DPScope Assembly Guide

Version 1.4 (Jan. 10, 2015)

Congratulations for purchasing the DPScope oscilloscope kit! This guide will lead you through all the steps required to put it together so youôll be measuring signals in no time.

While we made every effort to create a kit that is robust and simple to assemble, there are some components that are sensitive to mishandling, e.g. putting them in with wrong polarity, so please pay close attention to the description for every step. Moderate soldering experience is required.

You will need a few tools for the assembly:

Å Small soldering iron (about 17 Watts power) with sufficiently fine tip
Å Solder wire
Å Flat-nosed pliers (to bend component leads)
Å Small wire cutter (to cut off component legs)
Å 14mm wrench (to fasten the BNC connectors to the front panel)
Å Small Philips screwdriver (to adjust the trimmer resistors
Å Small non-metal screwdriver (to adjust the trimmer capacitors)

The time required for putting the scope together will depend on your experience ï a seasoned hobbyist should be able to do it in around one hour, but if you are new to this it will take longer.

If you have any questions or feedback, do not hesitate to contact us:

Email: support@dpscope.com
Webpage: http://www.dpscope.com

Step 1: Unpacking the Kit

Below you see the kit as it comes out of the box.
It contains all the electronic components necessary to build the scope.

To operate the instrument, you will need the following additional items:

Å Standard Mini-USB cable (i.e. type A connector on one side ï connects to the PC ï and type Mini B connector on the ther (connects to the scope).

Å A pair of oscilloscope probes (either simple grabber cables, or standard switchable 1:1/1:10 scope probes), in either case equipped with male BNC connectors on the scope side.

Step 2: Components

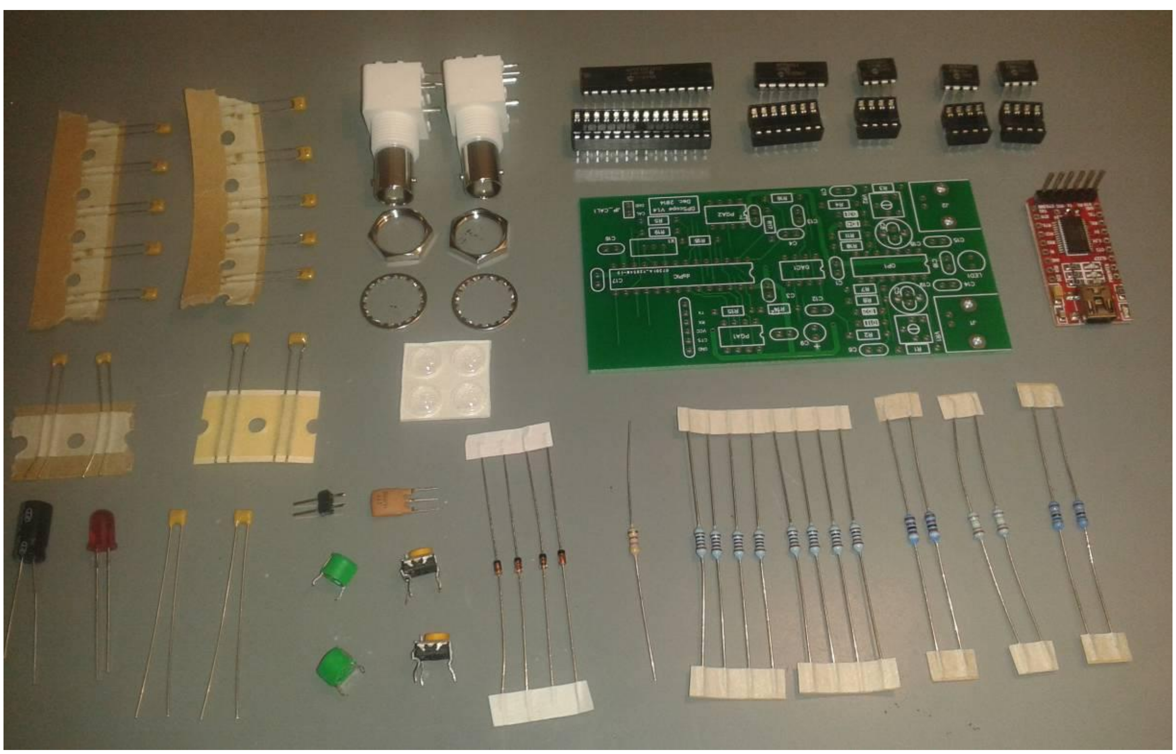
Below you see all the components spread out. Everything you need to build the oscilloscope is included. Please use the component list to verify that you have all the parts.

Some general remarks:

Å Some components may look somewhat different than in the pictures ï different color, different leg length, etc. Make sure you reliably identify each component before you solder it onto the board. Take your time! **It is much easier and much faster to perform a very careful assembly than it is to troubleshoot a circuit that does not work because some component was installed incorrectly!**

Å Some components are difficult to distinguish (e.g. resistors, ceramic capacitors). Refer to the next pages for some hints.

Å The integrated circuits, the USB interface board, and the diodes are sensitive to electrostatic discharge ï it is good practice to use a grounded wrist strap to avoid damage to them during assembly, and to place all the components on an antistatic surface. Donõt wear clothes that get easily charged up (e.g. wool sweater).



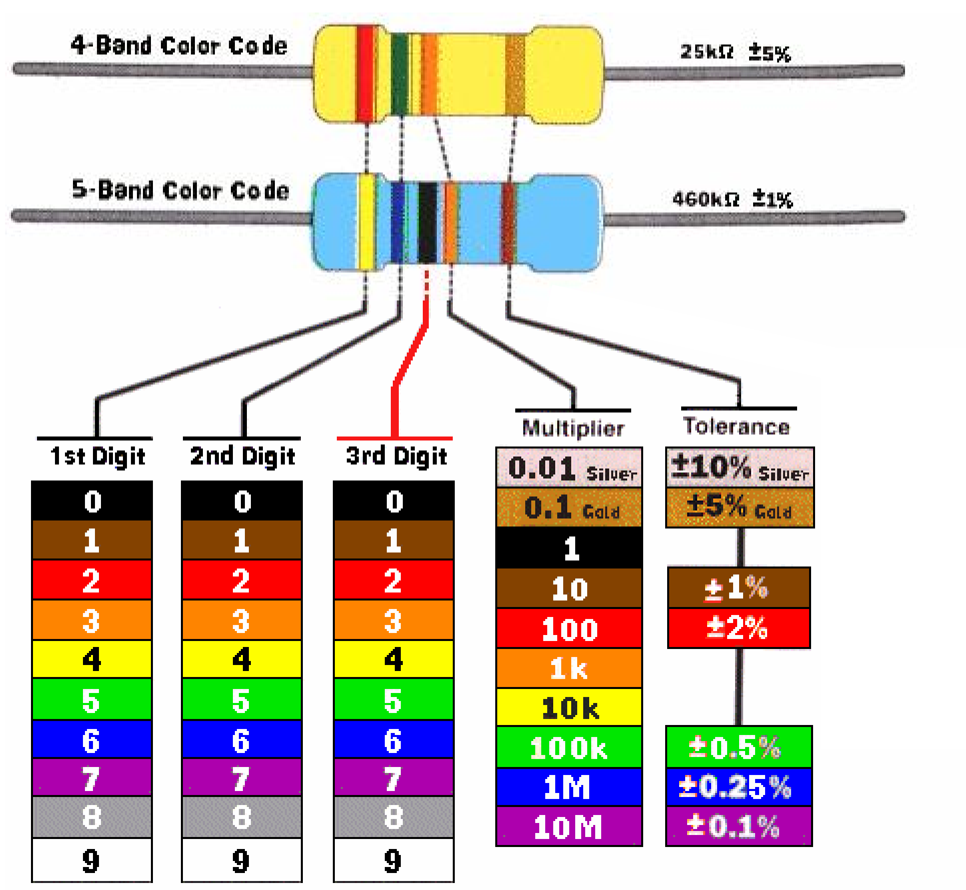
Step 3: Identifying Resistors

Resistor values are color coded (see table below).

The resistors used in the kit with 5% tolerance have 4 colored bands (two significant digits, one multiplier, one tolerance). E.g. brown(1) ï red(2) ï yellow(10E4) ï gold(5%) means 12*1E4 q = 120 kq , Tolerance 5%

Resistors used in the kit with 1% tolerance have 5 colored bands (3 significant digits, one multiplier, one tolerance).

If available, checking each resistor value with an Ohmmeter is recommended.

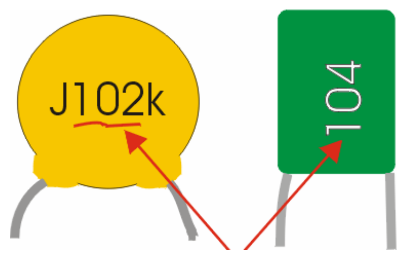


Step 4: Identifying Capacitors

Å **Ceramic capacitors:**

The value is given in pF as one 3-digit number ñxxyòcomprising 2 significant digits (xx) and one multiplier (y). The markings may be small so to read them use a magnifying glass if necessary. Sometimes there is only a single digit or two digits, this then gives the capacitance in pF directly. Letters (e.g. J, K,é) denote tolerances etc., for our purposes here simply ignore tem (i.e. ñkòdoes NOT mean ñkiloò).

474 means 47 * 10E4 pF = 47 * 10000 pF = 470 nF = 0.47 µF
104 means 10 * 10E4 pF = 10 * 10000 pF = 100 nF = 0.1 µF
181 means 18 * 10E1 pF = 18 * 10 pF = 180 pF
220 means 22 * 10E0 pF = 22 * 1 pF = 22 pF
24 means 24 pF
1 means 1 pF



Å **Electrolytic capacitors:**

Their values are typically printed without any encoding. Just be careful not to overlook the decimal point.

E.g. 100 µF, 4.7 µF

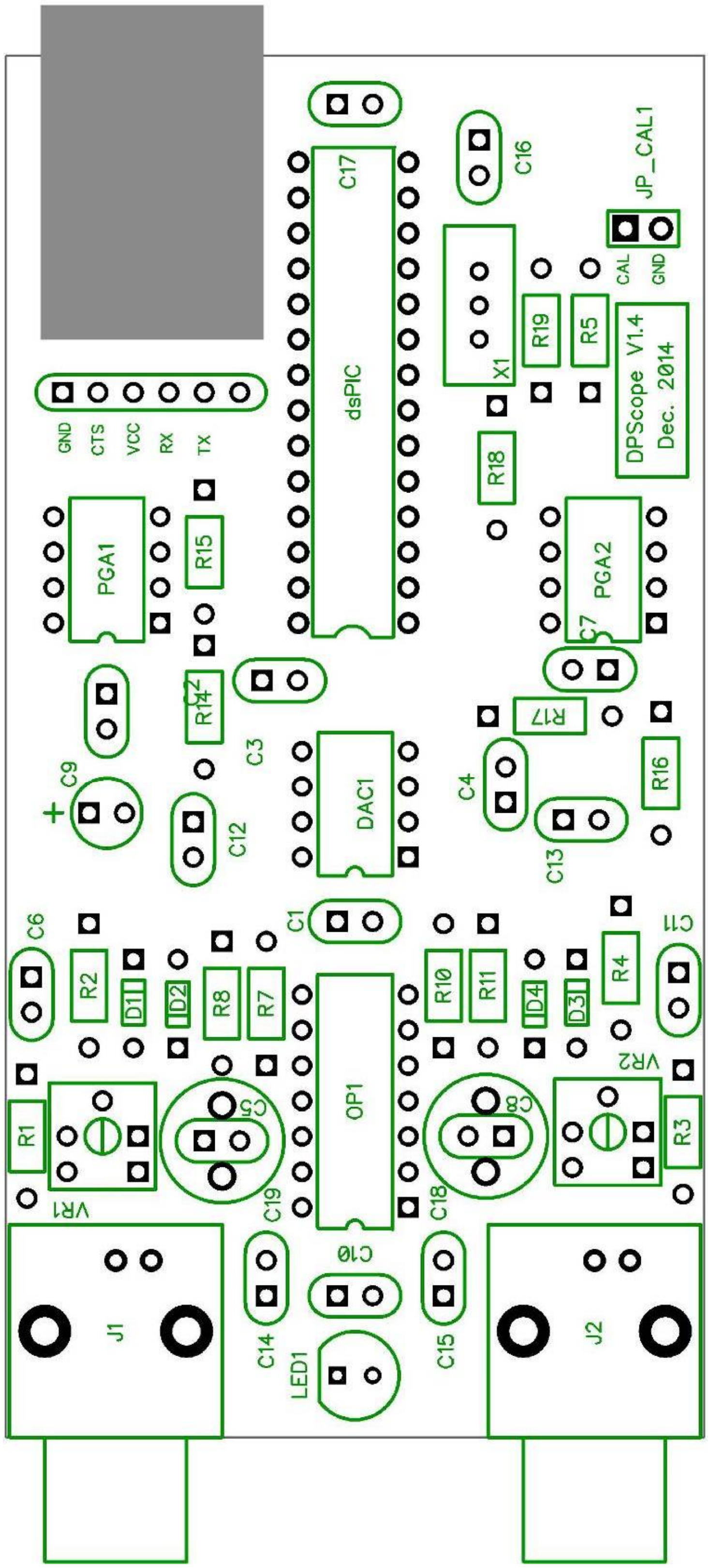
Since electrolytic capacitors are polarized (must be connected to positive and negative side the correct way, otherwise they will be destroyed), their polarity is indicated as well. Aluminum capacitors normally have the <u>negative</u> terminal denoted (by a big bar with ñ-òsigns), while tantalum capacitors have the <u>positive</u> terminal marked.

