# K40 Laser Cutter

## Alignment Instructions

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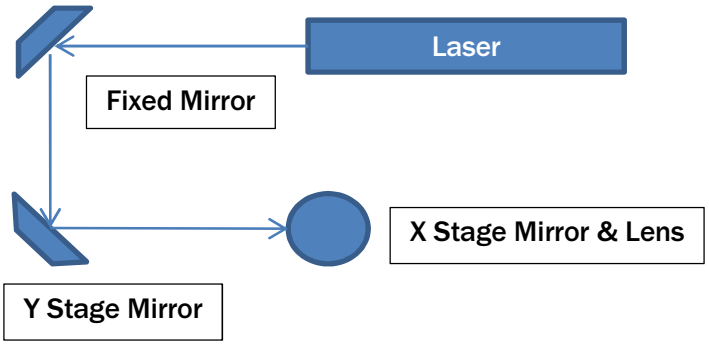
## Introduction

To get the best performance (or indeed any performance) from the cutter it is necessary to ensure the light path from the laser to the work piece is correctly aligned. My unit was supplied without the light path setup – in the end I had to modify the cutter to get a good alignment. Even now it is not perfect but it is pretty good.

To perform the alignment the following things are required:

- Meths (or acetone or Iso-propyl Alcohol) for cleaning the lens
- Kitchen roll for lens cleaning
- Masking tape for the alignment
- Spanner for the lock nuts
- Time – lots of time – 2 to 3 hours
- Patience
- More time & patience
- Several attempts

The light path of the laser cutter is:



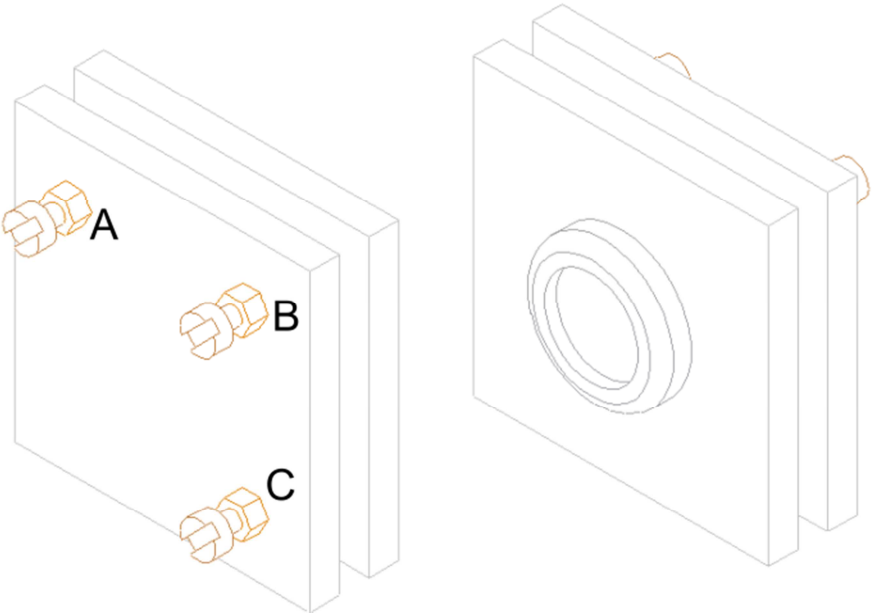
The laser lies parallel to the X axis of the X-Y stage, The beam is reflected onto the Y axis by the fixed mirror and then back onto the X axis by the Y stage mirror. The X stage mirror then reflects the beam so it is vertical and through the lens.

To get the correct performance the beam from the fixed mirror must be aligned along the Y-axis so it strikes the Y-stage mirror at the same point irrespective of where the carriage is positioned. The beam from the Y stage mirror must be adjusted so it strikes the X stage mirror at the same point irrespective of the position of the X-stage mirror on the X–axis.

If the beam is not correctly aligned there may be small errors in the positioning of the beam; however these will tend to be minimised by the focussing of the lens. The biggest problem with mis-alignment of the lens is uneven cutting power of the laser over the whole operating area of the laser. The lens is not of the same quality as a multiple element optical lens and there is significant distortion of the beam and loss of focus away from the centre of the lens. In the worst cases the beam can partially miss one of the mirrors giving loss of power or hit the inside of the lens holder assembly again losing power but also distorting the cutting spot.

## Adjusting the Mirrors

Beam alignment is achieved by adjusting the fixed and the Y-stage mirror in turn to get the best alignment of the beam. This adjustment needs to be performed carefully as the spot position is affected significantly by the setting screws – a small change in screw setting can result in a large change in the laser spot position.




The picture above shows mirror adjusting assembly. The three screws A, B & C are locked with lock-nuts. These should be treated with care - the screws and nuts are brass and have a fine pitch thread. Too much enthusiasm will result in stripped threads probably requiring a new mirror assembly.

