Assembly Instructions for FK244-Aus *(25 Tone Monophonic Stylus Organ)*

What it does:

This kit generates a single note whenever the Stylus(“Probe”) touches any of the keyboard pads (“Keys”) .

This is an ideal classroom project where several aspects of the STEM curriculum come together. This utilizes basic electronics in a practical application, which demonstrates several learning objectives. The kit builder will have the opportunity to use an Industry standard Integrated Circuit, build a transistor multivibrator and discover the relationship between Resistance-Capacitance (“R-C”) networks and frequency of the oscillations. The project also crosses the boundary between electronics and musical expression.

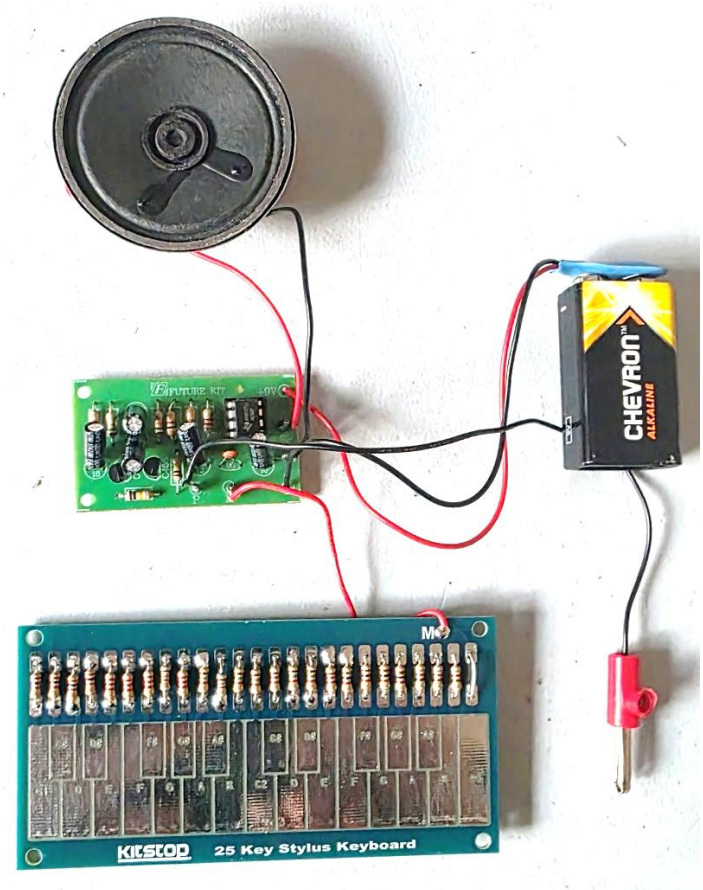

Fig 1: Finished Product

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What we are making:

This system consists of 5 main "components":

- The Motherboard consists of the Oscillator and Audio Amplifier.
- The Keyboard is a Resistor network (Laid out to simulate an electronic organ keyboard)
- The "Stylus"
- The speaker
- The Battery

It's key Features are:

- Single keyboard designed so that conventional resistors may be either surface mounted OR inserted "Through-hole" , which allows Teachers to offer an exercise in either construction technique.
- Two board construction allows for the electronics Motherboard to be installed inside an enclosure for protection or to "hide" that module.
- Simulation of a conventional keyboard layout.
- Resistor values have been optimized to give an "equal temperament" tone scale.

Technical Specs:

- Power supply: 9V DC
- Current Average: 83 mA (max.) when working. 9mA (standby) .
- Number of tones: 25
- PCB dimensions: 115 x 57 mm (keyboard) & 54.4 x 31.5 mm (Motherboard)

Circuit Diagram:

