The *PHAT PHILTER BANK* ©

A quad VCF with CV input and resonance controls
For the Casio SK5/SK8

By Graham Meredith ©2007
Based on a VCF design by Tim Escobedo

This mod truly turns the humble SK5/8 into an analog monster machine!

This true polyphonic 4-voice VCF filter has frequency and resonance controls, and CV input

You can choose manual control cutoff frequency, or select "envelope" control, where the filter follows the attack/decay envelope of the sound selected. You can also select LFO control of the filter if you have the LFO mod installed.

For example, selecting a preset sound like the violin preset will give a "wwhhaahwww" type filter sound, if set to "Envelope" mode. Choose a fast attack/slow delay sound like piano or guitar will give an "aaaoowww" type sound!! Using the sample envelopes will give even more variety.

Parts list

IC's

Op-amps NE5534AN – 4x
IC sockets, 8-pin – 4x

Diodes

IN4148 – 4x

Capacitors (ceramic)

470pF – 4x
http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&catalogId=10001&productId=15530

Capacitors (greencap)

0.0068uF (6.8nF) – 4x
0.01uF (10nF) – 12x
0.022uF (22nF) – 1x

Capacitors (metallised polyester)

0.1uF (100nF) – 4x
http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&catalogId=10001&productId=528438

Capacitors (electrolytic, SMD)

1uF 50V – 4x
47uF 10V ---------- 4x

http://www.jameco.com/webapp/wcs/stores/servlet/ProductDisplay?langId=-1&storeId=10001&catalogId=10001&productId=135302&pa=135302PS

Resistors 1/4W

1k – 4x
22k – 4x
100k – 24x
470k – 4x
1M – 4x

Potentiometers

4-gang 10k linear – 1x
4-gang 100k linear – 1x

http://www.alphapotentiometers.net/html/8mm_pot_4.html

or:

double gang 10k linear – 2x
double gang 100k linear – 2x

LED's

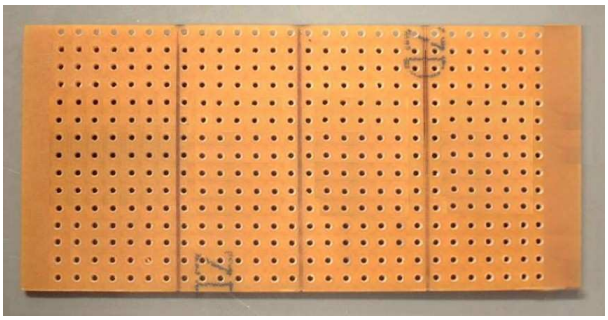
3mm Red - 4x

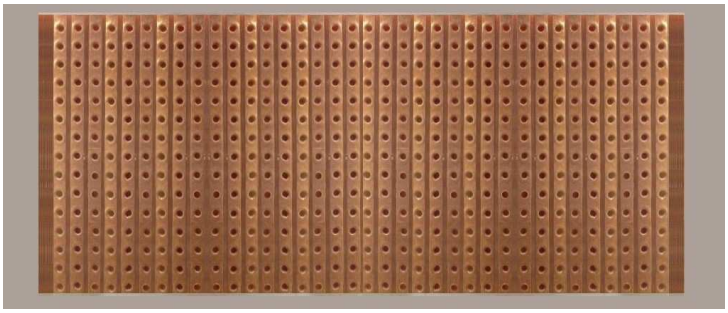
Switches

http://www1.jaycar.com.au/productView.asp?ID=ST0506&CATID=28&keywords=&SPECIAL=&form=CAT&ProdCodeOnly=&Keyword1=&Keyword2=&pageNumber=&priceMin=&priceMax=&SUBCATID=448

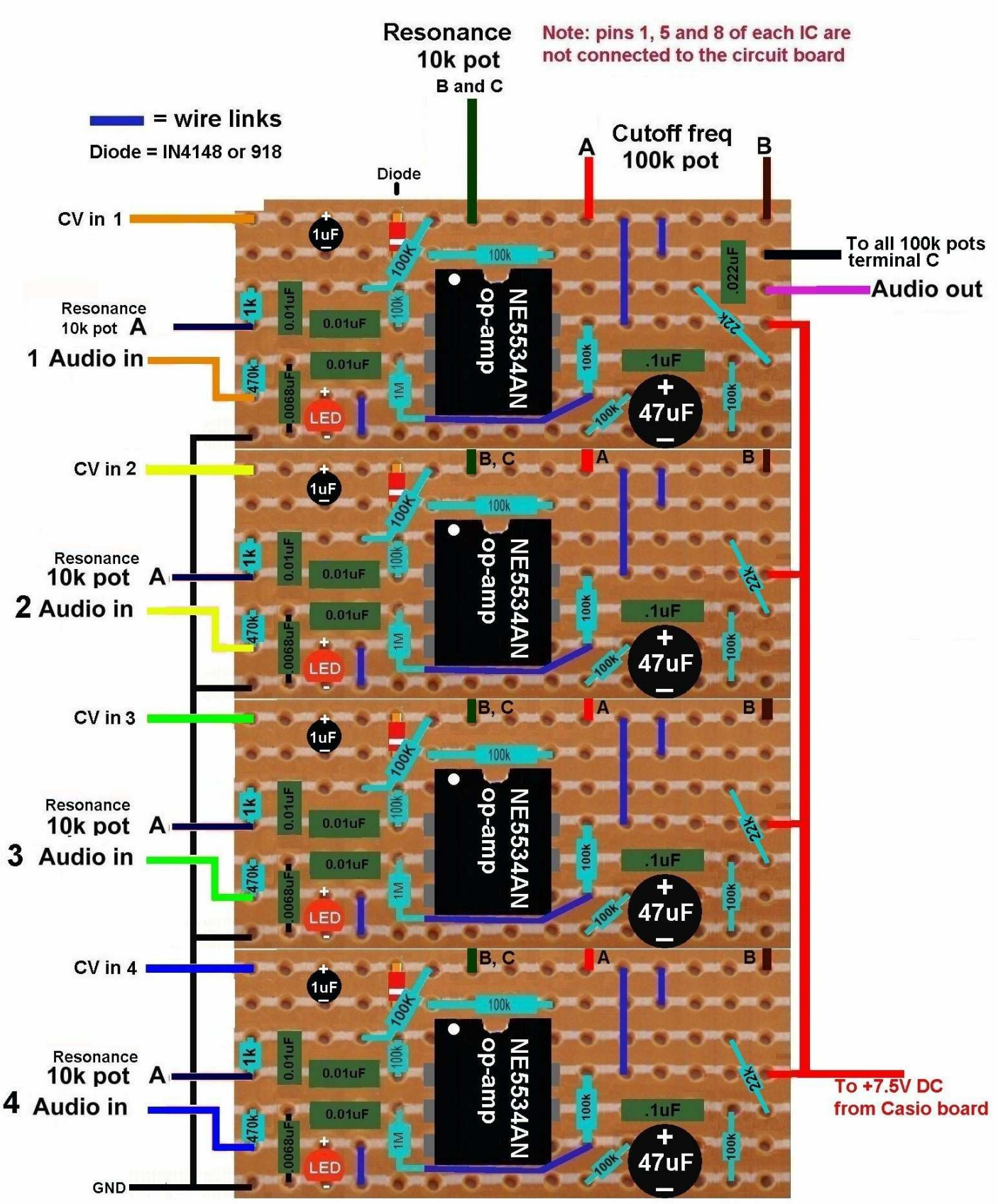
Other components

Hookup wire, insulated, various colours
Veroboard strip or similar, at least 28 holes long, 15 holes wide:

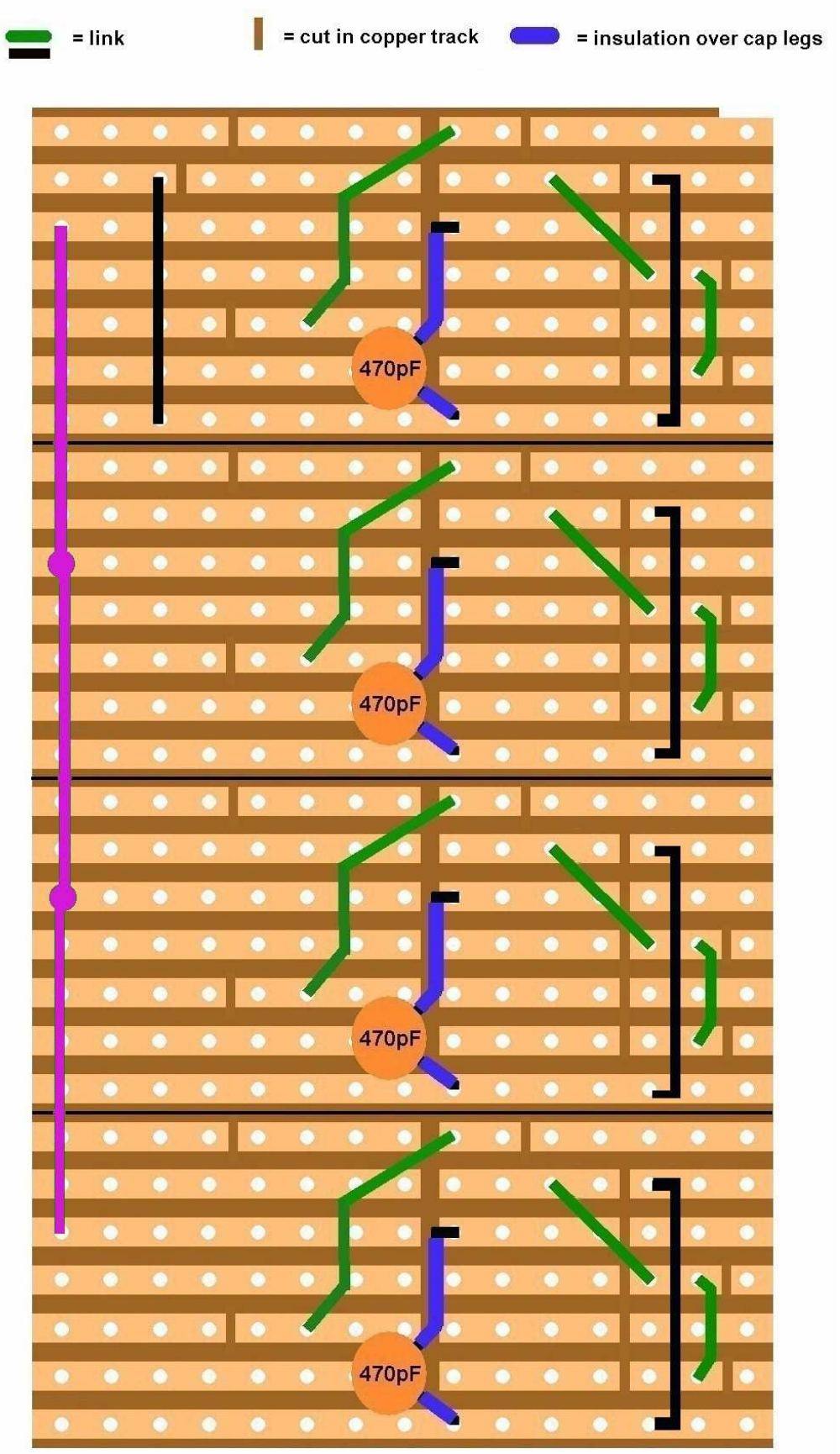




PHAT PHILTER BANK circuit board



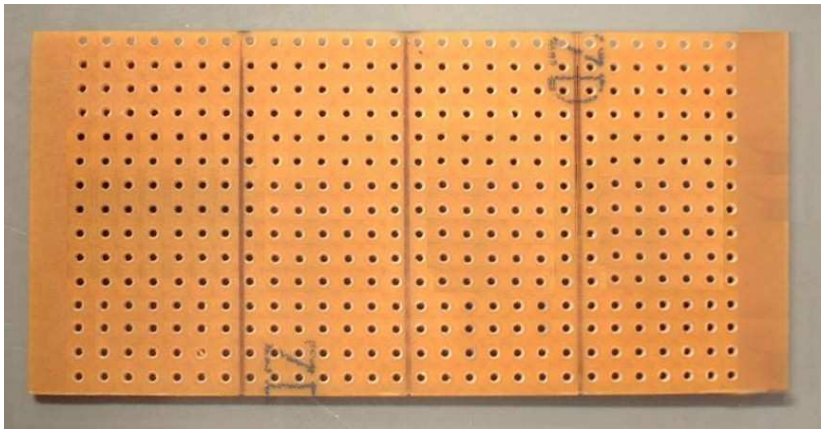
PHAT PHILTER BANK circuit board Track Side



Study this manual fully and carefully, to decide which options you wish to build. You may wish to only make a single module, or you may wish to make all 4 modules, depending on your needs.

