Designing of ram using memristor pratibha singh electronics and communication (vl...

Sociology, Communication

The memristor is a non-linear resistor which changes its state relative to the netcharge (or net electric flux) passing through its two terminals and whose resistance is varies as function of flux and charge. It saves its state after an electrical bias is removed. In 2008, researchers at HP Labs published a paper announcing model for the physical realization of the memristor based on tiitanium dioxide thin film. In this project, we are implementing a RAM using memrjstor which works as an EPROM.

The relationships among Flux, charge and memristance of diverse composite Memristor, using the HP – TiO2 model has been studied, and the characteristic of complex memristor circuits are analyzed.

Introduction

Ram Kaji Budhathok at. el. presents multiple memristors are connected to each other, the composite behaviour of the devices becomes complicated and is difficult to predict, due to the polarity dependent nonlinear variation in the memristance of individual memristor. In this paper, we investigate the relationships among flux, charge and memristance of diverse composite memristors, using the HP-TiO 2 model, and analyze the characteristics of complex memrjstor circuits. It is assumed that all memristor circuits operate at a stable composite memriistnce state, in which the composite flux curve does not vary and the memrjstor circuits act as a single memristive system, regardless of input current or voltage. Such study will be conducted for serial and parallel memristor circuits.

Zhang Xu Liang at. el. describes memrjstor is drawing more and more attraction since HP Laboratory has announced its invention. This reports our efforts on memristor application researches, which makes the further memristor exploring easier. In this letter, we proposed a new memristor emulator using several simple discrete components. The emulator can meet most of the behaviour characteristics of a generic memristor. Based on the emulator, a chaotic attractor has been observed in a simplest chaotic circuit that uses only three elements. Both the emulator and the chaotic circuit’s behaviours are demonstrated using SPICE and MATLAB simulation.

Karel Zaplatilek discussed various ways of memristor modelling and simulation in the MATLAB & Simulink environment. Recently used and published mathematical memristor model serves as a base, regarding all known features of its behaviour. Three different approaches in the MATLAB & Simulink system are used for the differential andother equations formulation. The first one employs the standard system core offer for the Ordinary Differential Equations solutions (ODE) in the form of an m-file. The second approach is to the model construction in Simulink envirnment. The third approach employes so-called physical modelling using the built-in Simscape TM system. The output data are the basic memristor characteristics and appropriate time courses. The features of all models are discussed, especially regarding the computer simulation. Possible problems that may occur during modelling are pointed.

History

The memristor was originally envisioned in 1971 by circuit theorist Leon Chua as a missing non linear passive two-terminal component of electrical relating electrical charge and magnetic flux linkage. According to the governing mathematical relations, the memristor's electrical resistance is not constant but depends on the history of current that had previously flowed through the device, i. e., resistance of its current depends on how electric charge has flowed in which direction through it in the past. The device remembers its history, that is, when the electric power supply is turned of, the memristor rememmbers its most recent resistance until it is turned on again. Thermodynami considerations, however, show that such a memristor component cannot exit as a solid state device in physical reality because its behaviour would be inconsistent with fundamental laws of non-equilibrium thermodynamics.

Leon Chua has more recently argued that the definition could be generalized to cover all forms of 2-termnal non-volatile memory devices based on resistance switching effectsalthough some experimental evidence contradicts this claim, since a non-passive nanobattery effect is observable in resistance switching memory. Chua also argued that the memristor is the oldest known circuit element with its affect predicating the resistor, capacitor and inductor. The memristor is currently under development by various teams including Hewlett-Packard, SK Hynix and HRL Laboratories. In 2008, a team at HP Labs claimed to have found Chue's missing memristor based on an analysis of a thin film of titanim dioxide. However, some scepticissm has been expresse regarding this analysis. These devicess are intended for applications in nano electronic memories, computer logic and neuro-morphic computer architectures. In October 2011, the team announced the commercial availability of memristor technology within 18 months, as a replacement for Flash, SSD, DRAM and SRAM. Commercial availability was more recently estimated as 2018.