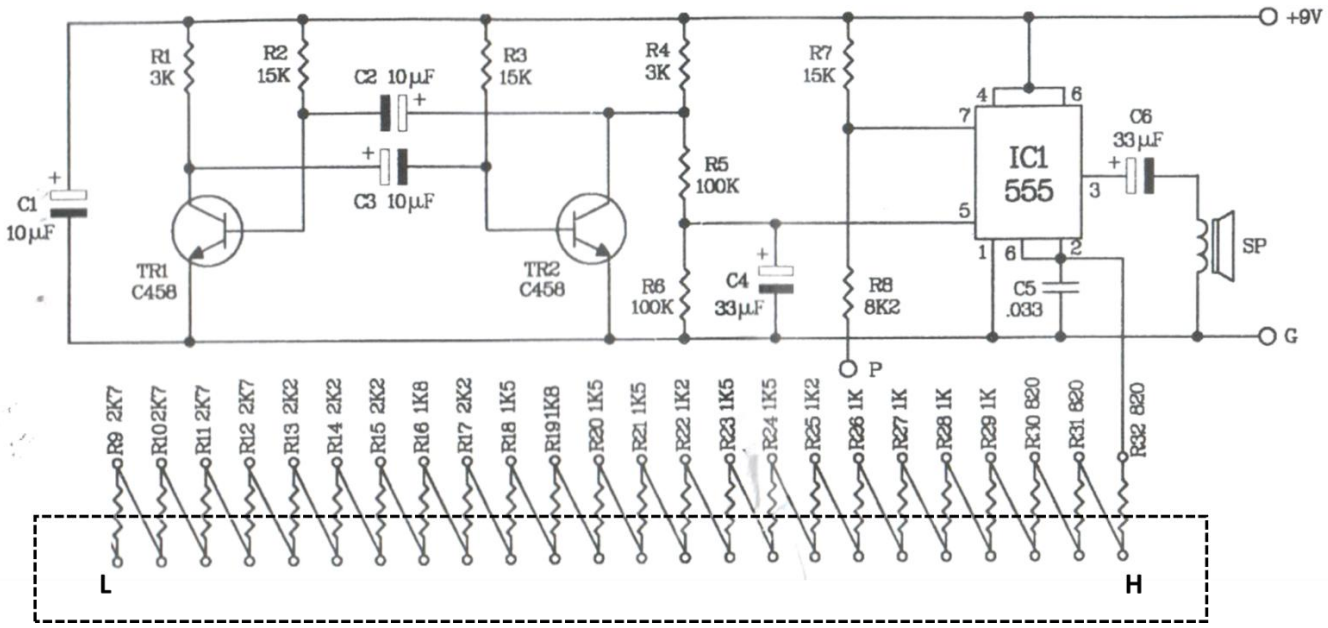


Fig 2: Circuit Diagram for the system.

How it works:

Refer to the Circuit Diagram in Figure 2. Different frequencies, or notes are selected by touching the Probe (P) or Stylus to the points contained within the dotted line (these relate to different "keys" on the keyboard PCB).

The probe completes a feedback circuit that discharges C5 through the combined resistors selected on the keyboard, R8 and the open collector amplifier at Pin 7 on the LM 555.

As the voltage on C5 reduces below the threshold level on pins 6 and 2 the output (pin 3) of the LM555 starts to conduct. And shuts off the pin 7 discharge circuit. The capacitor charges up, Pin 3 turns off and pin 3 turns on a gain and so the cycle repeats or oscillates. The charge/discharge time is increased when the value of the resistor chain is increased. The longer the Charge/Discharge time the lower the oscillation frequency obtained. The lowest frequency is obtained at point "L" which is actually the sum of all of the resistors R9 to R32 plus R8.
Selecting resistor points below "L" raises the frequency so at (point "H"). where the value of the padding resistor the lowest available resistance gives us the highest frequency.

The slight tone quiver, or **vibrato**, heard in real musical instruments is achieved by injecting a low frequency signal, created by the capacitance-filtered square wave output of the TR1 TR2 multi-vibrator, into pin 5. This will "pull" LM555's signal very slightly either side of its free running frequency.

Before you start:

1) Make sure that you have all your equipment available. You will need:
    a. Soldering Iron
    b. Solder
    c. Cleaning pad (We recommend sponge which is wet with water).
    d. Side Cutters
    e. Kit FK244 plus the Keyboard PCB
    f. Instruction sheet
    g. A waste bin (or bag) close by for a lot of small "off cuts".
    h. We recommend a clean mat or surface protector for your desk.
    i. Ensure that you are in a well ventilated area. The fumes from the solder resin can become annoying (though they are not toxic to humans).
    j. Wash your hands after working with the electronics kits and the solder. Especially before you eat anything ! !

