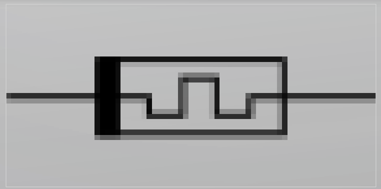
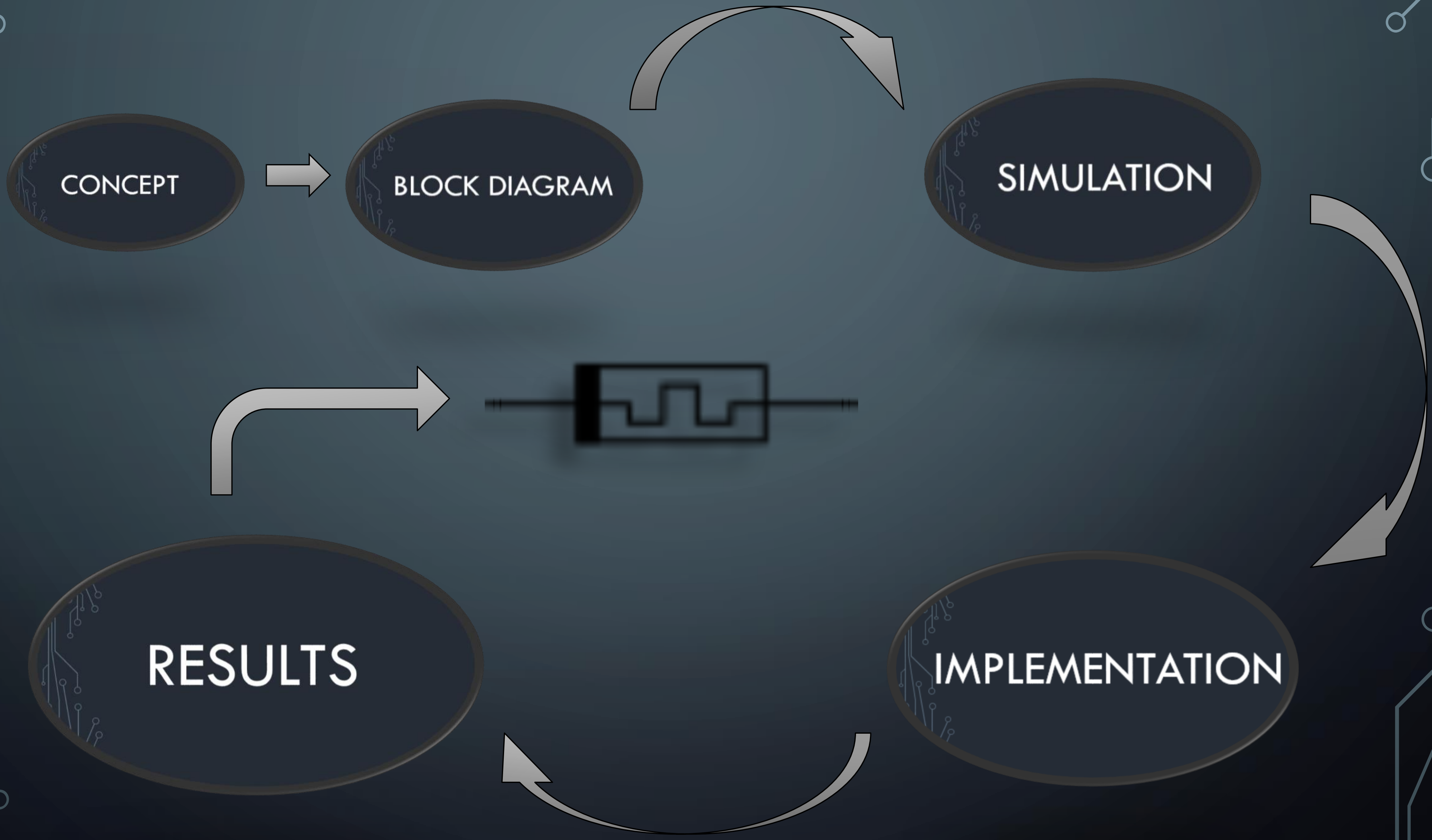
MEMRISTOR EMULATOR

THAI NGHIEM & SEAMUS PLUNKETT





CONCEPT
BLOCK DIAGRAM
SIMULATION
IMPLEMENTATION
RESULTS

CONCEPT

THEORY

$$i(t) = W(\varphi(t))v(t),$$

where

$$W(\varphi) \equiv \mathrm{d}q(\varphi)/\mathrm{d}\varphi.$$

- Realize the input voltage as flux (φ)

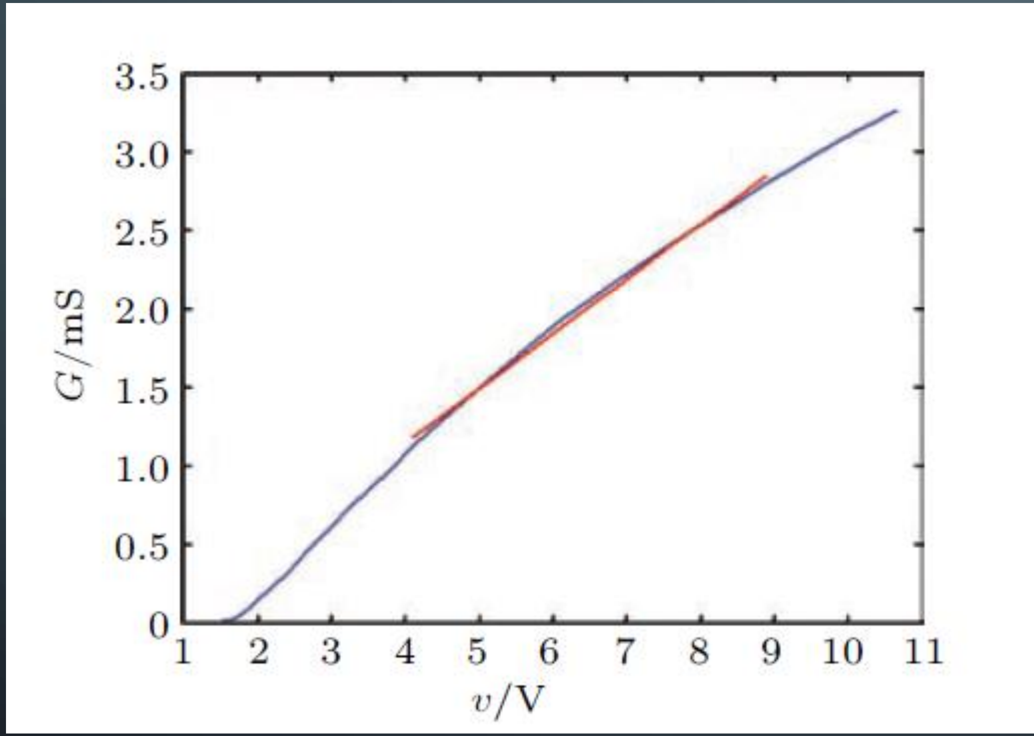
  → **Integrator**

- Emulates the memristive response

  → remotely control a variable resistor

  → **Light Dependent Resistor**

OPTOCOUPLER



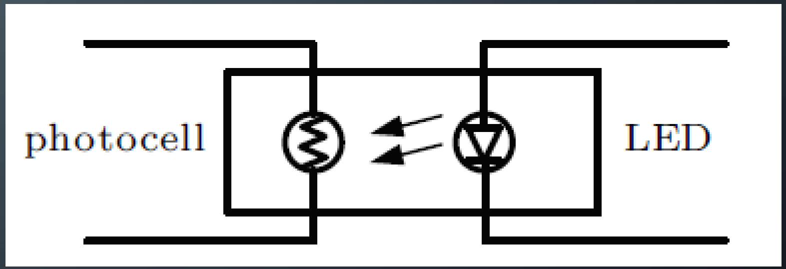


Fig. Voltage/conductance characteristics of the Silonex NSL-32.

