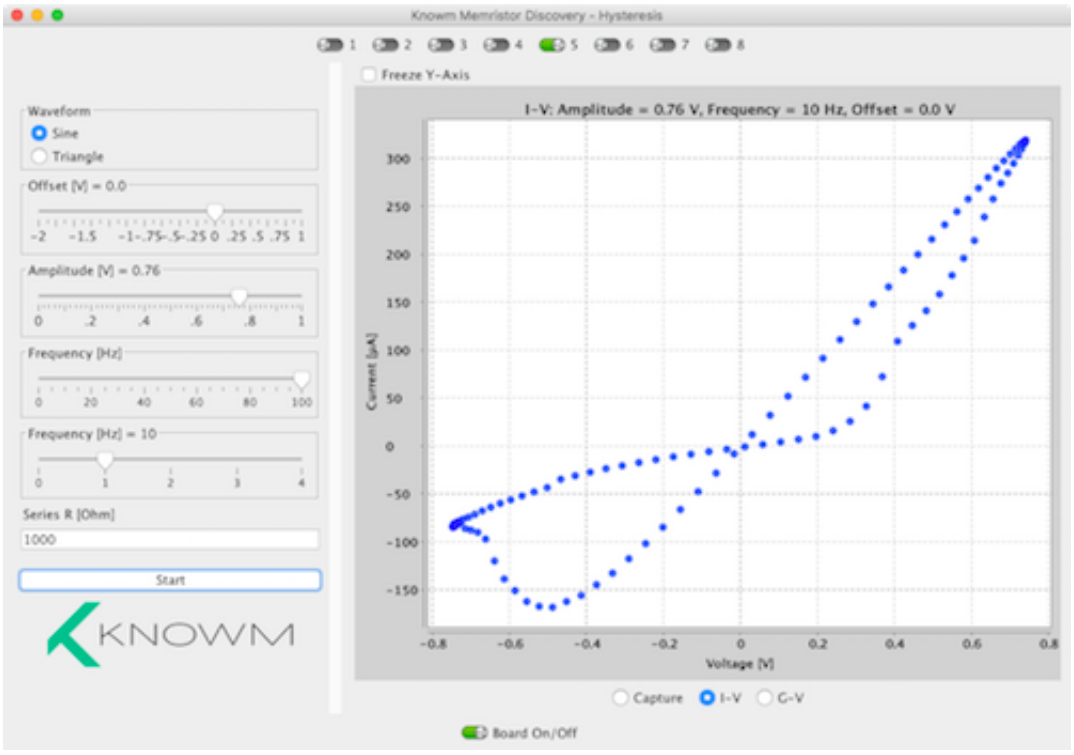
# Introduction

Memristor Discovery is a low-cost solution for exploring memristor behavior. The board plugs into the Digilent Analog Discovery 2 (sold separately). Digital IO channels 0–7 activate analog switches that couple memristors to the AD2 waveform generator and two oscilloscope channels. LEDs indicate closed switches. Easy access test-points and sockets allow for convenient coupling of the circuit to additional measurement equipment and bread-boards. An optional lever-actuated 3M DIP socket provides zero insertion force to prevent handling damage of chip pins. Configuration options include choice of analog switches and DIP socket.

