Universal Trainer 2

User Manual

INGENIERIA DE MICROSISTEMAS PROGRAMADOS S.L.

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SECTION 1: ASSEMBLY OF THE UNIVERSAL TRAINER 2

SECTION 2: DESCRIPTION OF THE UNIVERSAL TRAINER

SECTION 3: TESTING OF THE UNIVERSAL TRAINER

SECTION 1: Assembly of the "Universal Trainer 2"

1.1 INTRODUCTION

The "**Universal Trainer 2**" MICROELECTRONICS AND MICROCONTROLLERS Modular Laboratory is a powerful and effective tool for learning about, experimenting with, designing, and evaluating all types of modern electronic circuits.

Its users may be hobbyists or students, who wish to learn about electronics in the only way possible: **PRACTICE**. This laboratory may also be of interest to engineers and other professionals, who wish to quickly develop their projects and deepen their knowledge of particular subjects. Finally, laboratories at companies and training centers will find the "*Universal Trainer 2*" to be an economical, complete, and extremely useful development tool for their applications.

Ingeniería de Microsistemas Programados S.L. sells two versions of the "*Universal Trainer 2*". One version comes already assembled and tested, while the other comes in the form of a kit, ready for self-assembly, which is reflected in its price. We recommend potential customers, who just have started their apprenticeship in electronics, to purchase the self-assembly kit. You won't have any trouble, because we have included detailed instructions in the kit, and if you pay attention it will be rather difficult to make any mistakes. However, it must be kept in mind that the final appearance will depend on the user, and assembly by those who are not a little "handy" will not produce a professional, in terms of appearance.

The "*Universal Trainer 2"* can be used to assemble and evaluate your own designs, but is also useful for learning and internalizing the most important aspects of modern electronics. Our company also offers optional study modules containing a set of practice exercises and projects. These provide a theoretical introduction to Digital and Analog Electronics, Microcontrollers, PICs, etc. The modules consist of a collection of practical exercises on flash cards and the materials they require to complete them using the *"Universal Trainer 2"*.

This first section of this manual includes a step-by-step explanation of the trainer's assembly, for users, who have chosen to purchase the self-assembly kit. The later sections will provide a more detailed explanation of the contained circuits' and elements' general characteristics. A series of very elementary exercises is also provided to serve as an introduction to using the equipment and the ways in which its proper functioning can be verified.

We hope that assembly of the "*Universal Trainer 2*" will be as gratifying as possible, and that use of this trainer will serve as a convenient way to learn about the various types of basic electronic devices. Ingeniería de Microsistemas Programados S.L. has done its best to make this manual a useful and easily understandable guide, in order to ease the users' way into the fascinating world of electronics.

1.2 TOOLS

To put together the "*Universal Trainer 2*", a set of very basic tools is needed. These can usually be found in any shop or laboratory, and hence are widely available. The photograph in figure 1.1 shows some of these tools, which are listed below.

Figure 1.1. *Basic tools*

Multimeter

Also known as a "tester". This instrument is capable of measuring various electrical parameters or levels. There are many different models available, which are sold at a range of prices. The tester chosen should always have the ability to measure at least the following parameters:

- Resistance (ohms)
- Direct current voltage (VDC)
- Alternating current voltage (VAC)
- Direct current intensity (DCA)

In our case, the tester will help us to measure and identify the various resistors included in the "Universal Trainer 2". Therefore, once the equipment is completely assembled, we can measure and test the various voltages that the equipment should provide.

Soldering Iron

Is the tool we will use to sold and connect all of the circuit's components.

It generates heat for melting the solder and allowing it to be deposited between the leads of the components and the conductive pathways of the printed circuit board. When it cools, the solder becomes solid and creates a perfect electrical connection between the various components and these conductive pathways.

On the market, a wide variety of models of soldering irons can be found for sale. We recommend the use of a "pencil type" soldering iron with a straight tip. The soldering iron's power must not exceed 35W, since excessive heat can damage the components that we want to sold to the board.

There are also soldering irons described as "long life", their point is specifically treated to facilitate cleaning and maintenance.

Tin solder

This is an essential product needed for soldering. Solders used in electronics, tend to be sold in wire form, and come on rolls or spools of various weights. It should also be pointed out that the solder we use is not pure tin. The tin is combined with other metals to form alloys of various proportions.

For practical assembly of the *"Universal Trainer 2"*, the use of an alloy with a minimum of 60% tin and 40% lead is suggested. It is also possible to find other types of alloys that are purer and contain higher proportions of tin or even silver and copper.

They all come in wire-form with various thicknesses. For soldering electronic circuits, a thickness of no more than 1 mm is generally recommended. Thicker wire causes too much solder to melt, and it is never desirable to sully circuits with excess solder.

Tweezers

Metal tweezers can be used to fixate small components, while they are being soldered and also to bend and shape the leads or contacts of certain parts. For the latter purpose, various types of pliers with flat or pointed ends can be used as well.

Diagonal cutters

Some components such as resistors, diodes, capacitors, etc., come with excessively long leads. These must be trimmed once the components are soldered in place on the printed circuit board.

Diagonal cutters enable us to perform a clean and precise cut, flush with the level of the solder.

Electrician's scissors

This is the classic tool found in any electrical or electronics shop or laboratory. A good pair of "electrician's" scissors allows us to safely handle any type of conducting wire .

They can be used to strip the ends of wires, before they are used to assemble the circuits in the various practical exercises.

There is also a tool designed specifically for this purpose known as a "wire-stripper".

Screwdriver

This is another tool usually found in any shop. Although professionals will always have screwdrivers of various sizes and shapes, for assembly of this training unit only one small slot screwdriver is needed for tightening a couple of screws and nuts.

1.3 LIST OF MATERIALS

This section presents a complete list of the components and accessories needed to assemble the *"Universal Trainer 2"*. Some of which can be seen in photograph 1-2, below.

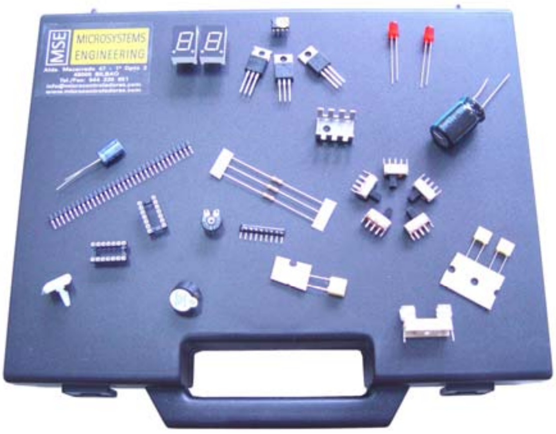


Figure 1-2. Some of the *"Universal Trainer 2* 's" components

In the sections below related to assembly, the components that make up the various sections of the trainer are described in detail.

The following list will help us to identify and classify all of the components included in the kit.

1.3.1 RESISTORS

Figure 1-3 shows the various types of resistors used in the assembly of the *"Universal Trainer 2"*.

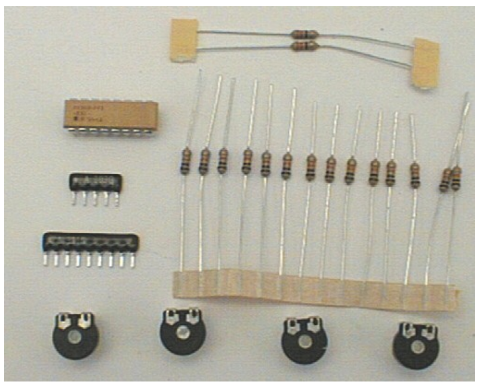
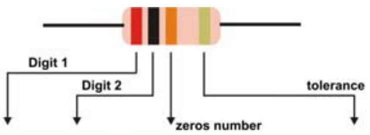


Figure 1-3. *Types of resistors*

Fixed resistors

They are cylindrical and their value is indicated by the colored stripes painted on them. These colors are standardized and their values are summarized in the table below.



Black		0	x1	
Brown	1	1	x10	1 %
Red	2	2	x100	2 %
Orange	3	3	x1000	
Yellow	4	4	x10000	
Green	5	5	x100000	
Blue	6	6	x1000000	
Violet	7	7		
Gray	8	8	x0,1	
White	9	9	x0,01	
Gold			x0,1	5 %
Silver			x0,01	10 %

1st Value, 2nd Value
Tolerance
Multiplier
Black, Brown, Red, Orange, Yellow, Green, Blue, Purple, Grey, White, Gold, Silver

Figure 1-4. *Color code*

There are a total of 25 fixed resistors available, with their values and reference points detailed below

- 3 of 220 Ω (R1-R3)
- 1 of 330 Ω (R4)
- 13 of 470 Ω (R5-R17)
- 3 of 4K7 (R18_R20)
- 4 of 10K Ω (R21-R24)
- 1 of 47KΩ (R25)

Variable resistors with rotary knobs

They are resistors whose value can be varied between a minimum and a maximum by turning a knob attached to the component. The maximum value of these resistors is written on their cases.

The *"Universal Trainer 2"* uses 5 variable resistors:

- 1 of 1K Ω (P1)
- 2 of 4K7 Ω (P2-P3)
- 1 of 100K Ω (P4)
- 1 of 1M Ω (P5)

Package resistors

They are multiple resistors that all have the same value, which are sold in multi-packs. There are packages with two rows of pins (DIL). The resistors integrated inside of these are in no way connected to each other.

There are also packages with a single row of pins (SIL). The resistors integrated inside of these all share one common pin. The common connection is accessible from the outside via a single pin in the package. This pin is marked by a dot on the package.

Regardless of the type of package, the value in terms of ohms of all resistors inside is indicated using a 3-digit code, with the third digit representing the number of zeros that must be added to the first two digits. For example, a package marked with the code 103 indicates that all of the resistors it contains are 10KΩ.

"Universal Trainer 2" uses 5 package resistors:

- 1 DIL package with eight 330Ω resistors (RP1).
- 1 SIL package with eight 470 Ω resistors (RP2).
- 3 SIL packages with four 4K7Ω resistors (RP3-RP5).

1.3. 2 CAPACITORS

Some of the capacitor types can be seen in figure 1-5.

Figure 1-5. *Types of capacitators*

The value of the capacitor is printed on its exterior. On some types, this also includes the maximum voltage that can be supported and the polarity.

Below, the full information related to the 18 capacitors we will need:

- 1 of 1nF (C1)
- 2 of 10nF (C2-C3)
- 10 of 100nF (C4-C13)
- 1 of 1µF (C14)
- 1 of 10µF (C15)
- 1 of 100µF (C16)
- 2 of 1000µF (C17-C18)

Electrolytic capacitors require special attention because they have polarity. Because of this, one of the leads is marked as "-" and the other as "+". These polarities must coincide with those on the printed board when the capacitors are soldered in place.

1.3.3 SEMICONDUCTORS

This is a set of components made up of LED diodes and a bridge rectifier, as seen in figure 1-6.

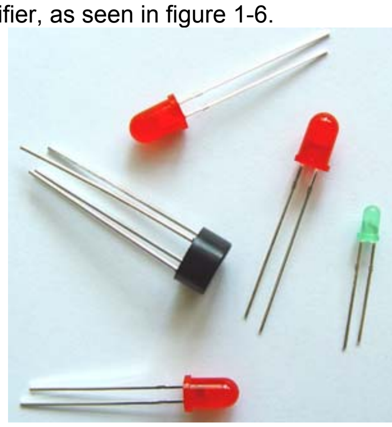


Figure 1-6. *Various semiconductors*

These are made up of the following:

- 1 Bridge rectifier, 1 A B250C (D1)
- 1 Green LED diode, 3mm (D2)
- 4 Red LED diodes, 3mm (D3-D6)
- 8 Red LED diodes, 5mm (D7-D14)

1.3.4 INTEGRATED CIRCUITS

The integrated circuits used in the *"Universal Trainer 2"* are shown in figure 1-7.

