CG1111: Engineering Principles and Practice I

Preparation for Week 2, Studio 1

Laboratory Safety and Equipment Familiarization

Overview

1. Safety
2. Resistor Color Codes
3. Handheld Digital Multimeter

- **Activity 1**

4. Breadboard
5. “DC Power Supply”: USB Breakout Cable

- **Activity 2**

6. BitScope Micro

- **Activity 3**

- **Questions & Answers**

1. Safety - Preparation

- Watch the prescribed videos listed below
  - Introduction to Laboratory Safety and Health in NUS
  - Basic Electrical Safety

- Attempt the ECE@NUS: Safety Quiz (https://online.ece.nus.edu.sg/safety/quiz/v4/)
  - Obtain & **upload** the safety quiz certificate to LumiNUS
  - Please **submit it before coming to the lab**, as you will **not** be allowed to work in the lab otherwise

1. Safety – Safe Practices

- In addition to your mask, what else to wear?
  - Covered (closed-toe) shoes
  - Long hair, very loose clothing and accessories must be secured before working in the laboratory
  - Wear goggles when working with equipment that may potentially injure the eyes
- Do not touch any electrical equipment with wet hands
- Never use any damaged or faulty equipment – report it to lab officer immediately
- Never work alone in the laboratory
- More details on safety are available at the DSA Lab Safety Notice Board near its entrance

1. Safety – Emergency Procedure

- What to do in an emergency?
  - Accidents
    - ✓ Report them to Lab Officer immediately
    - ✓ Only attempt to render first aid if you are trained to do so
    - ✓ Contact NUS Campus Security and other agency if needed (Please save the following 24-hrs hotlines to your phone contacts)

S/N	Agency	24-hrs Hotline
1	**NUS Campus Security**	**6874 1616**
2	Faculty of Engineering Safety Office	6601 3765
3	Police	999
4	SCDF (Fire Brigade and Ambulance)	995

1. Safety – Emergency Procedure

- What information to give when calling for an ambulance or the Singapore Civil Defence Force (SCDF) at 995 in an emergency?

You should have these details ready:

- ✓ Contact Person's Name & Tel No. :
- ✓ Floor & Unit No. : *e.g. E4A-04-08*
- ✓ Building Block No. : *e.g. E4A*
- ✓ Street Name : *e.g. Engineering Drive 3*

As NUS campus and roads leading to the building is complex, you need to also inform NUS Campus Security at 68741616, which would then lead the ambulance/SCDF to the location of the emergency.

1. Safety – Evacuation Procedure

- What to do in a Fire Emergency?
  - Inform the lab officer immediately
  - If fire **alarm** is activated, everyone must **evacuate** the DSA laboratory and the building E4A
  - Calmly exit from the fire exits and leave the building
  - DO NOT use the lifts
  - Gather at the designated **Emergency Assembly Point**, where attendance would be taken to ensure that all occupants have been evacuated safely
  - The designated Emergency Assembly Point for DSA lab is located in the carpark next to the building E6, as shown in the next slide

1. Safety – Evacuation Procedure

- Emergency Assembly Point for BLK E4A:

Assembly Point 39

AA: Carpark next to the building **E6**

1. Safety – Basic Electrical Safety

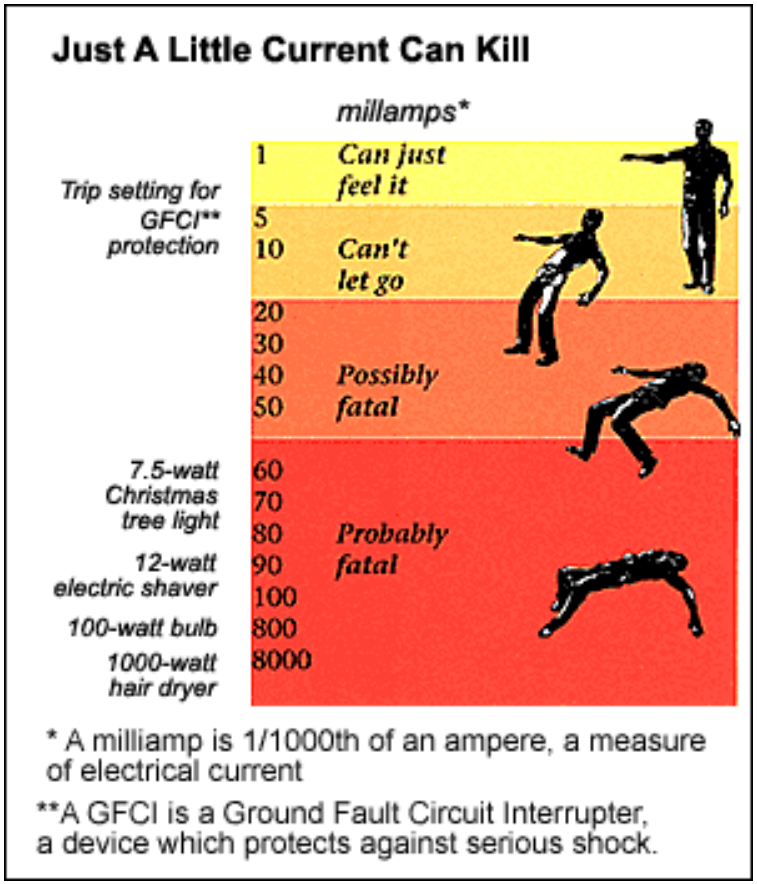
- Typical Electrical Hazards
  - Defective Equipment
  - Damaged Electrical cords
  - Exposed Electrical wires (see Figure 1)
  - Overloading of electrical circuits, plugs or extension cords (see Figure 2)
  - Using Electrical equipment in wet or damp conditions
- Typical Electrical Incidents
  - Electric Shock
  - Electrical Burns
  - Electrocution
  - Loss of muscle control
  - Fire / Explosion

Figure 1

Figure 2

1. Safety – Basic Electrical Safety

- A Common Misconception:
  - "Low voltages are harmless".
  - This is not true!
  - Current as little as **60 mA** can kill!



