Name: .... Student ID: ....
Name: .... Student ID: ....

Laboratory 01

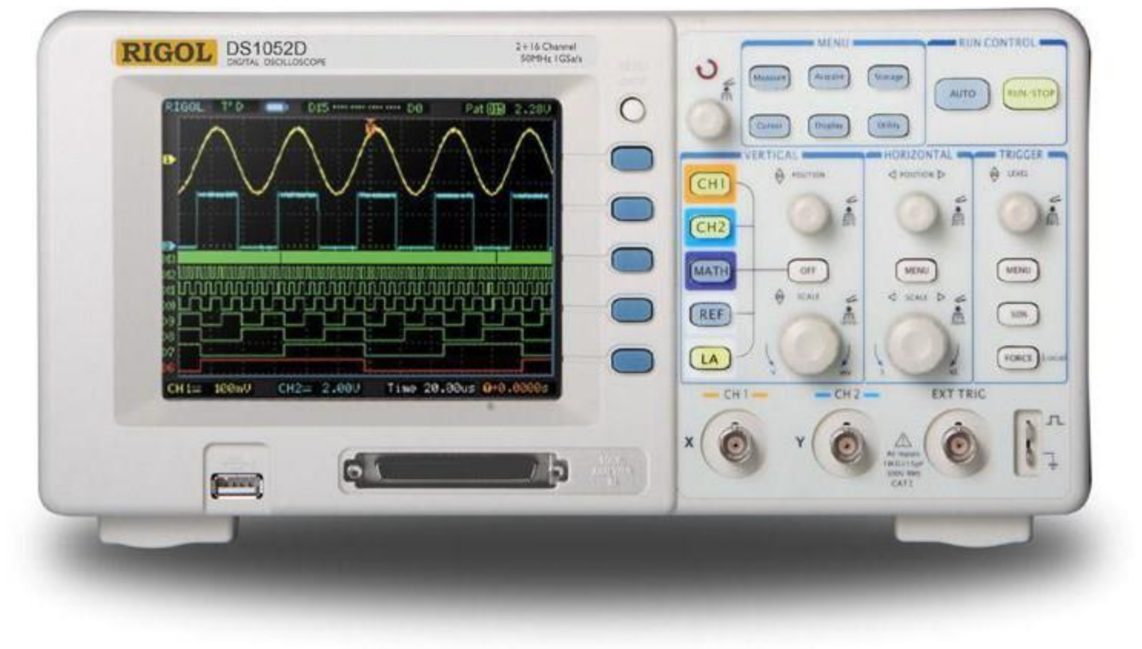
Introduction to Lab Equipments

1.1 Introduction

There are several equipments which are necessary for hardware design, test, and measurement such as oscilloscope, logic analyzer, and function generator. In this lab student will learn how to operate them and do some experiments that allow student to be more familiar with the equipments.

1.2 Oscilloscope

Oscilloscope is an instrument used to measure and display signal waveform in time domain. It shows amplitude of the signal on vertical axis versus time on horizontal axis. The first thing to do with an oscilloscope is to know its front panel. This document helps to be familiar with the layout of the knobs and keys and how to use them. Read the document carefully before further operations.



