

# Joule Thief

ELECTRONICS123

Skill Level: Beginner

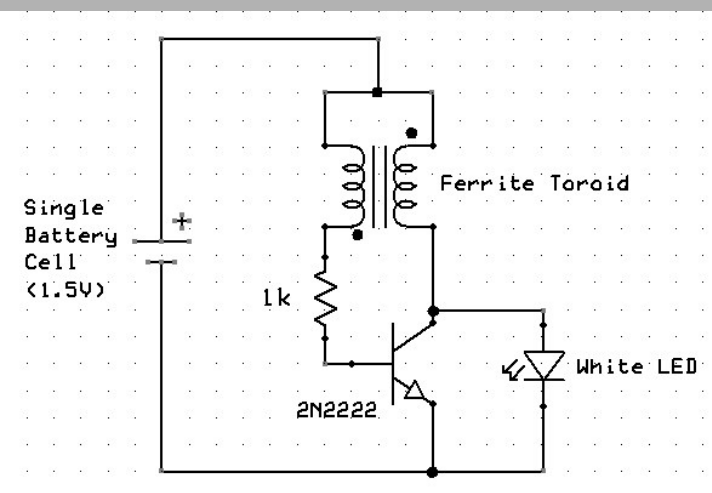
## OVERVIEW

The joule thief is a basic voltage step up circuit constructed using a ferrite core, enamel coated wire one NPN transistor and resistor. The joule thief has found uses in LED and low power applications.

One will often find a joule thief in a solar garden lamp where the low voltage from the solar cell will get converted into a higher voltage to charge a battery and power an LED. Joule thief's can work till a battery is very empty.

In this article we will have a look at the basic construction method and how we can rectify the output to have higher dc voltage. For that stage we will use a 12V zener diode to regulate the output voltage as high voltages are possible we do not want to exceed the capacitor voltage ratings.

Figure2: Schematic



## JOULE THIEF



Figure2: Simple Joule Thief.

In figure 2 a simple joule thief was constructed using a toroidal ferrite core some electrical wire a transistor and resistor. In this article we will make one in the same manner, the final product may be created on Vero board or a PCB.

## HOW IT WORKS

The joule thief will work using the fly back principle using the coil on the right in figure 1 for voltage conversion. The coil on the left has been used as a feedback coil. The feedback coil will switch the transistor on and off. Once the battery has been connected the current flows through the base of the transistor and causes it to switch on, now there is current flowing through the coil on the right and causes a magnetic flux to occur within the ferrite core. This magnetic flux will be present

## CONSTRUCTION

on the first coil as well. This magnetic flux creates a reverse voltage on the coil opposing current flow through the transistors base there for switching it off. Once the transistor is off the whole cycle continues. Although we know what happens here we need to have an idea of the second coils purpose. The second coil uses the change in magnetic fluxes and EMP (Electro Magneto Forces) to create a higher voltage. This topic goes quite in detail so we will just touch on it.

If you have ever made an electro magnet and powered it up, some cases there will be a spark if you disconnect it from the battery. This is what happens in the joule thief.

The magnetic flux in the core has a direction which one could say is applying force. Similar if the core was a tube with an iron ball spinning in one direction. If we had the ball spinning in one direction and stopped it all of a sudden with something to obstruct its path we will have a high energy transfer in mechanics this energy is conveyed in momentum, very similar to the flux in the core. The momentum of the object can be many times its own weight. In this case many times its own voltage. So now since the transistor is off we have a force in the core that wants current to flow but the transistors blocking it. If we have a look at the schematic you will see that the LED has provided an alternative route for this energy to continue flowing.

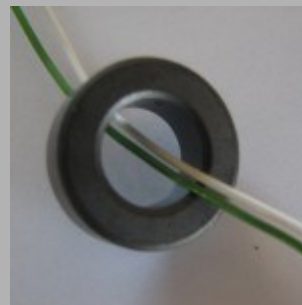
One simple example is the ram water pump. This pump uses water from lets say 10m above to create a stream in a pipe, once this stream has reached a specific speed the valve closes due to the forces applied to it. Then gets directed to another one way valve from this point the water could be pumped several times higher than its source at the cost of water between cycles to reach optimal speeds.

We will use the following components:

- 2N2222 NPN Transistor
- Toroidal Ferrite core
- Wire (get two different colours)
- 1k Resistor 1/4 Watt
- Bright LED
- 1.5V AA Cell battery

Lets start with the core windings first. Make sure they are the right way otherwise it will not work.

Take the two differently coloured wires and wind them together around the core starting at the middle point of the wires length as follows:



Keep both wires together while winding. Continue till you have between 7—15 windings. More windings will give you a higher voltage but lower output current



Notice we have 4 ends left we will need to create a center tap. We will use one wire from each end select one of each colours making sure its not from the same "twin pair" and join them.