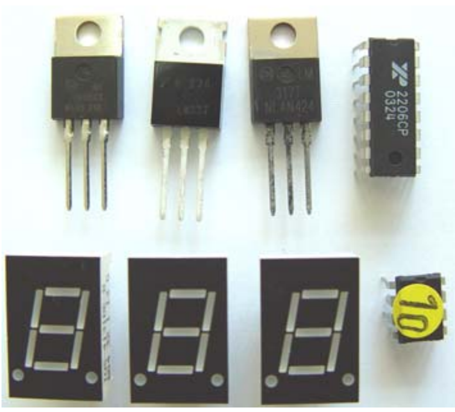


Figure 1-7. *Integrated circuits*

The list of integrated devices is as follows:

- 1 Regulator, 78L12, +12VDC (U1)
- 1 Regulator, 7805, +5VDC (U2)
- 1 Regulator LM317T, +VDC (U3)
- 1 Regulator LM337T, –VDC (U4)
- 1 Function generator, XR2206 (U5)
- 1 Logic analyzer (LOGEN) SYM-10 (U6)
- 3 Alphanumeric LED displays (U7-U9)

1.3.5 SOCKETS AND CONNECTORS

As shown in figure 1-8, the sockets are used to attach the various integrated circuits. The helps avoid damaging the integrated circuits during the soldering process.

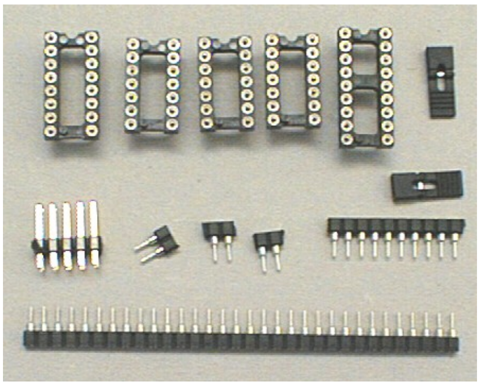


Figure 1-8. *Sockets and connectors*

The connectors are made up of strips of female pin sockets. During assembly of the *"Universal Trainer 2"*, these strips are cut into sections of two pins. Each of these sections will be used to connect one of the various devices used in the trainer.

The following list of materials makes up this section:

- 1 socket with 16 pins for U5
- 1 socket with 8 pins for U6
- 3 sockets with 14 pins for the U7-U9 displays
- 4 Strips with 32 female pin sockets
- 1 Strip with 2 x 5 male pins
- 2 Pin jumpers, 2.54 mm

1.3.6 SWITCHES AND BUTTONS

This are the most commonly used devices by in any kind of didactic trainer oriented towards digital electronics. In order to evaluate the functioning of a digital circuit, it is necessary to apply binary input combinations. The switches and/or buttons are the most economical mechanisms to allow generation of these combinations. Figure 1-9 shows a few of the switches used in the *"Universal Trainer 2"*.

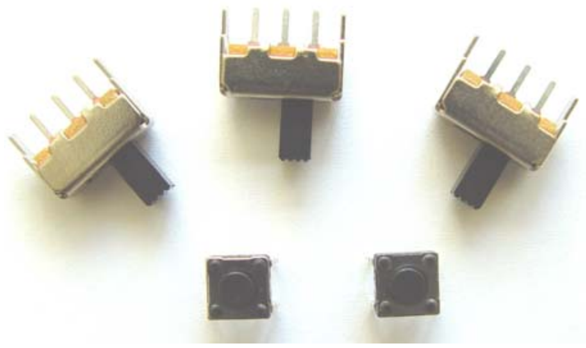


Figure 1-9. *Switches and buttons*

These include:

- 11 Sliding switches (SW0-SW10)
- 3 Buttons (SW11-SW13)

1.3.7 ACCESSORIES

As with any self-assembly kit, there are a series of accessories that allow the use to finish the circuit board properly. These are shown in the photograph below, figure 1-10.

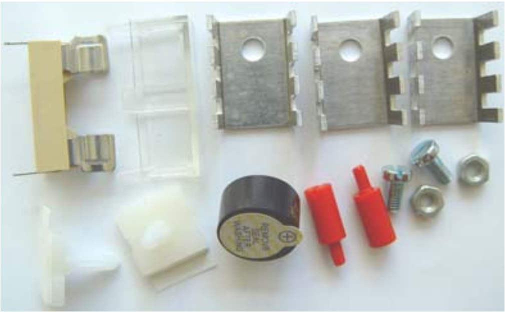


Figure 1-10. *Accessories*

List of accessories:

- 3 Screws, M3 x 6 mm, DIN 84
- 3 Nuts, M3, DIN-934
- 3 Heat sinks for the TO-220
- 1 Mini-buzzer (BZ1)
- 5 Control knobs, PT10 de 4 mm
- 6 Adhesive spacers, 4 mm
- 1 Fuse holder (FUS1)
- 1 Glass fuse, 750 mA
- 1 Fuse cover

1.3.8 MISCELLANEOUS

Finally, to complete the assembly of the *"Universal Trainer 2"*, a variety of additional elements are needed. These are shown in figure 1-11.

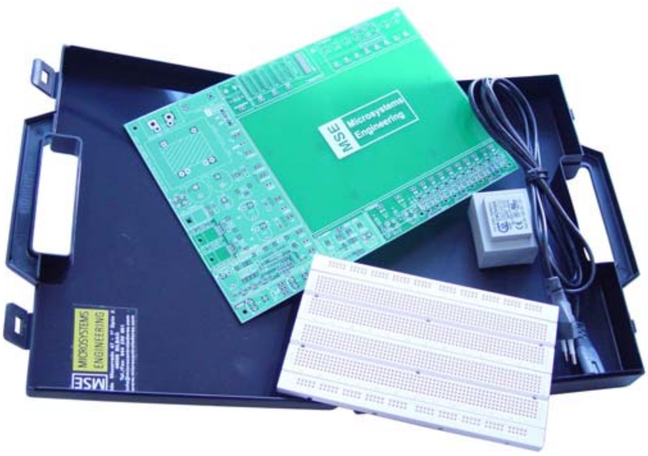


Figure 1-11. *Miscellaneous elements*

These are listed below:

- 1 Power cord
- 1 Transformer, 12 + 12 VAC / 10VA
- 1 Protoboard
- 3 Velcro strips
- 1 Printed circuit board
- 1 Carrying case

1.4 ASSEMBLY

All of the components have now been located and identified. Next, step-by-step instructions are provided for the assembly sequence of the *"Universal Trainer 2"*.

1.4.1 THE PRINTED BOARD

This design is exclusive to Ingeniería de Microsistemas Programados and is shown in figure 1-12.

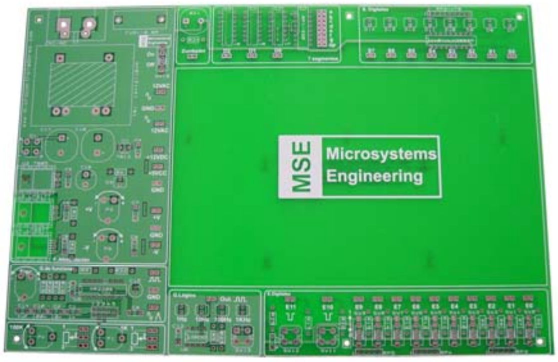


Figure 1-12. *The printed circuit board*

This is a professional circuit board with tracks on either side, metal holes, printing of component locations, and a solder mask.

The metal holes greatly facilitate soldering. The leads of the components to be soldered are placed into the holes. The soldering iron is used to heat the lead and the hole. When the solder wire is introduced it can be seen melting. The hole must be completely filled by solder, forming a perfect connection between the hole and the component's lead.

The printing on the board will also be very useful. Drawings are used, to represent the various components, their orientation, and their reference markings. The location for the component to be soldered next can be found on the board, and the component soldered in place according to the reference. Orientation must be correct. Some components can be damaged, when they are attached with an incorrect orientation (e.g., the electrolytic capacitors, transistors, integrated circuits, etc.).

Once the component is inserted in its appropriate place, soldering can begin. The solder mask is the green film that covers the entire printed board. Thanks to this film, melted solder is prevented, as much as possible, from spreading to any other holes close to the one being soldered. In spite of this, excess solder can nevertheless adhere to a nearby hole, which can cause short circuits, malfunctions, or even the destruction of components.

The correct amount of solder must be used to avoid exceeding the capacity of the metal hole that is being soldered. Just enough should be used to cover the hole and surround the lead of the component.

1.4.2 THE RESISTORS

As a general rule, assembly of a printed circuit board should begin by adding the flattest components with the least height, adding higher-profile components progressively.

In our case, we begin by soldering the fixed resistors since they have the lowest profile.

Classification

Using an ohm reading from the tester, or else by use of the color coding, the first step is to classify the resistors according to their values. See figure 1-13.

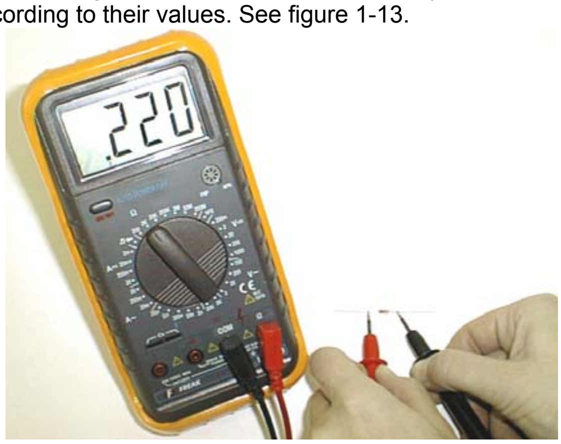


Figure 1-13. *Classification of the resistors*

Preparation

With the help of tweezers or flat-ended pliers, the legs of the resistors are bent to form right angles, to the proper size to fit in the place where they are to be inserted. See figure 1-14.

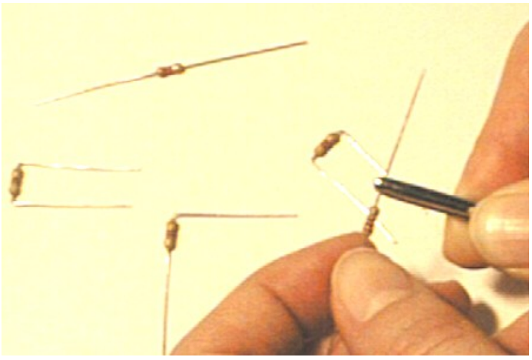


Figure 1-14. *Preparation of the* resistors

Insertion

The resistors can now be inserted in their corresponding locations on the board. These locations are marked with ***Rn***. The value in ohms of each resistor must correspond with the corresponding marking.

They must be inserted to the point of being level with the board as seen in figure 1-15. Although not completely necessary, it is a good habit to give all of the resistors the same orientation, basing this, for example, on the color or band corresponding to a certain tolerance.

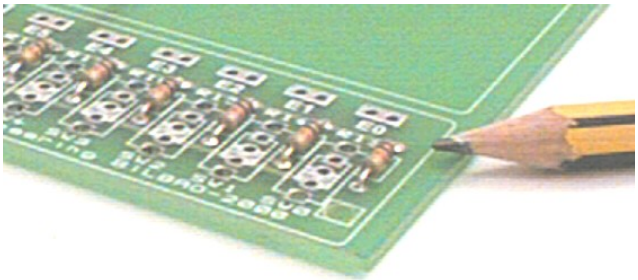


Figure 1-15. *Inserting resistors*

Soldering

Once the resistors are inserted, soldering can begin. The soldering iron should be used to heat the lead of the component and the metal hole at the same time. Then the solder is applied. See figure 1-16.

