EXPERIMENT X3: BASIC OPERATION OF OSCILLOSCOPE & FUNCTION GENERATOR

Related course: Circuit-related courses

OBJECTIVES:
To learn basic operation of digital storage oscilloscope (DSO) and function generator (FG)

EQUIPMENT:
Digital storage oscilloscope, function generator, breadboard, 2.2kΩ resistor (2 units), multimeter

INSTRUCTIONS:
1. Record all your results and observations in a log book or on a piece of paper
2. Follow the demonstrator's instructions throughout the experiment
3. Before starting this experiment, you are encouraged to read the "CFG253 Function Generator Guide" and "DSO-X 2002A and TDS 2014B Oscilloscope Guide," which can be downloaded from the Teaching Lab website.

REFERENCES:
Refer to the equipment manual

TESTS:
TEST 1: Connecting function generator (FG) and digital storage oscilloscope (DSO)
TEST 2: Generating a signal from FG and displaying the signal on DSO
TEST 3: Changing frequency and voltage amplitude of FG
TEST 4: Advanced functions of FG
TEST 5: Example of measurement using DSO and multimeter

INTRODUCTION:

Digital storage oscilloscope (DSO) is an oscilloscope used to store and analyse the signal digitally rather than using analogue techniques. It is now the most common type of oscilloscope in use because of the advanced trigger, storage, display and measurement features which it typically provides. The input analogue signal is sampled and then converted into a digital record of the amplitude of the signal at each sample time. These digital values are then turned back into an analogue signal for display.

Function generator (FG) is a piece of electronic test equipment used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the sine, square, triangular and sawtooth shapes. These waveforms can be either repetitive or single-shot. Although function generators cover both audio and RF frequencies, they are usually not suitable for applications that need low distortion or stable frequency signals. Function generators are used in the development, test and repair of electronic equipment. For example, they may be used as a signal source to test amplifiers or to introduce an error signal into a control loop.

Multimeter is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current, and resistance. Analog multimeters use a microammeter with a moving pointer to display readings. Digital multimeters have a numeric display and may also show a graphical bar representing the measured value. Digital multimeters are now far more common due to their cost and precision, but analog multimeters are still preferable in some cases, for example when monitoring a rapidly varying value.

TEST 1: Connecting function generator (FG) and digital storage oscilloscope (DSO)

1. On the DSO, disconnect all probes from the "Probe Comp" (Fig. 1) by pulling the probe cover first (Fig. 2) until the hook clip can be seen. Also, disconnect the black crocodile clip from the "Probe Comp."
2. Referring to Fig. 3, connect the 'MAIN' output from the FG to the Channel 1 (CH1) of the DSO. [Note: The red croc clip of the FG is where the AC voltage comes from while its black croc clip is the ground or 0V].
   IMPORTANT: Do not short circuit the red and black croc clips of FG!

