Analog circuits implementation using coherer based memristor

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Memristive system discovery

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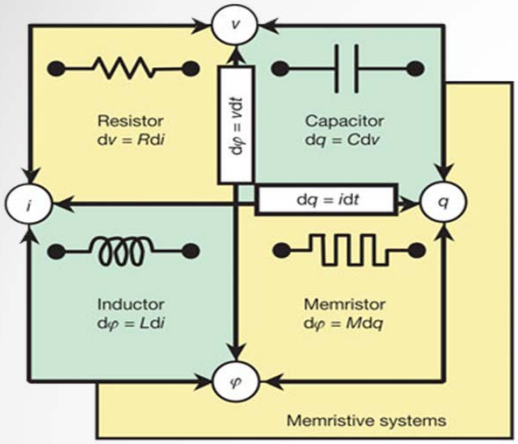
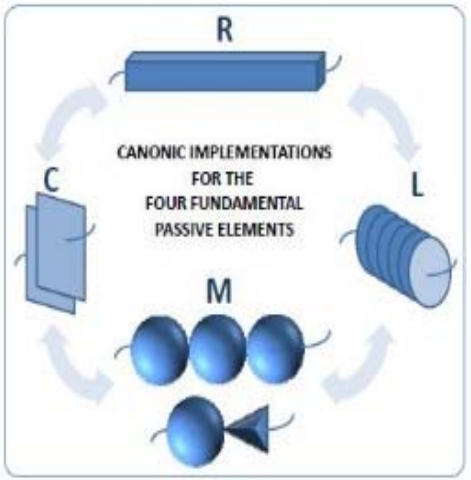
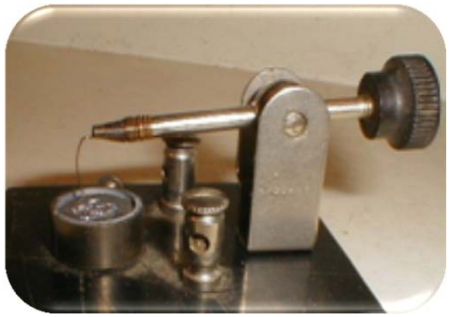


- Memristive system realized in 2008 and different forms of system exists-

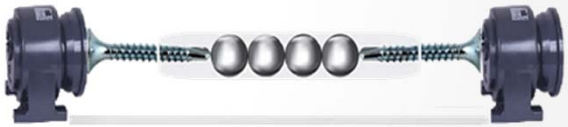
1. ReRam
2. Spintronic Memristors
3. Phase change memory
4. CBRAM

- The canonical implementation of memristive system was recently published by the group.





Metal-semiconductor point contact



Metal-metal point contact

1- The first radios were made using memristors! . G. Gandhi, V. Aggarwal, and L. Chua. Circuits and Systems Magazine.