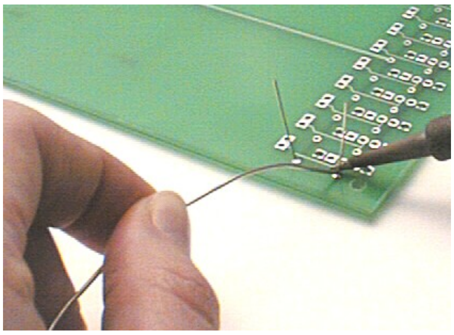


Figure 1-16. *Soldering a resistor*

The solder begins to melt and fills the hole, the lead passes through. When enough solder has melted to cover and fill the hole, remove both the soldering iron and the solder, allowing the area to cool.

The point of the soldering iron must remain shiny and clean, without scratching or cracking it.

Trimming

To finish, the excess wire at the ends of the leads are trimmed flush with the solder using scissors or diagonal cutters, as seen in figure 1-17.

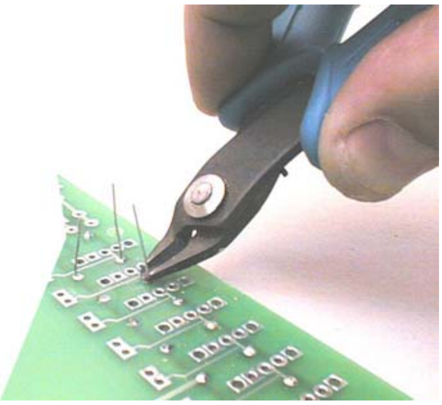


Figure 1-17. *Trimming the excess lead wire*

1.4.3 THE CONNECTORS

These make use of the female pin strips provided. These connectors will be used in the future to connect the various devices found in the trainer with the user's circuits, by use of the appropriate wires.

Observe the photograph in figure 1-18.

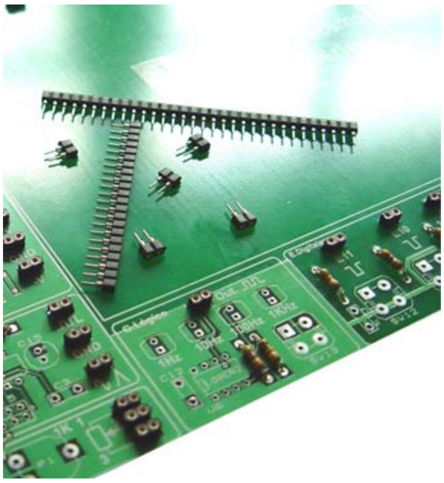


Figure 1-18. *Placement of the connectors*

Proceed as follows:

- Cut the 4 female pin strips in sections of 2.
- Insert them in the corresponding holes up to their base.
- Solder them according to the instructions above.

Now, each of the devices included in the *"Universal Trainer 2"* will have two contact points available, which will allow them to be used in the user's various experiments by means of rigid wires that will be prepared for this purpose.

1.4.4 THE SOCKETS

We continue adding components based on their height or profile. It is now time for the sockets and the resistor packages, as shown in figure 1-19.

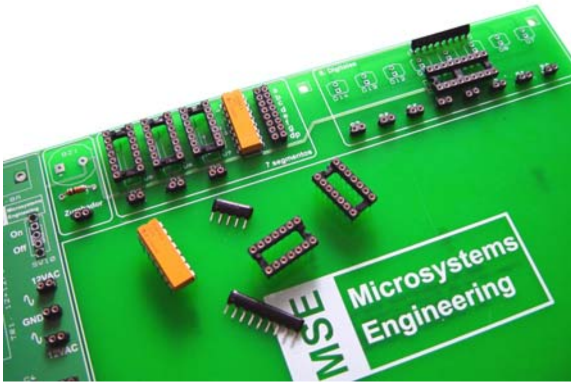


Figure 1-19. *Placement of the sockets and packs*

All of the sockets, , have a reference mark on one of their ends, where the integrated circuits will be inserted later. This mark must correspond to the one printed on the board. They must have the same orientation.

They are inserted to the point of being level with the board, before having all of their arms soldered. We must make sure that none are bent or are threaded through the wrong hole.

- Solder in the 16-pin base at reference point U5
- Solder in the 8-pin base at reference point U6
- Solder in the three 14-pin connectors in the places indicated as U7, U8, and U9.

The resistor packages must also be inserted flush with the board and must have a particular orientation, which corresponds with the one indicated on the board's printing.

- Insert the 8-resistor DIL package of 330 Ω at reference point RP1. This package is similar to those of the integrated circuits. Its reference points must correspond to those in the drawing printed on the board.

- Insert and solder the 8-resistor SIL package with 470 Ω to reference RP2. You will notice that there is a dot painted on one of its ends. This indicates the pin that is shared by all of the internal resistors, and must correspond to hole number 1 (the one on the left).

- Insert the three 4-resistor SIL packages of 4K7Ω at reference points RP3-RP5. The dot on this package must coincide with hole number 1 on the printing (on the left).

1.4.5 BUTTONS

Therefore temporary logic signals could be applied to the circuits in order to test them. They are added as they appear in figure 1-20.

- First, flat-ended pliers should be used to straighten out the leads of the buttons.

- These are then inserted in the locations designated as SW11, SW12, and SW13, until flush with the board and as indicated on the board's printing.

- They must be oriented so that the leads are facing towards the left edge of the printed board.
- Solder them as explained above.

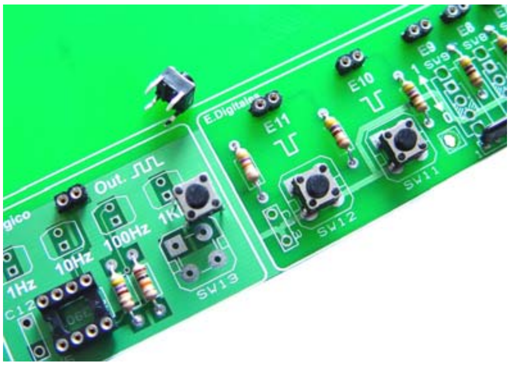


Figure 1-20. *Placement of the buttons*

1.4.6 THE BRIDGE RECTIFIER

This involves the D1, which is inserted until flush with the board as shown in figure 1-21.

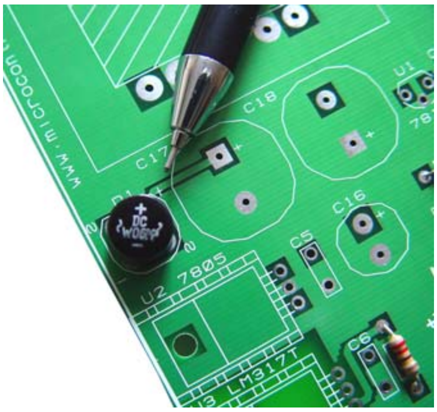


Figure 1-21. *Placement of the bridge rectifier*

- Straighten out the four leads of the bridge.
- Insert them so that the symbols painted on the exterior match with those printed on the board (+ , - , ~, ~).
- Trim the excess lead materials flush with the solder.

1.4.7 CAPACITORS AND POTENTIOMETERS

The appearance and placement of these is shown in figure 1-22.

Components are gradually added from the lowest to the highest profile. First, we begin with the potentiometers, or variable resistors, inserting them until flush with the board. The ohm values of these resistors are printed directly on their cases.

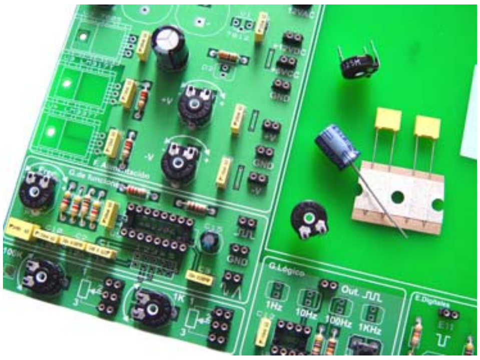


Figure 1-22. *Assembly of the capacitors and potentiometers*

- ***P1 of 1KΩ***
- ***P2-P3 of 4K7Ω***
- ***P4 of 100KΩ***
- ***P5 of 1MΩ***

Next, we position some of the capacitors that are used in the trainer. The capacitors to be positioned here must be inserted until they are flush with the board. They do not have specific polarities or orientations.

- C1 of 1nF
- C2-C3 of 10nF
- C4-C13 of 100nF
- C14 of 1000nF

Trim the excess leads of the installed capacitors flush with the solder.

1.4.8 LED DIODES, 3 mm

Next, the trainer's five 3 mm LED diodes are installed.

The LED diodes have one lead that is shorter than the other. This one corresponds to the cathode and also coincides with a flat spot on the edge of the capsule when viewed from the top. These are inserted until flush with the board. The lead corresponding to the cathode must be oriented towards the flat spot seen on the board's printing.

In figure 1-23 the location of the four 3 mm LED diodes is shown. These are associated with the logic analyzer and indicate the output frequencies of this component.

Figure 1-23 The 3 mm LEDs

Although it is not apparent on the photograph, we must also install the green 3 mm LED diode for the power indicator. In total, we must install:

- 1 green LED diode, 3 mm (D2)
- 4 red LED diodes, 3 mm (D3-D6)
- Trim the excess lead length.

1.4.9 LED DIODES, 5 mm

These are a set of 8 LEDs used to monitor logic levels coming from the circuit being tested. They are installed as shown in the photograph in figure 1-24.

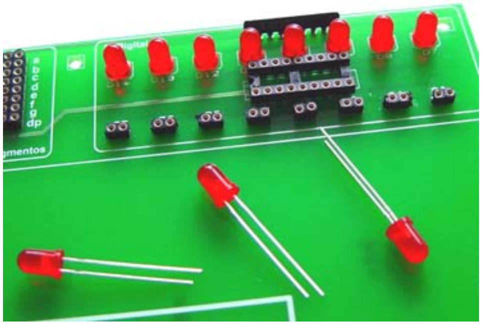


Figure 1-24. Placement of the 5 mm LEDs

These LEDs must be installed with their cathodes properly oriented.

- Install the eight 5 mm LEDs in D7-D14
- Trim the excess lead length

1.4.10 THE JUMPER STRIP

This double 5-pin strip will allow the user to choose the frequency and type of signal, the function generator produces.

It is also used to add two other capacitors. On this occasion these are the two electrolytic capacitors C15 and C16. The final result is shown in figure 1-25.

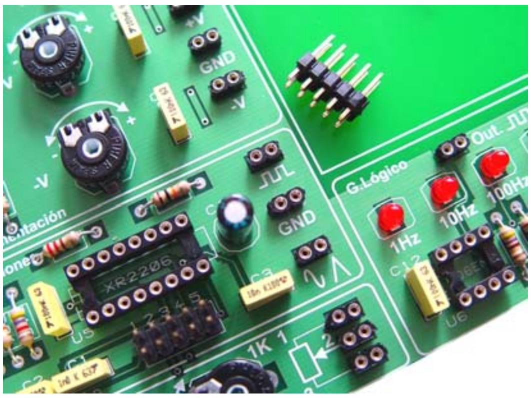


Figure 1-25. *The Jumper strip*

- Insert and solder the double 5-pin strip, into place, where indicated as JMP1. The short ends should be inserted, leaving the long ends visible.
- Insert and solder the 10 µF capacitor C15. This is electrolytic, and therefore the polarity must be respected by orienting its positive lead towards the hole marked with a + .
- Insert and solder the 100 µF capacitor C16. This is electrolytic, and therefore the polarity must be respected by orienting its positive lead towards the hole marked with a +.
- Trim the excess length of the leads for both capacitors.

1.4.11 FUSE and BUZZER

In this section we are going to attach the fuse holder with its corresponding accessories, the buzzer, the power cord input socket, and the power switch. See figure 1-26.