2) Ensure that you have plenty of space around you. (You are going to need to "spread out" your components at the start, and avoid getting them mixed with some-one else's.)

3) Ensure that you have good lighting to see and read your components.

4) We recommend that you also have some spare "bags" (or other containers) to store your components and work between classes. This is in the event that you do not get everything finished in one session.
(It can be disappointing to spend some time sorting your components and then finding them all mixed up again when you return!)

5) Do NOT rush! Time spent carefully sorting at the start and avoiding errors is wisely invested, rather than trying to fix problems later!

6) Read through the instructions for each "Step" before you start doing that step. There are often handy tips & advice in the instructions!

How to build it:

Step 1. Identify your components and sort them into groups.

Use the checklist below to ensure that you have all your necessary components. *(We recommend that you "tick off" each component when you know you have it clearly identified).*

FK244 25 Tone Organ Component Identification Chart

For this task you are required to :

- Identify all of the components within your kit, to ensure that your kit is complete
- Assemble the kit so that it works as per the instructions

Component Name	Value	Qty	Identification Marki	Image
Resistor 3kΩ	3,000 Ohms	2	Orange-black-red-gold	
Resistor 15kΩ	15,000 Ohms	3	brown-green-orange-gold	
Resistor 100kΩ	100,000 Ohms	2	brown-black-yellow-gold	
Resistor 8k2Ω	8,200 Ohms	1	grey-red-red-gold	
Resistor 2k7Ω	2,700 Ohms	4	red-violet-red-gold	
Resistor 2k2Ω	2200 Ohms	4	red-red-red-gold	
Resistor 1k8Ω	1,800 Ohms	2	brown-grey-red-gold	
Resistor 1k5Ω	1,500 Ohms	5	brown-green-red-gold	
Resistor 1k2Ω	1,200 Ohms	2	brown-red-red-gold	
Resistor 1kΩ	1,000 Ohms	4	brown-black-red-gold	
Resistor 820Ω	820 Ohms	3	grey-red-brown-gold	

Fig 3.1 Identifying Component Values

Capacitor (Electrolytic) 10µF	0.00001 Farads or $10X10^{-6}$ Farads	3	10µF	
Capacitor (Electrolytic) 47µF	0.000047 Farads or $47X10^{-6}$ Farads OR 0.000033 Farads or $33X10^{-6}$ Farads	2	47µF or 33µF	
Capacitor (Ceramic) 33nF OR 39nF in some kits	0.000000033 Farads or $3.3X10^{-8}$ Farads	1	333 OR 393	 OR
Transistors		2	C458 or C828 or C945 or C1815	
IC Socket		1		
Timer IC		1	555	
Battery Snap (9V)		1		
Stakes (for wire connections)		6		
Probe		1		

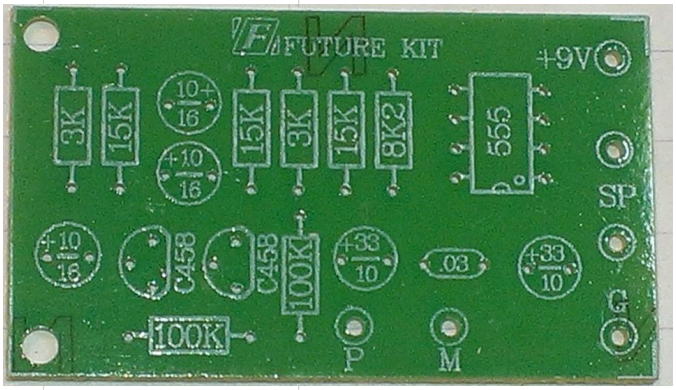
Stakes (for wire connections)		6		
PCB- Motherboard (Empty)		1		
PCB- Keyboard (Empty)				
Speaker		1		

Fig 3.1 Identifying Component Values

Step 2. Installing the Resistors onto the Motherboard:

By referring to *Fig 3.1* determine the value of each resistor and place them in their correct positions as indicated on the silk-screen printed on the circuit board (PCB).