2- L.O. Chua, "Memristor – The Missing Circuit Element," IEEE Trans., 1971

Characterization setup

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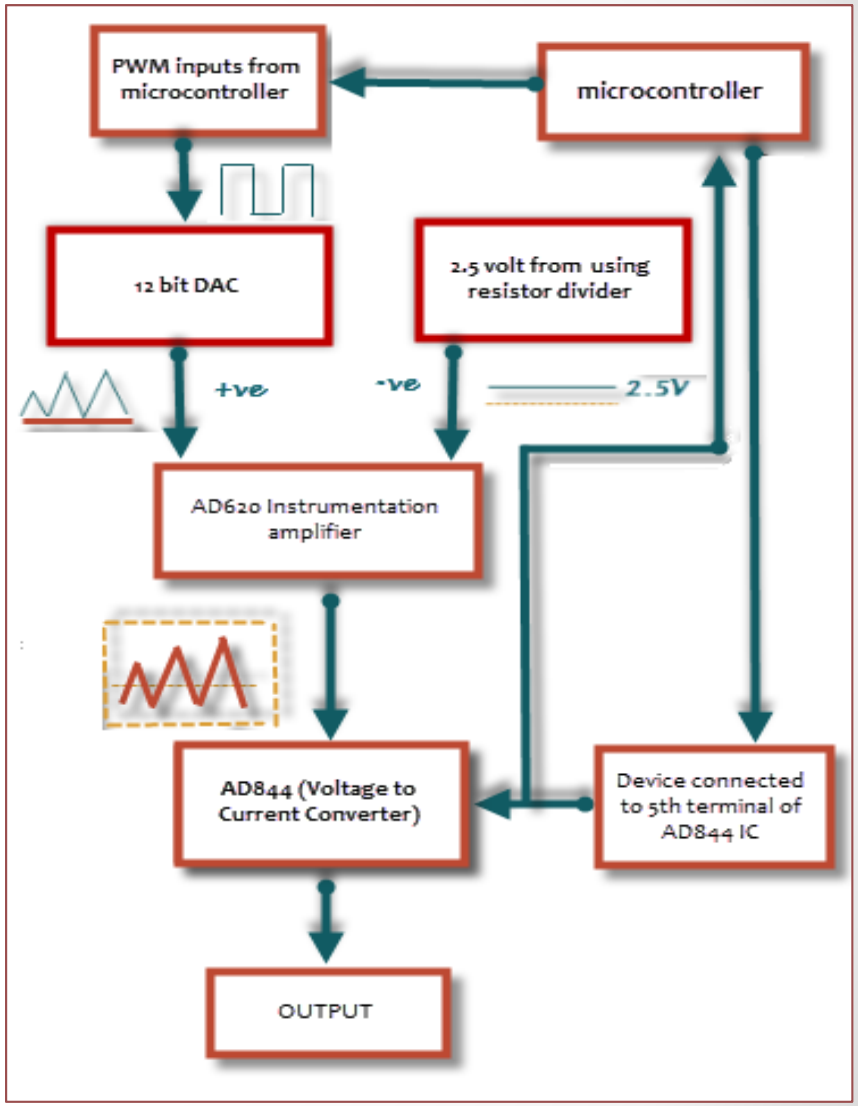
- Device was found to be current controlled, hence we input current peaks and observe the output voltage across the device to obtain the required I-V curves.

The main components installed in the current board include-