Procedure:

1. The board needs to be as small as possible to fit inside the SK5/SK8. Cut the board to the size below:

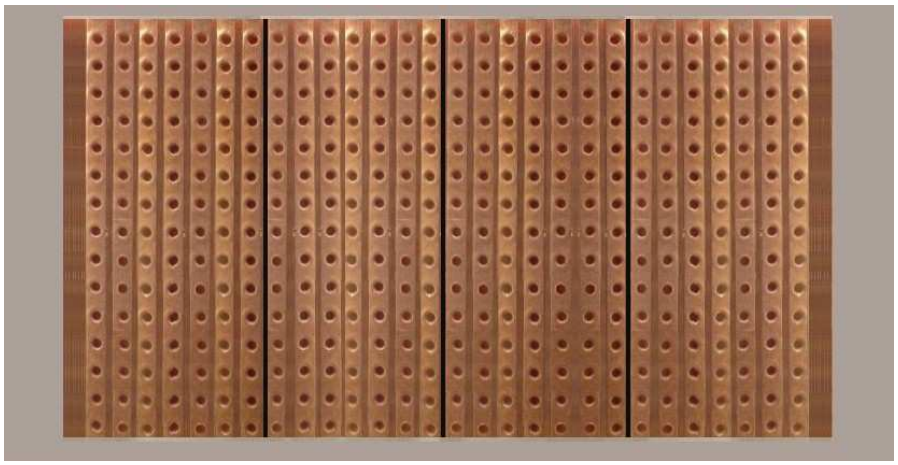


15 rows of holes,
28 columns of holes

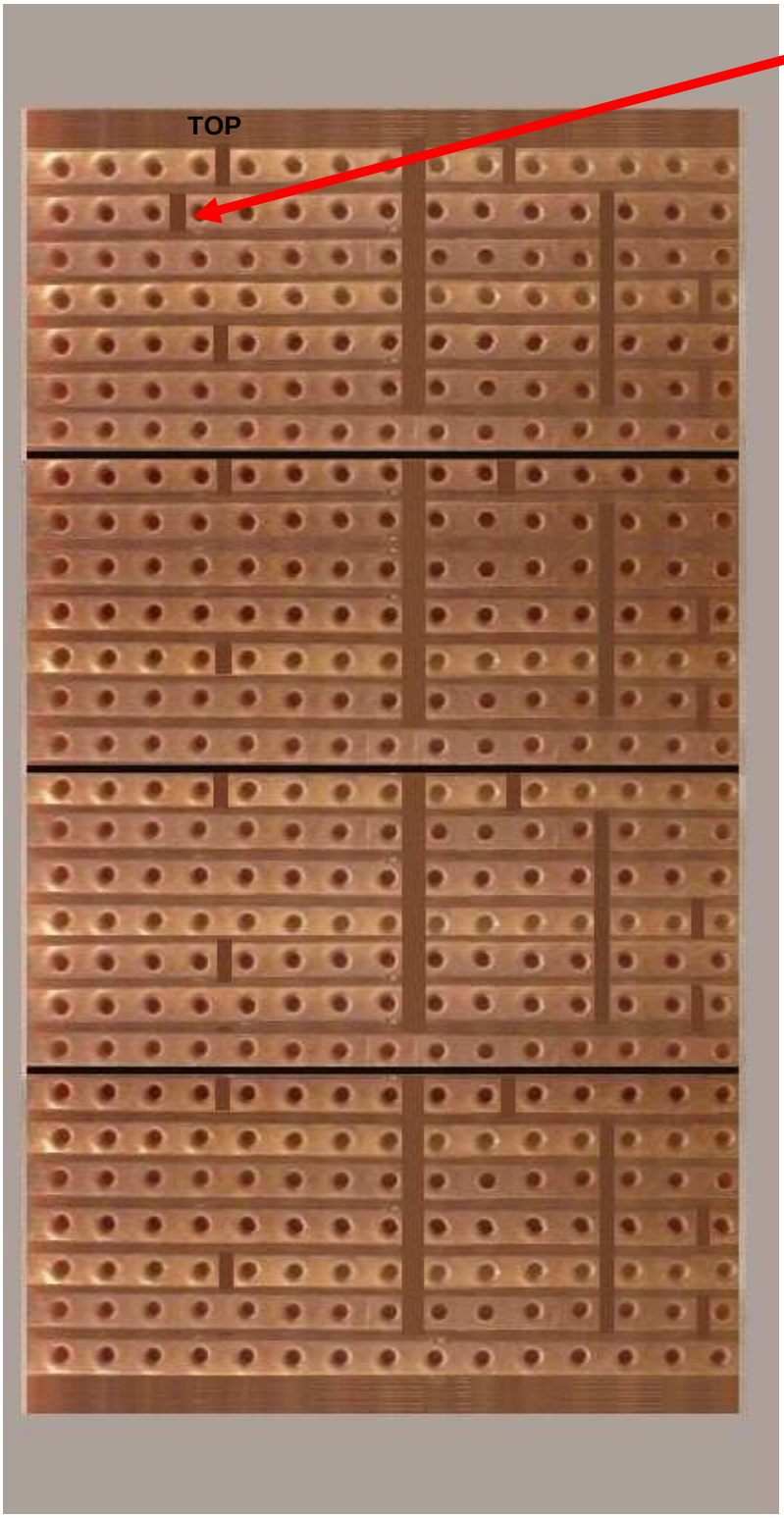
These instructions show how to make all 4 modules on a single board.

If you only intend to make a <u>SINGLE</u> module, the board can be cut to 15 rows of holes, 7 columns of holes.

2. Turn the board over and draw lines on the track side of the board every 7 track lines with a marker to divide each module of the VCF:

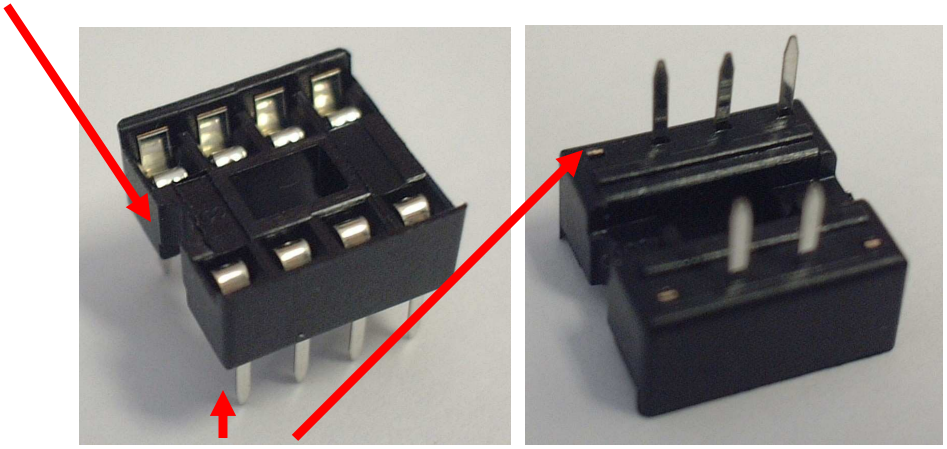


3. With a sharp hobby knife, cut the tracks as shown below to separate parts of them. You may wish to only cut the first module's tracks at this point in time; if you build it and find you made a mistake, you can correct it when you cut the other modules, once the first one is tested and working properly. When finished, turn the board over again to the component side.

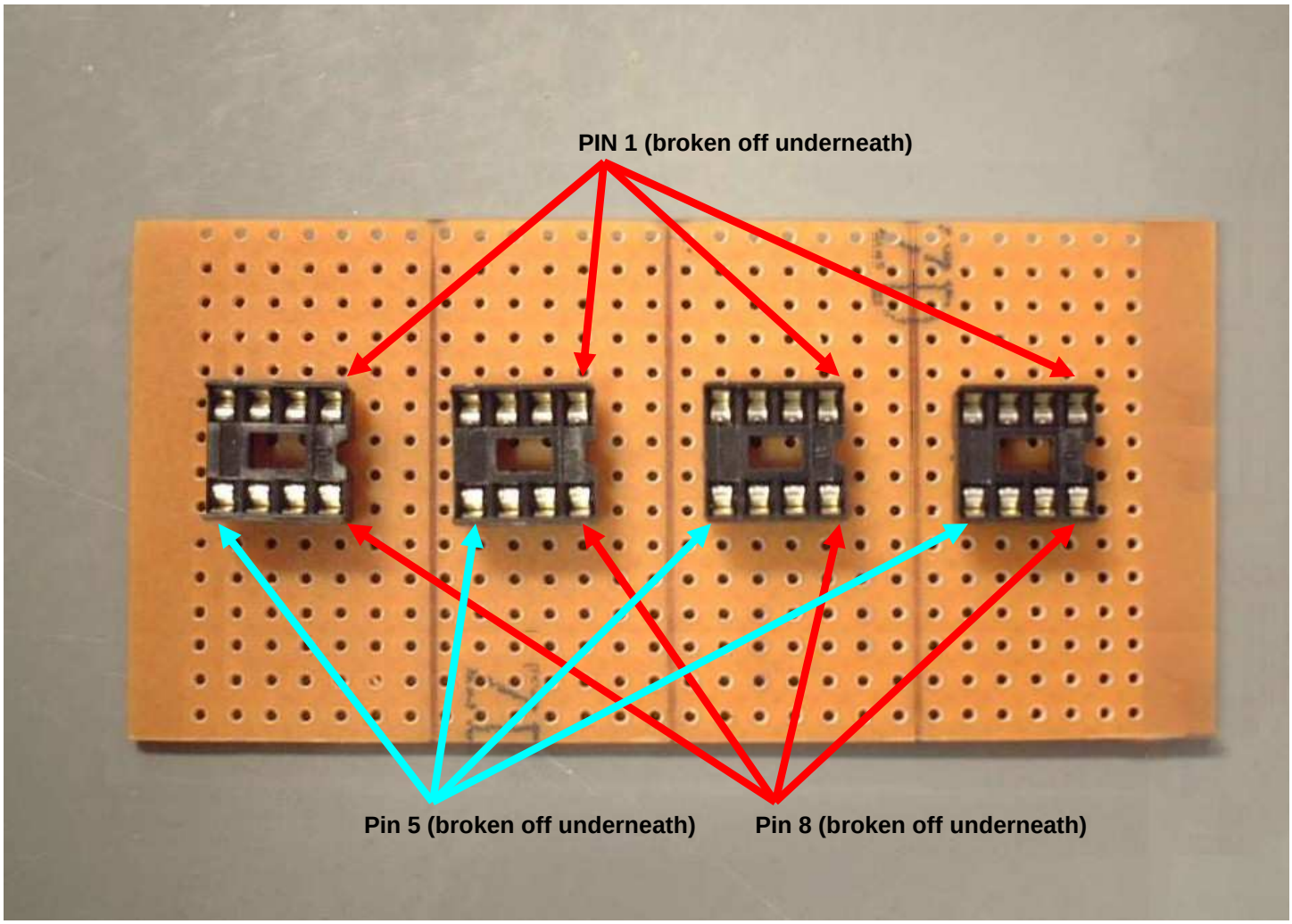


Note that this cut here is only done in the **FIRST** module – do not cut it in the other modules (although it will not cause any problems if you do – this track is unused in the other modules and will not affect the circuit)

4. Take an 8-pin IC socket, and orientate the notch in one end to the top of the page.
This is the IC orientation notch. Break off pins 1, 5 and 8, so they do not connect with the circuit board.