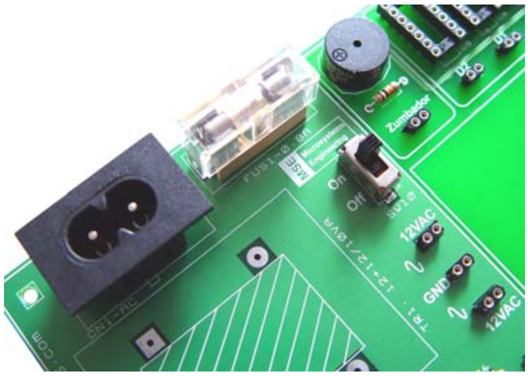


Figure 1-26. *Fuse and power cord input*

- Insert and solder in the male, 2-contact input socket for the power input in CN1-AC.
- Insert and solder in the BZ1 buzzer. Turning it over, we can see that one of its two leads is marked with a +. It has polarity and must be oriented towards the hole that is also marked with this symbol.
- Insert and solder in the SW10 power switch, which must be perfectly embedded in the board.
- Insert the fuse holder at FUS1 until flush with the board and solder in. Insert the glass fuse and cover the set with the transparent plastic cover. This is pressed into place.

1.4.12 THE SWITCHES

Now insert and solder in the 10 switches SW0-SW9, ensuring that they are perfectly embedded and aligned with each other, as shown in figure 1-27.

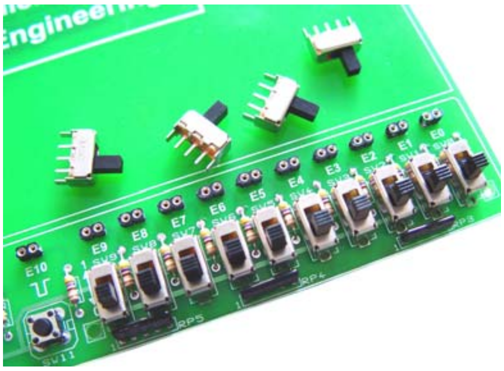


Figure 1-27. *Placement of the switches*

1.4.13 THE VOLTAGE REGULATORS

These are responsible for providing all of the voltage necessary for proper functioning of the *"Universal Trainer 2"*.

These consist of the following integrated circuits:

- 1 Fixed voltage regulator of +12VDC 78L12 (U1)
- 1 Fixed voltage regulator of +5VDC 7805 (U2)
- 1 Positive variable voltage regulator +VDC LM317T (U3)
- 1 Negative variable voltage regulator –VDC LM337T (U4)

Of these four regulators, U1 is the lowest profile and it is therefore attached first. Next, the other three regulators are attached with their corresponding heat sinks as shown in figure 1-28.

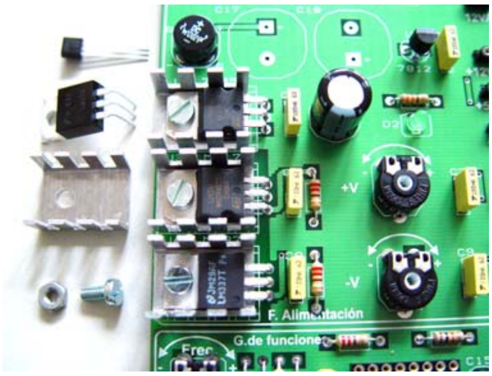


Figure 1-28. *Placement of the voltage regulators*

- The pins of the three regulators are bent at a right angle. We must ensure that when inserted into the board, the holes the pins are threaded through and those accommodating the screws all match up.

- Insert these as seen in the previous figure, ensuring that each is located at the correct reference and that they are not mixed up:

  L7805 (U2)
  LM317T (U3)
  LM337T (U4)

- Put each of the three heat sinks into place. These go between the package of the regulators and the printed circuit board. The holes for the screws and the holes in the heat sinks must match up.

- Put the screws through the holes from the top. The nut is screwed on from the bottom of the printed board. Using the screwdriver along with a key or pliers, tighten the three screws and their respective nuts. Make sure that each heat sink is in close contact with its corresponding package.

- Once screwed in place, they are soldered in the usual manner. It should be emphasized again that, since these are semiconductors, they can be damaged by excess heat.

- Trim the pin's excess length flush with the solder for each of the regulators.

1.4.14 TRANSFORMER AND FILTERS

To complete the assembly related to the trainer's power supply, the transformer and the two filter capacitors are next attached as seen in figure 1-29.

Figure 1-29. *The transformer and the filter capacitors*

- Insert and solder the TR1 transformer in its proper location. No problems should be encountered since it can only be inserted in one direction.

- Insert and solder in the C17 and C18 capacitors of 1000 μF. Remember that these both have polarity. The positive leads must be inserted into the hole marked (+).

- Trim the excess lead length flush with the solder for both capacitors.

1.4.15 INSERTION OF THE INTEGRATED CIRCUITS

Almost all of the soldering is now completed. Next we will insert the various integrated circuits into their corresponding sockets. For this, it should be kept in mind that each integrated circuit has its corresponding reference mark on its package. These must be made to correspond with the appropriate reference markings on the base, which in turn correspond with the printing on the board.

It is equally important to ensure that during insertion, none of the chips' pins are bent and that all enter properly. To do this, tilt the chip slightly and insert the pins on one row first. Next, level out the chip and introduce the other row of pins. Finally, press down vertically so that all of the pins are firmly inserted into their holes.

- Insert the XR2206 integrated circuit into socket U5. Its reference marking must be oriented towards the left side of the board.
- Insert the SYM10AA integrated circuit into socket U6. Its reference marking must be oriented towards the left side of the board.
- Insert the 3 alphanumeric displays into sockets U7, U8, and U9. The decimal points on these displays must face towards the bottom.
- At this point we will also attach the control knobs of the P1-P5 potentiometers or variable resistors.
- The two pin jumper caps are inserted in pins 4 and 5 of the JMP1 double-pin strip.

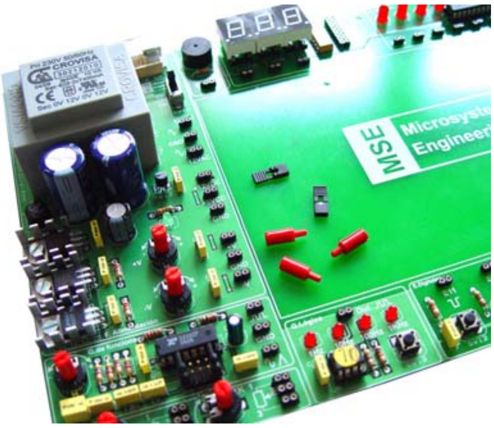


Figure 1-30. *Inserting the integrated circuits*

The photograph in figure 1-30 represents the appearance of the board after these components have been inserted.

1.4.16 THE SPACERS

As shown in figure 1-31.

This is a set of 6 adhesive plastic spacers.

They are placed inside of the 6 holes in the board, until they are embedded.

For now, the adhesive tape should not be removed. This will be done later, when the board is completely ready to be affixed inside of its carrying case.

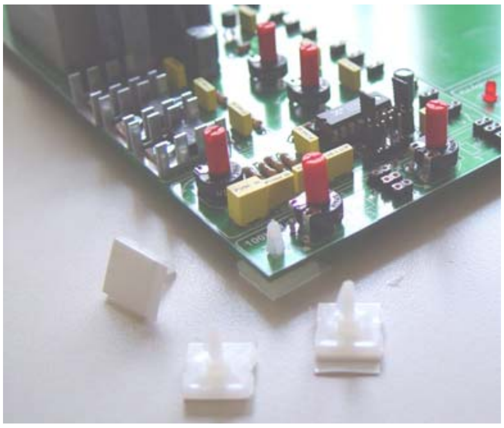


Figure 1-31. *The spacers*

1.4.17 THE PROTOBOARD

This is a set of four separate modules as shown in figure 1-32.

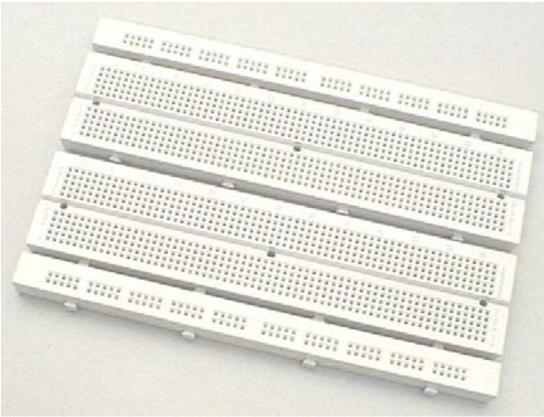


Figure 1-32. *The protoboard*

Each module has molded grooves that allow these to be attached to each other and create a single module.

- Attach the four modules in the arrangement shown in the previous figure, in order to create a single module.
- In the upper part of the module created, attach the three velcro strips, one on each corner.

1.4.18 FINAL APPEARANCE

This is shown in figure 1-33.

Here, the *"Universal Trainer 2"* can be seen completely assembled.

The protoboard has been affixed to the board using the velcro that was attached in the previous section.

This simple attachment of the protoboard to the trainer's printed board will allow the protoboard to be configured with various easily interchangeable circuits.

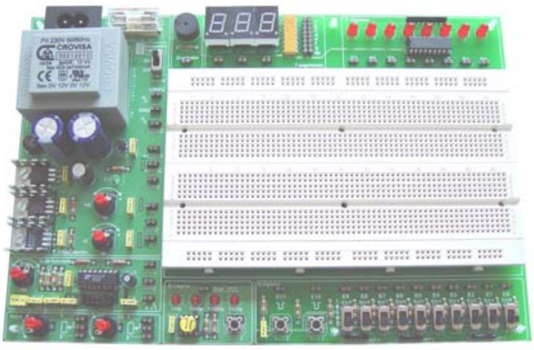


Figure 1-33. *Final appearance*

1.4.19 CARRYING CASE

The *"Universal Trainer 2"* is mounted inside of a plastic case, which allows it to stay protected and be transported easily.

The printed board with the 6 adhesive plastic spacers is placed inside the case, remaining securely attached as shown in figure 1-34.

Figure 1-34. *Final appearance of the "Universal Trainer 2"*

1.4.20 THE WIRES

In order to check the trainer works properly once assembly is finished and later for use during the user's experiments, it is recommended that a series of wires is prepared.

These wires are used to make connections between the various components inserted into the protoboard as part of the user's applications, as well as to connect these applications with the various testing devices and circuits that the trainer provides.

The wire should be rigid and protected with plastic sheathing. A silver wire is preferable to a copper wire. The thickness should not be greater than 0.6 mm, as thicker wire will not fit into the connectors included on the trainer. Thicker wire will also stretch the holes on the protoboard, causing its electrical contracts to begin to fail over time.

It is recommended that wires of various lengths and colors are prepared, in order to facilitate tracing of the circuits. The last 5 mm must be stripped so that the wires can be attached to the protoboard and to the trainer. See figure 1-35.

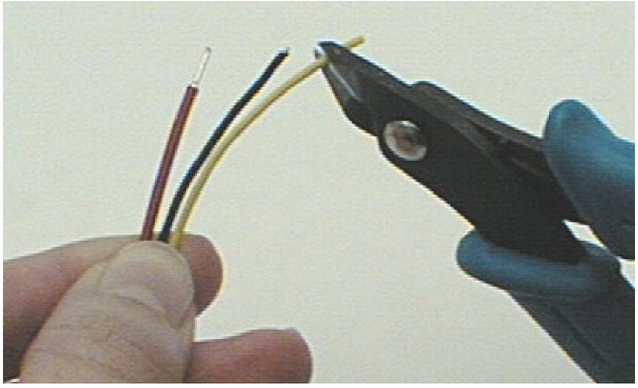


Figure 1-35. *Preparing the connection wires*

SECTION 2: Description of the "Universal Trainer 2"

2.1 INTRODUCTION

This second section of the "*Universal Trainer 2*" manual is dedicated to a complete functional description of each section and electronic circuit, the trainer contains.