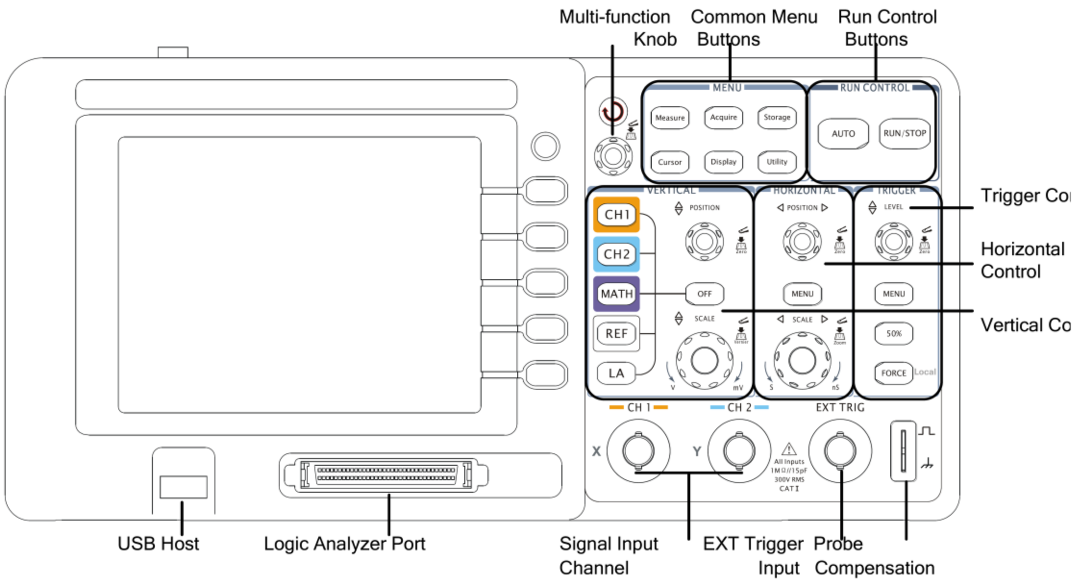


Fig1. Front Panel and its control

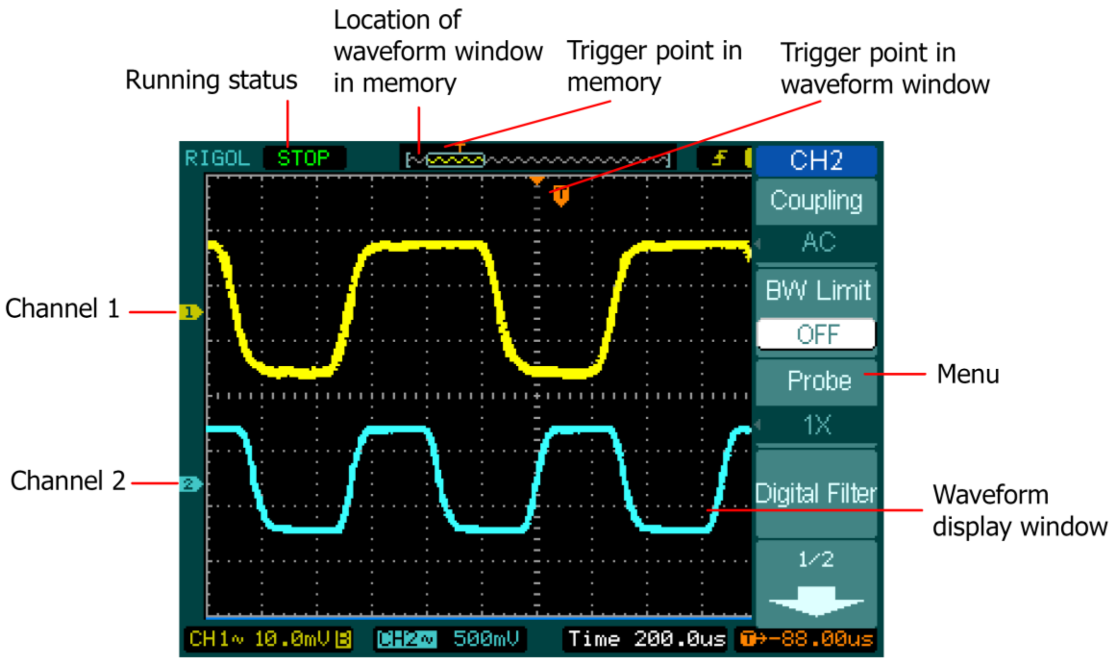


Fig. 2 Display screen shows analog waveforms

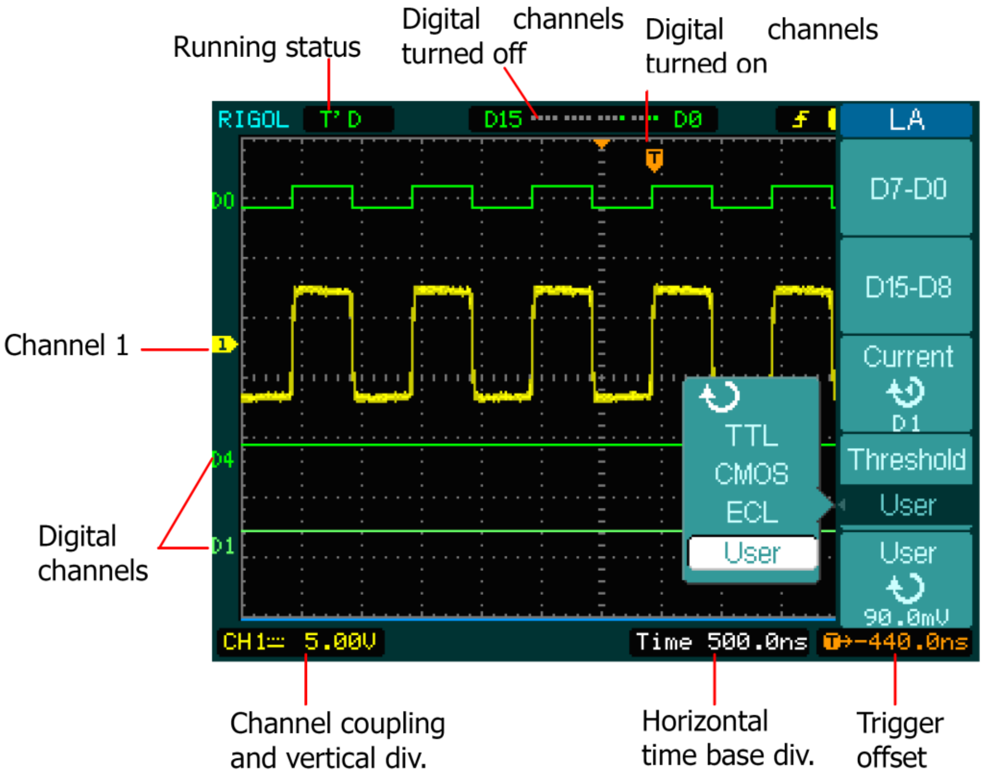


Fig.3 Display screen shows both analog and digital waveforms

The first step before using oscilloscope is to perform probe compensation. This will not only adjust the probe characteristic to match with the channel input but also to ensure the proper connection from probe tip up to input channel of the scope.