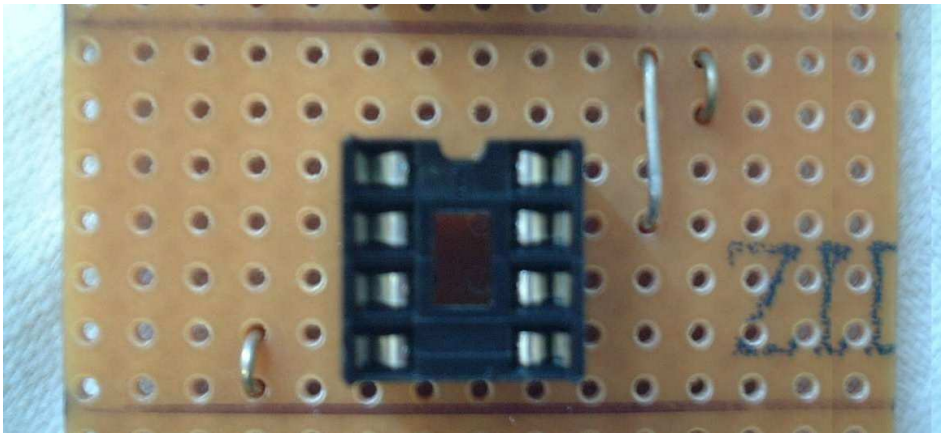
Put the IC in position on the board as shown, and solder in place.



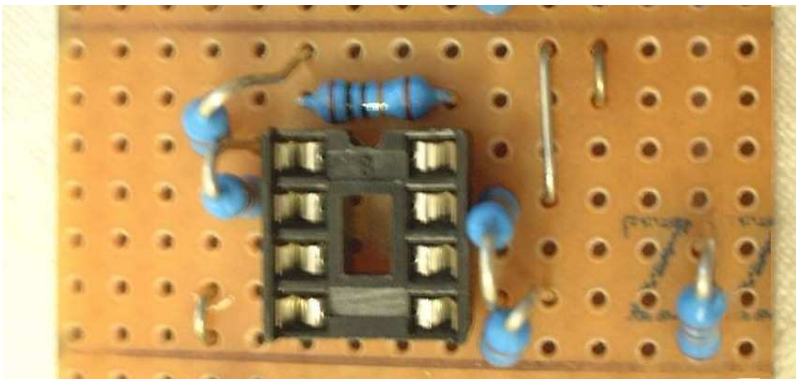
From now on, only build ONE module at a time – complete the first one, then test it to make sure it works. Then move on to the next one, then test it, etc. The board very quickly becomes crowded, and it is easy to duplicate mistakes when building the board all at once.

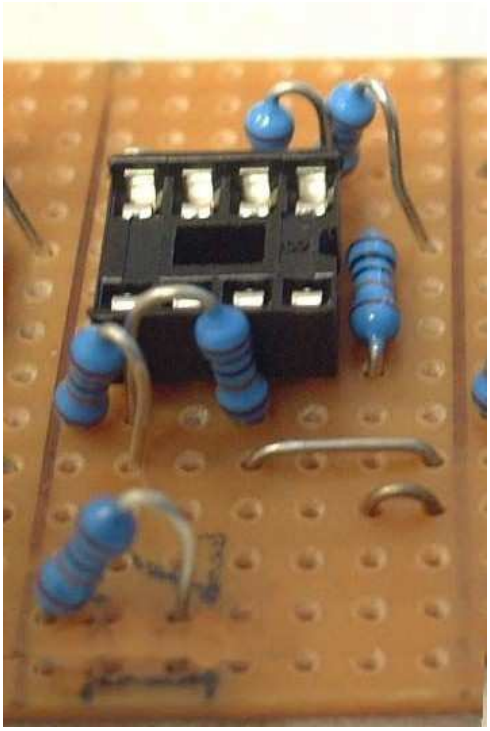
Install the components in the order shown; otherwise it is difficult to fit some components in.

5. Install the links first.



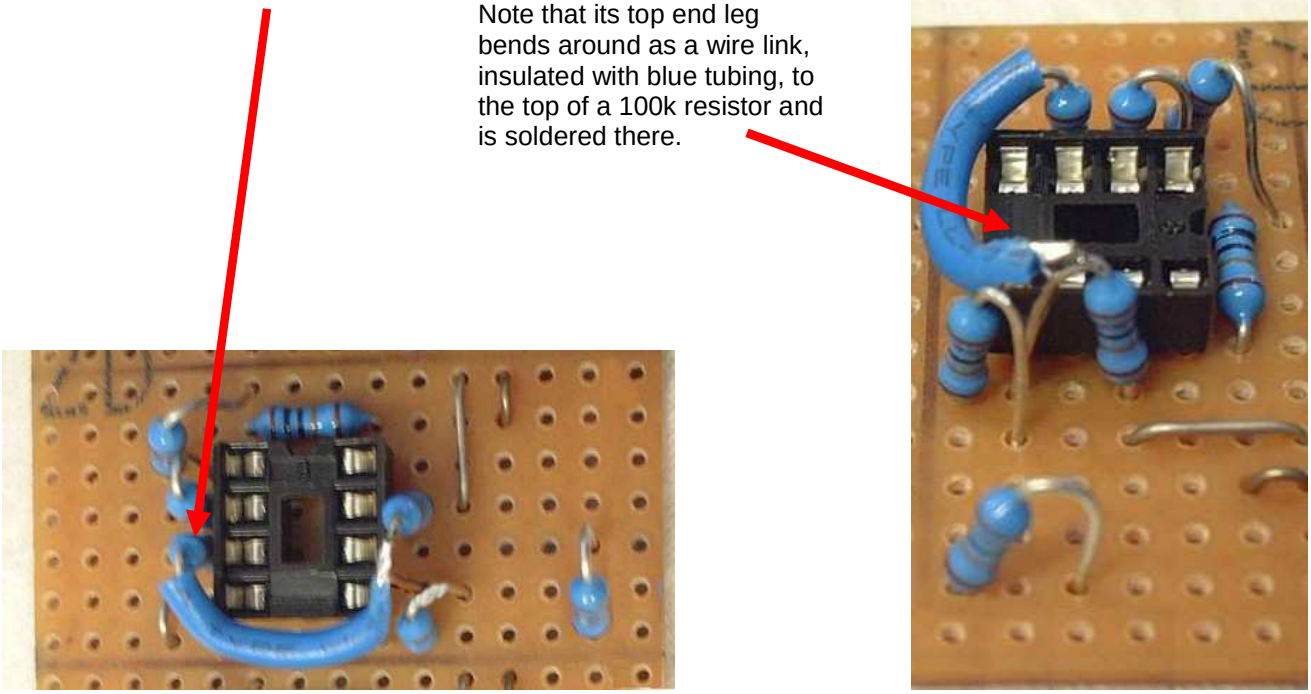
6. Solder in the 6x 100K resistors in place. Mount some up on their ends to save space.



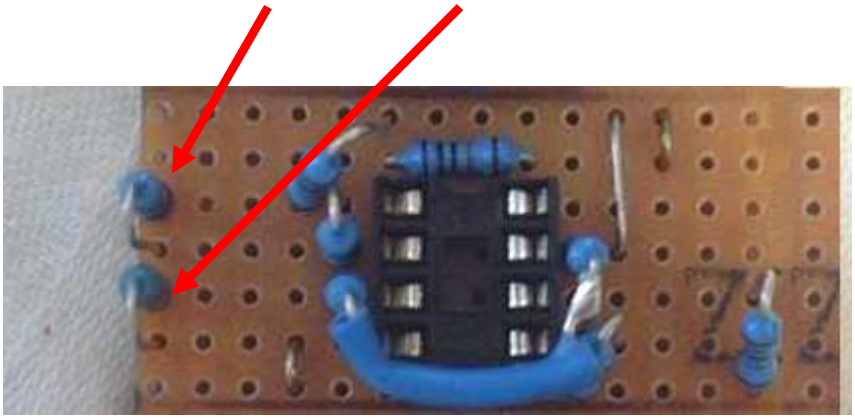


7. Solder in the 1M resistor in place.

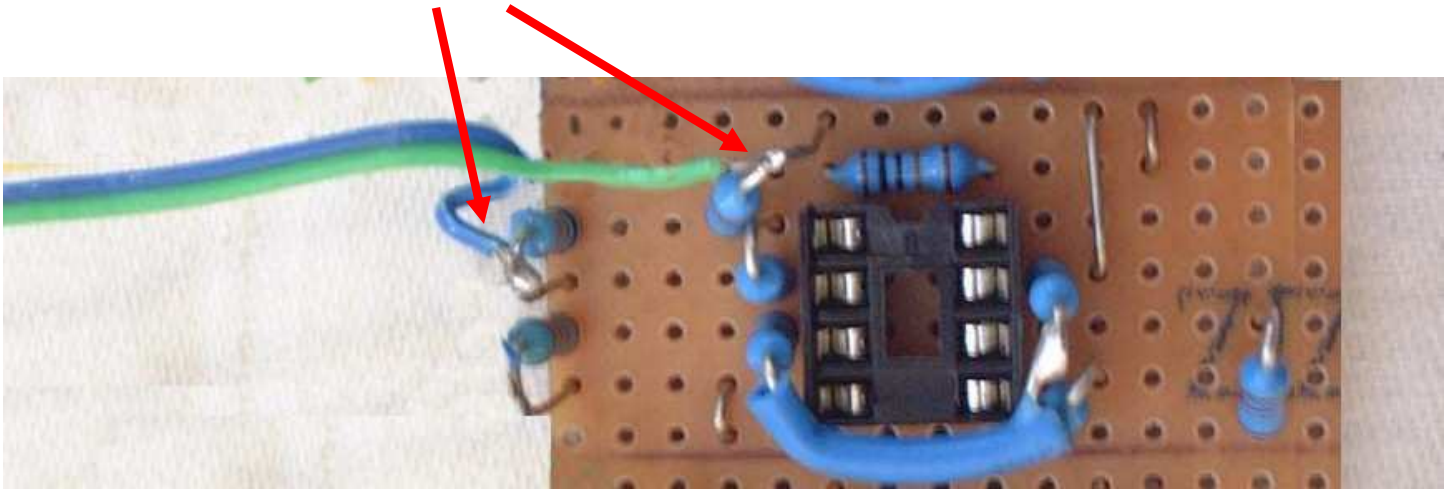
Note that its top end leg bends around as a wire link, insulated with blue tubing, to the top of a 100k resistor and is soldered there.



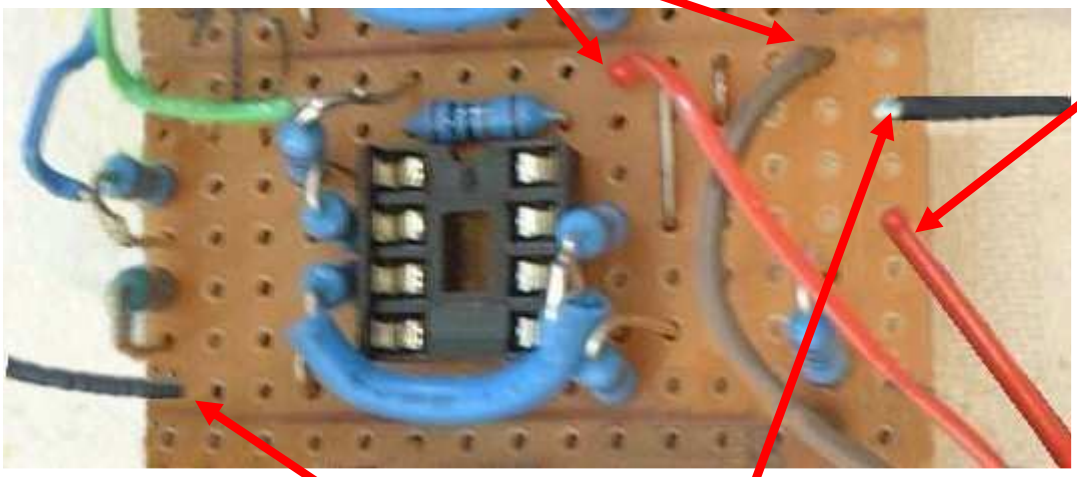
8. Solder in the 1k resistor and 470k resistor.