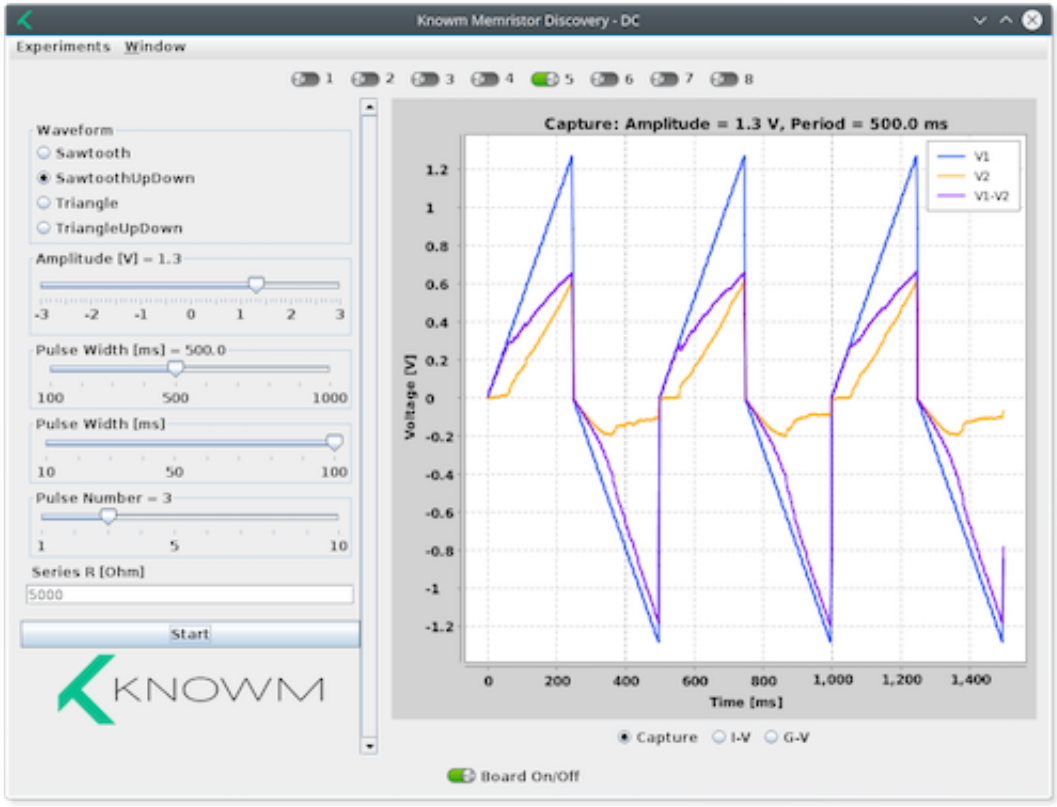
## Memristor Discovery Software

Software for the Memristor Discovery board is open-source and available at https://github.com/knowm/memristor-discovery. Updates are always free of charge. The Memristor Discovery app is a Java application for running memristor “experiments” on the Memristor Discovery board. It is designed to be cross-platform, meaning it runs on the latest versions of MacOS, Debian-based Linux and Windows 10. Running Memristor-Discovery requires Java and the Digilent waveforms Framework to be installed on your system (see previous software link for amore details).

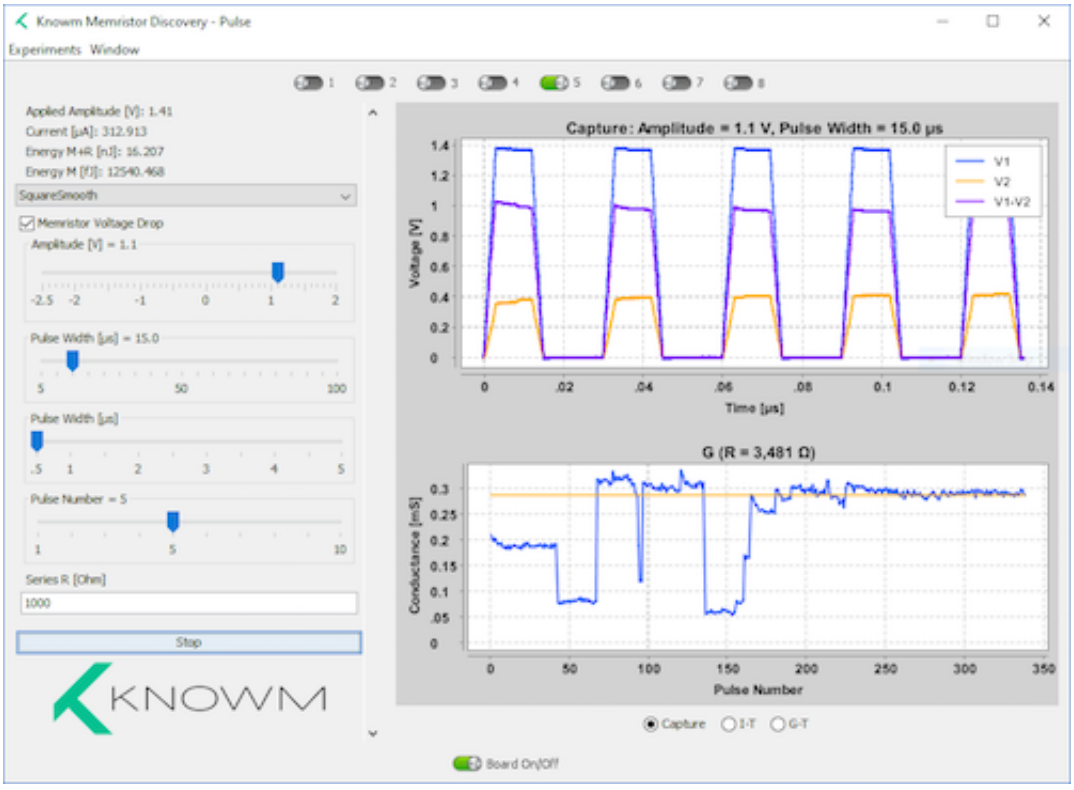
The following screenshots how Memristor-Discovery running on the three supported operating systems.




