iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 9 **Issue:** XII **Month of publication:** December 2021

**DOI:** https://doi.org/10.22214/ijraset.2021.39190

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429*
*Volume 9 Issue XII Dec 2021- Available at www.ijraset.com*

# Joule Thief and its Applications

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***Abstract: In this rapidly evolving world where the technology is flourishing at an exponentially steady rate the need and the requirement for various distinct and efficient sources of energy has become a significantly crucial requirement to fuel the technology of the world to come. We as consumers use an extensive array of devices and appliances in our day to day lives which are powered by discrete kinds of batteries and power sources which till date haven't been able to be utilised to their superlative potential. The battery resurrection circuit can be implemented on a variety of appliances and devices to utilise the complete capacity of the cells and batteries they use to provide a more economical and efficient use of a battery.***
***Keywords: Joule Thief, circuit, efficiency, battery, appliances, LED***

## I. INTRODUCTION

After creating machines and devices that use electricity as a medium to operate, we humans discovered and optimised various natural and unnatural sources of energy to fill the ever proliferating need of fuel and power. All the various sources of energy that have now been refined to some extent are still lacking, since an immense amount of this energy is left unutilised or untapped. Similarly, the various different kinds of cells or batteries (Lithium Ion Polymer, Lithium Ion, Lead Acid, Nickel-Metal Hydride, Nickel Cadmium) that are now used to power our daily use devices can only power them for a brief amount of time since only a particular capacity of the battery is actually utilised to power the device and the rest is wasted when its replaced as it can no longer be used to operate the device it was designated to power.

## II. CIRCUIT DIAGRAM & WORKING

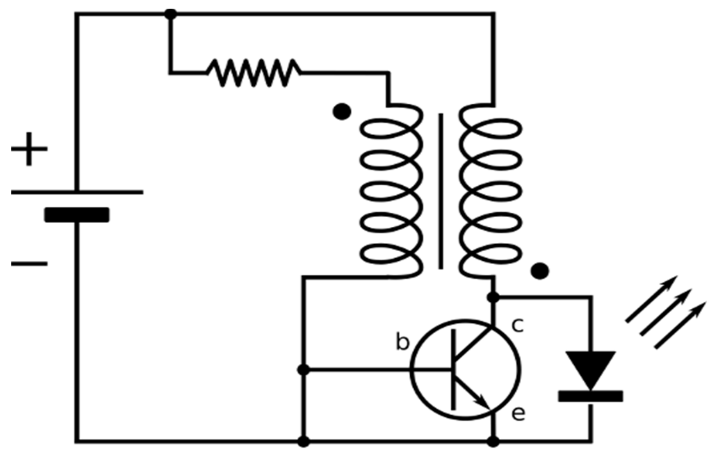

Fig.1 Circuit of A Simple Joule Thief

First current flows through the primary winding of the transformer, the resistance, into B connection (Base) of the transistor and out of the E connection of the transistor (Emitter). When this happens, a magnetic Field is induced through the primary winding. However, flow of electrons through the primary winding isn't at maximum or peak level since the beginning because the electromagnetic inductance of the transformer's primary coil obstructs the flow of current. Therefore, the moment that power is applied, there's zero flow of electrons through the primary coil. On the other hand there's some voltage induced on the secondary, as there's a rise in the flow of electrons (derivative of current is positive) through the inductors output voltage according the derivative of the current and primary coil. Therefore, the secondary winding of the transformer is producing an output voltage at the moment power is applied to the circuit. Since the battery is additionally wired in a serial combination to the transformer's secondary winding, and with appropriate polarity to sum up to the battery's output EMF. Now, because constant power is applied to the device, flow of electrons through the secondary winding of the transformer and LED rises (same occurrence as on the primary winding, inductive impedance).

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Even now the flow of electrons within the primary winding of the transformer and transistor is gradually increasing. At one instant the flow of electrons through the transistor and the primary winding of the transformer becomes plenty enough to turn on the transistor. When this happens, the output of the transformer is linked to ground, by moving from the secondary coil of the transformer into the C connection (collector)of the transistor and out of the E connection (Emitter) of the transistor, and to the negative terminal of the battery. When this happens, there's a sharp rise in the flow of electrons on the secondary side of the transformer and relative inductive voltage surge opposing this flow on the secondary side of the transformer. At an equivalent time (because the primary winding and secondary winding are magnetically coupled), there's the same voltage surge on the primary winding plenty enough to oppose the flow of current through the primary coil of the transformer and therefore the B connection (base of the transistor). Hence as a result the transistor switches off, causing the whole cycle to repeat itself. Switching off a transformer abruptly with a transistor will produce a significant voltage surge through the transformer and transistor which can cause permanent breakage of the transistor. So, another diode in parallel with the LED in the opposite polarity as the LED can be connected so that instead of getting a voltage spike (which can damage the transistor and LED) you get an acute increase in the current through the diode.