Do this by carefully bending their wires down to form a 'U' shape and poke through the holes in the PCB as shown in *Fig4.1*.

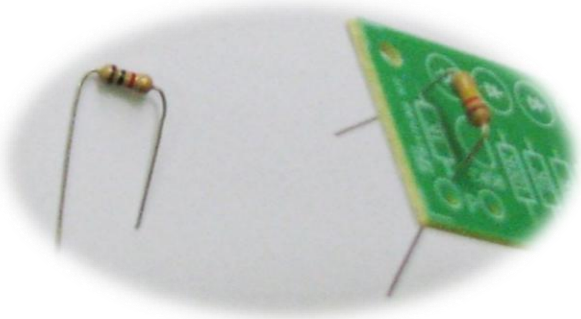


Fig 4.1 Installing Resistors

As far as possible, try to keep the resistors "oriented" in the same direction. (Try to keep the gold band at the same end of the installed resistors.) See Fig 4.2 for a suggested pattern.

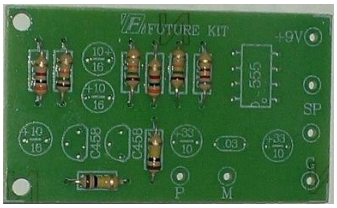


Fig 4.2 Installing Resistors with consistent orientation.

Step 3. Installing the Capacitors

Carefully identify all the different capacitors to be used.

There are two "families" of capacitors used in this kit. These are "Electrolytic" Capacitors , and a "Ceramic" Capacitor
Refer to Fig 3.1 to determine the values of the different capacitors.

Start by identifying the (small) ceramic capacitor to installed. For this capacitor polarity does not matter, so you can insert it in either direction. Refer to Figure 5.1 for the PCB with the Ceramic Capacitor installed.

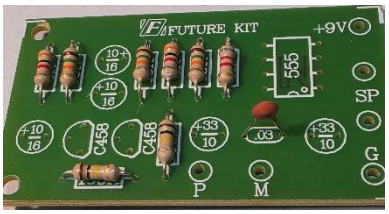


Fig 5.1 Identifying the position of the Ceramic Capacitor.

Once this capacitor is in the correct position solder it into place and trim the excess wire from under the PCB.

Next identify the "electrolytic" Capacitors *(They are the larger, blue cylindrical ones. There are two different values used in this kit.)* Now carefully identify which are their "+" and "-" legs. This is important!

Hints:

i) On new components, the longer leg is the "+" leg.
ii) These capacitors also have a big stripe marking their "-" leg.

Refer to Figure 5.2

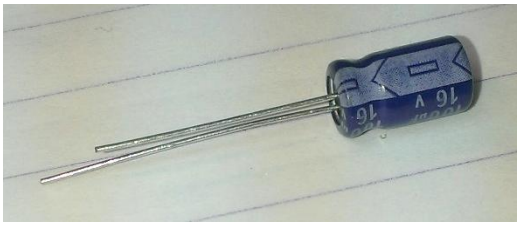


Fig 5.2 Showing the different leg lengths and the "-" marking on the body of an electrolytic Capacitor.

Next , identify the "+" hole on the PCB for each of the electrolytic capacitors. This MUST have the longer leg inserted into it! Refer to Figure 5.3 for some of the marked holes.

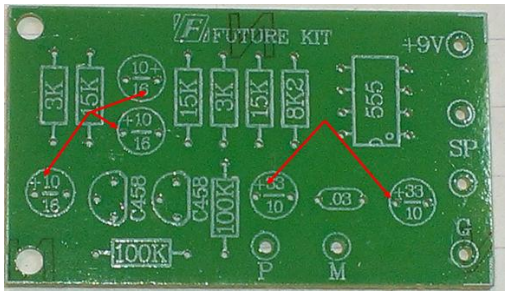


Fig 5.3 Showing the "+" holes on the PCB for some of the electrolytic Capacitors.

