
D
batterijen
Coulomb counting measurement

https://batteryuniversity.com/index.php/learn/article/
how_to_measure_state_of_charge

---

### Geram Electric Limited

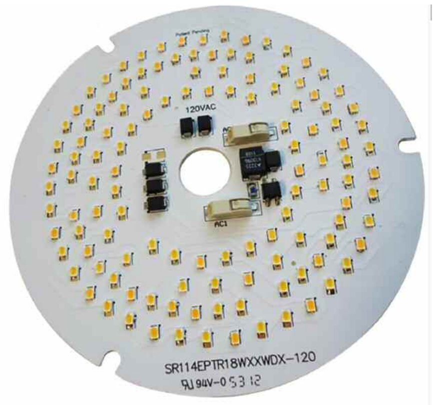
fabricage van LED's is voor een deel nog steeds handwerk.
https://www.geramled.com/about-us/

### LED drivers Ottima Technology Co. Ltd. China

Ultra Thin LED Driver
Dimmable LED Driver
Round LED Driver
LED Tube Driver
LED Bulb Driver
DC DC LED Driver
Waterproof LED Driver
Plastic LED Driver


Cabinet light led driver

Ottima Technology Co., LTD
Floor 2, Building 3,
Lihao Industrial Park, 78 Ainan Road,
Baolong Street, Longgang District,
Shenzhen, China




OTTIMA TECHNOLOGY Co., ltd. is a world-wide supplier of LED driver established in 2006. OTTIMA is a high-tech enterprise specializing in the R&D, manufacture and export of LED driver/LED power supply.

https://www.ottima-tech.com/led-bulb-driver/
ac-dc-led-driver.html

---

### FastPCBA factory, LED Circuit Board Factory

3F, Building 1, No.18-1, East Yuquan Road,
Yulu Village, Gongming Street,
Guangming New District, Bao'an District,
Shenzhen City,
Guangdong Province, China

Onderdelen spoeltjes
http://m.cnfastpcb.com/

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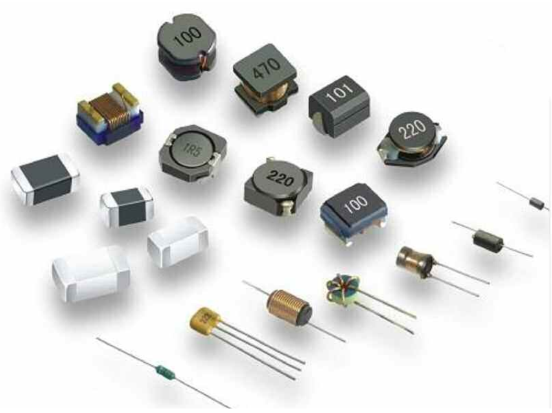



**Led circuit board**
When electrons and holes recombine, they can radiate visible light, and thus can be used to make light-emitting diodes.
Used as an indicator light in circuits and instruments, or as a text or digital display. The gallium arsenide diode emits red light, the gallium phosphide...

http://m.cnfastpcb.com/pcb-assembly/lighting-led/led-circuit-board.html

---

**Witte strip waterproef**

AST Lighting


Xiamen Sales Office

Shenzhen Factory
Shi Yan Town,
Bao'an District,
ShenZhen City,
Guangdong, China

https://www.astlighting.com/product/smd3014-140led-m

Interessante PDF: 2019 AST Lighting LED

Strip catalog.pdf

https://drive.google.com/file/d/15XiTbhK_MW7S6k9gcXFrTTOfMtNC_62E/view

---

**LED Tuinverlichting met zonnecel**

Ningbo Addlux Electric Co., Ltd.
China

https://nbaddlux.en.made-in-china.com/product/TCIEhwFgnVWa/China-20W-Ce-UL-Saso-IP65-Intelligent-Remote-Control-5054-LED-Solar-Flood-Light-Made-in-China-for-Outdoor-Garden-Street-Park-Lighting-From-Best-Distributor-Factory.html

**Grow lamp** 50 Watt

https://nbaddlux.en.made-in-china.com/product/jspQKZbYyCck/China-50W-Sunlike-Full-Spectrum-LED-Grow-Lamp.html

