Laser Cutting system QuikLaze-II 40Hz Green/UV (532nm/355nm)

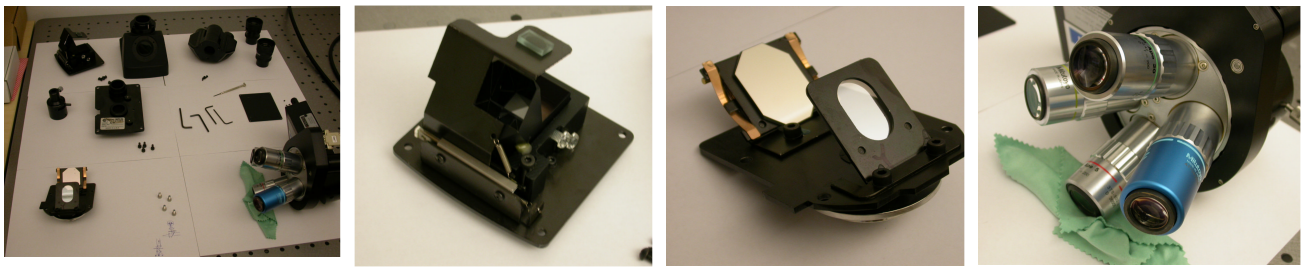
Manufacturer: New Wave Research Inc., USA
Date of production: May 1999
General information: http://www.new-wave.com/products/quiklaze.html

This system consisting of the laser head mounted on top of the Mitutoyo FS-60 microscope and laser control unit with remote control (picture 1) was received on loan for my hardware security research in April 2003. Unfortunately, as it always happens, this equipment was out of good working order and therefore could not be used straight away for my research. Firstly, the whole system was misaligned resulting in cuts too far away from the desired rectangular shape. Secondly, the laser head behaved strangely, sometimes placing the filter revolver in a slightly wrong position out of the laser beam and, moreover, sometimes changing all servo settings spontaneously to a random position. Also the optics inside the laser head and the microscope was a bit dusty.

Picture 1. The laser cutting system: a) laser head and microscope; b) control block and illuminators; c) remote controls

In addition I would like to get the system to cut with an infrared laser (1064nm wavelength) as well.

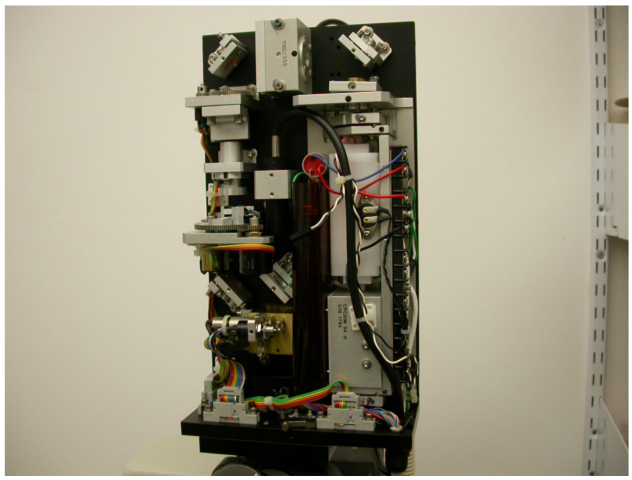
I started with sorting out the laser alignment, then repairing the laser control and finally upgrading it to the IR mode.


Picture 2. Taking the microscope apart: a) all the parts; b) shutter and prism; c) light mirrors; d) objectives on revolver

Clean up and alignment were not very difficult and reasonably straightforward. The microscope was partially disassembled, dust removed, mirrors and prisms adjusted to