This kit contains only normal aluminum capacitors.

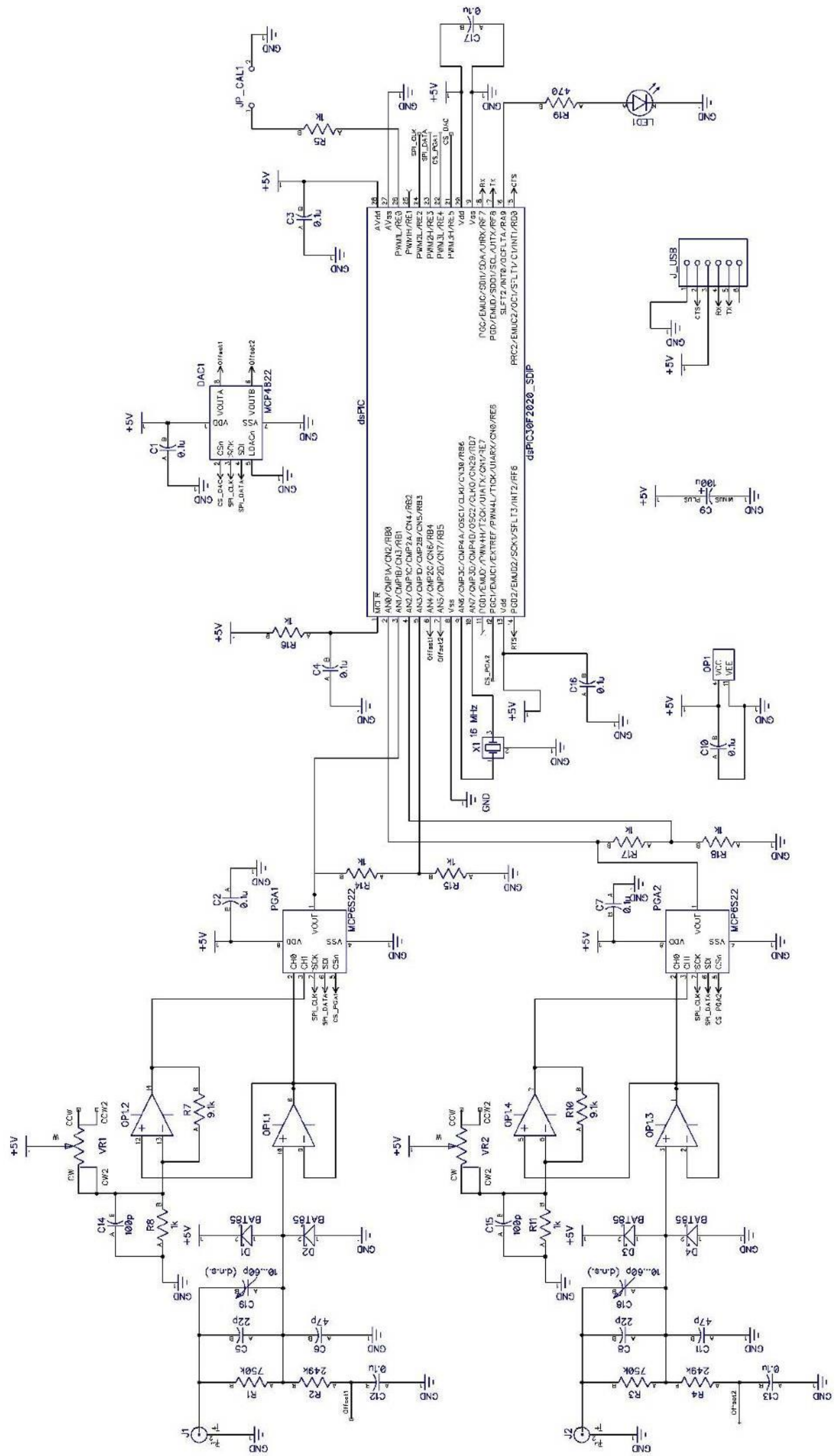
Step 5: Component List

RefDes	Description	Value	Qty.
R19	resistor	470	1
R5, R8, R11, R14, R15, R16, R17, R18	resistor	1k	8
R7, R10	resistor	9.1k	2
R2, R4	resistor	249k	2
R1, R3	resistor	750k	2
VR1, VR2	trimmer	500k	2
C5, C8	ceramic capacitor	22p	2
C6, C11	ceramic capacitor	47p	2
C14, C15	ceramic capacitor	100p	2
C18, C19	trimmer capacitor	10..60p	2
C1, C2, C3, C4, C7, C10, C12, C13, C16, C17	ceramic capacitor	0.1u	10
C9	electrolytic capacitor	100u	1
X1	ceramic resonator, 3 pin	16 MHz	1
D1, D2, D3, D4	Diode	1N914A	4
LED1	LED	red, 5mm	1
OP1	MCP6024		1
PGA1, PGA2	MCP6S92		2
DAC1	MCP4822		1
dsPIC	dsPIC30F2020		1
PGA1, PGA2, DAC1	DIP socket 8 pin		3
OP1	DIP socket 14 pin		1
dsPIC	DIP socket 28 pin	300 mil	1
J1, J2	BNC connector		2
JP_CAL1	Jumper 2-pin		1
J_USB	Jumper 6-pin right angle		1
	USB-to-serial converter		1
	Rubber standoffs	5mm dia.	4
	Printed circuit board	2 layers	1

Step 6: Component Placement



Step 7: Circuit Schematic

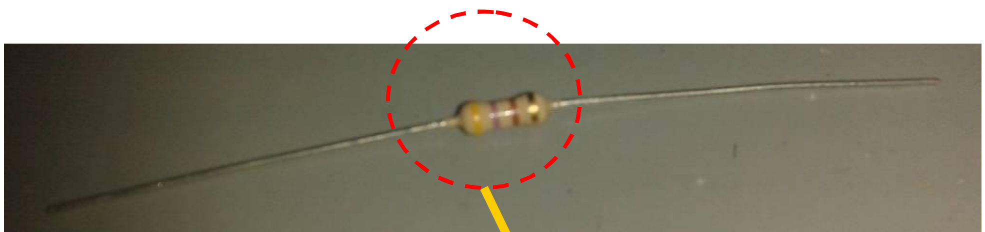


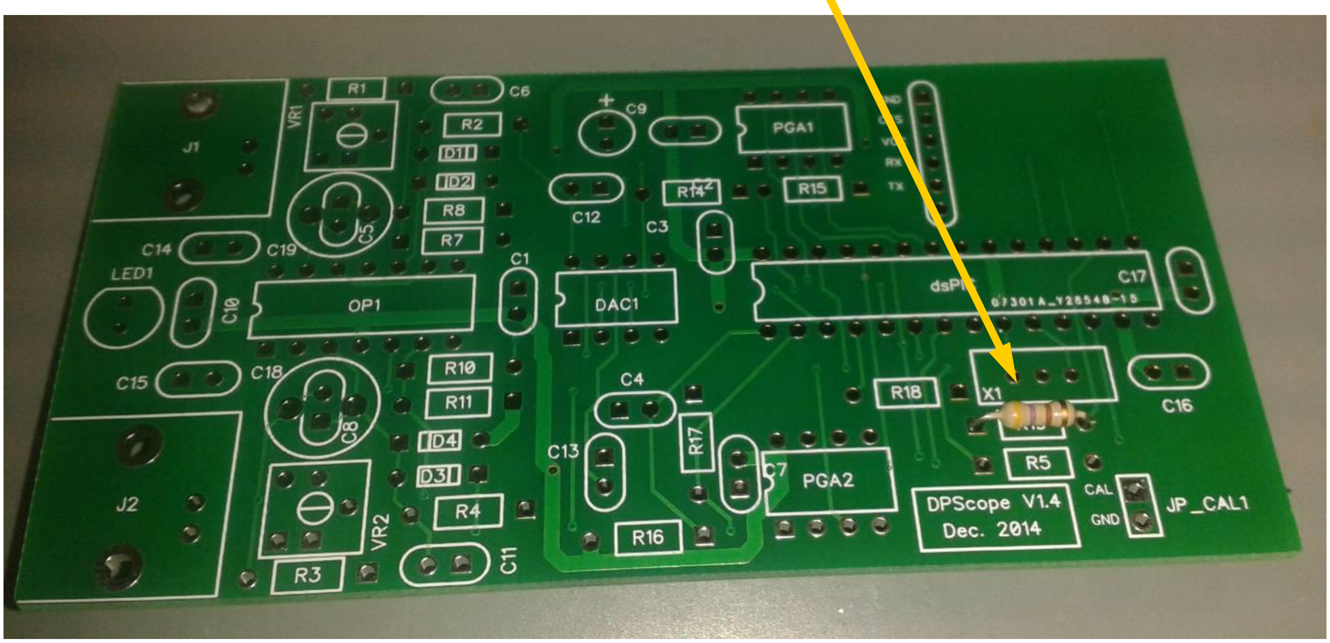
Step 8: Installing the First Part – R19

Letôs start out with a simple part ï resistor R19, which has 470 Ω. All the other parts will get assembled in a very similar way.

Identify the resistor among all the parts (see picture below).

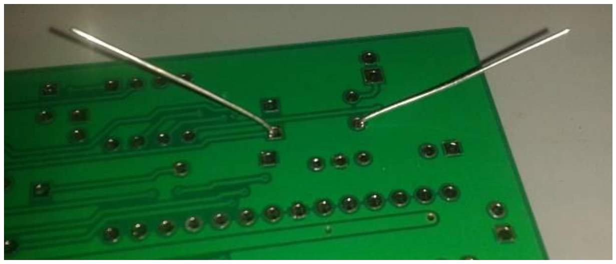
On the printed circuit board (PCB) locate the component outline labeled ìR19î. Bend the resistor leads and stick them through the board. The final result is shown below.



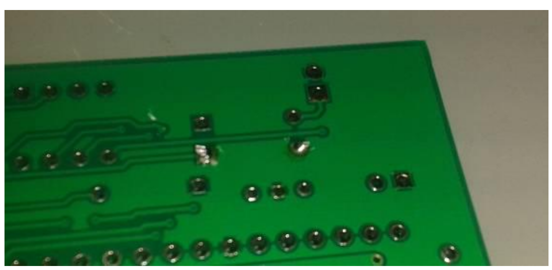


Step 9: Soldering the First Part

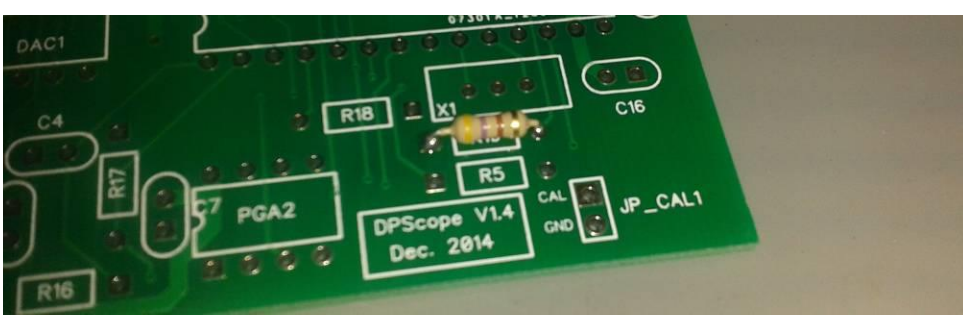
On the PCB bottom bend the component leads apart ï this will hold the resistor securely in place when you turn over the PCB to solder it on:



To solder, touch the component lead (wire) with the soldering iron and the solder wire at the same time. Add enough solder so it completely fills the hole and leaves a small ñhillò of solder. Remove the solder wire and the soldering iron but donõt move the board before the solder has become completely solid again. The solder joint should be shiny and bright (if using lead-based solder). Repeat for the other lead. Check that the resistor still sits flush on the board, then clip off the leads with the pliers..