Once all your capacitors are in their correct positions and facing the correct way, solder each one into place and trim the excess wire from under the PCB. Refer to Figure 5.4 .

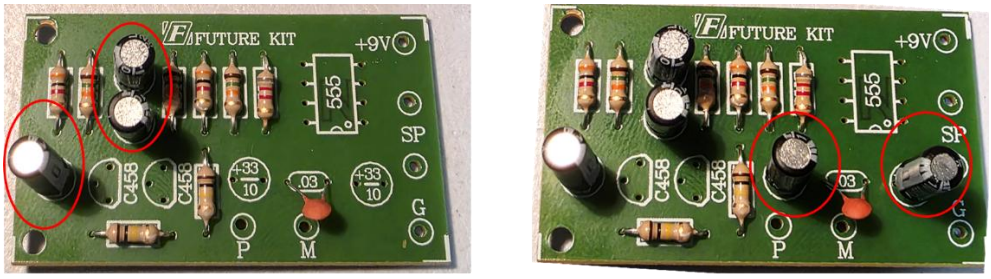


Fig 5.4 Showing the PCB with all five of the electrolytic Capacitors installed.

Step 4. IC Socket

Please inspect the IC Socket closely, and identify a small "notch" at one end of the plastic body.

Carefully insert the IC Socket so that the "notch" is at the same end as the marking on the PCB.

Take particular care to align the "notch" correctly, as that will later be used to identify the orientation for the IC to follow. Refer to Figure 6.1.

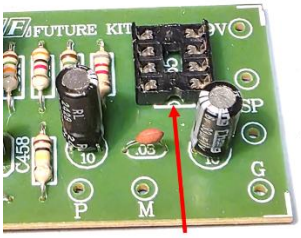


Fig 6.1 Showing the PCB with the IC Socket installed, and the "notch" highlighted for correct orientation.

Step 5. The Transistors:

Carefully spread the three legs of the Transistor to match with their mounting holes. *(Please note that the Transistor body MUST align with the silk-screen outline on the PCB.)*

Refer to Fig 7.1 to see a sample of mounted transistors.

Fig 7.1 Showing the two transistors installed .

Step 6. Insert the "Stakes".

These are the short, thick gold pins which are inserted from the rear of the PCB, and then soldered into place. *(We strongly recommend using a large amount of solder on the underneath of the PCB, to hold these stakes in place while you are later soldering to the top side of the PCB.)* Refer to Fig 8.1 to see the 6 stakes installed.

Fig 8.1 Showing the stakes installed .

Step 7. Install the Integrated Circuit ("IC").

Carefully orient the IC to ensure that the "notch" is aligned with the markings on the PCB and the "notch" on the IC Socket. *(Please note: Sometimes the IC will NOT have a "notch" in it, BUT IT WILL then have it's Pin 1 identified with a small "dot" or Indentation. It is then important to align the IC with its pin 1 in the correct location.)* Refer to Fig 9.1 to see the IC correctly installed .

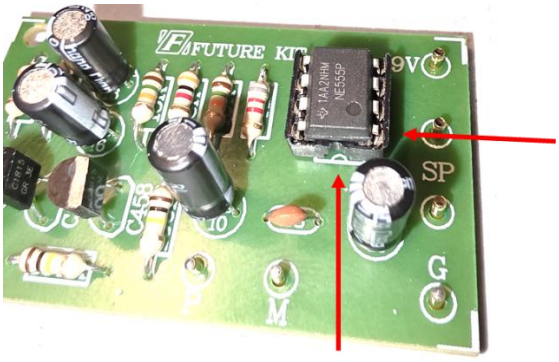


Fig 9.1 Showing the I.C. correctly installed .

Step 8. Connecting wires, speaker and Battery snap.

Once the stakes are set, 'tin' each with solder. *(For more information on "tinning", please refer to our separate document "Towards Better Soldering").* The battery snap can be soldered into place by 'tinning' the leads and ensuring the black wire is attached to the 'ground' (G) or negative (-) pole and the red wire to the positive (+).

Refer to Figure 10 for the final Motherboard.