---

*In China gemaakt:*
**Printed Circuit Boards**

PDF als download aangeboden

https://kmc2010.en.made-in-china.com/Product-Catalogs/

---

**Specificaties van LED's**
Spanning, stroom, sperspanning, vermogen etc.

De rode LED's hebben een lagere voorwaartse spanning, gevolgd door oranje, geel, groen, puur groen, ultra blauw en ultra wit.
Zie de link op de volgende pagina.

https://lightkeyled.en.made-in-china.com/product/mSFEnirTFJYI/China-Through-Hole-Lamp-LED-with-Various-Emitting-Color.html

## Ultra Violet LED’s

Lang niet alle UV LED’s kunnen worden gebruikt voor het onschadelijk maken van bv. Corona. Er moet aan specifieke spectrale eisen worden voldaan samen met de lichtsterkte.

https://lightkeyled.en.made-in-china.com/product-group/pqInvywAXrYM/UV-LED-catalog-1.html


## Electronics Component Pack with Resistors LEDs Switch Potentiometer

Eén van de vele voorbeelden van onderdelen kits voor een bijzonder lage prijs
$ 5,- - $ 5,85 per set.

https://xuanyao.en.made-in-china.com/product/uwXmCqKvyTWB/China-Electronics-Component-Pack-with-Resistors-LEDs-Switch-Potentiometer.html

## Joule Thief bij Facebook

https://www.facebook.com/pg/blockingoscillator/posts/

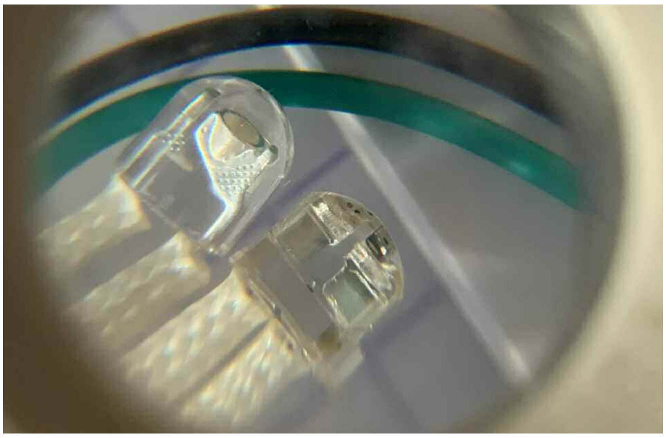
## One-Volt LED

blz. 804 Everyday Practical Electronics november 1999.

https://worldradiohistory.com/UK/Everyday-Electronics/90s/EPE-1999-11.pdf
Cover practical Electronics tijdschrift
In deel 1 genoemde verwijzing.

## LED’s

Twee verschillende LED’s onder een loep. Linksboven de standaard LED met links de plus aansluiting met gebogen draadje naar het halfgeleider materiaal in het kookpannetje.



De kom fungeert als reflector en container halfgeleider materiaal voor het uitgestraalde licht.
Rechtsonder een LED met een ingebouwde geïntegreerde schakeling, die drie zones aanstuurt met verschillende LED’s met verschillende kleuren. Deze worden afwisselend na een bepaalde tijd geactiveerd.
De prijs van dergelijke geavanceerde LED’s is nauwelijks hoger dan de ‘normale’ LED’s.

**Een LED groeilamp op bijna-lege batterijen laten werken**
Rolf Blijleven

Transistoren:
BC550
2N1711
met LDR voor automatisch licht in het donker

https://rolfblijleven.blogspot.com/2013/04/led-groei-lamp-op-bijna-lege-batterijen.html

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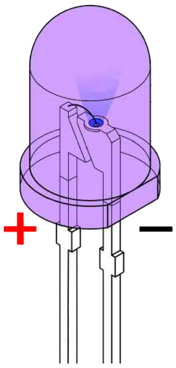
**Groeilampje** door Rolf Blijleven
https://rolfblijleven.blogspot.com/2015/08/groeilamp-jes-worden-rocket-science.html

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**Large-area Flexible Organic Photodiodes Can Compete With Silicon Devices**

https://rh.gatech.edu/news/641041/large-area-flexible-organic-photodiodes-can-compete-silicon-devices

---

Light-emitting diode Wikipedia

https://en.wikipedia.org/wiki/Light-emitting_diode

---

**LED onder de microscoop**
By Unconventional2 - Own work, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=58175752

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Grafieken kleuren spectrum LED
By Tijl Schepens, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=69091874