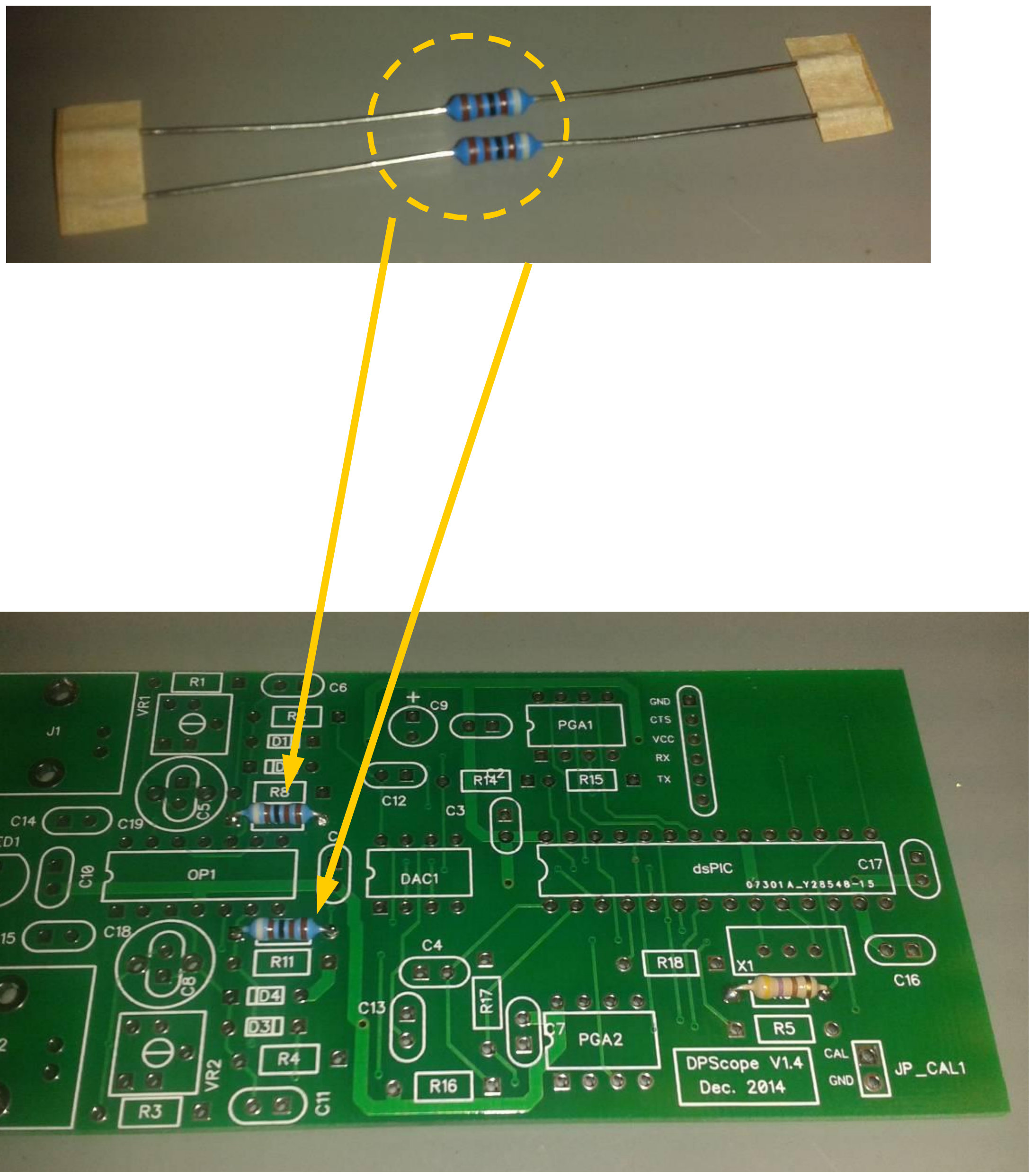


Check the topside of the board ï you should see solder protruding a bit from the via holes ï this shows the holes are nicely filled with solder (see picture below):



Step 10: Next Components

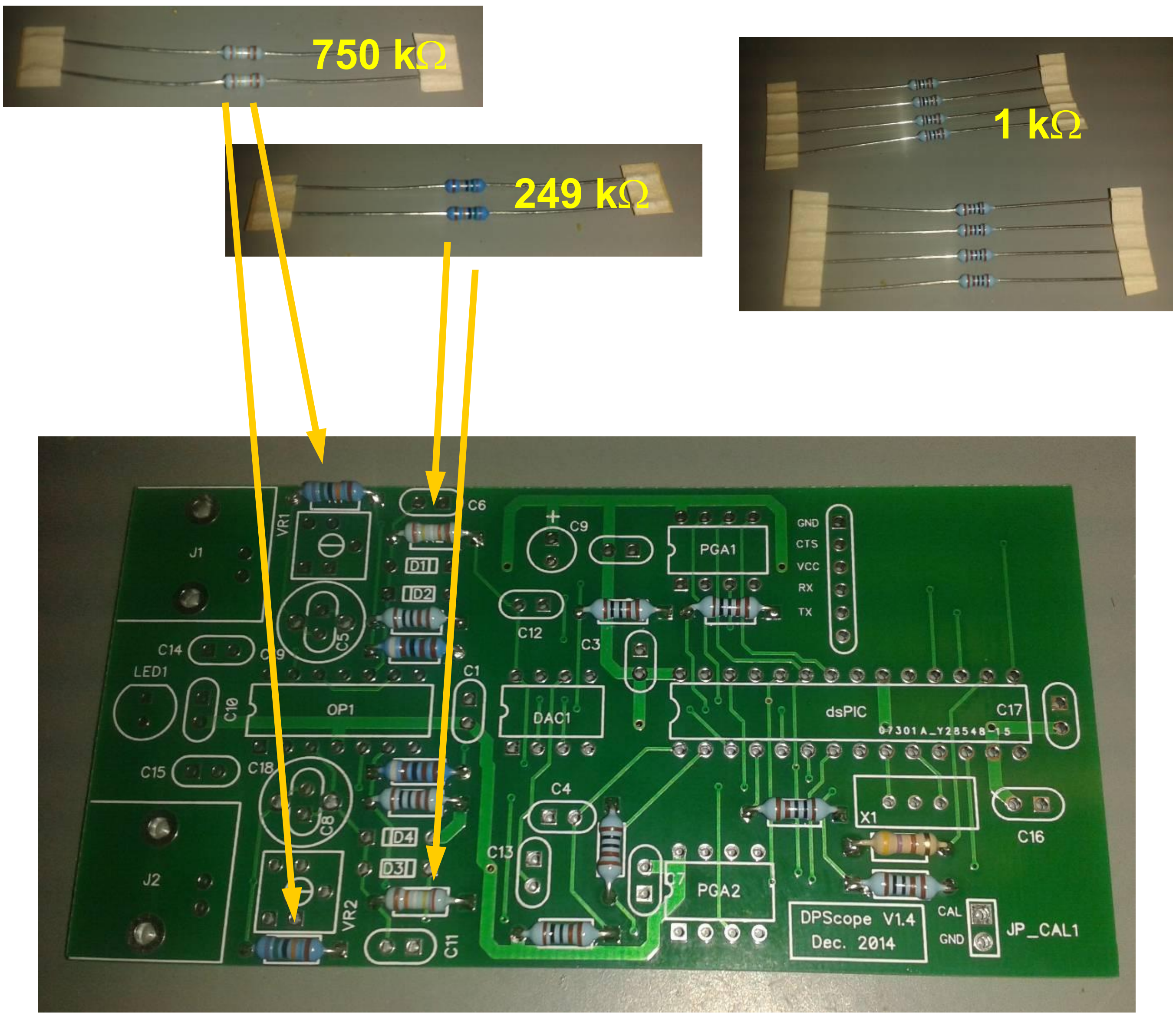
Next is a pair of resistors ï R7 and R10. Installation and soldering works just like for R19. Below you see what the board looks like with them installed.



Step 11: Remaining Resistors

Now lets finish up the resistors. We still got R2 and R4 (249 kΩ), R1 and R3 (750 kΩ), and 8 pieces of 1 kΩ resistors. Install the two pairs first, and then install the 1 kΩ resistors in all remaining resistor outlines on the PCB (refer to the parts list if find out which resistor is which value).

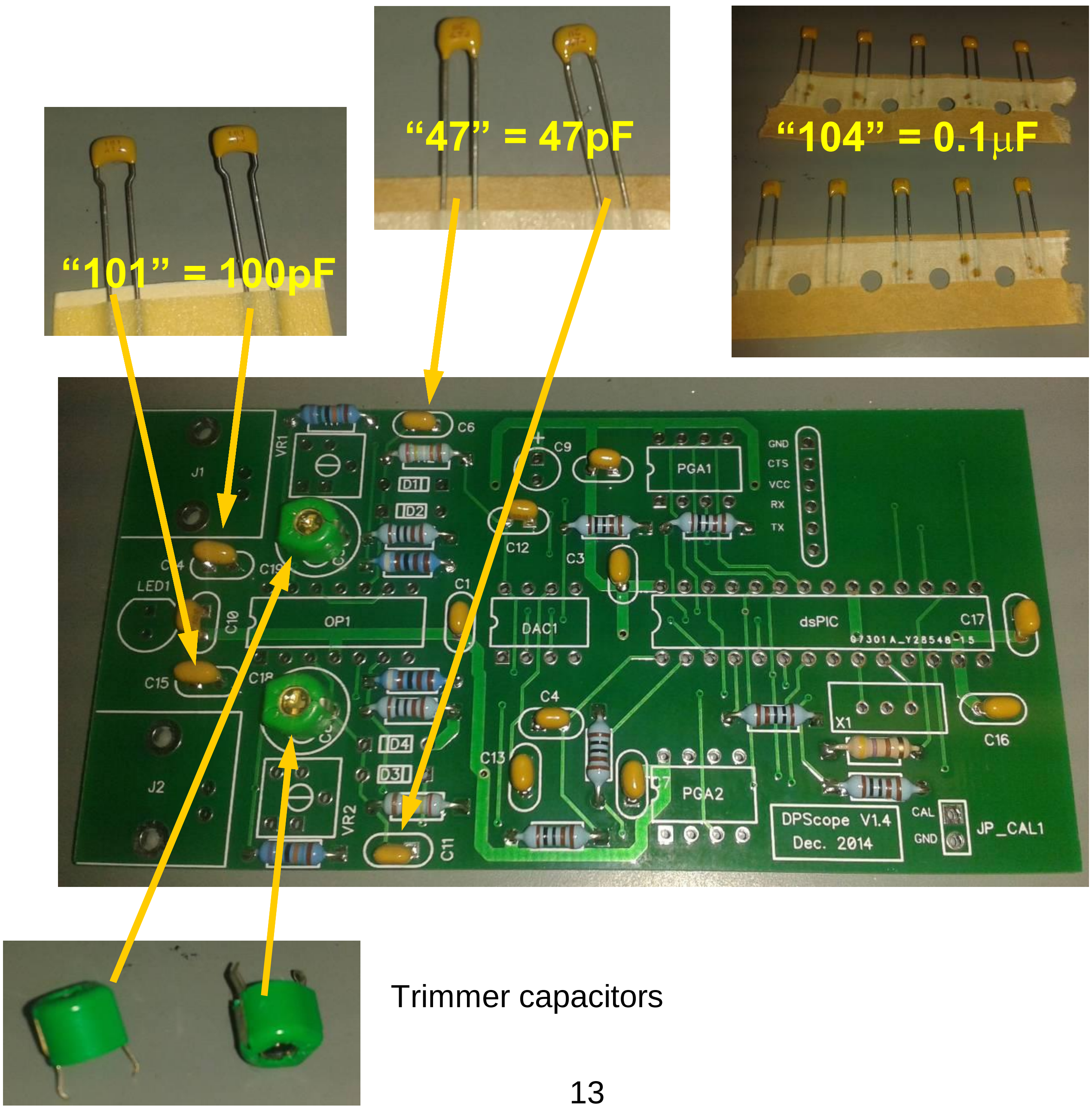
The picture on the bottom shows the PCB populated with all the resistors.