On my version of the K40 the above arrangement of screws applies to the Y axis mirror – the setup on the fixed mirror is the opposite way around, A is on the right and B and C are on the left when viewed from the rear of the unit. This affects the way the adjustment is performed. The instructions take this difference into account.

It is tempting to adjust the screws individually, but that can make predicting the position of the dot more difficult. I found it easier to adjust the screws in pairs, turning them the same

amount: adjusting A & B together moves the position of the spot up or down, keeping it in the same left-right position; adjusting B & C together moves the position of the spot left to right keeping the same up-down position. Adjusting an individual screw will move the spot by some arbitrary and possibly unpredictable angle which will mean alignment will take longer to complete.

Before starting adjustment, release all three locknuts on the mirror so the screws can turn freely. Once alignment is completed, tighten the nuts up without changing the position of the screws otherwise adjustment will have to start all over again.

## Alignment Procedure

The alignment procedure is divided up into phases – each one should be completed fully before moving onto the next one. The steps should be performed in the sequence below:

1. Preparing for the Alignment
2. Positioning the Fixed Mirror
3. Aligning the Fixed Mirror
4. Positioning the Y axis Mirror
5. Aligning the Y axis Mirror
6. Positioning the Lens Holder
7. Aligning the Lens Holder
8. Completing Alignment

## Preparing for Alignment

The first stage of the alignment process is to get the machine ready for the process. With the unit powered off, remove the laser tube cover and the front door. If you have been sensible and installed interlocks on the cover and door these will need to be overridden to allow the laser to be fired.

# WARNING

**Performing the alignment process leaves the laser beam exposed. Please follow these safety rules:**

**Keep all other people away from the cutter while performing the alignment**

**Wear laser safety glasses if you have them.**

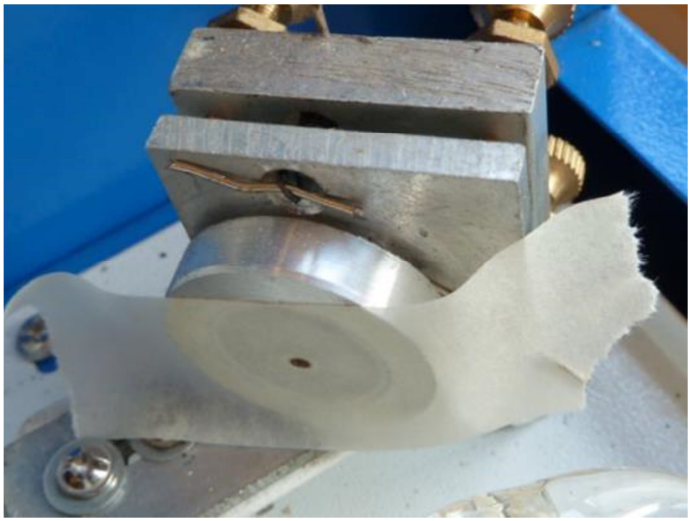
**Look away from the beam and close your eyes when firing the beam**

**Keep your hands out of the beam – even the unfocussed beam can cause third degree burns.**

**You are responsible for your own safety and any damage you cause yourself, the laser cutter or anything or anyone else. Treat the equipment with respect.**

The cooling water system needs to be running as the laser will be activated. Place a piece of masking tape over the fixed mirror as shown below:

Turn the laser power control down to minimum. Press the laser fire button; there should be no reading on the meter. Turn the power control up and perform a test fire using the fire button. Repeat this until the system starts to register current on the meter. On my cutter this happens at about 5mA. This is the point where the laser just starts to lase. Doing this should allow you to burn a small spot in the masking tape without blowing a hole through it or setting it on fire. It may require the button to be held for a couple of seconds to get a good spot – practice shows how long you need for your masking tape and laser.



This shows the sort of spot you can achieve – this is a reasonable size for aligning the mirrors.

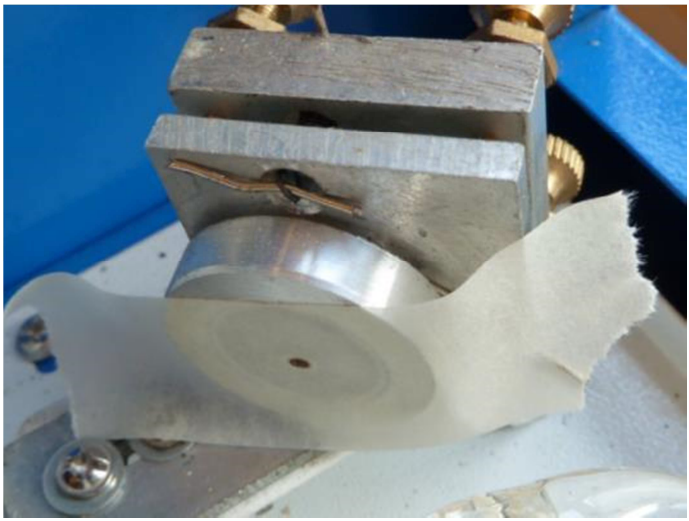
If you are still using Moshidraw run it on the computer and connect the computer to the cutter. Select the "Output to Laser" option and when the dialogue box is displayed click the "Free Motor" button. This disengages the motor drives so the carriage can be easily slid around. If you have upgraded the controller, use the equivalent command or disconnect the stepper motors.

