Memristor-based AMS Circuits: A Relaxation Oscillator For Vehicle Turn Signaling Case Study

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Abstract

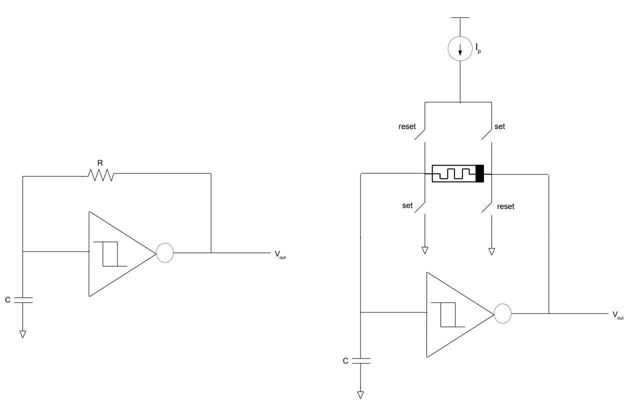
This paper proposes a memristor based relaxation oscillator for energy efficient blinking turn signals in vehicles. First the memristor based relaxation oscillator is proposed. This oscillator design is then used to achieve the energy efficient model for the turn signaling in vehicles. To use signals while changing lanes or taking a turn is a mandatory rule in every country. In 1907, a patent was used for a mechanism to show the intentions of a driver and his movements. The present mechanism used to blink the lights has been the same since almost when light signaling was introduced in vehicles. In this process, a lot of energy is wasted in the form of heat. This paper proposes an energy efficient way to blink signals and conserve energy using the memristor oscillator.

I. Introduction

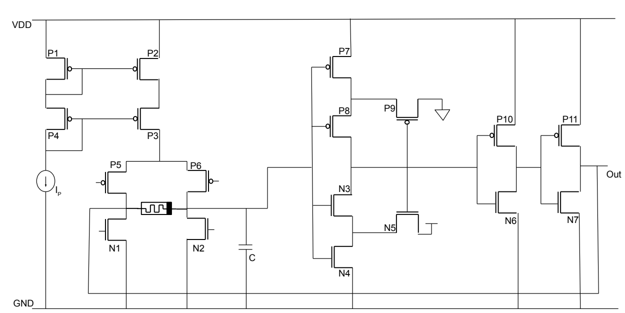
P. S. Douglas Hamilton filed a patent in 1907 on devices for signaling [1]. That marked the beginning of mechanical signaling in vehicles. Many significant changes have come in vehicles but the mechanism used for signaling the direction a driver intends has been the same for a long time. A thermal flasher is used to blink the signal lights in most vehicles. This dissipates energy in the form of heat and consumes a lot of energy which can be conserved by making the whole process digital. This paper proposes a method to digitize the process of blinking turn signaling of vehicles in an energy efficient way. This can be achieved using a memristor based relaxation oscillator. As its name suggests, "Memory+Resistor" memristor, this element can store data [2], [3]. The memristance of the memristor can be programmed by changing the value of the current that is passed through it. Extensive research is being done to use the memristor in many applications. One such area of application is in oscillators. This paper shows a memristor-based relaxation oscillator for energy efficient turn signaling of vehicles.

II. Design and Characterization of Memristor-based Relaxation Oscillator

The memristor based oscillator design is shown in Fig. 1. Fig. 1a shows a traditional Schmitt trigger oscillator design (Left) and a memristor based Schmitt trigger oscillator (Right).