- AD844 (current feedback operational amplifiers).
- MCP4725 (12-Bit I^2C Digital to Analog Converter)
- AD620 (Instrumentation Amplifier IC).



Flow Chart

Characteristics

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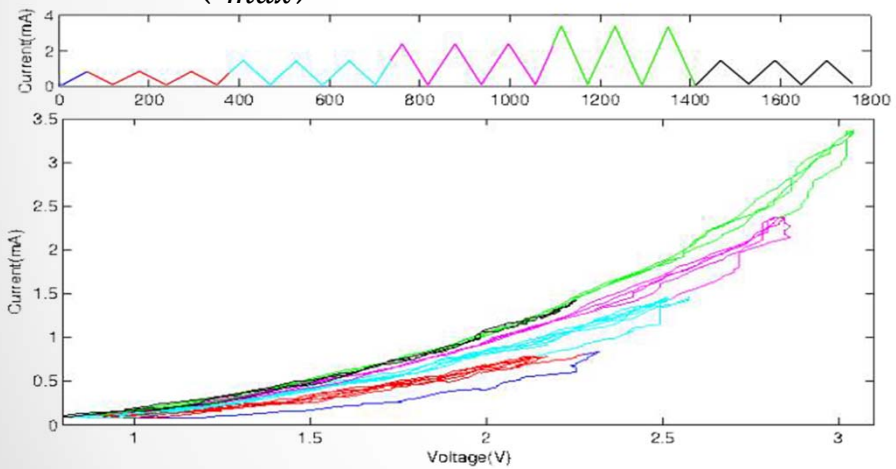
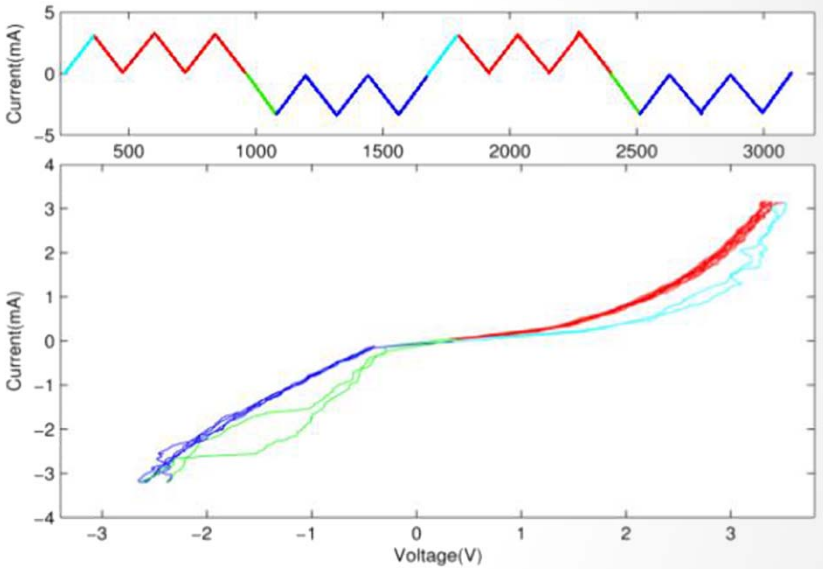
- We have observed that coherer setup exhibits-