"Electrical Injuries." *The Merck Manual of Medical Information: Home Edition*. Pennsylvania: Merck, 1997.	"At currents as low as 60 to 100 milliamperes, low-voltage (110-220 volts), 60-hertz alternating current traveling through the chest for a split second can cause life-threatening irregular heart rhythms. About 300-500 milliamperes of direct current is needed to have the same effect."	0.06–0.1 A (AC) 0.3–0.5 A (DC)

1. Safety – Basic Electrical Safety

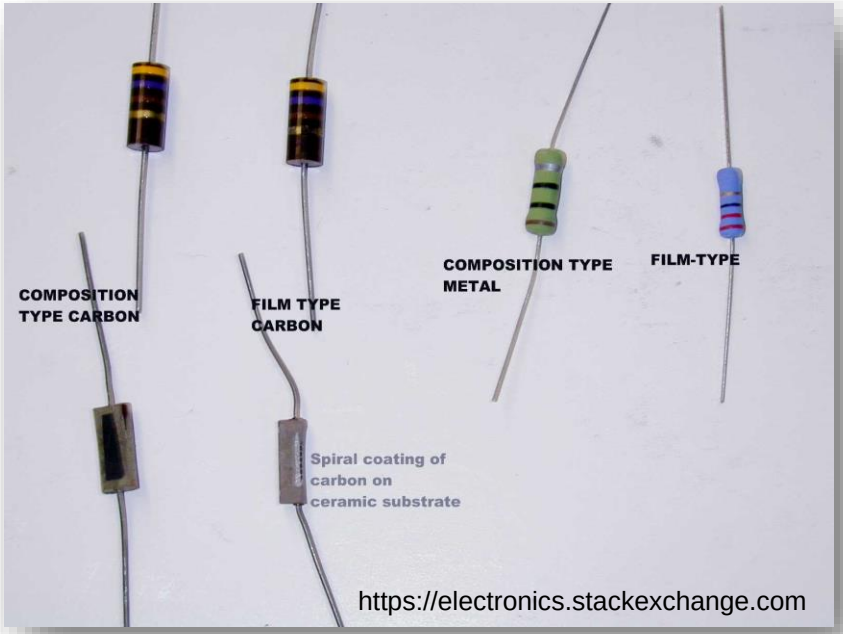
- Major causes of electrical accidents
  - Ignorance, negligence and forgetfulness
  - Working on live electrical equipment deliberately
  - Disabling and working without safety devices (e.g. removing grounding connectors) or tampering with safety devices (e.g. inappropriate fuse replacement)
- Every NUS lab equipment should have its **Safe Work Procedure**
  - Please ask for it if you need it

- Bottom Line:

Always follow safety procedures !

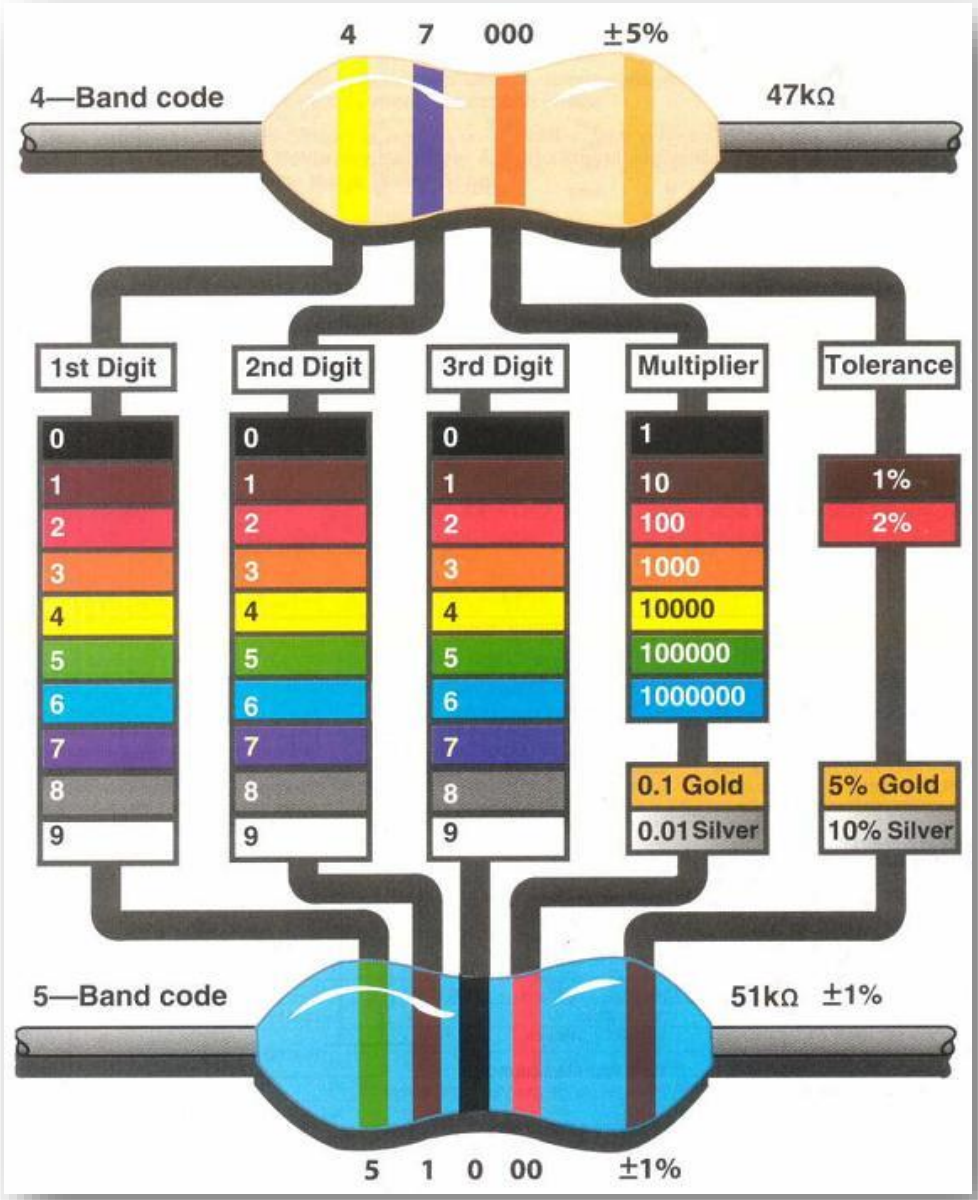
2. Resistor Color Codes

- Resistor manufacturers usually provide the resistance values of the resistors on their casings in the form of color codes.
- The resistance value indicated is only the ***nominal value*** of the resistor, which is an approximation to the actual resistance value and there is a possibility of a slight deviation from the nominal value, which is known as the ***tolerance***.
- This information is usually coded in 4 or 5 bands, although the rarer 3-band (fixed 20% tolerance) and 6-band (with temperature coefficient) resistors also exist.



2. Resistor Color Codes

- For the 4-band resistors available in our lab, the first 3 bands indicate the **resistance value**, while the fourth band represents the **tolerance value**.
- Do you know some of the common resistor color codes mnemonics? What about coming up with one yourself?
- Use a Resistor Color Code Calculator app to help you.
- Can you still remember what the primary role of resistors is in a circuit?



3. Handheld Digital Multimeter

- A digital multimeter (DMM) is an indispensable tool for testing, diagnosing and troubleshooting electrical circuits, components and devices.

- It is a test instrument used to measure multiple electrical values. Many common measurements, e.g. **DC voltage** and **AC voltage** (voltmeter), **DC current** (ammeter) and **resistance** (ohmmeter), can be made by selecting the functions (as shaded) appropriately with the rotary dial.

- It is also often used to check for electrical **connectivity** and test **diode** for its working condition and polarity.

3. Handheld Digital Multimeter – Safety Precautions

- The portable palm size TENMA® handheld DMM that will be loaned to you comes with a User Manual which you should read at least once ***before*** you start using the DMM. Please ***retain and return it to the lab*** together with the DMM at the end of the semester. You may download the digital version from Luminus.