---

**Allerlei soorten LED's**
By Afrank99 - Own work, CC BY-SA 2.0,
https://commons.wikimedia.org/w/index.php?curid=248198

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**LED onder de microsocoop**
By Volkan Yuksel - Own work, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=37002613

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**Drie kleuren LED van dichtbij**
By Sven Killig - Self-photographed, CC BY-SA 3.0 de,
https://commons.wikimedia.org/w/index.php?curid=15320589

---

**Grow rode LED kleur**
By NASA Marshall Space Flight Center

https://commons.wikimedia.org/w/index.php?curid=39544881

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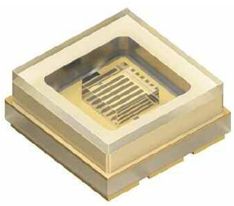
**Desinfectie**
**Speciale UV-C LED van Osram**

https://www.ledinside.com/node/view/31774



**LED INSIDE**

LED NIEUWS
https://www.ledinside.com/

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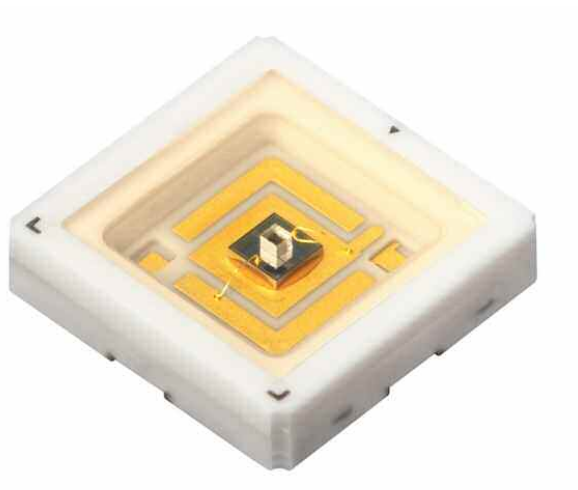
**UV leds**

LG Innotek Introduces UV LEDs with World-class Power Performance

https://www.ledinside.com/products/2014/10/lg_innotek_introduces_uv_leds_with_world_class_power_performance



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**RGB LED met drie kleuren**

Waarom kunnen er geen weerstanden worden gebruikt om een bepaalde kleur te bereiken? Het probleem zit hem erin dat elke kleur LED een andere voorwaartse spanning (kan) hebben.
Rood heeft de laagste spanning, dan blauw en dan groen. De heldere witte of blauwe hebben meestal de hoogste voorwaartse spanning.

---

**Hoe kunnen we LED dimmen?**
Dat gebeurt meestal door PWM of te wel regeling van de pulsbreedte.
Maar het kan ook door het knijpen van de stroom middels een stroombron.

https://www.circuitbread.com/tutorials/how-to-dim-an-led

---

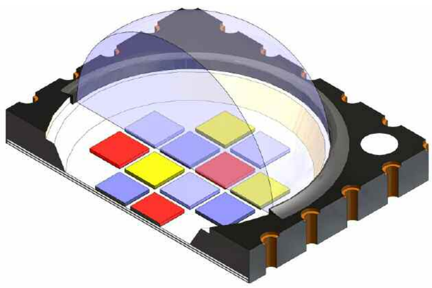
**How to choose LED driver IC?**
https://www.ledinside.com/knowledge/2009/12/led_driver_ic_2010a

---

**Osram**

LED Engin
Advanced LED emitters, optics and light engines for a wide range of lighting applications.

https://www.osram.us/ledengin/



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**Osram**

LuxiTune
Tunable White Light Engine
https://www.osram.us/ledengin/products/luxitune/index.jsp

## What's inside an LED Bulb?

'Normale' LED lampen van binnen bekeken

We took apart two LED lightbulbs, a CREE LED bulb from 2014 and a Philips bulb from 2018, and compared their build quality, the electronics, and their overall design. It was fascinating to see the differences in approaches they took and the challenges they faced with rectifying the incoming power and also keeping temperatures reasonable so the electronics don't fry.

https://www.circuitbread.com/tutorials/whats-inside-an-led-bulb

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## Voorwaartse spanning LED

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https://www.circuitbread.com/ee-faq/the-forward-voltages-of-different-leds