MacOS



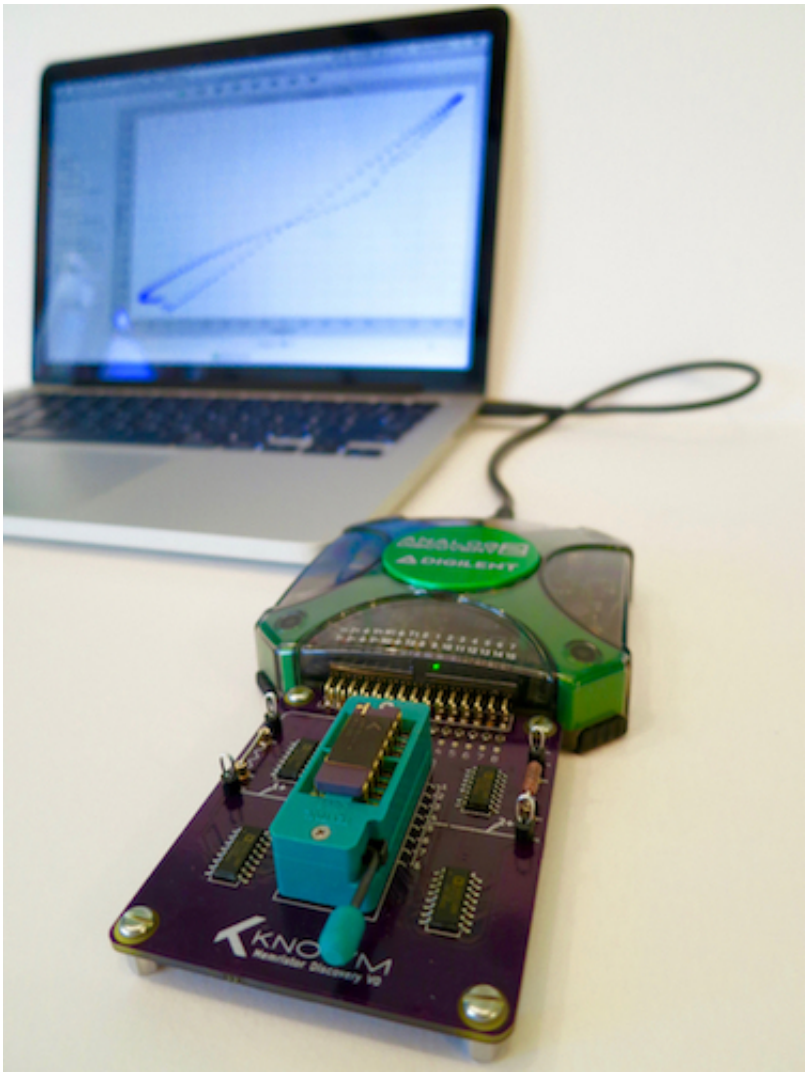

Linux




Windows 10

# Memristor Discovery and AD2

The Memristor Discovery board was designed to plug into the Digilent AD2 USB oscilloscope and accept a Knowm 16-pin DIP socket memristor chip. The board couples individual memristors in series with a resistor (used as a current meter) via analog switches. Individual switch access, via the digital I/O channels, allow for single or parallel coupling of memristor devices.



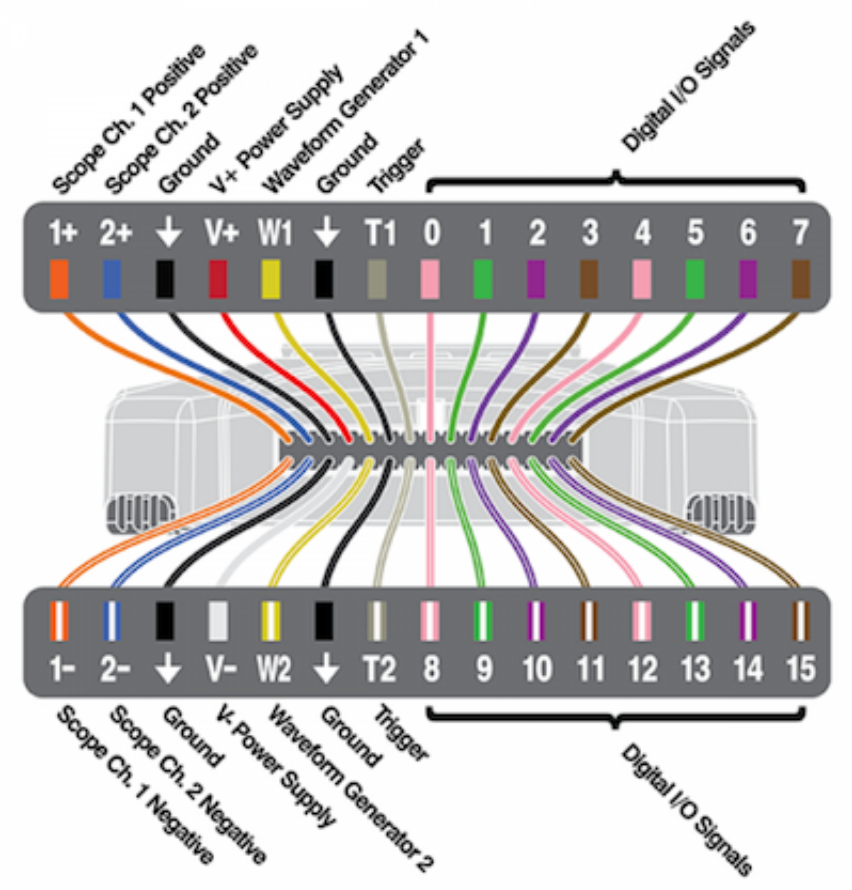
# Digilent Analog Discovery 2

After doing a thorough Review of USB Oscilloscopes with Software Development Kits the Digilent Analog Discovery 2 came out on top as the winner. The Waveforms 2015 software is excellent and they provide a C++ SDK with great documentation making it possible for us to develop our own cross-platform software. Academic discounts are available.

## AD2 Features

| Feature | Specs |
| --- | --- |
| Two-channel oscilloscope | 1 MΩ, 24 pF input impedance, ±25V (high) ±5V (low), differential, 14-bit, 100 Msample/sec |
| Two-channel arbitrary function generator | ± 5V, 14-bit, 100 Msample/sec |
| Digital I/O | 16-channel, 3.3 V |
| 2 input/output digital trigger for linking multiple instruments | 3.3V CMOS |
| 2 Power supplies | 0…+5V , 0…–5V |

## I/O Pin Out




# Memristor Discovery Experiments

The Memristor Discovery hardware and software works together to run a set of clearly-defined and encapsulated experiments, designed to ease the experience of running basic to intermediate experiments and data collection on memristors for students and hobbyists alike.