Maximum Current Resistance Behaviour(Imax): The resistance changes as the maximum current passing through the device changes. This demonstrates that the device at contact level has some kind of memory which makes it remember the amount of current that has passed through it. R=f(I_{max})



- Non-linearity, resistance range, threshold voltage is found to be dependent on the area, location and pressure applied.

Bistable Memristive Behaviour: We have demonstrated that under suitable bipolar input, the device exhibits pinched hysteresis.



- The device gets programmed in each direction by a large positive/negative input peak current and remains in the same resistance state when provided with a smaller input current.

Experimental observations

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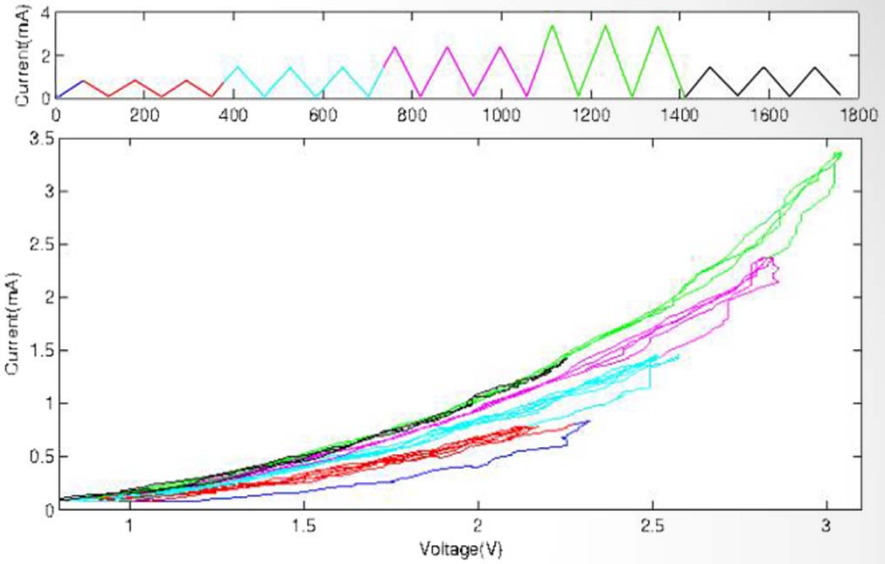
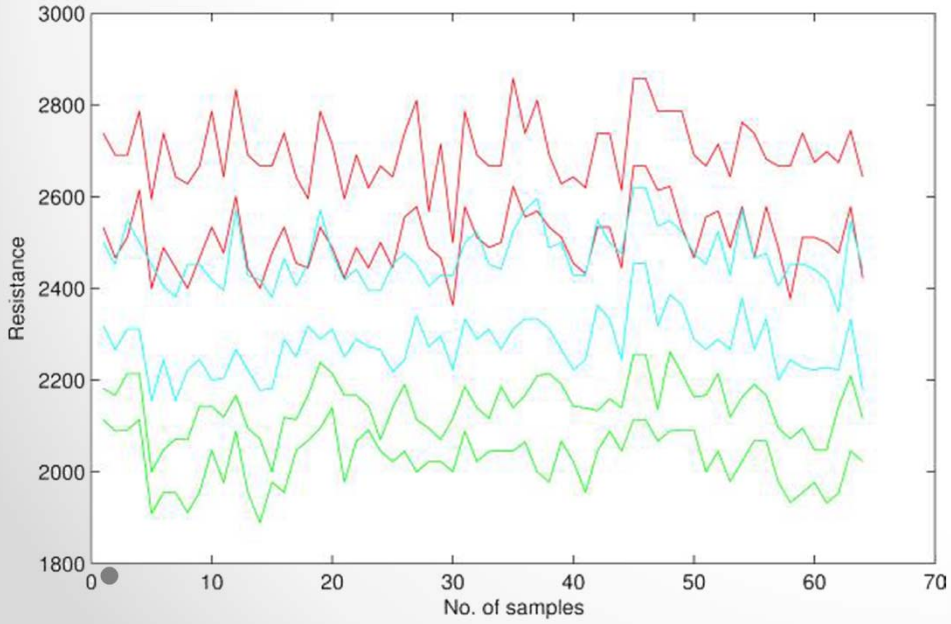
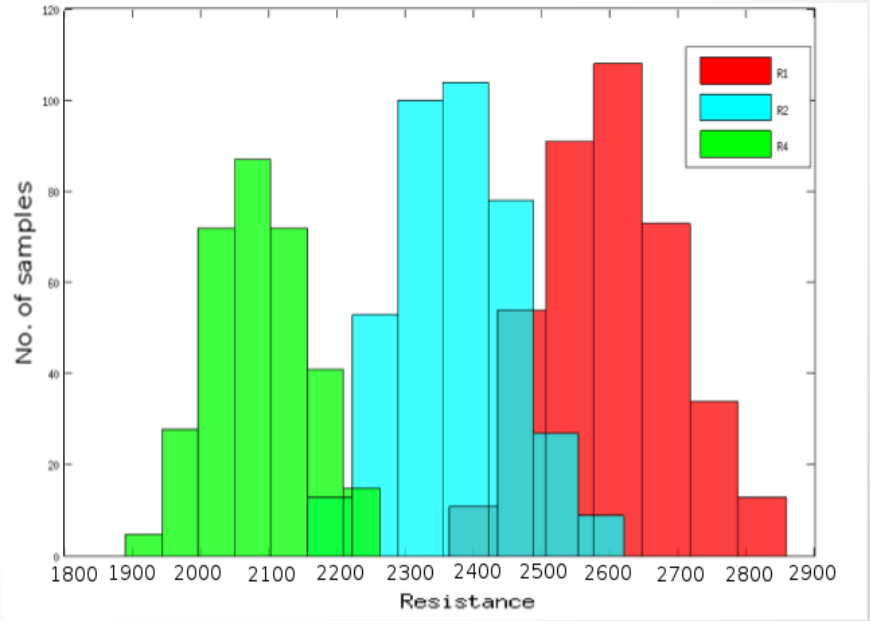
- The DC resistance at 0.7mA is plotted for various samples. Minimum and Maximum resistance in each sample is plotted.
- Device can be programmed in three different resistance ranges.
- Larger the difference between the currents, more the two dc resistance range separated.







Applications build using memristor and board

- Device can be programmed by high amplitude current pulses and low amplitude current pulses can be used in analog operation.
- Each programming current pulse changes the resistance by a discrete amount.