**Inductor and LED Tests @ 1.28V & 2N3904**

| From | Core Order # | O.D. (mm) | Wire Guage | ( # of ) Loops | mA | µH | Freq KHz | On (µs) | 1 Hz (µs) | On Time ( % ) | Peak Volts | LED Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Digi-Key | 495-3851-ND | 12.5 | 24 | 11 | 38.7 | 527 | 4.2 | 90 | 240 | 37 | 3.6 | Blue |
| Digi-Key | 495-3851-ND | 12.5 | 30 | 25 | 23.1 | 570 | 1.4 | 280 | 690 | 30 | 3.6 | Blue |
| Digi-Key | 495-3851-ND | 12.5 | 30 | 25 | 5.4 | 570 | 22.8 | 18.8 | 43.2 | 43.5 | 3.1 | White |
| Digi-Key | 495-3849-ND | 10 | 32 | 11 | 56.5 | 131 | 8.3 | 120 | 235 | 54 | 2.4 | Amber |
| Digi-Key | 495-3849-ND | 10 | 32 | 44 | 39.2 | 800 | 2.2 | 280 | 460 | 54 | 2.4 | Amber |
| Digi-Key | 495-3849-ND | 10 | 32 | 11 | 56.6 | 138 | 7.84 | 40 | 127.5 | 31 | 5.6 | White |
| Digi-Key | 495-3849-ND | 10 | 30 | 12 | 54.2 | 158 | 8.16 | 42.5 | 122.5 | 34 | 5.4 | White |
| Digi-Key | 495-3849-ND | 10 | 32 | 22 | 41.6 | 497 | 3.70 | 100 | 270 | 37 | 5.6 | White |
| Digi-Key | 495-3849-ND | 10 | 32 | 44 | 30.6 | 800 | 1.78 | 220 | 560 | 39 | 5.6 | White |

Fig. 2 Inductor and LED Tests

## III.APPLICATIONS

### *A. Using Joule Thief Circuit with Peltier*

Free Energy in this case is the body heat which is generated by the body as long as you live to perform various biological processes. The circuit makes use of the Peltier effect (Also called the thermoelectric effect, it is the direct conversion of temperature difference between two metal to electric voltage) to use the temperature difference between the body and the environment (Usually 30c) to generate electricity which in this circuit is used to drive a LED (Light Emitting Diode). A N-channel junction FET:2SK170 is used to achieve the self- starting oscillation even at a voltage as low as 30mV. The circuit only uses (4.2 mA at 60mV) input. The open circuit voltage is around 8-8.5V with two LEDs connected in series it is around 4.3V. The circuit show above has the ability to function with just a single FET:2SK170 but 4 FETs connected in a parallel combination are used in this circuit to increase its efficiency which also increases the current draw to 4mA. A toroid ferrite core wound with copper wire of different lengths and thickness (100 turns 32Awg & 4 turns 18Awg) is used in the circuit to store the electromagnetic energy. As output two LEDs in series combination are connected to the output terminals of the circuit.The circuit shown below (Fig 3) demonstrates an example cum application of how merely the heat perpetually radiating from one’s body can be used as a constant source of energy supply to power devices of the future and lend a helping hand towards diminishing the rising energy crisis. This mechanism could also prove to be profitable and advantageous when applied at places where the wasted energy after the completion of a particular process or processes is in the form of heat radiation, as the greater the temperature difference between two metals the higher is the voltage generated by this circuit.

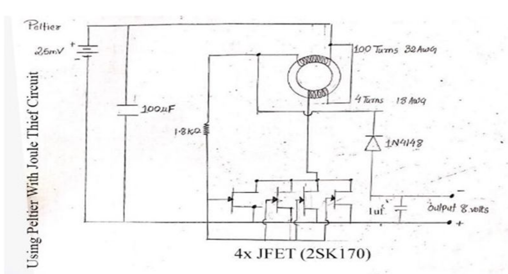


Fig. 3 Using Peltier with Joule Thief Circuit

*B. Using Piezoelectric Discs with Joule Thief to Charge Up Batteries*

A piezoelectric disc (usually made of Rochelle salt ($KNaC_4H_4O_6 \cdot 4H_2O$), Tourmaline, Topaz etc) when put under mechanical stress converts this mechanical energy to electrical energy and induces a certain amount of voltage which can be collected, stored and used as a power source to power or charge various devices. The piezoelectric disc being very useful is still lacking since the output it generates is too less to be used as optimal power source. However, if used with a joule thief circuit the output can be amplified and actually be used as a power source for various small-scale appliances. Since the actual construction of the joule thief is very cheap and easy to mass-produce commercially it could be a great alternative to be paired with a set of serially connected piezoelectric discs (connected in a serial combination to increase the EMF generated) and hence used as a power source at places where the wasted energy generated is in the form of mechanical stress or a deforming force to get the most effective use of it.