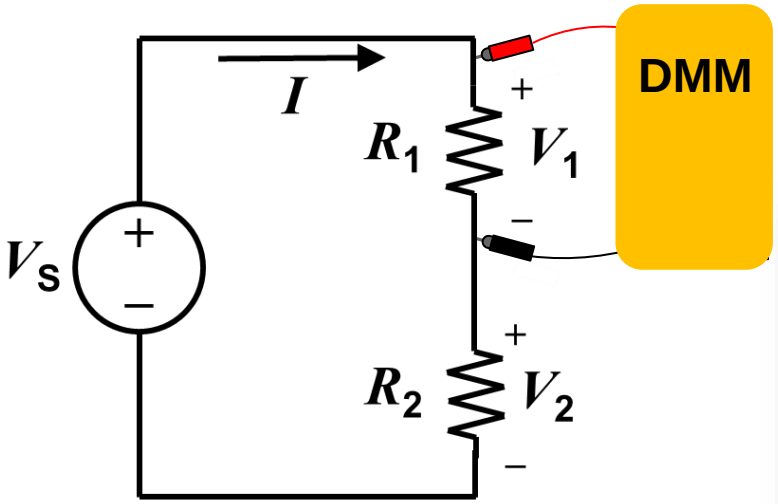
- Please pay special attention to the following prescribed **safety precautions** regarding taking measurements:

  ✓ If the range of the quantity to be measured is unknown, the **maximum range** should be selected and then gradually decreased.

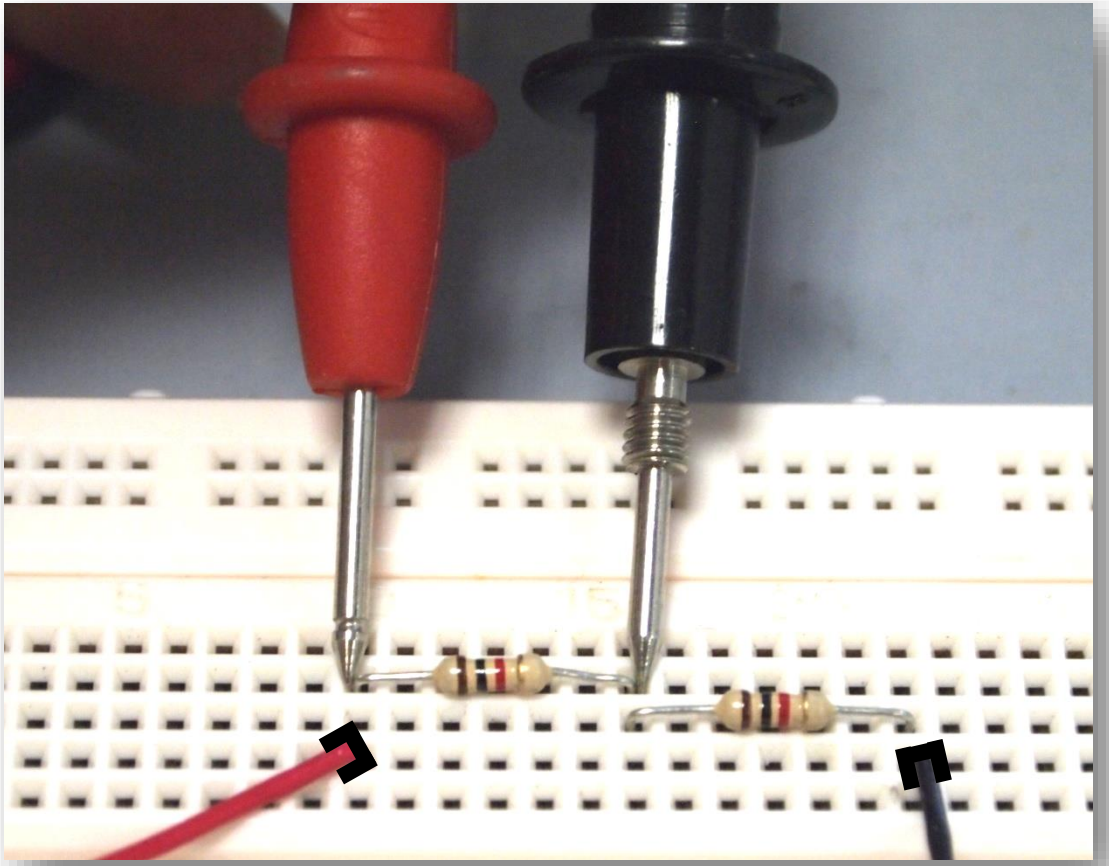
  ✓ **Never** input voltage or current **exceeding** the value listed on the device.

  ✓ Before switching ranges, make sure to disconnect the test leads from the circuit to be tested. It is **strictly prohibited to switch the ranges during the measurement**!

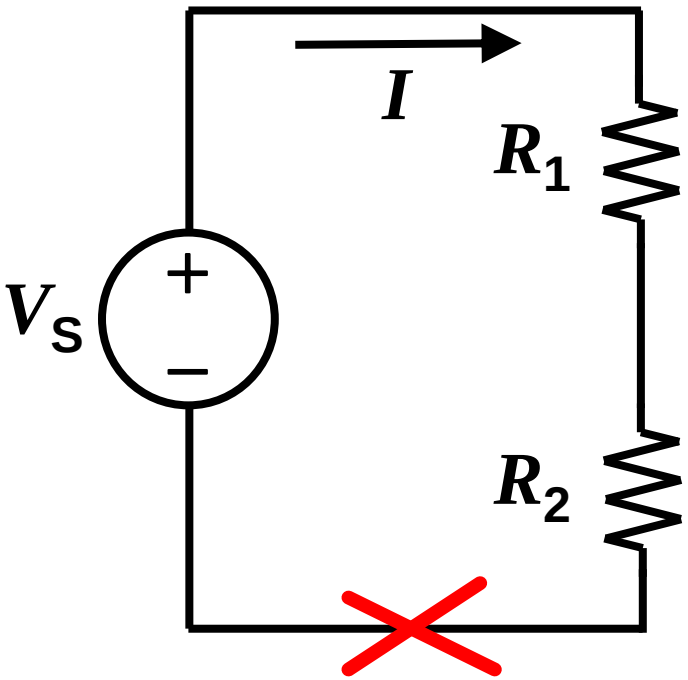
3. Handheld Digital Multimeter – Always Measure Voltage in Parallel



- Set the DMM to read DC Voltage
- Place the probes **across** the component (i.e. in parallel)
- The polarity is important for meaningful readouts