9. Solder a 20cm length of **blue** and **green** wires to the tops of the 2 resistors shown. These 2 leads go to the terminals of the 10k resonance pot (shown later).



10. Solder a 20cm length of **red** and **brown** wires into the holes in the board as shown. These 2 leads go to the terminals of the 100k cutoff pot.

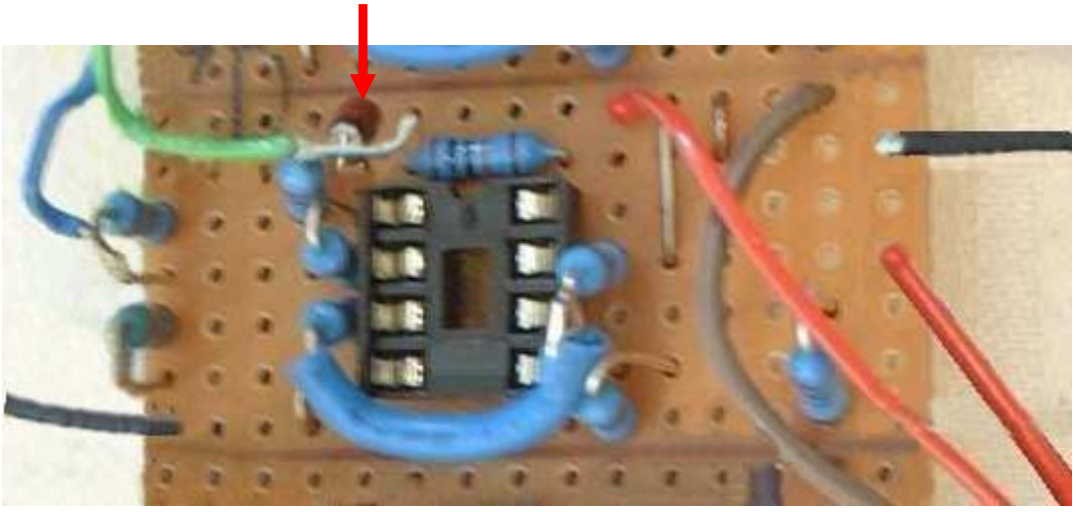


Solder a 20cm **red wire** in the hole in the board as shown. This is the 7.5V DC power lead for the circuit

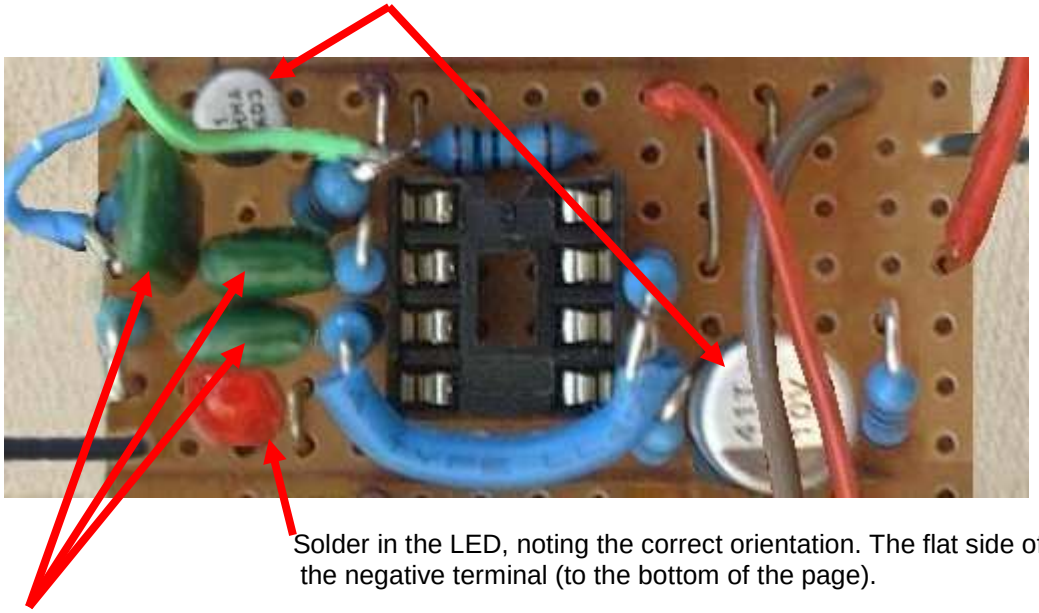
Solder a 20cm **black wire** in the hole in the board as shown here. This is the **0V ground** power lead for the circuit.

Solder another 20cm **black wire** here. This wire connects to the third terminal of the 100K cutoff pot.

11. Solder in place the diode, noting that there is a black band on one end of the diode to mark direction orientation



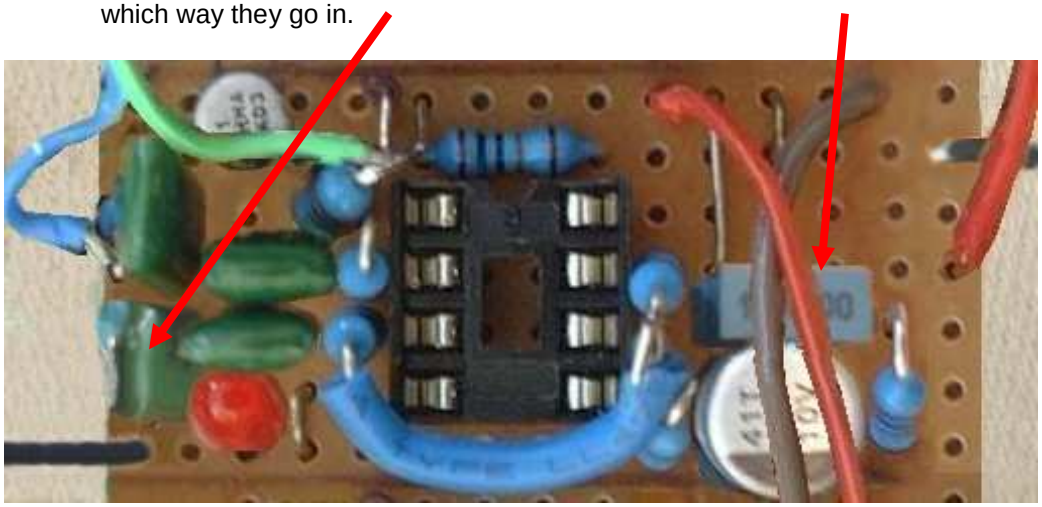
12. Solder in the 1uF and 47uF electrolytic capacitors. Make sure they are orientated the correct way (the black end is the negative terminal).



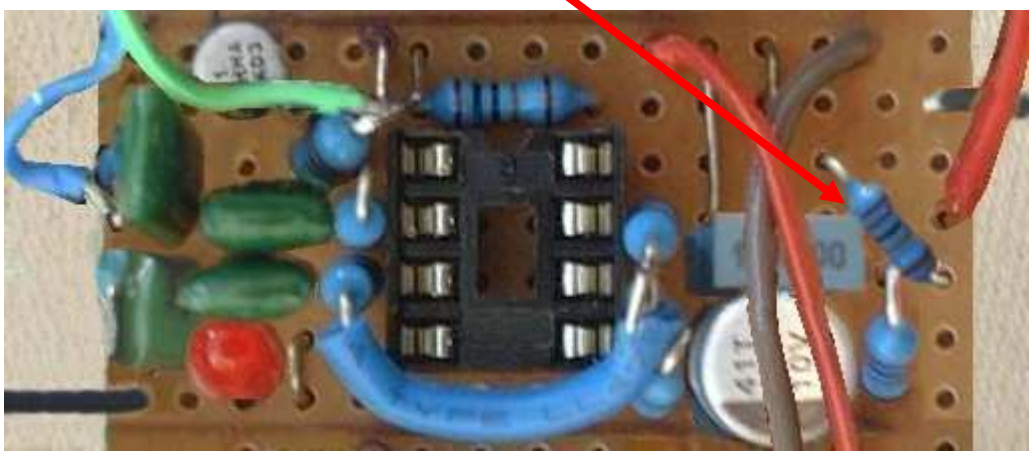
Solder in the LED, noting the correct orientation. The flat side of the base indicates the negative terminal (to the bottom of the page).

Solder the 0.01uf greencap capacitors in place. It doesn't matter which way they go in.

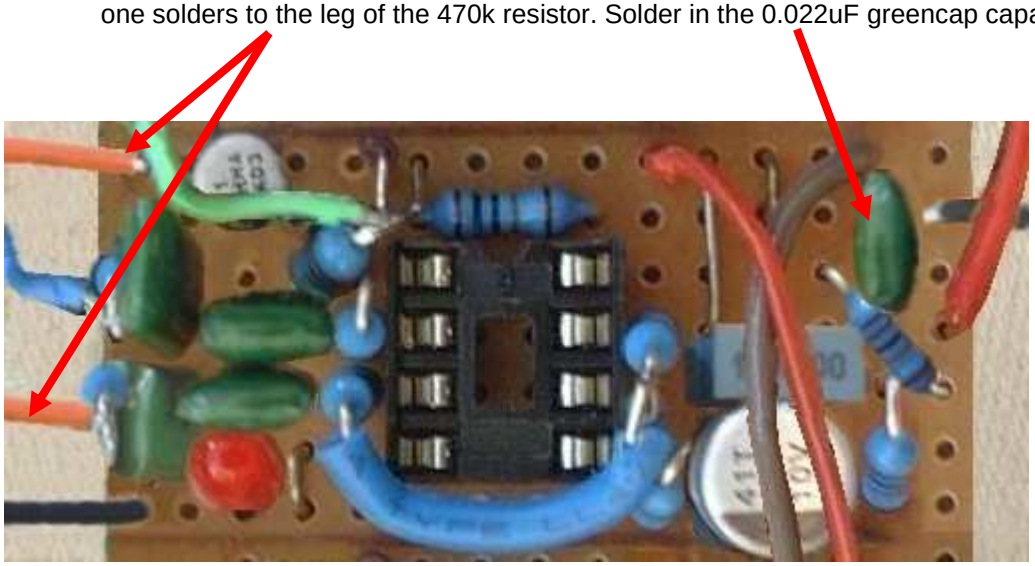
13. Solder the 0.0068uF greencap capacitor in place. Solder the 0.1uF polyester capacitor in place. It doesn't matter which way they go in.



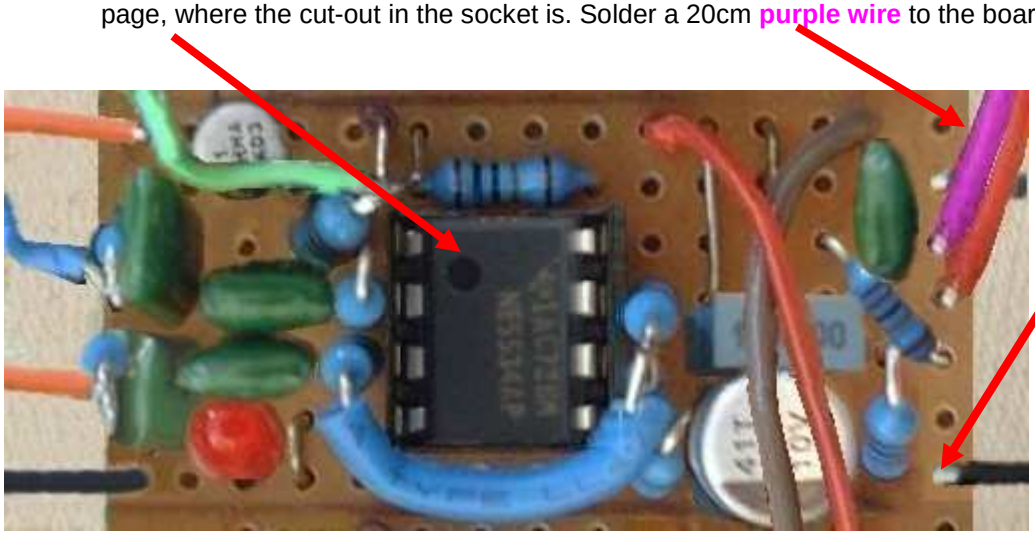
14. Solder in the 22k resistor as shown.



