

K40/D40 Compact Chinese Laser Machine - DSP Upgrade Procedures

By Marco K. Wong Dec 2012

www.lightobject.com

Background

The D40/K40, a small Chinese CO2 laser machine is very well known for its price and compact size. The machine can accommodate a non-standard (700mm) 40W CO2 laser. In fact, the laser tube is not 40W but 35W based on the length of the tube. The laser machine is originally equipped with a controller card named “Moshi (磨石)”, made by a company in Shanghai, China. The K40 has good mechanical structure but the controller is not well designed and limits the full performance of the machine. Many users have found it very useful to upgrade the Digital Signal Process (DSP). The DSP upgraded machine will be more versatile and powerful. This article will discuss how to do it.

Parts required for the upgrade:

- 1) 1x DSP controller card
- 2) 2x small stepping motors, each with a driver supporting 1.2A current
- 3) 2x proximity limit switches for home parking
- 4) 1x DC24V 3A power supply
- 5) Digital or analog current meter (50mA)
- 6) 5V regulator (needed if digital current meter is used)
- 7) Laser power supply (need only if the machine came with non-Pulse Width Modulation (PWM) power supply)
- 8) Air-assisted laser head (optional for better performance)

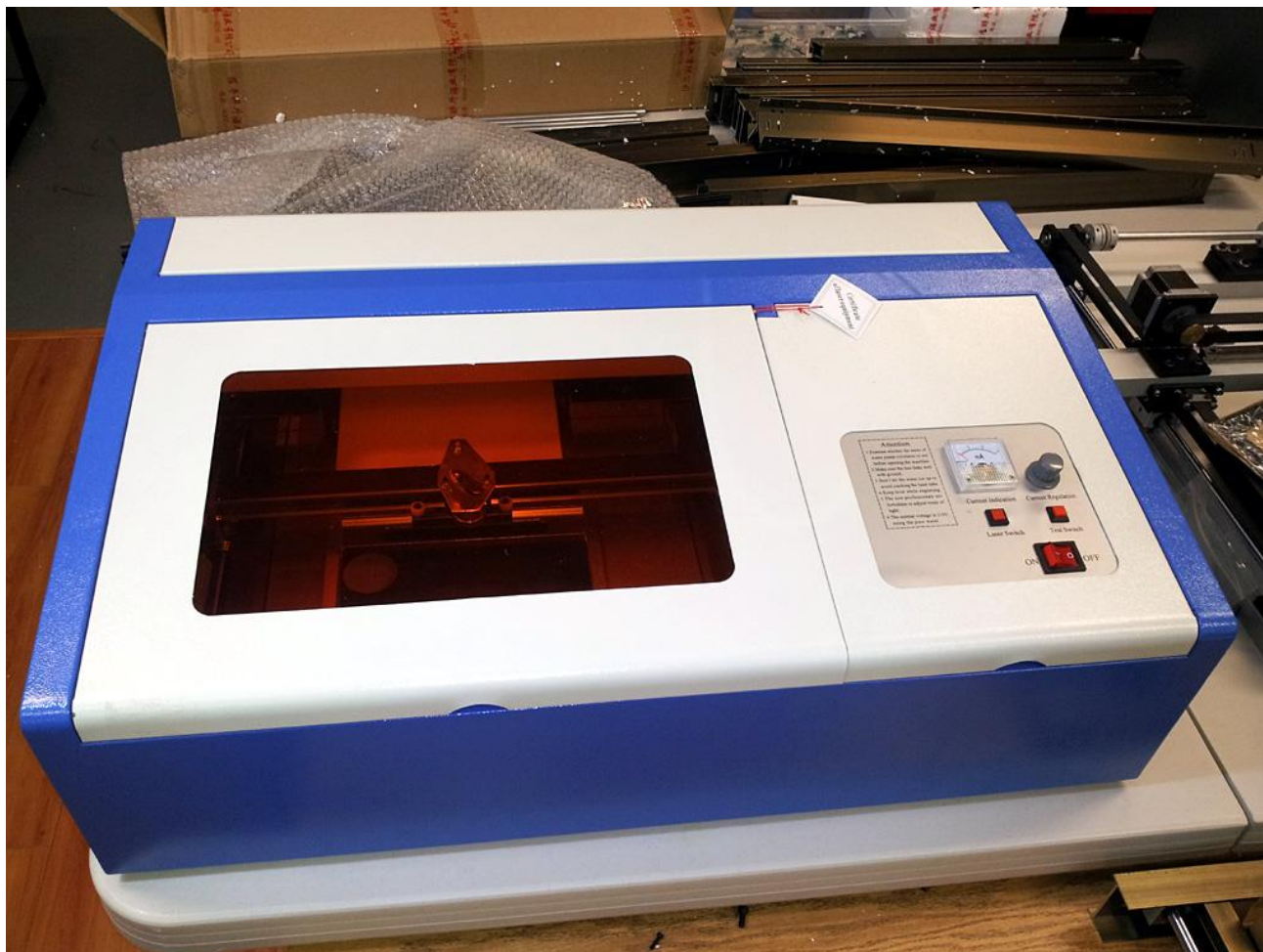


Fig 1. The original K40 machine

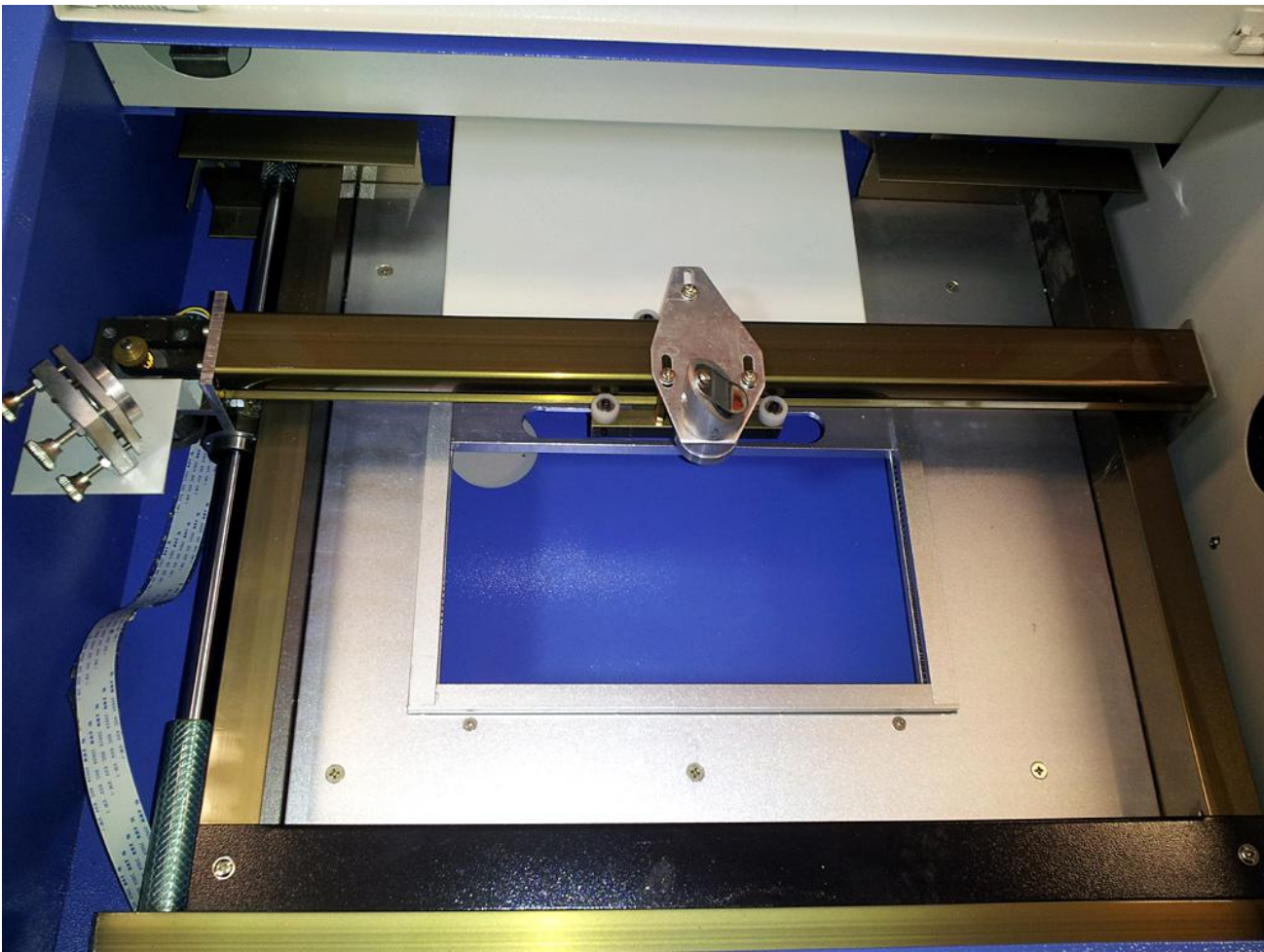


Fig 2. XY stages and flat bed

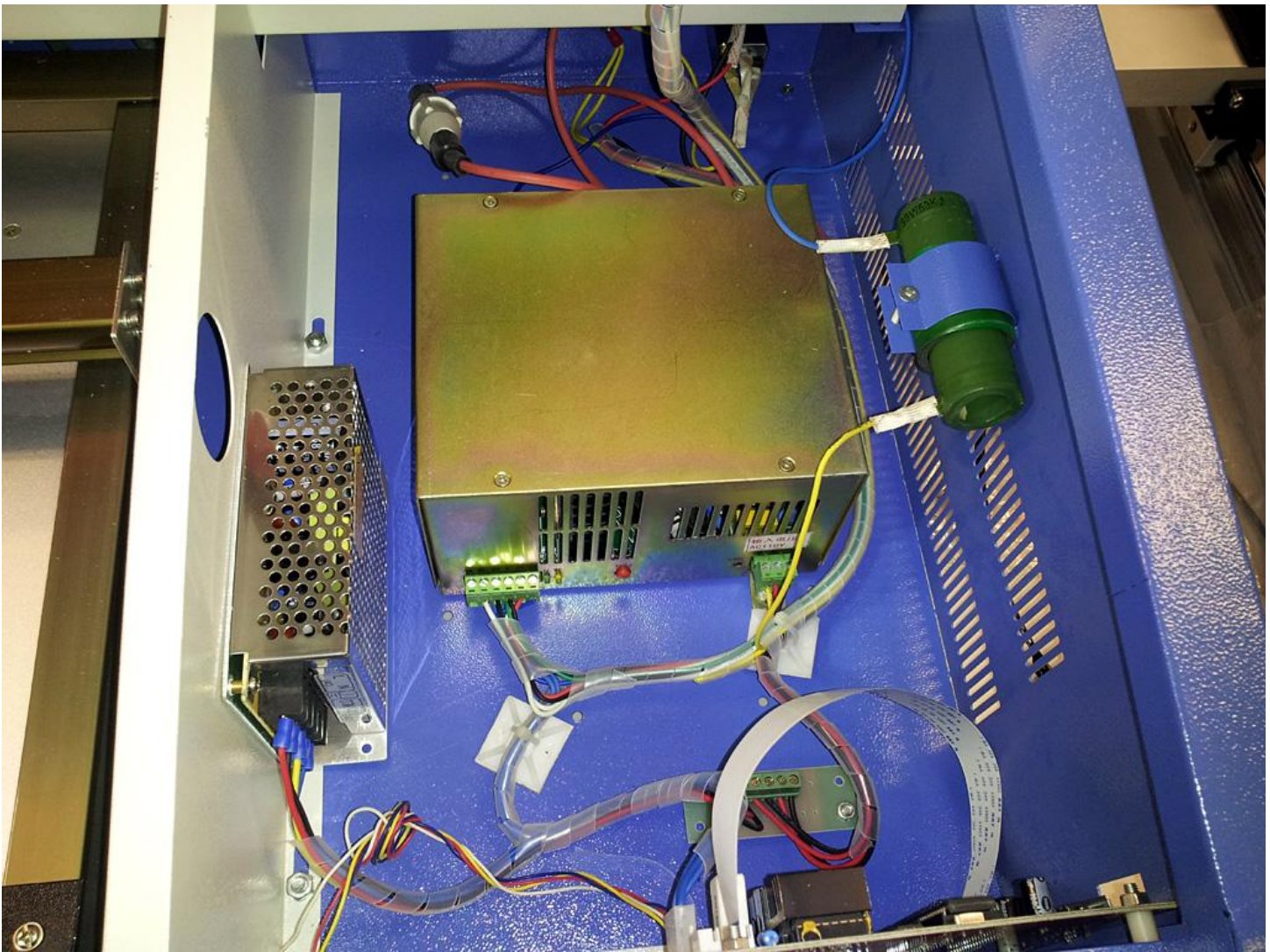


Fig 3. Control compartment

Step 1 Clean up

1.1 remove parts that will be no longer needed including the Moshi card, DC power supply, and the 'green giant' resistor. It shouldn't take more than 20min to do it.

1.2 Uninstall the XY stages by XXXX on which a limit switch on the X and Y track will be added. Also, be ready for motor rewiring.

Step 2 Flat bed unleashed

2.1 remove the flat bed (silver panel, see Fig 2) from the machine. To do so, the machine must be lifted up in a vertical position to unscrew the unit from the bottom. See Fig 4:

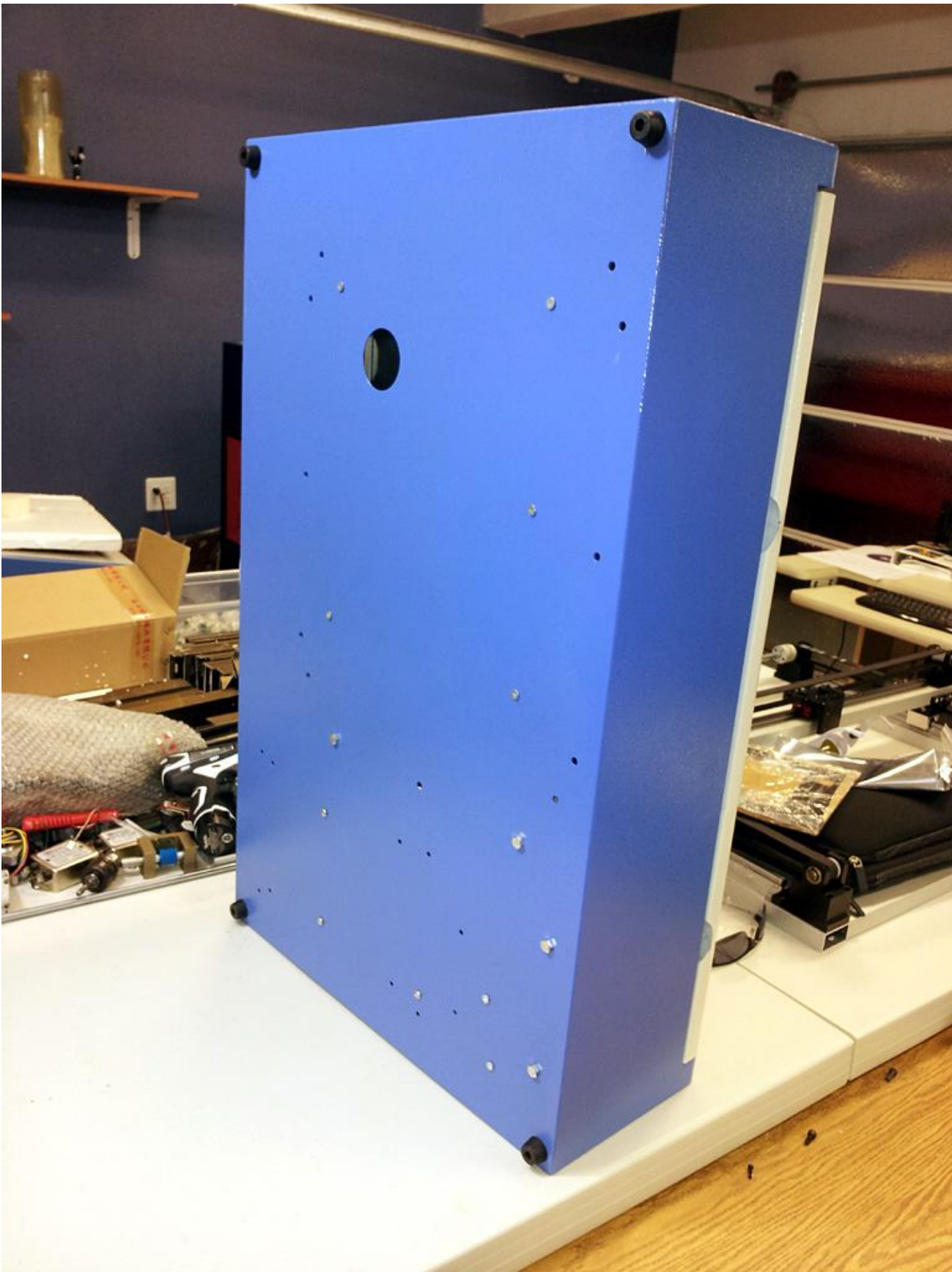


Fig 4.

There are five screws to be removed for the separation of the flat bed.