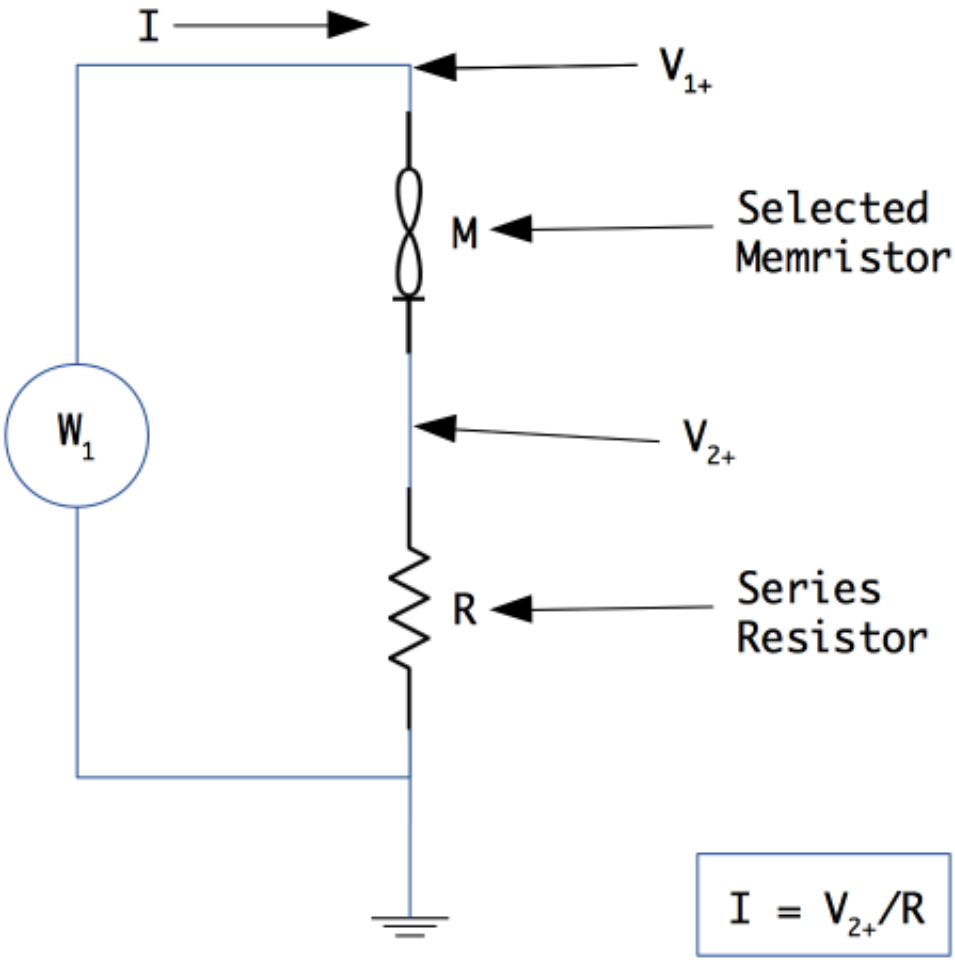
The experiments that come bundled with the software include:

1. Hysteresis

2. DC
3. Pulse

Each different experiment comes with a help page, which explains the basics of the experimental controls and the gist of the demonstration including a circuit diagram. In addition, all experiments come with a preferences panel allowing the student to save any of the experimental controls so that these values don't need to be manually adjusted every time the software is restarted. All experiments allow for the export of the data shown in the plot as a bitmap chart or as a CSV file.

## Circuit




## Connections

1. Arbitrary Waveform Generator W1 (Analog Discovery 2's "W1" and "gnd" connectors) is connected across the memristor (M) and series resistor (R).
2. Oscilloscope Probe V1+ (Analog Discovery 2's "1+" and "1-" connectors) is connected across the memristor (M) and series resistor (Rs).
3. Oscilloscope Probe V2+ (Analog Discovery 2's "2+" and "2-" connectors) is connected across the series resistor

(R).

# Common Experiment Features

## Memristor Selection

Use the toggle switches near the top of the experiment window to connect one or more individual memristors into the circuit.

## Series Resistor

The series resistor provide two important functions:

1. Limits the maximum current through the memristor to prevent device damage (see memristor datasheet).
2. Allows for a current measurement to be made with the oscilloscope (I = V2+/R).

## Controls

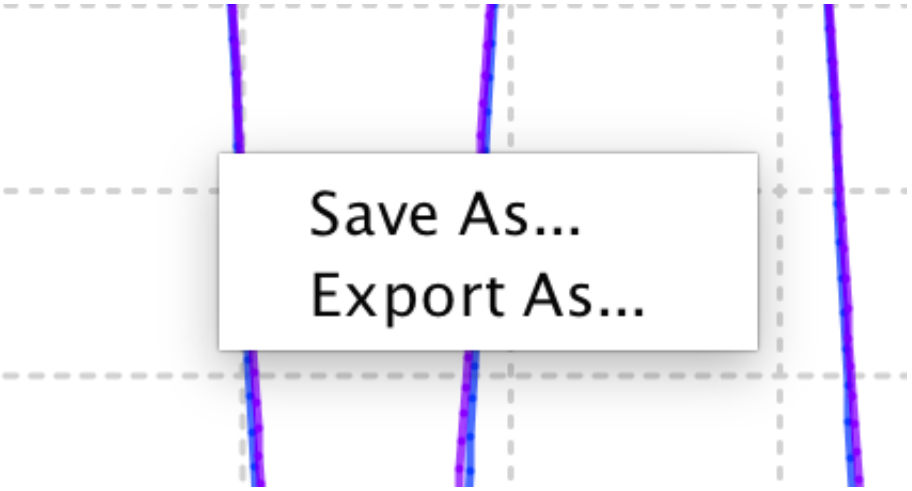
The control panel can be used to adjust the driver waveform of W1. The series resistor value control should correspond to the actual series resistance value used in the experimental setup in order to calculate an accurate current value.