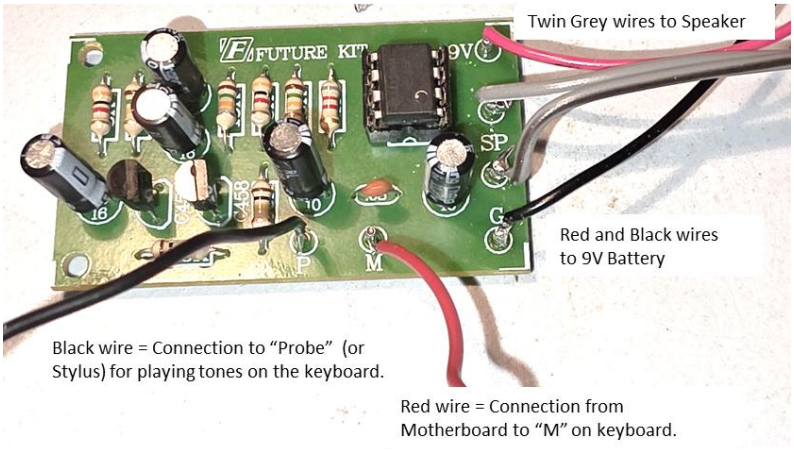


Fig 10 Showing the assembled Motherboard with wires attached.

Step 9. Assembling the Keyboard:

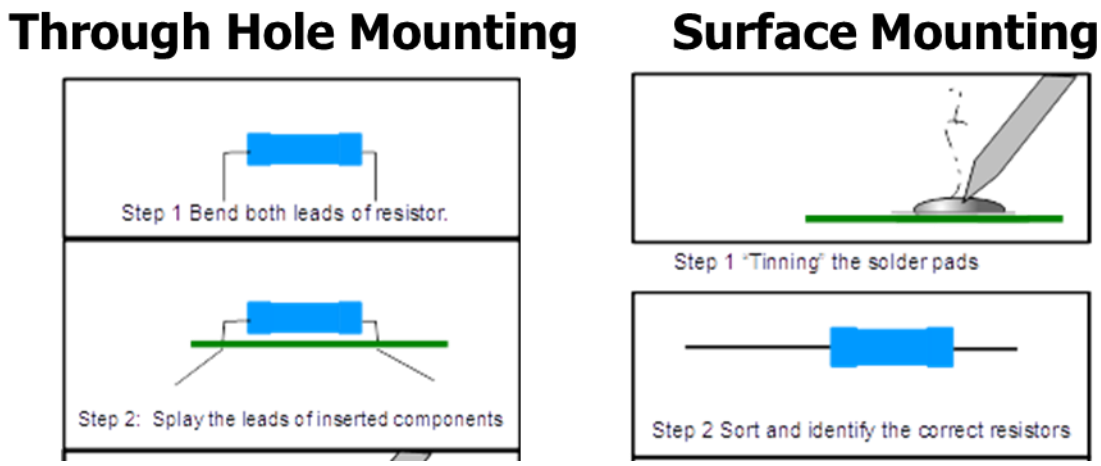
The keyboard allows you to assemble it in either of 2 different component mounting techniques. We will describe and show both here.