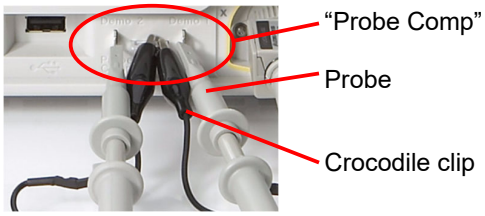

Fig. 1

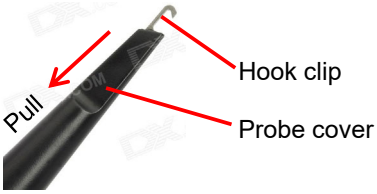

Fig. 2

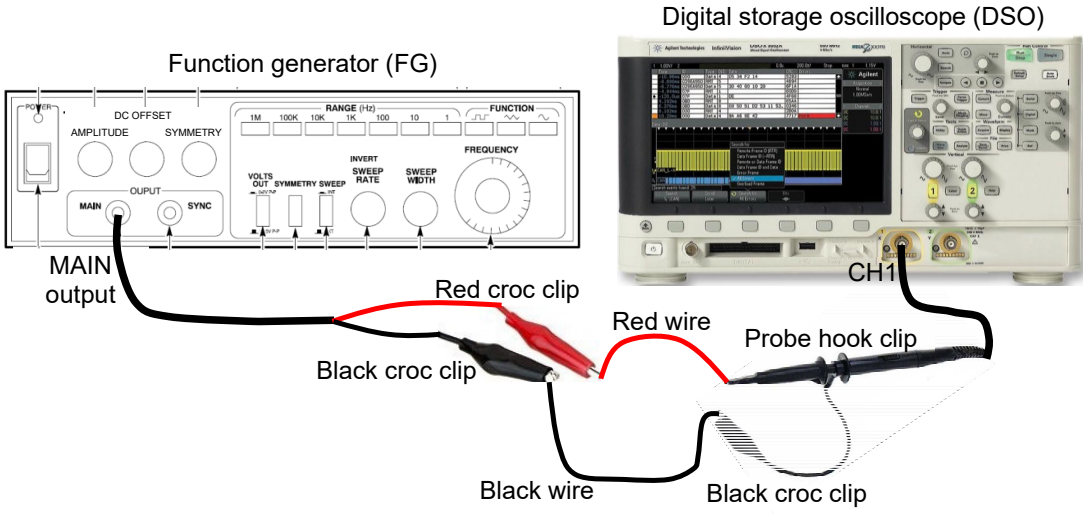

Fig. 3

TEST 2: Generating a signal from FG and displaying the signal on DSO

1. Switch ON both FG and DSO by pressing their main switch button. On DSO screen, after loading, you will see two lines; one is for CH1 and the other for CH2. Press CH2 button on the DSO (marked with **2** -refer to Fig. 4) until the CH2 line disappears.
2. On FG, ensure the 'DC OFFSET' knob is pushed in and 'SYMMETRY' button, 'VOLTS OUT' button and 'SWEEP' button are pushed out (▁▁).
3. On the FG, press '100' button on the 'RANGE (Hz)' window and press sinusoidal button (marked with ~) on the 'FUNCTION' window. Using the 'FREQUENCY' knob, turn it to '0.5.' This is the way to set frequency to 50 Hz because 0.5 x 100 = 50 Hz.
4. On the DSO, turn the 'Sec/Div' knob (the larger knob) on the 'HORIZONTAL' panel so that the 'Sec/Div' setting is 5ms/Div (this is the x-axis setting). The 'Sec/Div' can be seen on top right on the DSO screen (for DSO-X 2002A) or at the bottom on the DSO screen (for TDS 2014B). Turn the 'V/Div' knob of CH1 (the larger knob) on the 'VERTICAL' panel so that the 'V/Div' setting is 2V/Div (this is the y-axis setting). The 'V/Div' can be seen on the DSO screen.

5. Adjust the position of the signal up or down using the smaller knob of 'VERTICAL' adjustment of CH1 so that the y-axis offset is 0.00V.
6. Adjust the position of the signal left or right using the smaller knob of 'HORIZONTAL' adjustment so that the x-axis offset is 0.0s.
7. To display the frequency and peak-to-peak (pk-pk) voltage of CH1 and CH2 on DSO screen, press [MEASURE] button (for TDS 2014B) or [Meas] button at 'MEASURE' panel (for DSO-X 2002A).
8. On the FG, turn the 'AMPLITUDE' control knob until the pk-pk voltage shown on the DSO screen is 10V pk-pk (under 'Measurement' window – refer to Fig. 4).
9. On the DSO screen, if the signal is moving or not stable, adjust the trigger level by turning the 'TRIGGER' knob on the DSO. The trigger level is marked by 'T▶' (for DSO-X 2002A) or ◀ (for TDS 2014B) on the DSO screen.
10. Next, look at the value of the frequency displayed on the DSO screen (under 'Measurement' window). Is it 50 Hz? If it is not exactly 50 Hz, adjust the 'FREQUENCY' knob of the FG until the frequency is 50 Hz.
11. To save the oscilloscope waveform, first insert a pendrive in one of the USB ports on the oscilloscope. Then, press [SAVE/RECALL] button. For DSO-X 2002A, this button can be found on 'FILE' panel on the 'DSO control panel.' Press 'Save' or 'Save Image' button. Set a desired 'Format' (usually PNG) and then press 'Press to Save' or 'Save' button. If you do not have a pendrive at the moment, use any camera to capture the screen.