OPTOCOUPLER

$$W(v) = 0.3v + 0.11.$$

- Ensure optocoupler operate in linear region

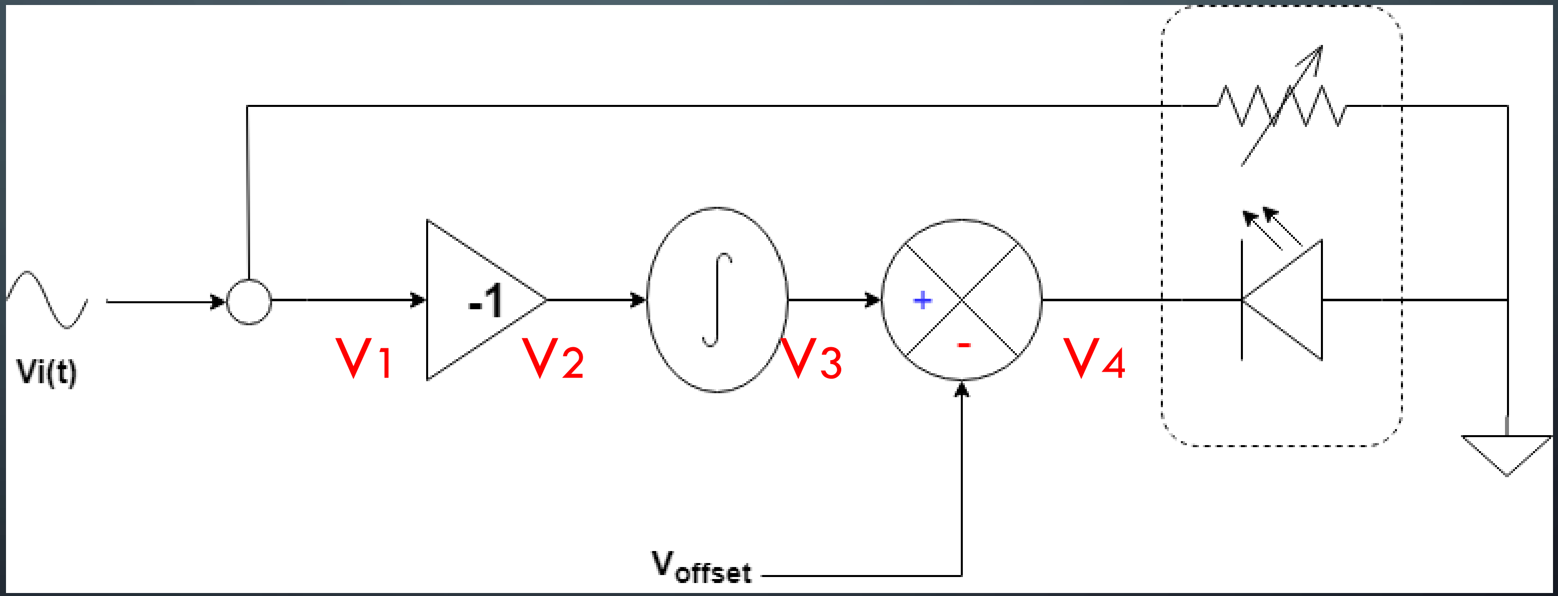
  → **Summing Op-amp**

- Minimize current draw from the input signal

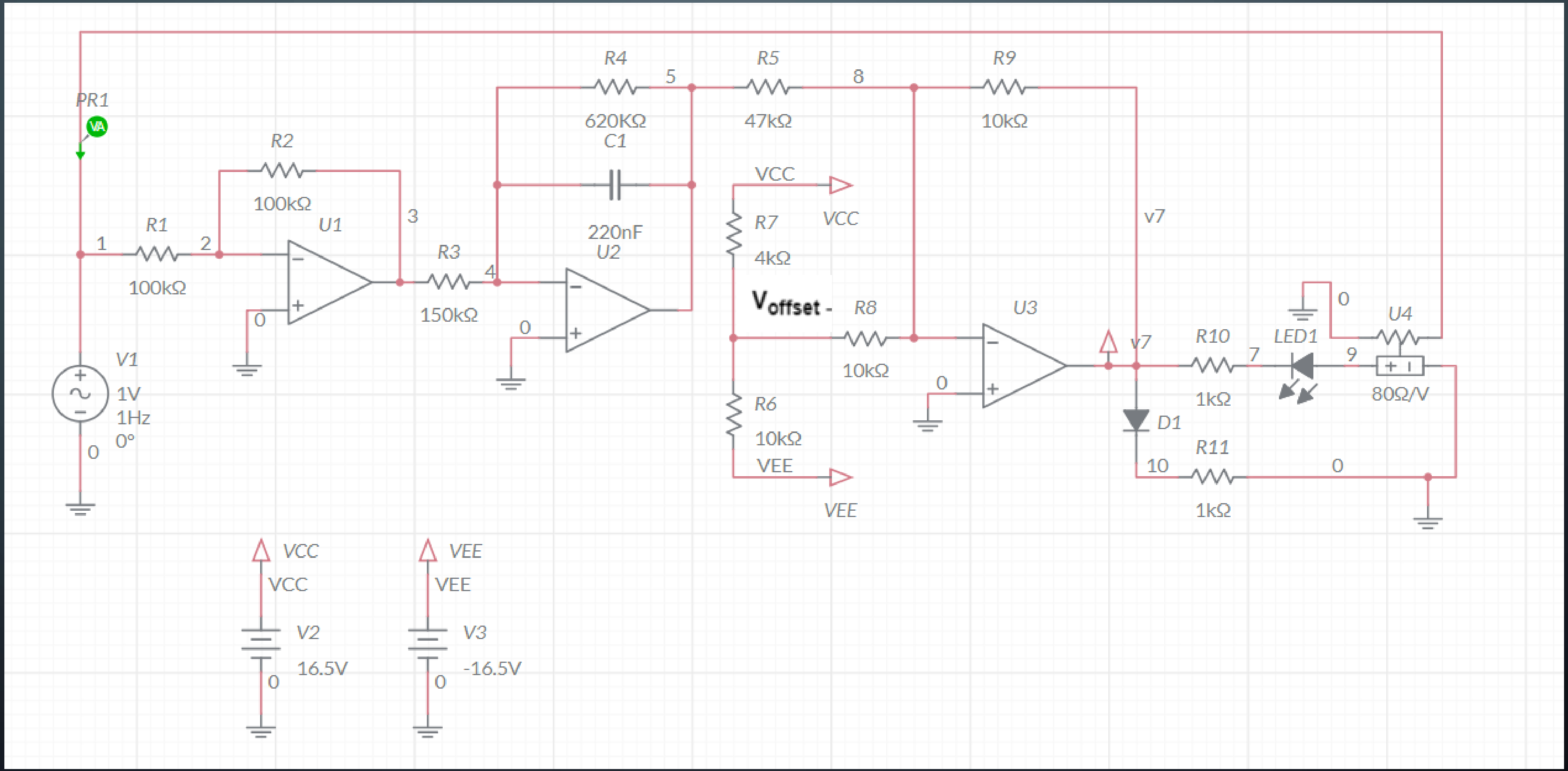
  → **Inverting Buffer**

BLOCK DIAGRAM

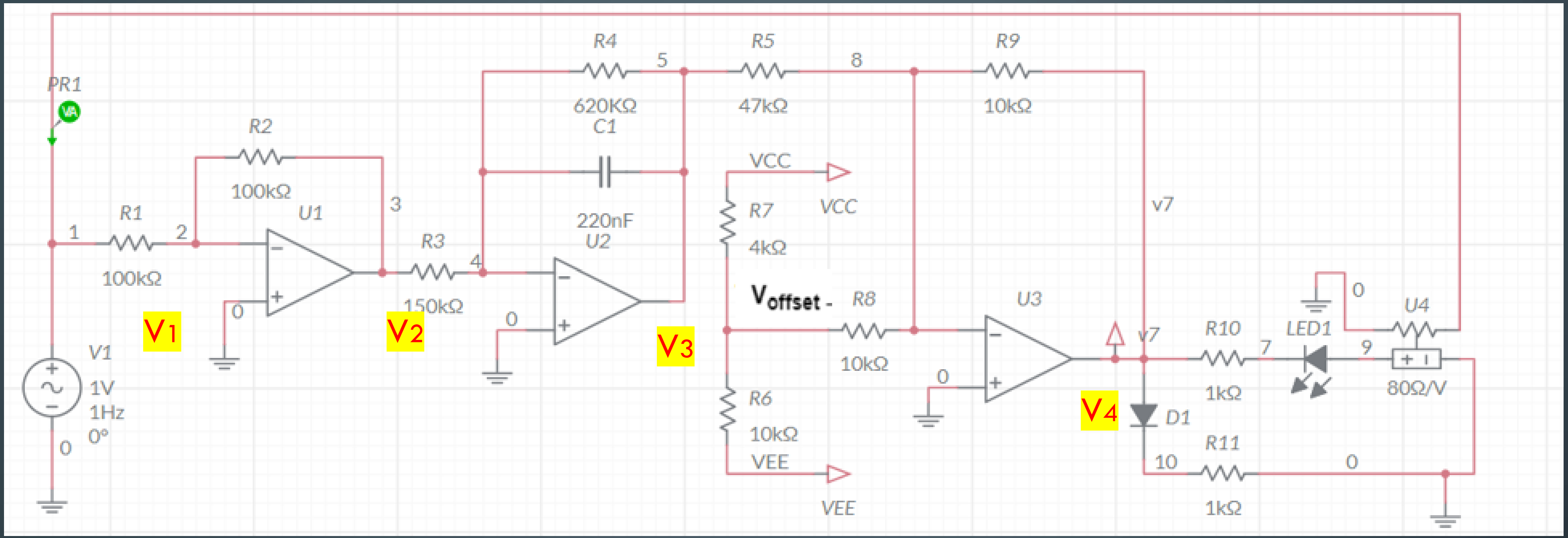
BLOCK DIAGRAM



SIMULATION



PR1
R1
100kΩ
R2
100kΩ
U1
R3
150kΩ
R4
620KΩ
C1
220nF
U2
R5
47kΩ
R9
10kΩ
VCC
R7
4kΩ
V_{offset} -
R8
10kΩ
R6
10kΩ
VEE
U3
v7
D1
R10
1kΩ
R11
1kΩ
LED1
U4
80Ω/V
V1
1V
1Hz
0°
VCC
V2
16.5V
VEE
V3
-16.5V