Each of these is explained and each is accompanied by a photograph along with the corresponding electrical diagram. It is hoped that the reader will perfectly understand how the system works in its entirety, in order to take maximum advantage of its use.

2.2 THE POWER SUPPLY

Is responsible for using the AC supply current.to generate the various voltages available to the user.

- The input voltage is 220VAC at 50/60Hz
- The maximum total intensity is 800 mA

The voltages available are obtained through the corresponding terminals:

- 12VAC: AC output of 12VAC/400mA
- GND: Ground from supply source 0V
- 12VAC: AC output of 12VAC/400mA
- +12Vdc DC output of 12VDC/100mA
- +5Vdc: DC output of 5VDC/500mA
- GND: Ground from supply source 0V
- +V: Adjustable positive DC output of +1 ≅ +15VDC / 500mA
- GND: Ground from supply source 0V
- -V: Adjustable negative DC output of -1 ≅ -15VDC / 500mA

The photograph in figure 2-1 shows the location of the power supply.

Figure 2-1. *The power supply*

The electrical diagram is presented in figure 2-2.

The 220VAC from the supply grid is applied through the CN1 connector from the power cord. This voltage arrives first at the TR1 transformer after passing the FUS1 protective fuse and the SW10 power switch.

The transformer lowers the incoming 220VAC to 12+12 VAC with a maximum intensity of 800mA. The secondary outputs are available to the user via the terminals marked as 12VAC, GND, and 12VAC. This allows users to implement their own practice exercises and experiments related to full-wave and half-wave rectification, peak clipping, etc.

On the other hand, the 12+12 VAC represented in the secondary transformer is applied to the D1 bridge rectifier. Here it is rectified and filtered via the C17 and C18 capacitors. The C17 terminals will produce positive DC voltage if a ground of approximately +17VDC is applied. The C18 terminals will produce negative DC voltage if a ground of approximately –17VDC is applied.

The C17 terminals' voltage will be sent to various areas. On one hand, it is applied to the UA78L12 (U1) voltage stabilizer circuit, which turns it into a stabilized voltage of +12VDC at 100mA, which the user can access via the terminal marked as +12VDC.

On the other hand, this voltage is also applied to the UA7805 (U2) stabilizer circuit. This provides at its output a stabilized voltage of +5VDC at 500mA. This voltage supplies part of the electronics that make up the "*Universal Trainer 2"*, and is also available to the user via the terminal marked as +5VDC. This can be used to power the user's own applications. A green LED (D2) pilot light is powered by this voltage through the R2 resistor.

Finally, the positive voltage present in the C17 is applied to the LM317T (U3) regulator circuit. This provides stabilized positive voltage at its output, adjustable between approximately +1VDC and +15VDC. The desired voltage is regulated and adjusted using the P2 potentiometer. The minimum voltage is obtained by turning it all the way to the left and the maximum by turning it to the right. This voltage is made available to the user between the +V and GND terminals.

Finally, the C18 terminal makes a negative voltage available, which is applied to the LM337T (U4) regulator circuit. This provides a negative, stabilized voltage at its output, which is adjustable between approximately -1VDC and -15VDC. The regulation and adjustment of the desired voltage is done using the P3 potentiometer. The minimum voltage is obtained by turning it all the way to the left and the maximum by turning it to the right. This voltage is made available to the user between the -V and GND terminals.

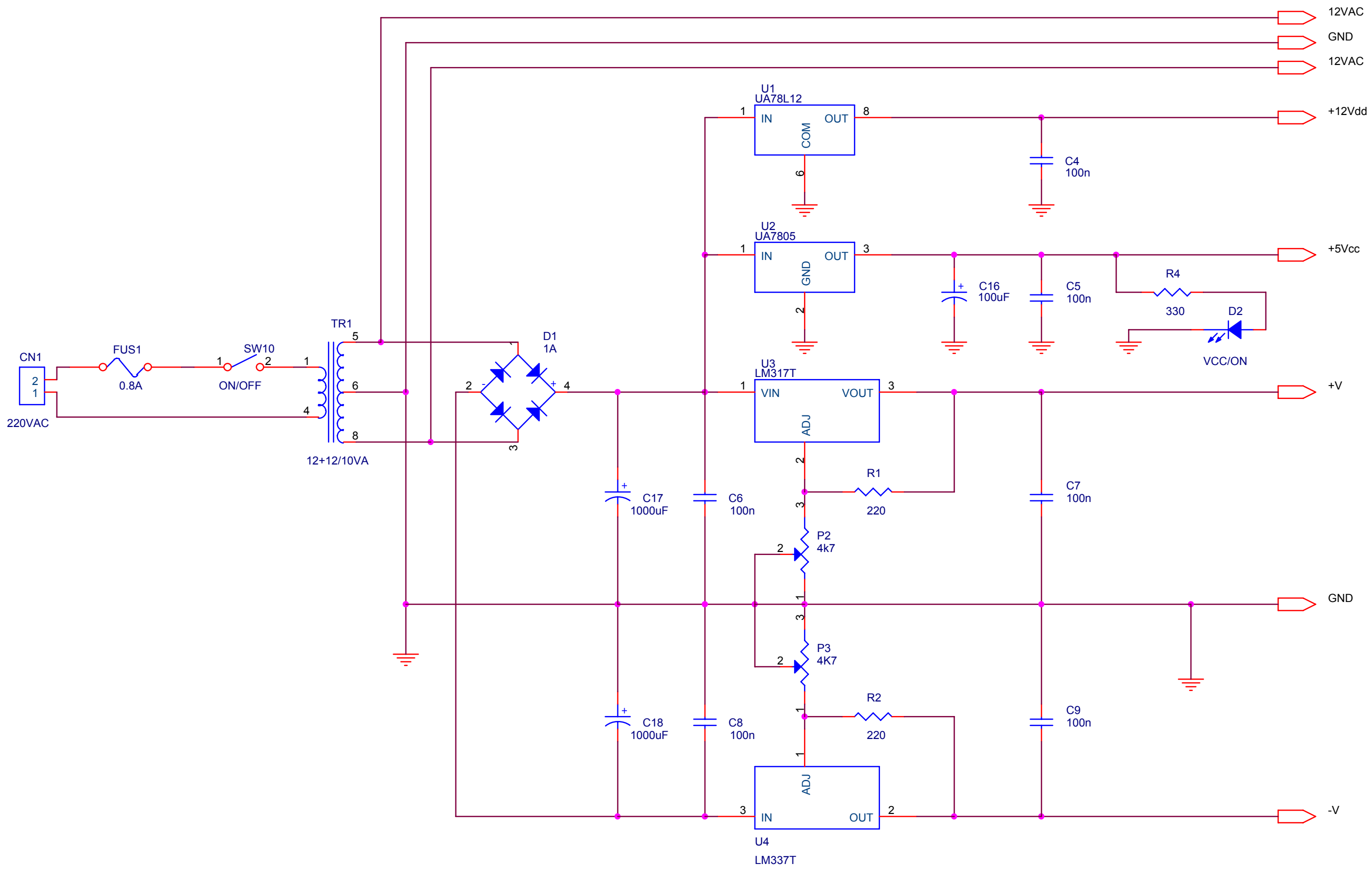


Figure 2-2. Electrical diagram of the power supply

2.3 THE FUNCTION GENERATOR

This provides three types of signals to be used with analog experimental circuits:

- Square
- Sine
- Triangular

Figure 2-3 shows its location on the trainer.

Figure 2-3. *The function generator*

This is based on the XR2206 (U5) integrated circuit, and the corresponding electrical diagram is shown in figure 2-4.

This circuit is supplied by the +12VDC. The square wave signal is obtained between the GND terminal and the terminal marked with the square wave symbol. The sine and/ or triangular wave signals are obtained between the GND terminal and the terminal marked with the sine and triangular wave symbols (SIN/TRI).

You can choose between the sine and triangular waves by using the JMP 1-5 jumper. When this jumper is closed, an approximately 2 Vpp sine wave signal is obtained between the terminals mentioned above. When the jumper is open, an approximately 4 Vpp triangular signal is obtained.

The C14, C10, C2, and C1 capacitors determine the range of frequencies that are generated. Closing the JMP1 jumper in any of these 4 positions will select one of the four capacitors, and therefore a particular range of frequencies, as indicated in table 2-1.

JMP1 in:	Capacitor:	Range
Position 1	C14 of 1 μF	1 Hz to 200 Hz
Position 2	C10 of 100 nF	10 Hz to 2 KHz
Position 3	C2 of 10 nF	100 Hz to 20 KHz
Position 4	C1 of 1 nF	1 KHz to 200 KHz

Table 2-1 *Range of frequencies of the function generator*

The freq. potentiometer (R7) allows adjustment to a specific frequency within a determined range. The frequency selected is applied to the square wave, the sine wave, and the triangular wave.

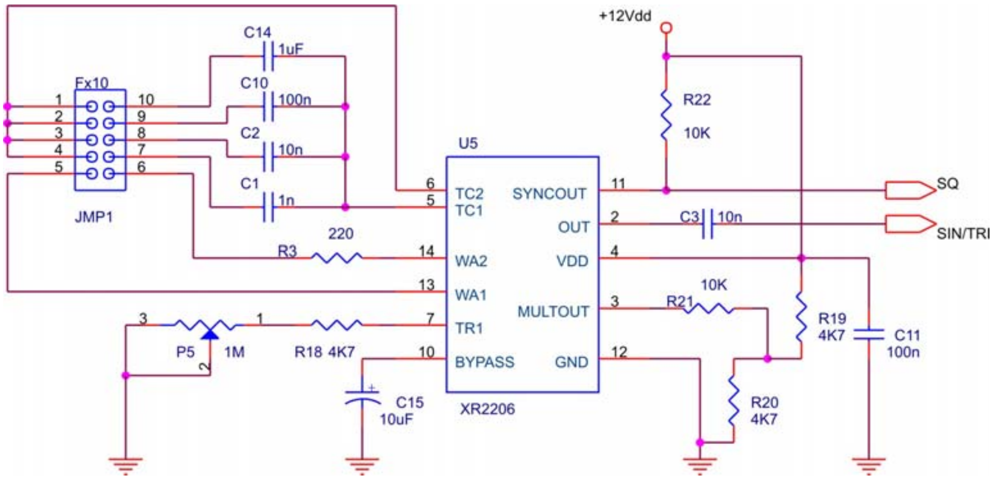


Figure 2-4. *Electrical diagram for the function generator*

2.4 ANALOG POTENTIOMETERS

Their location on the trainer is shown in figure 2-5.

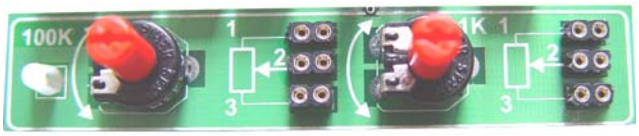


Figure 2-5. *The potentiometers*

They allow the user to analyze and experiment with circuits that require analog input variables, such as for analog-to-digital converters (ADC), reference adjustments, offset adjustments, input signal attenuation, etc.

As seen in the electrical diagram, figure 2-6, the potentiometers do not have any connections or relationships with the "*Universal Trainer 2*". Users can make use of these according to their own needs and applications.

The P1 potentiometer is of 1KΩ, while the P4 is of 100KΩ.

Each potentiometer is individually associated with three terminals numbered 1 to 3.

Referring to the electrical diagram, and as printed on the circuit board, it can be seen that terminals 1 and 3 correspond to the two potentiometers' extremes. They represent their full resistance values.

The number 2 terminals correspond to the wipers, through which a variable resistance value is obtained with respect to either of the extremes.