15. Solder two 20cm lengths of **orange wire** to the points below. The top one goes into a hole in the board. The lower one solders to the leg of the 470k resistor. Solder in the 0.022uF greencap capacitor. Either way will work.



16. Insert the NE5534AN op-amp in its socket, taking note of the orientation of the chip. The dot goes to the top of the page, where the cut-out in the socket is. Solder a 20cm **purple wire** to the board here for the audio out.

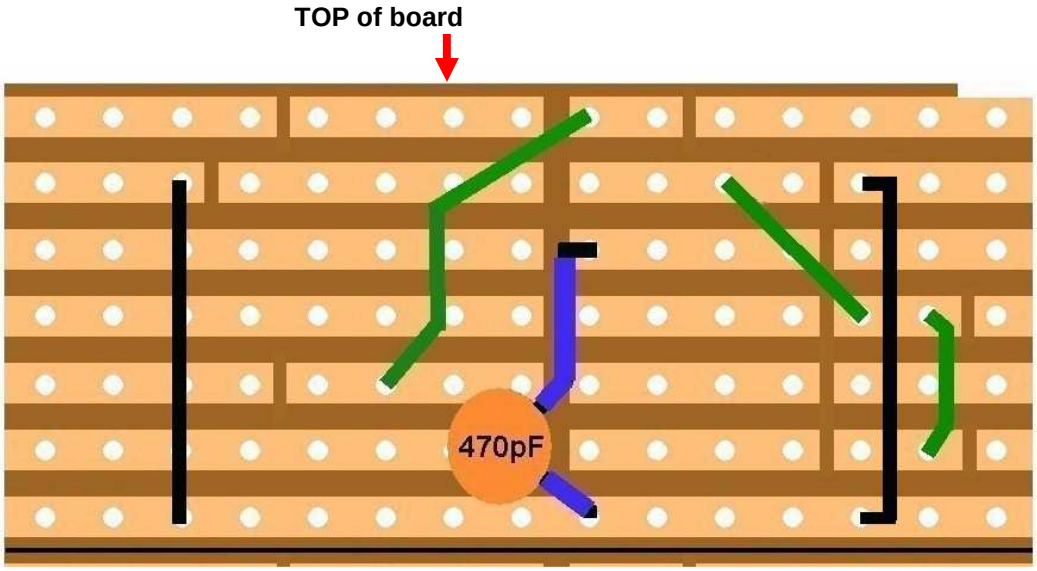


Solder a 20cm **black wire** in the hole in the board as shown here. This is the **0V ground** power lead for the circuit while it is being tested.

<u>This completes the top component installation for the first module.</u>

The Track side wiring

Turn the board over, and wire up the board with insulated links as shown. The black ones represent links going to the 0V ground in the circuit.

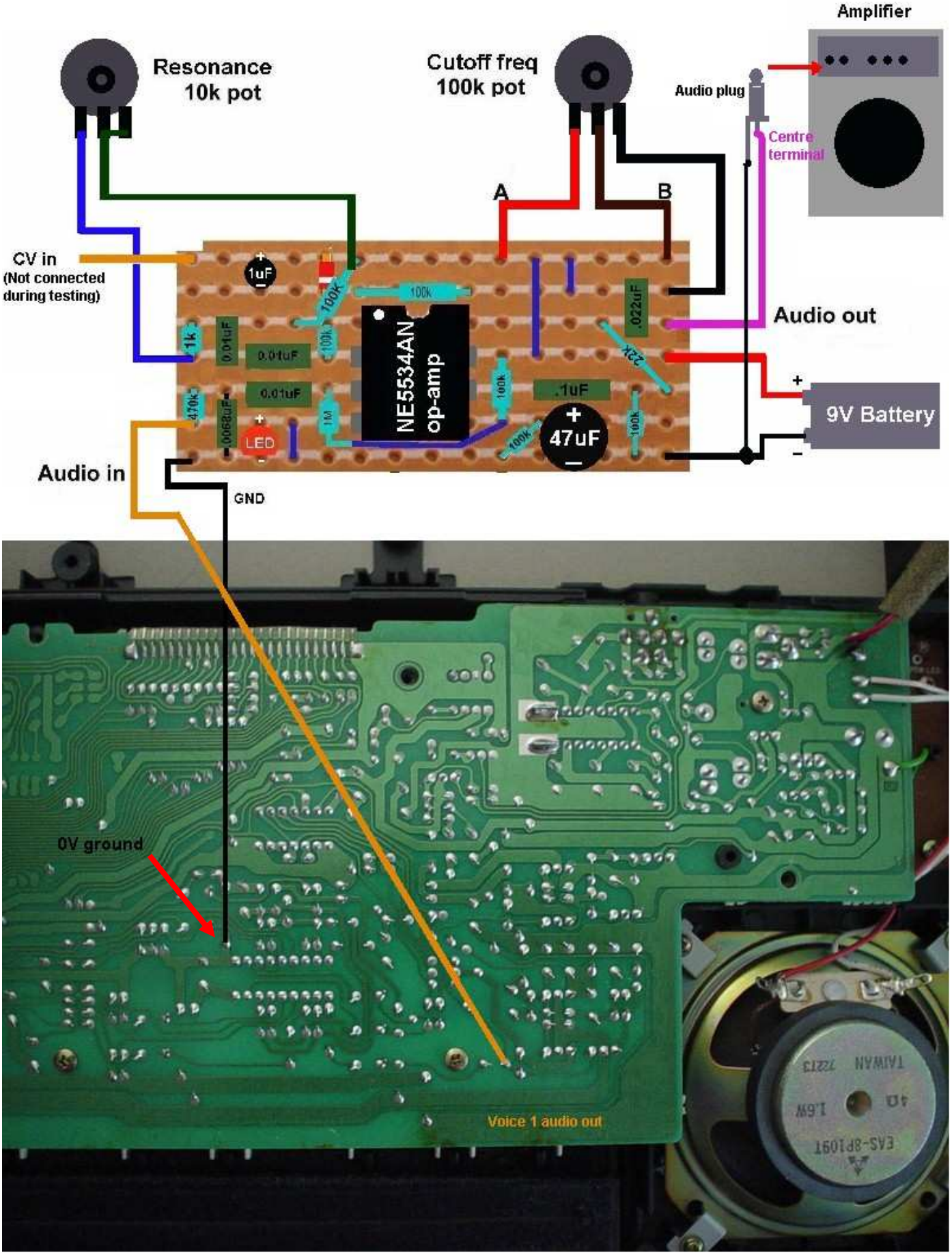


This completes the construction for the first module.

Hooking up

Connect the wires from the module as shown on the next page.

Casio SK5, SK8 test hookup diagram



Testing the circuit

1. Remove the batteries from the Casio SK-5 or SK-8 and remove the back cover off the keyboard. Lay the keyboard face down on a bench.

2. Connect the **audio input** and **GND** wires of the circuit to the points marked on the circuit board of the SK in the diagram above, using a soldering iron.

3. Connect a mains power adapter to the SK to power it during testing. Switch the keyboard on and turn the SK volume down fairly low. Play it so you can hear that it is on. Select a sound such as the piano.

4. Turn the controls of the circuit both up to half way. Connect a 9V battery to the circuit.

5. Plug the **audio output** of the circuit into an audio amplifier such as a guitar or keyboard amplifier and switch the amp on, with the volume turned down low.

6. Turn the amplifier up slightly and play a note on the keyboard once. Play another note and turn the volume up a bit more. You should hear the piano sound through the amplifier. Turn the level up to a comfortable level for testing. At this point, don't play more than one note at a time, because you won't hear them. Their audio lines haven't been hooked up yet. If you play a single note quickly in succession, you'll only hear a note on every 4th key press from the amplifier. This is because the SK has 4-note polyphony, and each of the 4 polyphony "voices" comes out of a different output inside the keyboard. We will hook these up later after testing is complete.

   You should hear the filter working as a kind of midrange "hollow sound" to the piano sound, like it's inside a box. Turn the resonance up carefully, a small amount at a time and note the change of the sound. The sound should now become more "boxy". If you turn it up too much, it will self-resonate and feedback uncontrollably. Back off the resonance to just before the feedback point.

   Now play a note and move the cutoff control up and down. You will hear the tone of the sound sweep up and down the frequencies as you move the cutoff control, like a wah-wah pedal on a guitar.

   If you have got this far and it is working, congratulations!!!

   At this point, the filter circuit is operating as a manual, stand-alone VCF effects unit. You could disconnect it from the SK, put a socket on the input wires and connect an electric guitar into it if you like, or anything, as an effects box!!

   At this point in time, you can make a choice about what you want to do with the filter, whether you want to stop here and use it like this as a stand-alone single filter, powered by a 9V battery, with a power switch. If so, you can mount it in a box with the controls mounted on it, and sockets for the inputs and outputs. You can then simply connect the SK with a lead from its output socket into the input socket of the filter, and away you go. If you do it this way, you will be able to play and filter ALL of the SK notes at once, and play chords and quick notes and hear them all filtered. But the filter effect will only act "globally" - you won't get each note INDIVIDUALLY filtered independently of the others.

   The other choice is to build the other three modules on the board, in order to filter EACH voice of the SK individually and independently of the others. Why would you want that? Because you can then take advantage of controlling the filter by the option of in **"Envelope" mode**.

What is "Envelope Mode"?

This is where the filter responds to the VOLUME envelope of each sound of the keyboard – you don't control the filter manually in this mode – the keyboard controls it. For example, the volume envelope of the "piano sound" is a sharp attack, then a gradually fading away of the sound as you hold the key down. The "violin" sound envelope has a slow attack, starting quietly, swelling to full volume, and then fading away after the key is released.

The Casio SK keyboards create their volume envelopes for each of the 4 voices of polyphony, by using 4 simple pre-shaped DC control voltage signals to the keyboard internal amplifier section. The filter circuit you have just built has a Control Voltage (CV) signal input. You can hook up the Control Voltage (CV) from the 4 Casio CV lines to 4 of these filter circuit modules.

In this situation, when you play a note on the keyboard, the filter circuit CUTOFF control will respond to the volume CV signal. If you choose a sound such as the violin, the effect is a "whhaaaahhhwwww" sounding effect each time a note is played, as the volume swells and fades. Sharp attack sounds such as the piano sound like "aaaooooowww", as the filter opens sharply, then closes slowly.