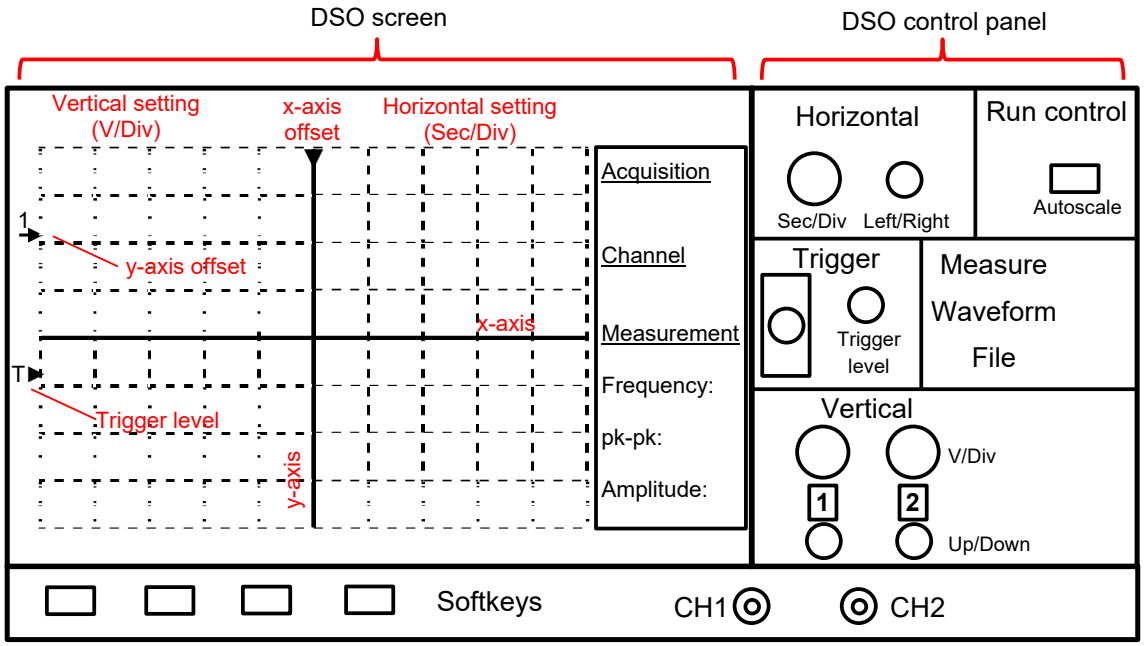

Fig. 4: DSO screen and control panel for DSO-X 2002A. For TDS 2014B, refer to the actual unit

TEST 3: Changing frequency and voltage amplitude of FG

At this stage, you should already know how to display a signal on the DSO screen properly and set the desired frequency and pk-pk voltage amplitude (Vpp) of the FG. Repeat TEST 2 (steps 3 to 11), but this time set the frequency and voltage amplitude as shown in Table 1. Set the V/Div and Sec/Div of the DSO on your own so that around 2 cycles of the signal are displayed on the DSO screen. For each case, save the waveform in a pendrive or in any camera.

Table 1

Frequency from FG	500 Hz	3 kHz	85 kHz	200 kHz	100 Hz
Voltage amplitude from FG	6 Vpp	12 Vpp	10 Vpp	16 Vpp	4 Vpp
Sec/Div from DSO					
V/Div from DSO					

Notes:

1. To set different frequency range, you can press any button on 'RANGE (Hz)' window.
2. Up to this point, you have familiarised yourself with 'Horizontal' and 'Vertical' setting of the DSO, how to output a voltage of certain frequency and amplitude from the FG and read the frequency and pk-pk voltage from the DSO screen.
3. To set the Horizontal (Sec/Div) and Vertical (V/Div) settings automatically, you can simply press "Auto Scale" or "AUTOSET" button on the DSO.

TEST 4: Advanced functions of FG

1. On the FG, set the frequency as 50 Hz and pk-pk amplitude as 10 Vpp. Press 'Square' wave button (⎍) on the 'FUNCTION' window and observe the signal on the DSO screen. Press "Auto Scale" or "AUTOSET" button on the DSO. Save the oscilloscope screen in your pendrive or capture the screen using any camera.
2. Then, press the 'Sawtooth' button (⩘) on the 'FUNCTION' window and observe the signal on the DSO screen. Save the oscilloscope screen in a pendrive or capture the screen using any camera.
3. On the DSO screen, if the signal is moving or not stable, adjust the trigger level by turning the 'Trigger level' knob on the DSO so that the signal stops moving.

