

ECE 1315

Digital Logic Design

Laboratory Manual

Laboratory Equipment Description

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IV. - Laboratory Equipment Description.

In this section, we describe briefly the main characteristics and the use of the equipment that you will use in the lab to build and test your circuits.

Every work bench in the lab is equipped with all the necessary equipment that you need to implement, test and debug your experiments. This equipment includes a prototyping system, an oscilloscope, a signal generator, a digital frequency/period counter, an IC tester, and a set of gates and digital packages that you will use to build your projects. The only piece of equipment that every student needs to acquire is the breadboard that is used for the wiring of his or her circuits.

A brief description of the main equipment used in this lab follows. If you do not understand how to use it, or need more information about the use of this equipment, ask your instructor or your TA. Do not move or disconnect the equipment, also do not play with the controls of the equipment, since it could be mis-calibrated or damaged if it is not used appropriately.

4.1. - Heathkit Laboratory Prototyping System.

In order to power up, and test your laboratory experiments you will use mainly the Heathkit prototyping system that is available at every work bench in room MWAH 393. A picture of this system is shown in Fig.1. The set of functions that are provided by this system are listed next:

- a) Pulse Generator
- b) Square, Triangular and Sinusoidal Wave Generator
- c) 8 channel Binary Static Switches
- d) 2 channel Binary Pushbutton
- e) 8 Channel Logic Signal Indicators
- f) 1 Channel Logic Probe
- g) Power and Ground Connectors
- h) Prototyping Board

4.2. - Prototyping System Controls, Connectors and Displays.

Next we describe the use and main characteristics for each of the functions of the Heathkit prototyping system, please refer to Figure 1 shown next, and the arrows and numbers pointing to the specific controls and connectors.