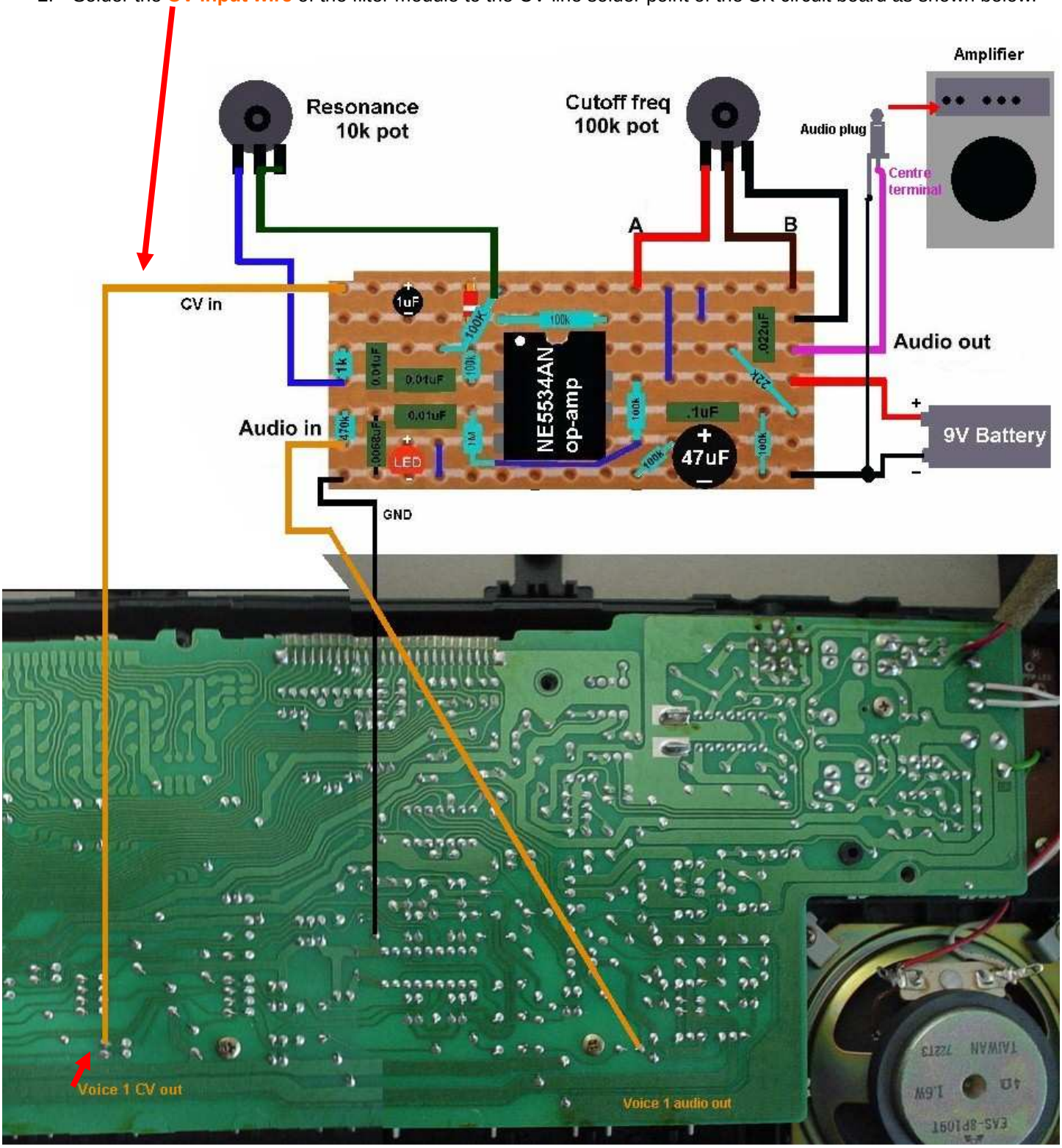
This **4-filter** module version of the filter is the***"PHAT PHILTER BANK"***©

The ***PHAT PHILTER BANK*** is quite spectacular, and makes the humble SK keyboard sound like a real analog synthesizer!!

Building the *PHAT PHILTER BANK ©*

1. Confirm that the first module you have built works correctly. Have it connected to the SK as previously shown in the hookup diagram below. Unplug the power from the SK and disconnect the battery from the filter module. Switch off the instrument amplifier.

2. Solder the **CV input wire** of the filter module to the CV line solder point of the SK circuit board as shown below:



3. Connect the power to the SK and switch it on. Connect the 9V battery to the filter circuit, and switch the instrument amplifier on.

4. Set the Cutoff and Resonance controls on the filter to half way. Select the violin sound on the SK, and play a single note. Release it. You should hear a “waaooow” filter sound. Set the resonance to just under feedback level. The effect should get stronger.

   Turn the Cutoff control lower. Play a note. The effect sound should start lower in the frequency range. Turn it up high. The effect should start higher in the frequency range. In this way, although the filter is controlled by the SK envelope, you can still adjust the sweep start and end range of the filter.

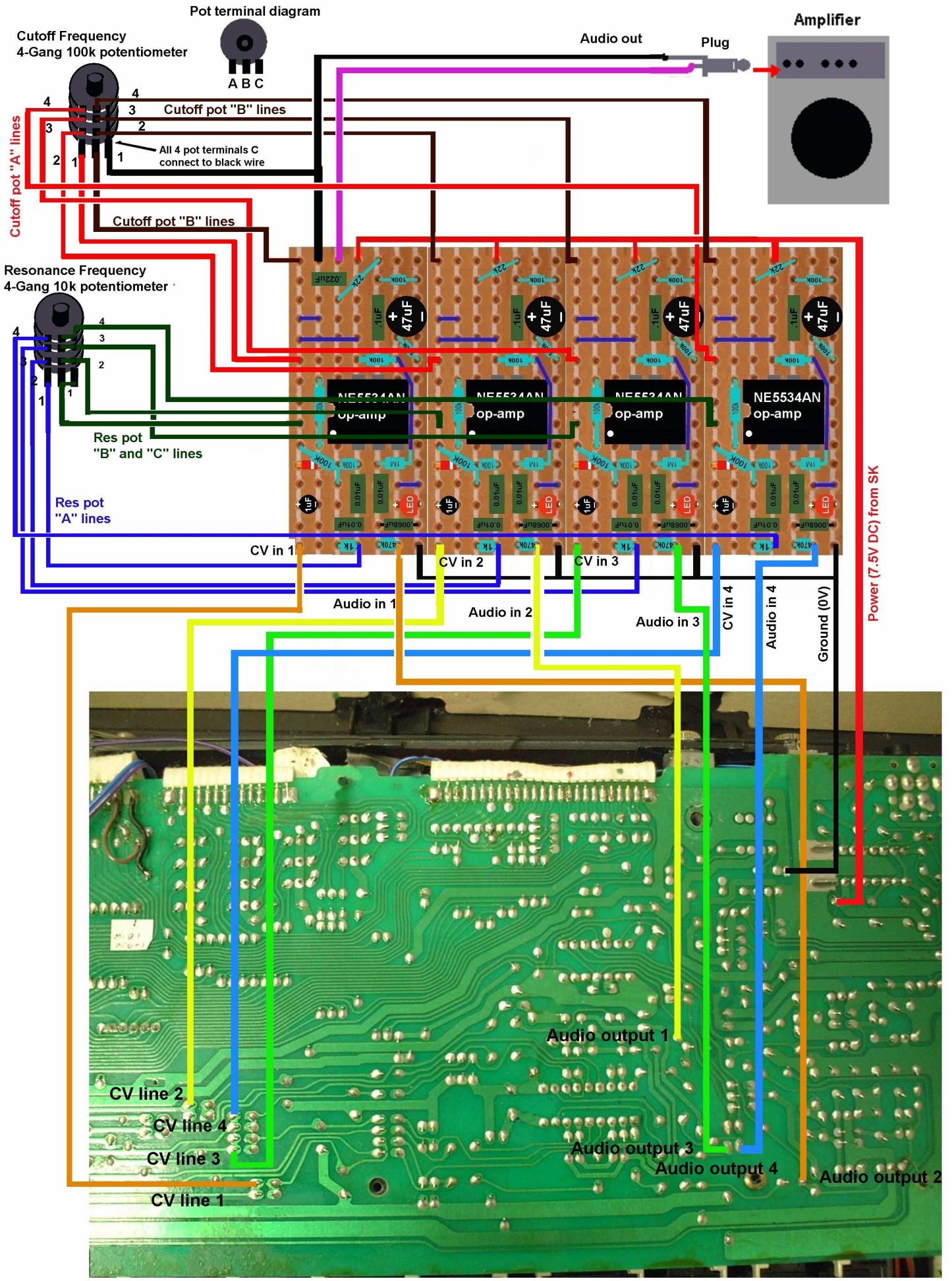
   You can now put a toggle switch on the CV wire to choose between Manual control and Envelope control if you wish.

This completes the first module of the ***PHAT PHILTER BANK*** mod.

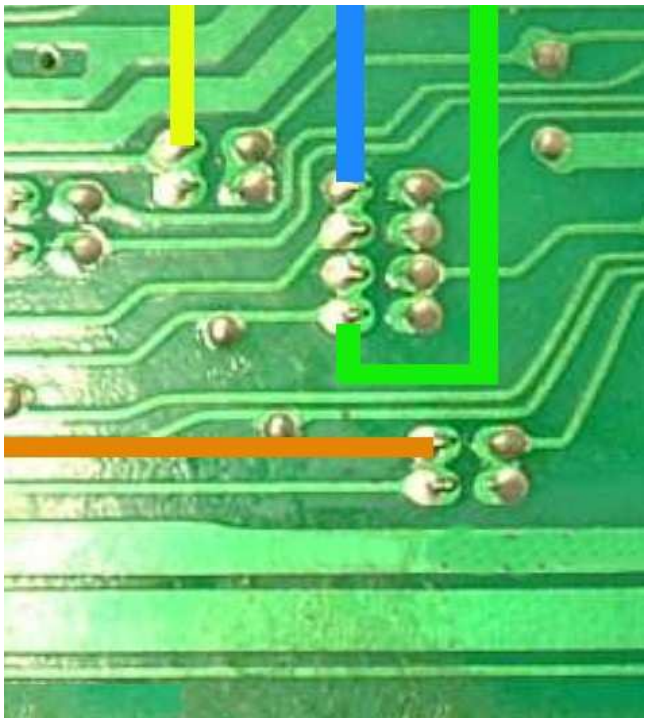
5. Continue making the other 3 module on the same board in exactly the same way. **Make one module at a time**, and then test it, before moving on to the next module. At this point in time, don’t link the modules together as shown by the wiring on page 3, just build each module and wire it EXACTLY as the first module.
   That way, if a module doesn’t work properly, you can easily see which components may be wrongly placed, or bad solder joints that may show. If you do all the modules at once, it is very difficult to see what is wrong. If the next module doesn’t work, compare it to the working module for differences. Most problems I had were due to incorrect component positions and bad solder joints. Always follow the **parts layout diagram** on page 3 of this guide for correct positioning and orientation of components. Use the photos as a guide only.

   Test the modules individually as you tested the first module. Use the SK circuit board voice 1 audio output point and CV point to test each module at this stage. Later on, we will locate the other voice and CV points for each module.

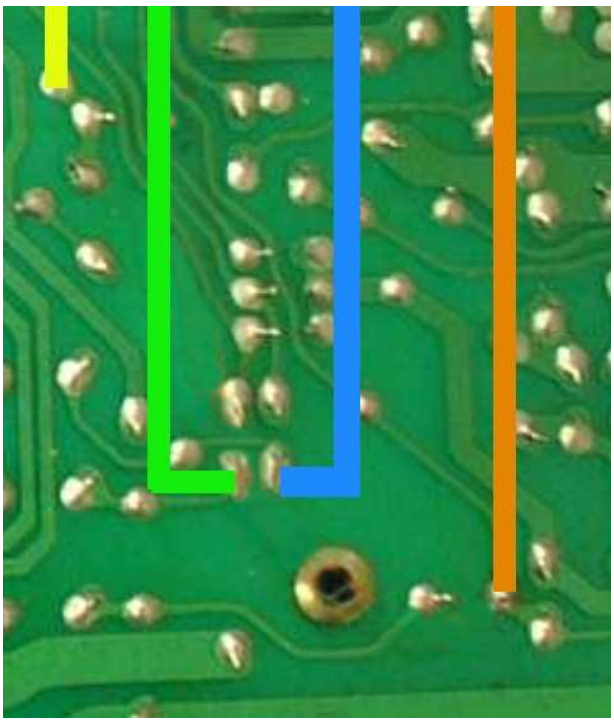
6. **When all 4 modules are confirmed operating correctly individually, wire up the *PHAT PHILTER BANK* board as shown in the diagram below.**


Pot terminal diagram
A B C
Cutoff Frequency
4-Gang 100k potentiometer
Cutoff pot "A" lines
Cutoff pot "B" lines
All 4 pot terminals C
connect to black wire
Cutoff pot "B" lines
Audio out
Plug
Amplifier
Resonance Frequency
4-Gang 10k potentiometer
Res pot
"B" and "C" lines
Res pot
"A" lines
NE5534AN
op-amp
CV in 1
CV in 2
CV in 3
Audio in 1
Audio in 2
Audio in 3
CV in 4
Audio in 4
Ground (0V)
Power (7.5V DC) from SK
Audio output 1
Audio output 3
Audio output 4
Audio output 2
CV line 2
CV line 4
CV line 3
CV line 1

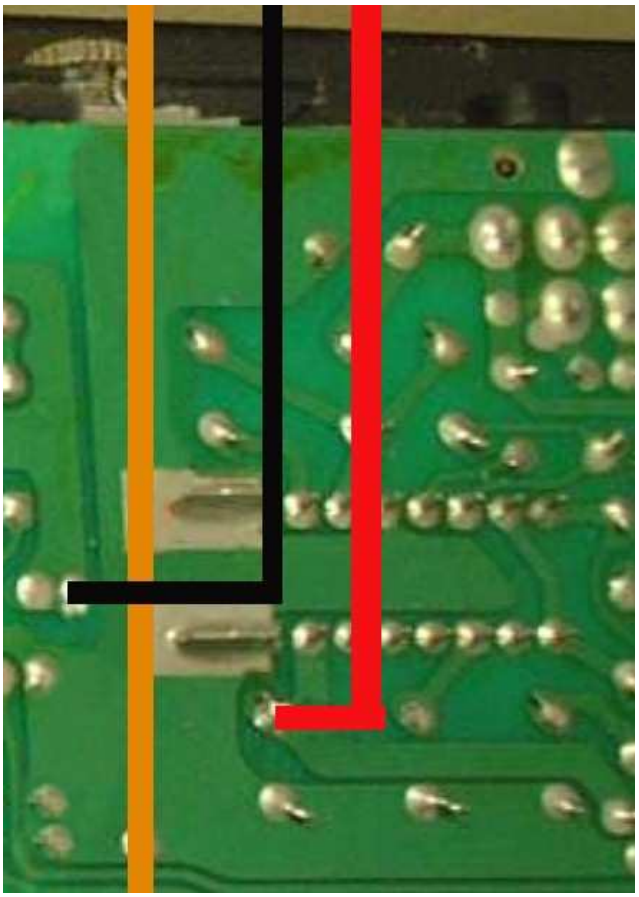
CV points wiring close up



Audio voice output points close up



Internal power supply and ground points close up (get these right!!!)