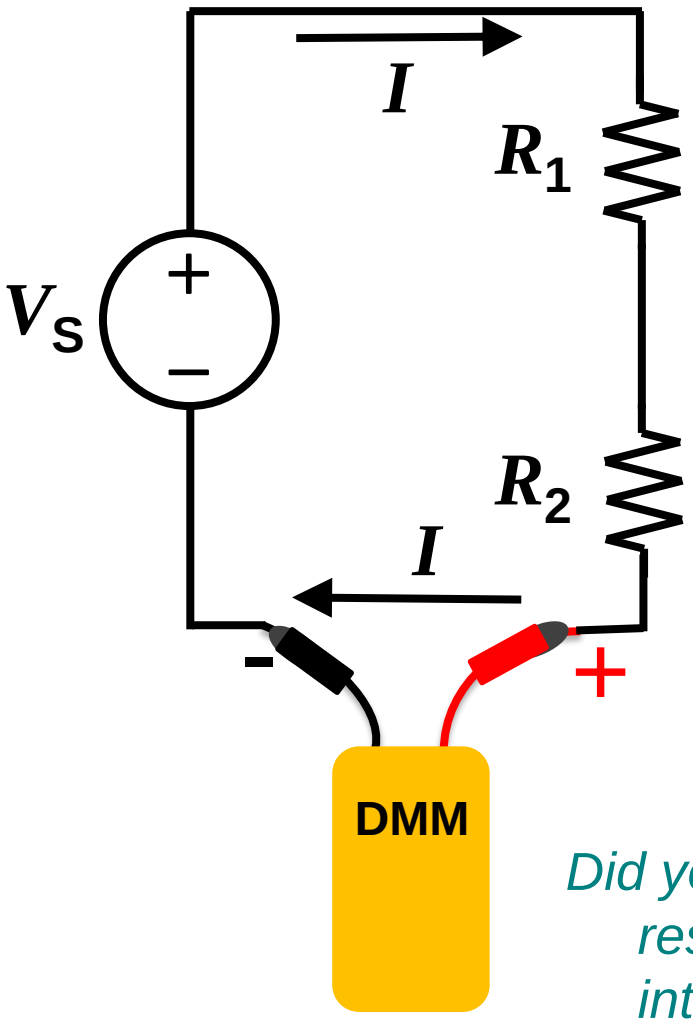
3. Handheld Digital Multimeter – Always Measure Current in Series



Because the DMM needs to be in series with the circuit, you will need to break the circuit to insert the DMM. A convenient place to break the circuit is between the voltage source (either + or – terminal) and the components.

1) Break the circuit at ✕

3. Handheld Digital Multimeter – Always Measure Current in Series



2) Insert DMM in series

- Always disconnect the power supply from your circuit first as a safety precaution
- Set the DMM to read DC Current
- Place the DMM **in series with** the component(s)
- The polarity is important for meaningful readouts

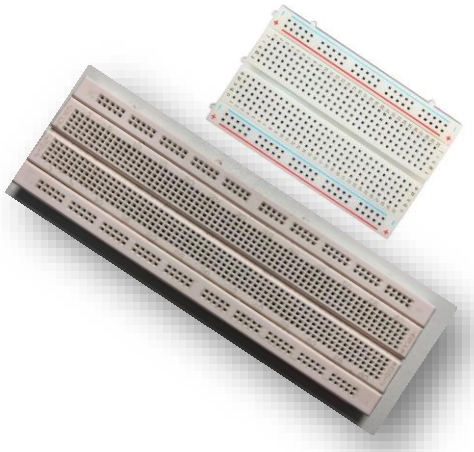
Tips: simply imagine the DMM to be another element that needs to be placed in series!

Did you know: an ammeter has close to zero internal resistance which makes it possible for us to insert it into a circuit without affecting the circuit current.

ACTIVITY 1:

Resistor color codes and resistance measurement using handheld DMM.

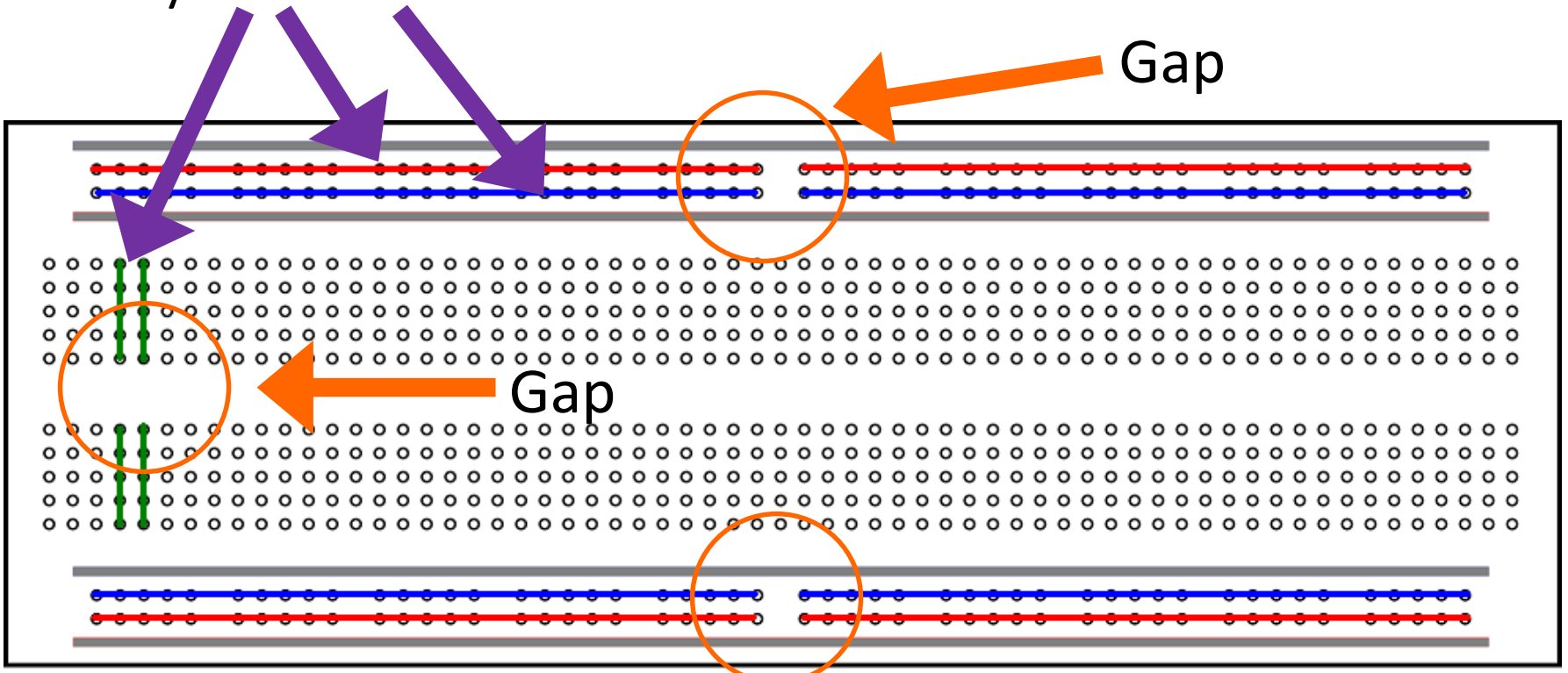
4. Breadboard – for Prototyping/Testing of Electrical Circuits