Notes:

1. Most of the application in the world use 50 Hz sinusoidal voltage, especially for power system transmission and home electrical appliances. However, some devices require frequency other than 50 Hz to operate, for example LC circuits, transistors, etc. Certain devices also require voltage shape other than sinusoidal to operate.
2. You will see various applications using different level of frequency and voltage shapes while progressing through your Degree study.

TEST 5: Example of measurement using DSO and multimeter

1. Switch OFF the function generator (FG) and digital storage oscilloscope (DSO).
2. Place two 2.2 kΩ resistors and wires/jumpers on a breadboard as shown in Fig. 5. (Refer to Fig. B in the Appendix about the breadboard available in the lab)
3. Connect the red croc clip of FG to the red breadboard binding post and its black croc clip to the green breadboard binding post.
4. Connect DSO probe hook clip of CH1 to point 'a' and its black croc clip to the green breadboard binding post.
5. Connect DSO probe hook clip of CH2 to point 'b' and its black croc clip to the green breadboard binding post.
6. Switch ON the function generator and oscilloscope. Set the frequency to 50 Hz and amplitude to 10 Vpp (peak to peak) sinusoidal. If the signal is moving or not stable, adjust the 'Trigger level' on the DSO until the signal is stable.

7. Press “Auto Scale” or “AUTOSET” button on the DSO or adjust the ‘Sec/Div’ and ‘V/Div’ of CH1 and CH2 appropriately so that both signals are clearly displayed.
8. Press [MEASURE] button (for TDS 2014B) or [Meas] button (for DSO-X 2002A).
9. Adjust the position of CH1 and CH2 signals up or down using the smaller knob of ‘Vertical’ adjustment so that the y-axis offset of both CH1 and CH2 is 0.00V.
10. Write down the pk-pk voltage amplitude from CH1 and CH2 as shown on the DSO screen. The pk-pk amplitude should be around 10Vpp for CH1 and 5Vpp for CH2 according to the calculation of voltage divider as follows:

    Voltage from CH1 = 10 Vpp (because it is connected across FG output)
    Voltage from CH2 = 2.2kΩ / (2.2kΩ+2.2kΩ) x 10 Vpp = 5 Vpp
11. Disconnect the oscilloscope from your circuit.
12. Connect the red probe of multimeter to point ‘b’ and its black probe to the green breadboard binding post. Turn the multimeter knob to AC voltage setting (V~) and observe the value shown by the multimeter. The value shown on the multimeter is always rms (root mean square) value. Compare this rms value with the value that you have obtained using oscilloscope CH2 based on:

$$V_{rms} = \frac{V_{pp}}{2\sqrt{2}}$$

13. Once you have done all measurements, switch OFF the FG and DSO. Then, switch OFF the power plug outlet. Remove the resistors and wires/jumpers from the breadboard and arrange them neatly on the table.
14. Place the DSO probe hook clips and black croc clips as shown in Fig. 6 before leaving the lab.