In March 2012, a team of researchers from HRLLaboratories and the University of Michigan announced the first functioning memristor array built on a CMOS chip. As a result of his work on nonlinear circuit elements, Chua made an interesting observation. For traditional linear circuits, there are only three independent two-terminan passive circuit elements: the resistor R, the capacitor C and the inductor L. However, when he generaljzed the mathematical relations to be nonlinear, there was another independent differential relationship that in princjple coupled the charge q that flowed through a circuit and the flux φ in the circuit, dφ= Mdq, that was mathematically different from the nonlinear resistance that coupled the voltage v to the current i, dv= Rdi. As a strictly mathematical exercise, he explored the properties of this potentially newnonlinear circuit element, and found that it was essentially a resistor with memory – it was a device that changed its resistance depending on the amount of charge that flowed through the device, and thus he called this hypothetical circuit element M a memristor.

This conclusion was independent of any physical mechansm that might couple the flux and charge, and in fact he did not postulate any mechanism at all. Moreover, the memrstor definition did not even require causality. In other words, the mathematical relationship between flux and charge could be the result of some other cause– any mechanism to the constraint embodied by the equation dφ= Mdq would lead to a device with the properties of a memristor. He published these initial findings essentially as a curiosity – it was not obvious at that time that such a circuit elementexisted. Chua has shown mathematically that it is not possible to construct an equivalent circuit for a memristor using any combination of only passive nonlinear resistors, capacitors and inductors. Thus, the memrstor represents an independent basis function for constructing passive nonlinear circuits, so it has a status similar to the nonlinear resistor, capacitor and inductor. The figure below is an illustration of this argument. The upper panel shows an applied voltage sine wave (gray) versus time with the corresponding current for a resistor (blue), capacitor (red), inductor (green) and memristor (purple). The lower figures show the current-voltage characteristics for the four devices, with the characteristic pinchedhysteresis loop of the memristor in the bottom right. It is nearly obvious by inspection that the memristor curve cannot be constructed by combining the other.

Memristor

The three basic two-terminal devices namely the resistor, the capacitor and the inductor are well understood. These elements are defined in terms of the relation between two of the four fundamental circuit variabls, namely, current I, voltage v, charge q and flux. The current i is defined as the time derivative of the charge q. According to Faraday' s law, the voltage v is defined as the time derivative of The flux Φ. According to the general mathematical model, a memristor is any passive electronic circuit element that displays a pinched hysteresis loop in its i-v characteristic, independent of what the physical mechanism is that causes the hysteresis. The model is useful because it provides quantitative means to predict the properties of such a device in an electronic circuit, for example in a SPICE model. However, no mathematical model is perfect – it is only an approximation to real behaviour– this is as true for a resistor as a memristor. In circuit theory, the three basic two-terminal devices namely the resistor, the capacitor and the inductor are well understood. These elements are defined in terms of the relation between two of the four fundamental circuit variables, namely, current I, voltage v, charge q and flux. The current i is defined as the time derivative of the charge q.

According to Faraday' s law, the voltage v is defined as the time derivative of The flux Φ . A resistor is defined by the relationship between Voltage and current (dv= Rdi), the capacitor is defined by the Relationship between charge and voltage (dq= Cdv) and the Inductor is defined by the relationship between flux and current (dΦ= Ldi). Out of the six possible combinations of the four fundamental circuit variables, five are defined. In 1971, Prof. Leon Chua proposed that there should be a fourth fundamental circuit element to set up the relation between charge and magnetic flux. The memristor is a non-linear resistor which changes its state relative to the net charge (or net electric flux) passing through its two terminals. It saves its state after an electrical bias is removed. In 2008, researchers at HP Labs published a paper announcing a model for the physical realization of the Memristor based on titanum dioxide thin film. Memristance is a property of the memrstor. When, the charge flows in one direction through a circuit, the Resistance of the memristor increases and its resistance Decreases when the charge flows in the opposite direction in the circuit. If the applied voltage is turned off, thus stopping the flow of charge, the memristor " remembers" the last resistance that it had. When the flow of charge is started again, the resiistance of the circuit will be what it was when it was last active. M(q) is physically restricted to be positive for all values of q. A negative value would mean that it would perpetually Supply energy when operated with alternating current."