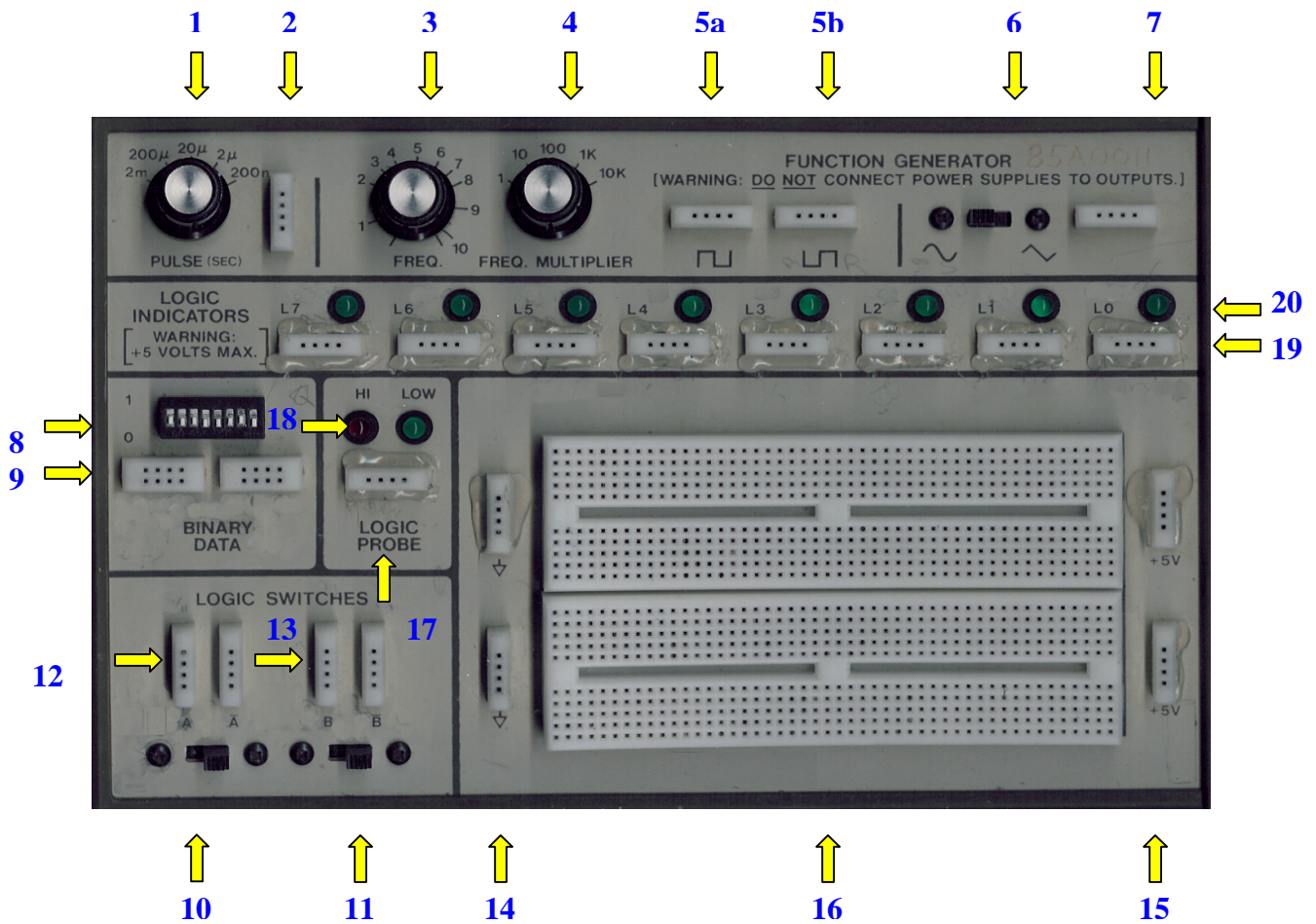


Fig. 1- Prototyping System

- 1 . - Pulse Generator Width Selector
- 2 . - Pulse Generator Output Breadboard Connector
- 3 . - Signal Generator Frequency Selector
- 4 . - Signal Generator Frequency Multiplier
- 5 . - Square Signal Output Breadboard Connectors (Normal and Complemented)
- 6 . - Sinusoidal/Triangular Wave Selector
- 7 . - Sinusoidal/Triangular Wave Output Breadboard Connector
- 8 . - Binary Static Switches (8 independent channels)
- 9 . - Binary Static Switches Outputs Breadboard Connector
- 10 . - Pushbutton (Channel A)
- 11 . - Pushbutton (Channel B)
- 12 . - Pushbutton Breadboard Connector (Normal and Complemented Outputs)
- 13 . - Pushbutton Breadboard Connector (Normal and Complemented Outputs)
- 14 . - Ground Connection Breadboard
- 15 . - Power Connection Breadboard
- 16 . - Prototyping Breadboard

- 17 . - Logic Probe Input Breadboard
- 18 . - Logic Probe Output Displays
- 19 . - Logic Value Indicator Breadboard connectors (8 independent Channels)
- 20 . - Logic Value Indicator Displays

4.3. - Prototyping System Functions Description.

- a) The pulse generation function is used to generate pulses with a specific width (from 2 milliseconds down to 200 nanoseconds). The height of the pulse is fixed, while the width of the output pulse is selected using knob (1), and the output is taken from the breadboard connector (2). The typical output for the pulse generator looks as shown in Figure 2.

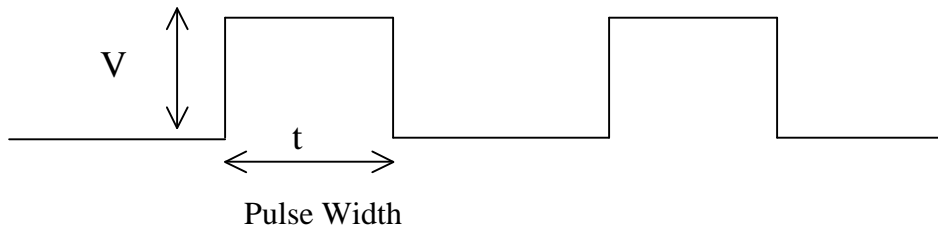


Fig. 2. - Pulse Generator Typical Output

- b) The wave generator function can be used to generate square, sinusoidal and triangular wave signals as those shown in Figure 3 below. The output voltage of the square signal is TTL¹ compatible, while the output voltage for the sinusoidal and triangular waves is fixed at ± 2 V.