1.2.1 Probe compensation

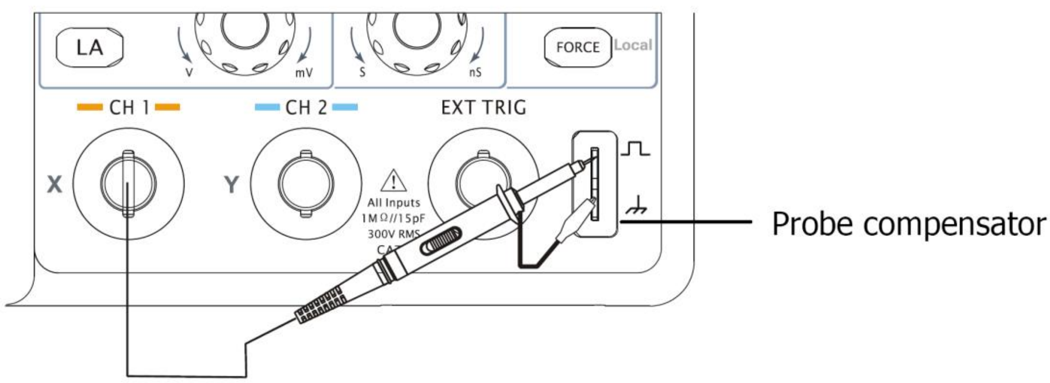
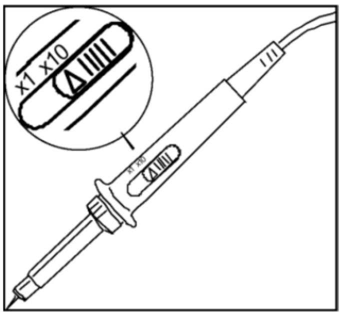


Fig.4 Probe compensator



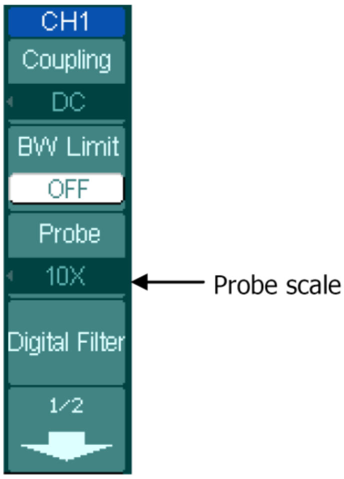


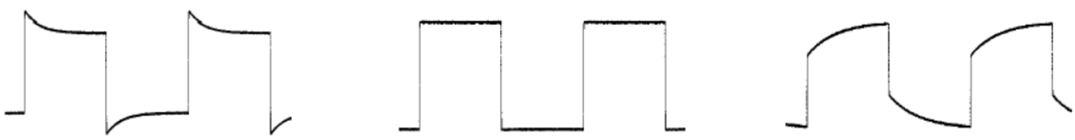
Fig.5. Probe attenuation

Perform this adjustment to match the characteristics of the probe and the channel input. This should be performed whenever attaching a probe to any input channel for the first time.