STRUCTURE OF TiO2 MEMRISTOR

In the TiO2 memristor, a thin undoped titanium dioxide (TiO2) layer and a thin oxygen-deficient doped titanium dioxide (TiO2-x) layer are sandwiched between two platinum electrodes. When a voltage (or current) is applied to the device, the width of the TiO2and TiO2-xlayer changes as a function of the applied voltage (or current). As a result, the resistance between the two electrodes is altered. Fig. 1. 3 shows the structure of the 2TiO memristor. Let D and w denote the thickness of the sandwiched area and the doped area (oxygen deficient area) in the TiO2 memristor, respectively, and let ON R and OFF R denote the resistances at high (w/D= 0) and low dopant (w/D= 1) concentration areas, respectively.

Current voltage relationship

Memristor is the pinched hysteresis loop current-voltage characteristic. For a memristor excited by a periodic signal when the voltage v (t) is zero the current i(t) is also zero and vice versa. Thus both voltage v(t) and current i(t) have identical zero-crosing. If any device has a current–voltage hysteresis curve then it is either a memristor or a memristive device. Fig. 2. 3 shows the V-I characterises of memristor at frequency 1Hz. we can clearly observe that the memristor device toggles between two states of high and low conductivity. As the device transitions between low to high conductivity states it goes through high nonlinear diode-like processes at two different threshold voltages. The threshold voltage analogy is used here to describe the biasing regions where nonlinear behaviour occurs. Another property of the memristor is the pinched hysteresis loop shrinks with the increase in the excitation frequency.

Memristive flip-flop

Memristor Sine-wave is to provide continuous time input. The frequency of the signal used is π and Amplitude is 1V. The Puls Generator is used show the power down signal. The amplitude of the pulse is 2V and pulse width is 25% of the input sine signal. The memristor simulated by the window function technique is used as a sub-circuit with one input and four outputs viz. flux, charge, current and voltage. A comparator is used to convert the continuous signal to a digital signal to be fed as input to the flip-flop. It compares the charge to a threshold constant value of 1e-5 Columbs and 1e-6. The product of comparators passes to data type conversion system.

It is observed that the input voltage and the output voltage through the memristor are identical in Fig. 2. 6. Moreover, the charge in the memristor saturates or freezes when the power down signal is encountered. And when the input is applied again, it starts from its previously held value. When the clock goes from 0 to 1, D-Flip-flop output attains the same value of input.

Advantages and disadvantages

A memristor is a circujt element which is able to change its resistance to " remember" changes in current.

Advantages of memristors:

- Have properties which cannot be duplicated by the other circuit elements (resistors, capacitors, and inductors).
- Capable of replacing both DRAM and hard drives.
- Smaller than transistors while generating less heat.
- Works better as it gets smaller which is the opposite of transistors.
- Devices storing 100 GB in a square centimetre have been created using memristors.
- Quicker boot-ups and requires less voltage (less overall power required).

Disadvantages of memristors:

- Not currently commercially available.
- Current versions only at 1/10th the speed of DRAM.
- Has the ability to learn but can also learnt the wrong patterns in the beginning
- Since all data on the computer becomes non-volatile, rebooting will not solve any issues as it often times can with DRAM.
- Suspected by some that the performance and speed will never match DRAM and transistors.

Applications of memristor

Non-volatile memory applications: Memristors can retain memory states, and data, in power-off modes. Non-volatile random access memory, or NVRAM, is pretty much the first to-market memrjstor application we'll be seeing. There are already 3nm Memristors in fabrication now. Crossbar lattch memory developed by Hewlett Packard is reportedly currently about one-tenth the speed of DRAM. The fab prototypes resistance is read with alternating current, so that the stored value remains unaffected. Rosy coloured industry analysts' state there is industry concurrence that these flash memory or solid state drives (SSD) competitors could start showing up in the consumer market within 2 years.