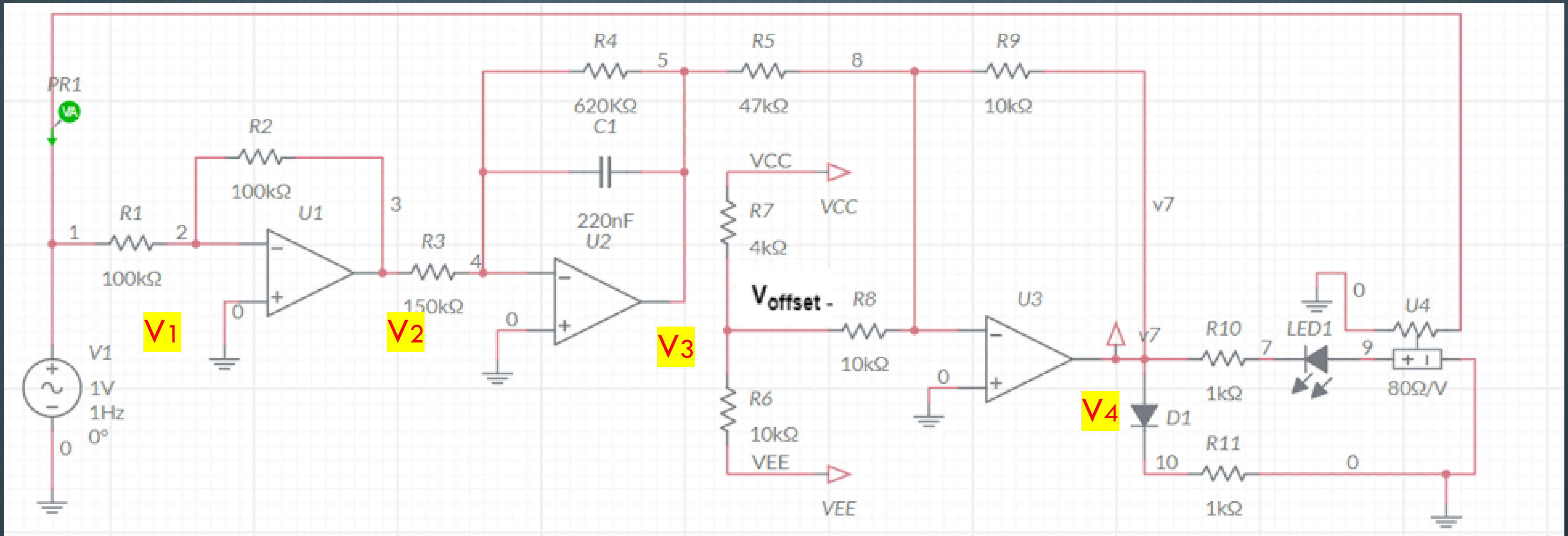
$$1)\ V_{1(t)} = V * \sin(wt)$$

$$2)\ V_{2(t)} = -\frac{R2}{R1} * V_{1(t)}$$

$$3)\ V_{3(t)} = -\frac{1}{R3*C1} * \int V_{2(t)} * dt$$

$$4)\ V_{4(t)} = -\frac{R9}{R5} * V_{3(t)} - \frac{R9}{R8} * V_{offset}$$

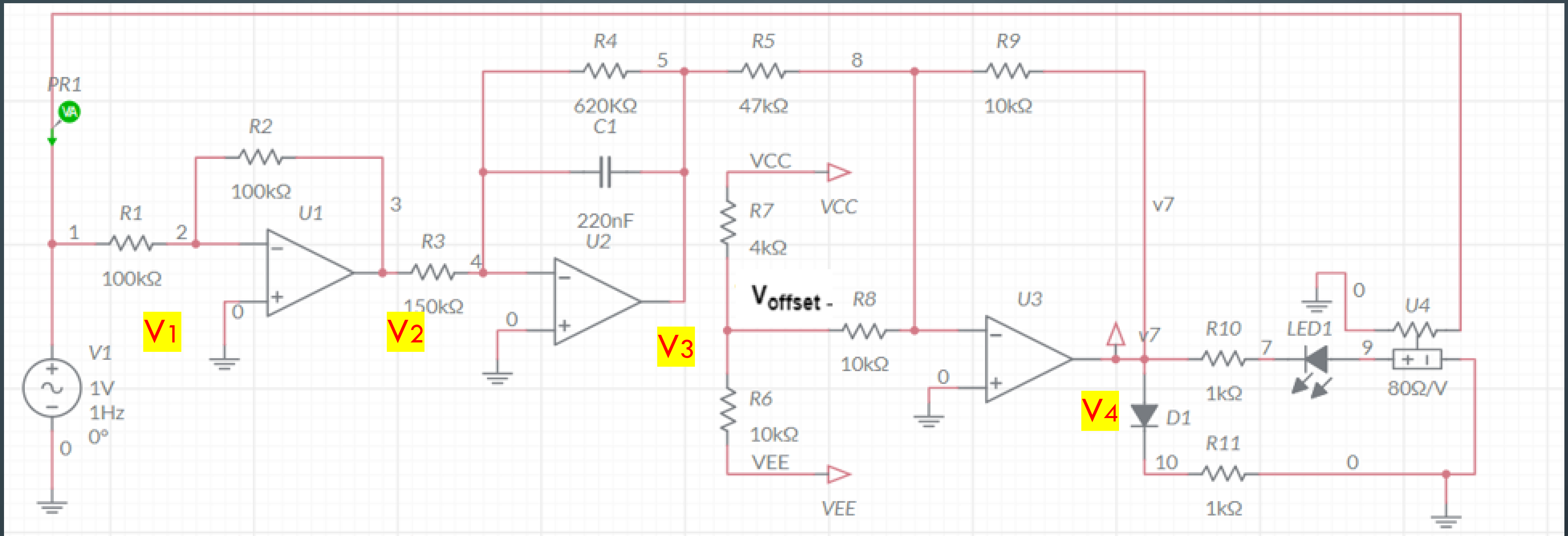
$$\boxed{V_{4(t)} = \frac{R_9 R_2 V}{w R_5 R_3 R_1 C_1} * \cos(wt) - \frac{R9}{R8} * V_{offset}}$$



$$V_{4(t)} = -\frac{R_9 R_2 V}{w R_5 R_3 R_1 C_1} * \cos(wt) - \frac{R9}{R8} * V_{offset}$$

$$\boxed{W(v) = 0.3v + 0.11.}$$

$$W_{(t)} = 0.3 * (0 - \frac{R_9 R_2 V}{w R_5 R_3 R_1 C_1} * \cos(wt) + \frac{R9}{R8} * V_{offset}) + 0.11$$