1. From CH1 menu, set the Probe attenuation to 10X (press CH1⟶Probe⟶10X). Set the switch to 10X on the probe and connect it to CH1 of the oscilloscope. When using the probe hook-tip, inserting the tip onto the probe firmly to ensure a proper connection.

   Attach the probe tip to the **Probe compensator connector** and the reference lead to the ground pin, Select CH1, and then press AUTO.

2. Check the shape of the displayed waveform.



Over compensated Correctly Compensated Under Compensated

Fig.6 Shape of the waveform

3. If necessary, use a non-metallic tool to adjust the trimmer capacitor on the probe for the flattest square wave possible as displayed on the oscilloscope.

4. Repeat as necessary.

1.2.2 Vertical system

It is the control panel to adjust how oscilloscope acquires and amplify the amplitude of the input signal and displays its waveform.

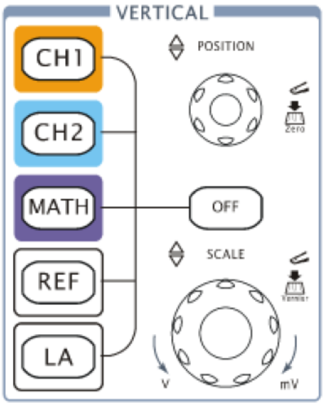


Fig.7 Vertical system panel

1. Center the signal on the display with the **POSITION** knob

2. Change the vertical setup and notice that each change affects the status bar differently.

- View the status bar which is on the bottom of the screen to understand the vertical scale.
- Change the vertical scale by turning the **SCALE** knob and notice the change in the status bar.
- Press **OFF** button to turn off the channel.

1.2.3 Horizontal System

It is the control panel to adjust how oscilloscope acquires (sampling) the input signal and displays its waveform.

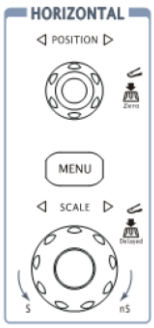


Fig.8 Horizontal system panel

1. Turn the **SCALE** knob and notice the change in the status bar. The time base ranges of the oscilloscope is from 2ns/div to 50s/div.

2. The horizontal **POSITION** knob moves displayed signal horizontally on waveform window

3. Press the **MENU** key to display the TIME menu.

1.2.4 Trigger System

To display non-moving waveform on the screen, the scope needs a trigger signal as a reference to synchronize between input waveform and its display system. The trigger system operates based on either it own internal trigger signal or external trigger signal. In this lab, only internal trigger signal will be used. The internal trigger signal can be set to synchronize with the input signal using combination of following conditions of the input signal: Mode, Source, and Slope.

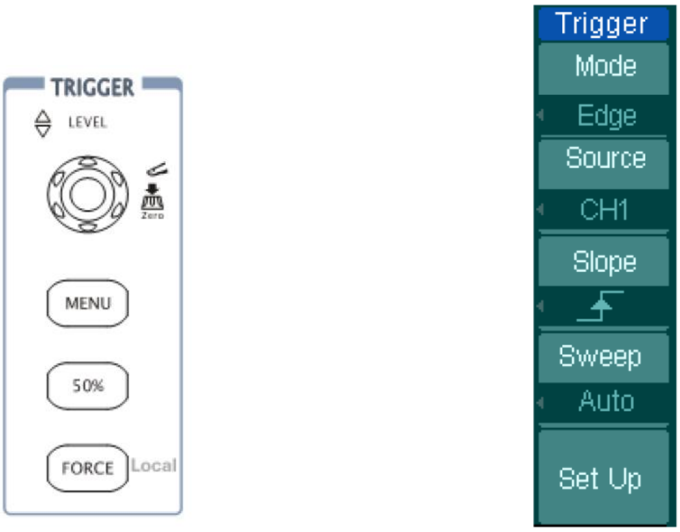


Fig. 9 Trigger system panel

1. Turn the trigger **Level** knob and notice the changes on the display.

2. Change the trigger setup and notice these changes in the status bar.

Press MENU button in the Trigger control. A soft button menu appears on the display showing the trigger setting choices as shown in Fig. 10

1.2.5 Settings of the Channels

Menu	Settings	Comments
Coupling	AC	Blocks the DC component of the input Signal
	DC	Passes both AC and DC components of the input signal
	GND	Disconnects the input signal

Fig.10 Coupling mode for the channel

Each channel has an operation menu and it will pop up after pressing <u>CH1</u> or <u>CH2</u> button. The settings of all items in the menu are shown in the table below.