Step 12: Ceramic Capacitors, Trimmers

Installing the ceramic capacitors works the same as for the resistors. We have 4 different types: C6 and C11 (ceramic, 47 pF), C14 and C15 (ceramic, 100 pF), C18 and C19 (trimmers), and 10 pieces of 0.1μF ceramic capacitors.

Also like the resistors, ceramic capacitors are not polarized, so you do not need to observe any special orientation when installing them.



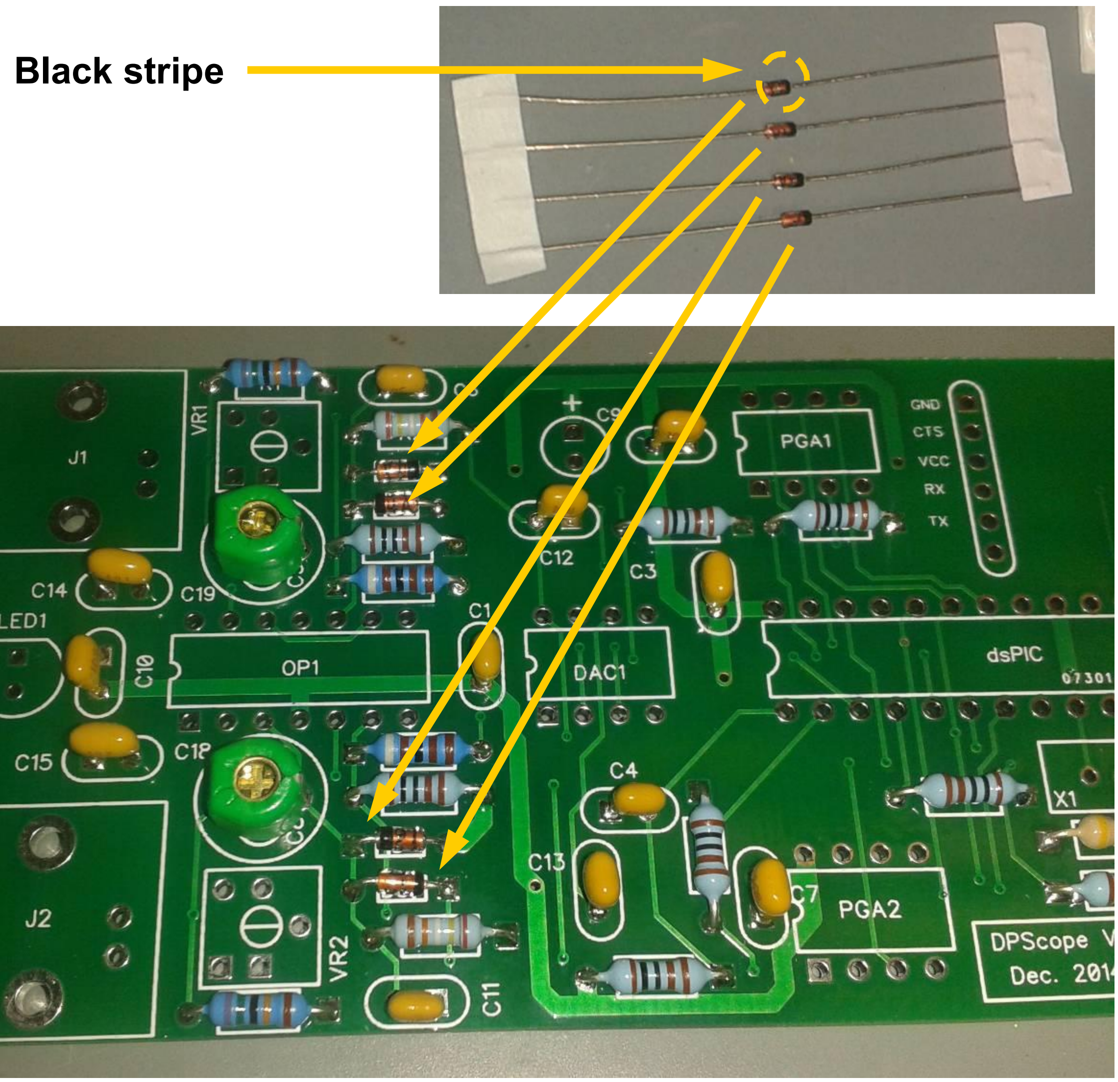
Trimmer capacitors

Step 13: Diodes

Next in the row are the clamping diodes. These components need more care than the resistors.

Å Make sure you insert them with correct polarity (correct orientation); the negative end is denoted by a **black stripe** around the diode body. The silkscreen outline also shows a (white) stripe ï this is the side the black stripe must lie. **Note that the orientation is *not* the same for all diodes**.

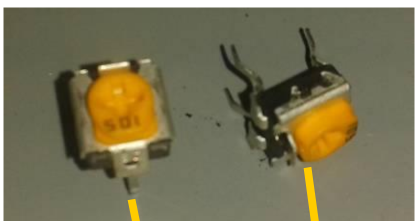
Å Diodes are quite sensitive to heat. Thus try to minimize soldering time. The best approach is to first solder only one end of all diodes, then the other end ï this gives them enough time to cool down in the time between.



Step 14: Trimmers, Resonator, Header

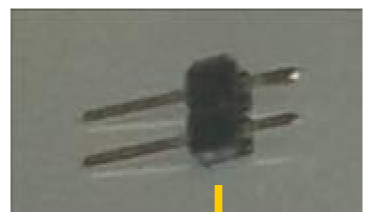
A few more small components are left: The two trimmer resistors (VR1 and VR2, the blocks with the adjustment knob on the top), the ceramic resonator (X1), and the probe calibration header (JP_CAL). Install them as shown below. Neither resonator nor jumper are polarized so they can be mounted in arbitrary orientation.

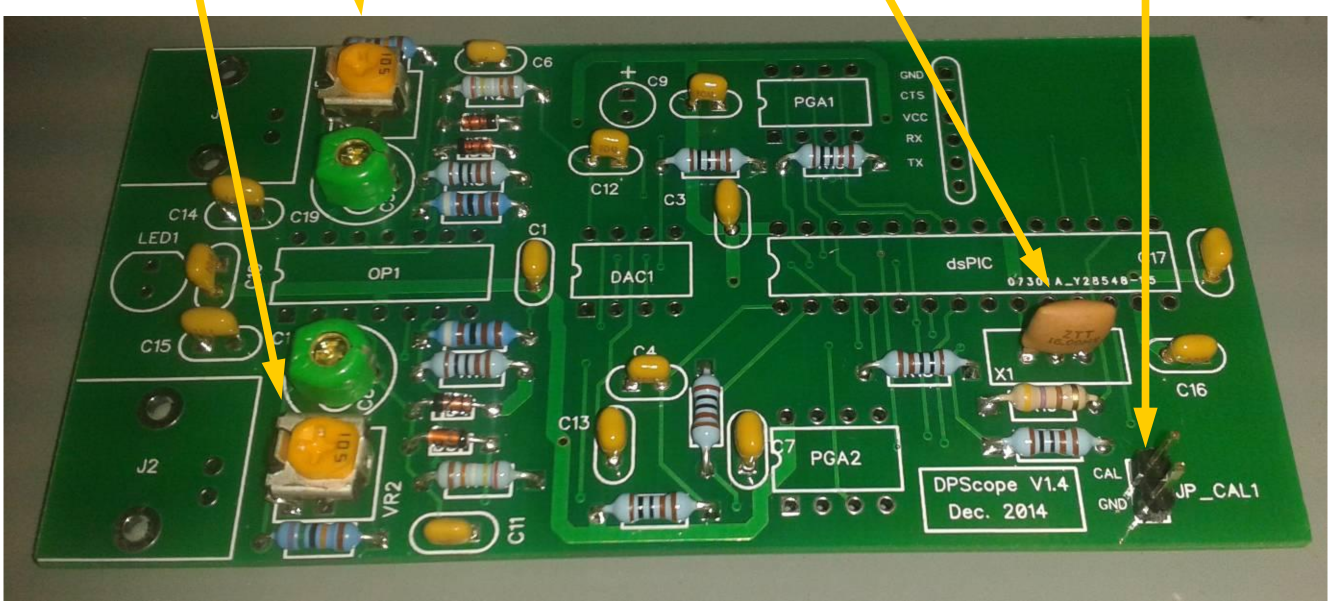
trimmer resistors



resonator

CAL header



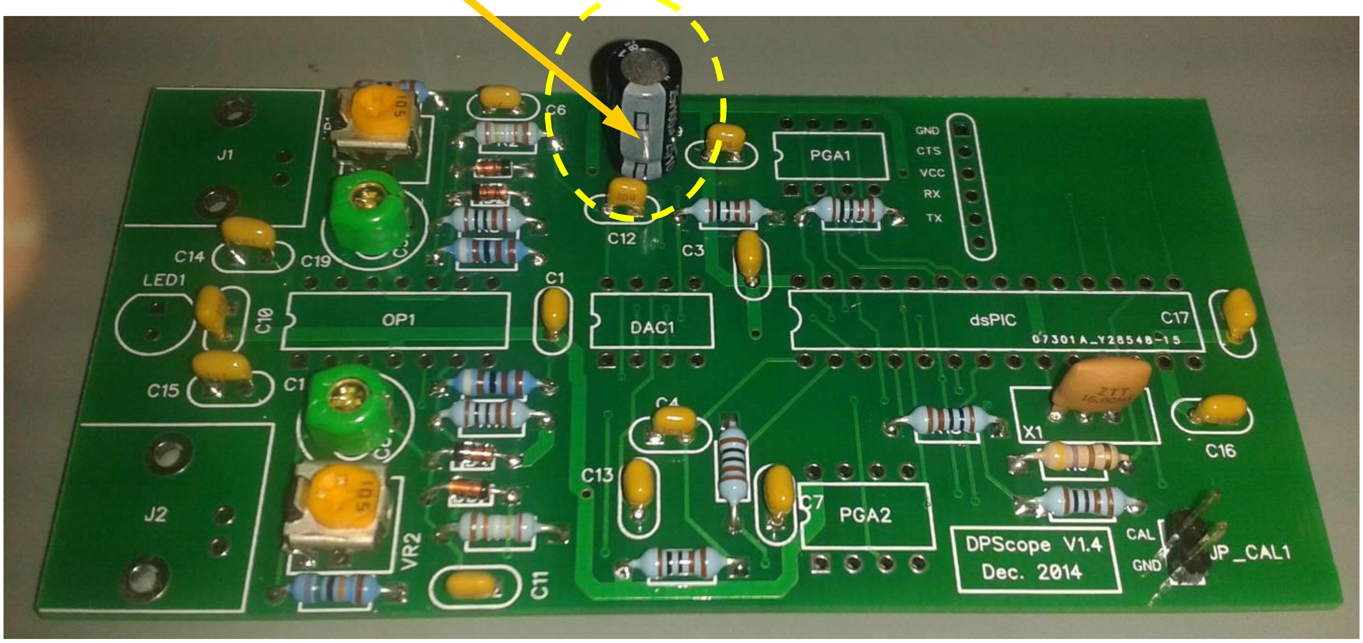


Step 15: Electrolytic Capacitor

The electrolytic capacitor is next.

Note: Be careful – this capacitor has to be put in with correct polarity. The negative side is clearly labeled with a white stripe and ñ-ò(minus) symbols ï make sure you install it as shown in the pictures below! Installing it the wrong way around will damage it immediately once the circuit is powered up ï it may even explode!

