A Review on Joule Resurrection Circuit and its Applications

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Abstract

Joule Resurrection Circuit may be defined as a boost mode switching supply circuit which is powered by a drained battery. Normally, it is used to drive small loads. This circuit is also known by other names such as Joule Thief Circuit, Blocking Oscillator, Joule Ringer and Vampire Torch. It is very cheap andeasy to build. Also, as it is very small, it can be implemented in a large number of applications. Other advantageous features include optimum power consumption and long life operation. Two interesting things about this circuit are: First, conventional circuit for operating the load is not required. The second point being, it can operate even when the battery is depleted down to the point where its terminal voltage is around 0.3V. This circuit sucks even the last bit of energy from the battery. Since energy is measured in joules and the circuit derives energy out of dead batteries, the name is Joule Resurrection Circuit.

Keywords:* *Joule Resurrection, Practical Electronics, Blocking Oscillator,Electromagnetic Induction

1. Introduction

Household batteries that power clocks, torches, remotes, cameras, wristwatches, smoke alarms and portable games and gadgets are so small that they are considered by many to be throwaway items. A 1.5V battery is thrown at 1V and a 9V battery at 6V. 0.5V and 3V capacity of batteries respectively still remain in it which are usually neglected as they become unusable. Each year, tons of batteries end up in landfill contributing to pollution.

The Joule Resurrection Circuit (JRC) is a voltage booster which takes its energy from an almost dead battery and can produce output and drive loads, where the other circuits consider the battery, to be drained. This circuit is a variant of the blocking oscillator[1] that forms an unregulated voltage boost converter.

There is a claim that JRC is an Armstrong oscillator[2] whereas it is not. An Armstrong oscillator uses a tank circuit and operates in a linear mode whereas the JRC do not incorporates tank circuit and operates in a non-linear switching mode.

The JRC was published as Joule Thief Circuit in November 1999 issue of Everyday Practical Electronics (EPE), by Z Kaparnik [2]. It was an execution of transformer-feedback single-transistor inverter. A one meter enameled copper wire was wounded around a ferrite (toroid core) to make it a high frequency (HF) transformer and the resistor limited the feedback current into the transistor and the transistor switched on and off about 50,000 times in one second making the Light Emitting Diode (LED) glow. Experimental prototype was designed by using 1.5V battery to activate only the LED as load.

2. Joule Resurrection Circuit

There are many circuits linear and non-linear that exist theoretically and their practical limitations govern the applicability [5]. Many devices are thrown away as soon as their battery is down, though their circuit may still be in working condition. Electrical devices that earlier required more energy to operate gradually began to get replaced with energy saving ones thus being more environmental friendly. The effort to save electricity is continuously being developed, along with the improvement in technology. Hence the electrical power source is expected to be power saving, optimum and having long operating life. The JRC is one such solution which raises electromagnetic force on wounded core when there is a current [3]. This circuit has a transistor operated as a switch to cut voltage and current flowing in the coils. The presence of current causes magnetic induction and generates energy.

JRC is a very tolerant circuit, bearing many changes in its component values. Following are the possible variables:

- Number of turns on ferrite core
- Turn ratio on ferrite core
- Types of ferrite core
- Cores other than toroid
- Bias resistor values
- Types of transistor
- Types of load
- Input voltages

3. Circuit Design

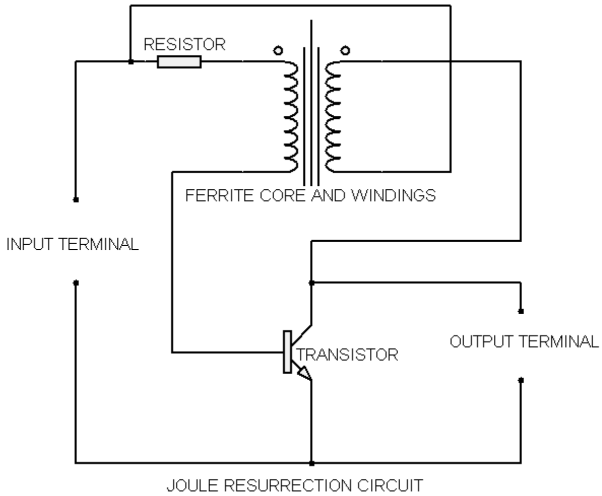

Figure1. Joule Resurrection Circuit without source and load components

In this paper, JRC [3], [7] is designed by connecting a power supply, solenoid in toroidal form (ferrite core and its windings), a transistor, a resistor and an output load as shown in Figure 1. Each block or subsystemis varied according to the characteristics of each component. The source is a variable voltage input. The transistor circuit is constructed from different types of resistance and the base current settings. Solenoid in toroidal form is wound with variablenumber of primary and secondary winding turns. The load is a variable load.