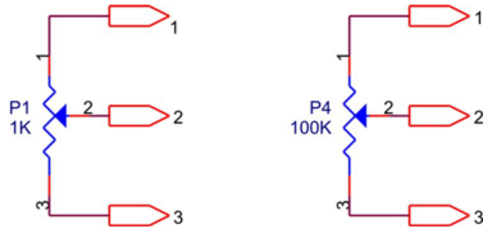


Figure 2-6. *Electrical connections of the potentiometers for analog input variables*

2.5 DIGITAL INPUTS, THE LOGIC ANALYZER

This is a square wave analyzer useful or necessary for some digital applications, circuits, or experiments the user may carry out. The photograph in figure 2-7 shows its appearance.

Figure 2-7. *The logic analyzer*

This generates a square wave with a 50% duty cycle and a frequency that is selected sequentially from among 4 values by pushing a button.

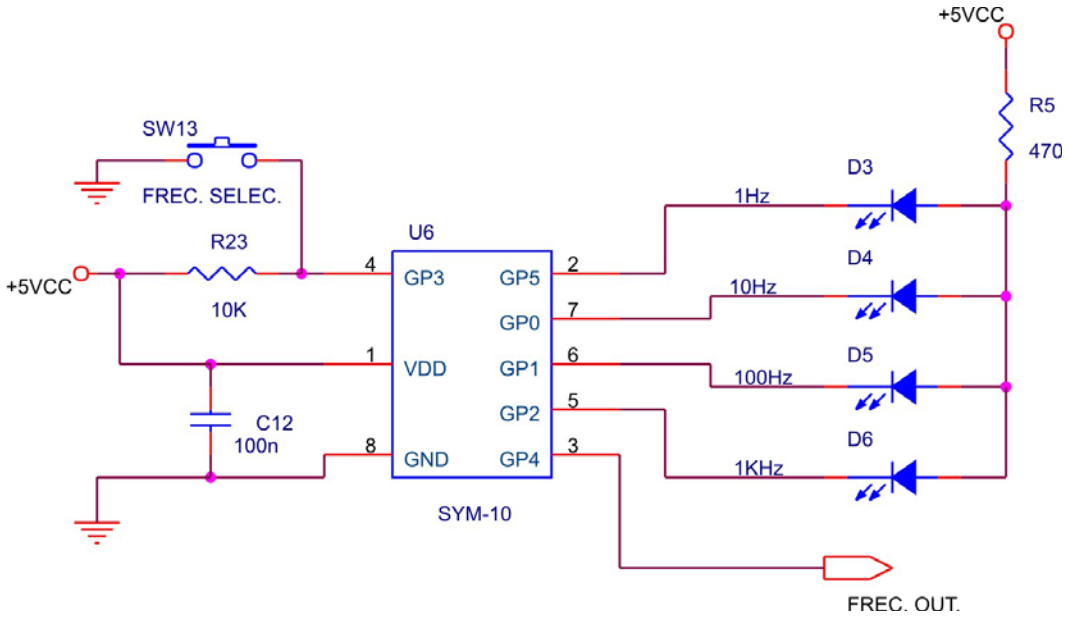


Figure 2-8. *Electrical diagram for the logic analyzer*

As shown in the electrical diagram in figure 2-8, the analyzer is based upon the SYM10AA (U6) programmed circuit.

The SW13 button is used to select the output frequency by pressing sequentially. This frequency is available through the OUT terminal and can vary between 1Hz, 10Hz, 100Hz, and 1KHz. The default output is 1 Hz.

The analyzer is connected to four LEDs (D3-D6), which always indicate the frequency that is being generated.

2.6 DIGITAL INPUTS, THE BUTTONS

Two buttons located on the "*Universal Trainer 2*" as seen in figure 2-9 allow manual generation of temporary or pulsing digital signals.

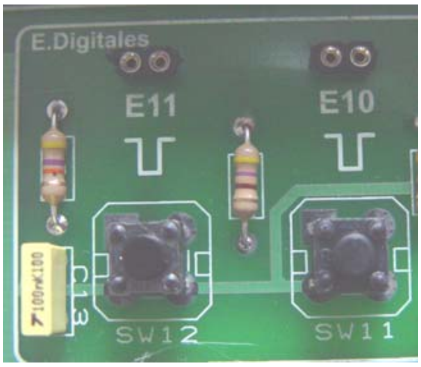


Figure 2-9. *The buttons*

The electrical diagram for these is shown in figure 2-10. The E10 terminal corresponds to the SW10 button, and the E11 terminal to the SW11 button. When either of these buttons is up, a level logic "1" signal can be obtained from the corresponding terminal, thanks to the corresponding "pull-up" resistors.

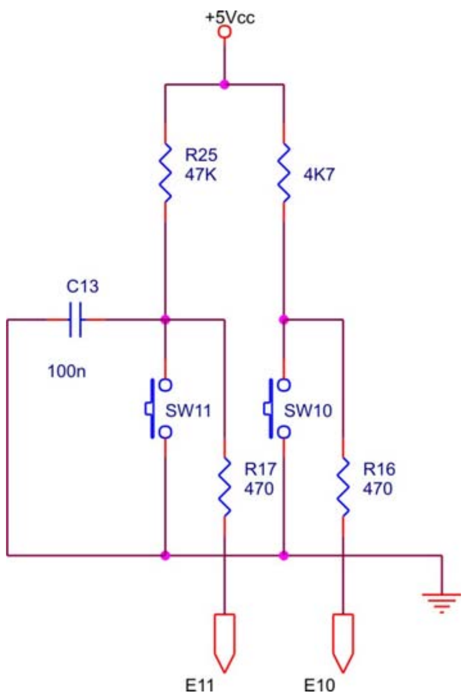


Figure 2-10. *Electrical diagram for the buttons*

When one of these buttons is pushed, a circuit is closed with the GND. A logic level "0" is then obtained at the corresponding terminal.

In other words, the action of pushing and releasing one of these buttons causes a negative pulse to emerge at the corresponding output terminal, changing from logical high to logical low and returning to logical high upon release.

It should be emphasized that the pulses obtained by the E11 eliminate the rebound effect as much as possible by using the C13 capacitor. However, the E10 is not protected from this effect. Since this trainer is a meant to be a teaching-based device, we think that anti-echo techniques and circuits should be studied and applied by users in their own applications and experiments. These techniques are explained in the various learning modules that **Ingeniería de Microsistemas Programados** provides for its customers and users.

2.7 DIGITAL INPUTS, THE SWITCHES

A set of 10 switches is provided, with wiring that allows binary strings or logic states to be generated, which will be applied for the user's circuits being analyzed. See figure 2-11.

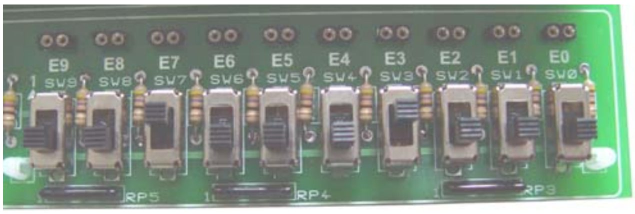


Figure 2-11. *The switches*

The ten switches numbered SW0 to SW9 are clearly labeled in the printing seen on the board. Each switch is associated with its corresponding terminal. These run from E0 to E9. The terminals are used to make connections between the switches and the user's circuit being tested.

To the left of the SW9 switch, markings can be seen indicating that if a switch is in the up position, a logic level "1" is provided, and if in the down position, a logic level "0" is provided.

Figure 2-12 shows the electrical diagram for the logic switches.

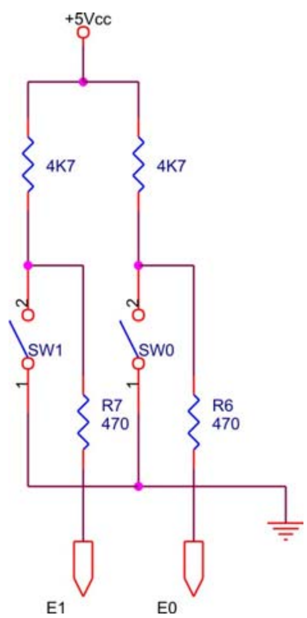


Figure 2-12. *Electrical diagram for the switches*

When any of the 10 switches is open (in the up position), the logic signal it generates is level "1", thanks to the corresponding pull-up resistors. When a switch is slid to the down position, the circuit is closed with the GND line. The logic level then obtained is "0". It must be remembered that, as in the case with one of the buttons, the switches are not protected against echoes.

It is understood that in actual industrial or commercial applications, etc., multiple types of devices are available that are capable of generating logic input signals. However, for teaching purposes, buttons and switches are the most simple and economical devices that exist for generating such signals. What really matters is, knowing how to interpret these signals, how to handle them, and how to process them to obtain the desired result.

2.8 DIGITAL OUTPUTS, THE LED DIODES

A set of 8 illuminating diodes (LEDs) are used to represent the binary strings or logic states that are obtained as a result of a particular process. See figure 2-13.

Figure 2-13. *The LED diodes*

These are numbered from D7 to D14, and each is associated with a corresponding connection terminal. These terminals are numbered as S0 to S7, with S0 corresponding to the LED on the right.

The electrical diagram in figure 2-14 gives us an idea of the circuit associated with each LED.

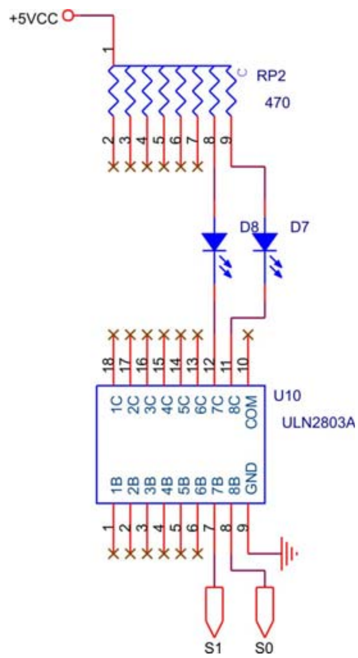


Figure 2-14. *Electrical diagram of the output LEDs*

Only the circuits corresponding to the first two are shown which correspond to the S0 and S1 terminals. The ULN2803A (U10) amplifier circuit allows for connections with the other six LEDs on the trainer.

The digital signal to be visualized is connected, from the user's circuit to the desired terminal (Sn), in order to apply it to the amplifier's input. This amplifies the intensity of the signal and applies it to the corresponding LED (Dn). The resistors connected to the anodes of each LED are each contained in a single capsule, or package (RP2). They are of 470Ω and act as absorption resistors.

When a signal with logic level "1" is applied to one of the terminals (Sn), the corresponding LED will light up. In the opposite case, it remains unlit.

As with the switches and buttons, the LEDs are simple and economical output devices that allow visualization of particular logic states. In reality, of course, more complex output devices exist such as motors, relays, solenoid valves, etc.

What matters is learning to control their activation or deactivation based upon particular processes or algorithms.

2.9 DIGITAL OUTPUTS, THE BUZZER

The buzzer's location on the "*Universal Trainer 2*" is shown in figure 2-15.

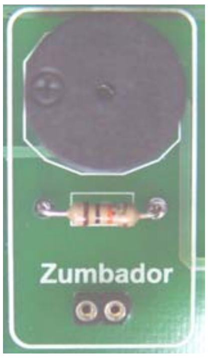


Figure 2-15. *The piezoelectric buzzer*

This is a simple output device that transforms a logic level "1" signal into an audible sound. Its electrical diagram is presented in figure 2-16.

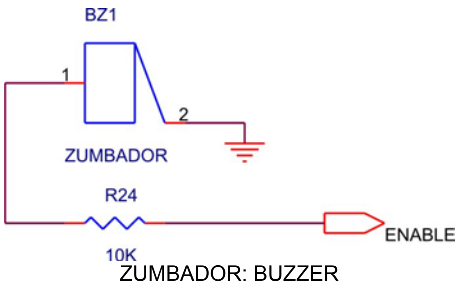


Figure 2-16. *Connection diagram for the buzzer*

The logic signal is applied to the corresponding connection terminal. If this is level "1", the buzzer is activated through the R24 absorption resister.