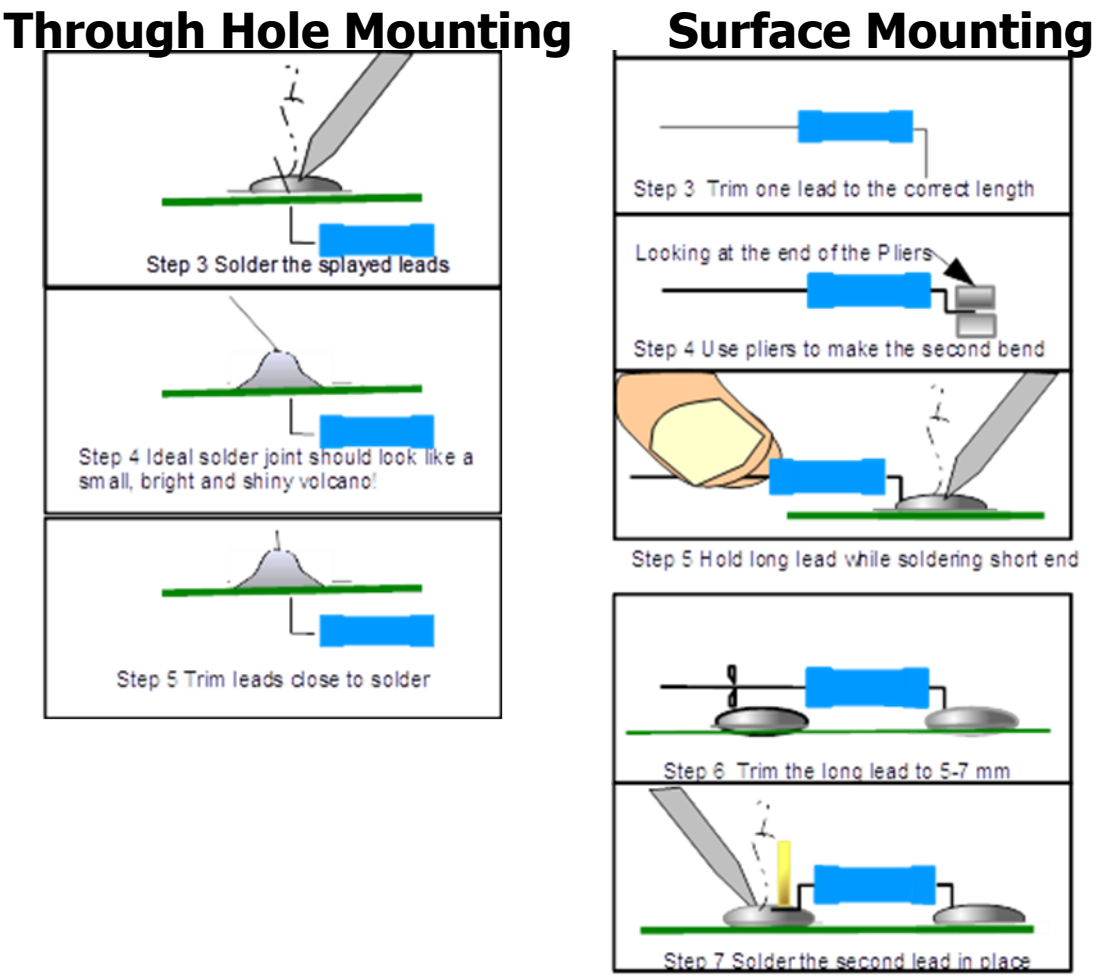
Method 1: "Through Hole" mounting of the resistors.

Method 2: Surface Mounting the resistors.

There are relative "Positives and Negatives" associated with each technique.

Below are the main process steps for each different mounting technique.





Ensure that the Resistors are installed in their correct locations, as this is critical to how the Keyboard will sound when it is being played. Refer to Figure 11 for the correct resistor positions.