## Conductance Plot

The conductance plot (G-V) uses a running average value, k, to smooth the data. A k value of 0 will eliminate all averaging. The larger k is, the more averaging will occur. If k is too big you may unknowingly hide important memristor behavior so it is best to keep k as low as possible.

## Exporting Data

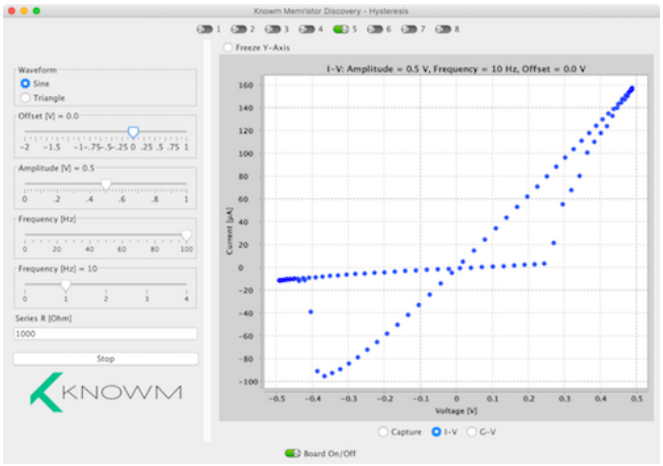
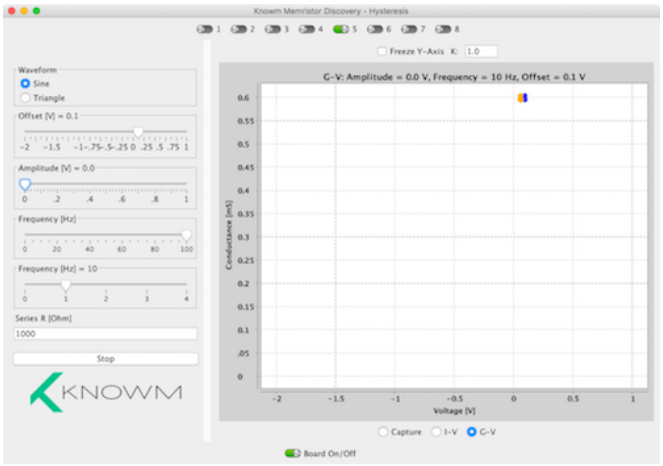
Any plot can be right-clicked to export the data in either chart format (save As…) or comma-separated-values (Export As…), which can be opened in spreadsheet software. For “Export As…” a directory needs to be selected. In that directory, an individual CSV file will be created for each series in the plot.




## Preferences

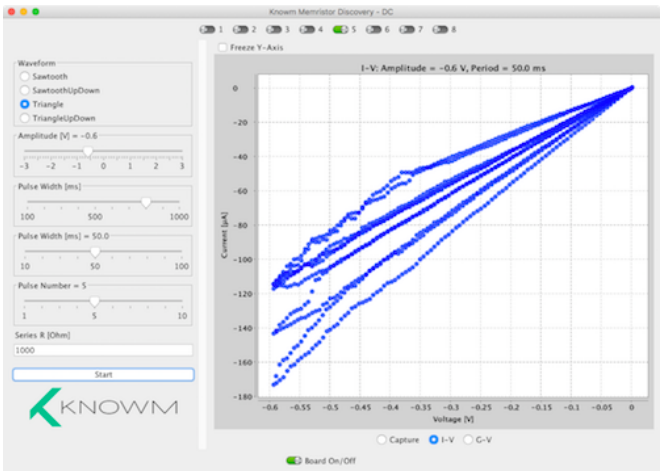
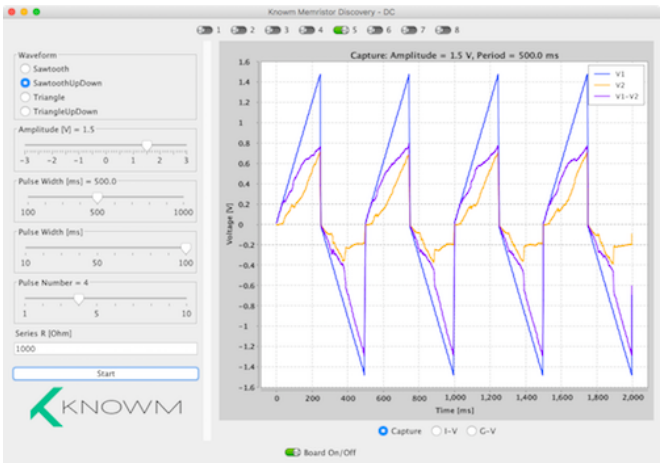
The preferences window allows you to save your preferred experimental control parameters between sessions of using the experiment.

# Hysteresis Experiment

| I-V | G-V |
| --- | --- |
|  |  |

This experiment allows you to drive a memristor in series with a resistor with a sinusoidal or triangle waveform and observe the response as either a time series (V1+/T and V2+/T), I/V or G/V plot, revealing the signature hysteresis behavior of the memristor.