4. Working of JRC

JRC is a self-oscillating voltage booster. It takes a steady low voltage signal as input and converts it into a series of high frequency pulses at a higher voltage level. The working of JRC [2], [4] is explained below:

Initially the transistor is in cutoff state (open circuited) and the main switch is open. When it is closed, a source is provided at the input terminals as a result of which small amount of current starts to flow through the bias resistor, the primary coil and the base terminal of the transistor, as they are connected in series. This base current partially opens up the collector-emitter channel. Current is now able to travel through the secondary coil and through the collector-emitter channel of the transistor which was earlier open circuited. The increasing amount of current through the secondary coil generates a magnetic field that induces a greater amount of current in the primary coil according to Law of Electromagnetic Induction (EMI). This induced current in the primary coil goes again into the base of the transistor and opens up the collector-emitter channel further. This lets even more current to travel through the secondary coil and through the collector-emitter channel of the transistor. This process repeats itself in a feedback loop until the base of the transistor is saturated (short circuited) and the collector-emitter channel is fully open.

The current travelling through the secondary coil and through the transistor is now at a maximum. Also, there is a lot of energy built up in the magnetic field of the secondary coil. Since the current in the secondary coil is no longer increasing beyond its maximum value and becomes constant, it stops inducing current in the primary coil. This causes less current to go into the base of the transistor. With less base current, the collector-emitter channel now begins to partially close. This allows less current to travel through the secondary coil. A drop in the amount of current in the secondary coil induces a negative amount of current in the primary coil. This causes even less current to go into the base of the transistor. Now, this process repeats itself in a feedback loop until there is almost no current going through the transistor and the base is cutoff (open circuited) resulting in full closure of collector-emitter channel. Some part of the energy that was already stored in the magnetic field of the secondary coil has drained out. However, there is still a lot of energy that was stored up left. This energy needs to get dissipated from somewhere. This causes the voltage at the output of the coil to spike. The built up current can't flow through the transistor owing to its cutoff. So, it has to flow through the alternative path i.e. the load. The voltage at the output of the coil builds up until it reaches a voltage where it can go through the load and get dissipated. The built up energy goes through the load in a big spike. Once the energy is dissipated, the circuit is effectively reset and starts the whole process all over again.In a typical JRC, this whole process of charging and discharging happens 50,000 times per second (50 kHz) making it act as a high frequency transformer.

5. Applications of JRC

5.1. Operating 12V DC Motor

A DC motor normally operates on 12V.Conventionally, a motor requires a motor driver for its operation as shown in figure 2, however, through JRC, it is possible to drive it directly.