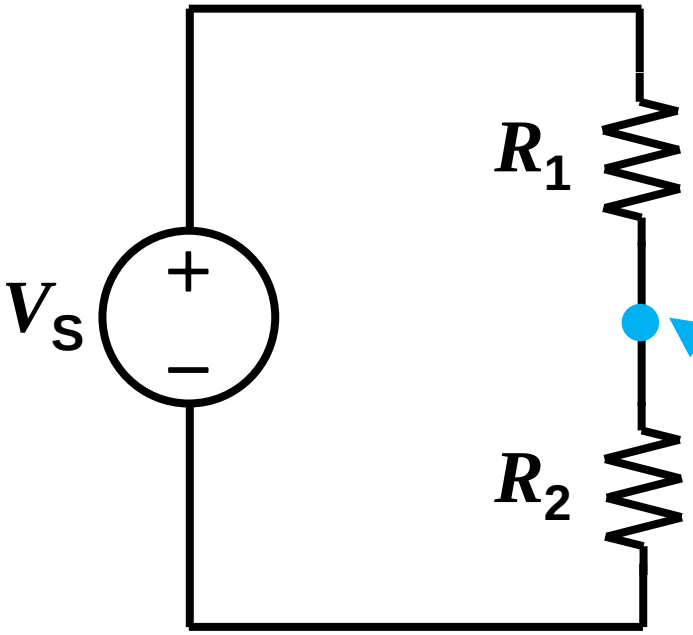
- A breadboard is a construction base for quick prototyping and testing of electronics and electrical circuits.
- Components of the electrical circuits can easily be connected to one another by inserting their leads or terminals into the holes on the breadboard and with connecting wires to complete the circuits.
- As shown in the next slide, the top and bottom rows of the holes are connected horizontally (i.e. red and blue lines), while the holes in the middle section are connected vertically (i.e. green lines).
- Take note of the “gaps” too. These gaps indicate that there are breakages in the electrical connection between the two sides of the gaps.

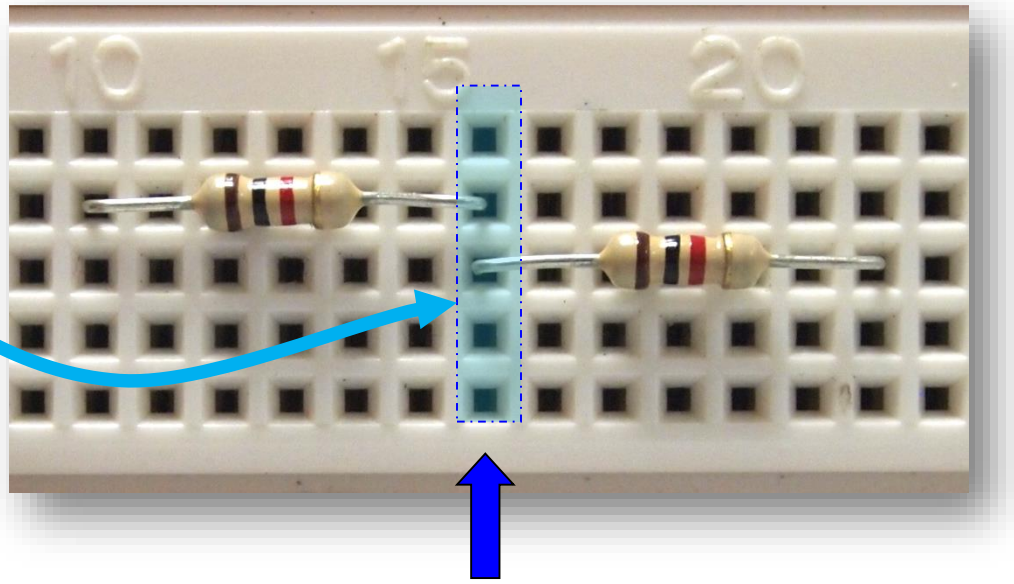
4. Breadboard – Electrical Connections

These adjacent holes, joined by the same lines, are electrically connected inside the breadboard