Testing the *PHAT PHILTER BANK* board

1. Double check all wiring as per the diagrams above. The ***PHAT PHILTER BANK*** board has been wired for "Envelope" control by the SK CV lines in the diagram.

2. Set the Cutoff and Resonance pots to their half way points.

3. Plug in the power supply to the Casio SK keyboard and switch it on. The ***PHAT PHILTER BANK*** board does not need a 9V battery now, as we are powering it from the Casio itself. It will switch on automatically when you switch the Casio on.

4. The Select the trumpet sound for testing. Plug audio output line of the ***PHAT PHILTER BANK*** board into an instrument amplifier and switch it on with the volume down low.

5. Start playing a note on the keyboard, and carefully turn the instrument amplifier up until you hear the filtered SK sound at a comfortable level.

6. Play a single note and listen to see if the filter is working. If it is OK, set the Resonance and cutoff controls so that the filter is very obvious.

   Play a single note again and hold it down. Play another note and hold it down while continuing to hold the first note down. Listen to see that the filter on the second note is working. Play a third note and hold it while holding the first 2, and then play a forth note in the same manner. Release the notes one at a time and observe the filter sound on each decaying note. Each note should have its own filter effect, sounding like a "wwhaaoooww" sound.

7. Experiment with the Cutoff and resonance controls in different positions to control the sound of the filter.

   If your ***PHAT PHILTER BANK*** board is working correctly, Congratulations!!!! Well done!!

   If only some of the modules are working correctly, recheck your wiring, especially the 4-gang pots. Check each incorrect module as an individual circuit for wiring mistakes, and compare them with the working ones.

   Make sure you don't have the CV wires mixed up with the audio wires, the modules won't work if they are.

This concludes the basic instructions for building your ***PHAT PHILTER BANK*** board.

Installation Options and other possibilities

Now you can decide how you will use your ***PHAT PHILTER BANK*** board.

You may decide to mount it in an external box, with the controls mounted in the box. If you use a 10-pin DIN plug and socket, or a serial port plug and socket, you can make a quick connect setup with a multicore cable and a socket in the Casio SK keyboard, for quick connections. You can have the Filter

If you are crazy like me, you can mount the ***PHAT PHILTER BANK*** board inside the Casio SK, so it is a built-in unit. The board has been designed to fit in a few places inside the SK5 and SK8, but if you do decide this, insulate the ***PHAT PHILTER BANK*** board with insulation tape, both on its track side, and over its components, to prevent it shorting out any thing in the SK.

Possible mounting places are:

1. The speaker cavity – you will need to remove the speaker for this, and only use the SK with an amplifier

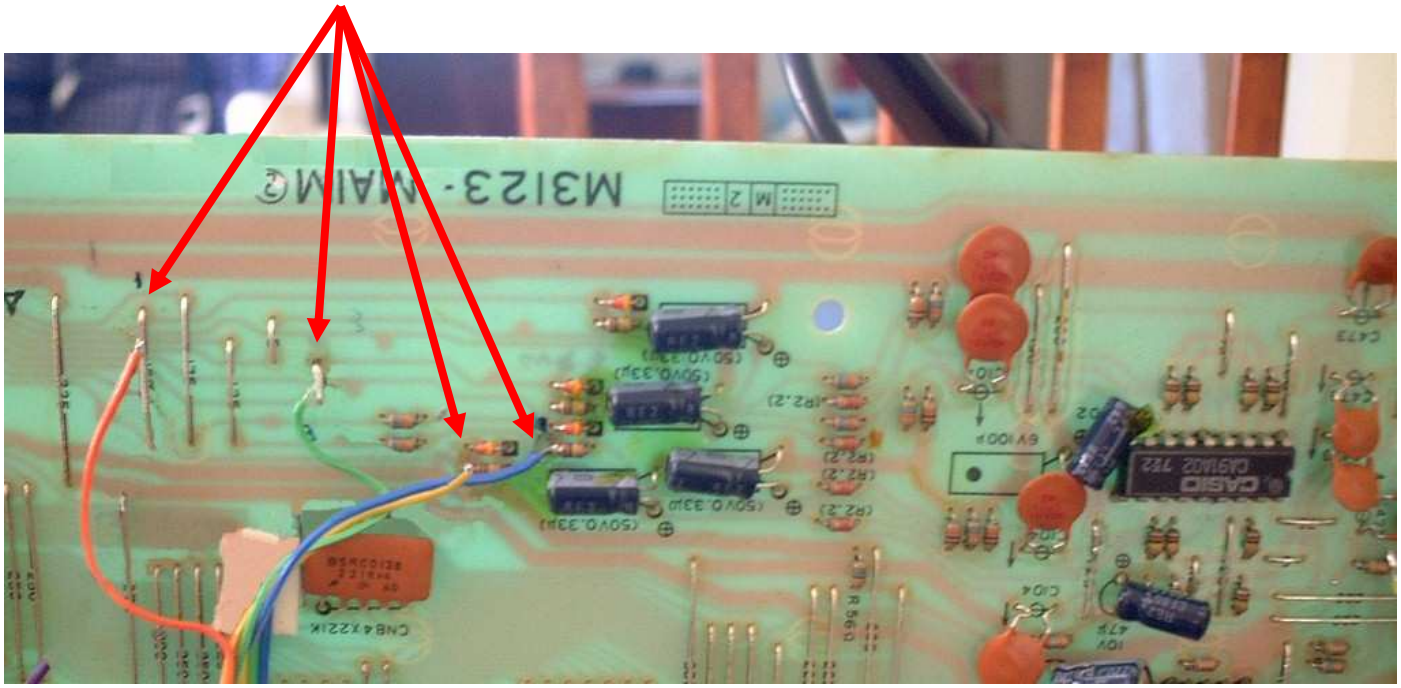
2. Between the Main SK board and the inner keypad board – this is where I mounted mine. It will fit just to the right of the centre of the keyboard, as viewed from the back. Remove the main SK circuit board and lift it up on one edge, being careful not to break any connecting ribbon cables inside the SK. Experiment in the approximate position I suggested, resting the main SK board on the ***PHAT PHILTER BANK*** board while it is place, until you get the SK board to meet its mounting posts. You may have to carefully bend a few components on the SK board down flat if they touch the ***PHAT PHILTER BANK*** board too much.

Wiring points for internal installation.

If you choose to install the ***PHAT PHILTER BANK*** board inside the Casio SK, you may choose to tap the individual voice outputs from the other side of the SK board, to save wires getting tangled.

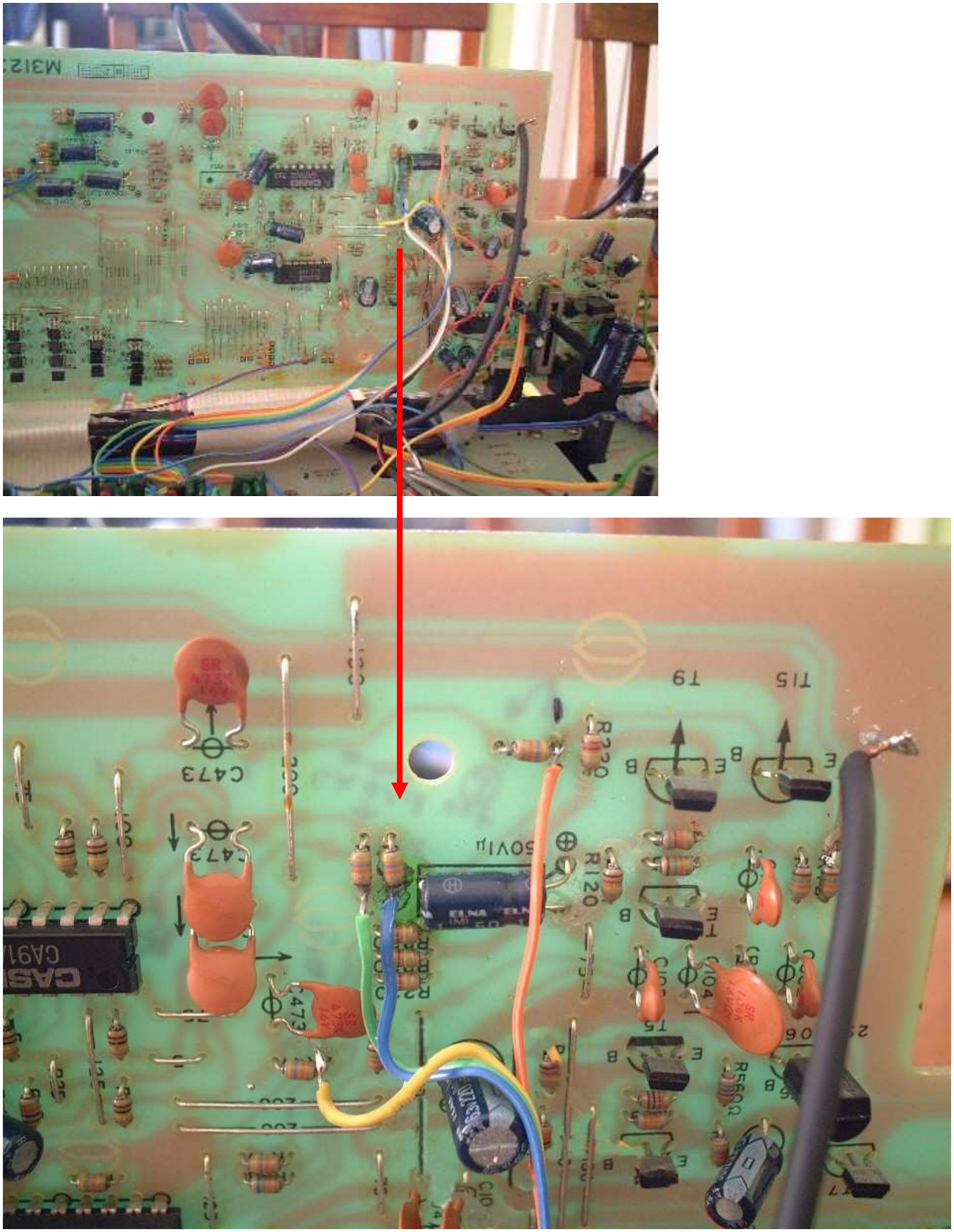
CV line soldering points

Below is a photo of the CV points from the other side of the board Note that there are 2 convenient wire links to solder the orange and green wires to. The yellow and blue wires solder on to the legs of resistors.