1. AC coupling

To use Channel 1 as an example, input a sine wave signal with DC shift.

Press CH1⟶Coupling⟶AC to set “AC” coupling. It will pass AC component blocks the DC component of the input signal. The waveform is displayed as Figure:

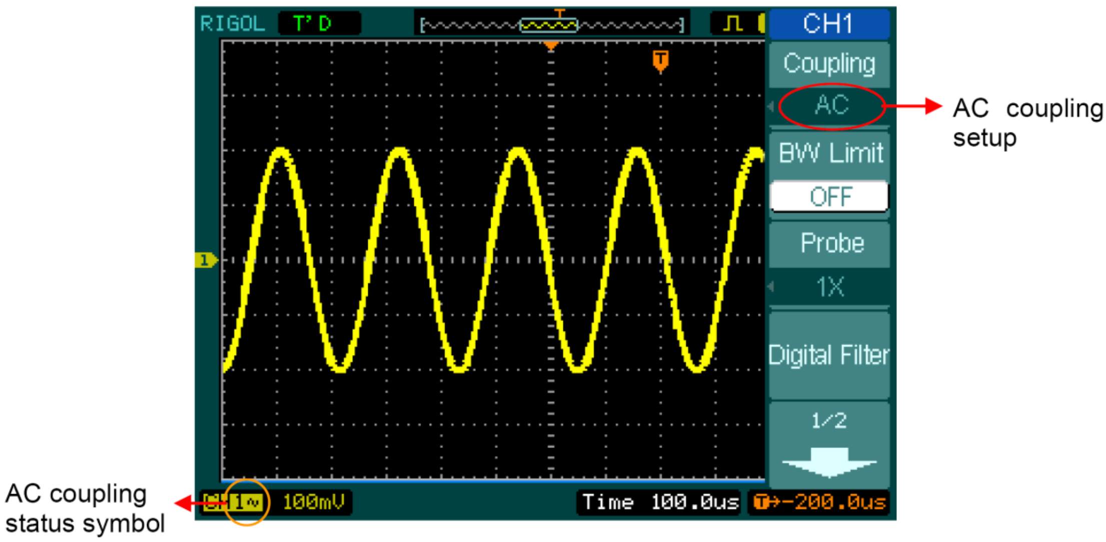


Fig.11. AC Coupling

2. DC coupling

Press CH1⟶Coupling⟶DC, to set “DC” coupling. It will pass both AC and DC components of the input signal.

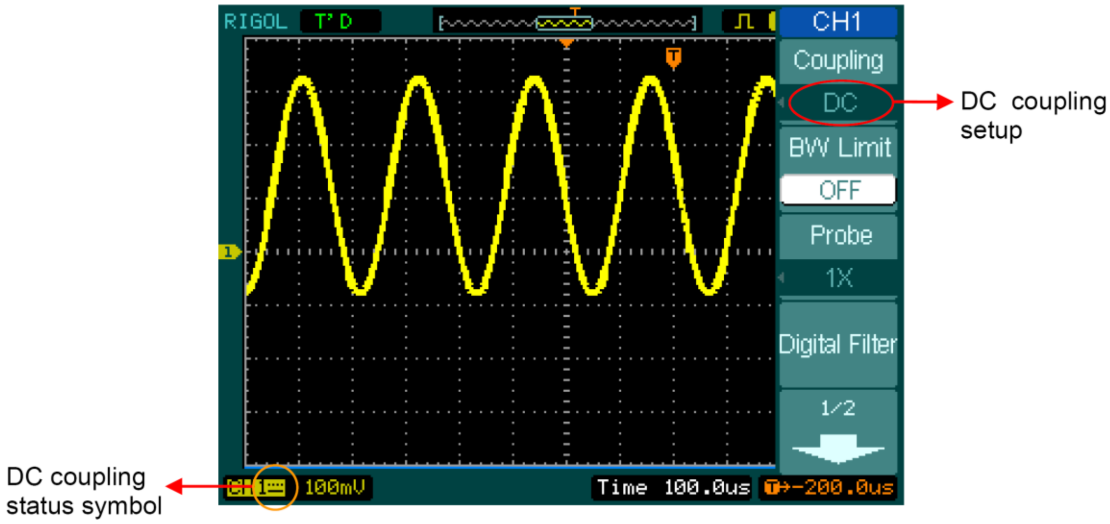


Fig.12 DC Coupling

3. GND coupling

Press CH1⟶Coupling⟶GND, to set “GND” coupling, it disconnects the input signal.