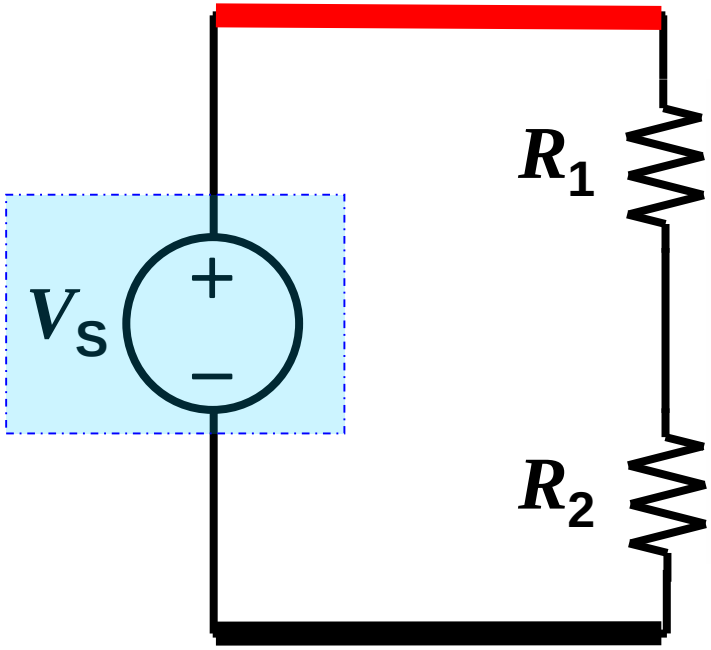
4. Breadboard – Series Connections

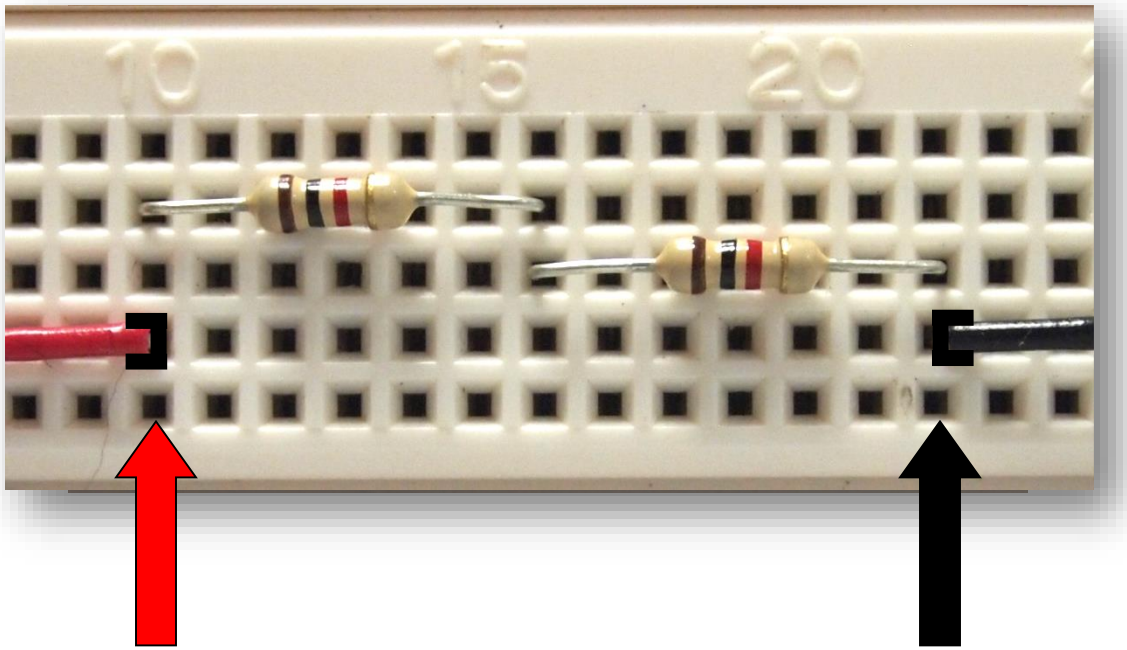




Use the electrically connected holes to connect components

4. Breadboard – Series Connections





If needed, place two wires here to connect to the voltage source, V_s

4. Breadboard – Parallel Connections

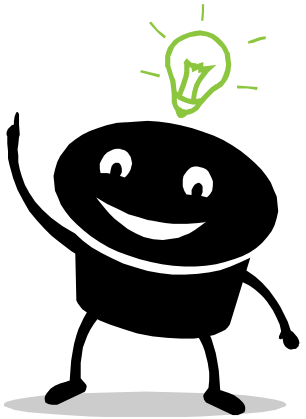
- How would you make parallel connections?

5. "DC Power Supply": USB Breakout Cable

- DC power supplies are power supplies that output DC voltages and DC currents (and hence electric power) to electrical load(s) or circuit.
- The benchtop DC power supplies you find in the lab allow you to control both the voltage and current limits.
- Although without the flexibility of limits control, a USB breakout cable allows you to easily power up your electrical circuits – a no-frills DC power supply!
- The output DC voltage available at the **Red** wire is *approximately* 5 V Fixed, with respect to the **Black** wire, which is the common ground. The supply current is limited only by the source. E.g. PC's USB port has a limit of maximum 0.5 A.

Output:
~ 5 V Fixed

5. "DC Power Supply" – Circuit Current?



- Voltage: Fixed 5 V
- Current: Max 0.5 A

- Connect a 1k Ω resistor directly across the **Red** and **Black** wires

What do you think will happen?

What will the resistor voltage be?

What will the circuit current be?

ACTIVITY 2

Simple circuit building on breadboard and taking measurements with DMM.

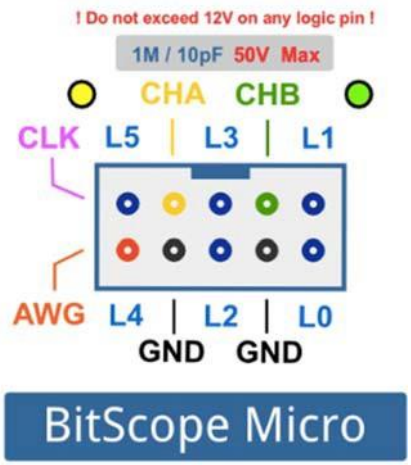
6. BitScope Micro

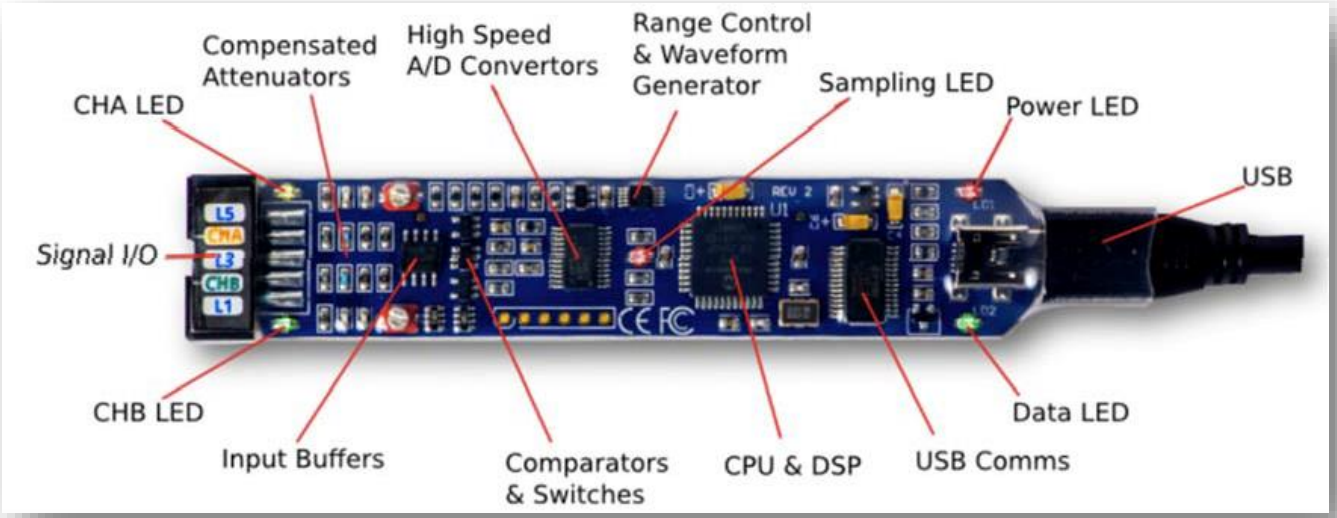
- Using DMM alone is often inadequate for complex circuit analyses – visualization of waveform shape, transients behaviors, unwanted pulses, timing problems, etc.
- BitScope Micro is a full-feature **mixed signal oscilloscope** (i.e. capable of capturing both digital and analog signals) that functions as both an oscilloscope and logic analyzer simultaneously.
- It also works as an **arbitrary waveform generator** (AWG), providing the users with a sine wave (Tone), square wave (Step) or triangular wave (Ramp).
- All these functionalities (and more) are available on the user's computer upon successful installation of its accompanying software, **BitScope DSO**, which is downloadable from BitScope website.

6. BitScope Micro – Contents

- Every enrolled student will be loaned a set of BitScope Micro (*a.k.a. BS05*).
- The following items are found in the BitScope Micro Box (clockwise from top left):
  - ✓Quick Start Guide
  - ✓BitScope Micro BS05
  - ✓10 mini-grabber test probes
  - ✓USB connection cable
  - ✓Pin connection card

6. BitScope Micro – I/Os





- **Inputs/Output pins**: the following pins will be used more extensively in CG1111. The other "L" pins are part of the 8-channel logic analyzer.