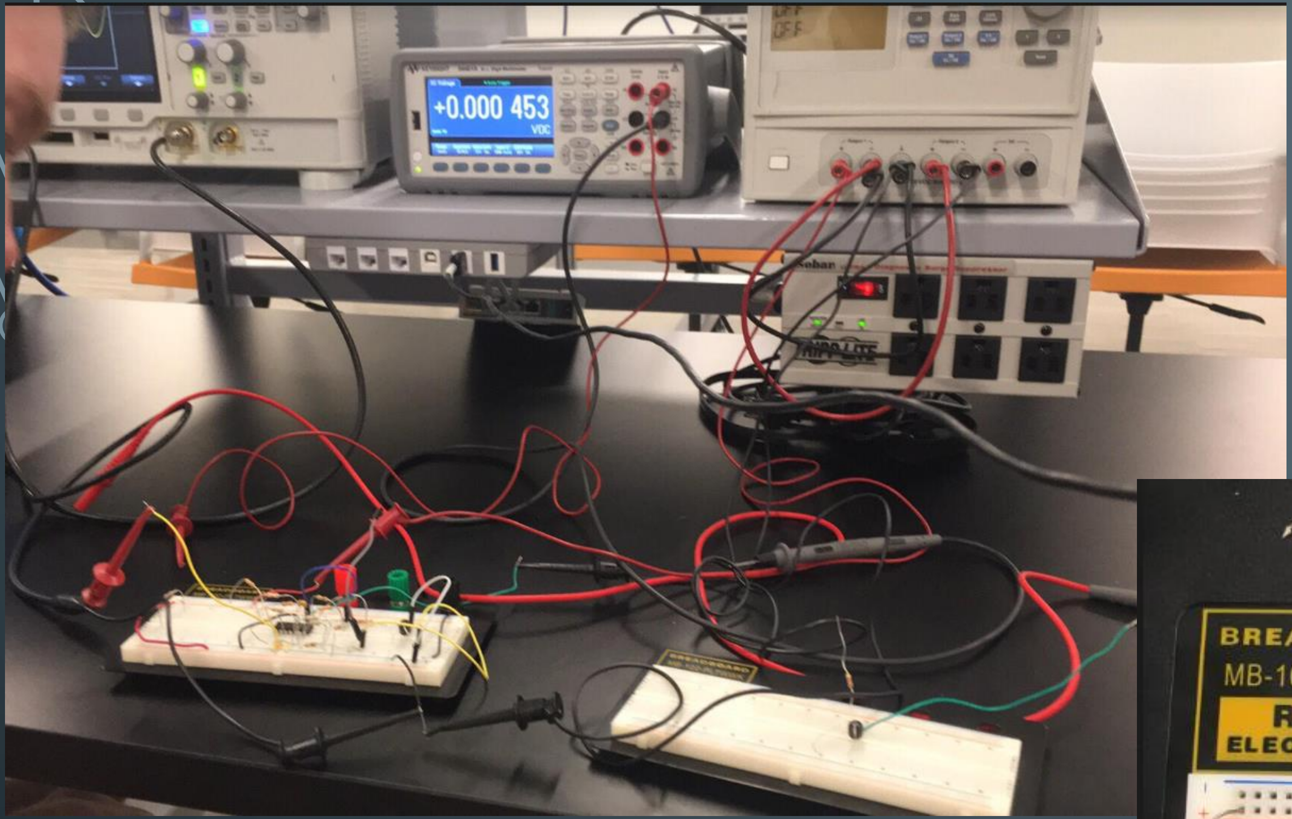


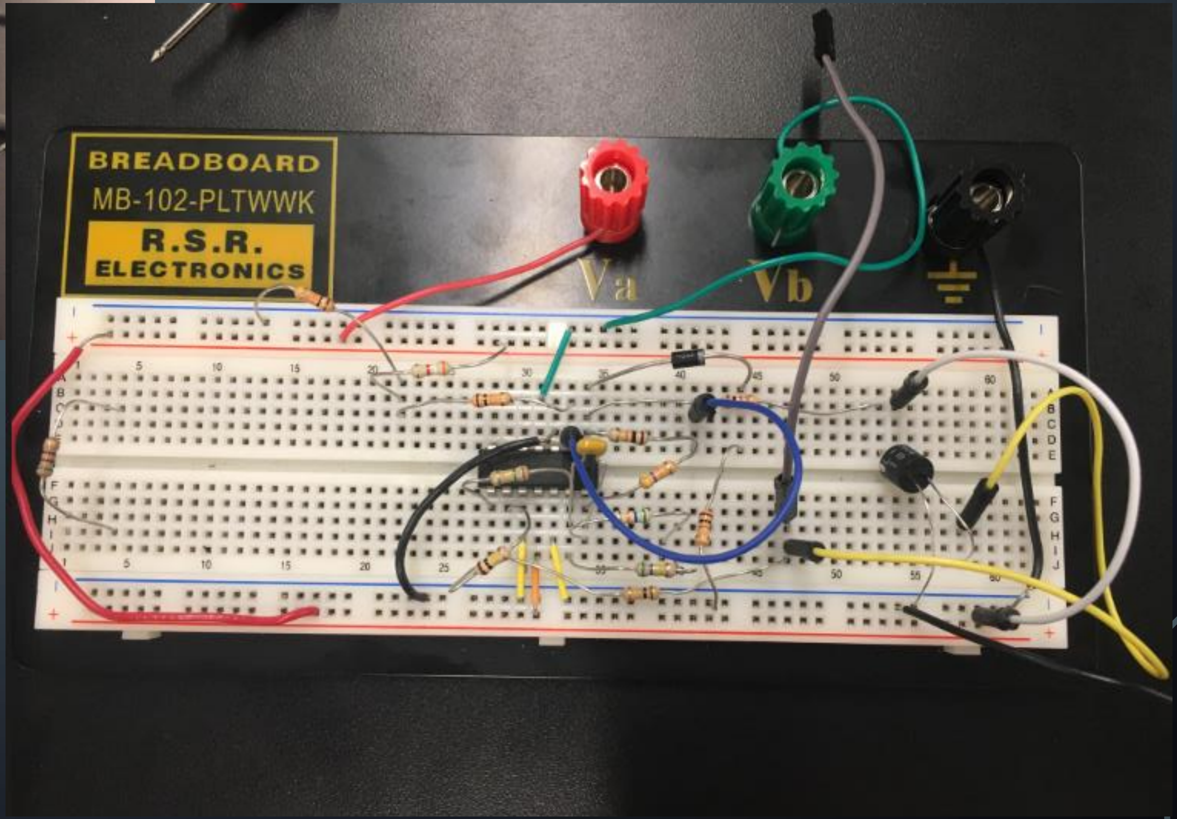
$$V = 1V \qquad w = 2\pi$$

$$V_1(t) = 1 * \sin(2\pi * t)$$

$$W_{(t)} = 0.3 * \left(0 - \frac{R_9 R_2 V}{w R_5 R_3 R_1 