Audio voice soldering points

Below are the points to attach the 4 audio input lines of the ***PHAT PHILTER BANK*** board from the component side of the SK board. Each wire solders to the leg of a resistor:



Other setup options

CV Envelope / Manual switch

You can add a 4 pole, double throw switch, connected in line with each CV line, so as to have the “Manual” control of the cutoff frequency in the switches’ off position, and “Envelope” control by the SK with the switch in the on position:

4-pole, double throw switch (4PDT switch)

Connect each CV line from the Casio to each of the 4 centre terminals of the switch. Connect the ***PHAT PHILTER BANK*** board CV input wires to the corresponding outer terminals of the switch (either one, as long as they are all on the same side of the switch).

Internal audio speaker connection

If you have chosen to mount the ***PHAT PHILTER BANK*** board **inside** the SK, you can have ***PHAT PHILTER BANK*** board use the onboard Casio speaker, for self contained use without an external amplifier. You can then have a switch to select “normal” SK sound, or select the ***”PHAT PHILTER BANK”*** sound.

Using an SPDT (Single Pole, Double Throw) toggle switch pictured below, you can hook up the switch and the ***PHAT PHILTER BANK*** board audio out as shown on the next page.

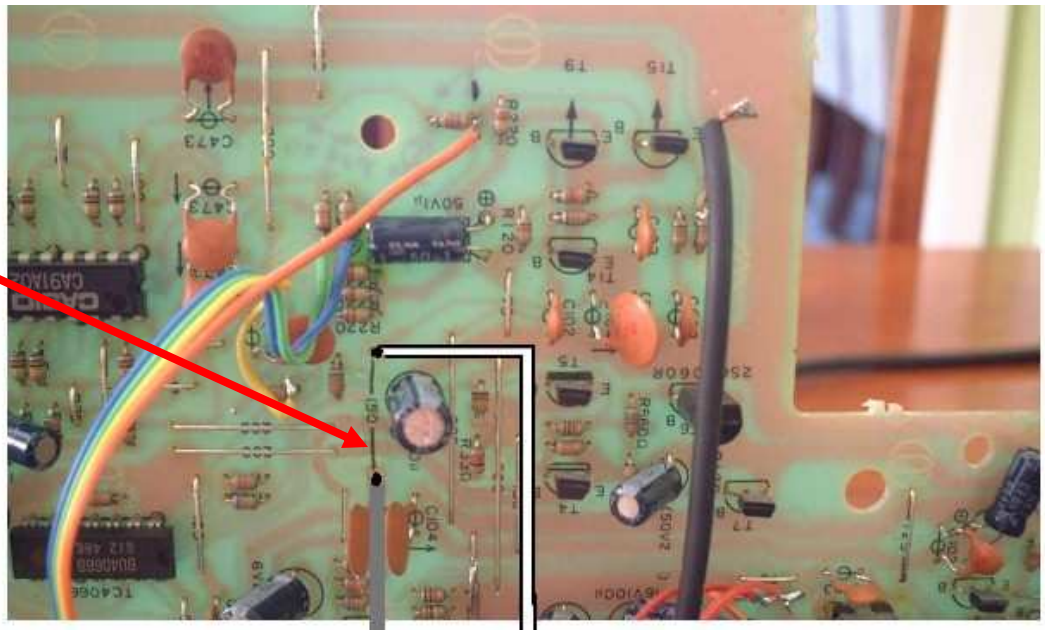
***** NOTE*****

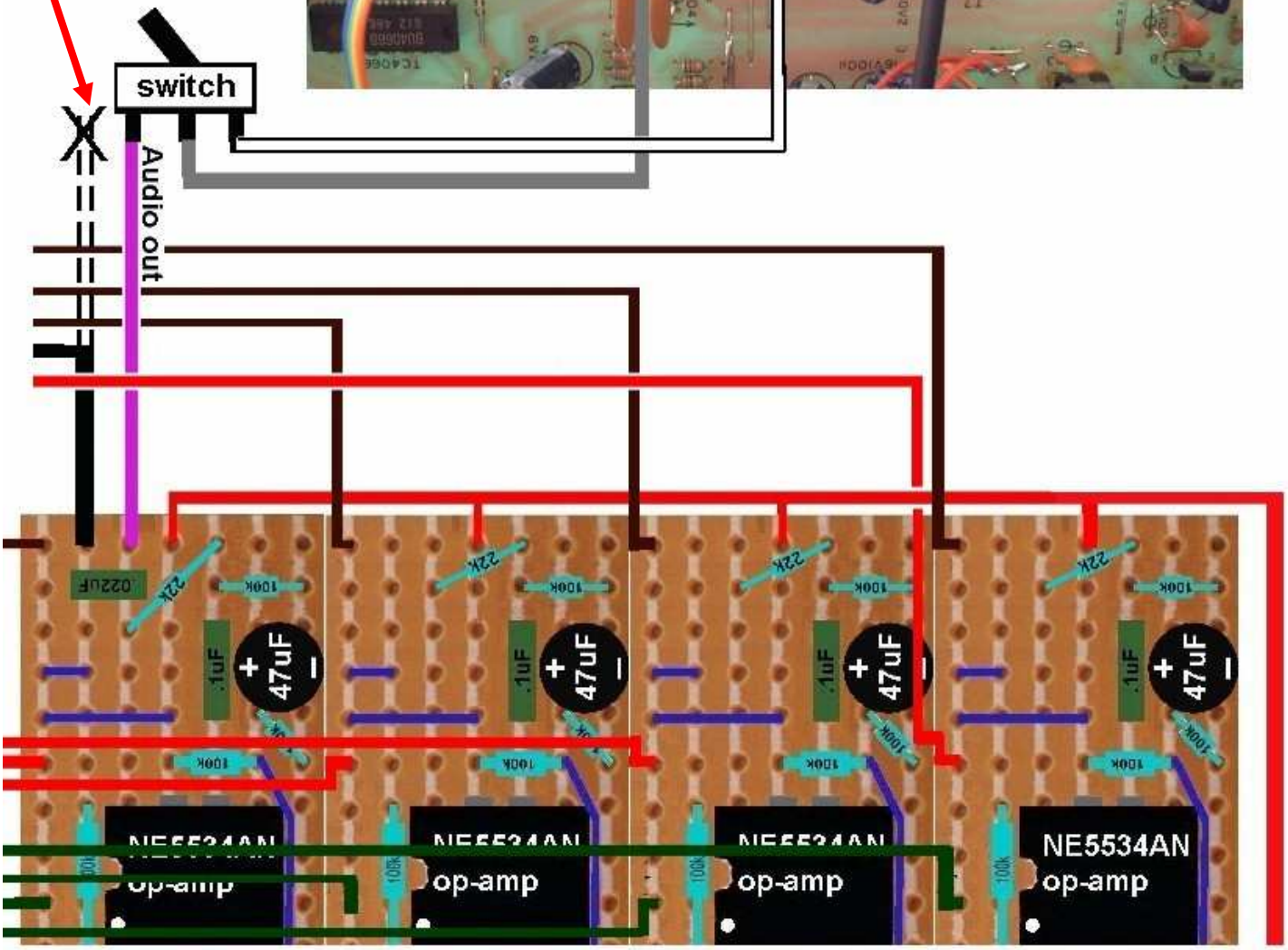
You don’t need the **audio output ground wire** (the black one) if you are doing this setup, because the board is already grounded using the internal 0V ground line from the SK board. Disconnect the audio output ground wire from the ***PHAT PHILTER BANK*** board.

Wiring diagram for internal audio speaker connection

There is a **wire link** soldered into the board here. Remove it, and solder the white wire into the upper link hole. Solder the grey wire into the lower link hole.

Disconnect the black **audio ground wire** used for the plug, you don't need it in this installation

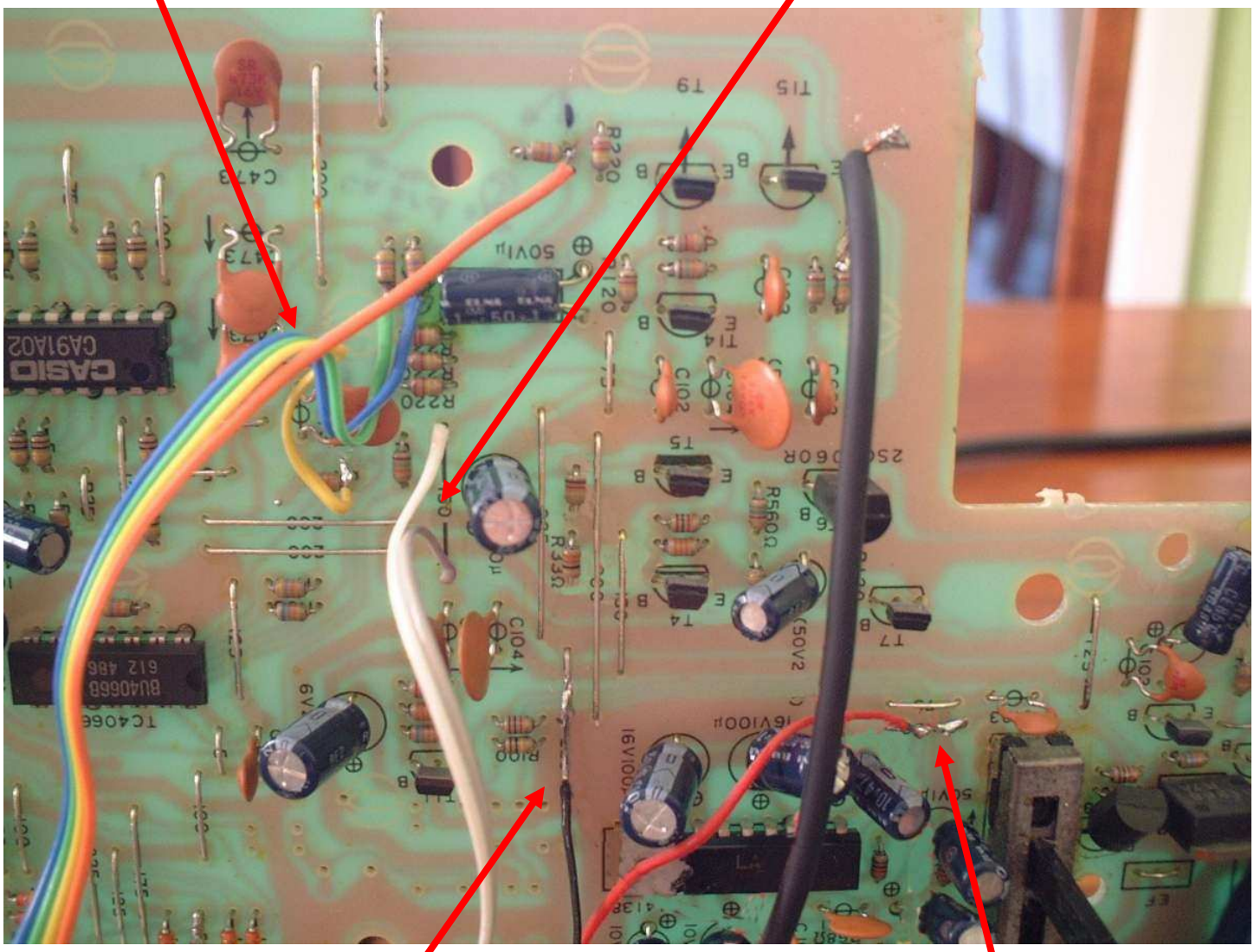




Picture of internal wiring points completed

Audio wires for each audio input into ***PHAT PHILTER BANK*** board

Wires for audio output bypass switching of the ***PHAT PHILTER BANK*** board using an SPDT toggle switch



OV ground wire (black) from the ***PHAT PHILTER BANK*** board. It solders to this link on the SK board.

7.5V DC power wire (red) from the ***PHAT PHILTER BANK*** board. It solders to this link on the SK board.

I hope you enjoy the ***PHAT PHILTER BANK*** mod!

You can find help or answers to problems at the **Yahoo Casio SK Group forum:**

http://launch.groups.yahoo.com/group/CasioSK/

Cheers, Graham