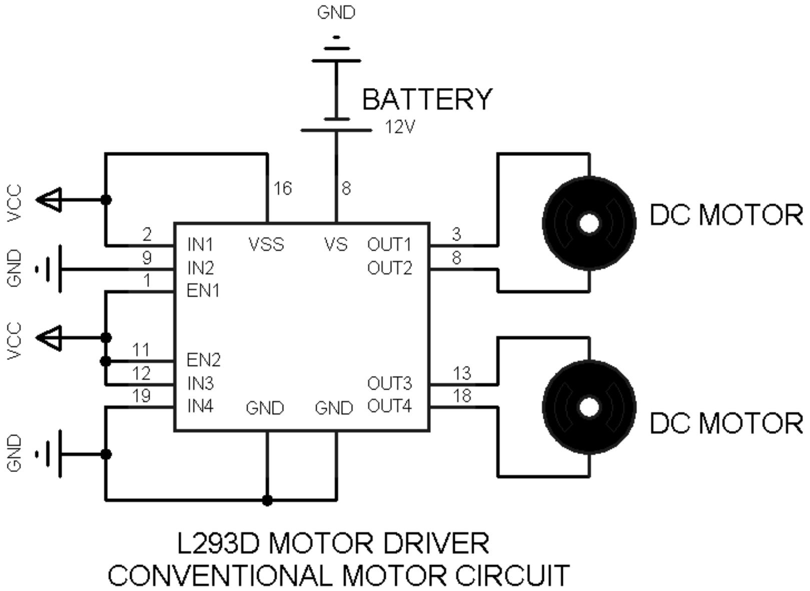

Figure 2. Conventional motor circuit

The circuit is prepared by firstly winding two wire gauges on a ferrite core of normal type. Polarities of these windings are to be noted carefully. This is the trickiest part of the whole circuit. Further, the connections of resistance (1kΩ) and transistor (BC547) are done as shown in the Figure 3. A dead battery is connected at the input terminals and a DC motor is connected at the output terminal. A main switch may also be provided.

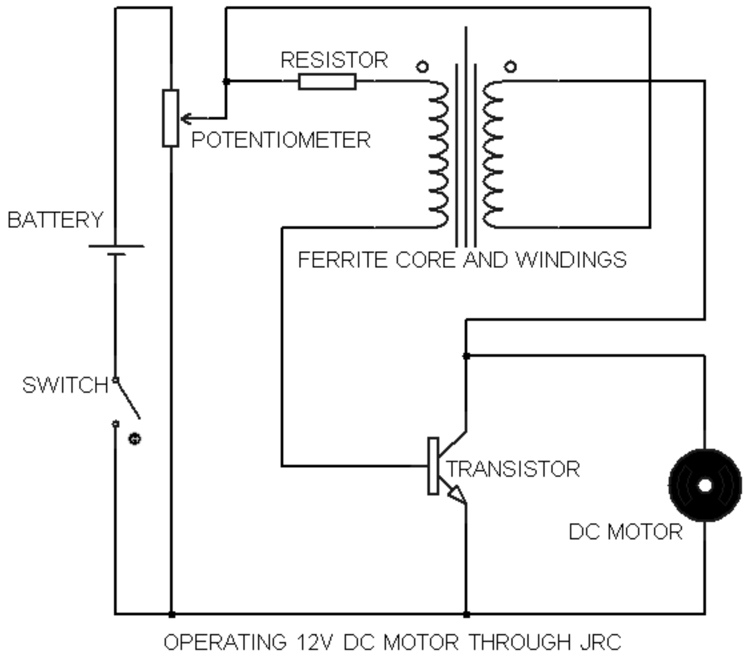

Figure 3. Operating 12V DC motor using JRC

The low DC voltage applied at the input terminals (as shown in Figure 4) is converted into train of DC pulses of high voltage of nearly 50kHz (as shown in Figure 5) and switches on and off the motor 50000 times a second, which seems to be continuously operating to us.

Whenever the switch is turned on, the motor rotates as per the mechanism explained in Section 4. To identify the lowest working voltage and to control the speed, a potentiometer can also be provided in series with the source.