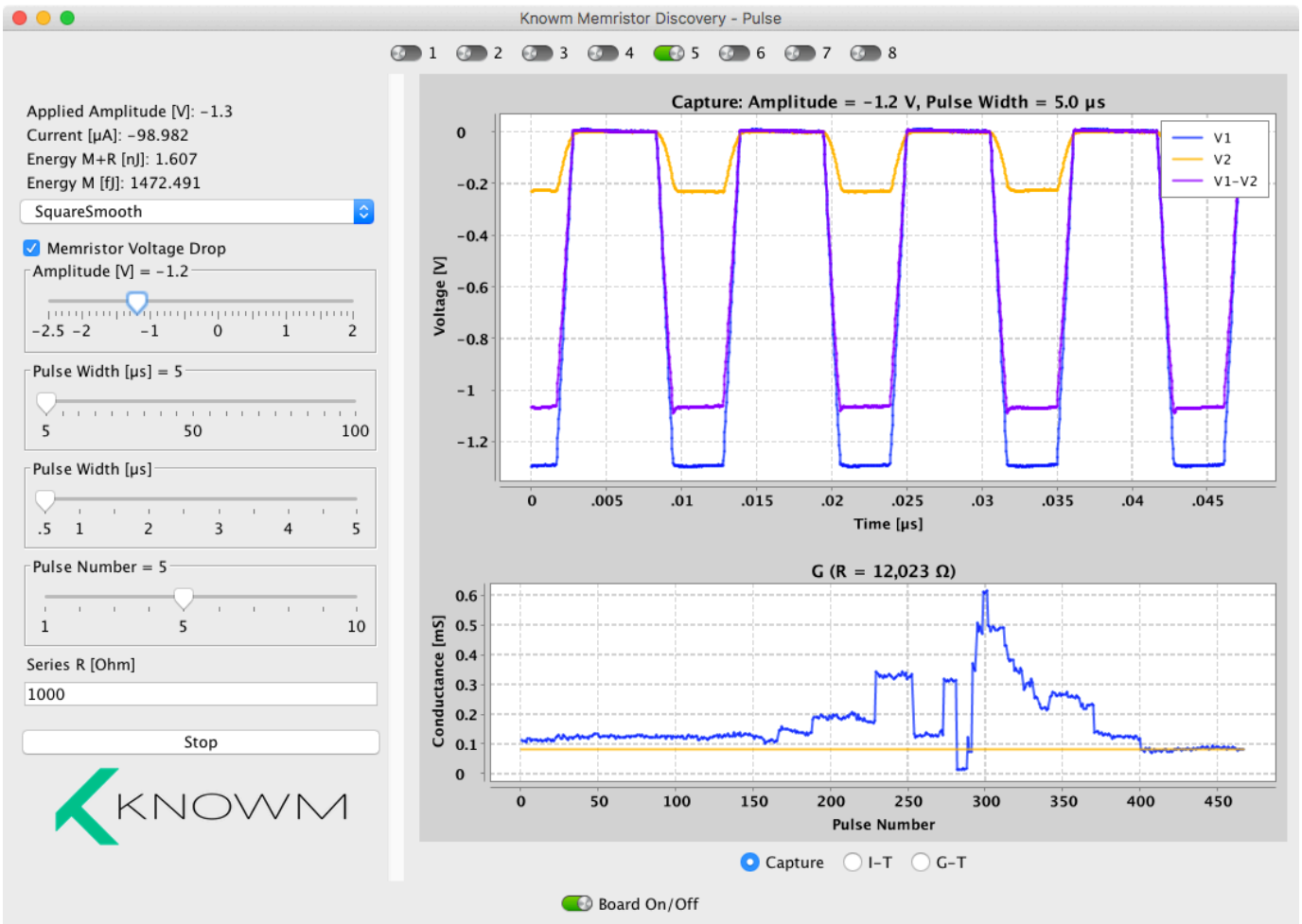
# DC Experiment

| I-V | Capture |
| --- | --- |
|  |  |

This experiment allows you to drive a memristor in series with a resistor with various ramping functions including sawtooth, sawtoothupdown, triangle and triangleupdown. The number of applied ramping signals can be chosen and the response can be observed as either a time series (V1+/T and V2+/T), I/V or G/V plot, revealing the DC behavior of the memristor.