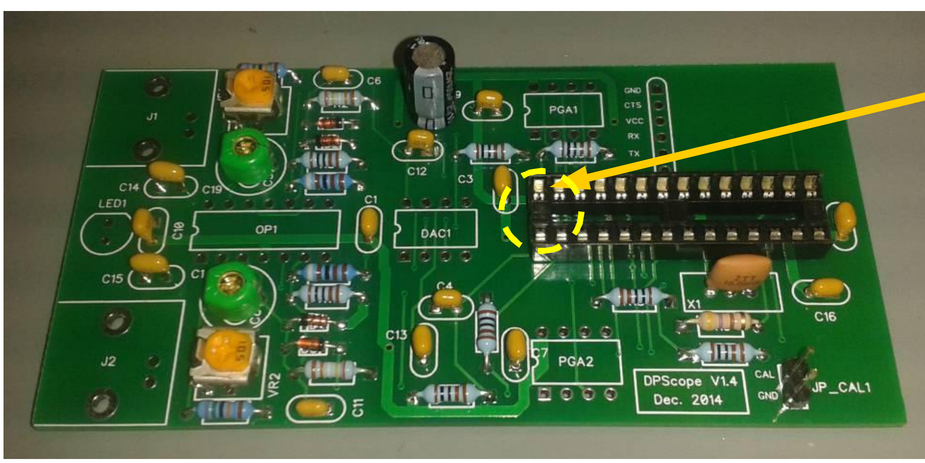
Negative (-) terminal



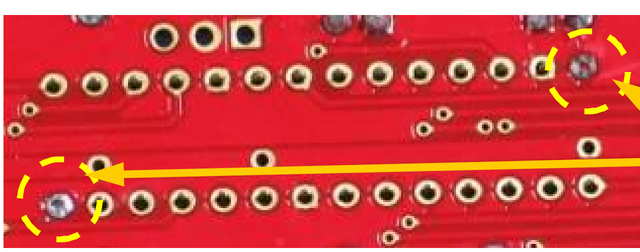
Step 16: First Socket

Now comes the first socket ï lets start with the 28-pin one, which goes into the outline labeled ñdsPICò and will later hold the microcontroller. Be careful with its installation because once soldered down it is almost impossible to remove. The best is to do it step by step:

1. Place the socket on the board as shown in the big picture. Note the **position of the notch** on the left side of the silkscreen outline ï make sure to orient the notch on the socket to the same side: Though the socket (not the chip that plugs into it!) will work in either orientation, matching the notch position of chip and socket will make installing the chip less error-prone.
2. Turn the board around an **solder only two of the corner pins** as shown in the zoomed-in picture below. The reasons is simple ï two pins diagonally opposed will securely hold the socket in place, but still allow you to make corrections.
3. Press the socket onto the board and re-heat both of these solder joint ï this allows the socket to sit flush against the board. Visually inspect the socket to make sure this is really the case.
4. Only now solder all the other pins.



notch

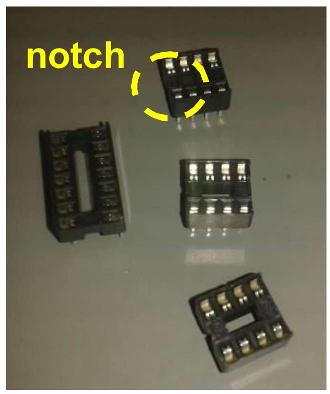


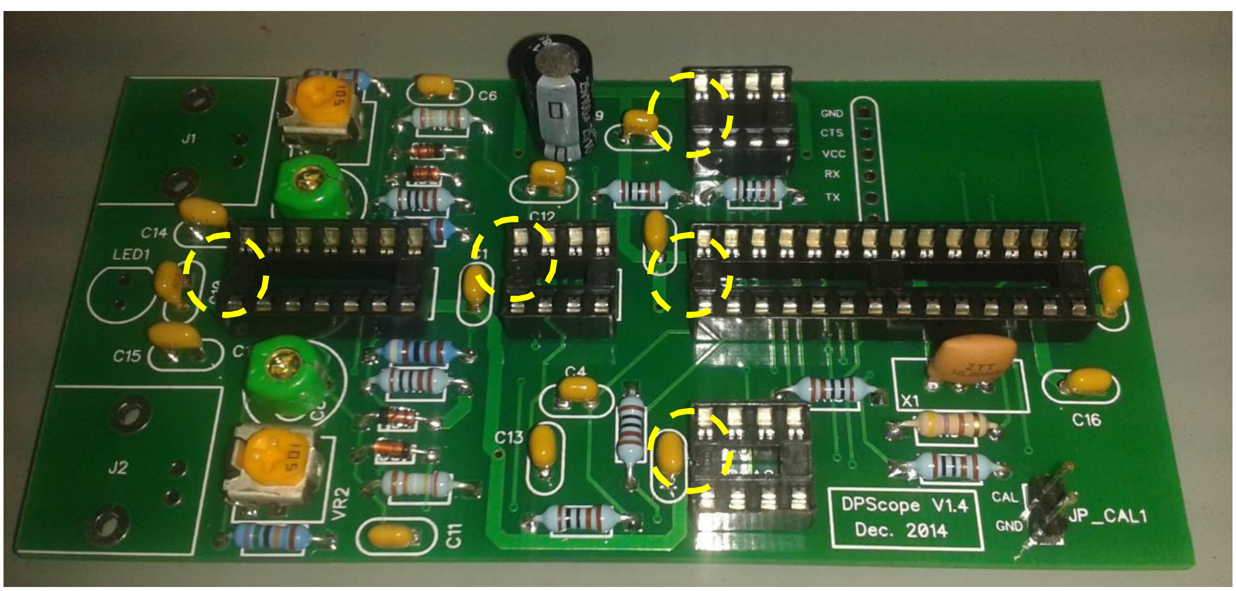
At first, solder only two corner pins

Step 17: Remaining Sockets

Now install the remaining sockets ï one 14-pin and three 8-pin ones. Proceed in the same manner as for the first socket. **Again make sure all the notches match the silkscreen outline** (they are all on the left side in the picture, marked with dashed yellow circles).

Below you see how the board should look like after this step.



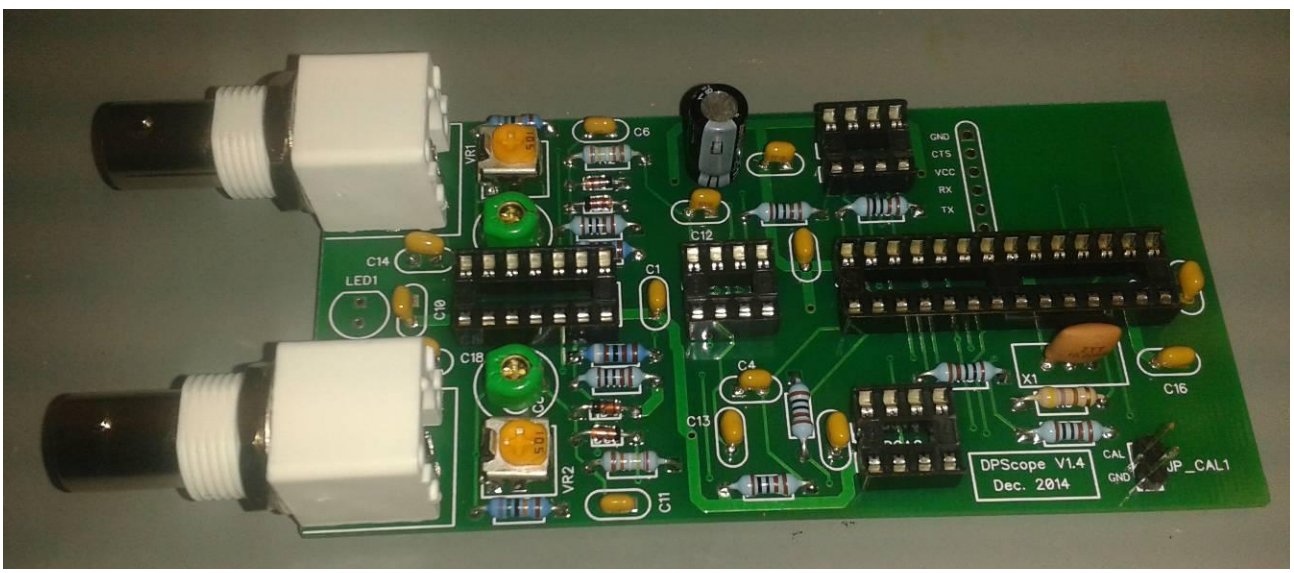


Step 18: BNC (Probe) Connectors

Put the BNC connectors in place. Turn the board over and solder down **one** of the thick alignment pins of each connector. Carefully check that both connectors sit flush and even on the board and are not tilted in any way. If corrections (resoldering) are necessary it is much easier to do this while only one pin of a component is fixed in place!

Now solder the other pins. Make sure there is no short between signal pin and ground pin.

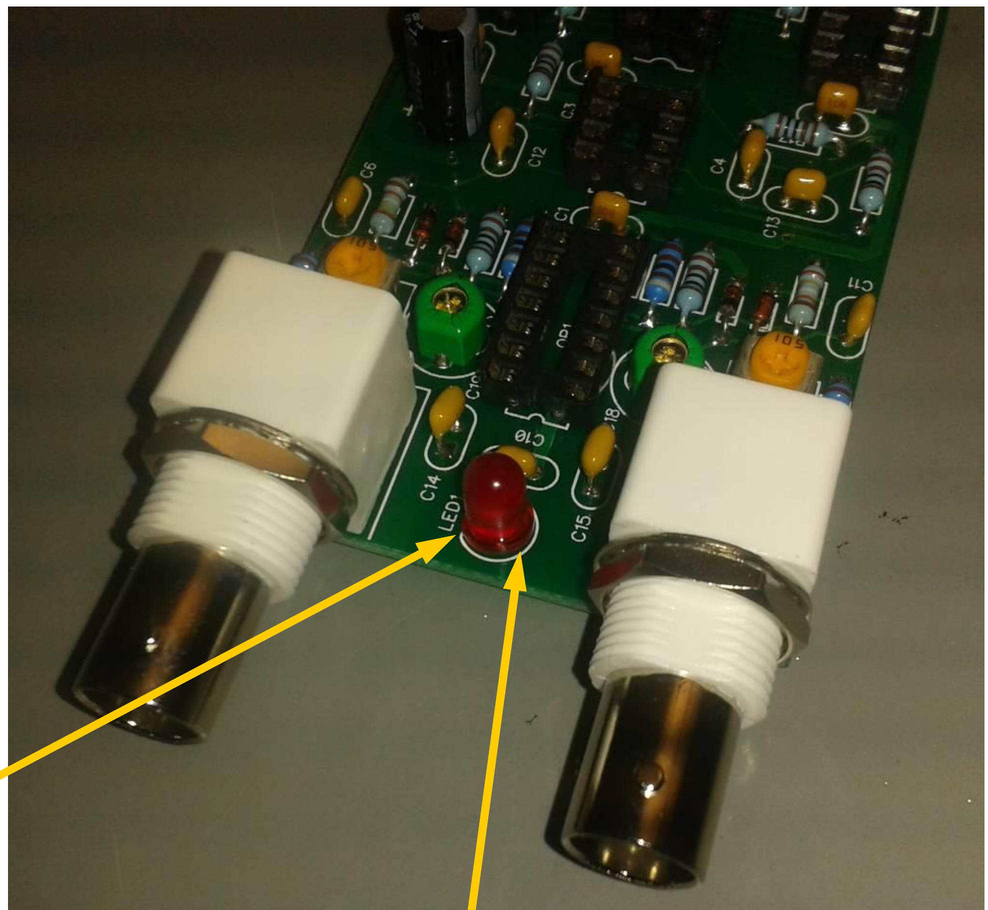
The washers and nuts (if included) aren't really needed for the bare board, but will come handy if you decide to mount the circuit into an enclosure (box) – then the BNC connectors can be used to attach the board to the enclosure's front pane. Tighten the nuts by hand fist, and then *very* gently with a wrench. The plastic threads are relatively sensitive so make sure not to over-torque them!



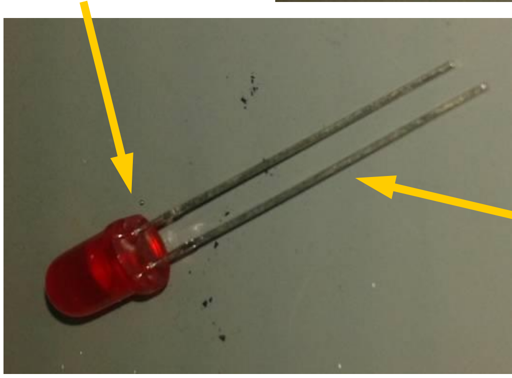
Step 19: Status Indicator LED

Take the LED (light emitting diode) and fit it onto the board. **Make sure the short leg of the LED goes into the side where the silkscreen circle has its notch (flattened side).** The diode body also has a notch at the same side.