Low-power and remote sensing applications: Coupled with mem capacitors and meminductors, the complementary circuits to the memristor which allow for the storage of charge, memristors can possibly allow for neon-scale low power memory and distributed state storage, as a further extensiion of NVRAM capabilities. These are currently all hypothetical in terms of time to market.

Crossbar Latches as Transistor Replacements or Augmentors: The hungry power consumption of transistors has been a barrier to both miniaturization and microprocessor controller development. Solid-state memristors can be combined into devices called crossbar latches, which could replace transistors in future computers, taking up a much smaller area. There are difficulties in this area though, although the benefits these could bring are focusing a lot of money in their development. So perhaps the " where there a will, or a dollar, there a way” adage will get these developed. Unless a competition war amongst industry giants becomes one of those patent showdowns, where companies buy out technological advances to bury them. Remember 3G? Well, someone bought out 4G back in 2004, before 3G even came to market, and has been sitting on it ever since. And have profited greatly.

Analog computation and circuit Applications: There was a track of electrical/mathematic engineering which was largely abandoned to stasis in the 1960s, as digital mathematics and computers rose to dominance. Analog computations embodied a whole area of research which, unfortunately, were not as scalable, reproducible, or dependable (or politically expedient in some cases) as digital solutions. However, there still exist some very important areas of engineering and modeling problems which require extremely complex and difficult workarounds to synthesize digitally in part, because they map economically onto analog models. The early work of Norbert Wiener has already started to be revisited, after the analog/digital split between him and John von Neumann. Analog was great, but required management for scalability beyond what even the extremely complex initial digital vacuum tube computers could provide. Memristor applications will now allow us to revisit a lot of the analog science that was abandoned in the mid 1960′s.

Circuits which mimic Neuromorphic and biological systems (Learning Circuits): This is a very large area of research, in part because a large part of the analog science detailed above has to do with advances in cognitive psychology, artificial intelligence modeljng, machine learning and recent neurology advances. The ability to map people's brain activities under MRI, CAT, and EEG scans is leading to a treasure trove of information about how our brains work. But modeling a brain using ratiocinated mathematics is like using linear algebra to model calculus. Simple electronic circuits based on an LC network and memristors have been built, and used recently to model experiments on adaptive behaviour of unicellular organisms. The experiments show that the electronic circuit, subjected to a train of periodic pulses, learns and anticipates the next pulse to come, similar to the behaviour of the slime mold Physarum polycephalum periodic timing as it is subjected to periodic changes of environment. The recent memristor cat brain is also getting a lot of mention. These types of learning circuits find applications anywhere from pattern recognition to Neural Networks No more neural pattern algorithm training on stock market data for the pop-sci investor: now, you can grow your own neural network! Just add two drops of memristor. Not anywhere close to realit, FYI, even in the 30 years range, but very realistic in terms of helping advance the science itself, if not the consumer market for intelligent brains-in-a-jar.

Programmable Logic and Signal Processing: A variety of Control System memristor patents are out there, waiting for the microchips to fall where they may. The memristive applications in these areas will remain relatively the same, because it will only be a change in the underlying physical architecture, allowing their capabilities to expand, however, to the point where their applications will most likely be unrecognizable as related.

Conclusion and future scope of work

In this project we have proposed the designing of RAM using memrstor. We studied about the fourth fundamental circuit element Memristor to set up the relation between charge and magnetic flux, proposed by Prof. Leon Chua. The memristor is a non-linear resistor which changes its state relative to the net charge (or net electric flux) passing through its two terminals. We studied the detailed structure of TiO2 memristor. Random access memory (RAM) is a form of computer data storag associated with volatile types of memory, where stored information is lost if the power is removed. Two main type of ram are static RAM and dynamic RAM. Three state buffers were used in implementation of RAM. We implemented the 4×4-bit RAM using memristor. Design of memristor, memrjstive flip-flop, 1-bit RAM, 4-bit RAM, decoder for memory was implemented on MATLAB Simulink. MATLAB is a multi-paradigm numerical computing environment and fourth-generation programming language. We worked with simulation which is a graphical extension to MATLAB for modeling and simulation of systems.