ENG 1450 Introduction to Electrical and Computer Engineering
Pre-Lab 4 - RC Circuit

1 Introduction to the instruments used in this lab

1.1 Oscilloscope

The oscilloscope is an electronic instrument that is capable of displaying an input signal versus another input. Oscilloscopes are divided into two groups: analogue and digital oscilloscopes.
An analog oscilloscope consists of a cathode ray tube (CRT), power supply, time-base generator, two sets of deflection plates to deflect the electron beam and a phosphorescent screen. The main part of the analogue oscilloscope is the CRT that consists of an electron gun. The electron gun is a heated metal filament (thin wire) that is negatively charged relative to the deflection plates. The electron gun emits a beam of high speed electrons whose kinetic energy converts to visible light when they strike the phosphorescent screen. The electron beam passes through a set of parallel plates oriented horizontally (**vertical deflection plates**). The voltage to be displayed is amplified and supplied to these plates which deflect the electron beam vertically. The polarity of the signal moves the electron beam upward or downward. Then, the electron beam passes through another set of parallel plates oriented vertically (**horizontal deflection plates**). A potential difference applied to these plates deflects the electron beam horizontally from left to right. These plates can be supplied by either another input signal (such as XY mode) or a saw-tooth signal which changes with time. In the latter case the plates sweep the electron beam from left to right of the screen and then return it quickly to the left of the screen to start another sweep of time. As the phosphorescent material has the ability to emit light for a few milliseconds after the electrons hit the screen, a visible trail of the time-varying signal is produced where the electron beam has struck the screen.
In a digital oscilloscope the vertical input is digitized by an analogue to digital converter and the sampled data is stored in an internal memory. Then, the sampled data is mixed with the time data and displayed on a LCD screen.
In this lab you will use Tektronix digital real time oscilloscopes (TDS 210-Series). This model has 60MHz bandwidth with 1GS/s sample rate. Here a brief discussion of the functionality of this oscilloscope is described.

- **Acquiring data**
  TDS210 has the ability to acquire and display two input signals simultaneously. The input signals can be connected to CH1 or CH2 BNC inputs. When you acquire analog data, the oscilloscope samples the signal and converts it to a digital signal. The SEC/DIV knob can be used to adjust the time base of the oscilloscope and control how often the digitization takes place. TDS210 has three acquisition modes:
  Sample: In this mode the scope samples the signal in equally spaced intervals.
  Peak detect: In this mode the oscilloscope finds the lowest and highest values of the signal in an interval and uses these values to display the signal.
  Average: In this mode the oscilloscope acquires several waveforms and displays their average.

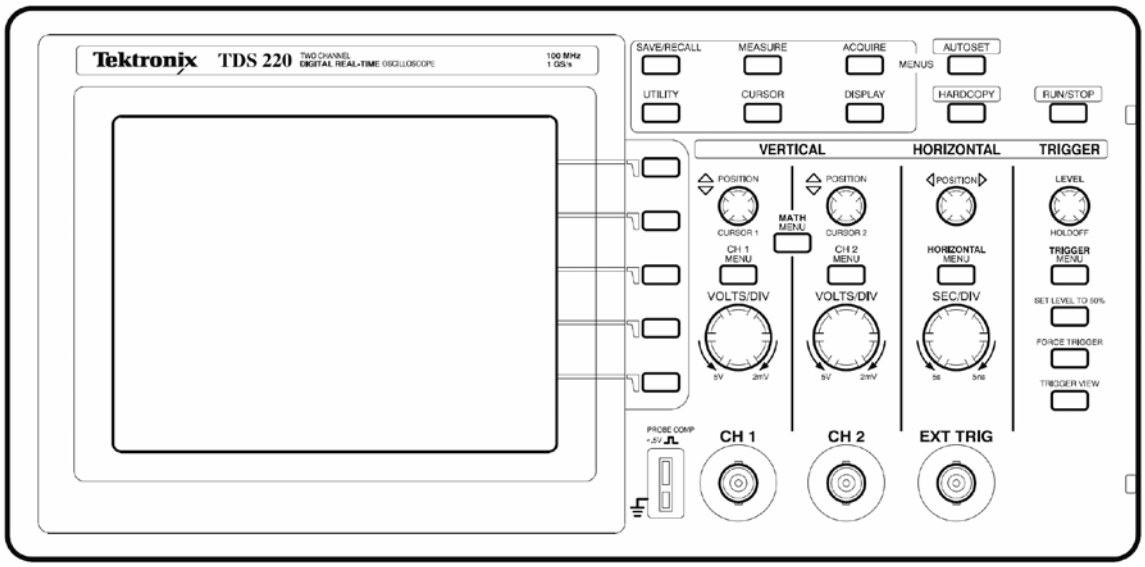

Figure 1. Front panel of TDS 210/220 oscilloscope

- **Scaling and positioning the waveform**
  The display of the waveform can be changed by adjusting the scale and position controls. The channel reference indicator (located on the left of the screen) points to the ground of each waveform.
  Vertical Scale and Position: The waveform moves up or down as the (vertical) position knob is changed. Also, the VOLT/DIV knob adjusts the vertical scaling factor to display the signal properly.
  Horizontal Scale and Position: The waveform can be moved to the left or right by changing the (horizontal) position knob. Also, the SEC/DIV knob adjusts the time per division of the display, changing the number of signal cycles displayed on the screen.