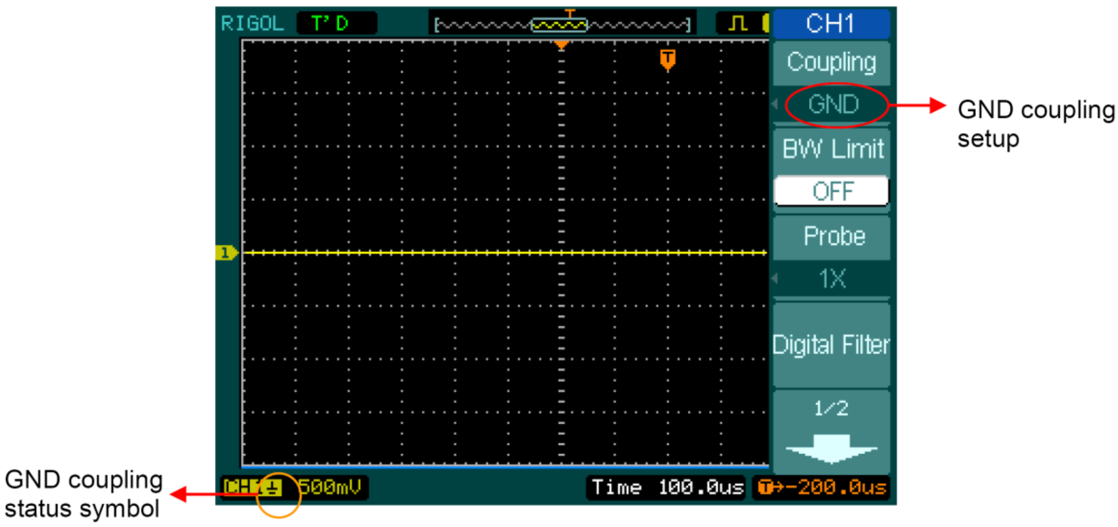
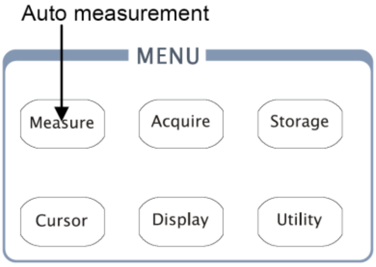


Fig.13 GND Coupling

There are more channel setting options, however it will not be covered in this lab document. For further detail please refer to the User Guide.

1.2.6 Measurement

The Measure button in the menu area activates the automatic measurement function.



Menu	Settings	Comments
Source	CH1 CH2	Select CH1 or CH2 as source channel for measurement
Voltage		Select to measure voltage parameter
Time		Select to measure time parameter
Clear		Clear measurement result on screen
Display All	OFF ON	Turn off all measurement result Turn on al measurement result

Fig. 14 Measurement menu

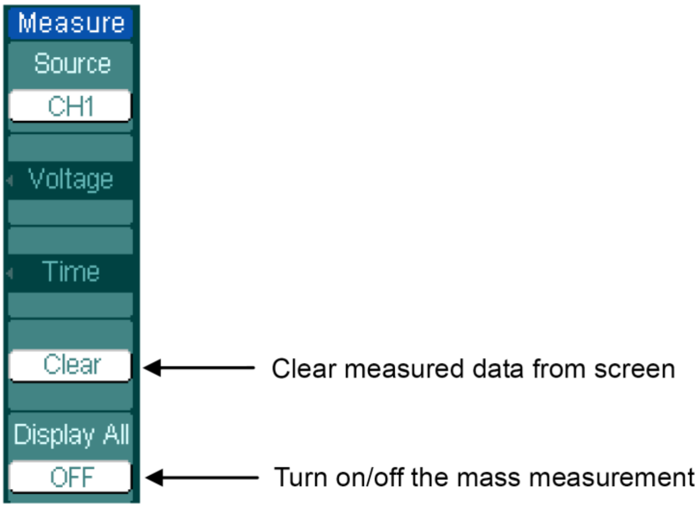
1. Voltage Measurements

Menu	Settings	Comments
Vmax		Measure maximum voltage of a waveform
Vmin		Measure minimum voltage of a waveform
Vpp		Measure Peak-to-Peak Voltage
Vtop		Measure a flat top voltage of a square waveform

2. Time Measurements

Menu	Settings	Comments
Period		Measure Period of a waveform
Freq		Measure Frequency of a waveform
Rise time		Measure Rise Time of a rising edge
Fall time		Measure Fall Time of a falling edge

3. Using Automatic Measurement



1. Select the signal channel for measuring. CH1 or CH2 according to the signal of interest.

Press soft buttons as follows: Measure⟶Source⟶CH1 or CH2.