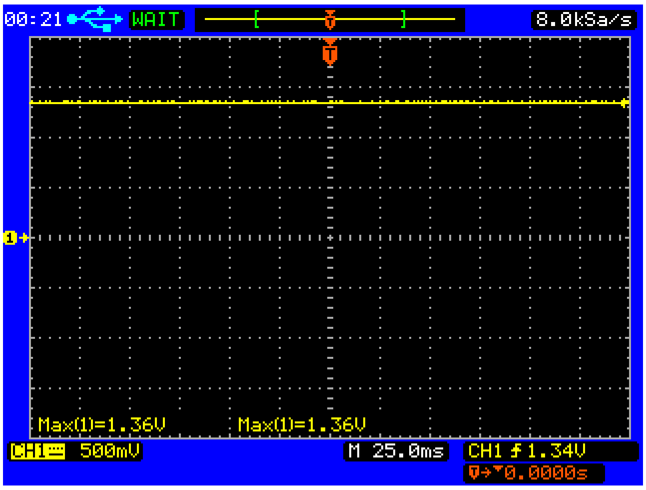

Figure 4.Constant DC input

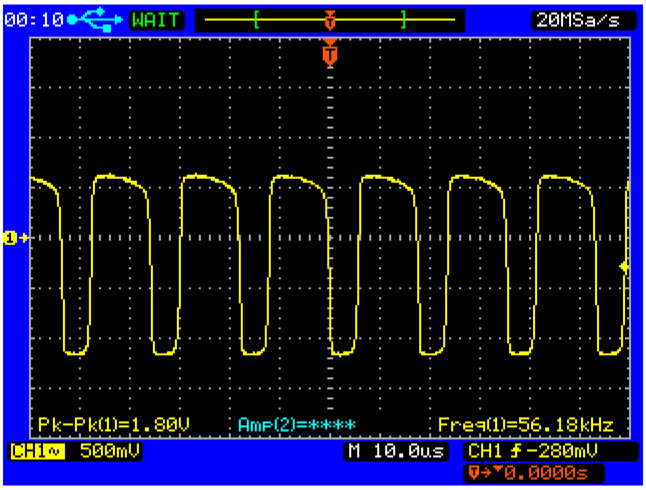

Figure 5.High Frequency Pulses at boosted voltage

5.2. Operating 5VPiezo-electric BuzzerFrom a Dead Battery

In this application, a piezoelectric buzzer which conventionally operates on 5V as shown in Figure 6 is operated through a battery which is supplying even less than 1.5V. In this applicationa piezo-electric buzzer is the load. The low DC voltage applied at the input terminals is converted into train of DC pulses of high voltage of nearly 50kHz (as shown in figures above) and switches on and off the buzzer 50000 times a second, which seems to be continuously operating to the viewer.

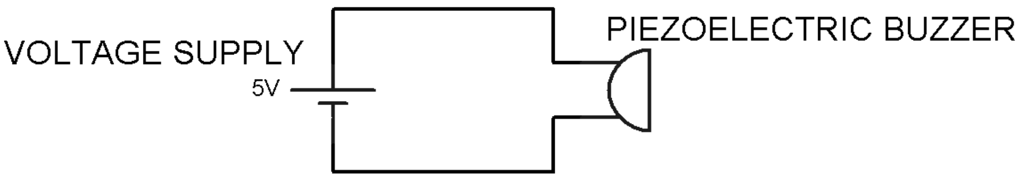

Figure 6.Conventional buzzer circuit

The circuit is prepared as shown in Figure 7. A dead battery is connected at the input terminals and a piezo-electric buzzer is connected at the output terminal. A main switch may also be provided alongside.

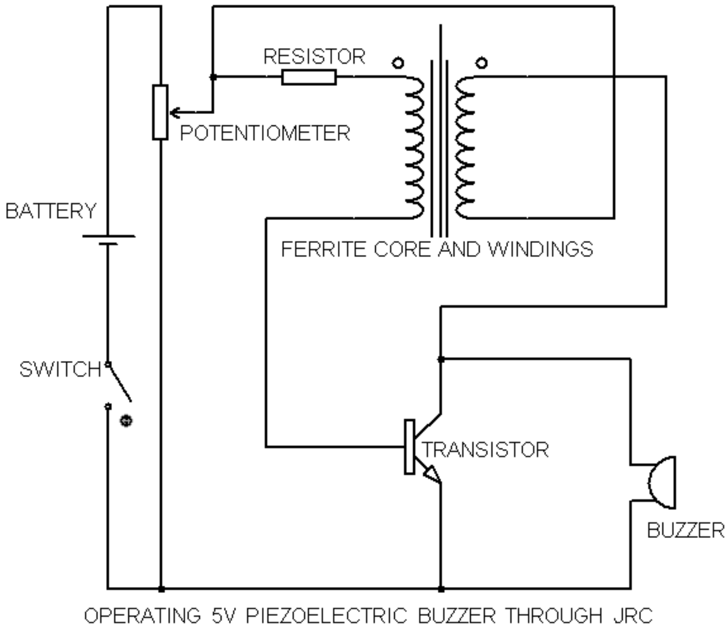

Figure 7. Operating 5V piezoelectric buzzer using JRC

Whenever the switch is turned on, the buzzer operates as per the mechanism explained. To identify the lowest working voltage and to control the intensity of the sound, a potentiometer can also be provided along with the source.