# Pulse Experiment

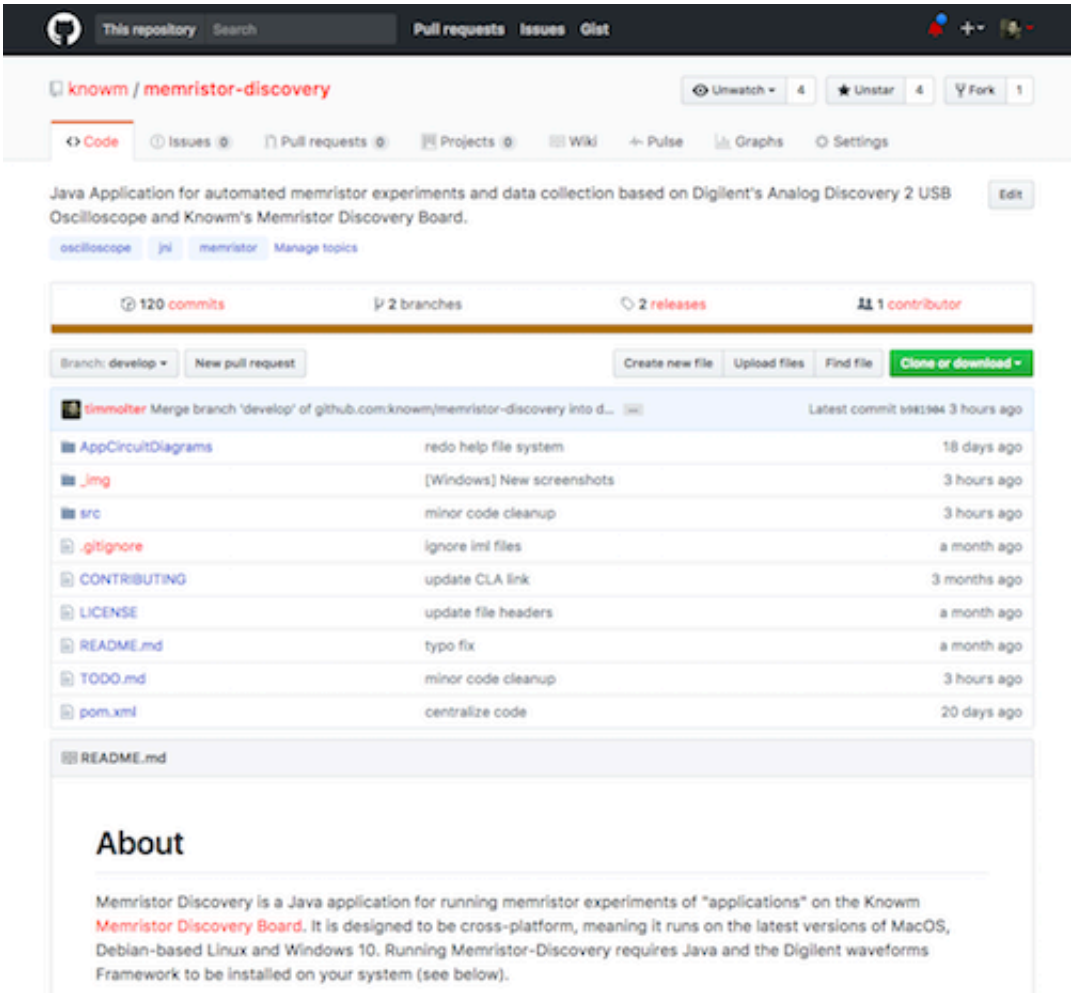
**Capture**



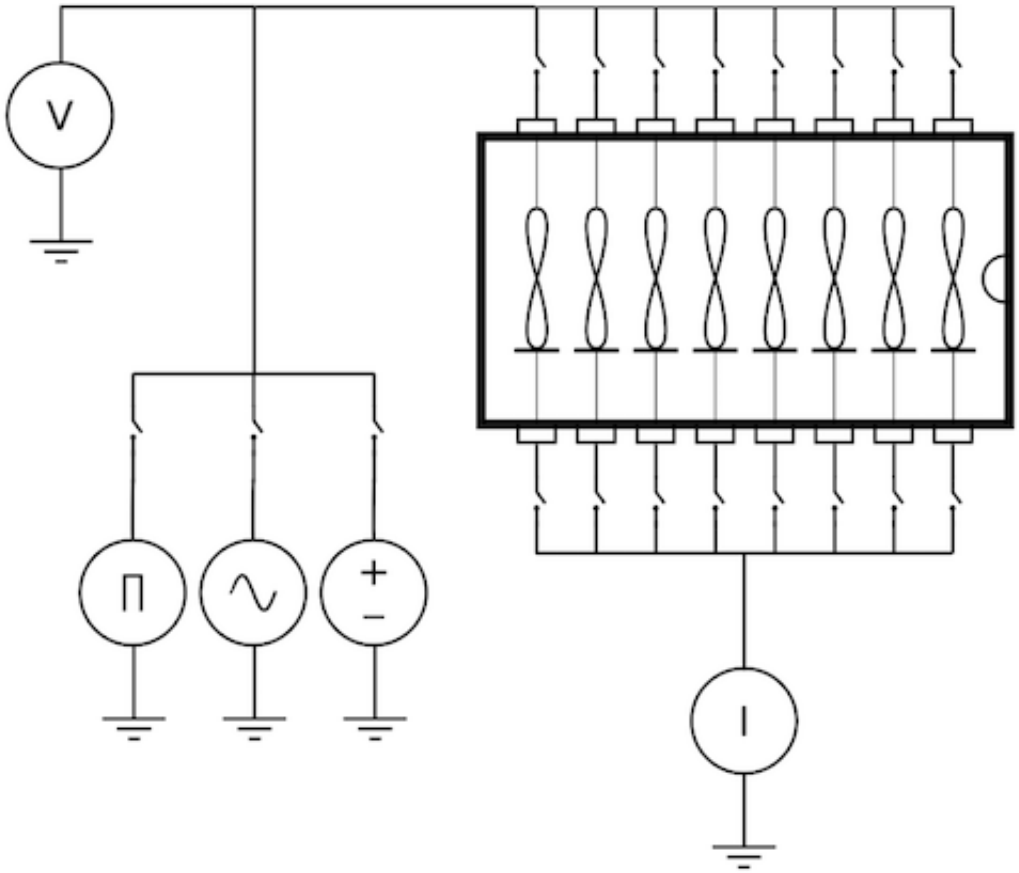

This experiment allows you to drive a memristor in series with a resistor with one or more pulse waveforms including square, square-smooth, quarter-sine, triangle and half-sine and observe the dynamic response as either a time series (V1+/T and V2+/T), I-T or G-T plot, revealing the incremental conductance behavior of the memristor. A second plot shows the conductance as measured by a 0.1 V 10 $\mu$s read pulse at a 0.5 second interval.