Now turn the board around and solder the LEDôs legs onto the board. Be careful ï like any diode the LED is both sensitive to overheating and to electrostatic discharge.



short leg / notch



long leg

Step 20: IC Installation

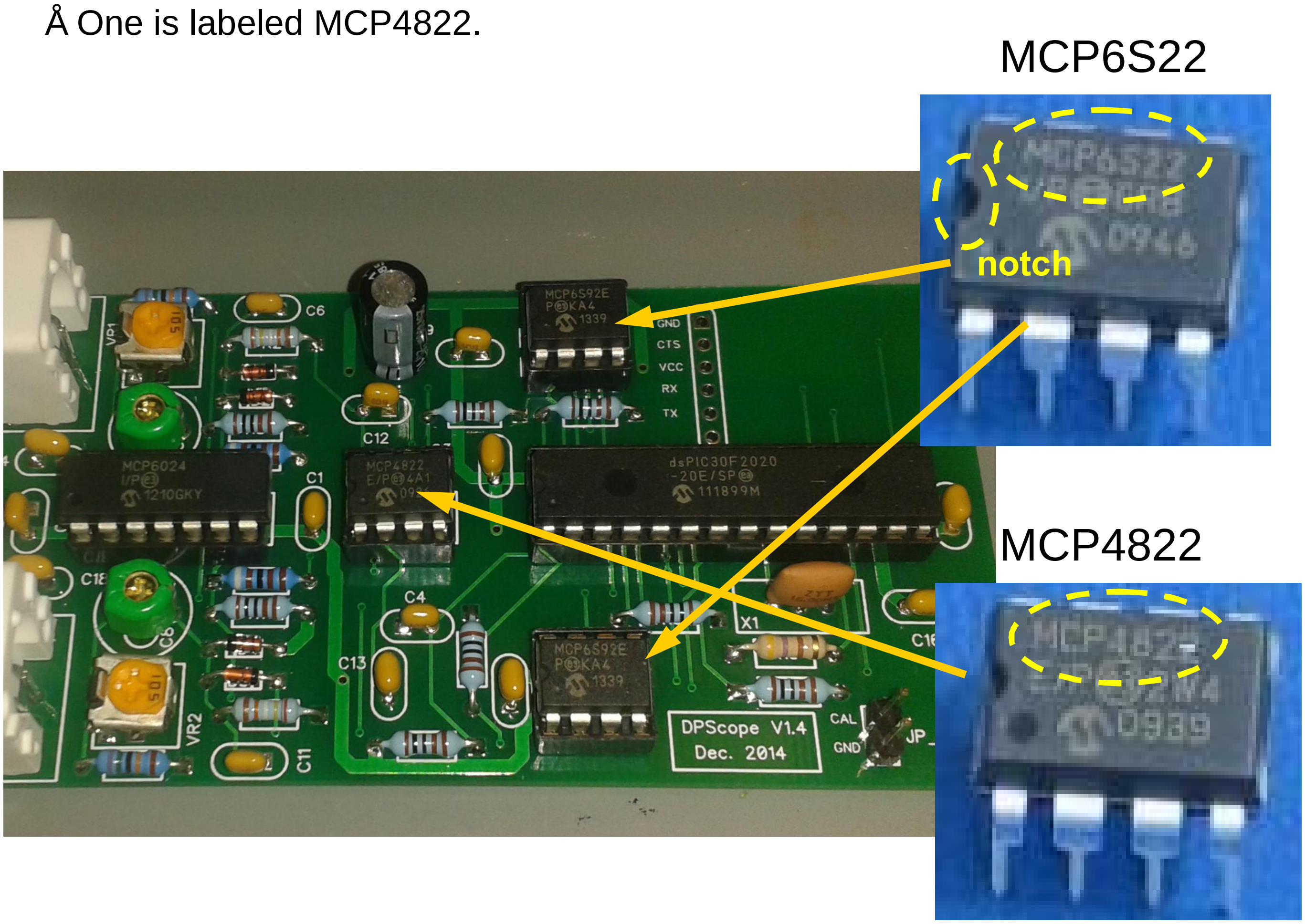
Now itôs time to install the ICs (integrated circuits). There are five of them.

Note 1: Make sure to put the chips on in the correct orientation. Each chip has a notch on one end ï this notch must go on top of the notch in the silkscreen outline (and the notch in the socket if you installed it correctly!).

Note 2: There are two different types of the 8-pin ICs – make sure you install them in the correct locations as shown in the picture below. Installing them in the wrong place (or the wrong orientation) will destroy them when you power up the oscilloscope. You can distinguish the chips by the labels printed on them:

Å Two are labeled MCP6S22 or MCP6S92,

Å One is labeled MCP4822.

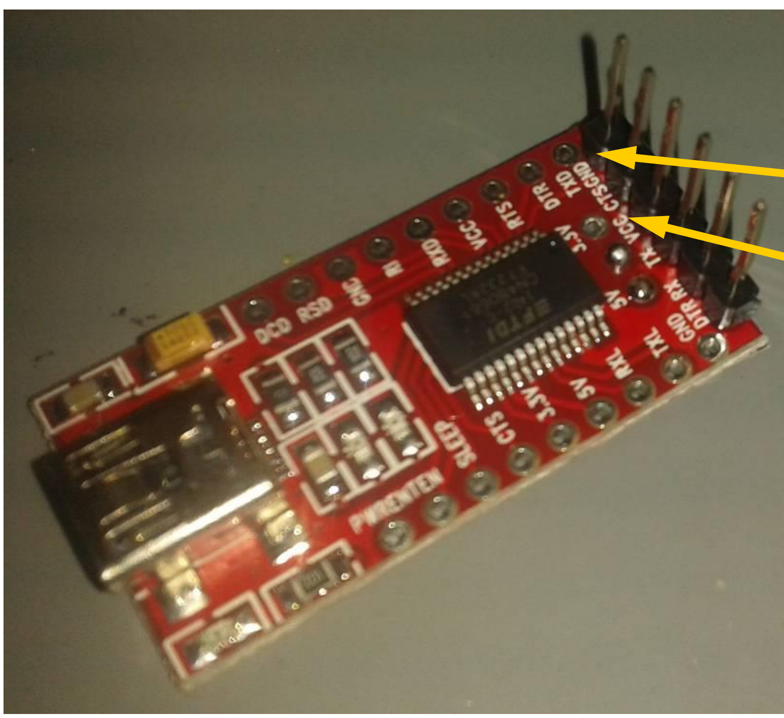


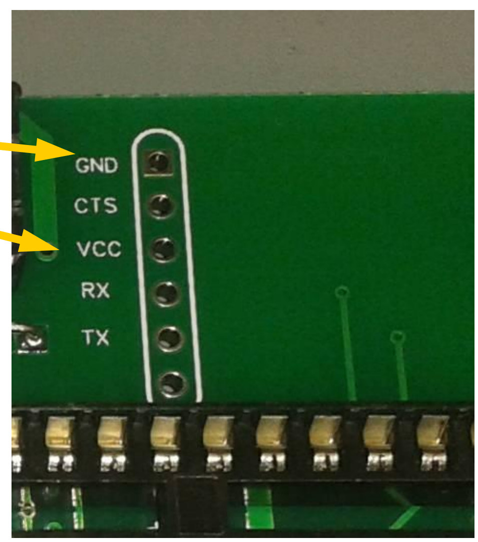
Step 21: USB Interface Board

The USB interface board carries the USB connector, the FT232RL converter chip, and a few discrete components. The FT232RL is only available in a small-pitch surface mount package (TSSOP) which many hobbyists would not be comfortable to solder.

The exact size, shape and design of the board may differ considerably from what is shown in the picture below ï however, being originally intended as download interfaces for the Arduino platform they all share the same pin assignment on the 6-pin header (right side of the picture). To find out the correct orientation, refer to the pins labeled ñGNDò(1st pin) ñVCCò(3rd pin) and match them to the corresponding position on the main circuit board.

Note: To avoid confusion ï TX on the interface board connects to RX on the main board, and RX connects to TX. This is because the labels ï transmit and receive ï correspond to the view of the scope and the PC/interface board, respectively; when one side transmits, the other side receives on that particular line.

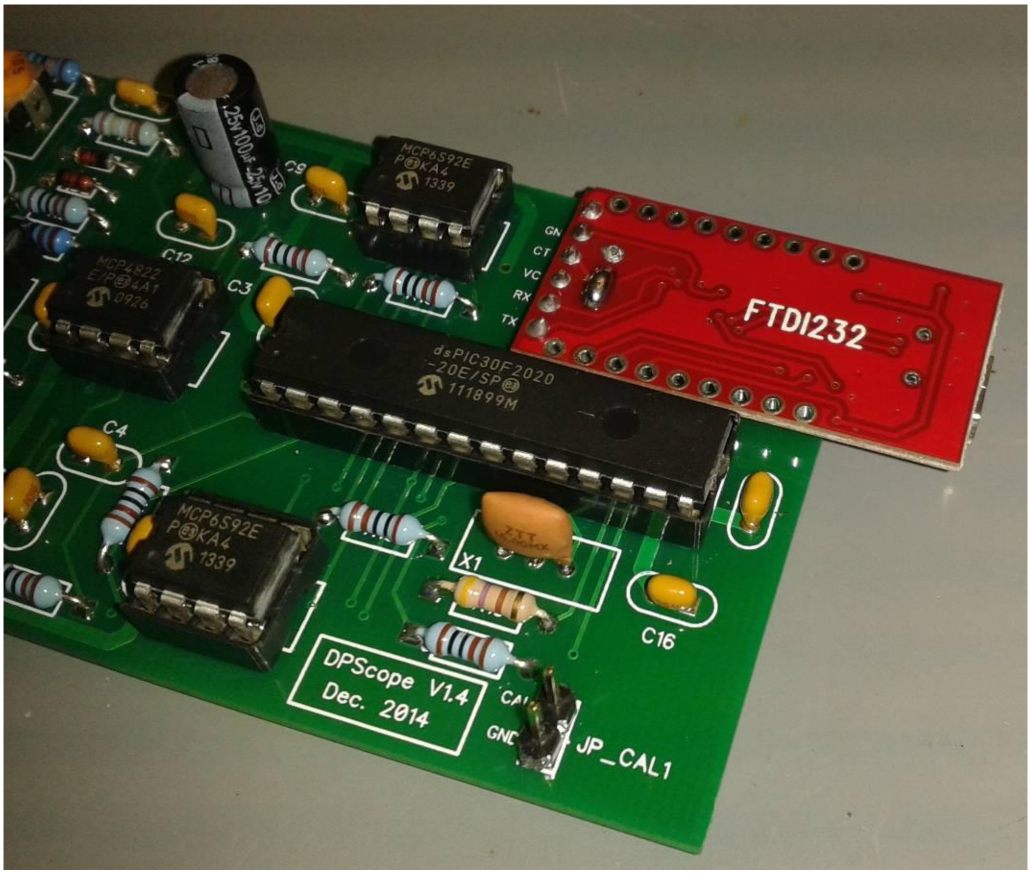




Step 21: USB Interface Board

In order to match the pin sequence to the main board, depending on the particular interface board, you may need to mount it either with the components facing down (i.e. upside down, like in the picture below) or facing up.

As with the other multi-pin components, first solder one pin into the board, check alignment of the board, and correct if necessary by re-heating the solder joint. Only when everything is file solder the five other pins.