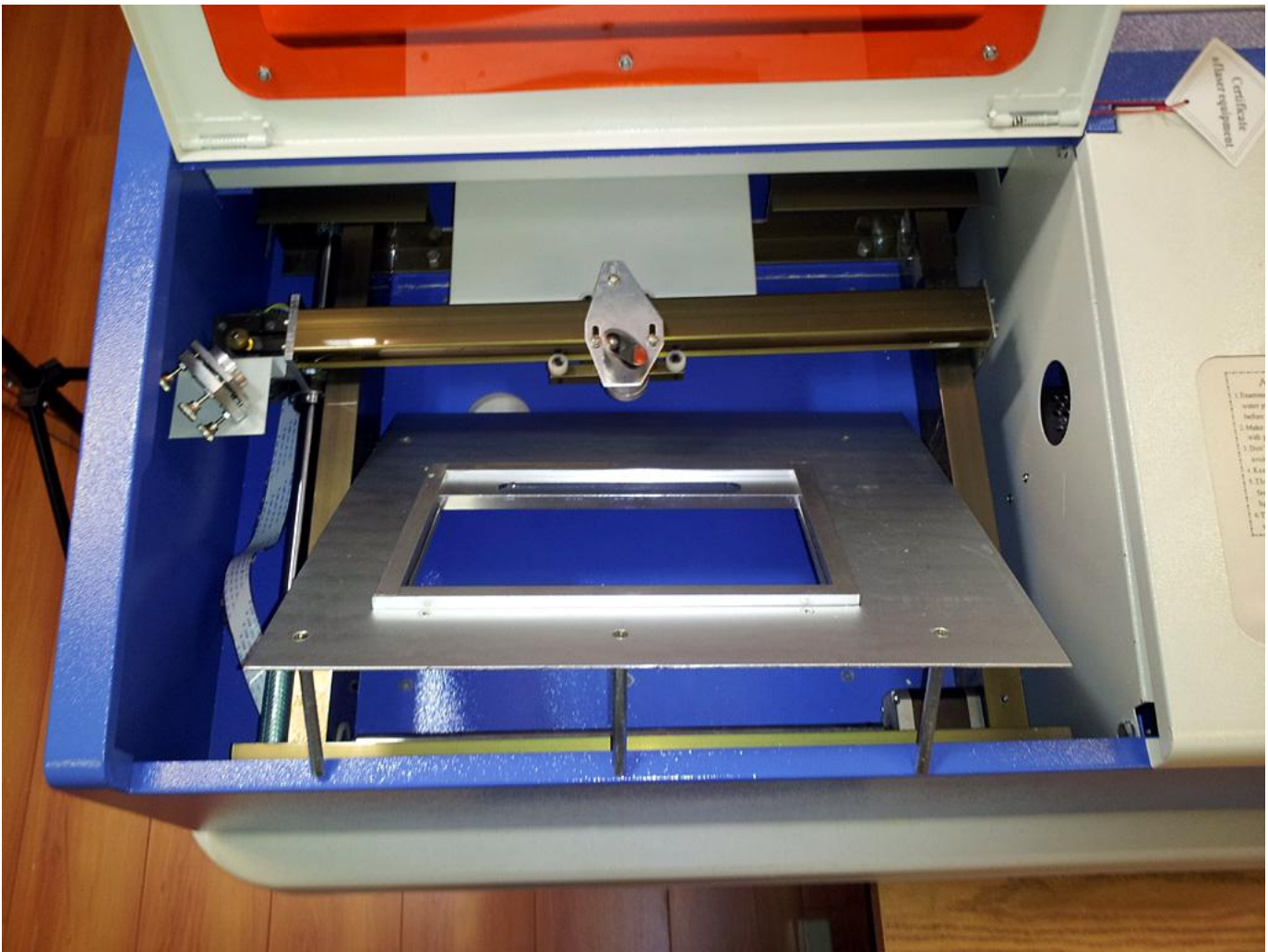


Fig 5.

Step 3. XY stage unleashed

3.1 Install a limit switch on the XY stage. The whole stage must be taken out for the rework. Unscrew 5 hex bolts- 2 hex bolts from the back end, 2 from front end, and 1 from the side panel.

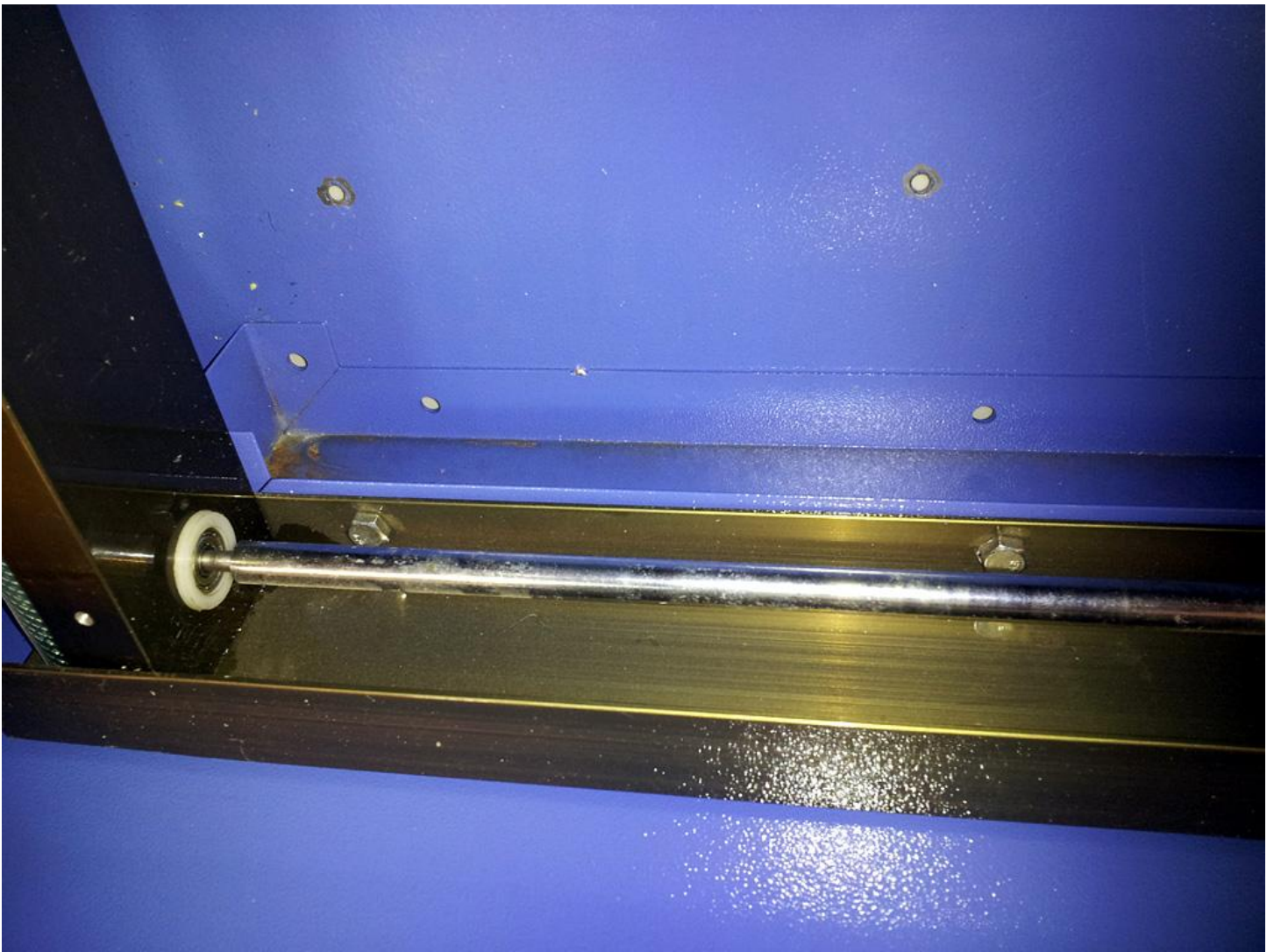


Fig 6. Hex bolts on the front end

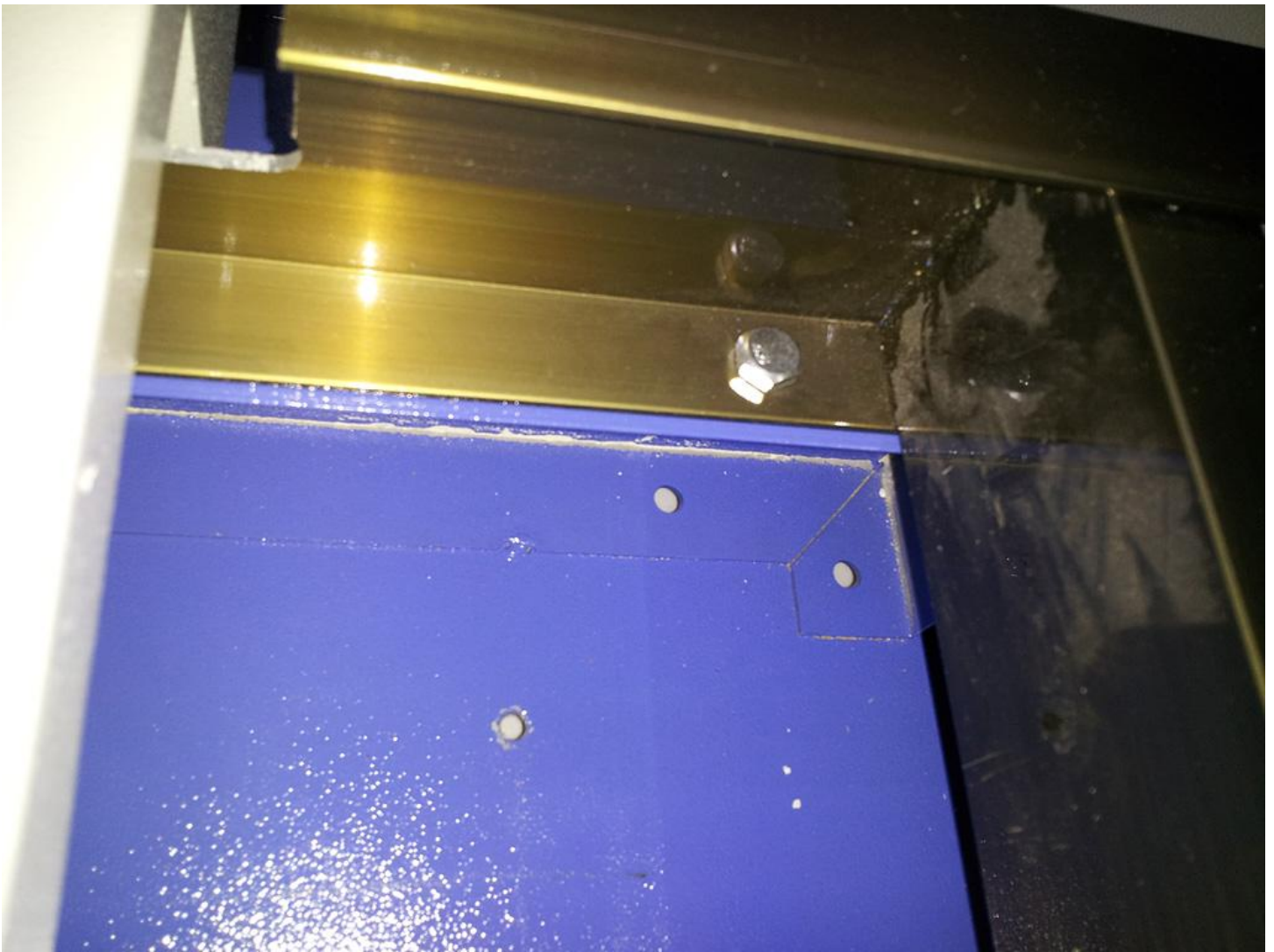


Fig 7. Bolts at the back end



Fig 8. Bolt at the side panel

3.2 Uninstall the second stage reflection mirror mount by unscrewing two screws from the mount before the XY stage can be removed. Before doing so, you may mark the screws so that you know where to mount them back. It is very important to position the mirror properly when it is reinstalled. The laser beam may not hit the center of the mirror perfectly. It is fine but the beam should not aim too far away from it.

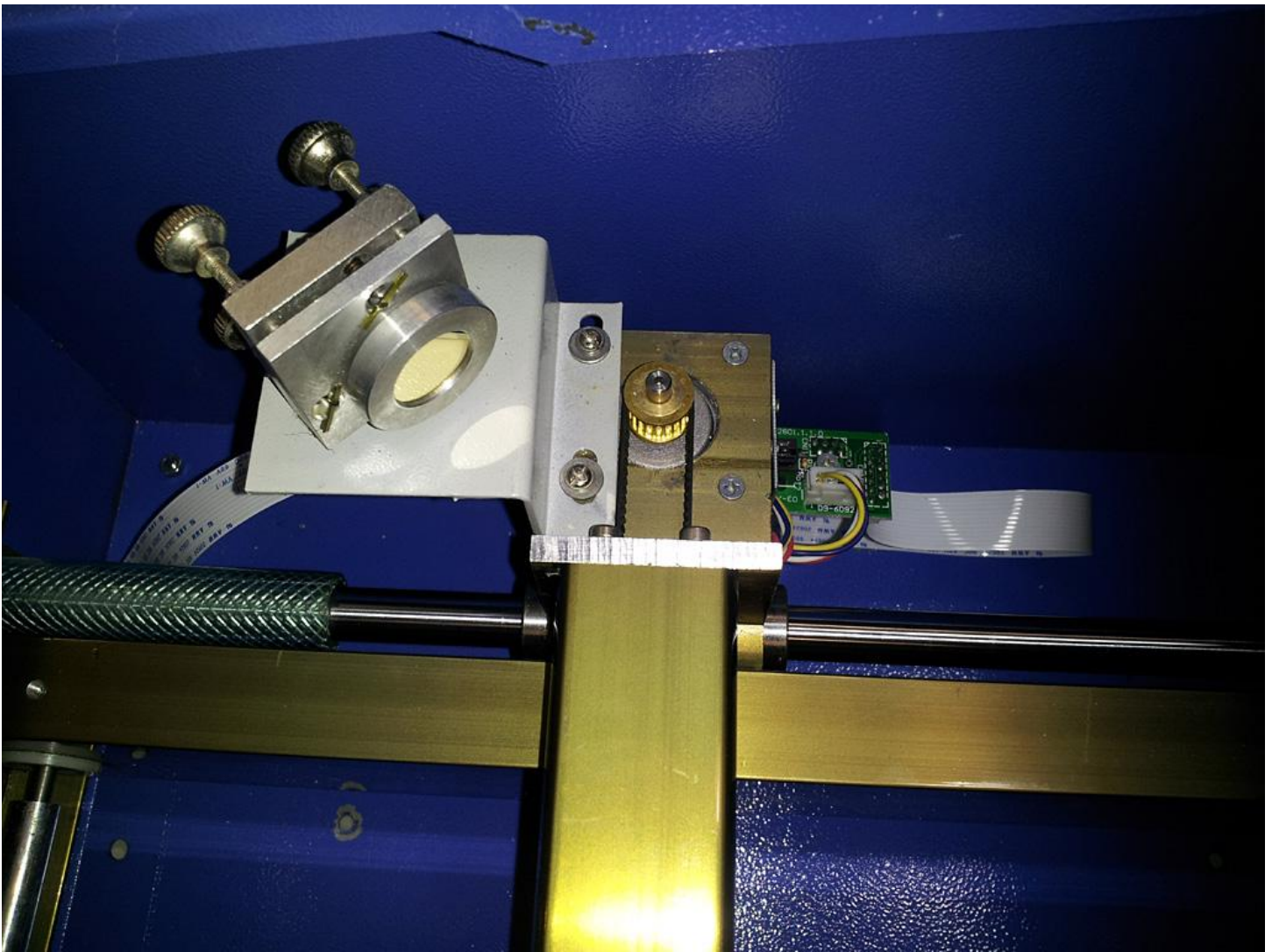


Fig 9. Reflection mirror and mount

After removing the flat bed, the Moshi card, and unleashed XY stage here is what we have left:

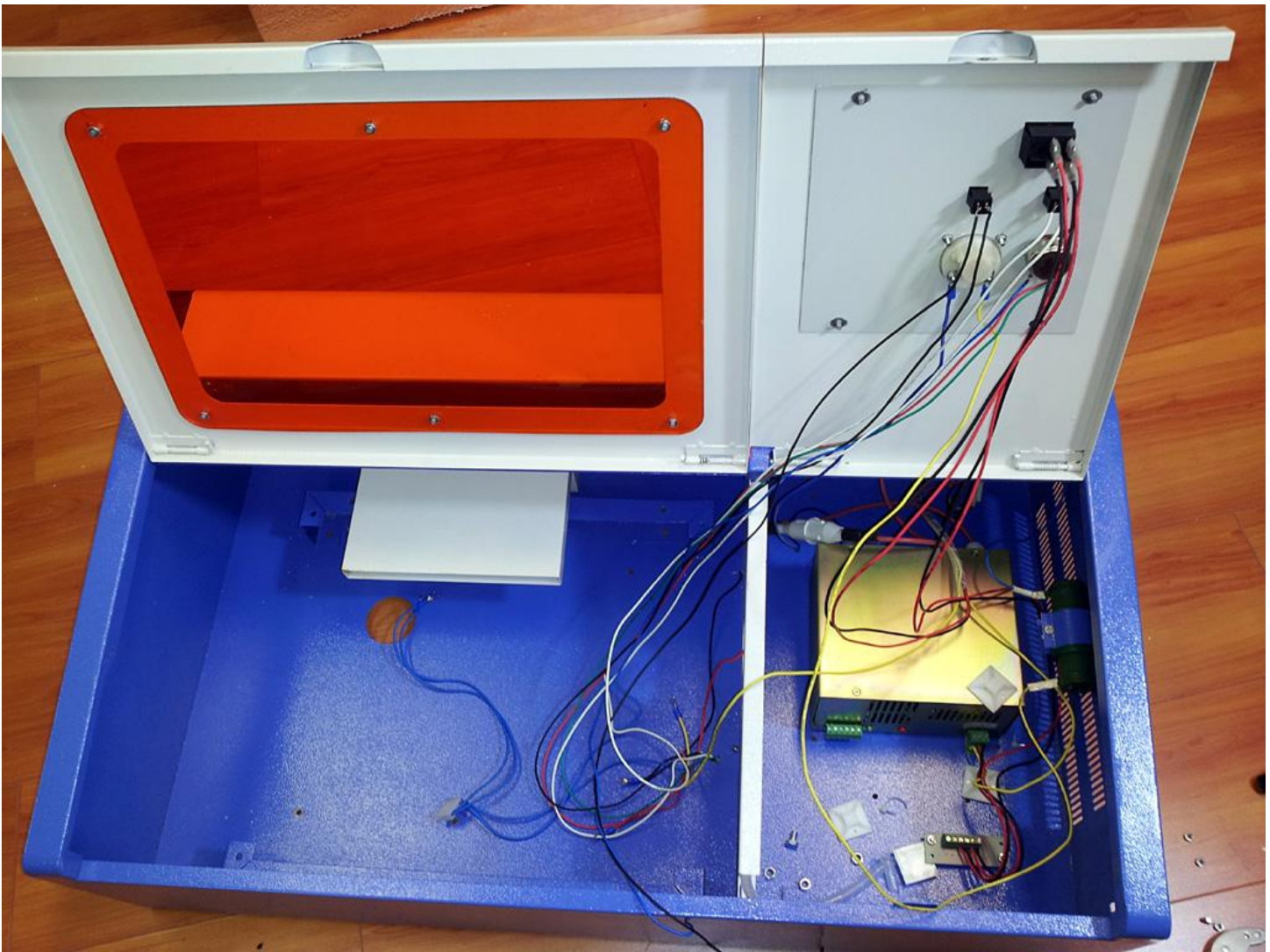


Fig 10. After clean up

Step 4. XY limit switches installation

4.1 The original K40 comes with optical 'Home' sensor. People often find this optical Home sensor vulnerable. It is very fragile and requires 5V to operate both the emitter and receiver. In case of future service, the wires are not easily traceable. This sensor will be replaced by 2 limit switches (mechanical) to eliminate the above problems. .