Programmable analog circuits

- Programmable gain amplifier
- Programmable threshold comparator
- Programmable switching thresholds Schmitt trigger

Y.V. Pershin and M. Di Ventra. Practical approach to programmable analog circuits with memristors. Circuits and Systems I: Regular Papers, IEEE Transactions on, 57(8):1857–1864, 2010.

a) Programmable Gain Amplifier

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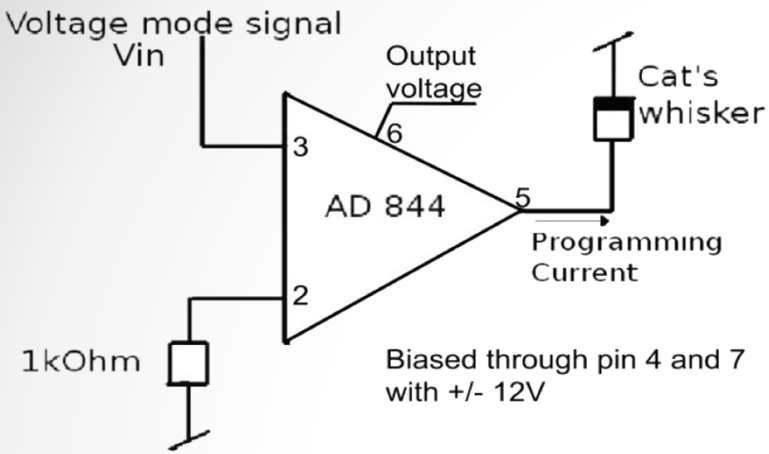
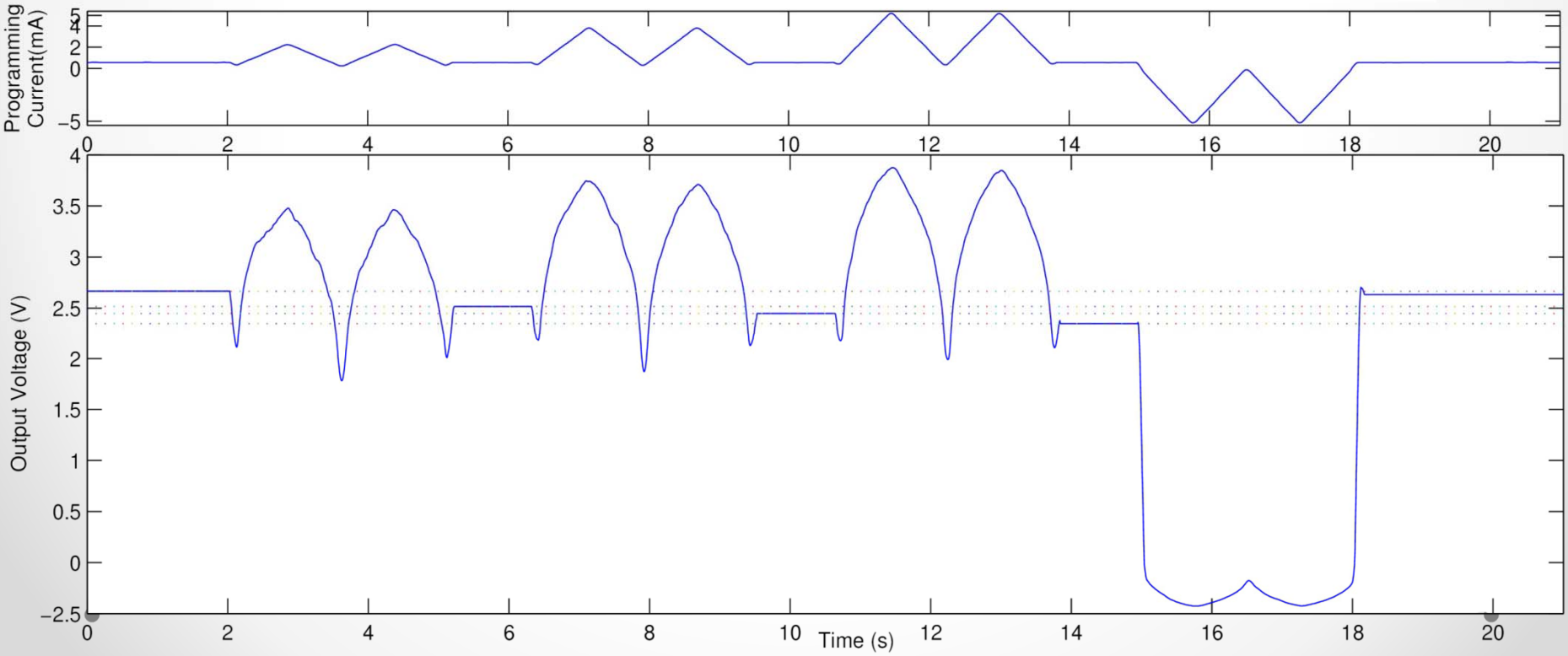