C_1} * \cos(wt) + \frac{R9}{R8} * V_{offset}\right) + 0.11$$

IMPLEMENTATION


+0.000 453
VDC


BREADBOARD
MB-102-PLTWWK
R.S.R.
ELECTRONICS
Va
Vb

RESULTS

SIMULATION

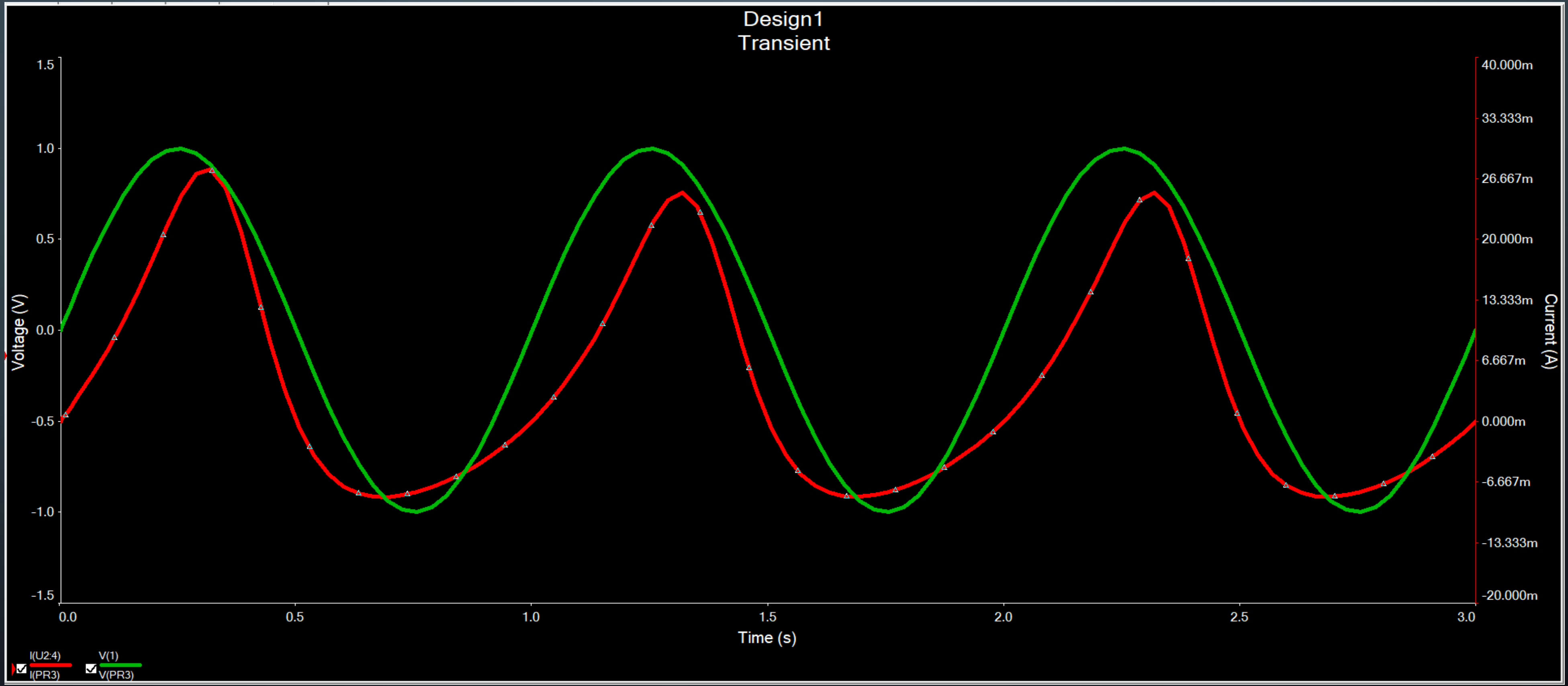
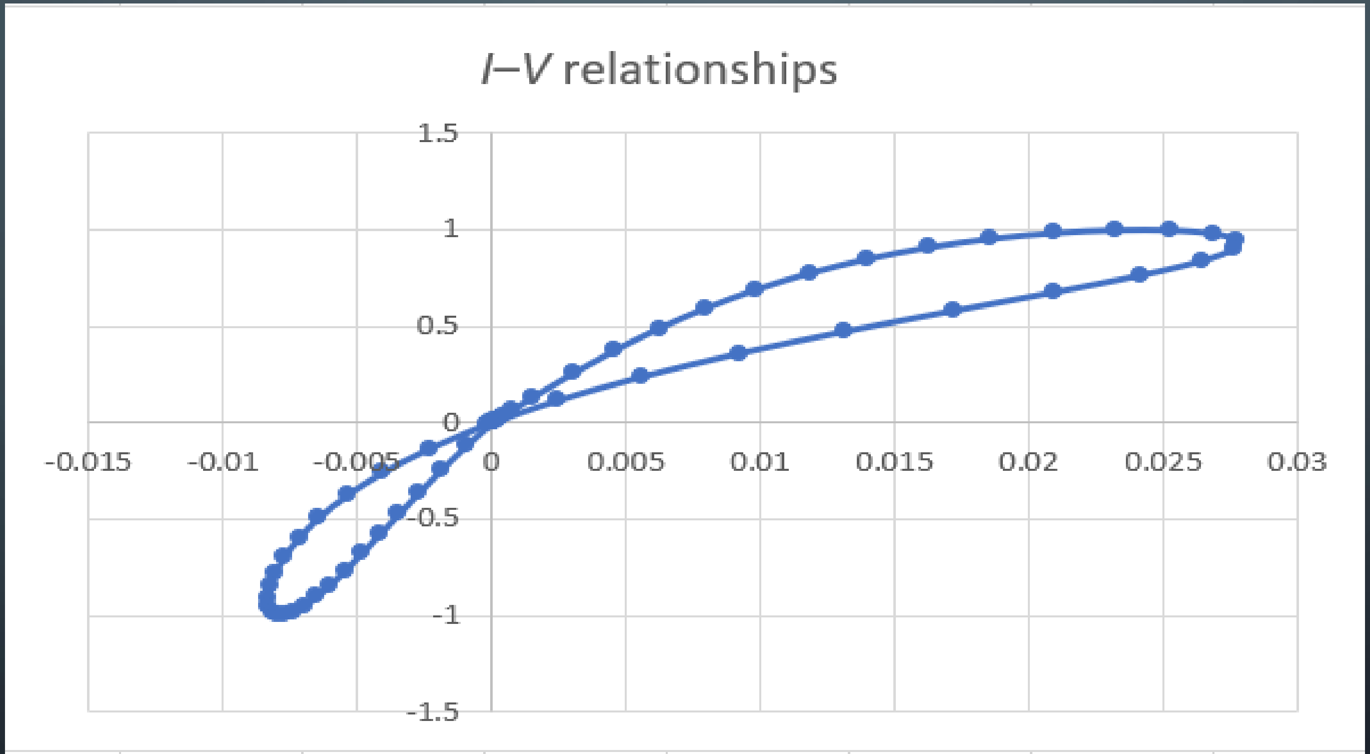