2. To see all measurement values, set the Display All to ON. 18 measurement parameters will be displayed on the screen.

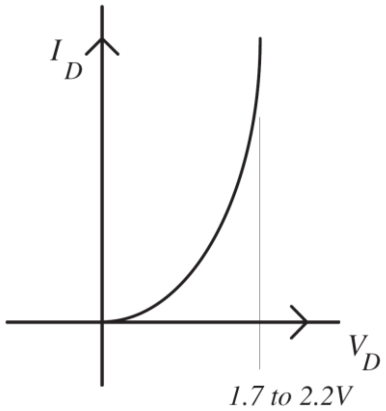
3. Select parameters page for measuring; select voltage or time parameters pages by pressing soft button as follows: Measure⟶Voltage or time

4. To get the measured value on the screen; select the parameters of interest by pressing the soft button on the right of the menu, and read the data on the bottom of the screen. If the data is displayed as "*****", it means the parameter cannot be measured in current condition.

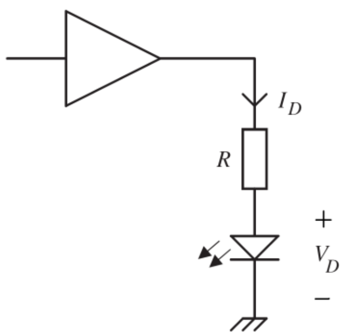
5. Clear the measure values: press **Clear** and all of the auto measure values would disappear from the screen.

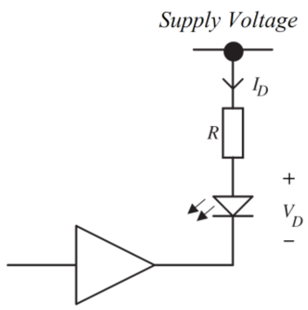
2. Driving LED from logic gate

LED is often used as a status of the I/O port. This experiment shows how to make direct connection of LEDs to the output of the logic. The LED is a semiconductor diode, and behaves electrically as one. It will conduct current in one direction, called the ***forward*** direction, but not the other. What makes it so useful is that when it is connected so that it conducts; it emits photons from its semiconductor junction. The LED has the voltage/current characteristic shown in Fig. 15a. A small forward voltage will cause very little current to flow. As the voltage increases there comes a point where the current suddenly starts flowing rather rapidly. For most LEDs this voltage is in the range shown, typically around 1.8 V.



(a) LED V-I characteristic





(b) Gate output sourcing current (c) Gate output sinking current

Fig. 15 LED and its connections to the logic gate output

Fig. 15 (b) and (c) show circuits used to make direct connections of LEDs to the output of logic gates. There are three important points to be observed

1) The connection of Fig. 15 (b) makes the LED lights when the gate is at logic high.

2) The connection of Fig. 15(c) makes the LED lights when the logic gate is at logic low

3) A current-limiting resistor needs to be connected in series with the LED, to control how much current flows.

3. Experiment

3.1 Measure signal from function generator and display on oscilloscope

3.1.1 Set up function generator to produce Sinusoidal frequency **100kHz**, amplitude **3 Vpp**, offset = **0** V

3.1.2 Use oscilloscope **CH1** measures the signal. Using front panel to adjust both vertical and horizontal until its display contains the waveform with the number of cycle as close to 5 cycles as possible and using vertical scale of 1 V/DIV

3.1.3 Change the offset to 5 V. Adjust vertical, horizontal, (and trigger if necessary) until it contains 5 cycles. Use measurement to read the peak values (maximum and minimum), the frequency and the period of the signal.

Maximum = ...V Minimum = ...V

Frequency= ....Hz Period = ...second

3.1.4 Change the input signal from function generator to be a square wave 50% duty cycle frequency 1 MHz, amplitude 3 Vpp, offset = 3 V. Repeat procedure as in 3.1.3.

Maximum = ...V Minimum = ...V

Frequency= ....Hz Period = ...second

Rise time = ...second Fall times= ....second

3.2 Measure waveform outputs from logic gates using oscilloscope

3.2.1 Connect a D-Flipflop (IC 74xxx74) to form a ***toggle register*** and connect its output to a ***buffer*** to drive LED as shown in Fig. 16

3.2.2 Apply a clock signal 50% duty cycle, frequently 1 kHz, Logic H=5 V, Logic L=0 V.

3.2.3 Measure signal waveform of the circuit simultaneously using oscilloscope as follows:

Set up trigger source as CH1

CH 1: Clock input

CH 2: Output Q

Observe both waveforms. Write down the relationship between both waveforms and your explanation below:

....