- Programming current I= Vin/R;
- Output Voltage Vout= I*M(r);
- R=1kohm;
- Vout/Vin= M(r)/R;

Amplifier gain is controlled by triangle pulses.

Gain decreases with every rising pulse and changes by 11.7% with peak of 5mA current.



b) Programmable threshold comparator

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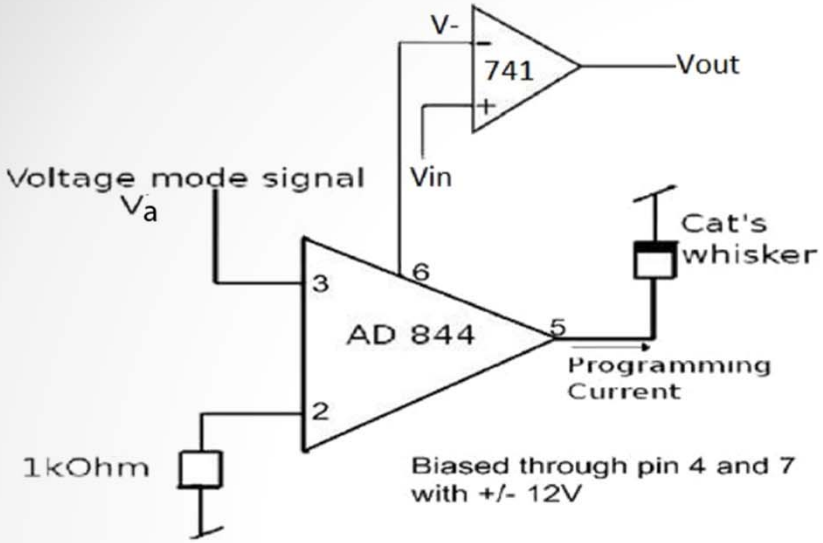
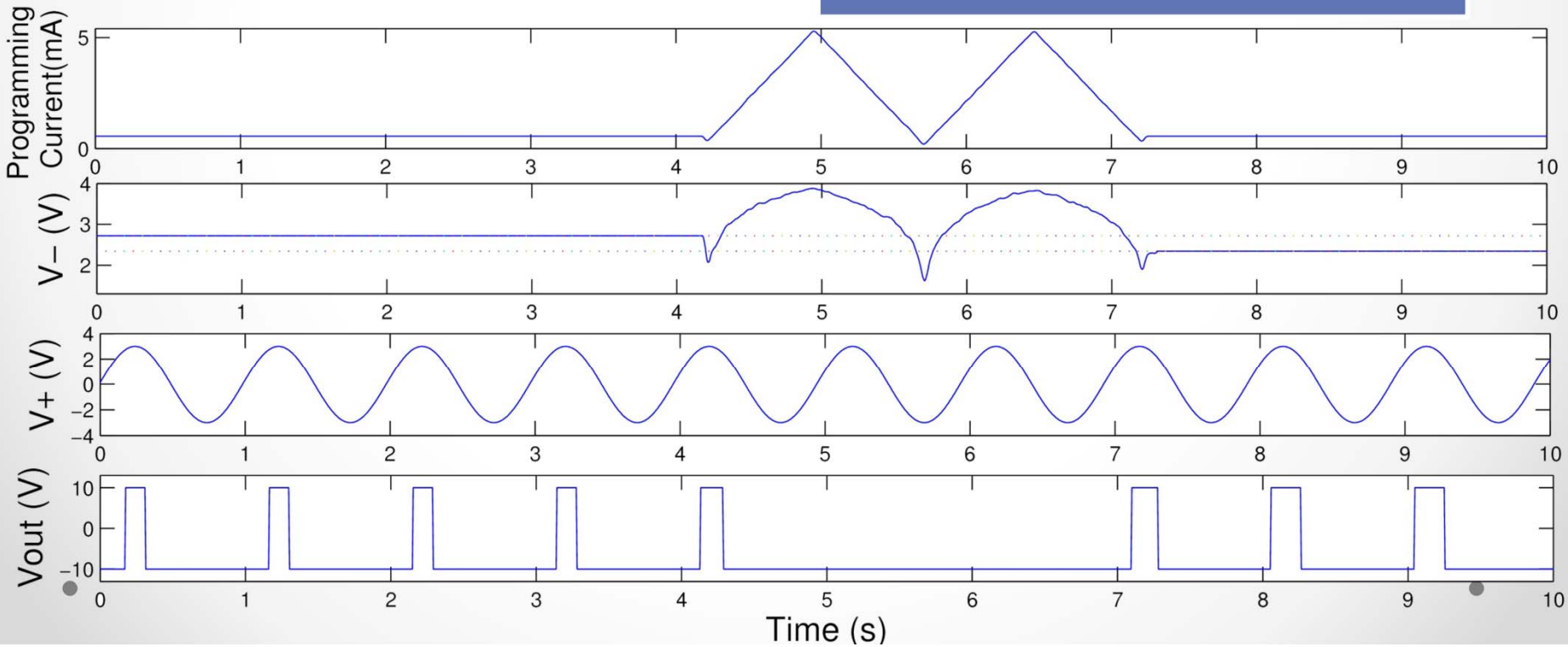