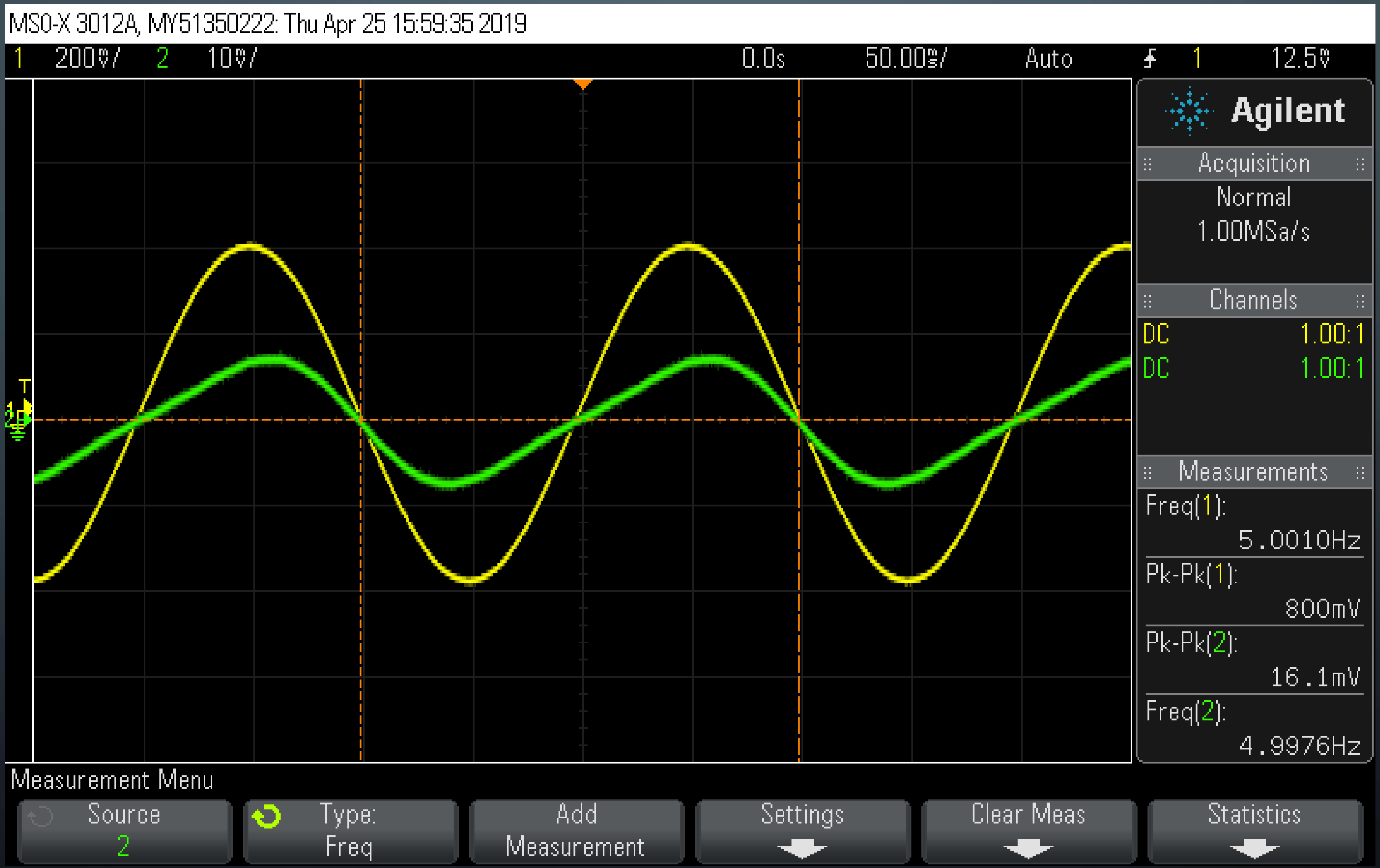
Fig. Voltage/Current wave form at V1

SIMULATION



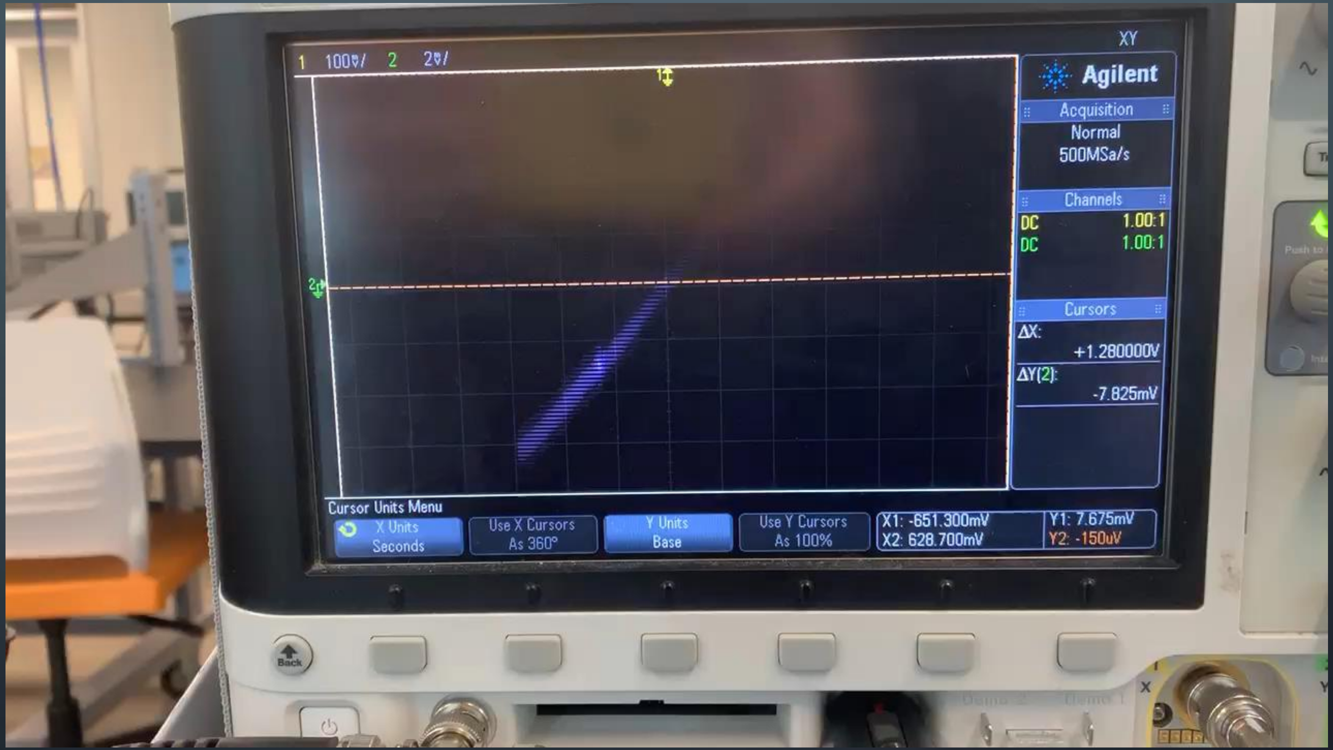
"If it's pinched, it's a memristor" – Chua, Leon

ACTUAL



MSO-X 3012A, MY51350222: Thu Apr 25 15:59:35 2019
1 200mV/ 2 10mV/
0.0s
50.00ms/
Auto
1 12.5mV
Agilent
Acquisition
Normal
1.00MSa/s
Channels
DC 1.00:1
DC 1.00:1
Measurements
Freq(1):
5.0010Hz
Pk-Pk(1):
800mV
Pk-Pk(2):
16.1mV
Freq(2):
4.9976Hz