Fig 11. X motor and optical sensor

4.2 X limit switch installation

In this example, we install a micro proximity switch for the X home sensor. This switch is designed with a roller instead of a long blade. Even though the space inside the K40 (340mm * 220mm) is limited, we still have to leave about 1mm margin from the physical limit when installing the limit switch. We put a limit switch to the origin (physical home location) and move the laser head toward to the limit until hearing a 'click' sound (engaged). Then, we set the limit switch approximately 1mm away from the origin in case there are settle happened due to the miscalculation or shafting due to temperature or other issue.

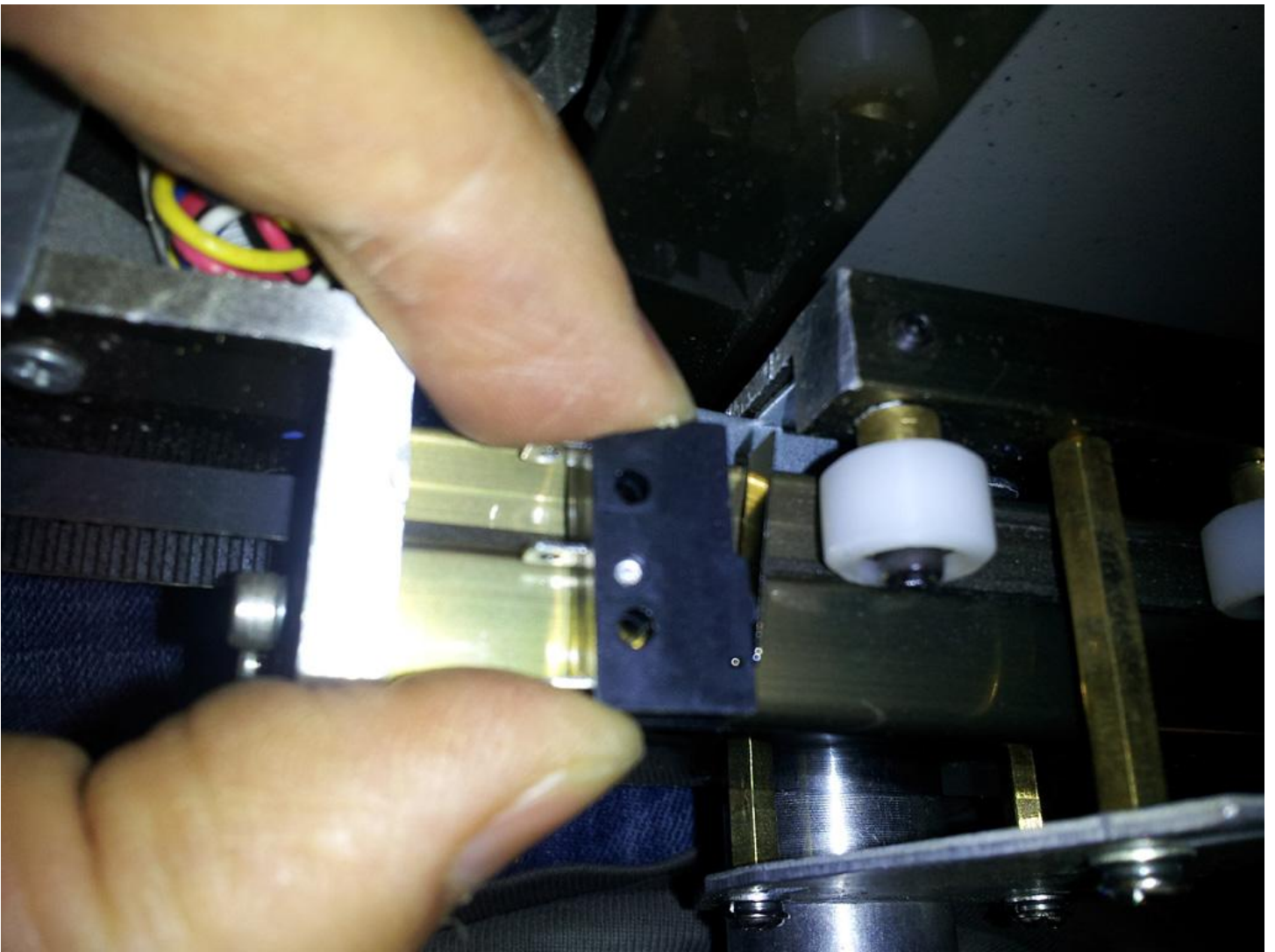


Fig 12. X limit switching positioning

Once location is determined, use a pen to mark the drill hole. Then, use a metal puncher before drilling to ensure a precise drilling position on the mark.



Fig 13. Center punches

Also, we suggest to add a drop of engine oil to lubricate the drill bit. The oil will help the drilling and prolong the life of drill bit.



Fig 14.

After drilling the holes (need 2 holes, positioned diagonally), we recommend to thread the holes. If you don't have a threading tool, you may pre-thread the holes by screwing them before the switch is installed.

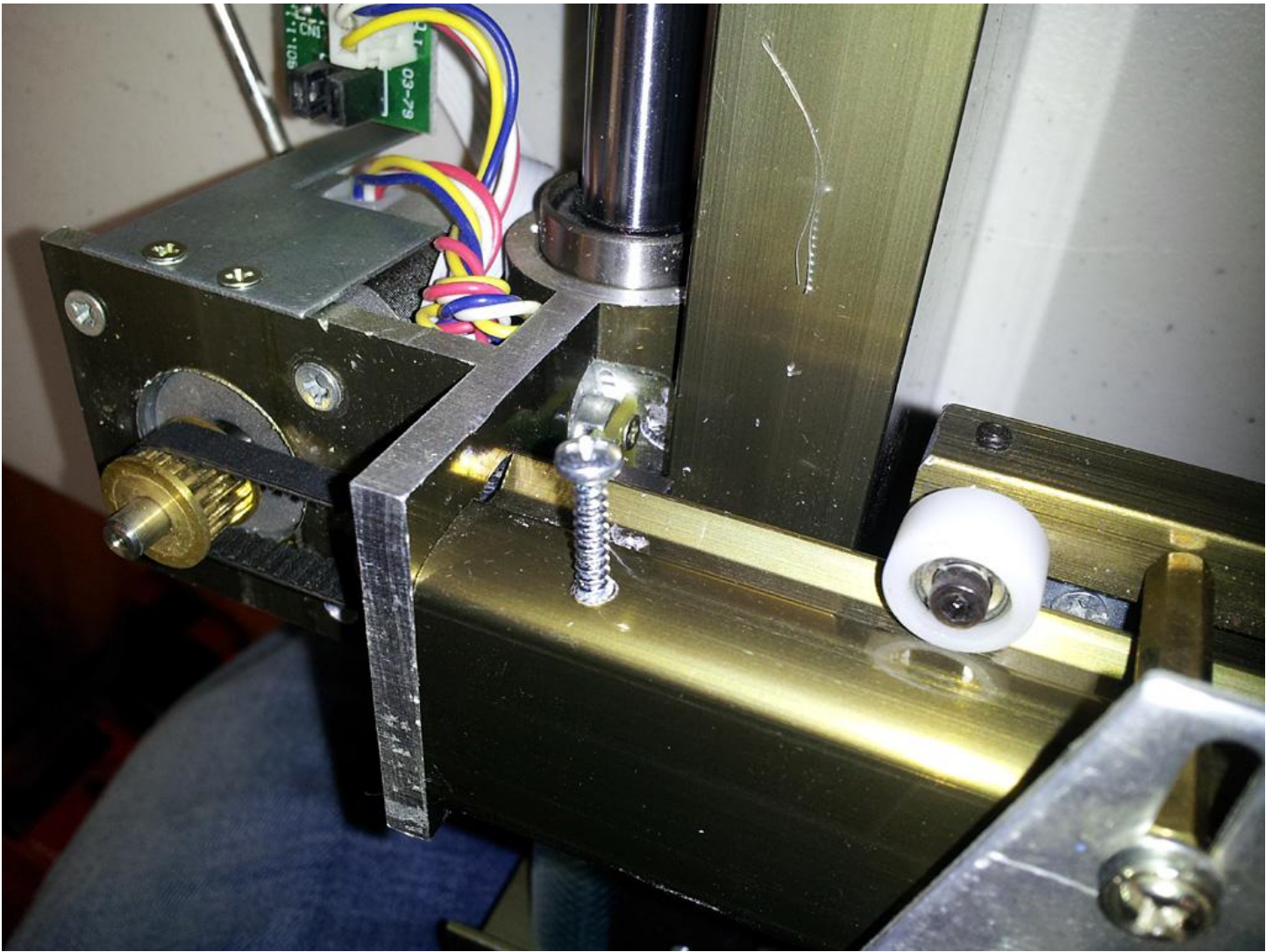


Fig 15.

Picture shows the setting after X switch installation

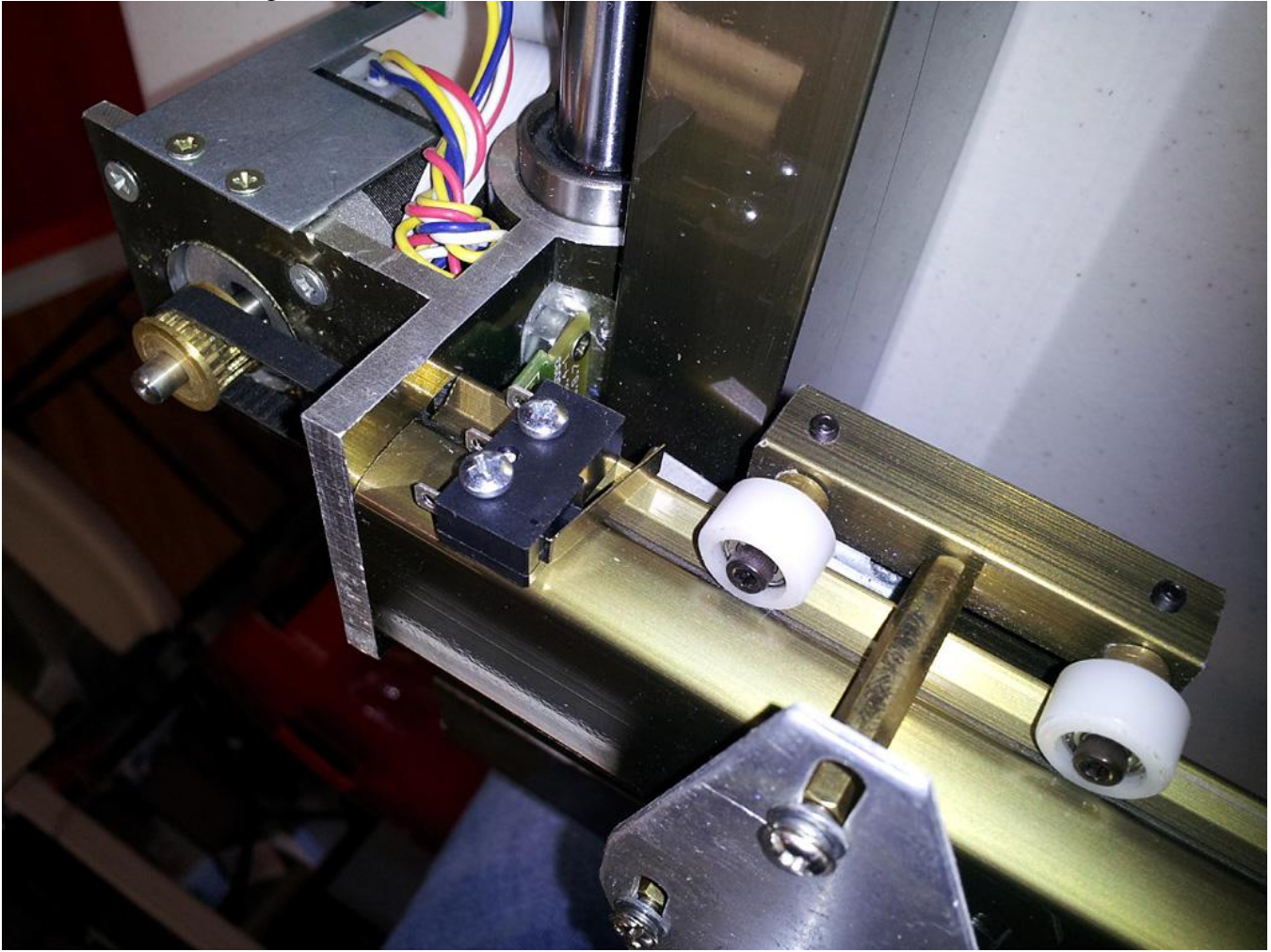


Fig 16.

Use a 3-wire cable for the home switch even this step only requires a 2-wire cable. In this case, you do not have to purchase a 2-wire cable specifically for this step. Instead, you may use the same 3-wire cable from other steps such as the optical sensor switch. Mark the cable with “X” and “Y” for the X and Y sensor connection respectively.

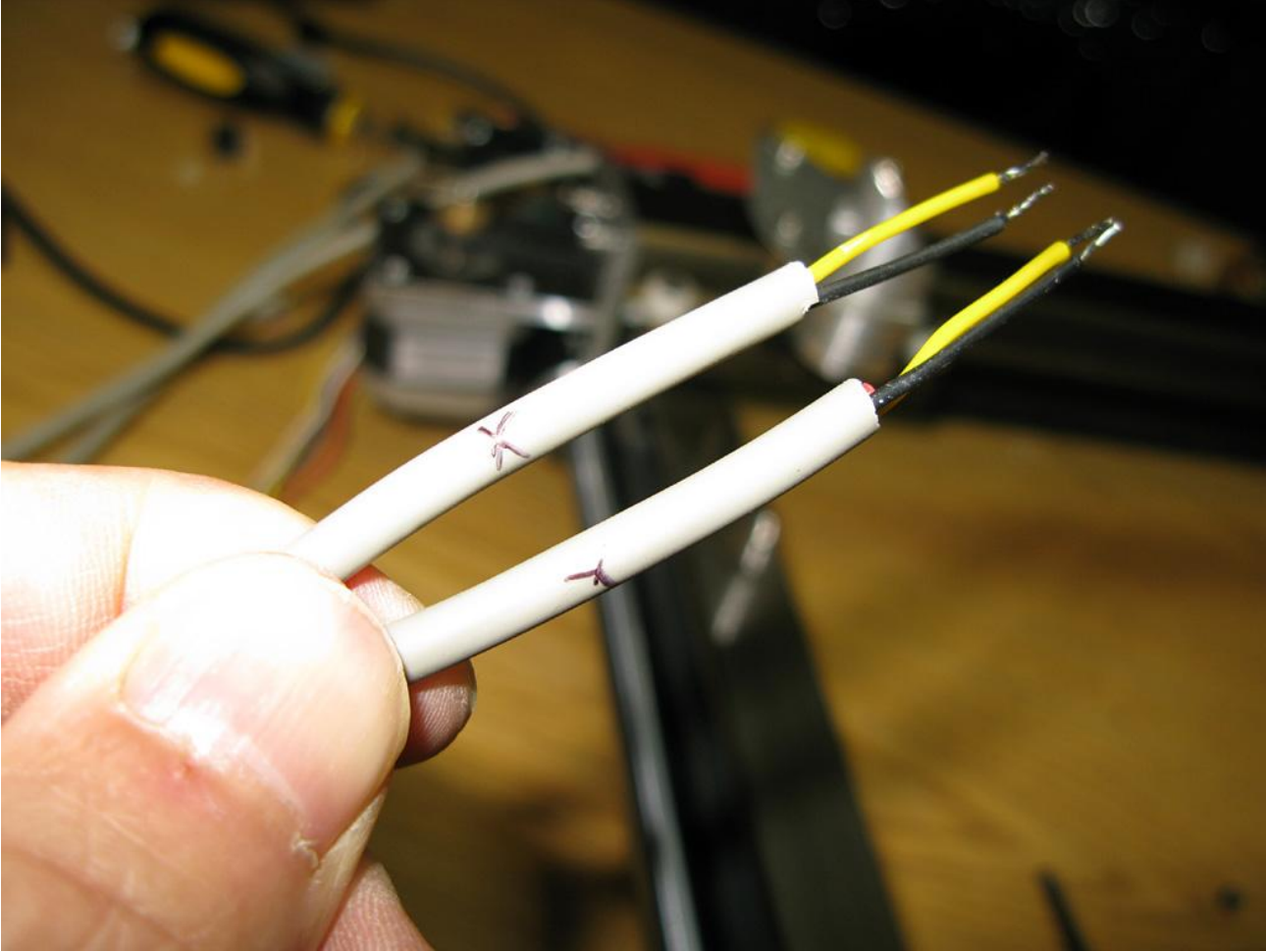


Fig 17.

You may cut the red line and keep the yellow and black wires. By convention, the red or black line usually means “power” while yellow line means “signal”. By cutting the red line, we know the yellow is signal and the black is power.

Do not forget to use heat-shrink to cover the soldering area. This will help protect the cable from break-out or accidental short circuit as the base is aluminum.

Use an ohm meter to check the contact before installing it. This little extra work is better than a costly 'regret'.
NOTE: a defective limit switch will cause a collision on the XY stage!