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## LED met multimeter testen

https://www.circuitbread.com/ee-faq/how-to-test-leds-with-digital-multimeters-dmms

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## Hoe de juiste weerstand berekenen

https://www.circuitbread.com/ee-faq/how-do-i-choose-the-correct-resistor-for-my-led

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## Hoe werkt een LED ?

https://www.circuitbread.com/tutorials/how-does-an-led-work

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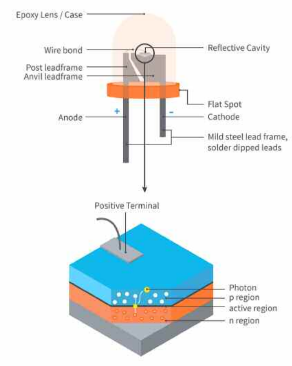
In het grote oppervlak zit een soort spiegel lens, waar het PN halfgeleider materiaal is opgeplakt.
De N-regio onderaan, daarboven aan de oppervlak het P-regio gebied, waar het uiteinde-




lijke licht vandaan komt. De p-regio is op de + van de spanningsbron aangesloten.

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## Why can't I share a resistor on the common anode or cathode of my RGB LED?

https://www.circuitbread.com/tutorials/why-cant-i-share-a-resistor-on-the-common-anode-or-cathode-of-my-rgb-led

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## How RGB LEDs work and how to control color?

2 soorten:
common anode +
common cathode -

https://www.circuitbread.com/tutorials/how-rgb-leds-work-and-how-to-control-color

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## Kies de juiste weerstand voor de LED

https://www.circuitbread.com/tutorials/selecting-a-resistor-for-an-led-6-easy-steps

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**Hoe kun je met een kleine beurs LED lampen in India gaan maken ?**

benodigd:

LED McPCB
Bulb Body
Heat Sinks
B22 Cap
Diffuser
HPF IC Driver
Packing Box
Warranty Card

https://www.differentwaysformoney.com/how-to-start-led-bulb-making-business-in-india/

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**Hoe worden LED's gemaakt?**

Hear from our experts on Everything LED Lighting

https://sitlersledsupplies.com/how-are-leds-made/

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**LED's magazine**

What is an LED?

Main LED materials
The main semiconductor materials used to manufacture LEDs are:
Indium gallium nitride (InGaN): blue, green and ultraviolet high-brightness LEDs
Aluminum gallium indium phosphide (AlGaInP): yellow, orange and red high-brightness LEDs
Aluminum gallium arsenide (AlGaAs): red and infrared LEDs
Gallium phosphide (GaP): yellow and green LEDs

https://www.ledsmagazine.com/leds-ssl-design/materials/article/16701292/what-is-an-led

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**Geschiedenis van LED**
https://www.circuitbread.com/tutorials/the-history-of-leds

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**What is a Light-Emitting Diode?**

https://sitlersledsupplies.com/light-emitting-diode/

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**UV**

Signify launches residential UV-C table top lamp in Asia and Middle East

The company agrees to supply UV-C ceiling units to Leipzig's soccer team. As the virus-fighting technology picks up, and as horticulture shines, the overall future remains uncertain in the pandemic as Q3 comparable sales fall.

With this UV-C tabletop lamp, Signify's tag line could be "try this at home." From a safety perspective, some people would say don't try this at home. (Photo credit: Image courtesy of Signify.)
The company agrees to supply UV-C ceiling units to Leipzig's soccer team.

https://www.ledsmagazine.com/lighting-health-wellbeing/article/14186058/signify-launches-residential-uvc-table-top-lamp-in-asia-and-middle-east

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**LED’s and OLED’s**

Small lights with big potential: light emitting diodes & organic light emitting diodes

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History of LED:
1961 eerste LED
1962 Nick Holonyak
1963 eerste commerciële LED de SNX-110.
1972 George Craford
1993 Shuji Nakamura

https://edisontechcenter.org/LED.html

PDF TheFirstPracticalLED
met veel referenties

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**What is a diode?**

How can a diode produce Light?