Measurement Menu
Source
2
Type:
Freq
Add
Measurement
Settings
Clear Meas
Statistics

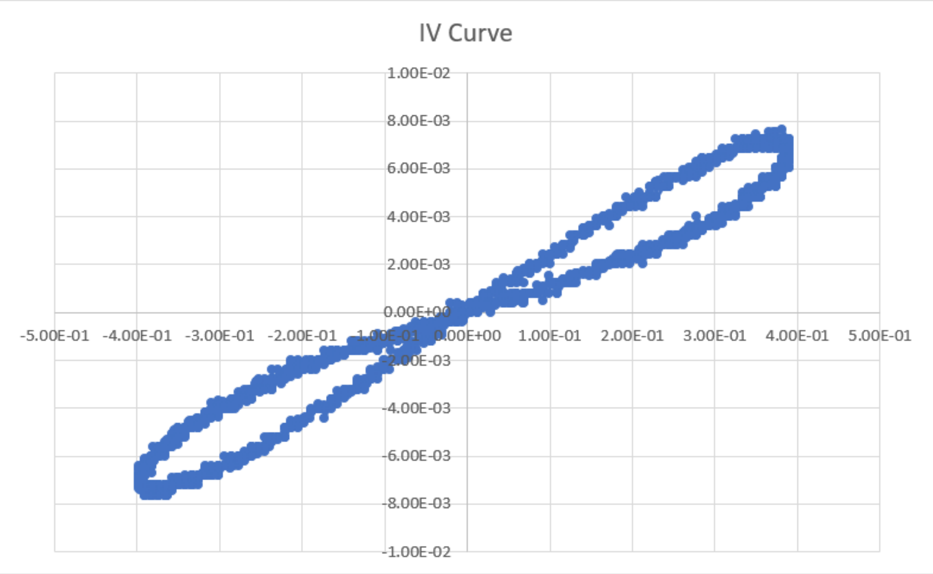
ACTUAL



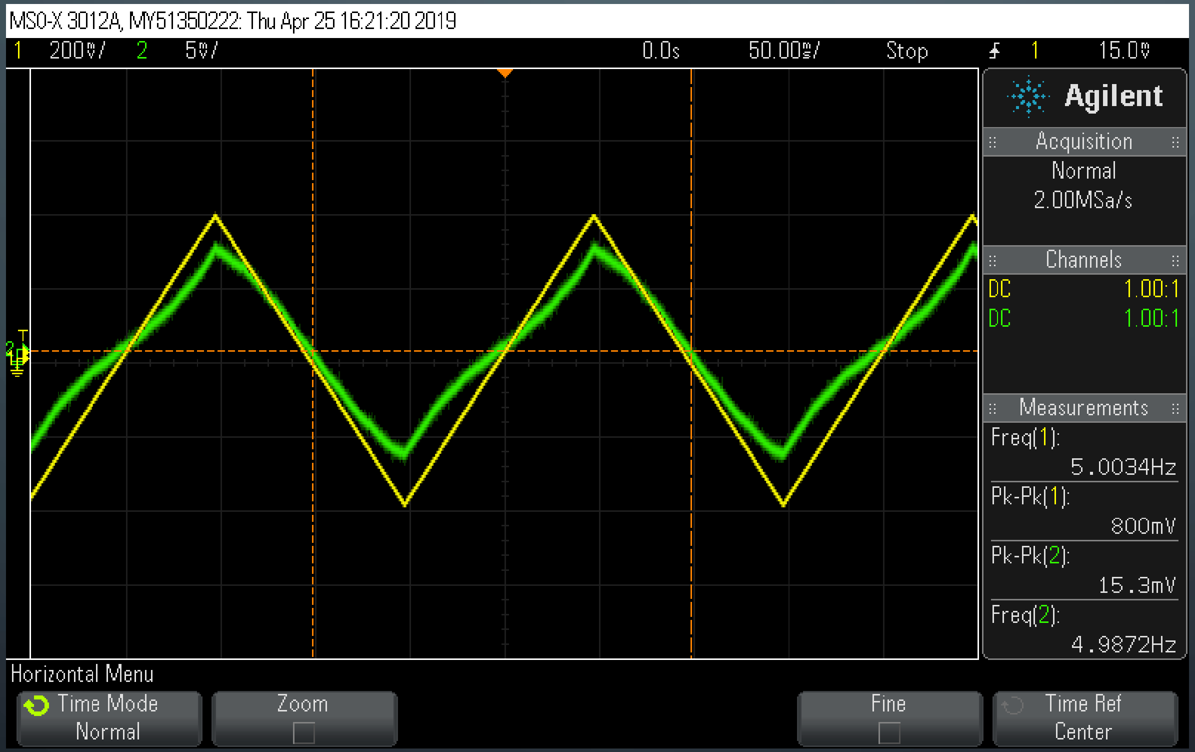
XY
1 100mV/ 2 2V/
Agilent
Acquisition
Normal
500MSa/s
Channels
DC 1.00:1
DC 1.00:1
Cursors
ΔX:
+1.280000V
ΔY(2):
-7.825mV
Cursor Units Menu
X Units Seconds
Use X Cursors As 360°
Y Units Base
Use Y Cursors As 100%
X1: -651.300mV
X2: 628.700mV
Y1: 7.675mV
Y2: -150uV