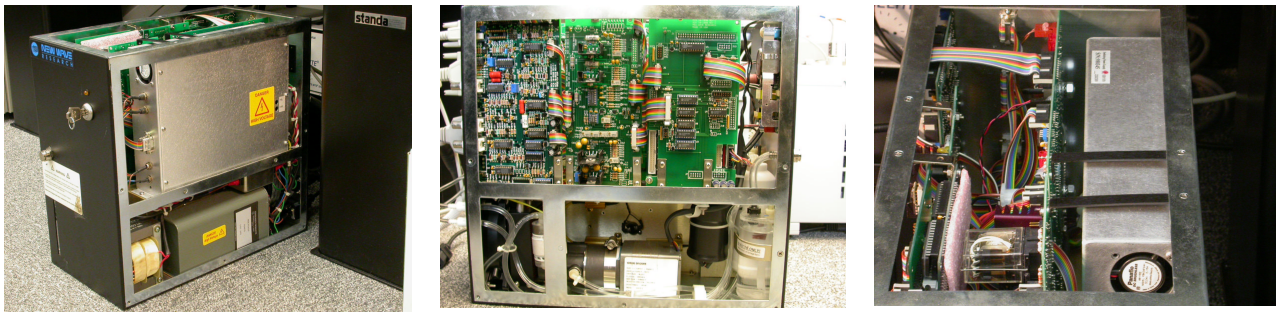
the proper position (picture 2). The same has been done to the objectives. The blue one has a fixed position and others can be adjusted, such that they point to the same location when turned.

Similar things have been done to the laser head (picture 3). Dust was removed from optics and by adjusting the mirrors inside it the laser beam was aimed at the correct position with even power distribution.



Picture 3. The laser head

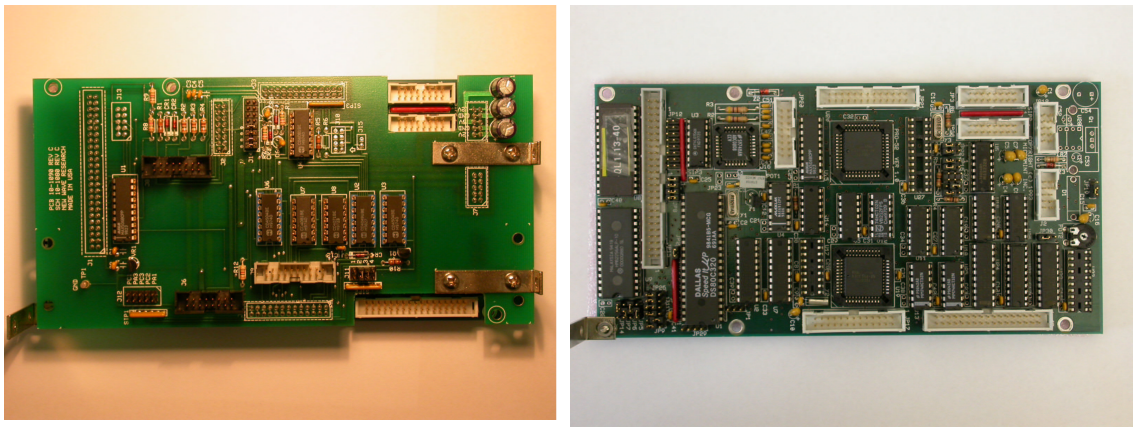
The next step was to sort out the laser control unit that sent incorrect signals to the laser head. I opened the control unit (picture 4) and found all the signals coming from the remote control and all the signals going to the servo motors inside the laser head. By observing the signals with an oscilloscope I located the problem related to the unpredictable changing of positions of all servo motors. Replacing the faulty component solved the problem.



Picture 4. The laser control unit: a) right side view; b) left side view; c) top view