5.3. Wind Power Generation

In this application, a LED which normally operates on 3.8V as shown in Figure 8 is operated through a DC fan which supplies nearly 0.6V. Conventionally, LED requires a comparatively high voltage supply and a resistor to limit the current flowing through it, to protect it from damage. Here, LED can be directly connected across the load terminal. The low DC voltage is boosted to a train of DC pulses of high voltage and frequency. It switches on and off the LED 50000 times a second as explained earlier, which seems to be continuously operating to us.

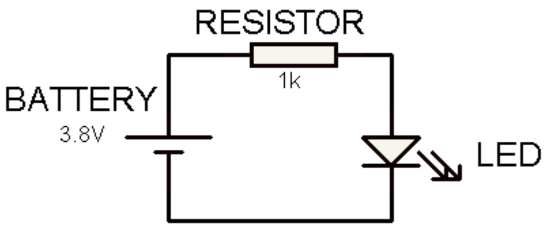

Figure 8. Conventional LED circuit

Again here, the circuit is prepared as shown in Figure 9. A DC fan is connected at the input terminals and LED is connected at the output terminal.

Whenever wind rotates the wings of the fan, the LED glows. Thus, wind energy can be harnessed at a small scale without the use of complicated components like turbines, shafts, generators and gear boxes.

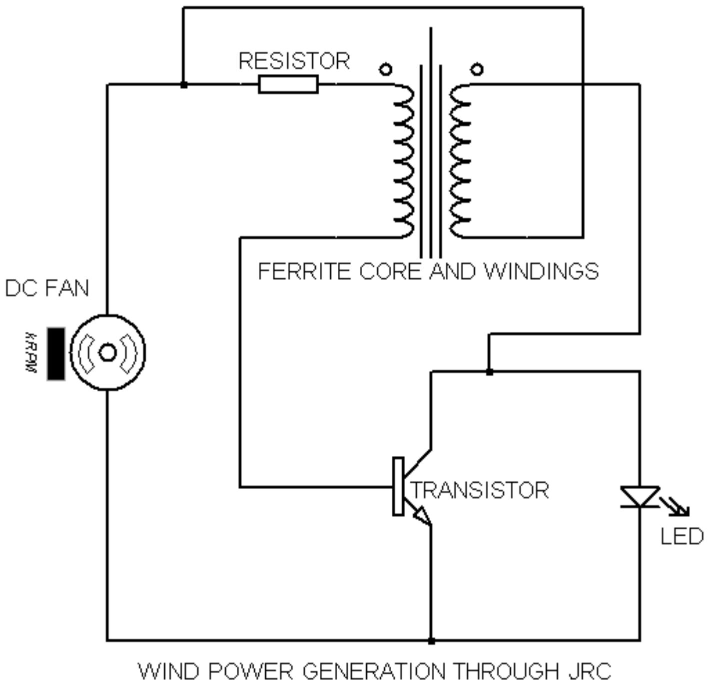

Figure 9. Wind power generation using JRC

6. Result

JRC can provide necessary current and voltage from a dead 1.5V DC battery to supply the loads by utilizing the reverse current flow that occurs through switching conducted by the NPN transistor.

The more the coils wound on ferrite core, the more the voltage and more the current. Hence to improve the performance of JRC for larger power applications, using a ferrite core with larger diameter and more winding and using a switching transistor [6] with the larger current type are helpful. Hence high power equipment can also be supplied using JRC.

7. Discussions

JRC keeps the battery in working condition for a longer period of time thus reducing the e-waste to a large extent. Also, implementation of this circuit is very cheap as it involves cheap components like a ferrite core which can be easily found in discarded compact fluorescent lamps (CFLs) or computer motherboards. Also, resistors and transistors are extremely cheap. Moreover, this circuit is very easy to design if the trickiest part of winding the core is done carefully. This circuit can be incorporated anywhere as it is so much smaller and highly compatible. As we have seen, this circuit has wide range of applications.

Unfortunately, this circuit is confined only for low power applications now, but research is being done using various other components and materials as core for making it suitable for high power applications too thus widening its application range further.

8. Conclusion

The Joule Resurrection Circuit was successfully designed and was checked for some of its applications. Both, the applications that have been implemented and the components that have been used have been found to work satisfactorily. Hence it is concluded that the project “Joule Resurrection Circuit and its applications” is technically feasible, reliable and commercially viable.

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