University of California at Berkeley
College of Engineering
Department of Electrical Engineering and Computer Sciences

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Lab 4
Using Test Equipment

1 Objective

This lab will familiarize you with more hardware debugging instruments. Each station in 204B has a triple-output bench power supply, a digital multimeter, a pulse generator, and a 100 MHz mixed signal oscilloscope. You will use each of these in this lab.

Test equipment can be complex. The oscilloscope has more than forty knobs and switches. Unfortunately, missetting these can make the equipment appear broken.

If you suspect faulty equipment, verify it with your TA!

When you leave the lab, please tidy up around your station.

Always verify that your equipment is working before using it. Some specific items to check:

- Are the power supplies outputing correct voltage? (check using multimeter)
- Are the oscilloscope probles working? (check by connecting to power and ground)
- Is the pulse generator working? (check using oscilloscope)

2 Prelab

As usual, read through this lab. Most of this handout describes things to know, not things to do. And these should be easy if you know how to do them.

3 The HP E3630A Triple-Output Power Supply

Each station has an HP E3630A triple-output power supply, whose three outputs can generate 0-6V, 0-20V, and -20-0V, marked +6, +20 and –20 respectively. There is also a ground connection labeled COM.

The E3630A's outputs are current-limited for safety: they will supply some maximum amount of current, and will drop the output voltage to ensure it. In particular, if you short the outputs, instead of blowing fuses or becoming arc welders, these supplies peacefully supply the maximum current.

The E3630A's three knobs set the voltage on the +6 output, the voltage on the +20 output, and the ratio between the +20 and -20 outputs. Turn the ratio clockwise (to FIXED) until it clicks to set the ratio to 1.

The analog meter on the E3630A can display the voltage of each output, selected by the three buttons labeled +6, +18, and -18. This is useful for setting the voltages approximately, but it is not as accurate as measuring the output voltage with a digital multimeter.

4 The Fluke 8010A Digital Multimeter

Each station also has a Fluke 8010A digital multimeter, which can measure AC or DC voltage, current, resistance, or conductivity.

- Measuring Voltage

  Press button marked V and select range with one of the grey buttons. Connect the COMMON input (a black lead) to the circuit's ground, and connect the V/kΩ/S input (a red lead) to the voltage to measure.

- Measuring Current

  Press button marked mA.

  Select the scale of current to be measured by plugging the red lead into either the "ma" (0-2000 ma) or "10A" (0-10A) input on the meter. Press a grey button corresponding to the range desired.

  To measure current, the meter must be inserted in series. Power down the circuit, break a connection, and connect the red and black leads. With the red lead connected to the "more positive" voltage, the current flow will show on the meter as positive.

- Measuring Resistance or Conductance

  Press button marked kΩ/S. With the circuit power off, connect the COMMON (black) and V/kΩ/S (red) leads across the resistive element. To do this accurately, the element usually has to be removed from the circuit, although simple continuity checking (determining if a wire is connected) can be done in-circuit.

5 The HP 8112A Pulse Generator

The pulse generator can generate single or periodic square waveforms with varying voltages, periods, duty cycles, pulse widths, and slew rates. These can be used, for example, as a digital system's clock.

To produce a square wave,

1. Make sure the DISABLE button (in the lower right corner) is off (unlit).
2. Set MODE to NORM by pressing the button beneath it. (second to left)
3. Set CTRL to disabled (nothing lit). (fourth to left)
4. Press the button underneath PER until the PER lights, and set the period using the vernier buttons.
5. Press the button underneath DTY until the DTY lights, and set the duty cycle using the vernier buttons (the duty cycle is the percentage of the period for which the signal is high).

   Or, set the pulse width (period x duty cycle) by pressing the same button until WID lights. Adjust using the vernier buttons.
6. Press the button under HIL and set the high voltage using the vernier buttons.
7. Press the button under LOL and set the low voltage using the vernier buttons.

6 The HP 54645D 100 MHz Mixed Signal Oscilloscope

6.1 Oscilloscopes

Oscilloscopes can display very high-speed periodic events. Think of the oscilloscope screen as a graph of voltage (x) versus time (y). The HP 54645D combines a digital storage oscilloscope with a logic analyzer in one chassis with extensive "mixed-signal" capabilities.

Conventional analog oscilloscopes do best with periodically repeating waveforms which can trigger the 'scope and generate a stable display. Events that rarely or never repeat can also trigger the 'scope, but the resulting sweep is difficult to see with the naked eye. Digital storage oscilloscopes and logic analyzers, combined in the 54645D, solve this problem.

Starting the sweep at the right time is necessary for a stable image. Figure 2a shows the effect of choosing the wrong times: many segments of the waveform are superimposed, resulting in an unreadable mess. If these times are chosen correctly, i.e., at some exact multiple of the period of the waveform, the traces superimpose to give a single, stable waveform, as shown in Figure 2b.

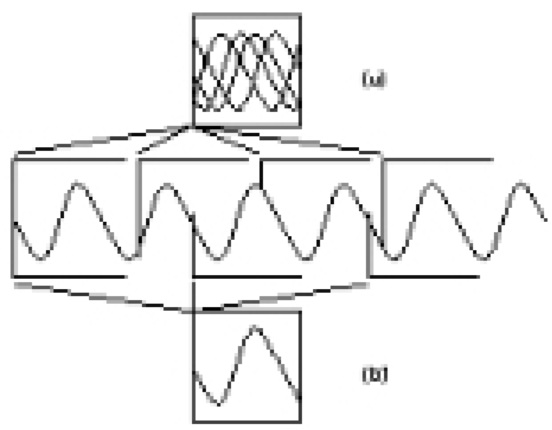

Figure 2: (a) Incorrect triggering. (b) Correct triggering.

Most oscilloscopes allow the user to set a voltage level and a slope ("rising" or "falling") for the trigger. For example, in Figure 2b (middle), the trigger is the voltage halfway between the two extremes, with a falling slope. Thus the waveform is displayed with its left-most point falling through that halfway voltage. For simple waveforms, this approach works well by itself. For more complex waveforms, the "variable holdoff" control can help. Variable holdoff sets the time between the end of a sweep and when the scope begins to look for the next trigger.

6.2 Digital Storage Oscilloscopes

DSOs, or digital storage oscilloscopes, digitize their inputs, store them in memory, and recall them through a digital-to-analog converter.

Using a storage scope is much like using a non-storage scope: set the trigger to catch what you want and view the results. Instead of displaying the waveform for each trigger, however, a storage scope can await a single trigger, capture a short waveform, and display it until you store another.

6.3 Logic Analyzers

Although four-channel scopes exist, most digital circuits have far more than four interesting signals, and the ``interesting'' things on those signals are too