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

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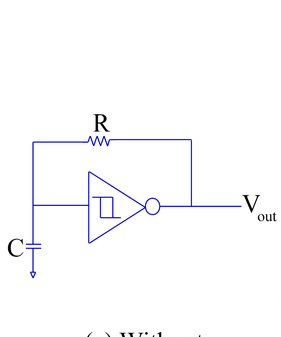
Abstract

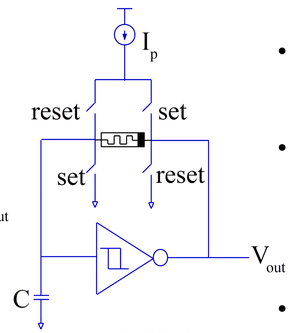
A Memristor based relaxation oscillator for energy efficient blinking turn signals in vehicles is proposed. This oscillator design is used to achieve an energy efficient model for turn signaling in vehicles. To use signals while changing lanes or taking a turn is a mandatory rule in every country. In 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 the time light signaling was widely introduced in vehicles. A thermal flasher is used to blink the signal lights in most vehicles. In this process, a lot of energy is wasted in the form of heat. This paper proposes an energy efficient way using a memristor based programmable relaxation oscillator. Here we replace the resistor in a Schmitt Trigger oscillator with a memristor and program it with a current source which in turn programs the whole relaxation oscillator.

Relaxation Oscillator Design

- A memristor based programmable relaxation oscillator is used in this case study.
- A Schmitt Trigger design was used as it exhibits minimum phase noise.
- The four switches around the memritstor are responsible for programmability.
- The current source I_p provides the necessary current required to program the memristor.
- This programmability allows us to vary the frequency of blinking of signal lights.



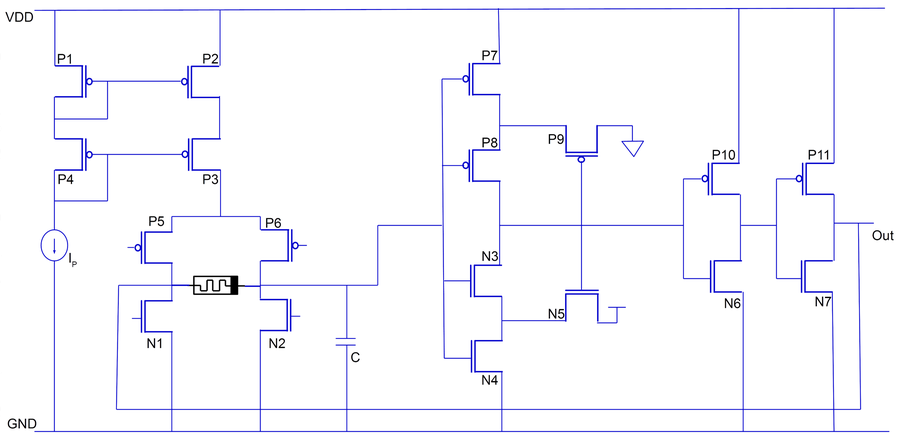
(a) Without Programmability



(b) With Programmability

DESIGNOF MEMRISTOR-BASED RELAXATION OSCILLATOR FOR VEHICLE TURN SIGNALLING

- The four switches on the memristor that determine the resistance operate the circuit in two conditions.
- When the set switches are closed and the reset switches are open, the memristance is set to Ron.
- When the constant current flows through the memristor in the opposite direction compared to the first condition it increases the memristance.
- In this circuit, the memristor is configured as follows: the state variable x varies from 0 to 1: the minimum resistance is 10KΩ, the maximum resistance is 100KΩ. The thickness D is 40nm. Width for 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 Ip is set to 100A and the capacitor is 85µF.
- For turn signaling of vehicles, the output frequency of the relaxation oscillator should be between 60 to 120 blinks per minute.
- To obtain this frequency, the capacitor value is increased to 50F and the memristor is set to 50K.
- The power consumption of the module in this configuration is 110µA.
- This module will be guiding the power to the required signal lights of the vehicles.
- The blinking frequency of the signaling lights can be varied on-the-go giving the consumer the freedom of customization.
- Electrical turn signaling modules are also designed based on the oscillations which require a voltage change to make an on-the-go oscillation change of the turn signal lights.
- This design has an advantage by incorporating transistors to do the change in the oscillation.



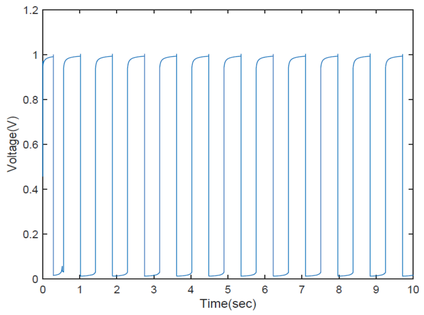
Characterizing The Memristor Based Relaxation Oscillator

- For characterization of the circuit, the capacitance is considered as 120fF
- The power consumption of the whole circuit is decreased considerably as the frequency is decreased.
- This ensures minimal consumption when implemented in an application.
- The output oscillations of the circuit for different temperatures also show that there is not much delay introduced due to the high temperatures that are possible in a vehicle.

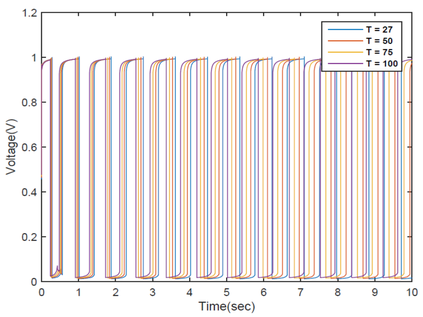
Technology	Supply	Memristance	Oscillating Frequency	Jitter	Power Dissipation
90 nm	1 V	10 KΩ	466.41 MHz	69 ps	161.2 µW
90 nm	1 V	25 KΩ	122 MHz	323 ps	133.9µW
90 nm	1 V	50 KΩ	72.46 MHz	536 ps	130.4 µW

Simulation Results of The Design

Simulation is performed in order to match the high temperatures exhibited in a vehicle environment. The design was observed at different temperatures for this purpose.



(a) Without Temperature Variation



(b)With Temperature Variation

Conclusion

- A low power design for blinking turn signals of a vehicle is presented using a memristor programmable relaxation oscillator.
- The proposed design conserves energy that is being dissipated in the form of heat in present technology and power consumption.
- Future research can be conducted in this case by introducing more energy efficient light system, such as LEDs.