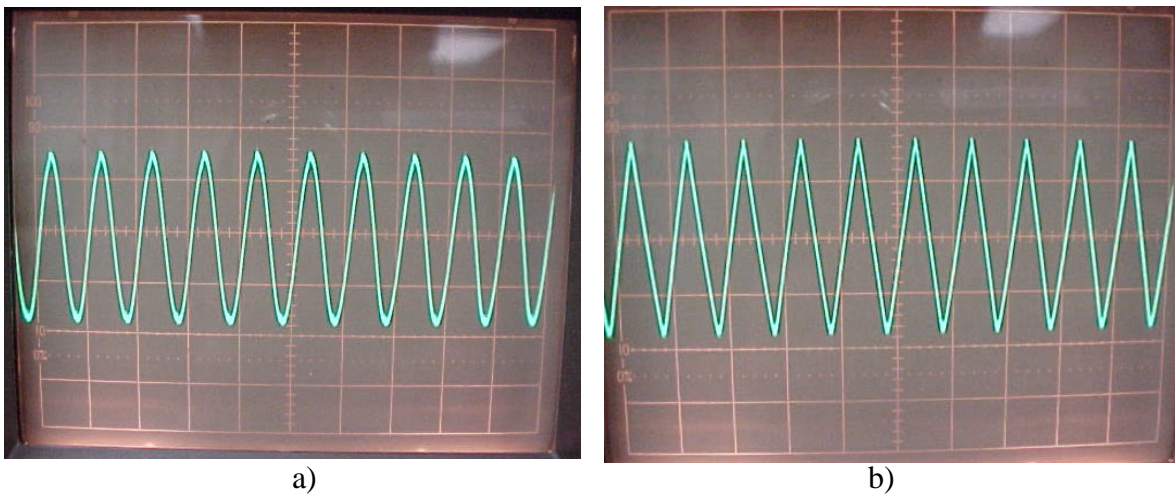
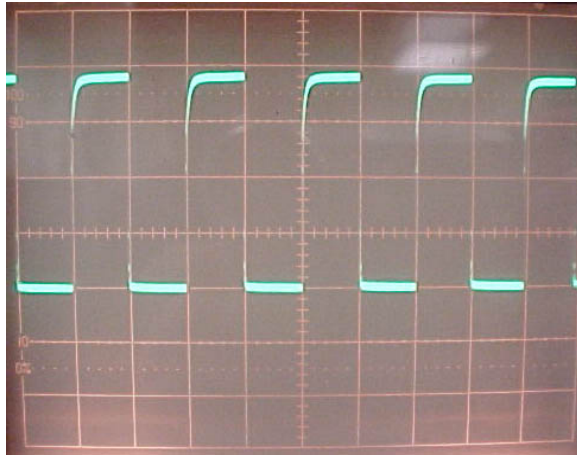


Fig. 3. – a) Sinusoidal, b) Triangular wave signals

¹ The characteristics for the TTL logic will be described later in this manual.



c)

Fig. 3c .- Square wave signal

- c) The frequency for any of the three signals is selected using knobs (3) and (4). The output for the square wave signal can be taken from either breadboard (5a) normal or (5b) complemented. Switch (6) selects between sine and triangular waves, and the output for these signals can be taken from breadboard (7).
- d) The eight binary static switches (8) can be used to generate digital values or variables that can be used as inputs for the lab experiments. The output for each switch can be fixed to a logical zero or a logical one. The outputs for the switches are taken from the breadboard connectors (9).
- e) The two pushbuttons (10) and (11) can be used to manually generate binary pulses, digital transitory values, or variables that can be used as inputs for the lab experiments. The pulses are similar to the one shown in Figure 2. The output (normal or complemented) can be taken from the breadboards (12) and (13).
- f) The logic probe can be used to detect and display a digital signal or variable that is connected to the breadboard connector (17). The value of the variable is shown as a high or a low value by lighting the respective display (18).
- g) The logic value displays (20) can be used to show the value of up to 8 different digital signals or variables. Each variable is connected to its respective display using the breadboard connectors (19).
- h) The prototyping breadboard (16) can be used as an extra board to build part of the lab experiments if needed, and breadboards (14) and (15) can be used to connect the circuits to ground and the power supply respectively.