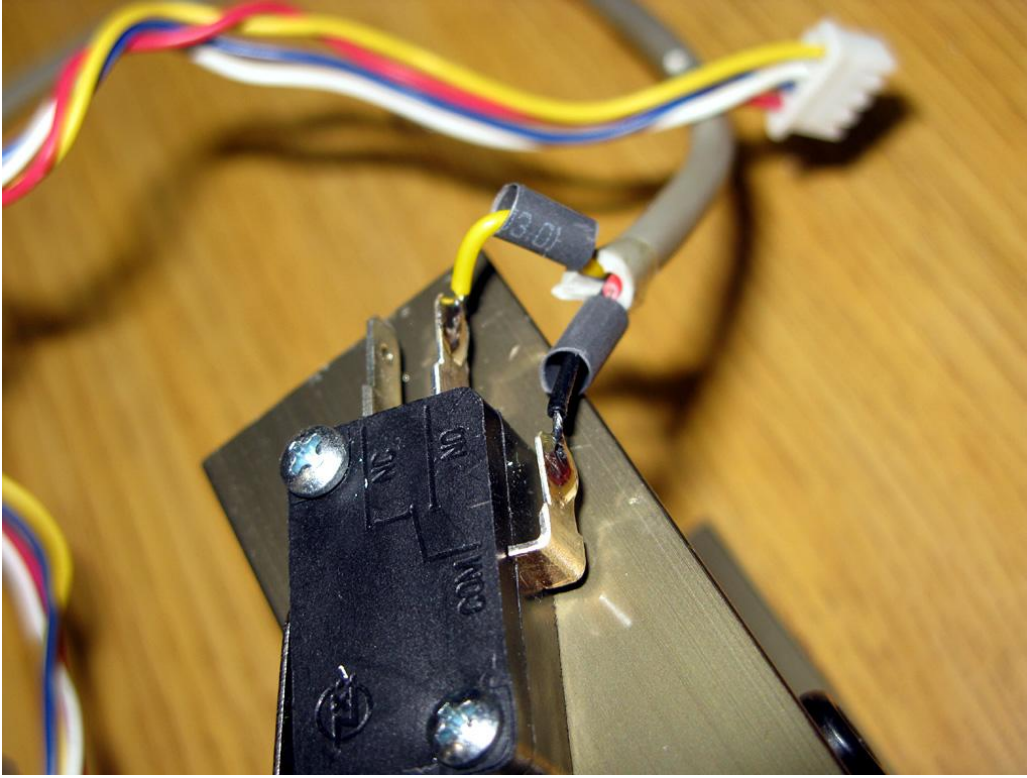


Fig 18. Limit switch soldering

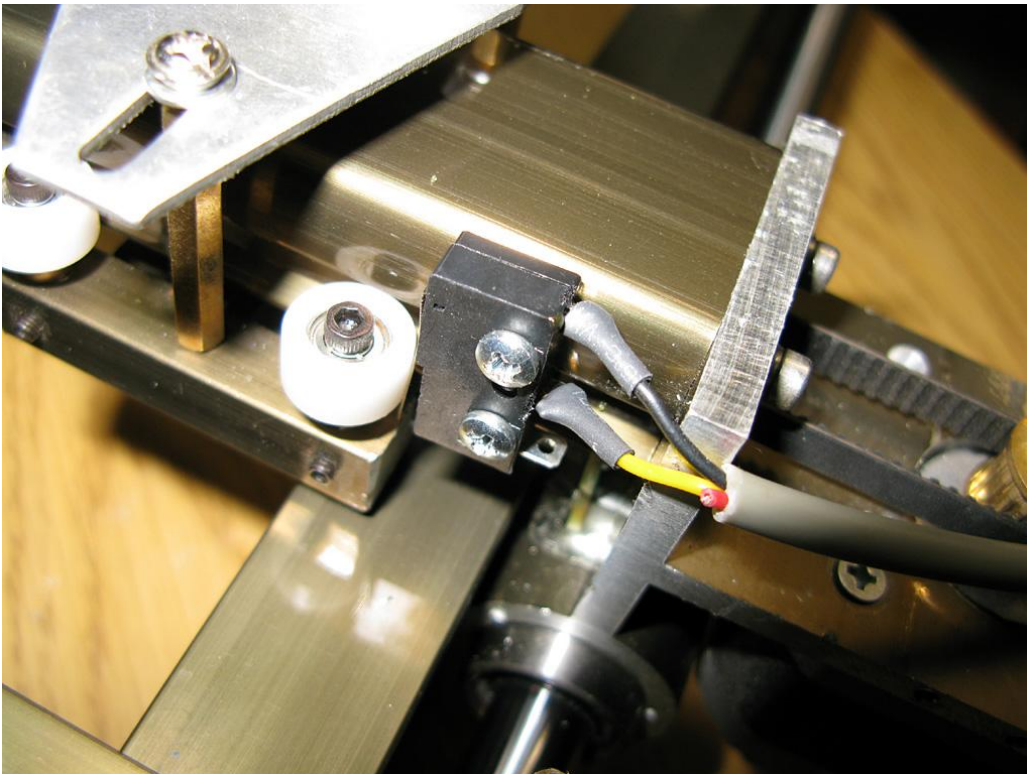


Fig 19. Limit switch setup

Step 4b Y limit switch installation

The installation of Y switch is similar to that of X switch. We recommend to use a bigger one with roller because of the structure of the K40. We setup the limit switch to a position where the roller could have the best contact point at the “T” junction of the aluminum block. This contact position offers the widest area for contact.

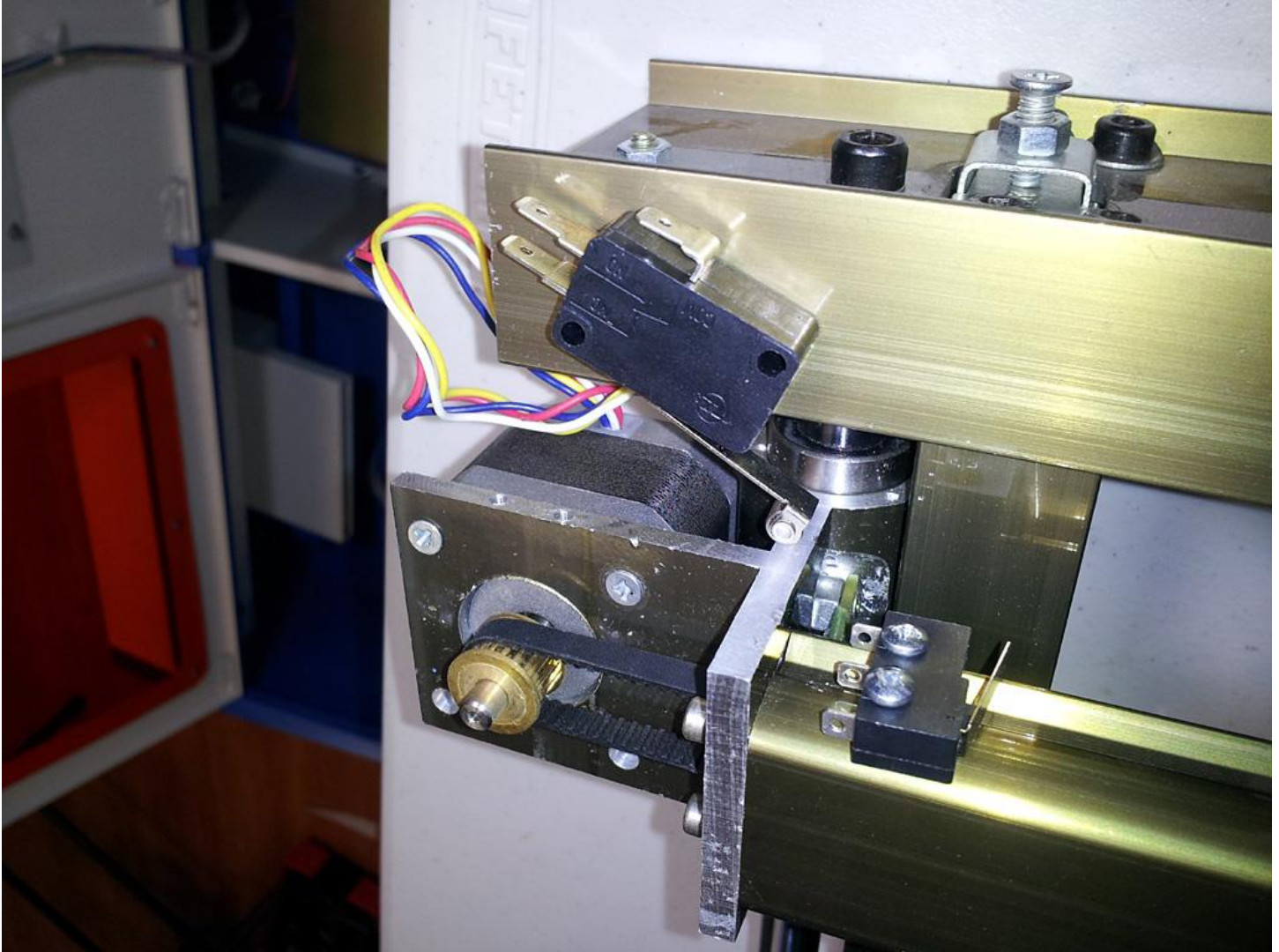


Fig . 20 Y limit switch

Step 5. Motor wire connection

- 5a. X motor wiring

Instead of using a flat cable in this conversion, we use a Cat5 cable with twisted pair. While it may not be the best solution, it works pretty well. We recommend the use of a terminal connector instead of soldering in case we may to rearrange the wiring . orr, in rare situation, when a motor is wore out and requires replacement in futureIt's hard to find the 12-pin connector for this step. If you can find one, be sure to use a flat cable for the connection.

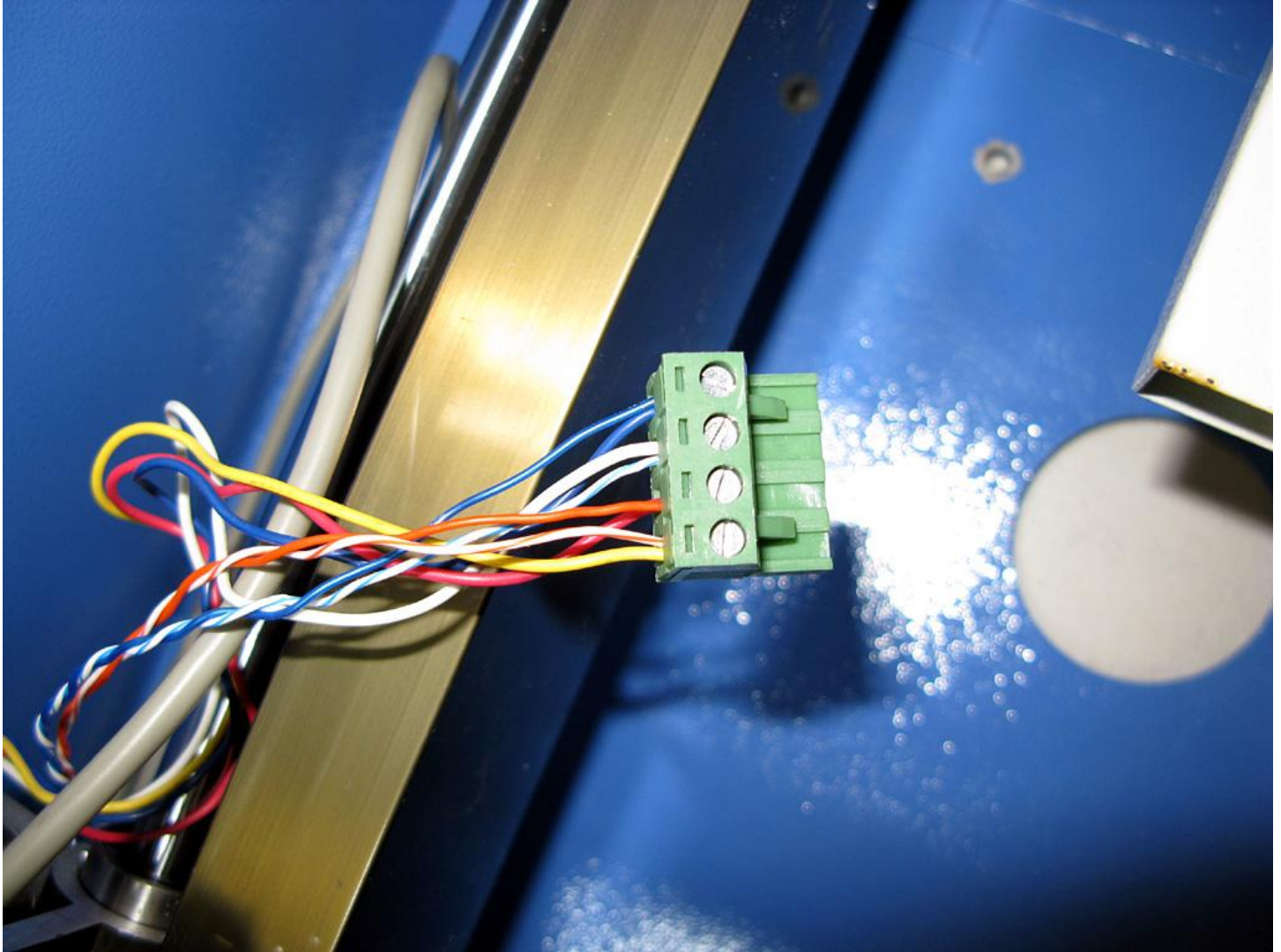


Fig 21.

-5b Y motor wiring.

In the connection of the Y motor, we cut and remove the little white connector. Then connect the wires to the motor driver.

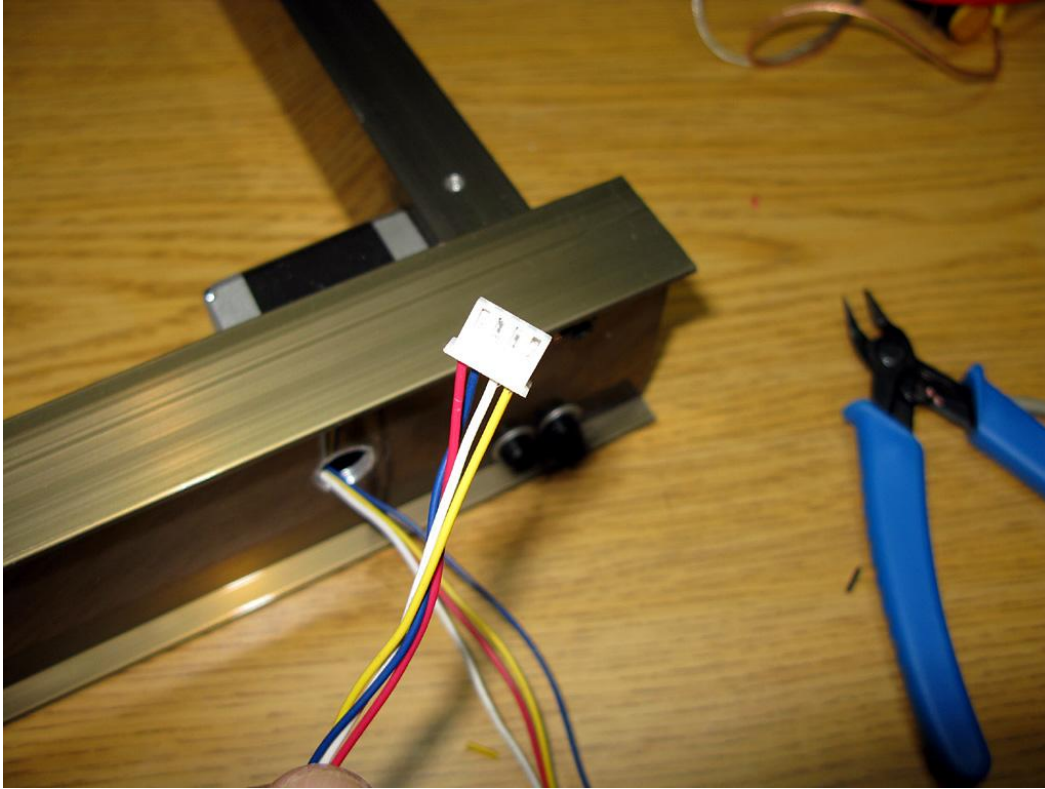


Fig 22

Pick the best position so that the Y motor wires are long enough to connect the motor's stepping driver.

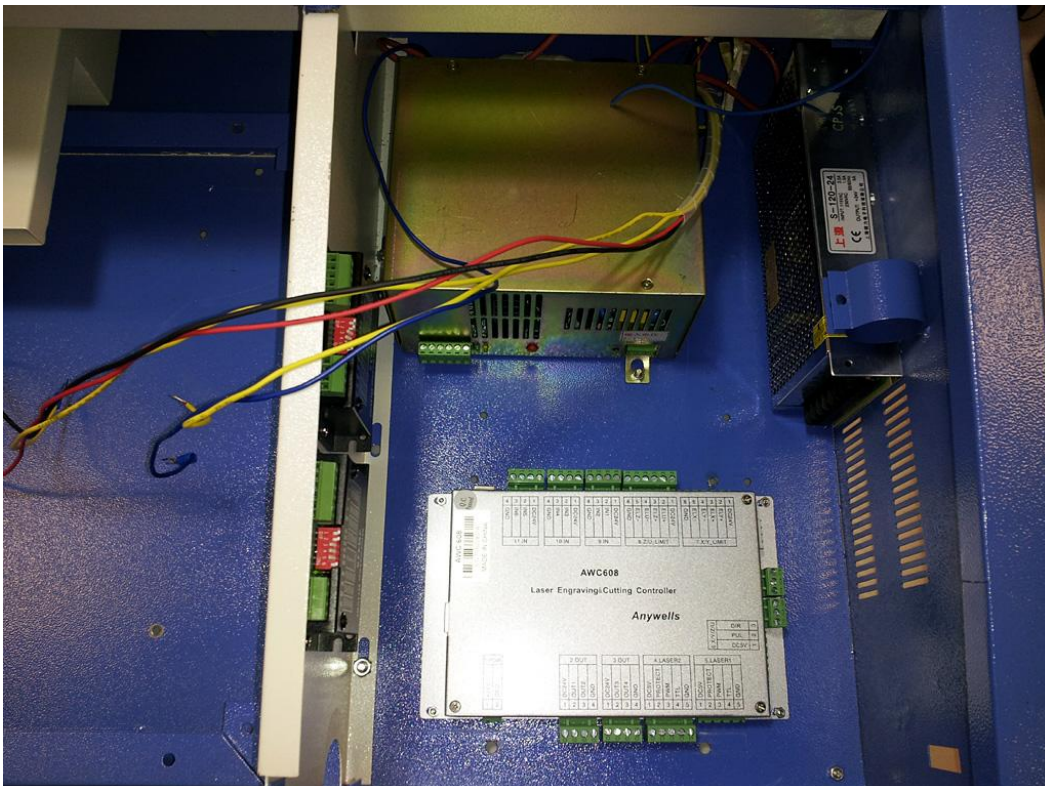


Fig 23. Control compartment overview

Mount the two drivers (X,Y) on the side panel See Fig 23. We have DIP switch & connector facing up for the convenience of setup. We also relocate the laser power supply to the back end. This relocation will spare room

for the DSP card. We mount the DC24V 5A power supply on the side panel. See Fig 23. It could be tricky to install the laser power supply as it is difficult to reach the screw mounts after it is relocated. Well, our solution is to use a glue gun to hot glue the nuts to the mounts firmly! When we drill holes for the power supply, we do it at the bottom of the case. We use the vertical vent holes on the side panel as gridlines to help the alignment. It works very well but requires some patience.