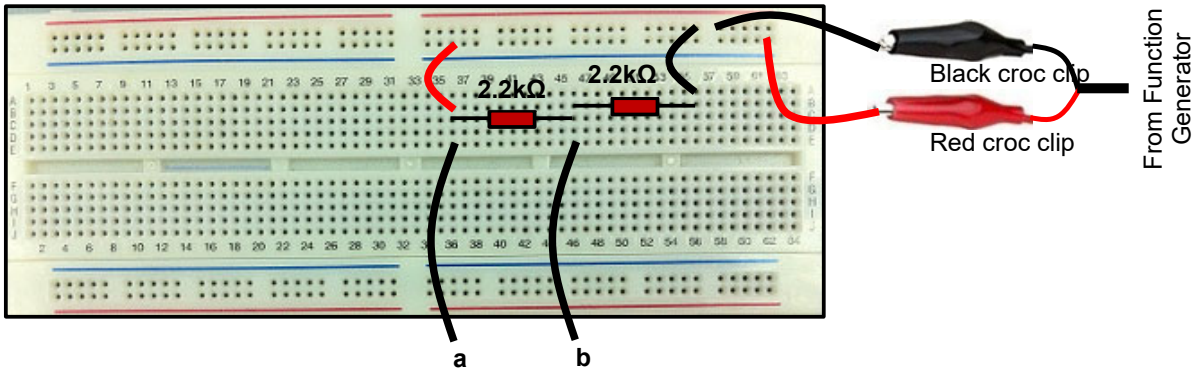

Fig. 5: Circuit connection on a breadboard

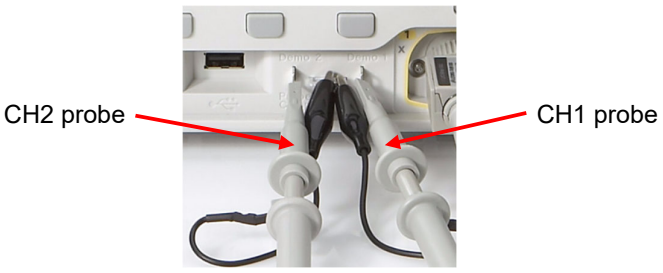

Fig. 6: Connection of DSO probe hooks and croc clips after experiment is done

END OF EXPERIMENT

APPENDIX:

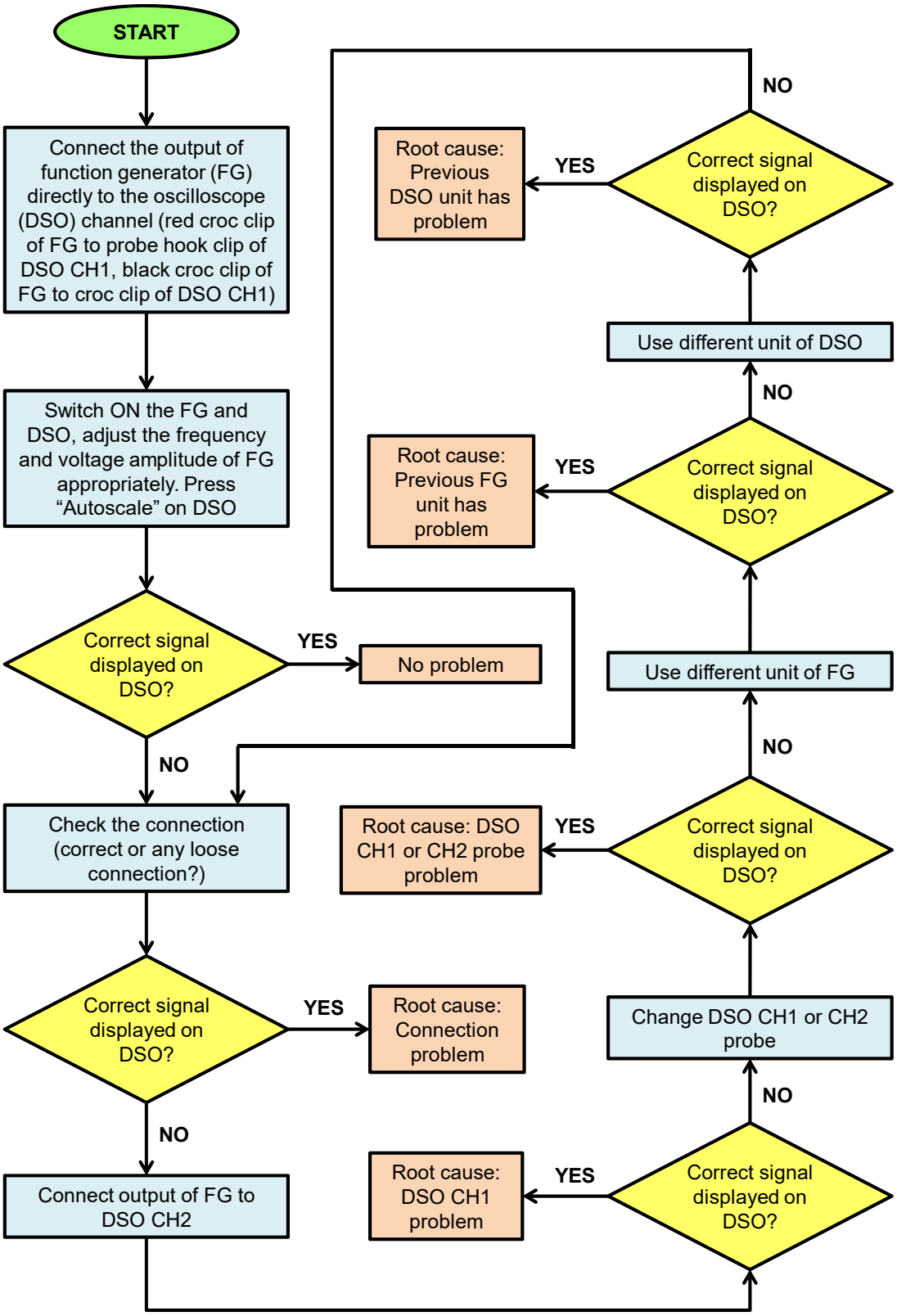

Fig. A: Flowchart of how to troubleshoot DSO and FG

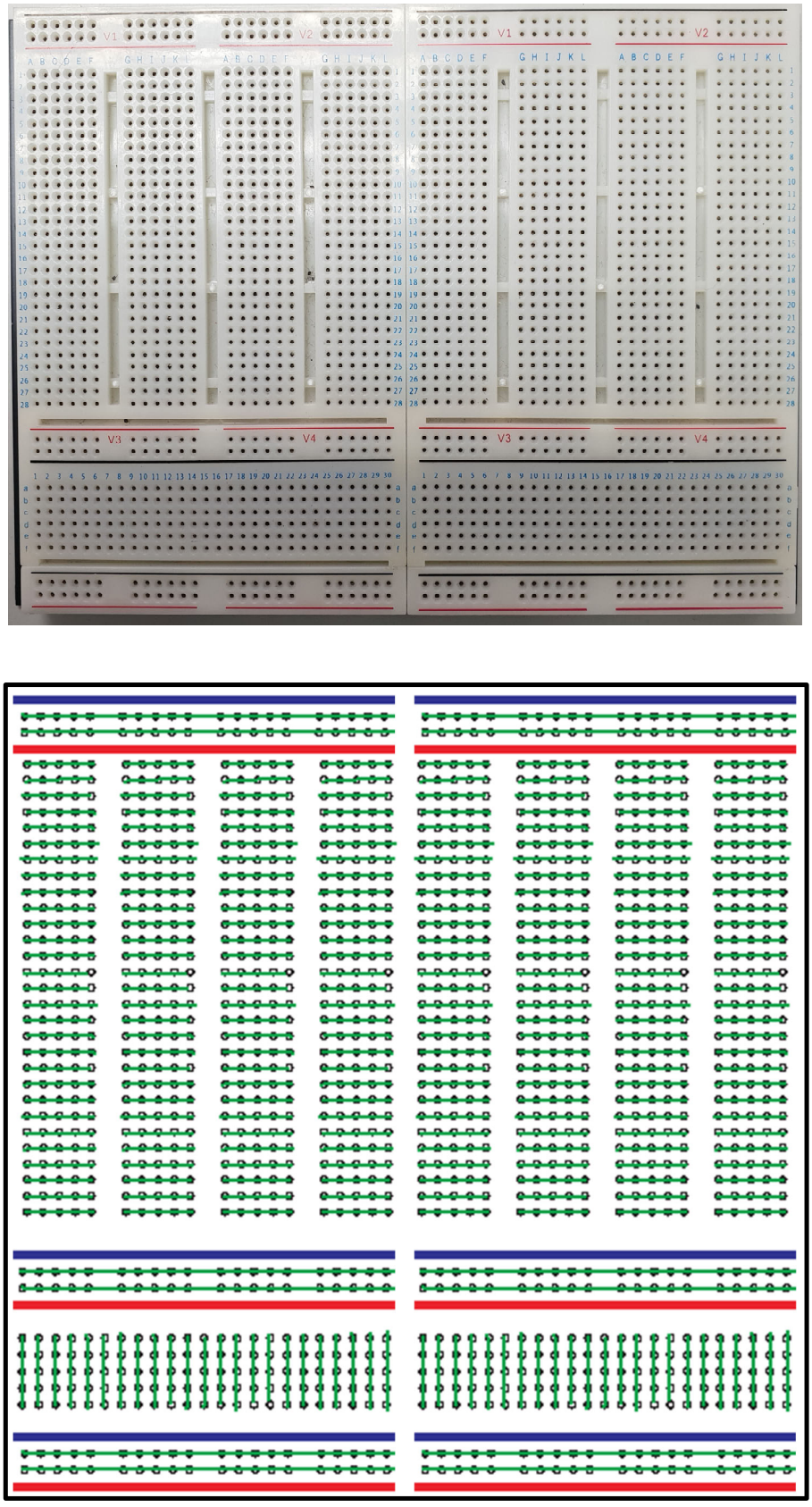

Fig. B: Breadboard picture and its internal connection