4.4. - Power Supplies Controls and Chipmonk Connector.

In Figure 4, we show the second module that is available from the Heathkit Prototyping system. This module contains controls and connections for different power supplies and the circuitry and connector for the Chipmonk², which can be used to test and display digital inputs and outputs from your experiments on the oscilloscope screen. The use of the Chipmonk connector will be explained in more detail in the forthcoming experiments.

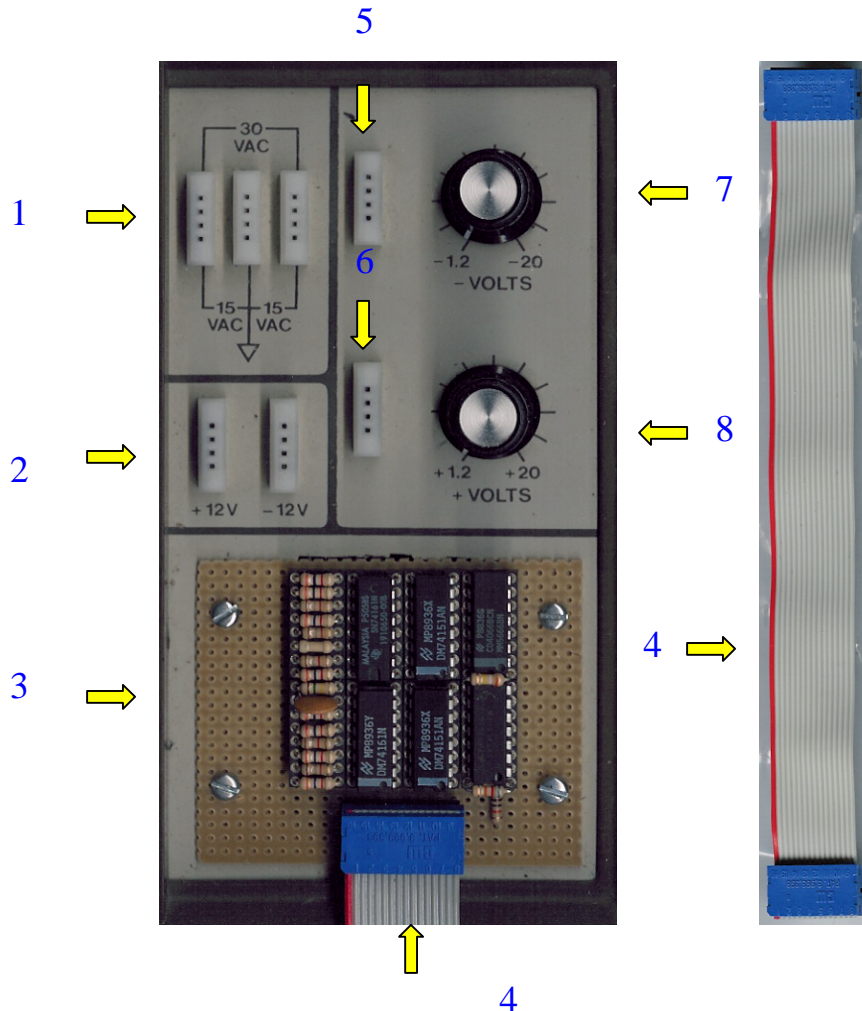


Fig. 4. - Power Supply Controls and Chipmonk Circuitry

The description of the functions of this module is given next:

- a) There are two independent variable power supplies. The output voltages for each power supply are set using the controls (7) and (8). The power supplies

² Developed by Dr. Chris Carroll

output voltages can be set from ± 1.2 V to ± 20 V. The outputs for the power supplies can be connected using breadboards (5) and (6).

- b) Breadboard (1) provides ± 15 VAC, while breadboards (2) provide +12V and -12 V respectively. These voltages, and those provided by (5) and (6) above, should not be used to power your lab projects, since they are not compatible with the devices used in this lab and the devices will be destroyed if they are connected to these power supplies.
- c) The Chipmonk circuitry (3) and connector (4) are used in the automatic generation of variables for the testing of the combinational and sequential circuits.