https://electronics.howstuffworks.com/led.htm

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**LED**

https://whatis.techtarget.com/search/query?q=LED

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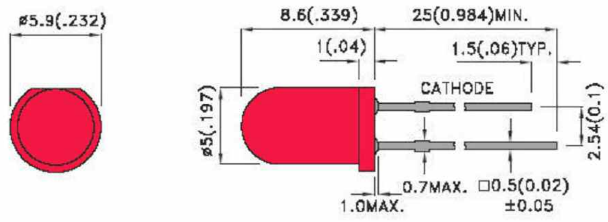
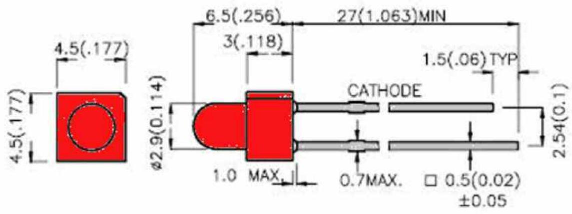
**Blinking LED**




*5 mm Blinking LED red*




*3 mm Blinking LED red*

https://www.circuitspecialists.com/l56bhd.html?otaid=gpl&gclid=CPSDktq9rNQCFQWSaQodVlwCiA

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**Follow up on Candle Flicker LED’s**

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Reverse engineering the controller chip

https://cpldcpu.wordpress.com/2014/03/01/follow-up-on-candle-flicker-leds/

Azoneberg **candleflicker**
**

https://siliconpr0n.org/archive/doku.php?id=azonenberg:unknown:candleflicker_led

**High resolution chip maps**

https://siliconpr0n.org/archive/doku.php

*Why use Dokuwiki and not Mediawiki?*

ACLs are required for certain projects that can't yet be made public.
Dokuwiki supports this much better than Mediawiki which is either fully closed or fully open

**Lijst met IC chip afbeeldingen per fabrikant**

https://siliconpr0n.org/map/

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A couple of “**Candle Flicker**" LEDs have been reverse engineered, as described here. The device consists of two chips, the actual LED and a fairly simple controller.

Lately, some solar powered garden lights have come on the market that have multicolor LEDs and controllers that change color and brightness in a long term pattern. Those have some simple microprocessor built in to the LED housing.

Link Tim’s blog:
https://cpldcpu.wordpress.com/2014/03/01/follow-up-on-candle-flicker-leds/

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**Hacking a Candlelight flicker LED**

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Deze kunnen ook nog andere LED’s aanstu-ren

https://cpldcpu.wordpress.com/2013/12/08/hacking-a-candleflicker-led/

**Reverse engineering a REAL candle**

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https://cpldcpu.wordpress.com/2016/01/05/reverse-engineering-a-real-candle/

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**LED’s, Displays & Lamps**

https://www.circuitspecialists.com/semiconductor-devices-lamps---displays

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**Flameless LED Candle Power Boost experimenter’s corner**

http://www.discovercircuits.com/dc-mag/Issue_nov10/pg-4.htm

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**LED’s, 555, PWM, Flasher and Light Cha-sers**

https://forum.allaboutcircuits.com/ubs/leds-555s-pwm-flashers-and-light-chasers-index.378/

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**Light Emitting diodes**

https://learn.sparkfun.com/tutorials/light-emitting-diodes-leds/all

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**Fabrikant in China**

Assortiment blinking LED’s

https://ledz.com/?p=led.blinking
met datasheets

https://ledz.com/

PDF leveringsoverzicht
https://ledz.com/E-Catalogue1.pdf

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**LED BRONNEN**

Angelle, Amber. "Will LED Light Bulbs Best Your CFLs and Incandescents?"
Aug. 2010. Jan. 6, 2020.

http://www.popularmechanics.com/science/environment/will-led-light-bulbs-best-cfls-and-incandescents

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**EarthEasy. "LED Light Bulbs: Comparison Charts."**
Jan. 7, 2020.
https://learn.eartheasy.com/guides/led-light-bulbs-comparison-charts/

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**LEDs Magazine. "Fact or Fiction: LEDs don't Produce Heat."**
May 10, 2005. Jan. 9, 2020.

The energy consumed by a 100-watt GLS incandescent bulb produces around 12% heat, 83% IR and only 5% visible light.
In contrast, a typical LED might produce15% visible light and 85% heat.

https://www.ledsmagazine.com/leds-ssl-design/thermal/article/16696536/fact-or-fiction-leds-dont-produce-heat

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**Morrison, Geoffrey. "LED Local Dimming Explained." CNET**.
March 26, 2017. Jan. 8, 2020.
https://www.cnet.com/news/led-local-dimming-explained/

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Scheer, Roddy and Moss, Doug. "**The Dark Side of LED Lightbulbs**." Scientific American. Sept. 15, 2012. Jan. 7, 2020

https://www.scientificamerican.com/article/led-lightbulb-concerns/

Study from the journal Environmental Science and Technology.