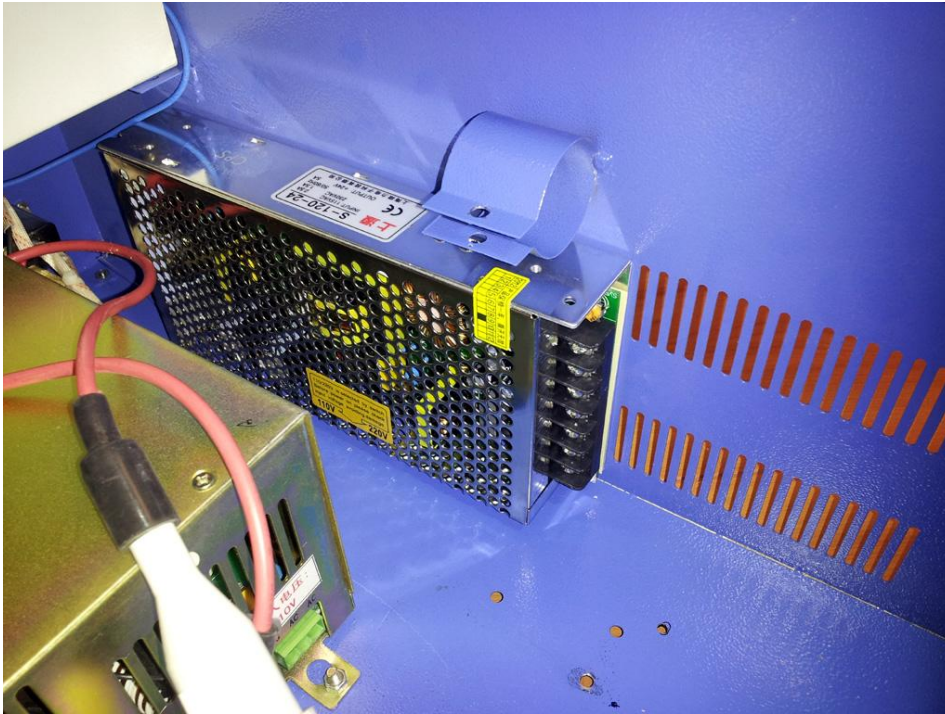


Fig 24.

Note: we remove the “Green giant resistor” as it is no longer required for a high quality power supply which is PWM ready. If you have a non PWM ready power supply, we recommend you replace it as well. The removal of resistor also spares space for the DC24V power supply. Very neat, isn't it!

- To determine if the power supply is PWM ready, check ...



Fig 25. Mounting screws for the DC24V power supply
Step 6. Front panel

The front panel that comes with the original K40 / D40 has a master power switch, laser (disable/enable) switch, power control knob, and an analog current meter.



Fig 26. Original panel front view

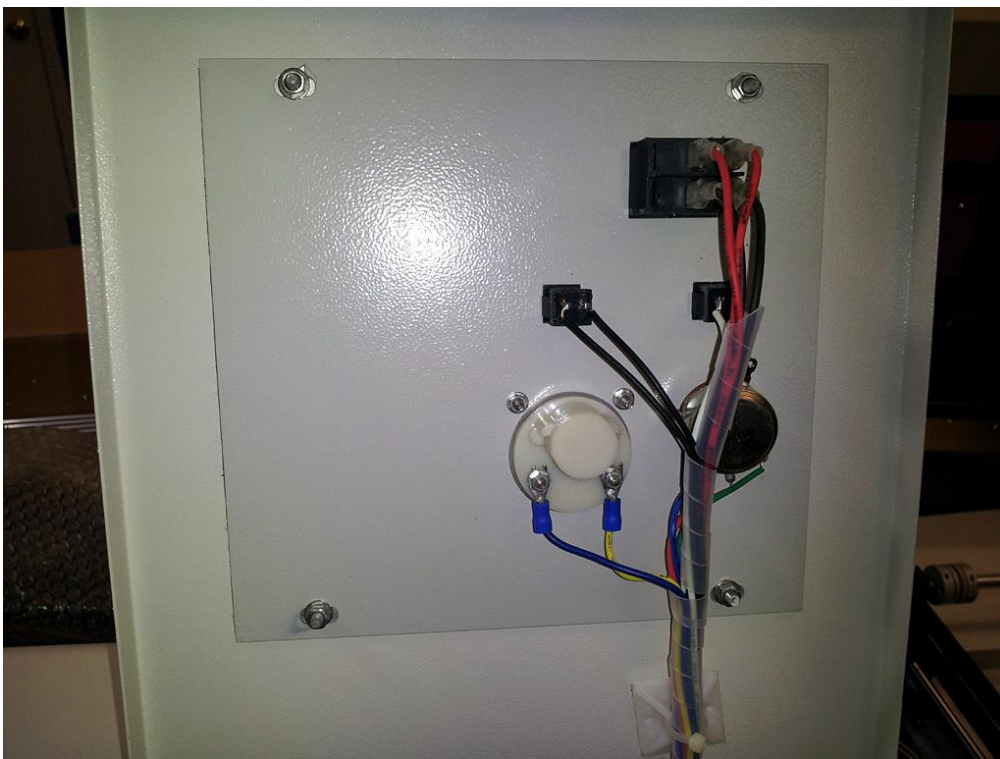


Fig 27. Original panel back view

we also carry acrylic front panel custom made for the K40. You may contact us if you are interested to purchase.

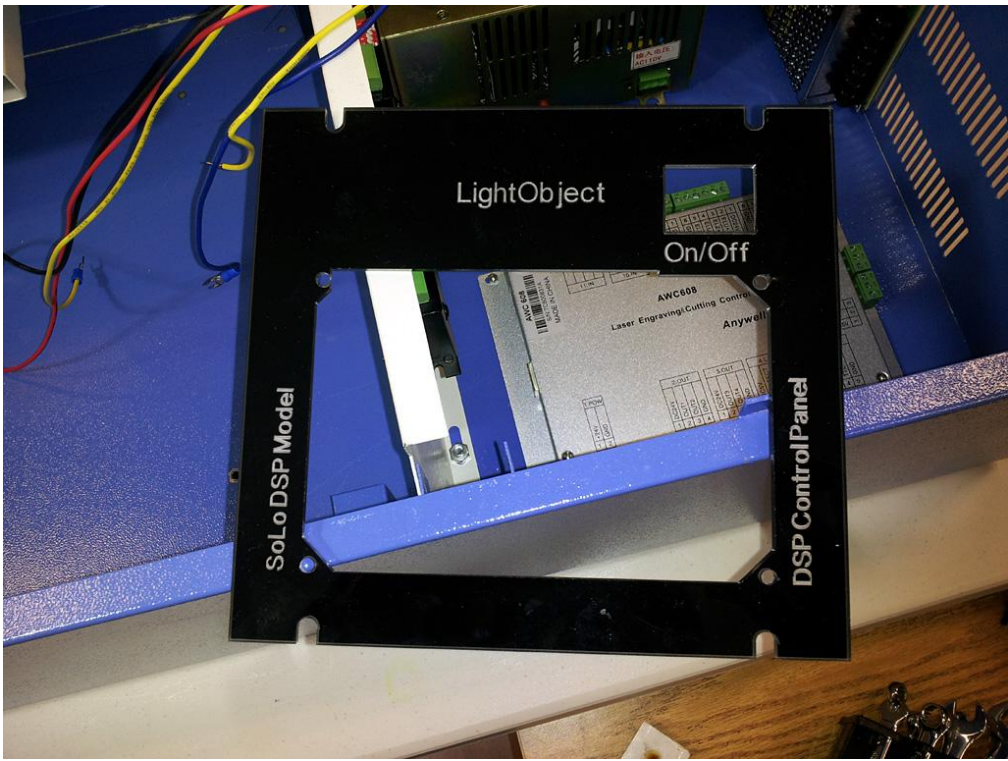


Fig 28. Acrylic control panel. Color options: blue, black, green, transparent.



Fig 29. Acrylic panel with LCD display



Fig 30. Acrylic panel with LCD display (back view)



Fig 31 New panel installed

Step 7. Power supply connection

It needs 3 wires to connect the laser power supply control with the DSP. They are TL, PWM, GND
TL = level low enable (marked as TTL on the DSP)
PWM = pulse width modulation (power control)
GND = ground

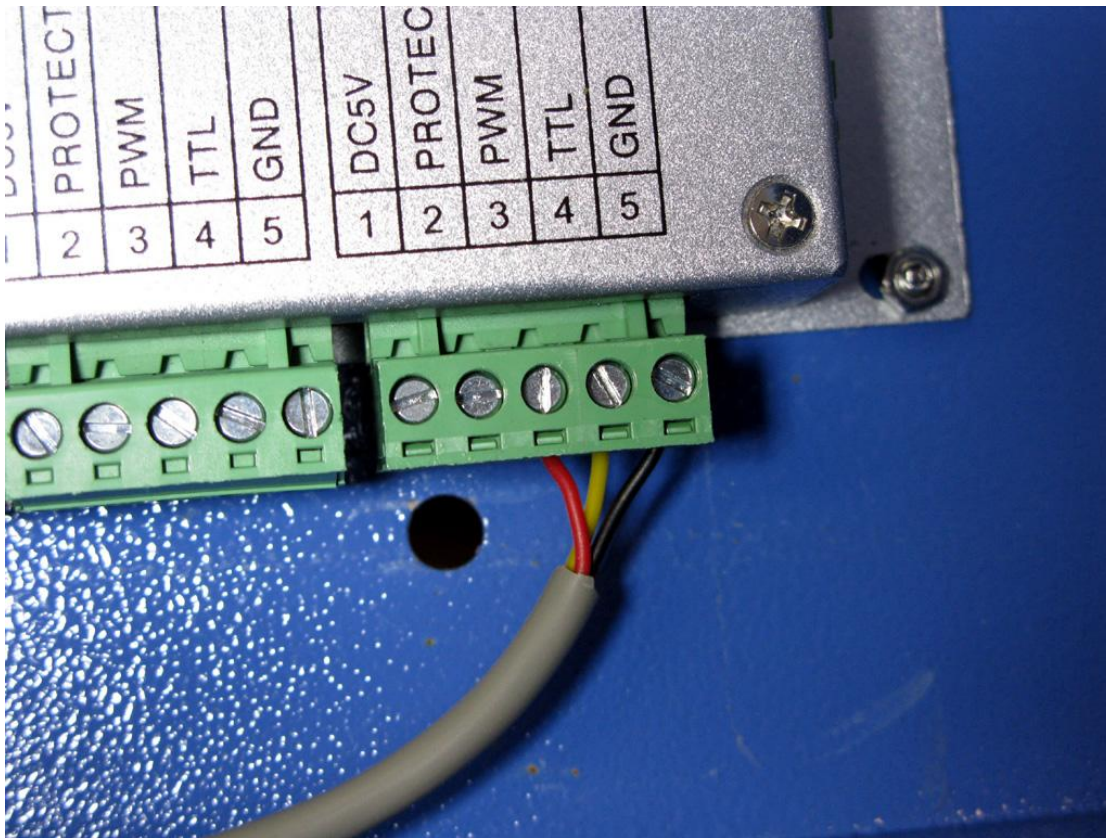


Fig 32. DSP laser power control port

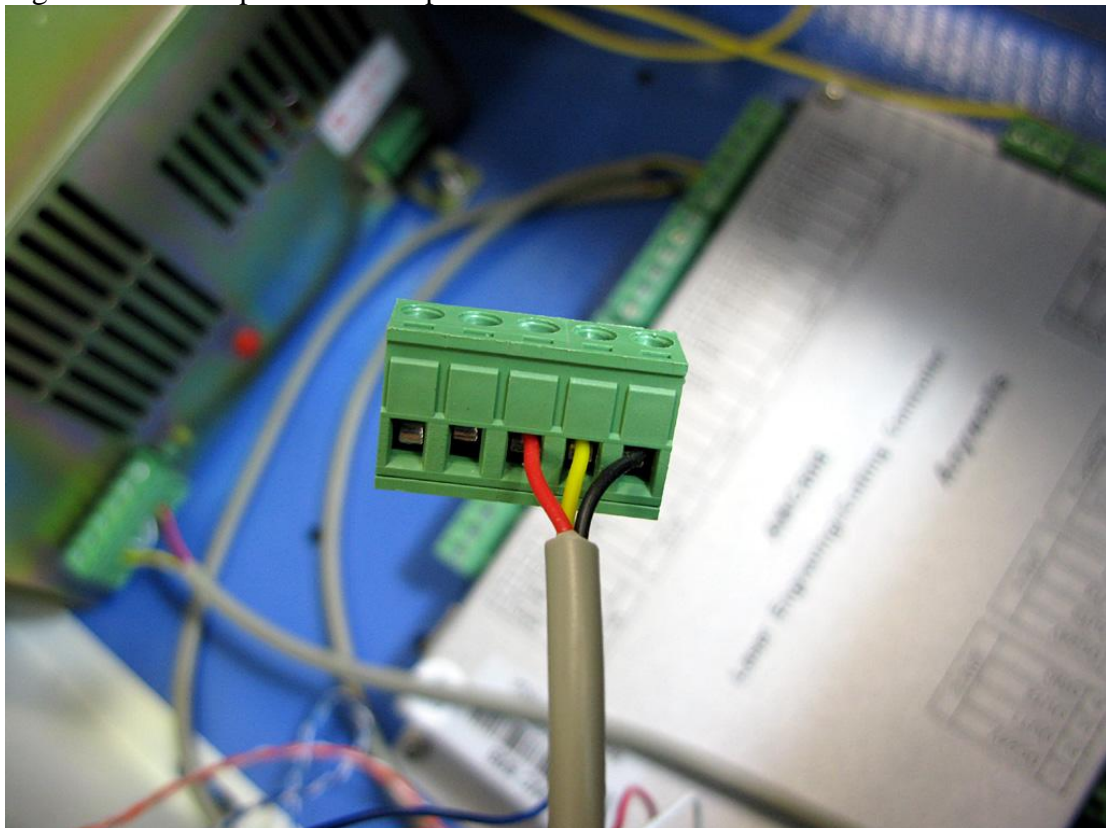


Fig 33. Connector on DSP laser control port

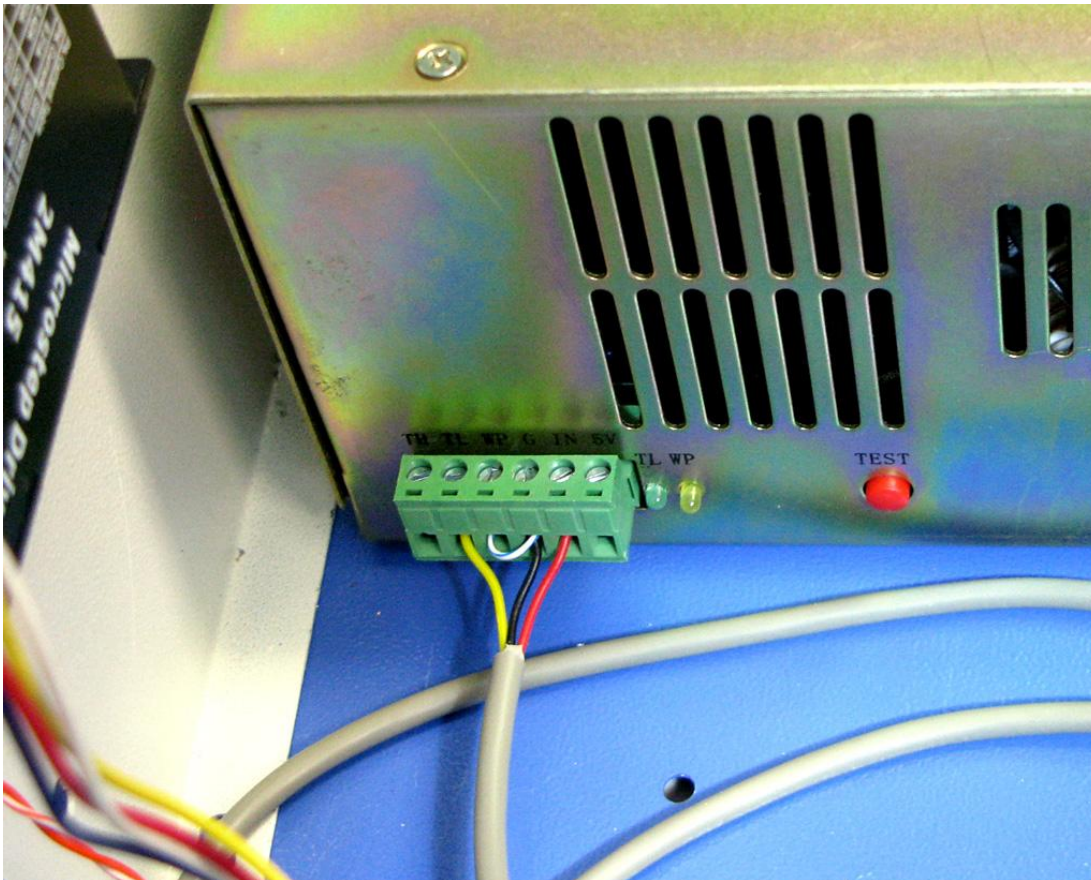


Fig 34. Connector on the laser power supply port
 Note: the notation on the laser power supply is showed below:

TH, TL, WP, G, IN, 5V (from left to right)
 where

- TH = level high to enable (seldom use)
- TL = level low to enable (default)
- WP = water protection
- G= ground
- In = Input (PWM power control or analog control)
- 5V = +5V output for analog control (manual control)

In Fig 34, there is a jump cable (white with blue strike) between WP and G. If a water sensor is installed, it must be connected to WP & G. The power supply must have WP level low (means ground) in order to enable the power supply. A water sensor is a normally opened (N.O.) switch but it will become closed when there is water flowing. Once water flow stops the circuit is open again. If WP is in level high, it will disable the power supply. In that scenario no laser light will fire. .

If you don't have water sensor installed on your machine, follow the way we doon Fig. 34 to enable the power supply. In this situation, we simply connect a wire to the WP & G.