....

....

....

....

....

....

3.2.4 Make the LED flash. Which circuit parameters do you adjust?

....

....

4. Design Problem

Design (or modify) a circuit based on 3.2 to give the following results

Produce an output clock signal at 50 kHz from the input clock 200 kHz (from function generator)

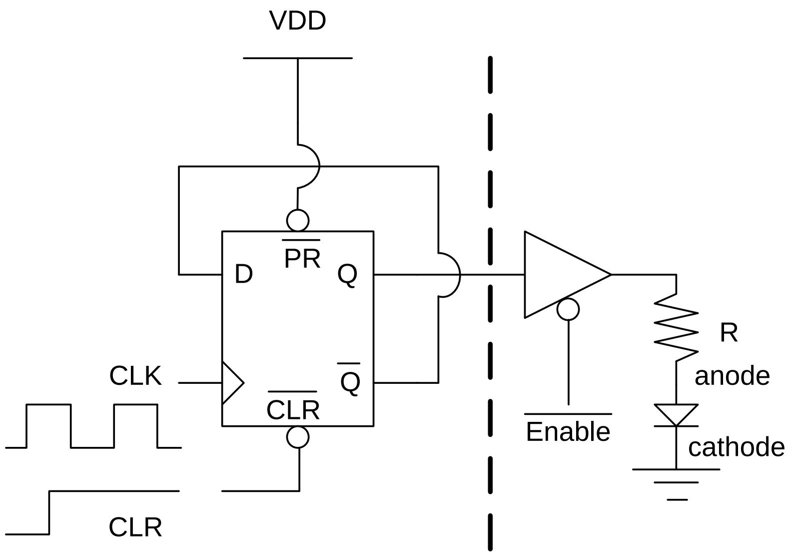
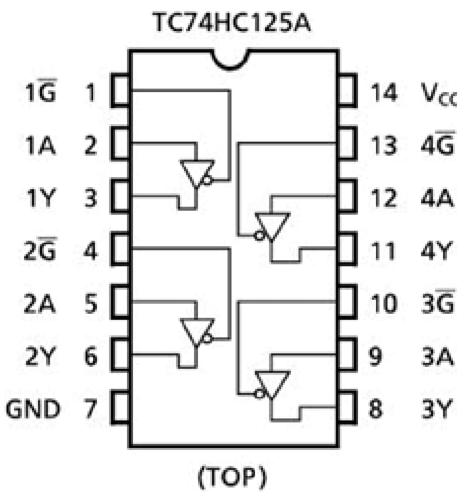
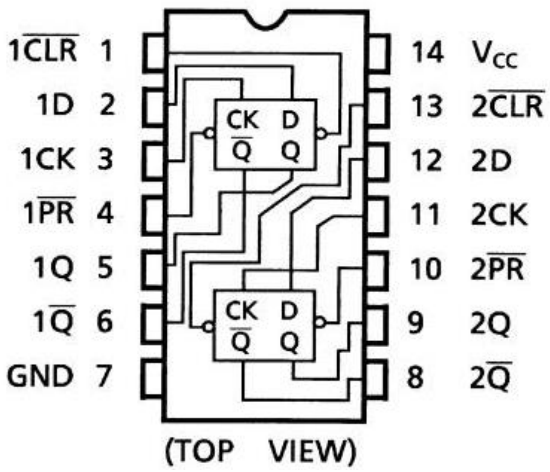


Fig. 16 Circuit for the experiment



74xxx125 Buffer



74xxx74 D-Flipflop

Fig.19 Pin assignment

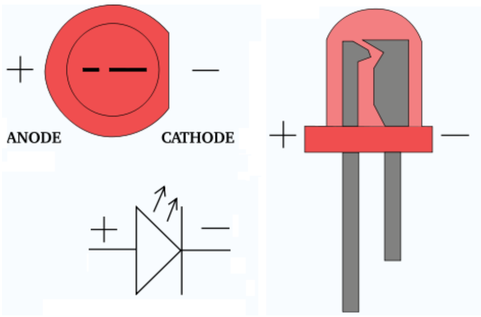


Fig. 18 LED

5. References

1. RIGOL Technology, **User's Guide RIGOL Oscilloscope**, 2008

2. Rob Toulson and Tim Wilmshurst, **Fast and Effective Embedded Systems Design**, Elsevier, 2012

3. Wikipedia