- **Triggering**
  The trigger determines when the oscilloscope starts to acquire and display data. If the trigger set up improperly you will have an unstable (moving) waveform. You can choose different sources to derive the trigger:
  Input: The most commonly used source of trigger is one of the input channels.
  AC line: This source is useful when you want to display signals related to power line frequency.
  External: You can use external trigger source when you want to get data on two input channels and trigger them with a third signal such as an external clock.

- **Taking measurements**
  The oscilloscope displays the signal in term of voltage versus time. There are several ways to take measurements from the displayed signals:
  Graticule: This method is helpful to make a quick and visual estimation of the waveform. You can use the graticule divisions and vertical/horizontal scaling information to determine signal's amplitude and duration.
  Cursors: In this mode you can move the cursors (always appear in pairs) to make measurements and read their numeric values from the display readout.
  Automated: In this mode, which is more accurate than the other modes, the oscilloscope does all the measurements and displays the results.

1.2 Function generator

Function generator is used to generate different waveforms to test and drive circuits. The Tektronix CFG253 Function Generator produces sine, square, and saw-tooth waveforms as well as TTL signals in a frequency range of 0.03 Hz to 3 MHz. Further, it has the ability to directly control amplitude and DC offset of the output signal. Figure 2 shows the front panel of Tektronix CFG253 Function Generator.

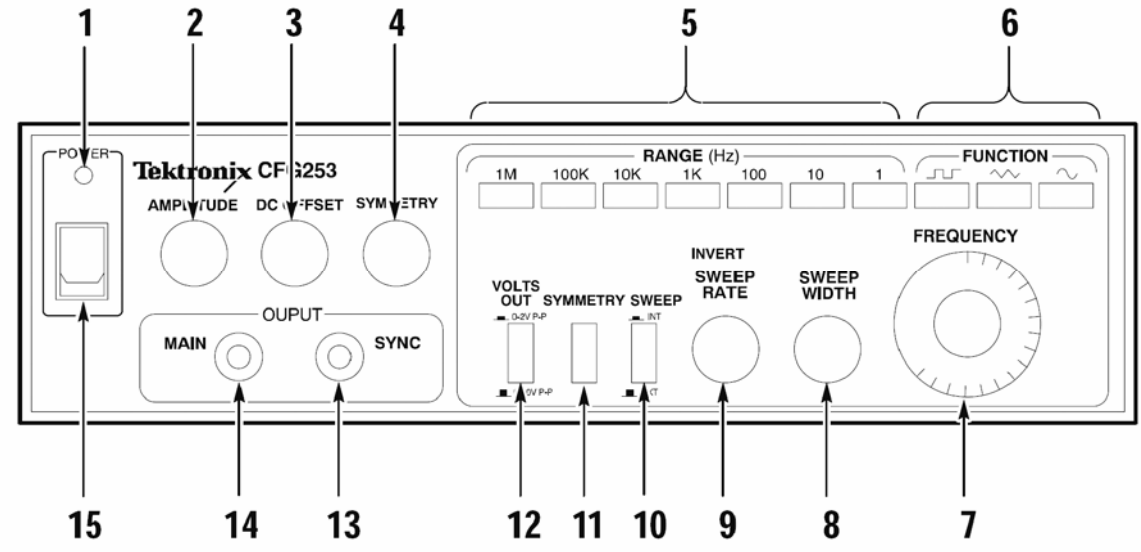

Figure 2. The front panel of Tektronix CFG253 Function Generator.

A brief description of the controls, connectors and indicators:

1. Power On Light: When lighted indicates power is on.
2. Amplitude: Determines the level of the signal.
3. DC Offset: Pull out this control to activate and set the DC level of the signal. When it is pressed in, the signal will have zero DC voltage.
4. Symmetry: This knob changes the duty cycle of a square wave or the rise and fall times of a sawtooth or sine waves. Note that this knob is activated only when the Symmetry button (**11**) is pushed in.
5. Range (Hz): This control determines the frequency range of the signal.
6. Function: These buttons, sine, square or sawtooth, select the type of signal.
7. Frequency: This control determines the exact frequency of the signal.
8. Sweep Width: This control adjusts the sweep amplitude.
9. Sweep Rate: This control adjusts the rate of the internal sweep generator.
10. Sweep: This button activates internal or external source for sweep signal.
11. Symmetry: Pushing this button activates Symmetry knob (**4**) to change the symmetry characteristic of the signal.
12. Volts Out: Controls the amplitude range of the signal.
13. Sync (TTL) Output: BNC output connector for TTL signals.
14. Main Output: BNC output connector for sine, square or sawtooth wave signals.
15. Power: Push it to turn the function generator on.