4.5. – Digital IC Tester.

Before you start building your projects using the TTL chips (described later in this manual), it's a good idea to make sure that these devices are in good condition, and that they operate according to their logical and electrical specifications. Since a bad chip will generate errors in your circuit and will make the debugging process more difficult. Because of the above, we recommend that you use the IC tester shown in Figure 5 to test all your TTL chips.

4.5.1 .- Tester Operation

- a) Power on the IC tester, wait until the SYSTEM READY! message appears.
- b) Put the IC into the ZIF socket (5), as shown on the tester's face (6)
- c) Select the IC type (1) and TTL chip number (74XXX) for testing, by using the up down arrows (2). If the IC number is unknown, press the AUTO key (3) to make an auto-search, and go to step g).
- d) Press the TEST key (4).
- f) Result shows up on the LCD display for TEST as:

PASS!! - Device is OK
FAIL!! - Device is damaged or put in the wrong position.

- g) For AUTO the display shows:

NOT FOUND - Device Damaged or not TTL
FIND - Device found, press TEST

If you get the FAIL or NOT FOUND messages, notify to your instructor or TA about the damaged chip and try another one.

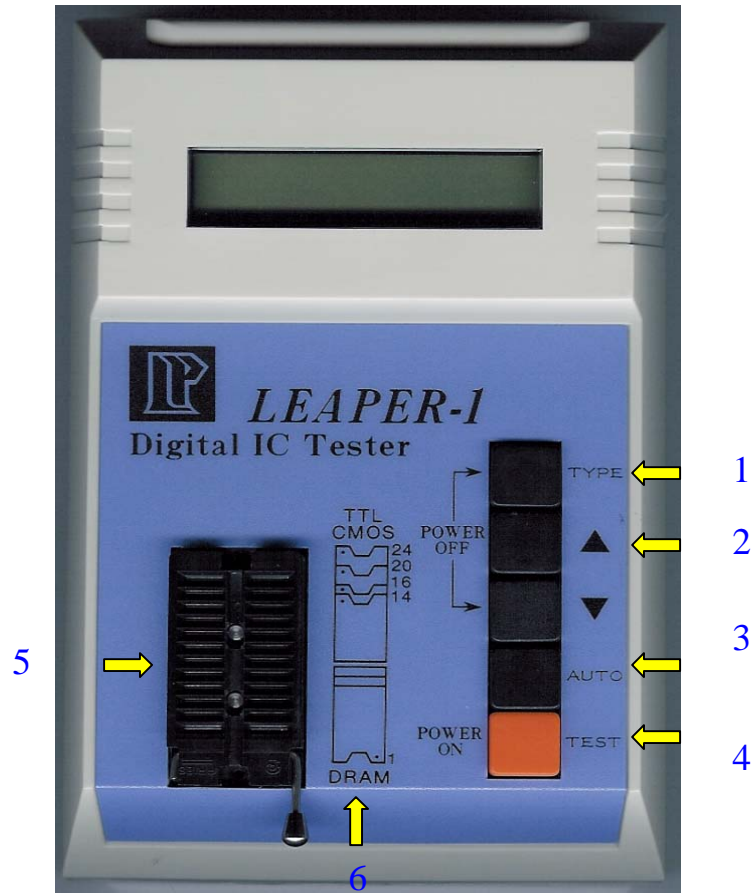


Fig. 5.- TTL IC Tester

Appendix A. - TTL Devices Electrical Characteristics.

In the design of logical functions we assume that there are only two values (0 and 1), which are used to represent the state of the variables or signals. However, to implement these functions we use electric devices (called also logic gates) that use voltages to represent the 0 and 1 values. In the following discussion we describe in more detail the electrical characteristics of the TTL family of gates.

The voltages that represent the two binary values are called V_H (to represent a 1 or high) and V_L (to represent a 0 or low), where $V_H > V_L$. The actual values of these voltages are not stable because they fluctuate due to changes in technology, temperature, loading, noise, etc. Because of this, instead of defining fixed voltage values for the 0 and 1 states, the states are given rather as a range of valid values as shown in Figure 32.