The buzzer is not included on the trainer for any special reason, but it can provide an attractive feature for some of the practice exercises or experiments performed by the user.

2.10 DIGITAL OUTPUTS, THE DISPLAYS

This is a set of 3 displays that each have 7 segments and a decimal point.

This is a classic type of peripheral device for any type of digital application. Used correctly, any type of numerical information or even certain symbols or signs can be displayed.

These displays greatly increase the number and types of applications and experiments that can be performed, which in turn enriches the equipment's range of teaching possibilities.

The photograph in figure 2-17 shows the location of these on the "*Universal Trainer 2*".

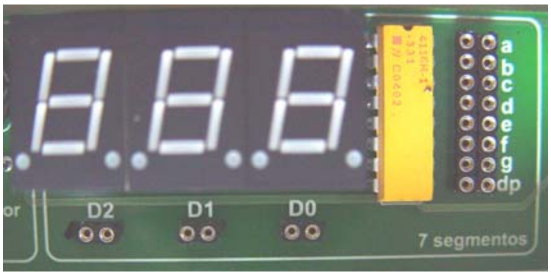


Figure 2-17. *The 7-segment displays*

The diagram in figure 2-18 shows the electrical connections for the three displays.

By default the displays installed in the trainer are of the common-anode type. These can be replaced with common-cathode types, as long as the pin arrangements are compatible.

As seen in the diagram, these are SA43-11HWA types or their equivalents (U7, U8, U9).

The three displays are connected in parallel. In other words, the individual segments on each display are connected to each other. This way, the connection terminal corresponding to segment *a* accesses segment *a* on all three displays, the *b* all three *b*'s, the *c* all three *c*'s, etc.

This is probably the most common type of arrangement. It avoids the need to connect all 8 segments of however many displays there may be, thereby greatly reducing the number of connections.

The terminals marked as D0, D1, and D2 access the corresponding anodes. It should be noted that this is the common pin for all of the segments on each display.

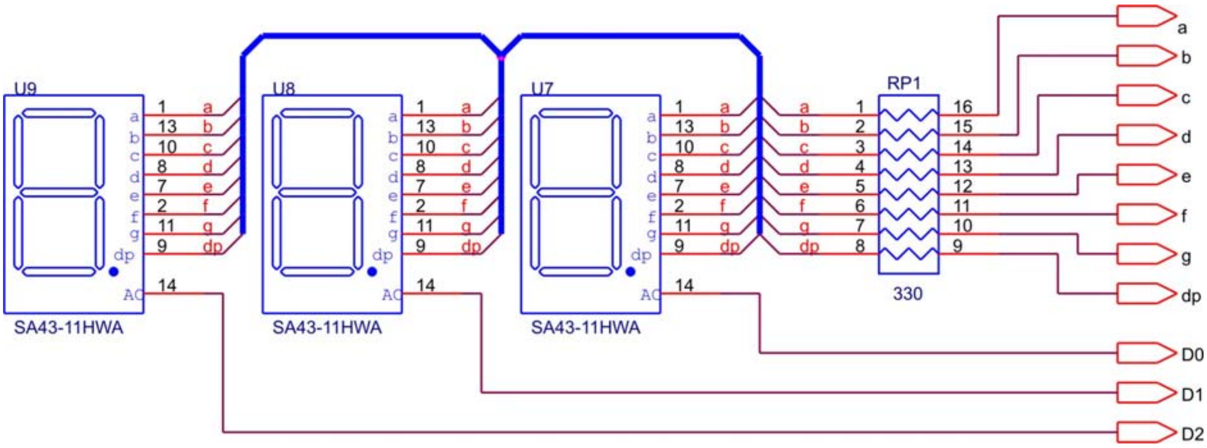


Figure 2-18. *Electrical diagram for the displays*

When one of these three terminals receives a high level "1" signal, the corresponding display will be activated. Later illumination of each individual segment will depend on the logic levels that are applied to the terminals corresponding to the segments (*a, b, c, d, e, f, g, and dp*). With common anode displays, the segments need a logic level "0" to be illuminated. If common cathode displays are used, the segments need a logic level "1".

The resistors associated with each segment are the absorption type. All of these are contained in the same package (RP1), and their value is 330Ω.

The arrangement of the displays in parallel is known as a "multiplexed display". The number of connections that must be made is reduced, but their control becomes a little more complex. Obviously only one display can be activated at the same time, but sequential, repetitive selection of all of them creates the optical sensation that they are all illuminated.

2.11 THE PROTOBOARD

This is the board where the user will install and wire the various circuits. This is a universal board with multiple standardized holes spaced at a distance of 2.54 mm. See figure 2-19.

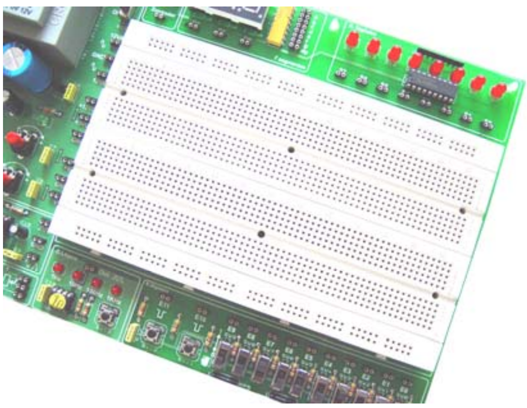


Figure 2-19. *The protoboard*

The use of this type of board is especially well-suited for settings involving teaching, research, experimenting, etc. The assembly of any circuit can be performed quickly, safely, and efficiently without any soldering. Changes of components and connections can be established quickly, and materials can be re-used. All of this increases the trainer's value for research, study, and experimenting involving electronic circuits in general.

The board used with the "*Universal Trainer 2*" has a surface of 168 x 100 mm and has 1480 connection points. It is wide enough to support reasonably complex circuits. Also, if it is attached to the trainer using velcro strips, as explained in the previous section, it is possible to make use of a variety of board modules with different circuits. These can be easily swapped to allow analysis at the proper moment.

The board module does not have any type of electrical connection with the various devices described above for the trainer. The connections between these devices and the experimental circuit created on the board takes place using wires. These should be rigid and coated, with a thickness no greater that 0.6 mm, thicker wires will stretch the holes on the board, and eventually connections will not remain secure.

All of the holes on the board are connected to each other internally according to their positioning, which is shown in figure 2-20.

The five holes in each of the columns are connected to each other, but no column is connected to any of the others. In total there are 256 columns isolated within themselves.

If, for example, the lead of a resistor is inserted into a hole in one column and the lead of another resistor into another hole in the same column, the leads of both resistors will be electrically connected.

The spaces that separate the upper group of columns and the lower group are necessary for insertion of integrated devices with DIL-type packages.

There are four horizontal rows, two in the upper part of the module and two more in the lower part. Each of these is in turn divided into two sections. Therefore, there are eight sections. Each section has a total of 25 holes that are electrically connected to each other.

The horizontal sections can be used, among other purposes, to transport the power supplies that the circuit being tested requires.

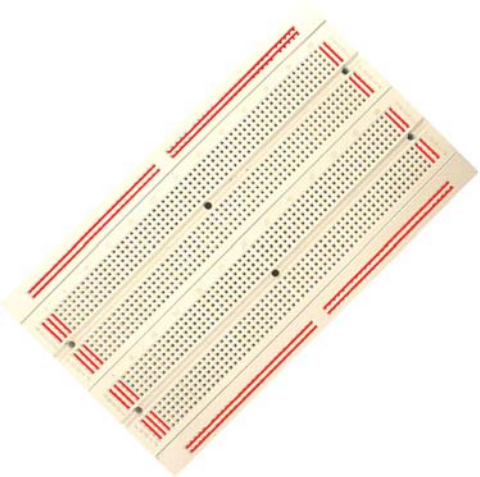


Figure 2-20. *Organization of the board's modules*

SECTION 3: Testing the Universal Trainer 2

3.1 INTRODUCTION

The manual's final section outlines testing the trainer to verify that it is functioning correctly. This is of special interest to customers and users, who have chosen to buy the "*Universal Trainer 2"*, in the self-assembly kit.

The trainer is a piece of equipment, designed for teaching and experimenting, for anybody interested in electronics: technicians, students, lab workers, instructors, researchers, developers, hobbyists, etc. For this reason, **Ingeniería de Microsistemas Programados S.L.** recommends buying the trainer in the self-assembly kit. The Assembly of the trainer as explained in SECTION 1, study and analysis of its design as explained in SECTION 2, and final testing as explained here in SECTION 3, will provide the highest degree of enrichment for anybody interested in electronics. It also brings a higher degree of personal satisfaction to any user of the learning system to have also been the one to assemble and test it.

However, **Ingeniería de Microsistemas Programados S.L.** also sells the "*Universal Trainer 2*" as a fully assembled and tested version. Those who choose this option will receive the equipment in good condition, ready to use.

The trainer does not need any kind of special adjustments in order to function. However, in order to test that it works properly, the following elements are needed:

- Multimeter
- Oscilloscope (optional)
- Various rigid wires 0.6 mm thick, with 5 mm of their ends stripped.

The testing and measurements should be performed step-by-step, whilst noting down the results in the corresponding tables or comments boxes. This way, we will maintain a written record of the measurements taken.

For some of the tests, the theoretical value that should be obtained is provided. These do not need to coincide exactly with the values actually measured. There could be some variation because of the components' tolerances or the instruments used, or because of the conditions under which measurements were taken.

3.2 THE POWER SUPPLY

The supply is responsible for providing the various types of voltages needed for the user's applications and experiments, derived from the 220VAC power grid. For its thorough testing, only a basic multimeter is needed.

Plug the trainer's power cord into the socket. Turn on the SW10 power switch. The D2 LED pilot light should light up.

3.2.1 VAC outputs

There are two AC currents that are obtained directly from the secondary output of the TR1 power supply transformer. These are made available via the 12VAC, GND, and 12VAC terminals. These can be used for classic rectification experiments for half and full waves, peak trimming, etc.

In order to take a measurement, set the multimeter's voltmeter to ACV, and choose a scale of greater than 20V. Place the testing probes in the terminals indicated on the table, take the proper measurements, and note them down below.

Place the tester's probes between the:	12VAC and GND	GND and 12VAC	12VAC and 12VAC
THEORETICAL	12 V	12 V	24 V
ACTUAL			

3.2.2 Fixed DC voltages

They are the two DC currents that are obtained between the GND, +5VDC, and +12VDC terminals. The +5VDC voltage will be used in most of the digital practice exercises.

The multimeter's voltmeter should be set to DCV, and a scale greater than 12V, should be selected. The point of the black probe is connected to the GND terminal and the red probe to the +5VDC and/or +12VDC. Take the following measurements and write them down

Measurement between:	GND and +5VDC	GND and +12VDC
THEORETICAL	+ 5 V	+ 12 V
ACTUAL		

3.2.3 Variable DC voltages

They are two DC voltages that can be adjusted between a minimum and a maximum. In this way, any experimental circuit can be powered with the voltage it needs.

One voltage is positive with respect to the ground GND, which is obtained between the GND and +V terminals. The voltage is adjusted using the P2 potentiometer (+V). Turning the knob all the way to the left produces the minimum voltage. Turning it all the way to the right produces the maximum positive voltage.

The other voltage is negative with respect to the ground GND, which is obtained between the GND and -V terminals. This voltage is adjusted using the P3 potentiometer (-V). Turning the knob all the way to the left produces the minimum voltage. Turning it all the way to the right produces the maximum negative voltage.

In order to measure them, set the multimeter's voltmeter to DCV and select a scale around 20V. The point of the black probe must be connected to the GND terminal and the red probe to the +V and/or -V, depending upon the measurement to be taken. Write the values measured in the following table.