## Positioning the Fixed Mirror

**Note:** This stage is normally only required when the cutter is being first setup or the laser tube has been changed or repositioned.

The first stage of the alignment process is to adjust the position of the fixed mirror. Put a new piece of tape over the mirror and fire the laser. The spot should be in the middle of the mirror. If

the spot is to one side or the other the mirror can be slid back or forward by loosening its fixing screws. If the mirror is too low it can be packed to raise it up. If it is too high, the only option is to adjust the rubber on the laser tube to lower it. Once the spot is in the centre of the mirror, the mirror is positioned correctly.



Once the mirror is positioned, ensure all the screws are tightened, remove the masking tape and clean the mirror to remove the burnt residue of masking tape.

## Aligning the Fixed Mirror

To align the fixed mirror, put tape over the Y-axis mirror and slide the carriage so the mirror is as close as possible to the fixed mirror. Fire the laser to burn a spot onto the tape. This is spot A Slide the mirror so it is as far as possible from the fixed mirror. Fire the laser again to burn a second spot, spot B.

In an ideal world, the two spots will be on top of each other. In practice there will be two spots. The relative position of the two spots tells you how to adjust the mirror. If you cannot see the second spot because the fixed mirror is too far out of adjustment, move the Y axis mirror a smaller amount at first until the alignment is close enough that two spots can be produced when the Y axis mirror is moved over its full travel or the spots are aligned.

| Position of Spot B relative to Spot A | Position Error | How to adjust it out |
|---|---|---|
| Left | Angle too acute | Turn B & C clockwise |
| Right | Angle too obtuse | Turn B & C anticlockwise |
| Above | Mirror angled up | Turn A & B clockwise |
| Below | Mirror angled down | Turn A & B anticlockwise |

When the mirror has been adjusted slightly, replace the tape, and repeat the previous step to produce a new pair of spots and

identify how the misalignment has changed. The spots should be closer if the adjustment has been performed correctly. Repeat the process until the spots are aligned.

In the picture above the spots are aligned correctly in the vertical axis but not in the horizontal axis so only screws B & C need to be adjusted. Typically, however, adjustment in the horizontal and vertical directions will be required. Rather than trying to adjust both directions at once, adjust the vertical direction first followed by the horizontal direction.

Once the adjustment is finished, tighten the locknuts and repeat the spot test and ensure the two spots still align. If not one of the screws will have turned slightly and will need to be readjusted. The final result should be something like this:

## Positioning the Y Axis Mirror

**Note:** This stage is normally only required when the cutter is being first setup or the laser tube has been changed or repositioned.

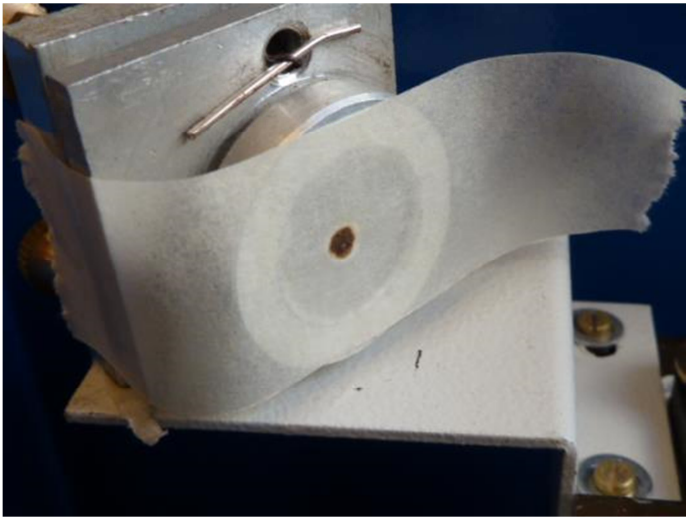
Once the fixed mirror is aligned the Y axis mirror can be positioned. The error in position can be seen from the position of the aligned single spot. In the above photo, from my cutter, it can be seen that the spot is high and to the left of the centre of the mirror. This could explain some of my early problems with loss of power – some of the laser power was being scattered on the edge of the mirror holder.