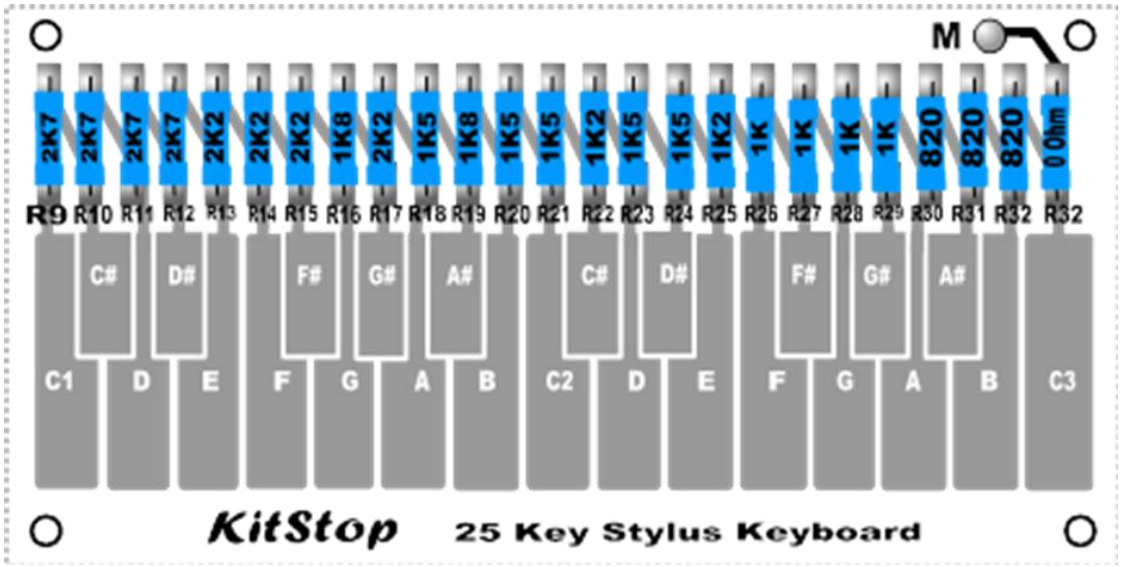
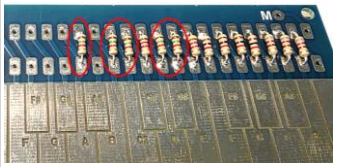
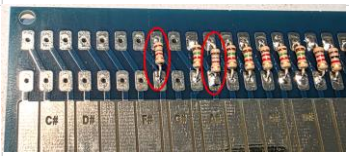
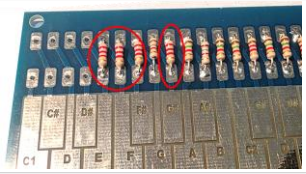
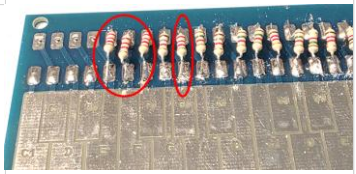
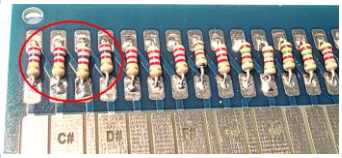
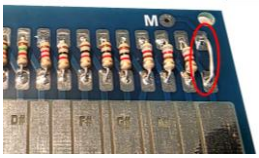
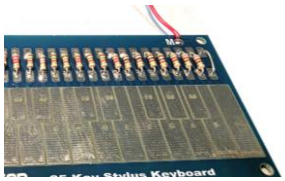


Fig 11 Showing the correct resistor positions.

Installing the Resistors to the Keyboard:

Key Step	Through Hole Mounting	Surface Mounting
Prepare resistors		
820 Ohms		
1k Ohms		
1k2 Ohms		
1k5 Ohms		
1k8 Ohms		
2k2 Ohms		
2k7 Ohms		
0 Ohms Link		
Wire to Mothrboard		

Step 10: Connect the Keyboard and complete the system…

Refer to Figure 1 for the completed System

Testing:

Attach the power supply of 9V DC.

Watch for any sparks or signs of overheating.
If you see any sparks:

- Disconnect the power immediately.
- Test for any "hot spots".
- If no obvious hot spots, then
    - Reconnect the power and watch for sparks a second time.
    - If NO sparks a second time, this is normal! Things are looking good!
    - If you continue to see sparks, you will need to recheck all of your soldering for any "Short Circuit" bridges.
- If you find a "hot spot" :
    - Check for solder bridges which are causing a short circuit somewhere.
    - Check that all components have been inserted correctly.
    - Check for any loose "wire" off cuts which may be causing a short circuit.

Once you have the power connected and no signs of other problems, it is time to test your Keyboard with the "Probe".

The speaker should give a tone which varies with the different "keys" that you touch If it does this, you are finished. If it does NOT do this, you will need to carefully go back over your work and check for problems.

Most of the problems we have experienced with this kit are one of three kinds:

1) Soldering induced problems. (Short circuit bridges as well as poor quality "cold solder joints")
2) Component misplaced or misaligned.
3) Wire connections (especially to the "probe") intermittent.