ACTUAL

	A	B	C
1	x-axis	1	2
2	second	Volt	Amp
3	-2.50E-01	-3.97E-01	-7.21E-03
4	-2.50E-01	-3.92E-01	-6.83E-03
5	-2.50E-01	-3.93E-01	-6.61E-03
6	-2.49E-01	-3.91E-01	-6.83E-03
7	-2.49E-01	-3.98E-01	-6.83E-03
8	-2.49E-01	-3.98E-01	-6.83E-03
9	-2.49E-01	-3.94E-01	-6.63E-03
10	-2.48E-01	-3.98E-01	-6.83E-03
11	-2.48E-01	-3.98E-01	-6.43E-03
12	-2.48E-01	-3.95E-01	-6.83E-03
13	-2.48E-01	-3.93E-01	-6.61E-03
14	-2.47E-01	-3.98E-01	-6.83E-03
15	-2.47E-01	-3.90E-01	-6.81E-03
16	-2.47E-01	-3.90E-01	-6.83E-03
17	-2.47E-01	-3.90E-01	-6.63E-03
18	-2.46E-01	-3.90E-01	-6.83E-03
19	-2.46E-01	-3.90E-01	-6.43E-03
20	-2.46E-01	-3.90E-01	-6.43E-03
21	-2.46E-01	-3.90E-01	-6.83E-03
22	-2.45E-01	-3.90E-01	-6.83E-03
23	-2.45E-01	-3.90E-01	-6.43E-03
24	-2.45E-01	-3.90E-01	-6.43E-03
25	-2.45E-01	-3.90E-01	-6.23E-03
26	-2.44E-01	-3.83E-01	-6.43E-03
27	-2.44E-01	-3.82E-01	-6.43E-03
28	-2.44E-01	-3.90E-01	-6.43E-03
29	-2.44E-01	-3.85E-01	-6.43E-03

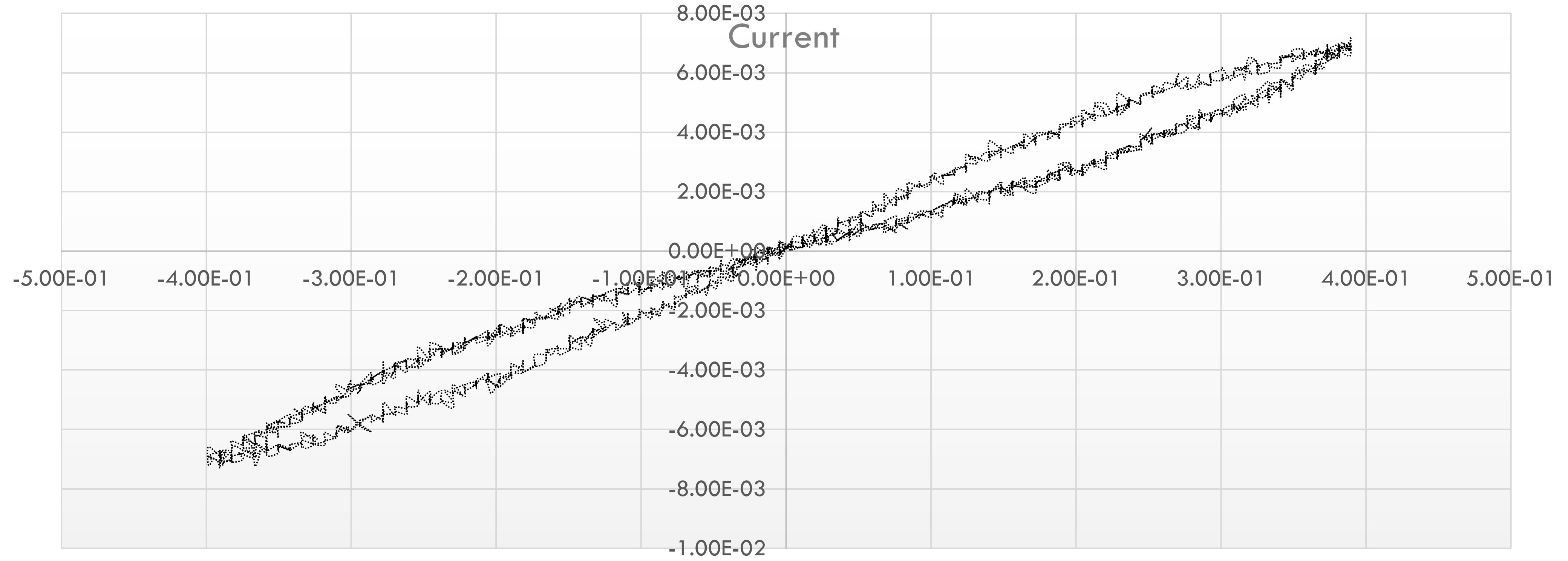


ACTUAL



MSO-X 3012A, MY51350222: Thu Apr 25 16:21:20 2019
1 200mV/ 2 5mV/
0.0s 50.00ms/ Stop
1 15.0mV
Agilent
Acquisition
Normal
2.00MSa/s
Channels
DC 1.00:1
DC 1.00:1
Measurements
Freq(1):
5.0034Hz
Pk-Pk(1):
800mV
Pk-Pk(2):
15.3mV
Freq(2):
4.9872Hz
Horizontal Menu
Time Mode
Normal
Zoom
Fine
Time Ref
Center

ACTUAL



Current
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
-2.00E-03
-4.00E-03
-6.00E-03
-8.00E-03
-1.00E-02
-5.00E-01
-4.00E-01
-3.00E-01
-2.00E-01
-1.00E-01
0.00E+00
1.00E-01
2.00E-01
3.00E-01
4.00E-01
5.00E-01

REFERENCE

- Xiao-Yuan, Wang, et al. "Implementation of an analogue model of a memristor based on a light-dependent resistor." *Chinese Physics B* 21.10 (2012): 108501

QUESTIONS?