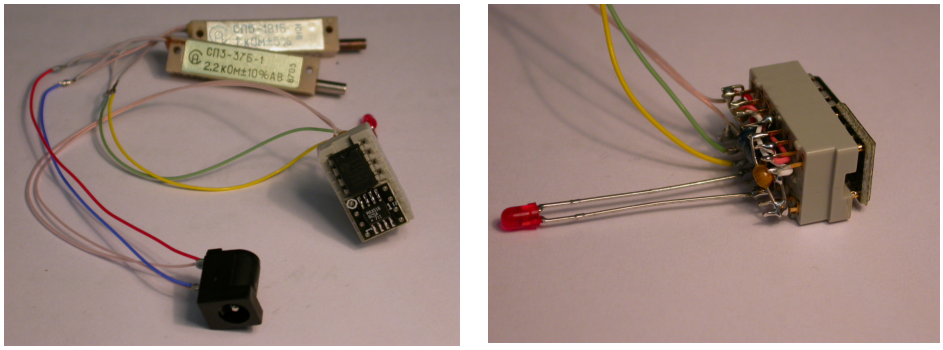
Unfortunately, the other problem (improper setting of the laser filters) still existed. By looking at the signals and waveforms related to the laser filter positioning I came to the conclusion that this was due to a bug in the firmware on the CPU board (picture 5) that controlled the operation of the whole system. Contacting the manufacturer directly was not of much help, as they refused to provide me with circuit diagrams and firmware source code. The option of sending them the whole cutting system for repair was not feasible because it would have taken a long time and cost a substantial amount of money. Therefore I have decided to sort this out myself.

One approach would be disassembling the firmware code, but it had over 30Kb size of 8052 code and without having the circuit diagram of the board, it would have taken a very long time. So I decided to go in a different way.



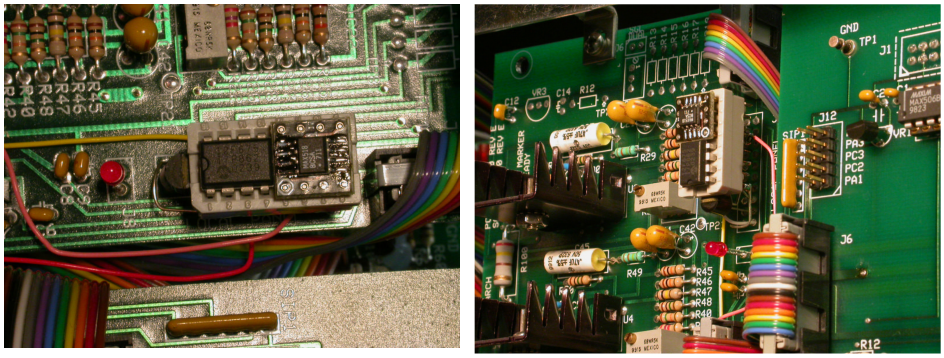
Picture 5. Dual PCB control board: a) top I/O board; b) bottom CPU board

I amended the wrongly implemented signal processing for the filter servo controller with a hardware patch (picture 6) involving a PIC16F675 and a MAX518. The microcontroller receives the analog signal, processes it correctly and forwards it via D/A converter. In addition, it always compares the output signal with the reference signal from the CPU board to ensure the correct operation and indicates any errors on the LED.



Picture 6. Debugging the hardware patch: a) front view; b) side view

The patch was soldered to the servo controller board (picture 7) and connected to the necessary internal points using wires. The 78L05 voltage regulator was used to convert the +12V present on the CPU board into the +5V to supply the patch.



Picture 7. Installed patch: a) top view; b) side view

Since then, the laser filters have always been in the correct positions.

The last step – upgrading the laser to infrared wavelength is in progress. I have to do this myself because the manufacturer refused to supply any sort of upgrade kit for the system and official upgrade requires sending the whole system to the manufacturer, which is too expensive.

What has been done so far is that the remote control unit was upgraded to support three wavelengths (picture 8). For this the third position of the laser switch was unlocked, a hole was drilled in the front panel and a red LED installed in it.

Picture 8. Upgrading the remote control: a) inside view; b) front view; c) close look

The laser control unit supports the infrared laser and my hardware patch worked perfectly for the third laser settings as well.

Recently I received the filters necessary for the infrared laser operation. They were so cheap that I received them for free from a European optical components supplier). All I had to do with them was to slightly reduce their diameter with a sand paper as they were half a millimetre too large.

Now I am waiting for NIR objectives for the microscope to try the infrared cutting.

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