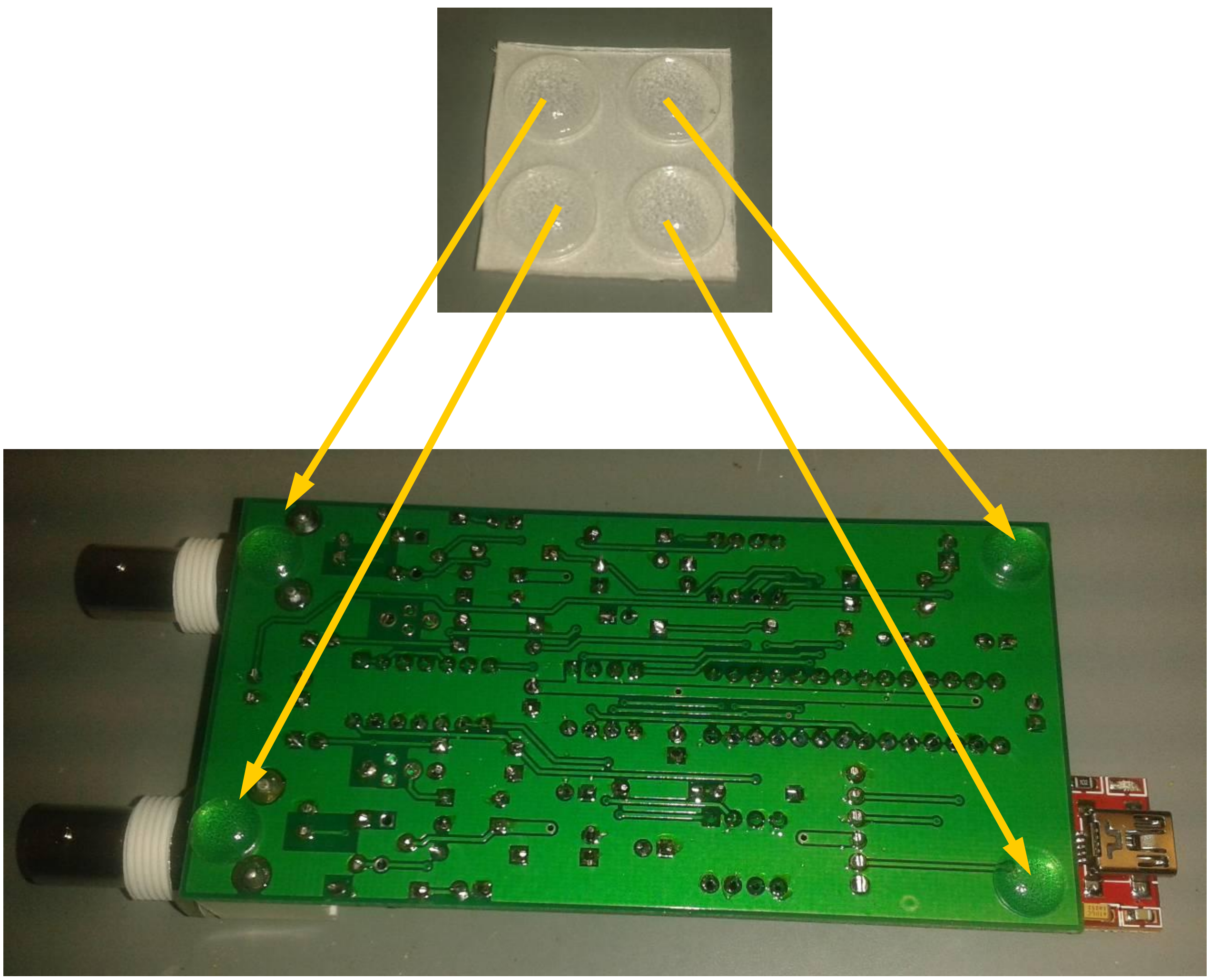


Step 22: Rubber Feet

Unless you are going to mount the board into an enclosure, now is the time to glue the four rubber feet to the bottom of the board as shown in the picture below.

First pull them out of their carrier sheet and gently(!) position them on the board and adjust them as necessary. Then press each of them firmly onto the board. (After that it is not longer possible to modify their positions).

Congratulations – your oscilloscope is now fully assembled!



Step 23: USB Cable

To connect the oscilloscope to your PC or laptop you’ll need a USB cable. You can use any standard Mini-USB data cable, i.e. with a type A connector on one side (plugs into the PC) and a type Mini B connector on the other (plugs into the scope).

Some hints for choosing a suitable cable:

- The scope connector must be MINI USB (see detail picture below right), not the nowadays more common MICRO USB cable found with many recent cell phones etc.

- It must be a DATA cable, not just a charging cable (the latter cuts down cost by omitting the data lines, which is clearly not usable here).

- Also, make sure to use a cable that does not have large resistance because this will produce excessive voltage drop (the DPScope draws around 250 mA of current). Thicker USB cable are more likely to have thicker, low-resistance wires inside.

Step 24: Software Installation

If you havenʻt already done so, go to the DPScope website (http://www.dpscope.com) and download:

Å The oscilloscope software
Å The FTDI USB driver
Å The USB driver installation guide

If for some reason you procured the USB converter board yourself then you will also need to burn the USB configuration file onto the converter. (The converter board that comes as part of the kit is already configured and you should do not need to do this). In this case also download from the DPScope webpage

Å The MPROG configuration program
Å The USB configuration file

First install the USB driver ï follow the installation guide for that. Note that the installer will actually install two different drivers on your computer, i.e. go through two installation cycles. Make sure to complete both of them.

Then install the DPScope software as well (unpack the files and click on Setup.exe).

After that, if necessary burn the USB configuration file into the converter board ï as described on the following page.

Step 24: Software Installation

<u>Note:</u> If your USB converter board came with the kit or the scope, skip this step because the board has already been configured correctly.

1. Plug the USB cable into the scope and into a free USB port on your computer.

2. Start the MPROG programming software. You should get a message ñFound New Hardwareò, followed after a while by a message ñYour new hardware is installed and ready to useò (or similar).

3. Remove any other peripherals (except for mouse) attached to a USB port.

4. Start the MPROG configuration software (see next page for screenshot).

5. Select **Device → Scan**. After a short moment it should report 0 (zero) blank devices and 1 (one) programmed device (which is the USB converter, which has a default factory configuration).

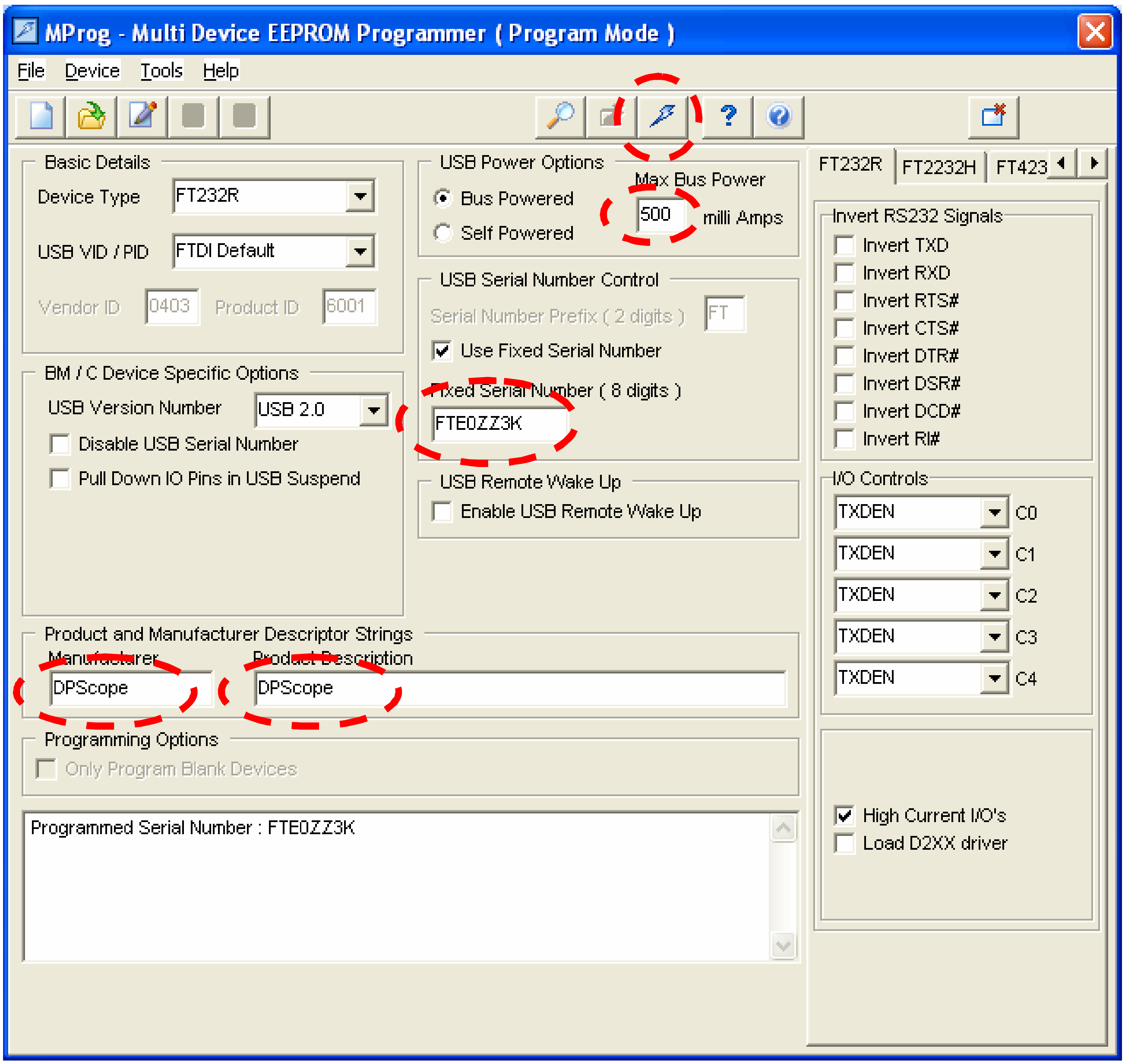
6. Open the DPScope USB configuration file that you just downloaded before (**File → Open**). The configuration data should now show a <u>fixed</u> serial number ñFTE0ZZ3Kò (the DPScope software recognizes the attached DPScope based on this serial number, so donôt change it!), and manufacturer and product description string should both say ñDPScopeò.

7. Press Ctrl-P or click on ñ**Program All Existing Devices**ò (the menu button with the Flash symbol).

8. After a short while the status display on the bottom should now say ñProgrammed serial number FTE0ZZ3Kò.

9. Close MPROG.

Step 24: Software Installation



Step 24: Software Installation

Attach the DPScope to a free USB port on your computer. Wait for a minute or two to give the computer time to recognize the new instrument (you should get a screen message when that happens).

The DPScopeõs status LED should blink a few times and then stay on. *The blinking should last for about one second total*. If thatõs the case then your oscilloscope has just passed the first functional test! (The LED will only come on if the microcontroller actually starts successfully. If the blinking speed is much slower this would indicate a problem with the 16 MHz resonator or its connection to the microcontroller).

Note 1: On some computers the software does not recognize the scope if the assigned (virtual) COM port has a number higher than 16. In this case, look up the assigned port in the Windows device manager (should appear when you plug in the scope, and disappear when you unplug it). Go to ñPropertiesò for that port, and in the ñAdvancedò section set it manually to some number not higher than 16. (Make sure not to use a port that is actually used by another device at the same time).

Note 2: The microcontroller (dsPIC30F2020) can get quite hot under operation ï typically about 65 degC, which is already quite uncomfortable to touch. However this is normal and no reason for concern (the dsPIC30F series is known to consume quite some power, and the DPScope runs the device at maximum speed).

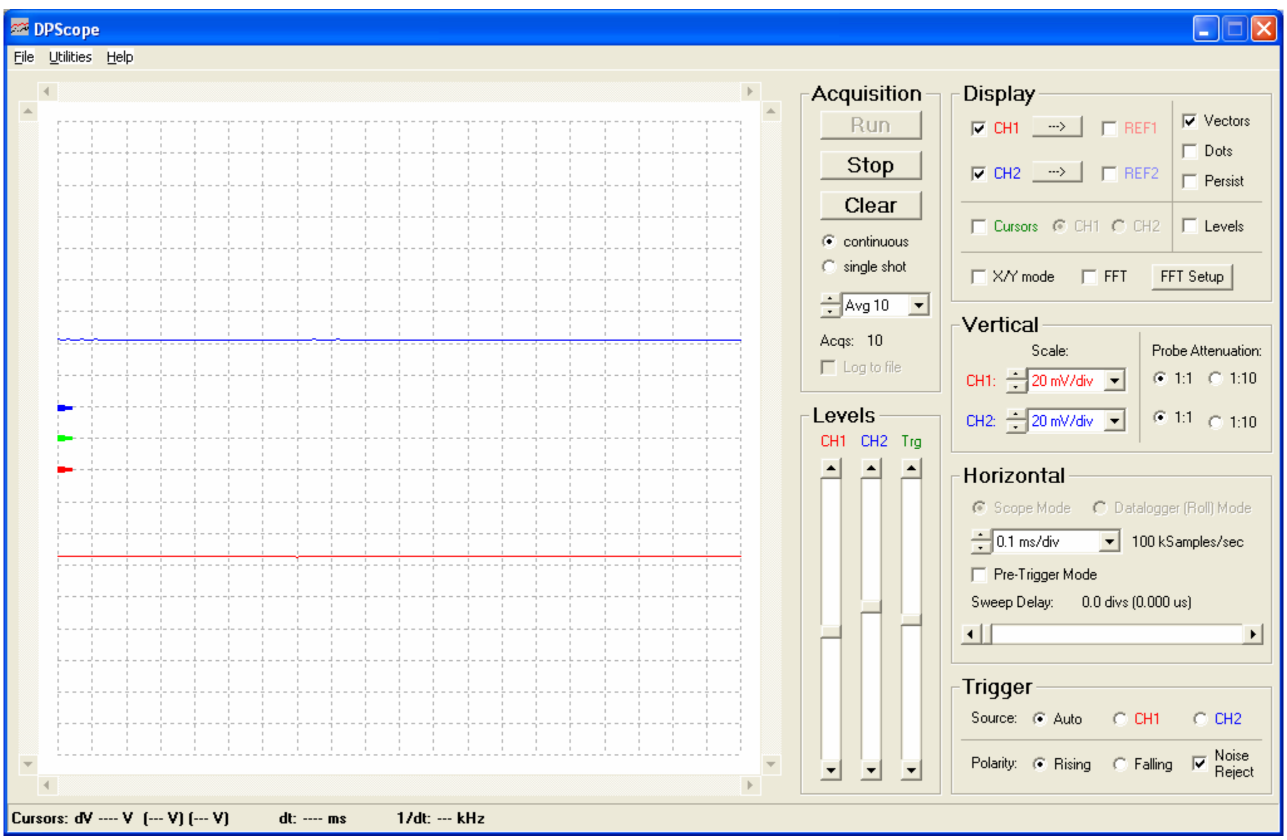
Note 3: The DPScope software needs a screen resolution of at least 800 x 600 pixels. If your screen is 1024 x 768 pixels or larger it will automatically select a somewhat larger layout for better visibility. Also note that increasing the Windows font size (through the Display control in the Setup panel) will make the windows larger, which can prevent you from running the program on smaller screens (even though they may be 800 x 600 pixels or larger). You will get a message if that happens. In this case try reducing the Windows font size and start the program again.