- $V_{-} = V_a \frac{M(r)}{R}$
- Va is the voltage mode signal input.
- Vin= 3sin(2πft) where f= 1Hz.

Threshold V- controlled by programming current.

At 5mA current, resistance changes by 670ohms, hence wider output from t=7sec.



c) Programmable switching threshold schmitt trigger

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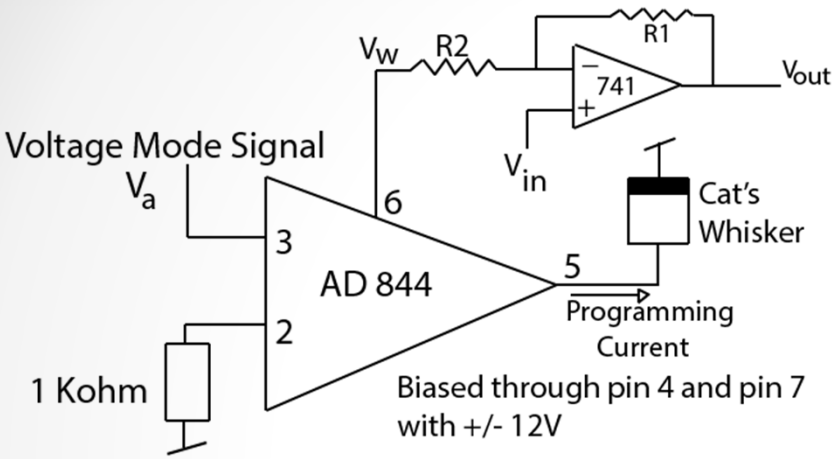
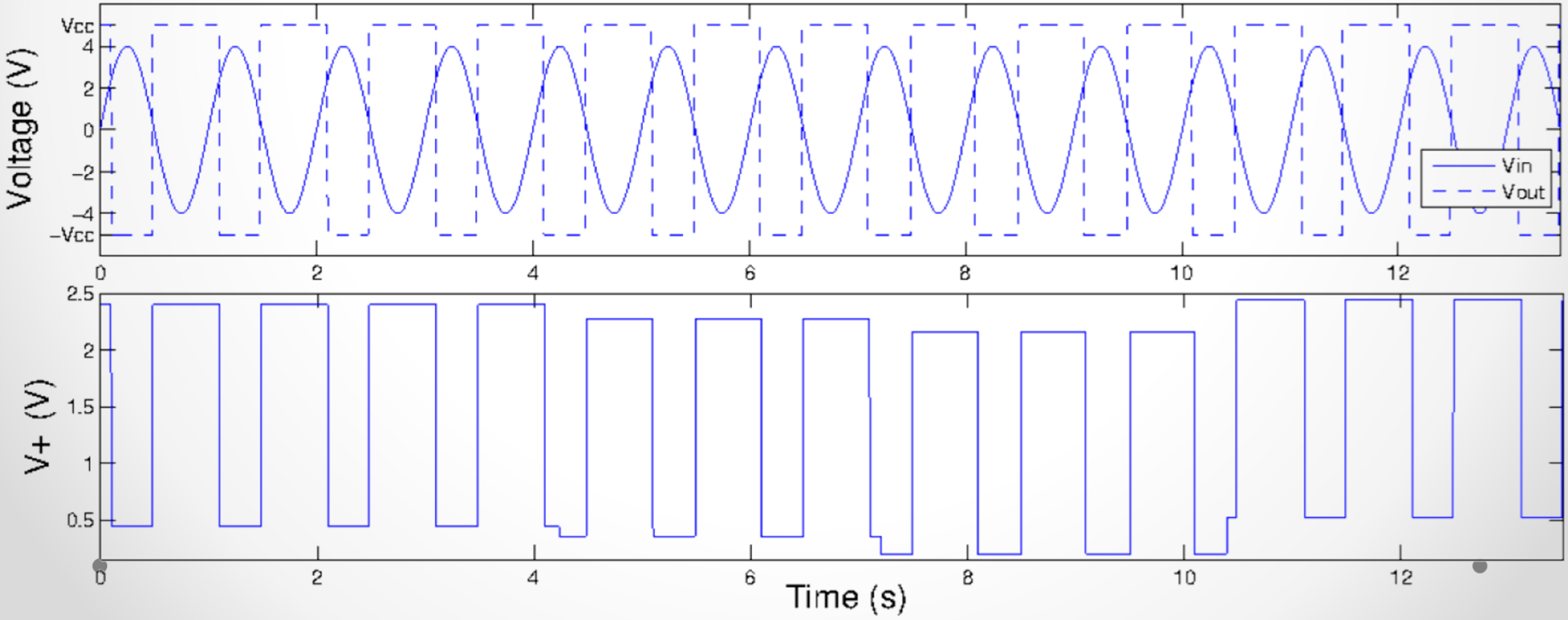


- Two switching threshold given by $(\frac{\pm VccR2+VwR1}{R1+R2})$
- Vcc=10V; R1=10kOhm; R2=100Ohm
- Vin= 4sin(2πft) where f= 1Hz.

Voltage Vw controlled using programming pulses.

Threshold changes hence output voltage Vout occurs at different values of Vin.



Conclusion

- We have discussed about the canonical implementation of memristive system.
- We have designed applications using this memristor which shows that coherer based memristor is as reliable as other memristors.
- Provides community with inexpensive memristor which can be implemented by anyone.

Future work!

- Building a reliable electrical model for the device.
- Studying the dynamics of resistive grid architecture based on the presented memristor.

Thanks!

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