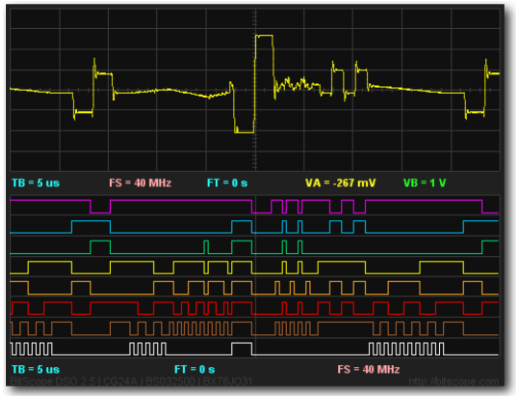
Common I/O	Function
CHA	Channel A of Oscilloscope
CHB	Channel B of Oscilloscope
AWG	Arbitrary Waveform Generator
GND	Ground

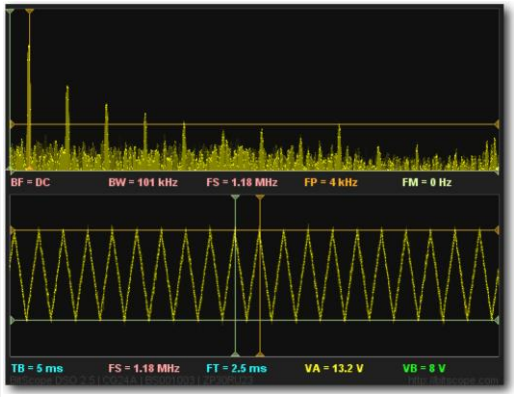
- **Status LEDs**: 5 bright LEDs (CHA, CHB, Power, Data, Sampling) turn on/off/blink to indicate their status and progress.

6. BitScope Micro – DSO

- **BitScope DSO** is a suite of high performance mixed signal virtual instruments in a single software application for use with all BitScopes (there are other models besides BS05)

- With a BitScope it provides the following virtual instruments:
  * Digital Storage Oscilloscope
  * Digital Sampling Oscilloscope
  * Mixed Signal Oscilloscope
  * Logic State Analyzer
  * Waveform Generator
  * Spectrum Analyzer
  * Data Recorder

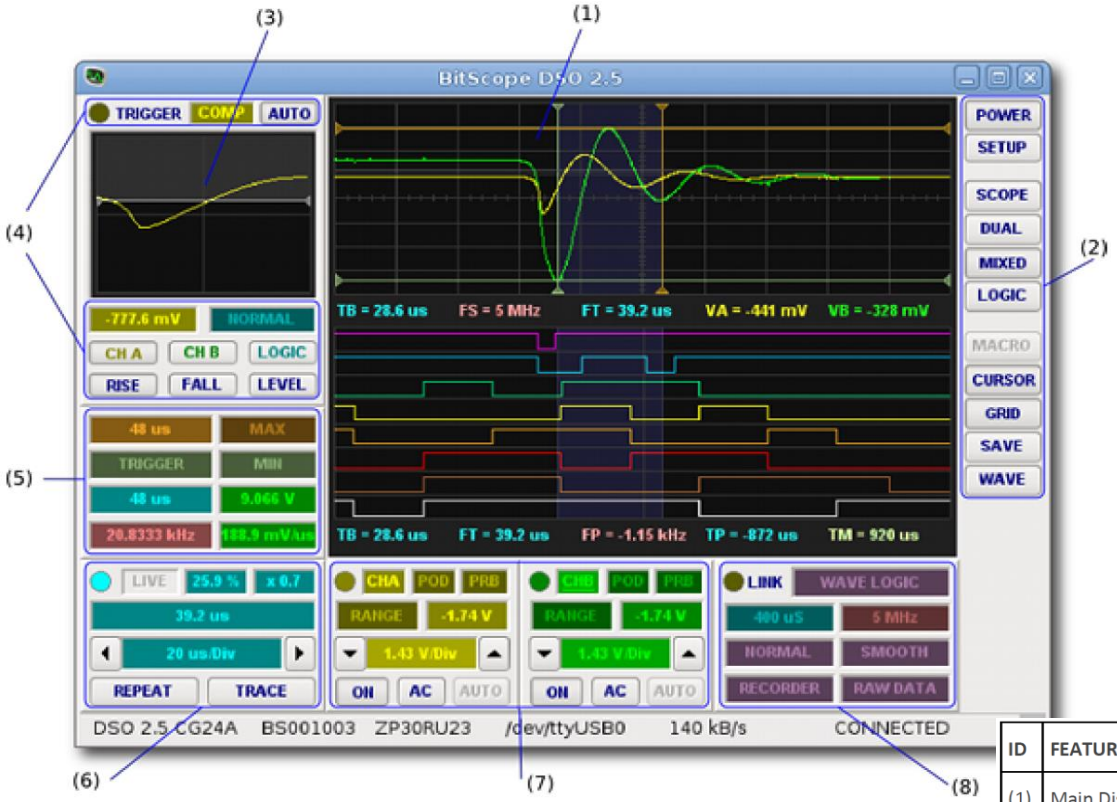




- The DSO may also be used by itself (i.e. not connected to a BitScope) to replay and analyze in detail previously captured (or synthesized) waveforms and logic data.

6. BitScope Micro – DSO

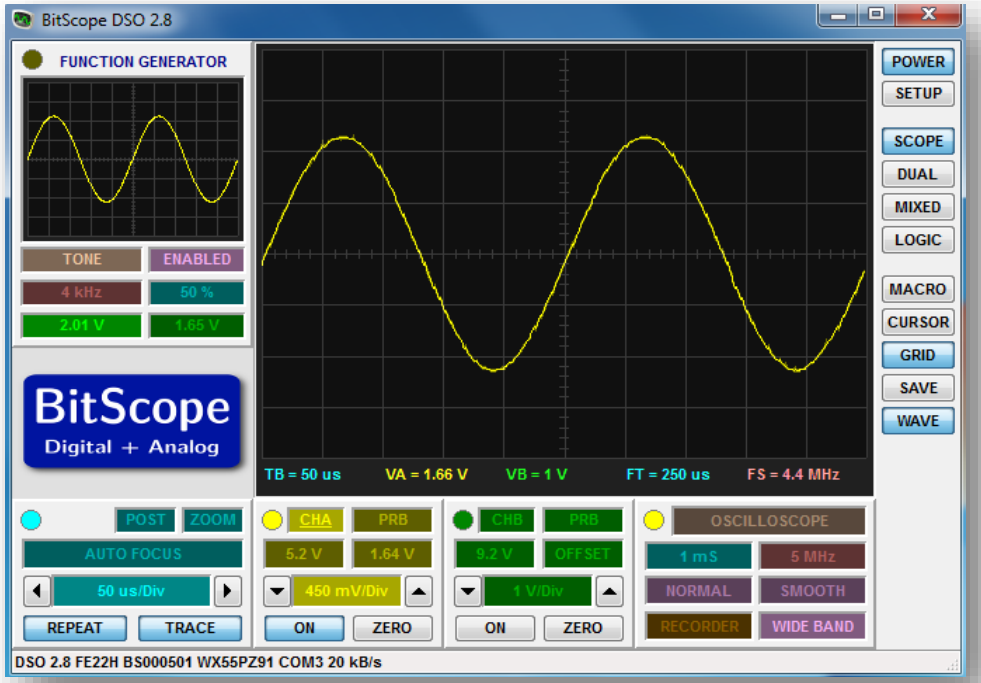
- DSO **features**:



ID	FEATURE	DESCRIPTION
(1)	Main Display	Waveform, logic and spectrum displays, measurements and cursors.
(2)	Scope Selectors	Virtual instruments, scope tools, presets, cursors, graticule etc.
(3)	Trigger Windows	Shows trigger levels, analog and logic waveforms at the trigger.
(4)	Trigger Controls	Controls trigger setup and displays trigger waveform and data.
(5)	Cursor Measurements	X and Y cursor values, voltage, time and rate measurements.
(6)	Timebase Control	Timebase, Zoom and Time Focus control parameters.
(7)	Channel Controls	Controls input source, range, vertical position and scaling.
(8)	Capture Control	Capture sample rate, duration, frame rate and display modes.