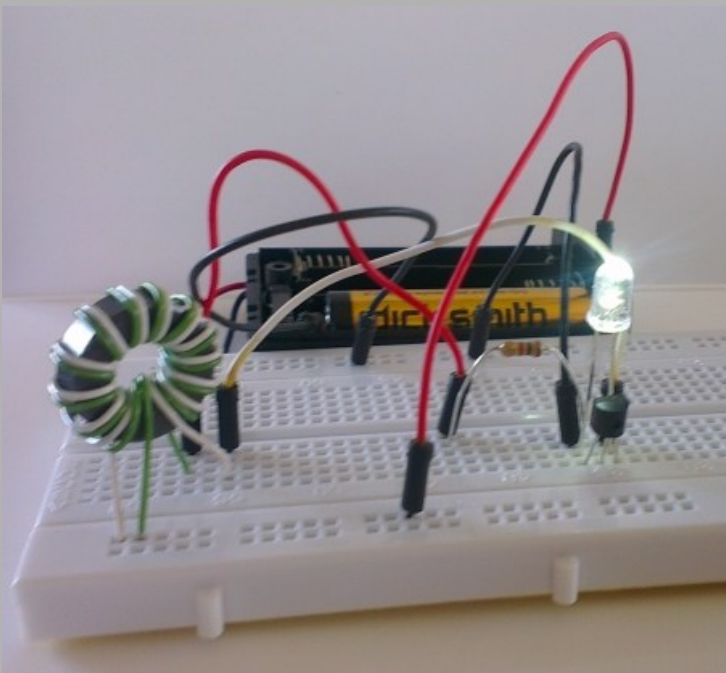


Joined windings now form the center tap of the transformer.

The center tap will connect to the +V of the battery then select one of the single wires and connect a 1k resistor to it followed by the transistors base pin. Next connect the collector of the transistor the remaining wire and connect the

round side of the LED to the same point. The flat side of the LED will now get connected to the emitter and ground of the battery as indicated in the circuit.

The joule thief is now complete.

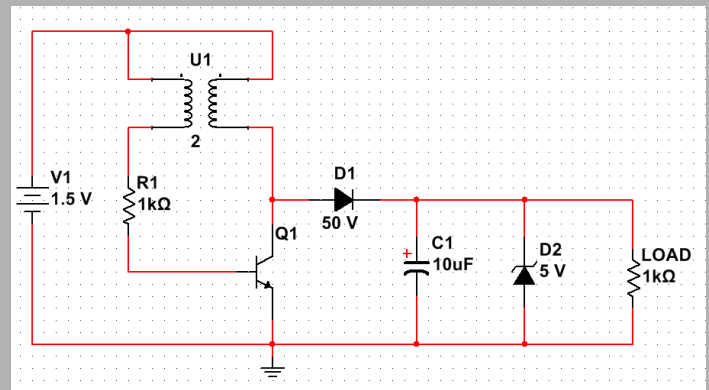


## DC—DC CONVERTER

Once the joule thief has been constructed we can modify the circuit to supply a DC voltage that could be rectified, This is a very low power converter and can be used for small solar battery chargers or peltier chip power conversions. For the DC to DC converter we will remove the LED and place a fast recovery diode and soothing capacitor. This will rectify the AC voltage generated and sooth its ripples. We have to use a fast recovery diode as normal diodes do not respond fast enough. Although

A normal diode might work a bit its not going to be efficient at all. The voltage will be regulated using a zener diode. Do not forget the zener diode as the voltages could exceed the maximum voltage of the capacitor and could rupture. I would suggest using eye protection as exploding capacitors can damage or remove an eye.

I will use a 5V zener diode



Once you have built the circuit above you may substitute the load resistor with a low powered load such as a Microcontroller or NE555 circuit etc. One thing to note is we are not using a resistor to limit the current through the zener. The current supplied is quite low so the zener will not be damaged. Do not remove the zener and charge the capacitor and place it back as this will create a current surge and destroy the zener.

Components:

- Fast recovery diode
- 10uF Electrolytic capacitor
- 5V Zener 1 Watt

All the components will be listed on the next page with Electronics 123 stock codes.

# PARTS LIST

Quantity	Description	Stock Code
1x	2N2222 or 2N3904	AA006
1x	5mm LED	AE969
2x	1 k $\Omega$ 1/4 Watt Resistors	DB056
1x	5.1V Zener 1 Watt	DB049
1x	Fast Recovery Diode	EB418
1x	10uF 25V Capacitor	HB245
1x	Toroidal Core	FP008
1x	1.5V AA Battery	AC586



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