*C. Using Joule Thief for Wind Power Generation*

The circuit shown below (Fig 4) is an example of how the rotation of a dc fan through passing wind can be used as a power source to drive a LED. We know that a LED requires a minimum input of 3V to light up but the voltage generated by the rotating fan is far less than that, therefore the fan can directly be connected to a joule thief to gain a viable output that will be sufficient enough to light up the LED. Similarly, this circuit can also be modified by replacing the led with a rechargeable battery circuit to help store the generated electricity and charge up a battery that can be later used to power other appliances. The low voltage input by the fan in this circuit is amplified to a series of high value DC voltage. The Joule thief circuit can be used in similar applications like these, for example- It can be used in dynamo mechanisms like using the rotational movement of ceiling fans to drive another motor (which will be the input end) between which the joule thief can be connected and at the output end other appliances or cells can be connected as per the user requirement. Similarly, this mechanism can be used to harvest energy from the rotational motion of car tyres, water turbines or almost anything that involves rotational motion.

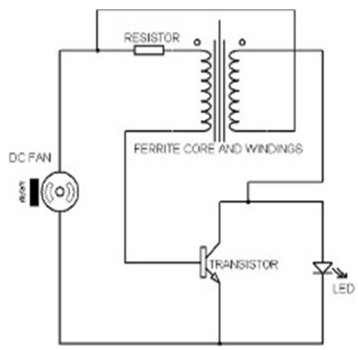


Fig. 4 Circuit diagram of wind power operated LED

*D. Other Miscellaneous Applications*

1) Using joule thief circuit with solar cells (converts solar energy to electric energy) to power appliances and/or charge rechargeable batteries.
2) Using Joule thief circuits in bicycle lights, portable reading lamps, portable heaters, remote controls and other small appliances that are powered by conventional Li-OH batteries.
3) Using the Joule Thief circuit with car batteries, CFLs, power tools, decoration lights, etc.

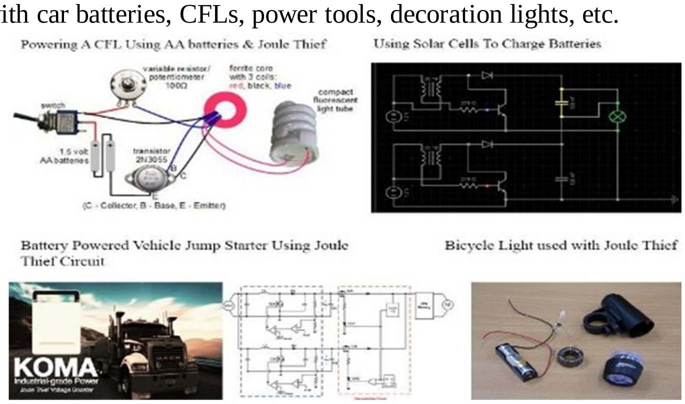


Fig. 5 Various Applications of Joule Thief

## IV. RESULTS & DISCUSSION

The Joule thief can be proficiently used by modifying various circuit parameters (like number of turns on the toroid core, types of transistors used, turns ratio on the core, etc) to extract and utilize the full capacity of various different kinds of batteries outputting different voltages. The joule thief can also be used with various kinds renewable sources of energy to collect and store energy in the form of electricity and use it to charge up batteries or operate appliances.

## V. FUTURE SCOPE

With significant improvements to the circuit components in the future this circuit can be used with various complex devices such as smartphones, tablets, smartwatches, laptops, portable power banks, etc to increase their battery lives and make complete use of the battery cycles of the rechargeable batteries (Lithium Polymer batteries) that they use.

## VI. CONCLUSION

In our day to day lives where we are completely enveloped by a plethora of devices the joule thief circuit could be evolved and improved to be implemented on a wide variety of appliances. Using the joule thief circuit in various kinds of small circuits and devices can help users save a substantial amount of money in the long run since the appliances when used with the joule thief will be able to utilise the complete capacity of the batteries giving the consumers a longer lasting usage and preventing the unnecessary wastage of energy. Furthermore, the reason joule thief could be easy to implement commercially with a variety of devices is because it is relatively easy and substantially more economical to mass produce since it requires just a few components to function and can be modified appropriately for different applications.

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