Step 8. Stepping motor driver connection

We use two stepping motor drivers (2M415, 1.5A) to drive two Nema 17 motors. The X motor is running at 0.6A setting and the resolution is 1/16 . Note: the "Opto" is common +5V for this driver.

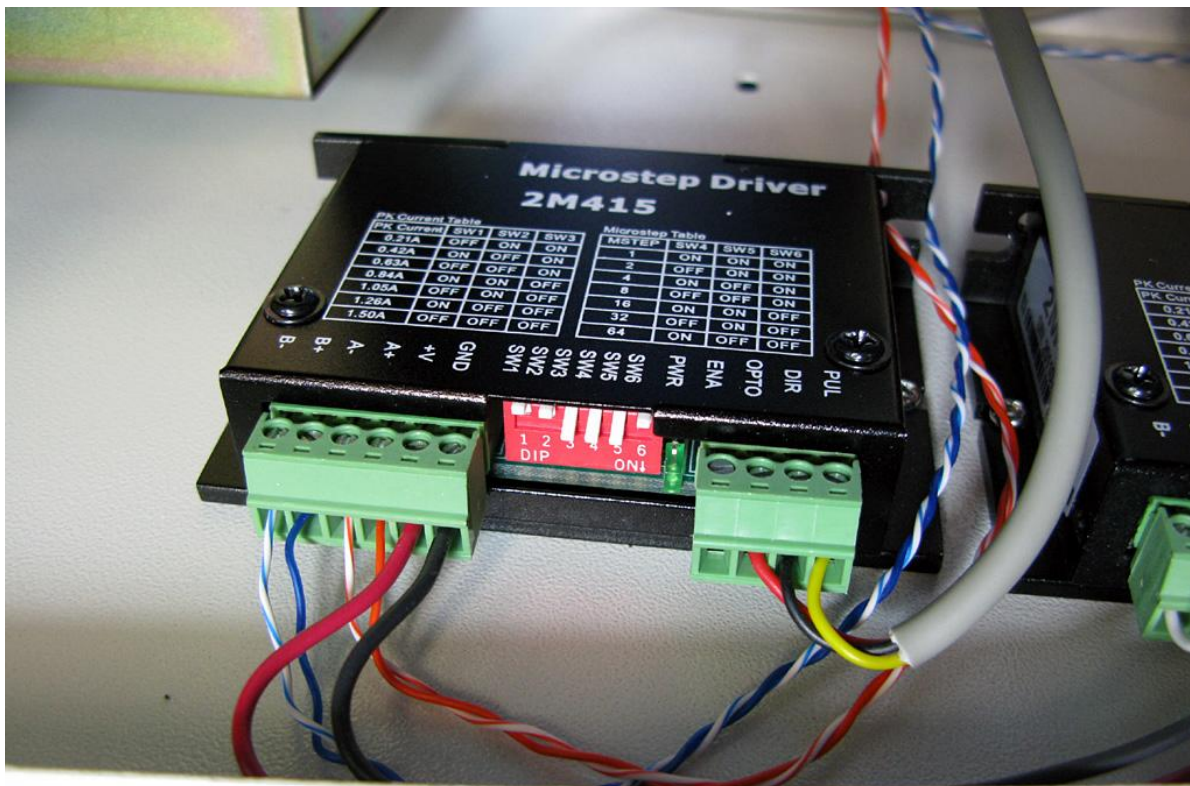


Fig 35. X motor driver connection

In Fig 35, the Red and Black cables on the left power (DC12~36V) the motor controller. The A+ A- and B+ B- are ports for a 2 phase stepping motor. Pay attention to the Red/Black/Yellow cables. they connect the stepper driver with the DSP controller. We will explain more later.

The DIP switches are used to set the current and the resolution. On K40, the X motor is either 0.4A or 0.6A. We use 0.6A so our setting is SW1=Off, SW2=Off, SW3 =On. For the resolution, we select "1/16". It is also OK to select 1/8 for higher speed. 1/16 setting means that for a 1.8degree motor, it takes 200 pulses to complete circle of 360degree. In other words, the resolution is 3200 (3200 pulse for a complete spin.). If you encounter a problem of immovable motor, the motor is probably incapable of handling the resolution. You may lower the setting to 1/8 (1600 resolution). 1600 means that it take 1600 pulse to move 360°.

The length of circumference is " $2\pi R$ " where $\pi=3.1415$ (per 360°). The radius (R) of a gear wheel is 6.2mm. Therefore, each pulse will drive the motor to move by a distance of: $2 * 3.1415 / 1600 * 6.2 = 0.024\text{mm}$. Note: a laser machine can hardly achieve a resolution with fine movement less than 0.05mm. We believe that the K40 is capable of achieving a fineness of 0.1mm.

Note: the 5V on the DSP is connected to "Opto" of 2M415 or "5V" of a stepping motor driver while DIR and PUL are connected to the same leads on the motor drive respectively. The DIR means Direction and the PUL means "Pulse". I used a Red wire to connect the 5V to the Opto, yellow wire for the PUL and the black wire for the DIR. See picture below.

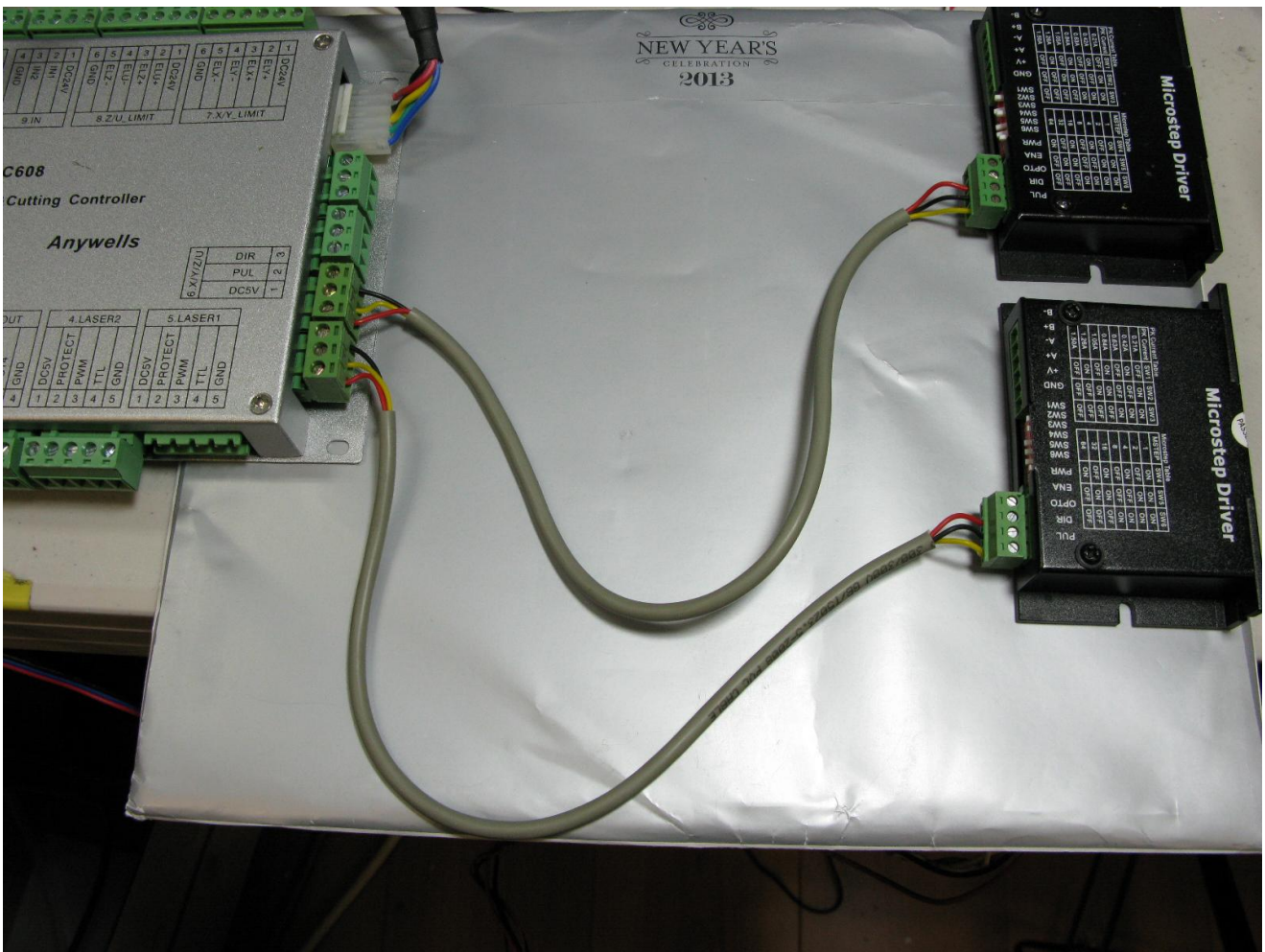


Fig 36. Overview of the XY motor drivers connection

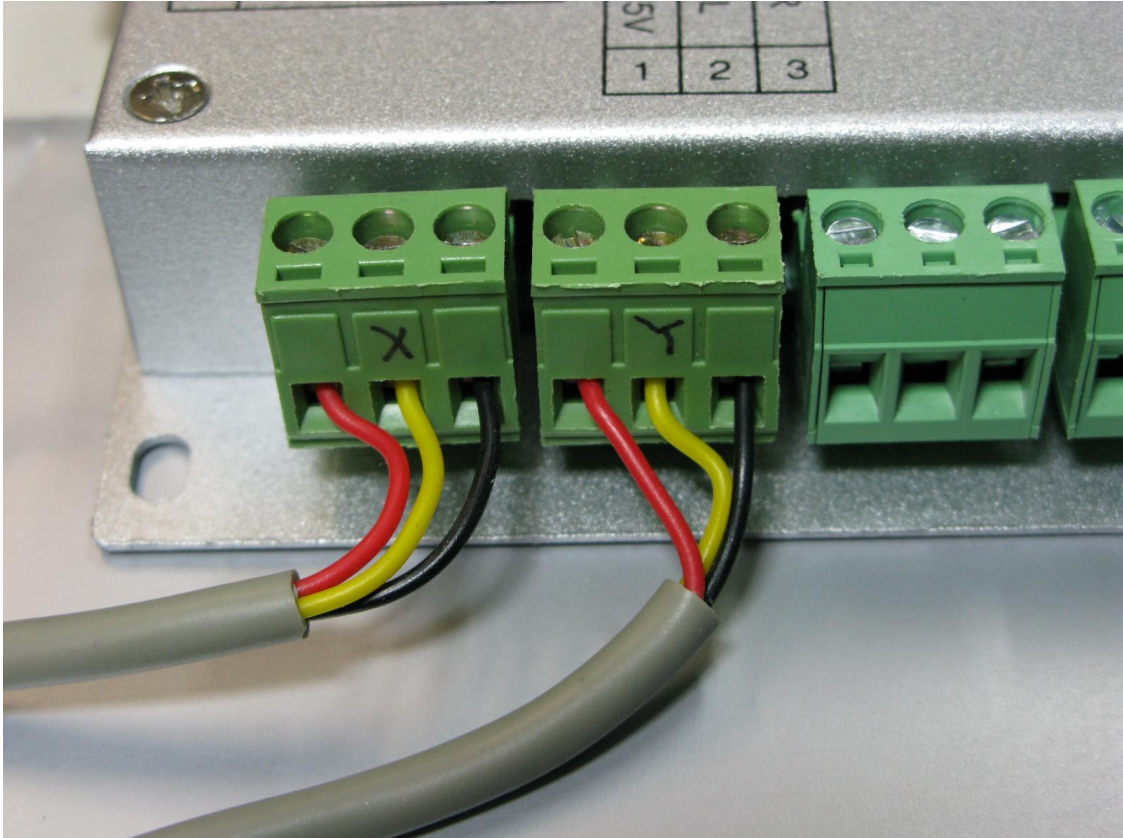


Fig 37. Close-up look of the XY control port

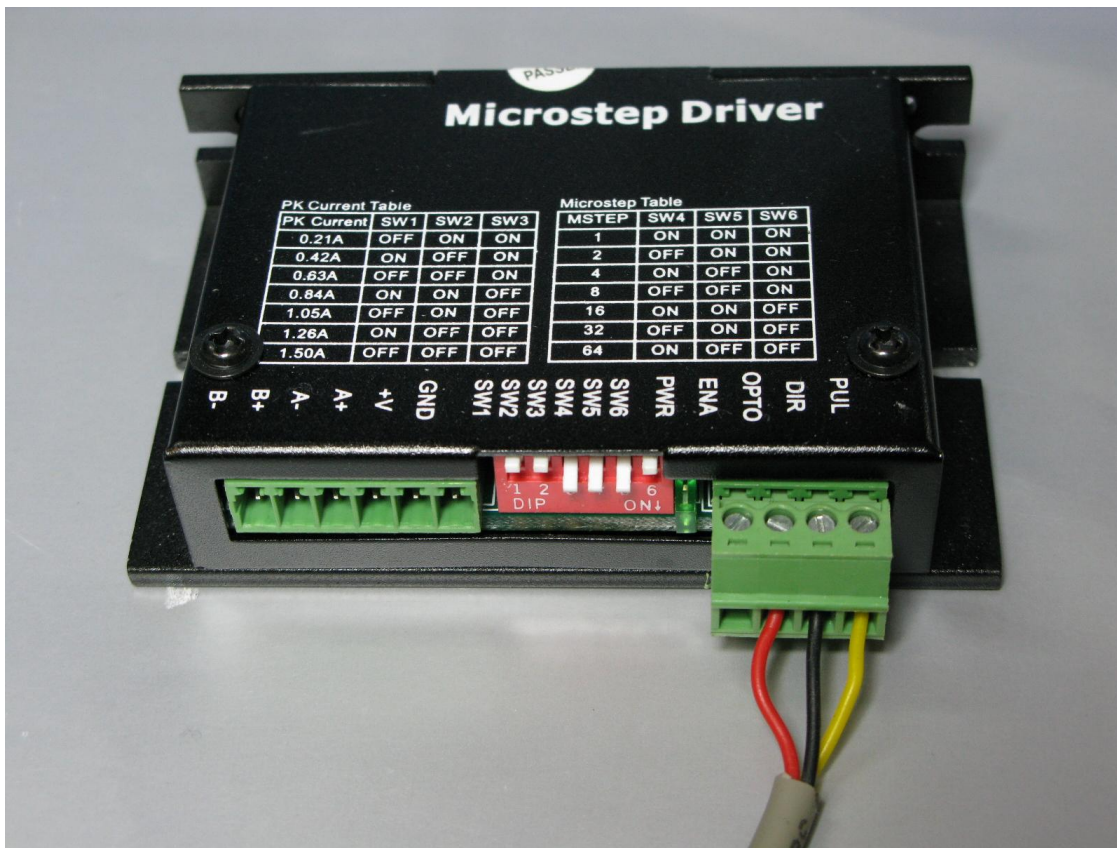


Fig 38. Stepping motor driver connection.

Step 9. Y stepping motor connection

The connection of the Y stepping motor is identical of the DIP switch setting. The current/power of Y-axis motor in most case is bigger than a X motor. For K40, it is commonly known that the Y motor is running at 1A. Therefore, we have SW1=Off, SW2=On, SW3=Off for 1.05A

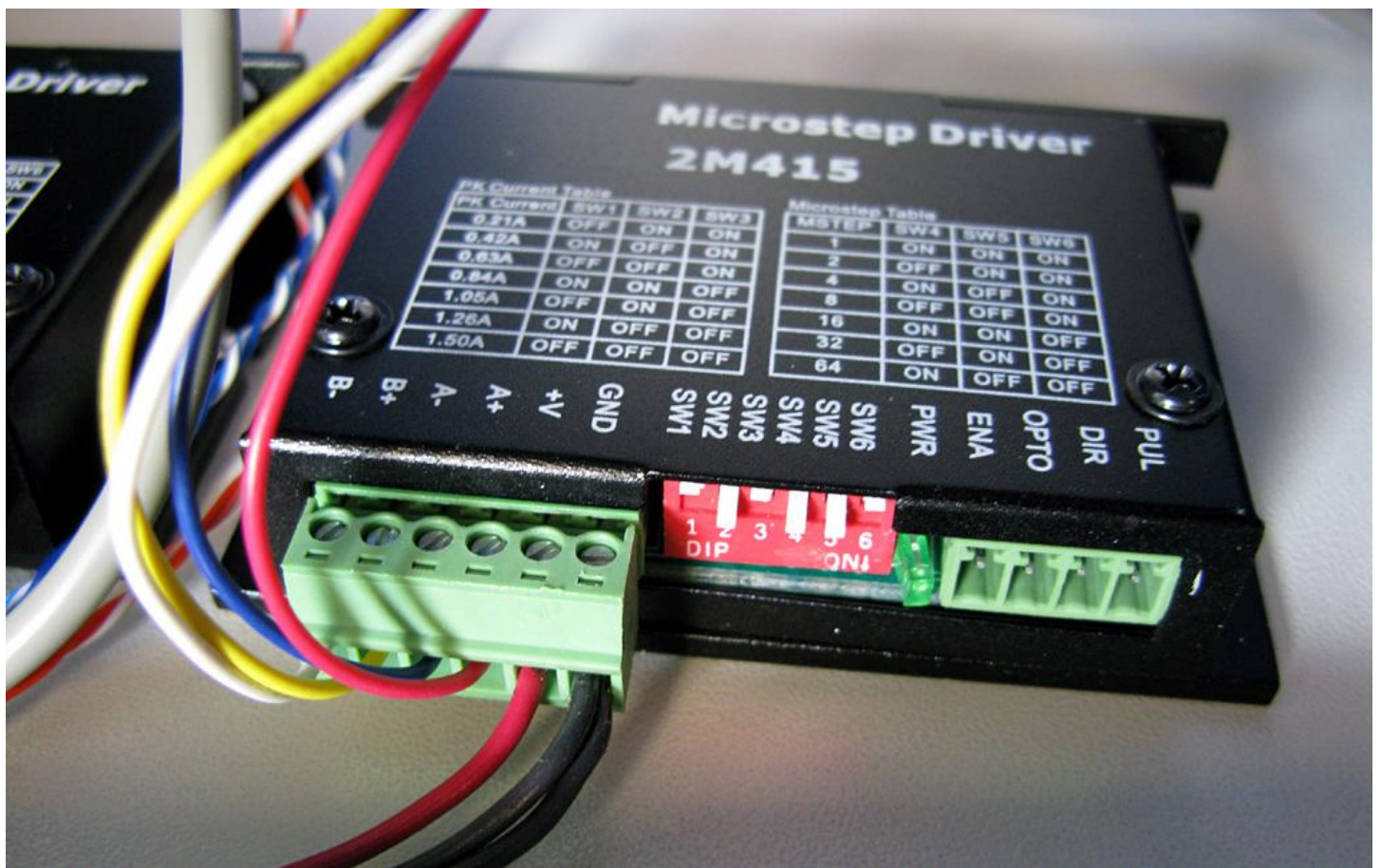


Fig 39. Y motor driver setup

Step 10. Air-assisted laser head

The original laser head is very basic. It does not have an air-assisted air-hole. It is easy to upgrade it by replacing the head with one with air-hole. In Fig 40, we recommend the use of silicone tubing because silicone is lighter and more flexible. This property will avoid putting extra load on the machine. Note: after upgrading to air-assisted laser head, the focus point may change as the lens position may be altered by 8~10mm. It is easy to check the focus by shooting a laser 'dot' on a piece of paper. If the focus is right, the dot should be very sharp and tiny. By moving the paper up/down, you're able to find the finest point (focus point) again.