The only way to raise the mirror is to put in a spacer below the mounting bracket. I had to raise the mirror by 5mm so used a piece of 5mm acrylic:

If the spot is too low it will be necessary to raise the laser tube and the fixed mirror (because if you followed step 2 the laser is centred on the fixed mirror and you are about to move it) the required amount by packing it at the bottom and then restarting the whole alignment process from scratch.

If the mirror is offset to the side, it can be adjusted on the mounting slots. Remove the mirror mount to access the screws and move the mirror. I had to extend the slots to give enough adjustment.

Replace the mirror and put on a new piece of tape and fire the laser to give a spot to verify the mirror position. Once the spot is in the middle of the mirror, remove the tape and clean the mirror.



A well-adjusted fixed mirror and correctly positioned Y axis mirror will give a result as above. Once this has been achieved the Y axis mirror can be aligned.

## Aligning the Y Axis Mirror

To adjust the Y axis mirror, place tape over the aperture on the lens holder. Move the lens holder as close as possible to the Y axis mirror and fire the laser to produce a spot – this is spot A. Move the carriage as far as possible from the Y-axis mirror and fire the laser to produce a spot – this is spot B. If you cannot see the second spot because the Y axis mirror is too far out of adjustment, move the lens holder a smaller amount at first until the alignment is close enough that two spots can be produced when the lens holder is moved over its full travel or the spots are aligned. The relative position of the two spots shows how the Y axis mirror is to be adjusted:

| Position of Spot B relative to Spot A | Position Error | How to adjust it out |
|---|---|---|
| Left | Angle too acute | Turn B & C anticlockwise |
| Right | Angle too obtuse | Turn B & C clockwise |
| Above | Mirror angled up | Turn A & B clockwise |
| Below | Mirror angled down | Turn A & B anticlockwise |

If the alignment is out both horizontally and vertically, adjust the vertical axis before the horizontal axis. Once the alignment is complete tighten the locknuts.

Place a fresh piece of tape and position the carriage to the lower left position and fire the laser to produce a spot. Move the carriage to the lower right position and fire to produce a second spot. Repeat again at the upper left and upper right corners to produce a third and fourth spot. If the fixed mirror and Y axis mirror are correctly aligned all four spots should lie on top of each other. When setting up my unit, I could not get the alignment better than in the following photograph. The lower left, upper left and upper right spots all aligned well but the

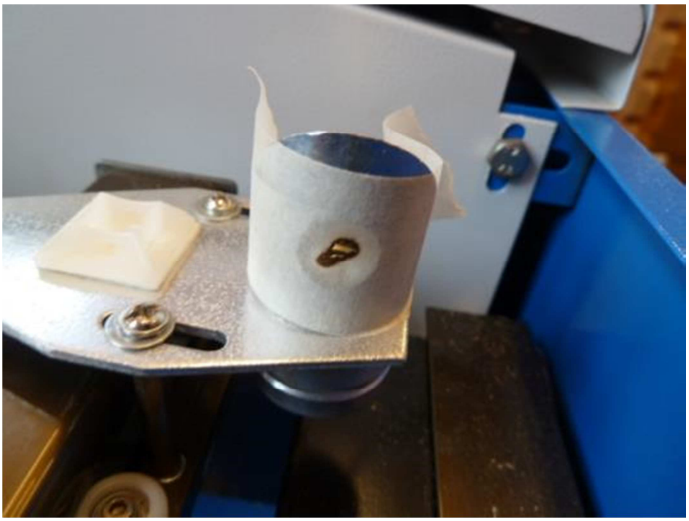
lower right spot was always slightly low and to the left, is suspect because of a mechanical misalignment in the carriage, possibly because of rough handling in transit.

## Aligning the Lens Holder

The last stage of the alignment process is to align the lens holder. The first stage is to ensure the laser spots are hitting the centre of the lens holder aperture. If the laser spot is below the centre of the aperture, it will be necessary to raise the level of the laser tube and repeat the whole of the alignment process from the start. If the spot is high remove the lens holder mounting plate and spacers and pack with washers to get the right position.

Replace the lens holder and fix on a new piece of tape and fire the laser to produce a fresh spot. If the spot is not aligned with the centre of the aperture, loosen the mounting plate screws and

slide the holder forwards or backwards until the spot is aligned with the centre of the aperture.



The last stage of the alignment process is to ensure the lens holder is straight. Remove the angled mirror from the top of the holder and place a piece of tape over the hole. Remove the tap from the front.

Fire the laser to produce a spot and ensure it is in the middle of the aperture. If not rotate the holder to centre the spot. Once this has been done, recheck the alignment at the front aperture and readjust if required. Remove and clean the lens and replace it; clean the mirror and replace it.

Completing the Alignment

If the alignment has been performed correctly everything should be aligned and locked and clean. Switch the cutter off, replace all connections and covers and re-enable the interlocks.