5.0 HP54645D Mixed Signal Oscilloscope (Logic Analyzer)

Shown in Figure 6 above, is the HP54645D Mixed Signal Oscilloscope, which we will generally refer to as simply “the oscilloscope” or “the logic analyzer.” It is in fact a combination of these instruments, both of which are design to graph waveforms (analog and digital respectively) over time. In this class we will almost exclusively use the logic analyzer portion of these devices, since this is a digital systems class.

Using the logic analyzer is significantly less complicated than it appears and it is an invaluable debugging tool. The logic analyzer allows us to examine signals over time at various scales, you can zoom in to see events on different clock cycles, or zoom out to see how a signal behaves over the course of seconds.

5.1 Front Panel Controls

This section will explain at least a little bit about all of the buttons and controls on the front panel of the logic analyzer.
5.1.1 Display & Brightness Control

Of course this is the screen, where you will see your waveforms and other such information. At the bottom left of the screen is a brightness control. If your screen appears blank, try the brightness.

Notice the row of softkeys across the bottom of the screen.

5.1.2 Softkeys

In order to provide more advanced controls without cluttering the front panel, there are six softkeys, whose meaning changes as you navigate the controls menus or change operating modes. If we mention a button that does not appear on the front panel, check the softkeys.

5.1.3 Calibration Output

This is used to calibrate the analog oscilloscope probes. If you are in doubt as to whether the probe is behaving correctly, hook it to the calibration output and hit Autoscale. You should see a nice clean 0-5V square wave at ~1.2kHz.

5.1.4 Autoscale

Located in the Measurement Keys section of the front panel, this is one of the most used buttons. It will cause the oscilloscope/logic analyzer to automatically search for signals on its inputs. When it finds signals it will attempt to place them in the middle of the screen and set the triggering to that they are stable and ready for use.

If you lose the signal, Autoscale may help.
5.1.5 Measurement Controls

Consists of three buttons; Voltage, Time, and Cursors. Voltage and Time will display options for types of measurements (V_{avg}, V_{p-p}, Freq, etc.) on the softkeys. When selected, the measurements will be displayed at bottom of screen. The Source softkey can be used to select the correct analog source channel.

The Cursors button is used to display or clear time and voltage measurement cursors which are selected with softkeys and moved with the Entry knob. Note that you can have the time cursors print out the value (in Hex, Binary or Decimal) of the 16 digital channels.

5.1.6 Analog Controls

The Volts/Div knob can be used to change the vertical (voltage) scaling of the two analog channels. Notice that there are two knobs: the scaling for each of the two channels are separate (1 division may be 1V on A1 and 2V on A2).

The A1 and A2 keys will turn the respective analog channel on or off while bringing up a softkey menu allowing you to select AC or DC coupling and Noise Filtering. The ± button will allow you to see sum and difference waveforms.

5.1.7 Horizontal

The Delay knob will allow you to scroll the screen left or right.

Main Delayed: Horizontal mode should be set as normal with softkeys, the Time Ref softkey controls what reference to use when zooming in with Time/Div knob. Vernier is used to minimize time steps in Time/Div knob.

Time/Div changes the time per grid block. The time/div scaling is displayed at the top of the screen.

5.1.8 Digital

The Label/Threshold button allows you to label any of the 16 probe leads of the logic analyzer. The threshold menu and softkeys let you choose what type of logic you are using, MOS or TTL should work fine.

The D0-D15 button allows you to select which logic analyzer probes will be displayed. Individual signals can be selected with Select knob and turned on or off with the softkeys.

The Position knob will let you reorder the signal on the display. Notice that this will affect the value readout produced by the time cursors (see 5.1.5 Measurement Controls).

5.1.9 Trigger

The Edge button will select edge triggering mode, where the scope will wait for a rising or falling edge (selectable with softkeys) on the channel you select using the softkeys.

The Pattern button will let you modify the pattern triggering mode pattern, where the scope will trigger on a pattern of High, Low, Rising, Falling or Don’t Cares on the various inputs. Use the Select knob and softkeys to set the pattern.
The **Analog Level** knob will let you set the analog voltage at which to trigger (applies to the analog signals only). The **Holdoff** knob will allow you to set the amount of time before the screen is redrawn; you will want to set this to the minimum.

The **Mode/Coupling** button will bring up a softkey menu of triggering modes: **Auto Level, Auto and Normal**. While **Auto** may be useful for analog work, you will always want **Normal** for using the logic analyzer.

The **Advanced** button brings up a softkey menu of the various triggering modes.

### 5.1.10 Storage

The **Run/Stop** button starts and stops the refresh on the display. This is useful when you want to freeze the screen to examine it more closely.

The **Single** button can be used to set the scope to single mode, where it will trigger once, remember the data and then freeze the screen. This is perfect for capturing a one time event, like something that happens at reset.

**Erase** will clear the screen; measurement should be restarted with the **Run/Stop** button.

### 5.2 Triggering

Triggering the logic analyzer properly is key to being able to actually see the waveforms you are interested in. We recommend that you become intimately familiar with the various triggering modes, but perhaps the most useful for digital work is pattern mode. This section is a brief tutorial on how to set up and use pattern triggering mode.

1. Make sure the logic analyzer is on
2. Make sure the **channels you are interested in** are showing
   a. The **A1** and **A2** buttons can be used to enable or disable the analog channels.
   b. The **D0-D15** button and **Select** knob will let you select specific digital signals. You can then use the **softkeys** to enable or disable them.
3. Switch the logic analyzer to **Normal triggering mode**.
   a. Press **Mode/Coupling** in the **Trigger Box**
   b. Select **Normal** under **Trigger Mode** on the softkey menu
4. Switch the logic analyzer to **Pattern advanced triggering mode**.
   a. Press **Advanced** in the **Trigger Box**
   b. Select **Pattern** under **Advanced Trigger Mode** on the softkey menu
5. Set up a triggering pattern
   a. Press **Pattern** in the **Trigger Box**
   b. Use the **Select** knob to select a signal
      i. Select the value that signal should have
      ii. Note that each signal is compared against its bit in the pattern, when all 18 (16 digital, 2 analog) channels match, the scope will trigger
      iii. L: Logic Low
      iv. H: Logic High
      v. X: Don’t Care (Ignore this signal for the pattern)
vi. ↑: Rising Edge
vii. ↓: Falling Edge

6. Set the **Time/Div**
   a. Play with the **Time/Div** knob until the time per division is approximately what you need.
   b. Remember a 27MHz clock cycle is 37ns from rising edge to rising edge.

7. Start the logic analyzer running
   a. To trigger once and save the waveforms press **Single**
      i. If you want to trigger again you will need to press **Single** again
   b. To trigger every time the pattern is matched press **Run/Stop**