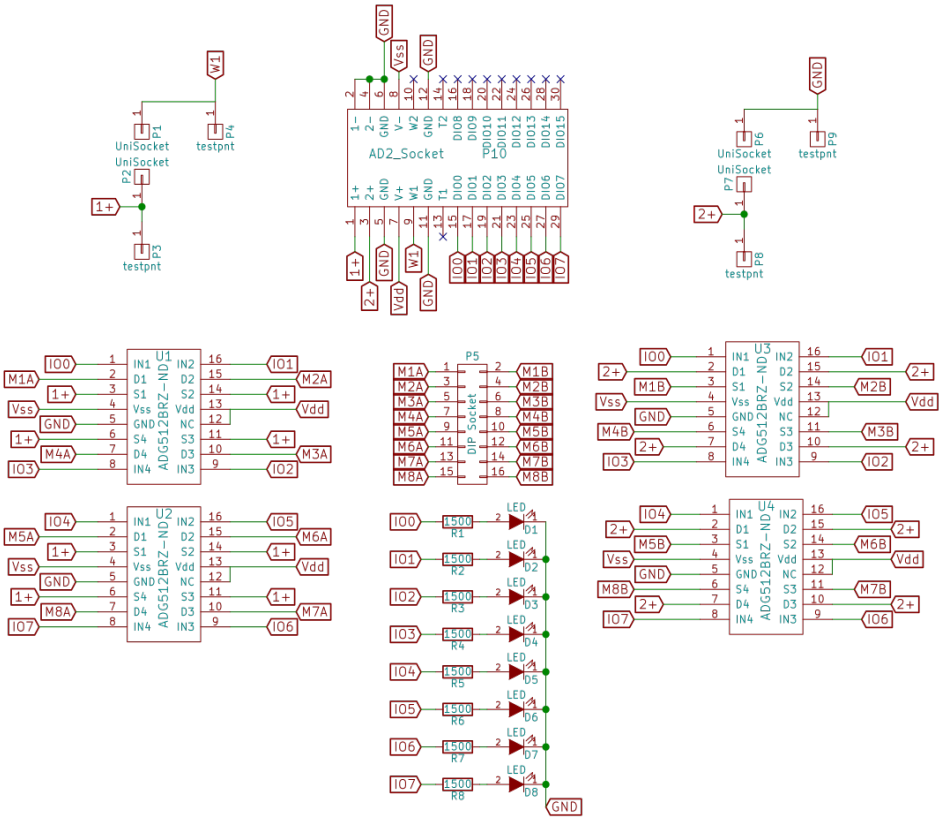
# Open Source

The Memristor-Discovery Application is 100% open-source licensed under the GPL–3 license and hosted on github. Updates to the app will always be free and you can customized the app however you need to. If you need to add new functionality or automate some memristor data-collection experiment, no problem. And it will run on Windows 10, Linux and MacOS!


This repository Search
Pull requests Issues Gist
knowm / memristor-discovery
Unwatch 4
Unstar 4
Fork 1
Code
Issues 0
Pull requests 0
Projects 0
Wiki
Pulse
Graphs
Settings
Java Application for automated memristor experiments and data collection based on Digilent's Analog Discovery 2 USB Oscilloscope and Knowm's Memristor Discovery Board.
Edit
oscilloscope
jni
memristor
Manage topics
120 commits
2 branches
2 releases
1 contributor
Branch: develop
New pull request
Create new file
Upload files
Find file
Clone or download
timmolter Merge branch 'develop' of github.com:knowm/memristor-discovery into d...
Latest commit 3 hours ago
AppCircuitDiagrams redo help file system 18 days ago
_img [Windows] New screenshots 3 hours ago
src minor code cleanup 3 hours ago
.gitignore ignore iml files a month ago
CONTRIBUTING update CLA link 3 months ago
LICENSE update file headers a month ago
README.md typo fix a month ago
TODO.md minor code cleanup 3 hours ago
pom.xml centralize code 20 days ago
README.md
About
Memristor Discovery is a Java application for running memristor experiments of "applications" on the Knowm Memristor Discovery Board. It is designed to be cross-platform, meaning it runs on the latest versions of MacOS, Debian-based Linux and Windows 10. Running Memristor-Discovery requires Java and the Digilent waveforms Framework to be installed on your system (see below).

# Schematic


V


W1
P1
UniSocket
P4
testpnt
UniSocket
P2
1+
P3
testpnt
GND
Vss
GND
AD2_Socket
P10
1+
GND
W1
Vdd
GND
2+
GND
P6
UniSocket
P9
testpnt
UniSocket
P7
2+
P8
testpnt
IO0
M1A
1+
Vss
GND
1+
M4A
IO3
U1
ADG512BRZ-ND
IN1
D1
S1
Vss
GND
S4
D4
IN4
IN2
D2
S2
Vdd
NC
S3
D3
IN3
IO1
M2A
1+
Vdd
1+
M3A
IO2
P5
M1A
M2A
M3A
M4A
M5A
M6A
M7A
M8A
DIP Socket
M1B
M2B
M3B
M4B
M5B
M6B
M7B
M8B
2+
M1B
Vss
GND
M4B
2+
IO3
U3
ADG512BRZ-ND
IO0
2+
M2B
Vdd
M3B
2+
IO2
IO4
M5A
1+
Vss
GND
1+
M8A
IO7
U2
ADG512BRZ-ND
IO5
M6A
1+
Vdd
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IO0
IO1
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IO3
IO4
IO5
IO6
IO7
1500
R1
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R3
R4
R5
R6
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R8
LED
D1
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D4
D5
D6
D7
D8
GND
IO4
2+
M5B
Vss
GND
M8B
2+
IO7
U4
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IO5
2+
M6B
Vdd
M7B
2+
IO6