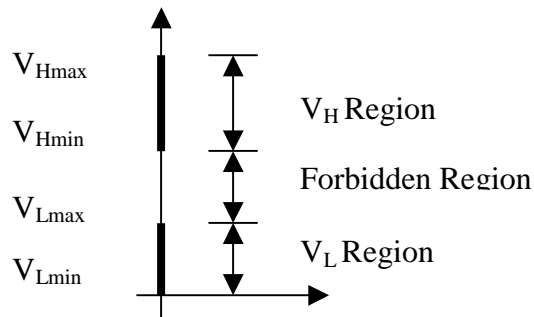


Fig. 32. - Valid Voltage Regions for 0 and 1 states

From the figure we notice that a valid “0” is any voltage between V_{Lmin} and V_{Lmax} , and a valid “1” is any voltage between V_{Hmin} and V_{Hmax} . Any voltage between V_{Hmin} and V_{Lmax} is not allowed since the device won’t be able to recognize this voltage as valid 0 or a valid 1.

A.1 - Noise Margins.

Electronic circuits are constantly subjected to random noise produced by the environment, which can alter the output voltage levels produced by the gate. In Figure 33, refer to the gates G_1 and G_2 . . In order to make sure that any TTL output is able to drive any TTL input, two different ranges of voltages are allowed to represent the high and low levels in the output than in the input. These levels are defined as shown in Fig. 33. The high output voltage values ranges between 2.4 (V_{OHmin}) and 5 V (V_{OHmax}) and the low output voltage values ranges 0 (V_{OLmin}) and 0.5V (V_{OLmax}). On the other hand, the values for the high input voltage ranges between 2 (V_{IHmin}) and 5 V (V_{IHmax}) and the low input range allows 0 (V_{ILmin}) to 0.8 (V_{ILmax}) to be recognized as valid values.

Consider the case when G_1 produces its maximum low voltage V_{OLmax} . The presence of noise may alter the voltage level, but as long as it remains less than V_{ILmax} it will be interpreted correctly by G_2 . The ability to tolerate noise without affecting the correct operation of the circuit is known as *noise margin*. For the low output voltage, the noise margin is defined as:

$$NM_L = V_{IL} - V_{OL}$$

In the same way, when G_1 produces its minimum high output voltage V_{OHmin} , noise can alter the voltage level, but as long as the voltage is greater than V_{IHmin} , the state value will be interpreted correctly. For this case the noise margin is defined as:

$$NM_H = V_{OH} - V_{IH}$$

In Figure 34 we show the two typical TTL gates interconnected and show how this connection is used to calculate the noise margin. Table shows these values.

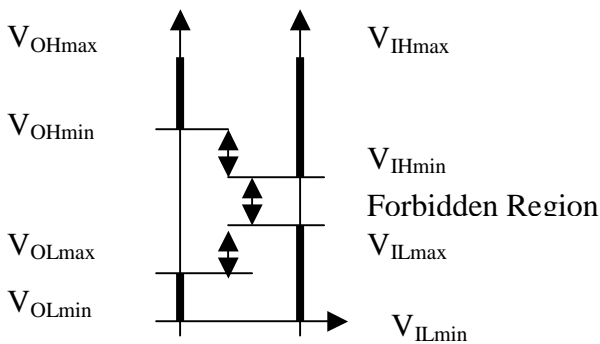
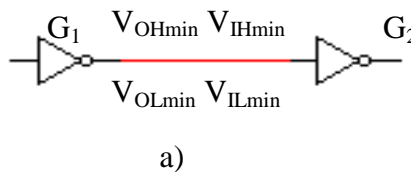


Fig. 33. - Noise Margin Calculation Relationship



<i>Logical Level</i>	<i>Signal Voltage</i>	<i>Noise Margin</i>
<i>High</i>	$V_{OH\ min} = 2.4\ V$ $V_{IH\ min} = 2.0\ V$	<i>0.4 V</i>
<i>Low</i>	$V_{OL\ max} = 0.4\ V$ $V_{IL\ max} = 0.8\ V$	<i>0.4 V</i>

b)

Fig. 34. - a) Noise Margin Calculation Circuit, and b)Table

Appendix B. - iPAQ Handheld Computer.