(a) Without Programmability (Left) - With Programmability (Right)



(b) Schmitt Trigger with Memristor

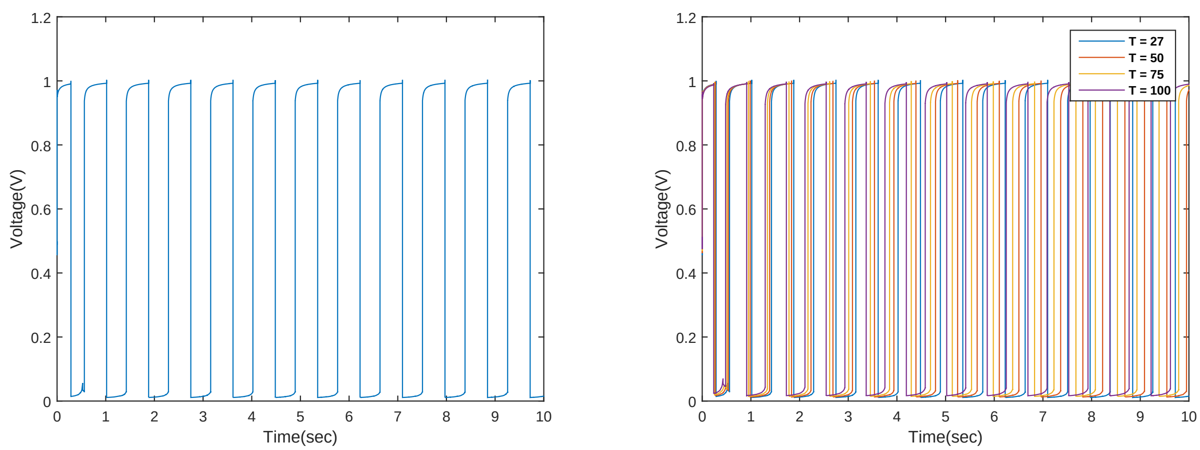
Fig. 1: Relaxation Oscillator using a Schmitt Trigger.

The output frequency in a conventional Schmitt trigger is determined by the resistance and the capacitance. In this design, the resistor is replaced by a memristor. The four switches on the memristor determine the resistance and are used to program it. There are two conditions in this circuit. One is when the **reset switches** are closed and set switches are open and the other is when the **set switches** are closed and reset switches are open. In the first condition the memristance is set to R_{on}. In the second condition, the constant current flows through the memristor in the opposite direction compared to the first condition to increase the memristance. Fig.1b shows the memristor based relaxation oscillator. In this circuit, the memristor is configured as follows: the state variable $x = 0.1$ the minimum resistance is 10KΩ, the maximum resistance is 100KΩ. The thickness D is 40nm and the mobility of the electrons when the voltage is zero is $\mu_v = 10^{-14} m^2/s/V$. Width for the transistors P1 - P4 is 4μm. P9 and N5 have a width of 2.5μm and 1.5μm respectively. For all PMOS transistors W = 2μm and for all NMOS transistors 1.5μm. The current source I_p is set to 100μA and the capacitor is 85μF

For characterizing the Memristor Based Relaxation oscillator, first the capacitor value is taken as 200 fF. Then the simulation is done by programming the memristance for different values and calculating the resulting frequency and power. First the "set" is closed and the current I_p passes through the memristor increasing its resistance. Table.1 shows the results.

TABLE I: Characterization of Memristor Based Relaxation Oscillator

Technology	Supply	Memristance	Oscillating Frequency	Jitter	Power Dissipation
90 nm	1 V	10 KΩ	466.41 MHz	69 ps	161.2 μW
90 nm	1 V	25 KΩ	122 MHz	323 ps	133.9μW
90 nm	1 V	50 KΩ	72.46 MHz	536 ps	130.4 μW



(a) Without Programmability

(b) With Programmability

Fig. 2: Simulation of Relaxation Oscillator.

For turn signaling of vehicles, the output frequency of the relaxation oscillator should be between 60 to 120 blinks per minute [4], [5]. To obtain this frequency, the capacitor value is increased to 50μF and the memristor is set to 50KΩ. The output is shown in Fig.2a. The peak power consumption of this module is 110μW. The simulations are done for the same module at different temperatures, as shown in Fig.2b. Though the temperature of the module increases, the frequency is not affected but the signal advances in time.

III. Conclusions

The proposed circuit can be used with LED and laser lights being used in vehicle signaling and headlights to conserve energy. Maximum power can be saved if LED lights are used [6].

References

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