Measurement between:	GND and +V	GND and –V
MINIMUM		
MAXIMUM		

3.3 THE FUNCTION GENERATOR

This generates a series of square, triangular, and sine waves of various frequencies. It is mainly used for analysis and experiments involving analog or operational circuits, etc.

The square wave signal is obtained between the GND terminal and the terminal marked with the square wave symbol. The sine or triangular waves are obtained between the GND terminal and the terminals marked with the corresponding symbols.

Selection of either the sine or triangular wave is performed by using jumper 5 of the JMP1. If closed the sine is obtained, if open, the triangular.

Depending on whether the 1, 2, 3, or 4 jumpers of the JMP1 are closed, frequency ranges can be obtained from 1 to 200Hz, from 10 to 2KHz, from 100 to 20KHz, and from 1KHz to 200KHz, respectively. Within a particular range, the P5 potentiometer (Freq) allows adjustment between the range's minimum (turned to the left) and maximum (turned to the right).

The oscilloscope is the ideal instrument to verify that it is working properly. With this instrument, the various wave forms can be seen, and their periods, frequencies, and amplitudes measured. A frequency meter can also be of great help.

However, since these are expensive instruments that are not available to every user, a simple test can be performed that will allow the functioning of the generator to be evaluated reasonably well.

3.3.1 Simple testing

We will test the square wave output. We will assume that if this wave is being generated properly, the sine and triangular waves are too.

- Using a rigid wire 0.6 mm thick and with 5 mm of its ends stripped; connect the square wave output terminal to the terminal corresponding to the S7 LED.
- Turn the P5 potentiometer all the way to the left.
- Close jumper 1 on the JMP1.
- The S7 LED should blink at approximately 1 cycle per second.
- As the potentiometer's knob is slowly turned up, the S7 should be seen blinking with increasing speed. When the knob is all the way right, the output frequency is about 100 Hz. Now the blinking of the light is so fast that it appears to us optically to be permanently lit.
- Now close jumper 2 on the JMP1 and turn the R7 potentiometer all the way to the left. The LED blinks at a frequency of approximately 10 times per second.
- Closing any other position on the JMP jumper generates frequencies that keep the LED illuminated regardless of the position of the P5 potentiometer.

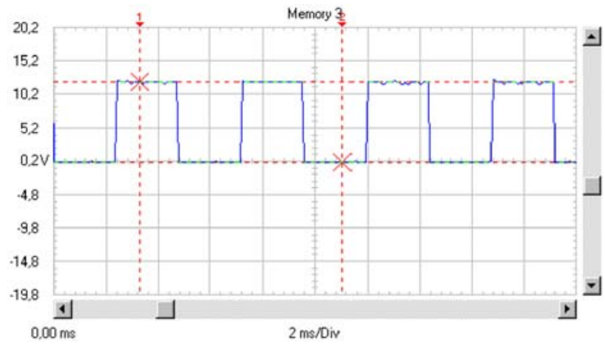
3.3.2 Testing with oscilloscope and/or frequency meter

The use of either of these two instruments allows more exhaustive testing of the trainer's function generator.

Square wave

This is a 12Vpp signal that is shown on the oscillogram in figure 3-1.

Figure 3-1. *The square wave*



Place the oscilloscope's probes between the GND terminal and the square wave output terminal.

Close the JMP1 jumpers in the positions indicated in the table below. With the P5 potentiometer turned all the way left (minimum frequency) and all the way right (maximum), fill in the table with the values measured.

JMP1 in position:	1	2	3	4
Minimum F.				
Maximum F.				

Sine wave

This is a signal of about 2 Vpp that is obtained between the GND terminal and the terminal marked with the sine/triangular symbol, when jumper 5 on the JMP1 is closed. This is shown in figure 3-2.

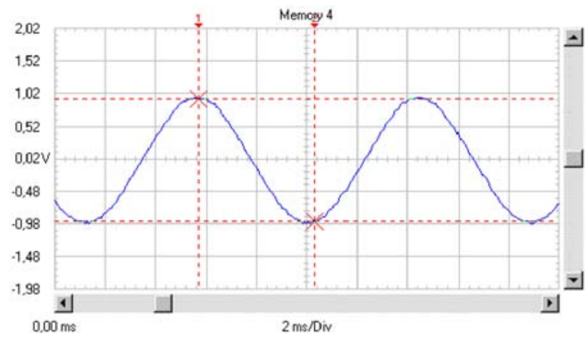


Figure 3-2. *The sine signal*

Place the oscilloscope's probes between the GND terminal and the sine/triangular wave output terminal.

Close the JMP1 jumpers in the positions indicated in the table below. With the P5 potentiometer turned all the way left (minimum frequency) and all the way right (maximum), fill in the table with the values measured.

JMP1 in position:	1	2	3	4
Minimum F.				
Maximum F.				

Triangular wave

This is a signal of about 4 Vpp, which was obtained between the GND terminal and the terminal marked with the sine/triangular symbol, when jumper 5 on the JMP1 is open. See figure 3-3.

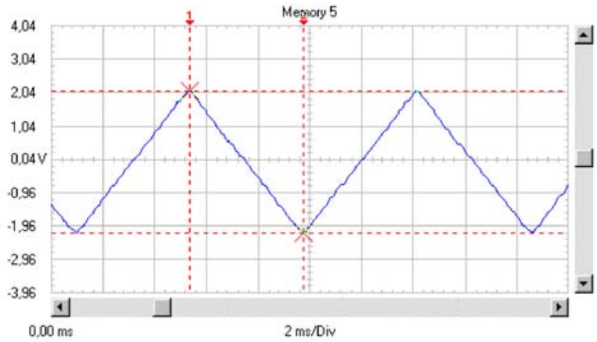


Figure 3-3. *The triangular wave*

Place the oscilloscope's probes between the GND terminal and the sine/triangular wave output terminal.

Close the JMP1 jumpers in the positions indicated in the table below. With the P5 potentiometer turned all the way left (minimum frequency) and all the way right (maximum), fill in the table with the values measured.

JMP1 in position:	1	2	3	4
Minimum F.				
Maximum F.				

3.4 THE POTENTIOMETERS

The "*Universal Trainer 2*" provides the user with two adjustable potentiometers that can be used with various experimental circuits for adjusting amplitudes, offsets, analog variables, etc.

P1 has a value of 1KΩ and P4 of 100KΩ. Each of these has three associated connection terminals. Terminals number 1 and 3 correspond to the extreme resistance values, and number two to the wiper in between them.

Their correct functioning can be checked with a simple multimeter set to the ohms scale.

P1

- Measure and write down the total resistance present between terminals 1 and 3.

....

- Turn the knob to approximately the center of its range.
- Measure and write down the partial resistance present between terminals 1 and 2.

....

- Measure and write down the difference in resistance between terminals 2 and 3.

....

P2

- Measure and write down the total resistance present between terminals 1 and 3.

....

- Turn the knob to approximately the center of its range.
- Measure and write down the partial resistance present between terminals 1 and 2.

....

- Measure and write down the difference in resistance between terminals 2 and 3.

....

3.5 THE LOGIC ANALYZER

It generates square waves of various frequencies and about 5Vpp of amplitude. It is used especially for digital experimental circuits.

The output frequency is selected sequentially by pushing the SW13 button, and varies between 1Hz, 10Hz, 100Hz, and 1KHz, with 1Hz being the default frequency.

This frequency is obtained from the corresponding Out-terminal. A group of four LEDs indicate the frequency being generated at all times.

Use a rigid wire to connect the generator's output with any of the S0-S7 LEDs. With a frequency of 1Hz, the LED will be seen to light up once per second. As the frequency is increased, it will be obvious as the blinking becomes faster. With a frequency of 100Hz or 1KHz, the LED remains almost permanently lit.

3.6 THE BUTTONS

They allow logic pulses to be generated each time they are pushed. The trainer has two buttons available, the SW11 and SW12, which correspond to the E10 and E11 terminals, respectively.

Using the multimeter's voltmeter set to DCV, fill in the following table. To do this, place the point of the black probe in GND and the red in the E10 and E11 terminals.

Button	Pushed	Not pushed
SW11 (E10)		
SW12 (E11)		

3.7 THE SWITCHES

A set of 10 switches allow logic levels or binary strings to be generated, to be applied and used by the digital circuit that is being tested.

The 10 switches SW0 to SW9 are associated with their corresponding connection terminals E0 to E9, respectively.

To test that they work properly, a multimeter's voltmeter can be used, set to DCV, in order to test the voltage or logic level that is generated when the switches are slid up or down. The point of the black test probe is placed in GND and the red probe in each of the E0 – E9 terminals. Fill in the following table.

Switch	Down	Up
SW0 (E0)		
SW1 (E1)		
SW2 (E2)		
SW3 (E3)		
SW4 (E4)		
SW5 (E5)		
SW6 (E6)		
SW7 (E7)		
SW8 (E8)		
SW9 (E9)		

3.8 THE LEDS

A set of 8 LED diodes allow visualization of various logic patterns that the digital circuit, which is being tested may generate. These are numbered D7 to D14 and correspond to connection terminals S0 – S7.

For testing, we are going to use the switch with input E0. A wire will be connected from this E0 terminal to each of the S0 – S7 terminals. Using the switch, logic level "0" and logic level "1" will be generated, which will cause the corresponding LED to turn OFF or ON.

Test the functioning of each of the LEDs and write down the state it is in on the following table, depending on the logic level that is applied from the SW0 switch (E0).

LED #	SW0 (E0) = “0”	SW0 (E0) = “1”
D7 (S0)		
D8 (S1)		
D9 (S2)		
D10 (S3)		
D11 (S4)		
D12 (S5)		
D13 (S6)		
D14 (S7)		

3.9 THE DISPLAYS

The “*Universal Trainer 2*” has a total of 3 displays, containing 7 segments (*a, b, c, d, e, f, g*) plus a decimal point (*dp*). They can be used in any application or experiment that may require numbers to be visually displayed.

As explained in the previous section, these displays are of the common-anode type and are connected in parallel. In other words, all of the segments are connected to each other and correspond with the cathodes.

For testing them, we will use a wire to connect the individual D0, D1, and D2 anodes with the +5VDC supply terminal. By doing this, the anode of a display will be activated.

Using another wire, the E9 terminal of switch SW9 is connected with one of the segment terminals (*a, b, c, d, e, f, g* and *dp*).

When this switch is used to apply logic level "0", the corresponding cathode is activated, causing the segment to light up.

Testing the D0

Connect the D0 terminal with the +5VDC terminal. Using E9, apply logic levels to each of the segments and fill in the following table, indicating ON/OFF depending upon whether or not that segment lights up.

Segment	SW9 (E9) = “0”	SW9 (E9) = “1”
A		
B		
C		
D		
E		
F		
G		
Dp		

Testing of D1

Connect the D1 terminal to the +5VDC terminal. Using E9, apply logic levels to each of the segments and fill in the following table, indicating ON/OFF depending on whether or not that segment lights up.

Segment	SW9 (E9) = "0"	SW9 (E9) = "1"
A		
B		
C		
D		
E		
F		
G		
Dp		

Testing of D2

Connect the D2 terminal to the +5VDC terminal. Using E9, apply logic levels to each of the segments and fill in the following table, indicating ON/OFF depending upon whether or not that segment lights up.

Segment	SW9 (E9) = "0"	SW9 (E9) = "1"
A		
B		
C		
D		
E		
F		
G		
Dp		

3.10 THE BUZZER

This emits an audible signal each time its connection terminal receives a logic level "1" signal.

Its testing procedure is very simple. Just use a wire to connect terminal E0 of switch SW9 to the "Buzzer" terminal.

Each time the E9 input is at "1", the piezoelectric buzzer will emit an audible signal. Test it.