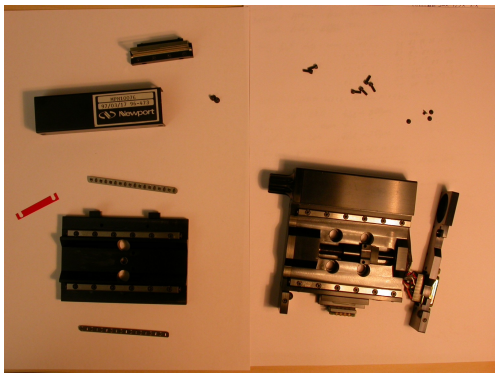
# Motorised Linear Stage PM500-1L.25
# (25mm, 40mm/sec, 0.025µm)

Manufacturer: Newport Corporation, USA
Date of production: March 1997
General information: ftp://download.newport.com/MotionControl/Archive/Motion%20Controllers/PM500/

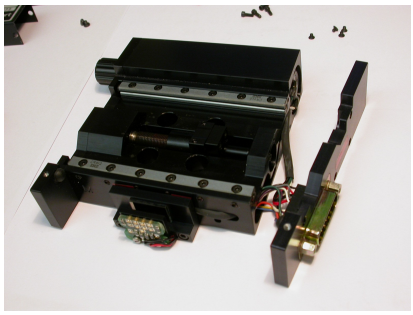
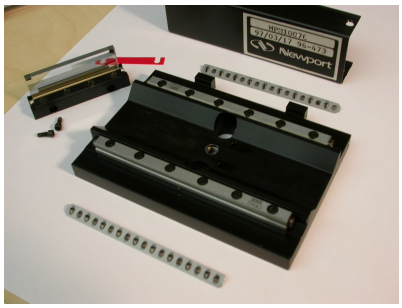
This motorised stage (picture 1a) was a part of the XYZ-stage assembly I received on loan for my hardware security research in April 2003. Unfortunately, as it always happens, this was second-hand stage out of good working condition. Firstly, the stage was producing buzzing noise when it was not moving. Secondly, the positioning of the stage was slightly non-linear. In addition I would like to have all the positioning signals coming directly from the stage for faster and easier synchronisation with my laser system.

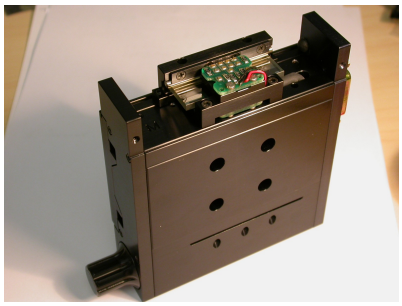


Picture 1. The motorised stage: a) side view; b) taking it apart

The noise was due to the gap between the moving parts. Because the positioning is constantly monitored by the controller through the feedback loop such a small movements are producing buzzing noise with the frequency depending from the size of the movement and the delay of the controller circuit. Non-linearity was caused by misalignment of the glass scale encoder inside the stage.

I started with disassembling the stage (picture 1b) and learning how all the parts work together.

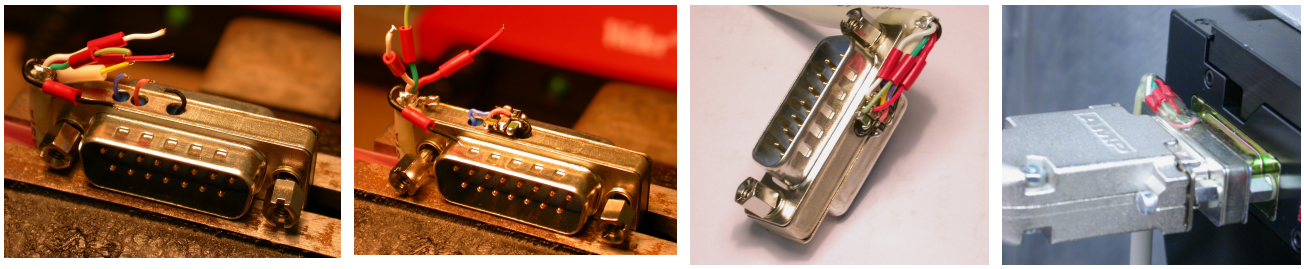




Picture 2. Taking the stage apart: a) base with controls; b) moving part with bearings; c) glass scale encoder

The gap between moving parts was reduced by unscrewing, repositioning and tightening the bearing rails (picture 2b). To align the glass scale encoder (picture 2c) I unscrewed and repositioned the glass scale holder unit until the signal from the encoder became linear along the whole moving range and had the same amplitude. That was observed with an oscilloscope. I put small plastic washers to slightly change the position of the glass encoder and to achieve better signal quality.

Unfortunately the stage had a permanent mechanical damage resulting in severe non-linearity every 2mm of movement. This is because the stage was probably dropped before it came to me. I noticed

small dents on the bearing rails every 4mm on each side, but it is impossible to fix that problem without replacing the rails. If the stage is stopped within 50-100µm from these dents it starts producing buzzing noise caused by the feedback loop that tries to keep the stage in the desired position.



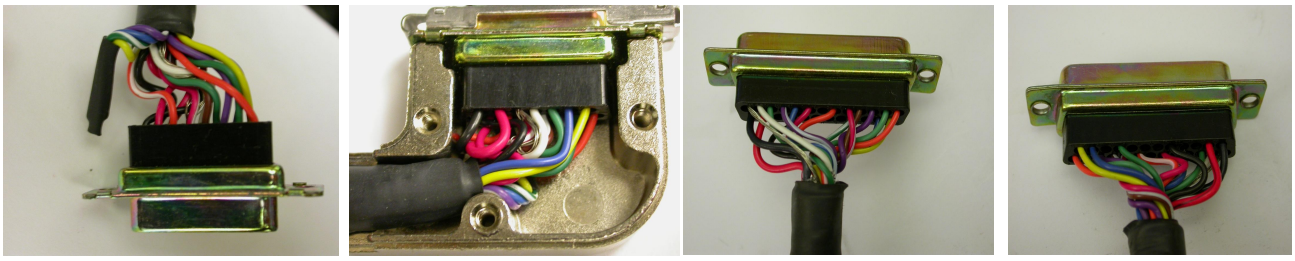
Picture 3. Building signal eavesdropping circuit: a) taking signals out; b) soldering OpAmp IC circuit; c) assembled module; d) connected module

To get the positioning signals out of the stage interface I built the buffer circuit (picture 3) based on MXL1013 Operational Amplifier mounted on the port saver connector. This was necessary because all the signals coming from the stage position encoder are not buffered. This module then goes between the controller cable and the stage connector (picture 3d).

Now I am waiting for another similar stage to have identical positioning capabilities for X and Y coordinates because at the moment I have PM500-4L.100 stage for another horizontal movement and it has maximum 0.1µm precision which is not enough for precise positioning.

The directory at the Newport FTP site (see the link at the top of this page) contains operation manual and calibration manual. However, there is no information on the custom cable that connects the controller with the stage apart from the pinout of DB25 connector. Below is the table which outlines the cable wiring. Pictures shows the wiring to DB25 and DB15 connectors in the cable.

| DB25 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 11 | 12 | 13 | 14 | 15 | 21 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 11 | 12 | 13 | 9 | 10 | 8 | 14 | 15 |



Picture 4. Pictures of the cable connectors: a) DB15 (1-8); b) DB15 (9-15); c) DB25 (1-13); d) DB25 (14-25)

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