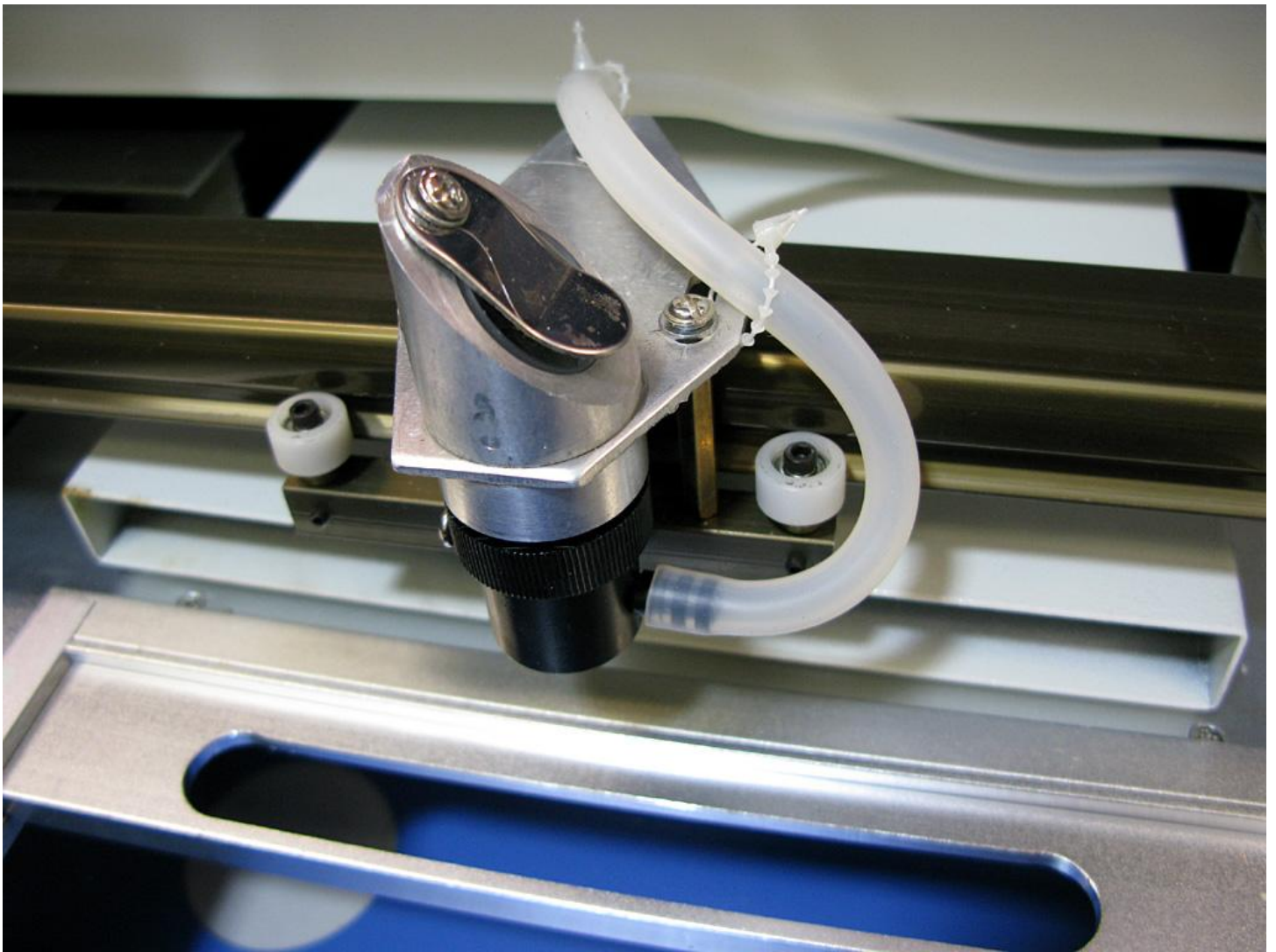


Fig 40. Air-assisted laser head installed.

After the DSP upgrade, the machine should run much better than the original system in terms of. speed and fineness. The performance is absolutely stunning.

The upgraded machine can cut hardwood with thickness of approximately 9.6mm with 3mm/s speed or cut acrylic board with thickness of 3mm in 5mm/s speed. It can engrave chars of thickness 2mm with 100m/s speed.

Step 11. UM setting

By default, the DSP controller card and the LaserCad has default 'um' value set to '3.5'. Without proper setting on the um value, the XY stages will not be able to move or will move noisily. In addition, the output will not be in scale. The image may be either bigger or smaller, or the X-Y may be out of not proportion.

Assuming the stepping motor driver is set to "1/16" (very important!), set the um value to "5" to enable XY stepping motor to run. Note: if you set the driver to "1/8", change the um value to "12" instead. With um=5, the XY stage will move but the motors may not be tuned to their optimal performance yet. To find the magic number for optimization, use the 'um' calculator built-in in the LaserCad!

First of all, a communication between the PC and the DSP must be established. Follow the steps below:

- a) Open LaserCad
- b) Click the “Select Mode” on the top right corner

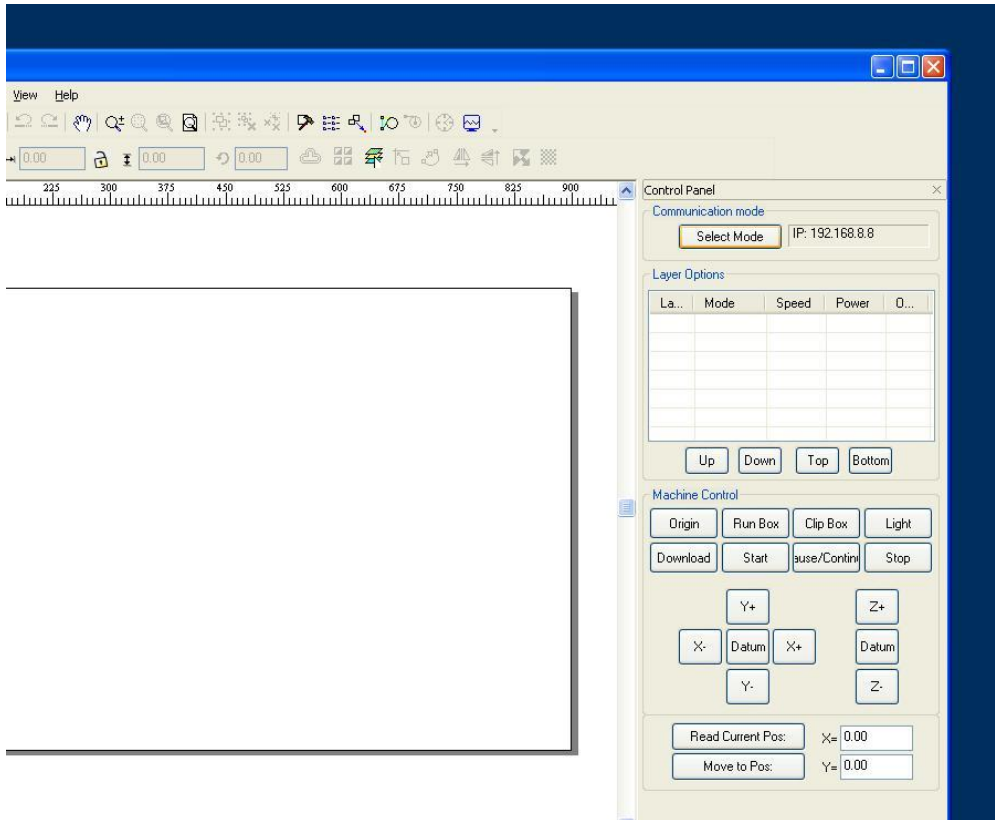


Fig 41. DSP communication

- c) Select USB Mode and double click the “MachName”
- d) Click “FindCom”

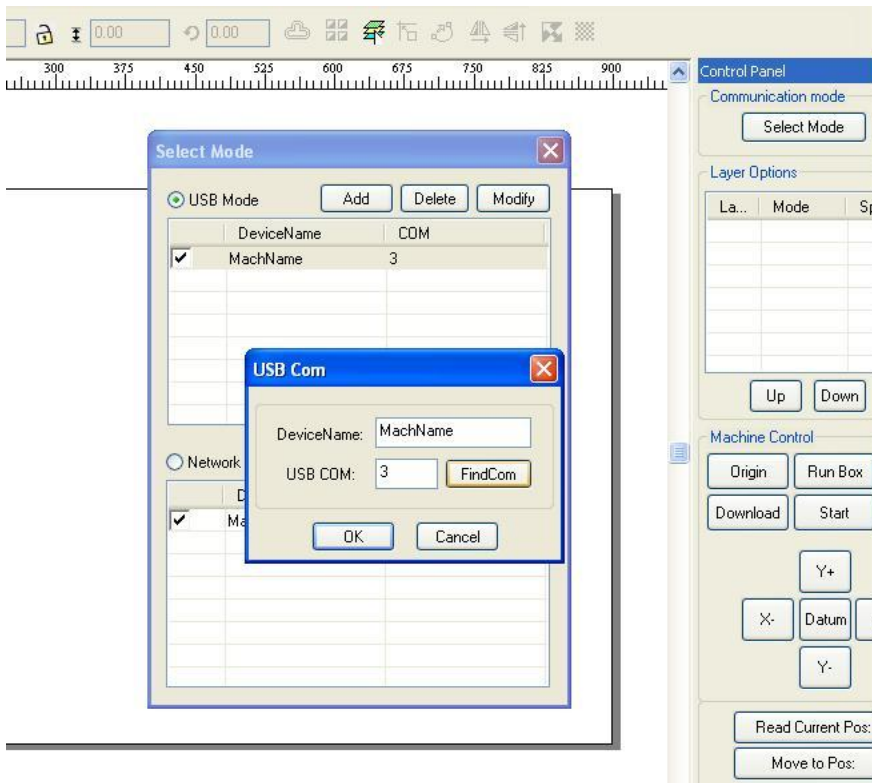
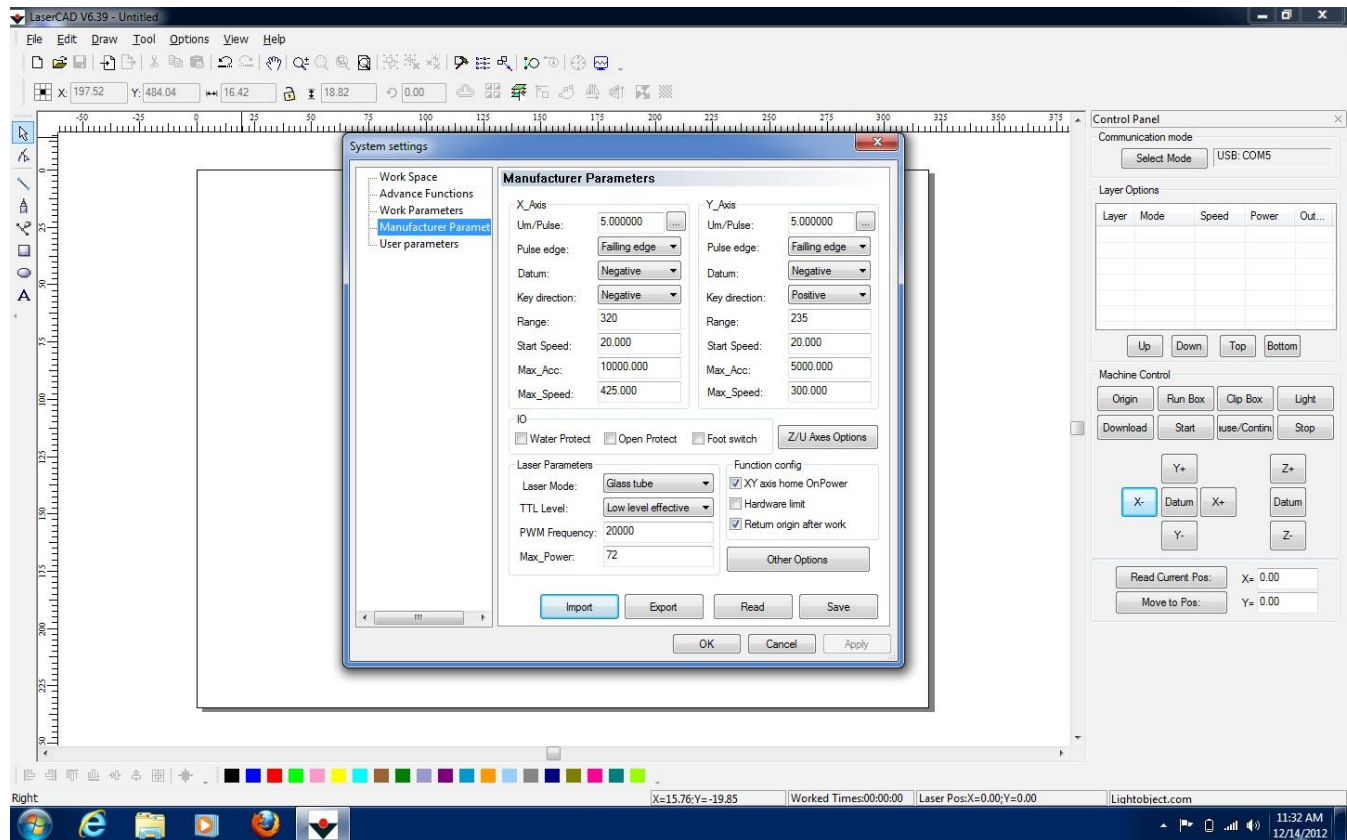
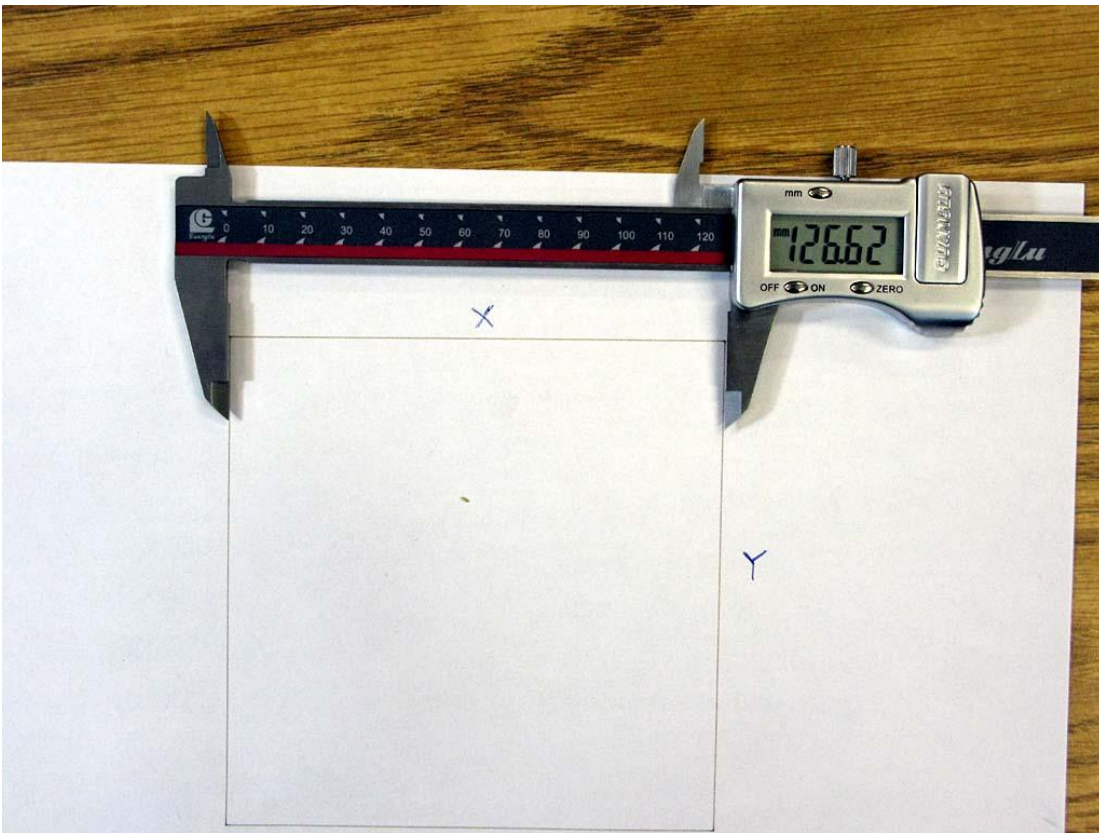


Fig 42. Find Com

- e) Enter “5” on Unit/Pulse for now
- f) Click Save
- g) When you are asked about the password, enter “608”
- h) Hit “Reset” button on the LCD panel to make the new setting in effect



- i) Now use the LaserCad to draw a square box in 100mm x 100mm dimension and select ‘cut’ mode. Depends on the power supply, you may choose speed = 100, max power =15%, min power =12%
- j) Place a piece of paper in the machine and click “Start” to cut the square box. The dimension of the actual cut may not be exactly 100mm x 100mm. We use a digital calibrator to measure the actual dimension in this example. It is 126.62mm on X and 127.13 mm on Y.