The iPAQ handheld computer, shown in Figure 35, is a new tool that is available for the ECE1315 students. The iPAQ small size, set of multimedia features and internet access capabilities, makes this device suitable to be used as an in lab and in class tool and also enables the user to connect wirelessly to the internet.

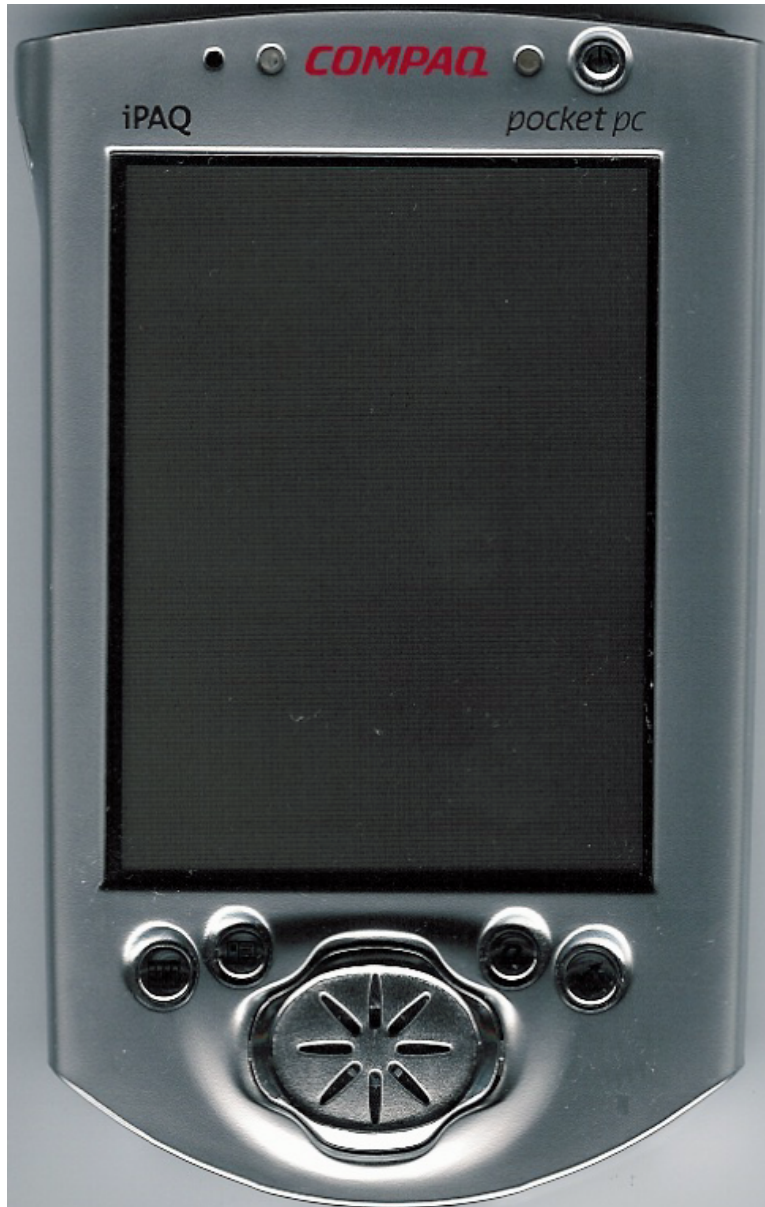


Fig. 35. – iPAQ Handheld Computer

In particular, for the exclusive use of this class we have developed a set of programs, graphics and tables that can be accessed through the internet or be downloaded to the

iPAQ. These applications can be used to learn, simulate and display information on the computer screen.

For general information about the iPAQ program at UMD go to the following webpage address:

<http://www.d.umn.edu/itss/computing/ipaq/>

For information about how to set up your IPAQ for wireless networking and email, you can see the following information:

<http://www.d.umn.edu/itss/computing/ipaq/wireless.html>

<http://www.d.umn.edu/itss/computing/ipaq/email.html>

For information about iPAQ programs and applications for the ECE1315 class go to the address:

<http://www.d.umn.edu/~friosgut/www/ECE-1315/IPAQ/index.html>