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**Electronics LED Tutorials**

Infrared RGB LED controller - Microcontroller Basics
How to Blink an LED - Microcontroller Basics
How does an LED work?
Why can't I share a resistor on the common anode or cathode of my RGB LED?
The History of LEDs
What's inside an LED bulb?
Your LED Questions Answered!
How to Dim an LED
Your LED Questions Answered!
How RGB LEDs work and how to control color
Selecting a resistor for an LED
Why Are LED's Better? (Comparing different types of light bulbs)

https://www.circuitbread.com/tutorials/tags/leds

LEDs and Forward Voltage
**Voorwaartse spanningen LED's:**

| | |
|---|---|
| ultraviolet | 3,1 - 4,4 V |
| Violet | 2,8 - 4,0 V |
| Blauw | 2,5 - 3,7 V |
| Groen | 1,9 - 4,0 V |
| Geel | 2,1 - 2,2 V |
| Oranje/goud | 2,0 - 2,1 V |
| Rood | 1,6 - 2,0 V |
| infrarood | > 1,9 V |

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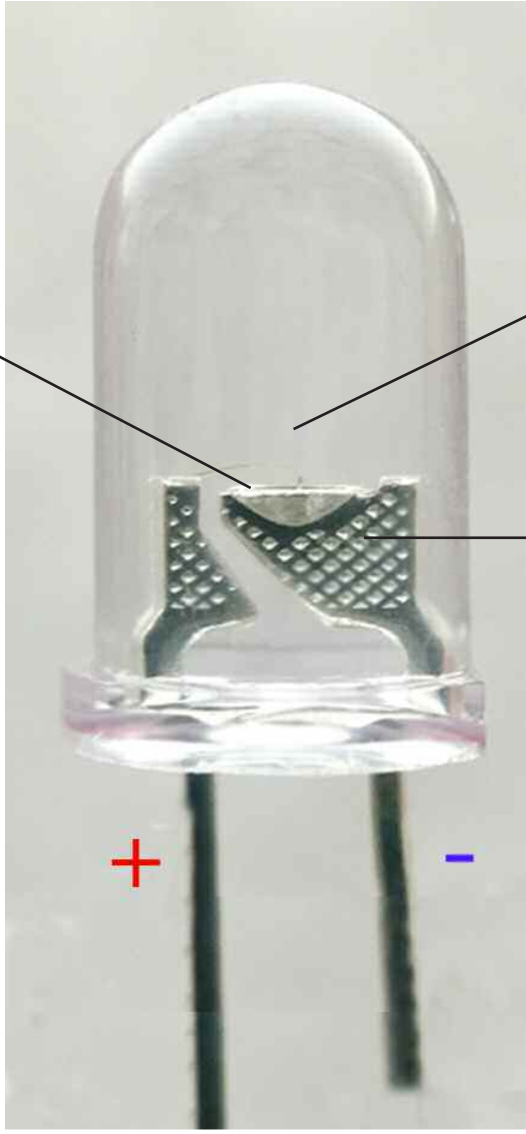
Het reflecterende deel met daarin het halfgeleider materiaal (P-N)

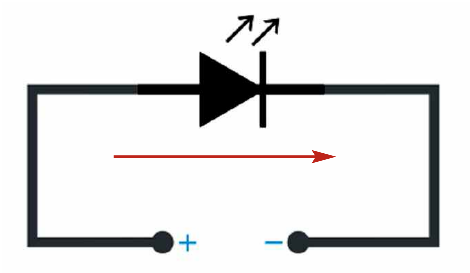



Gebogen draad van de + naar de bovenzijde van de p-laag (met photons).

Anvil (aanbeeld) houder

De langste draad / aansluiting is vrijwel altijd de + (anode)

De kortste draad / aansluiting is met de grotere reflecterende deel verbonden.
De kathode of te wel het streepje in de symbool tekening.




De voorwaartse stroom loopt van + naar min door de geleidende diode.

**Vervolg zie deel 3**