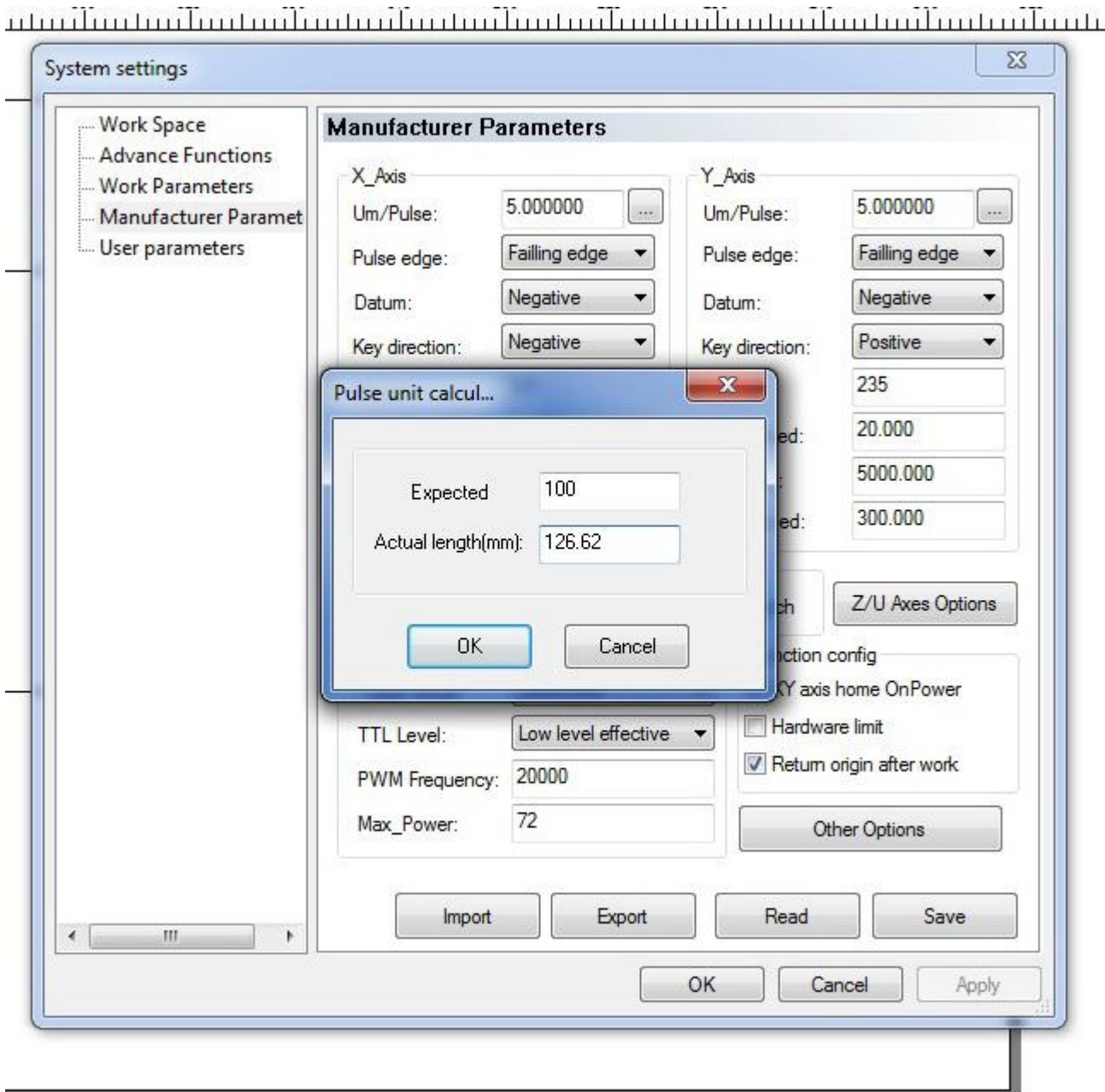


Actual X cutting

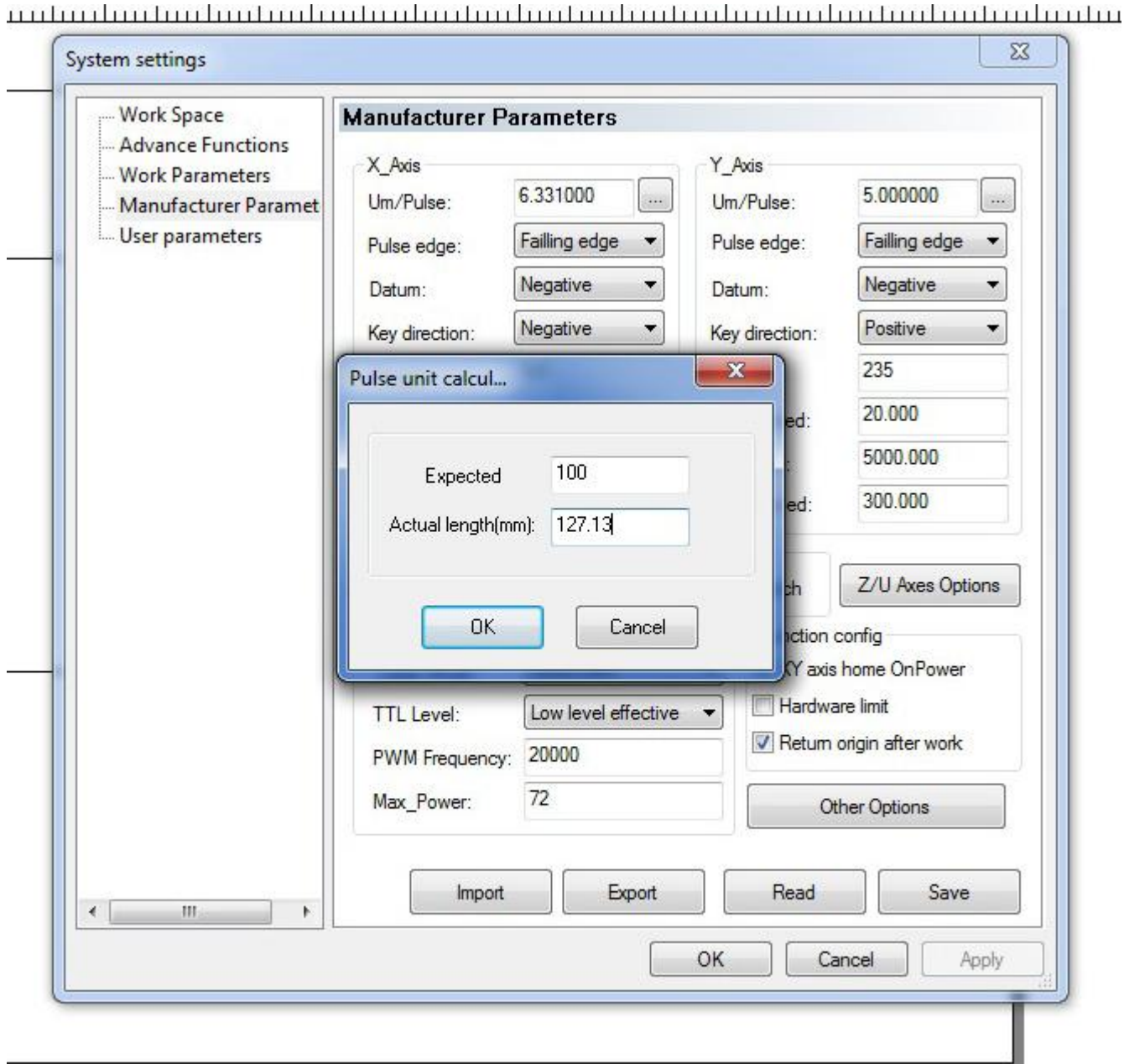


Actual Y from cutting

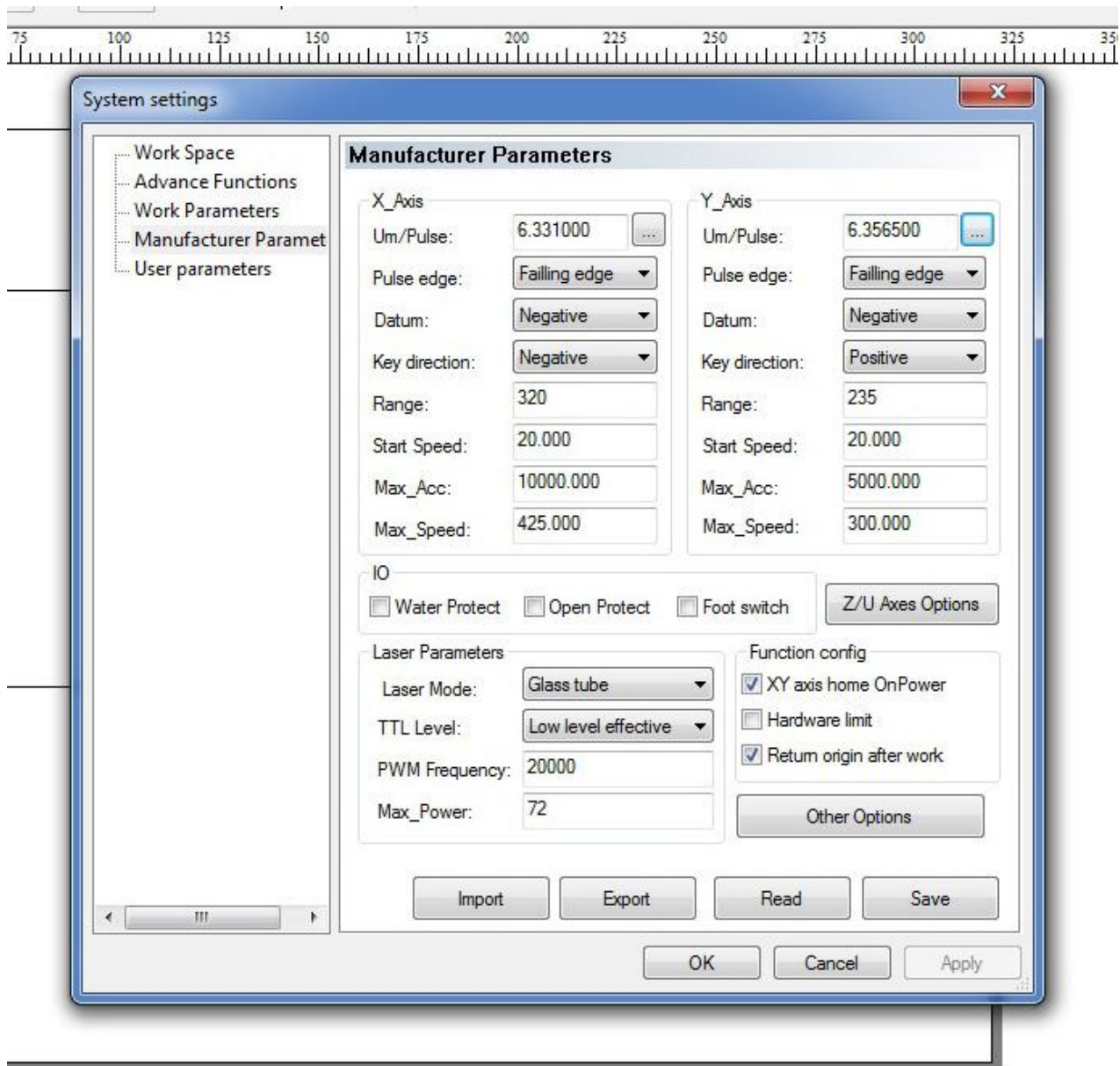
k) Enter 100mm (expected value) and actual X,Y value to the um calculator to find the value of 'um'



Expected X value 100mm, Actual X value: 126.62mm

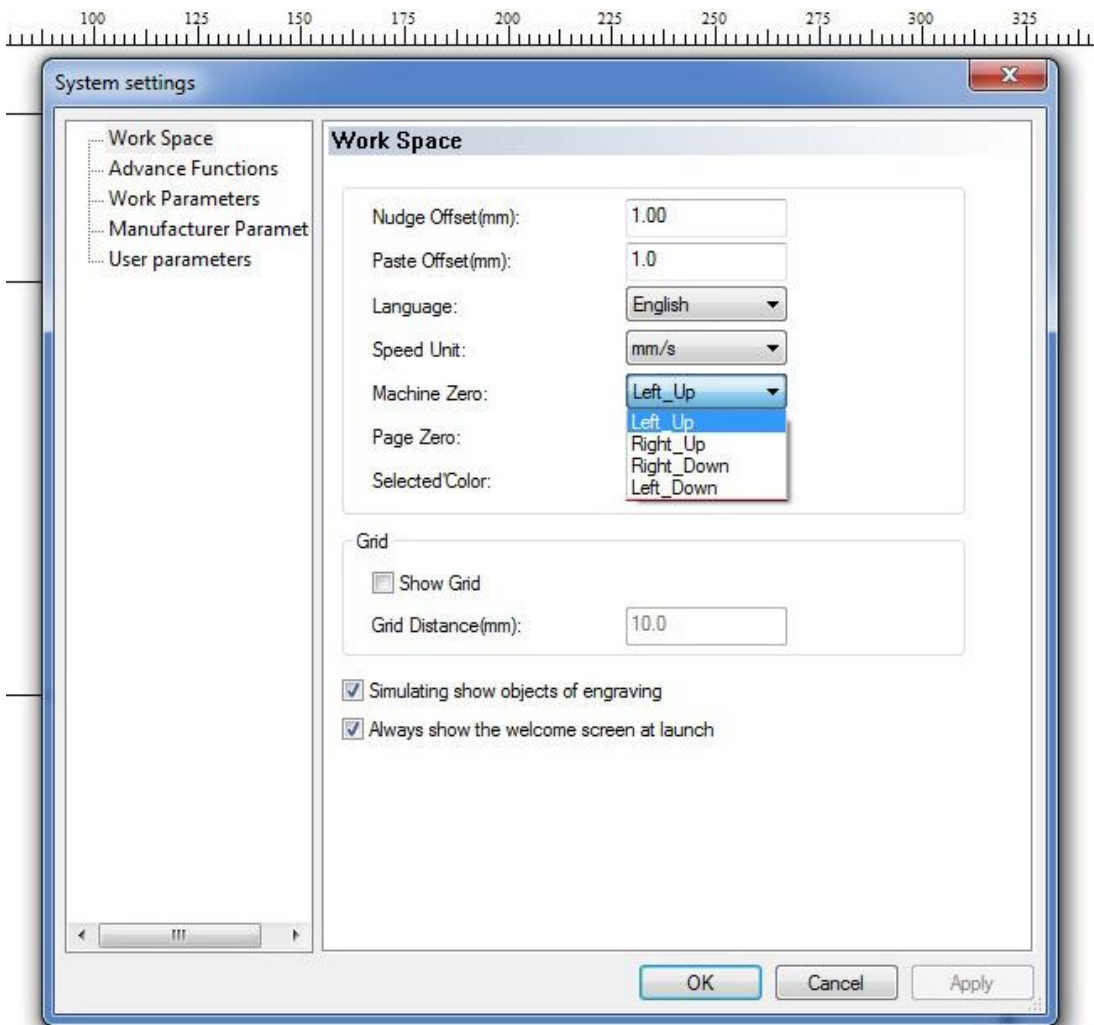


Expected Y value: 100mm, Actual Y value: 127.13mm



The results of μm calculation for X is 6.331 and for Y is 6.356. Click the “Save” button to save the setting and hit ‘Reset’ on the LCD control panel to initiate the new setting.

k) Since the ‘Home’ of the laser head is on the Top Left, it is necessary to set up the “Work Space”. On system setting, click “Work Space” and select both *Machine Zero & Page Zero* to “Left_up”



Sample after conversion



Fig 41. Sample (2mm engraving)

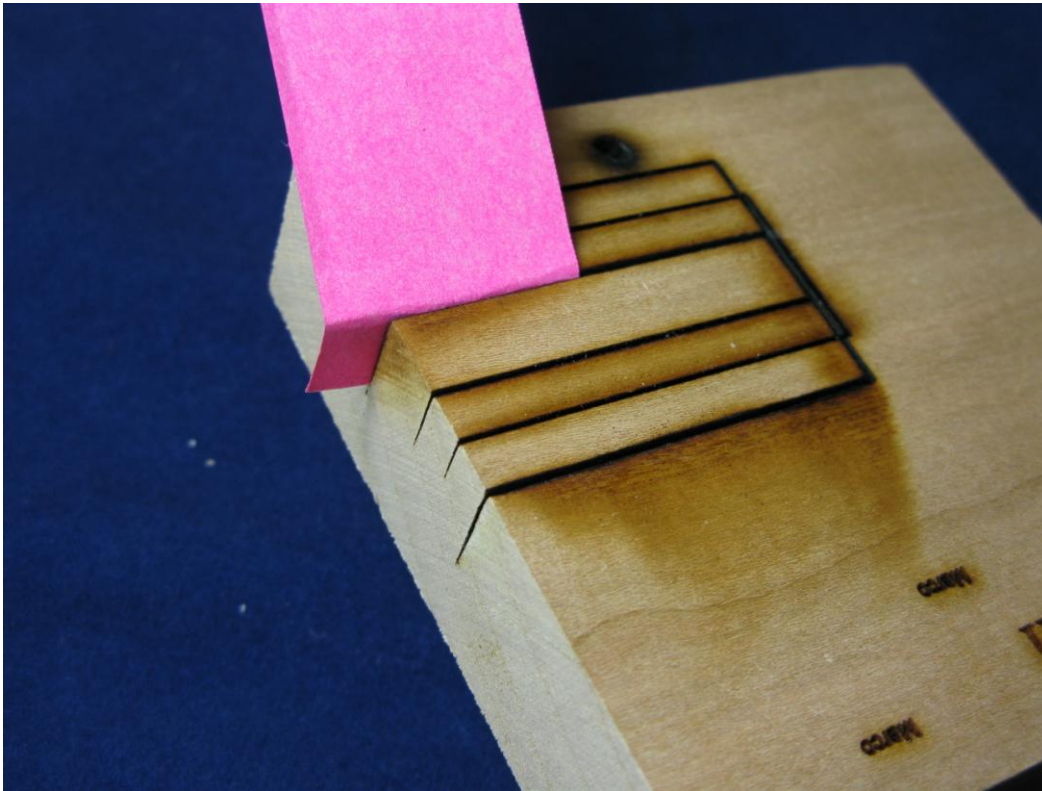


Fig 42. Deep cut on hardwood.



Fig 42. Deep engraving on hardwood (approximately 1.5mm)

At this point, the conversion is completed. There are other things you may consider tuning or upgrading to further enhance the machine performance. For example, the alignment of lens and focus lens, the setting of tension on the belt, the focus point, addition of smoke fan and a digital current meter..
Have fun!



Hummingbird

Solo DSP