Step 25: Software Start

Launch the DPScope software. It should look like the picture below. Press the ñRunò button ï the two scope traces should come alive.

Attach the two scope probes to the BNC connectors (CH1 and CH2).

Now we need to make two simple adjustments to optimize the scope performance.



Step 26: Offset Adjustment

Å In the ñVerticalò menu change the scale for both channels to 20mV/div.

Å In the ñAcquisitionò menu change the averaging to ñAvg 10ò

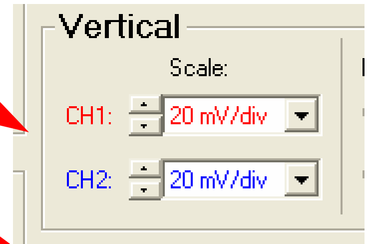
Å In the ñLevelsò menu move the sliders ñCH1ò and ñCH2ò roughly to the middle. The ground level indicators (blue and red arrow on the left in the waveform display) will be in the middle as well.

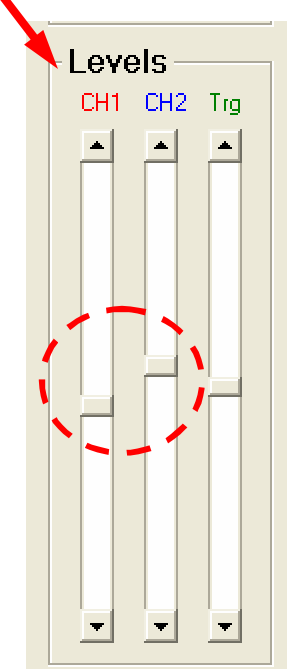
Å Short the probes, i.e. connect their signal pin to the ñGNDò pin of the JP_CAL connector.

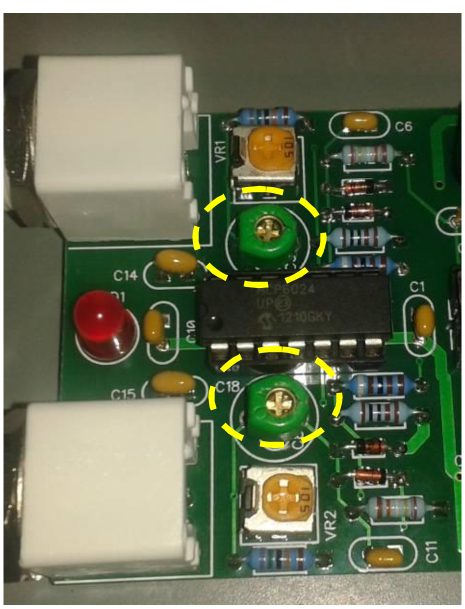
Å With a small screwdriver you can now adjust the offsets of the two channels:

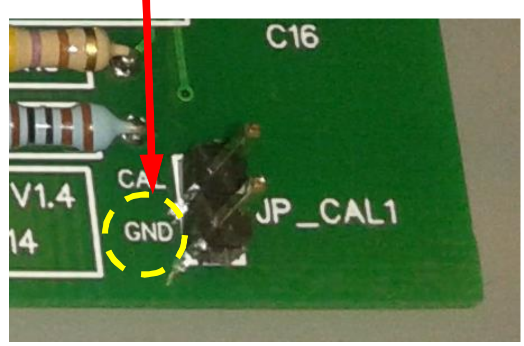
Å Adjusting the two blue square trimmers (VR1 and VR2) will move the respective trace (red = CH1 and blue = CH2) up and down.

Å As shown on the next page, adjust the trimmers so the red trace is exactly at the height of the red arrow on the left, and the blue trace is exactly at the height of the blue arrow. Done!



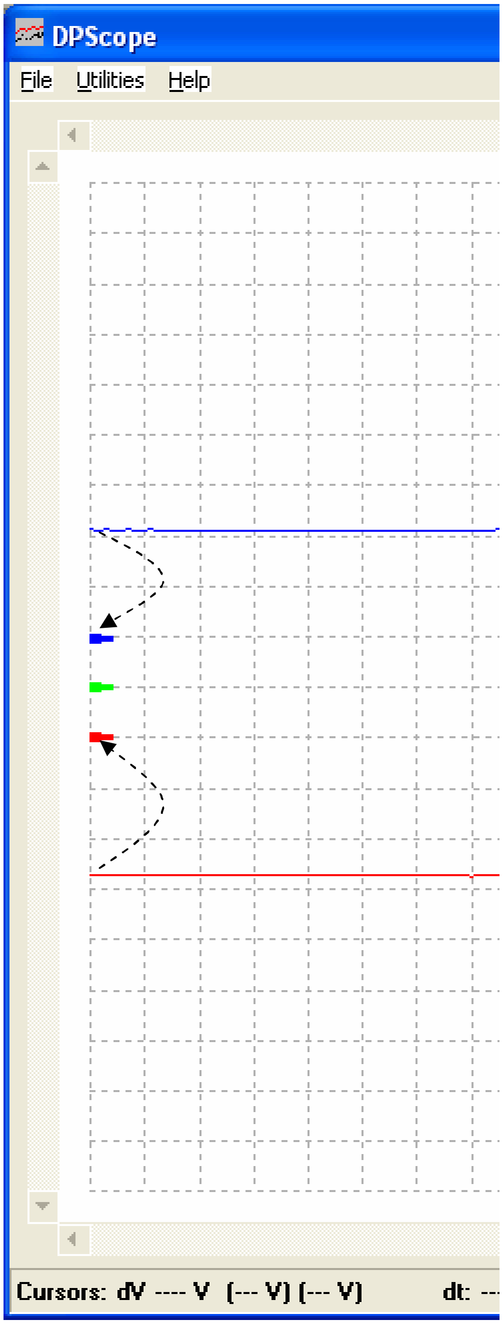




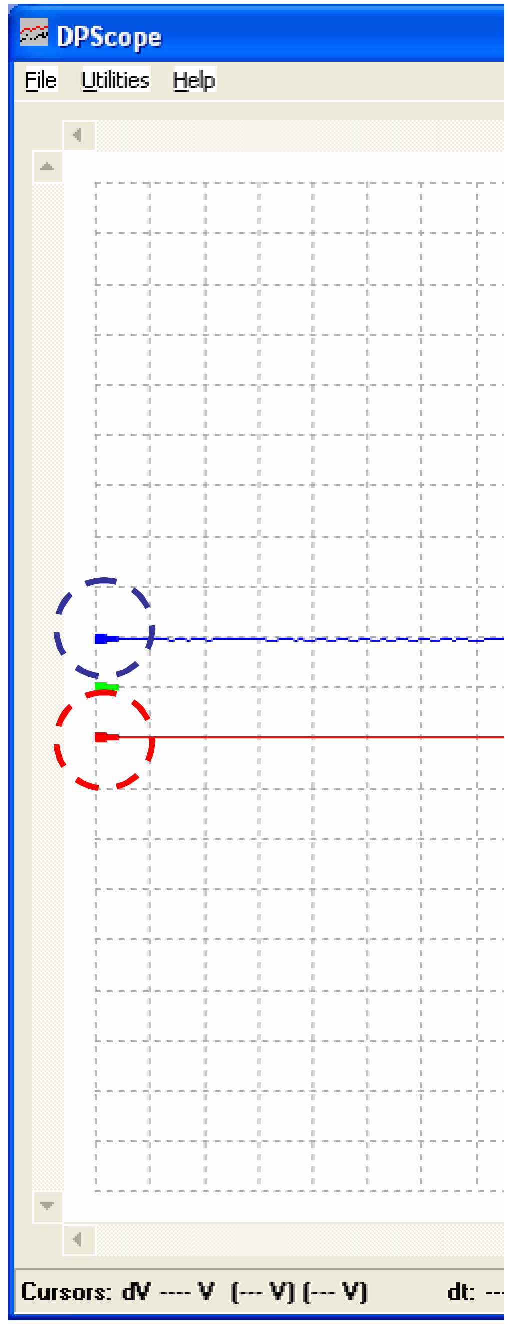


Step 26: Offset Adjustment

Before offset adjustment:



After offset adjustment:



Step 27: Probe Compensation

Å In the ñVerticalòmenu change the scale for both channels to 1V/div or 0,5V/div.

Å In the ñAcquisitionòmenu leave the averaging at ñAvg 10ò

Å In the ñLevelsòmenu move the sliders ñCH1òand ñCH2òhalfway towards the bottom.

Å Connect the probes to the calibration outputs on the back side of the oscilloscope:

ï Signal connects to ñCALòpost

ï Ground connects to ñGNDòpost

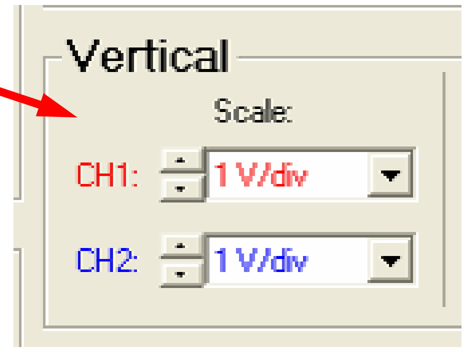
Å In the DPScope window on your PC select Utilities → Probe Compensation. A small window with instructions will pop up.

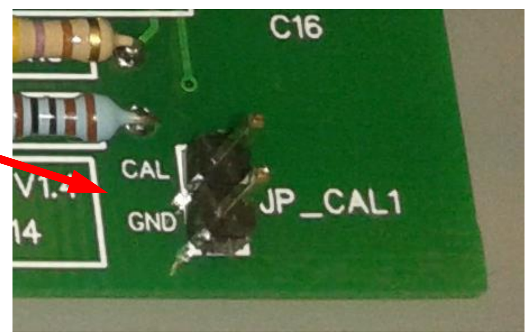
Å With a small *non-metal* screwdriver you can now adjust the probe compensation capacitors (C18 and C19, respectively).

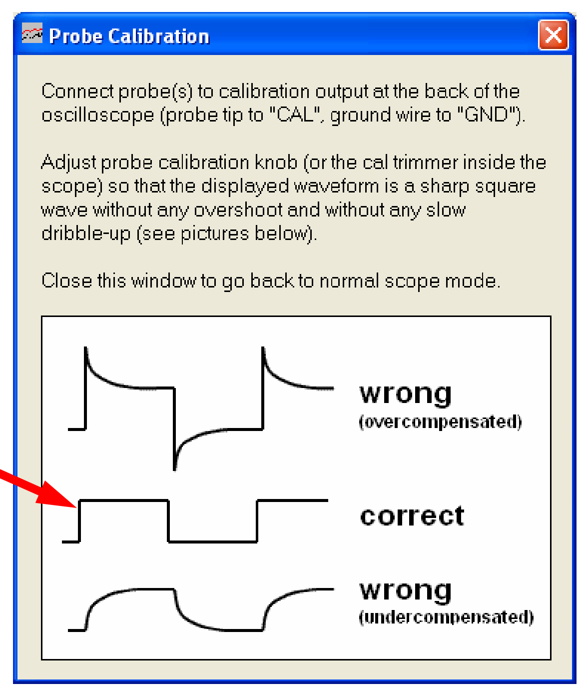
Å On the right side you see signal examples for overcompensated, undercompensated, and correctly compensated probes.

Å The adjustment is correct when the displayed signals are nice square waves with sharp corners, i.e. when there is neither overshoot (sharp peaks after each transitions) nor slow settling (rounded edges).

Å At the same time, you have tested the scopeõs acquisition circuitry.







All Done!

Congratulations, you have successfully assembled, set up and tested your new oscilloscope!

If you still have questions:

Email: support@dpscope.com

Webpage: http://www.dpscope.com