6. BitScope Micro – DSO

The DSO panel has two **displays**:



- The **top left smaller display** shows the waveform generated by BitScope's arbitrary waveform generator (AWG). A sine wave (Tone) can be easily generated by clicking the WAVE button (last button on the right hand side panel). The parameters shown below the display characterize the waveform, including type of waveform, frequency, peak-to-peak voltage, duty cycle, and DC offset.

- The **main bigger display** shows the signal measured by the oscilloscope at channel A – CHA (yellow) and/or channel B – CHB (green) and reports relevant parameters and capture statistics such as sample rate, frequency, period, voltage etc. It also provides time, voltage, frequency and level cursors for precise measurements of signal features in both time and frequency domains.

6. BitScope Micro – DSO

To **adjust the parameters**, such as increasing/decreasing the frequency and amplitude, or setting the time scale for the time-domain analyzer, there are two options:

- For **coarse** adjustment, hover the mouse over the chosen parameter, right-click (or control-click on Macs) and select from a menu of options for the parameter. Alternatively, left-click on the left or right edge (arrows, if they are available) of the parameter to select the next (higher or lower) value in the menu.

- For **fine** adjustment, BitScope uses a gesture-based user interface called Act on Touch, which allows clicking and dragging the mouse/track-pad (or a finger/stylus if you have touchscreen device) up and down or left and right on a parameter to adjust its value.

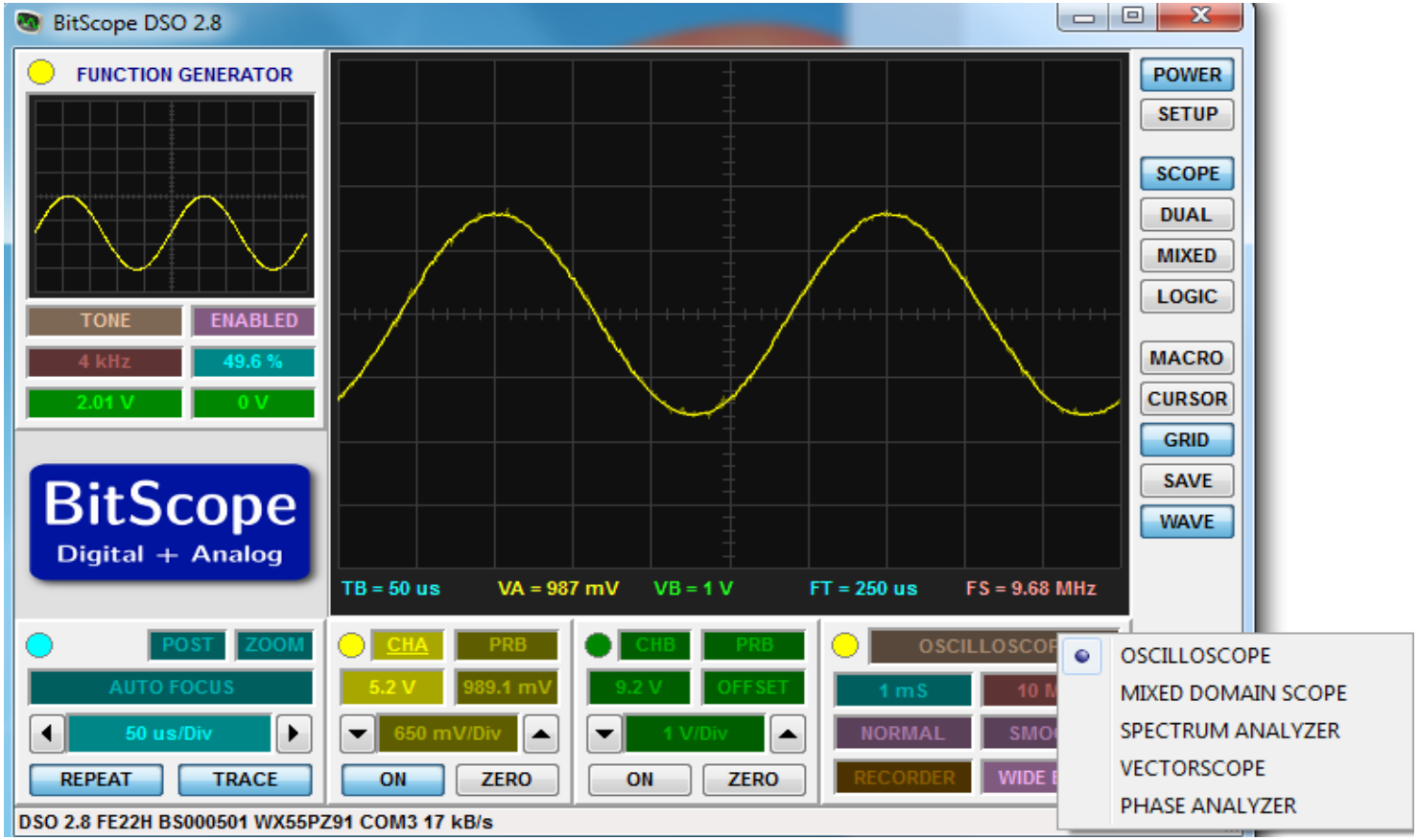
6. BitScope Micro – DSO

Time-Domain and **Frequency-Domain/Spectrum** Analyses:

- To fully analyze a signal, time-domain and frequency-domain/spectrum analyses should be carried out together.
- While time-domain signal (i.e. voltage versus time relation) is able to give you the general shape of the waveform, it is not possible to see the compositions of the signal, i.e. what the harmonics (components at different frequencies) and their corresponding amplitudes are.
- Many circuits, such as amplifier and filter, are designed based on the information on the harmonics for optimal performance.
- BitScope DSO provides option to view signal in time-domain and/or frequency- domain. To toggle between the various viewing options, right-click on the viewing panel located on the bottom right corner of the panel, as shown in the next slide.

6. BitScope Micro – DSO

- The 3 viewing options most commonly used in CG1111 are:
  - ✓ Oscilloscope – for time domain analysis
  - ✓ Spectrum Analyzer – for frequency domain analysis
  - ✓ Mixed Domain Scope – combination of time-domain and frequency-domain analyses



6. BitScope Micro – Extra Info

Useful links to learn more about BitScope:

- BitScope Micro official website, http://www.bitscope.com/product/BS05/
- BitScope Quick Start Guide, http://www.bitscope.com/support/?p=quick
- BitScope Micro tutorial, http://www.bitscope.com/blog/EJ/?p=EK07B

ACTIVITY 3

BitScope DSO setup.

End of Week 2 Studio 1

QUESTIONS?