On positioning a platform with IPMC muscles

System setup

PC running National Instruments **LabView 8.2**
National Instruments Analog Voltage Output card : **PCI 6034**
Current Amplifier **LN 675**
Koutech Systems FireWire 1394b card : **PEFU330**
Point Grey Research camera : **Dragonfly EXPRESS**
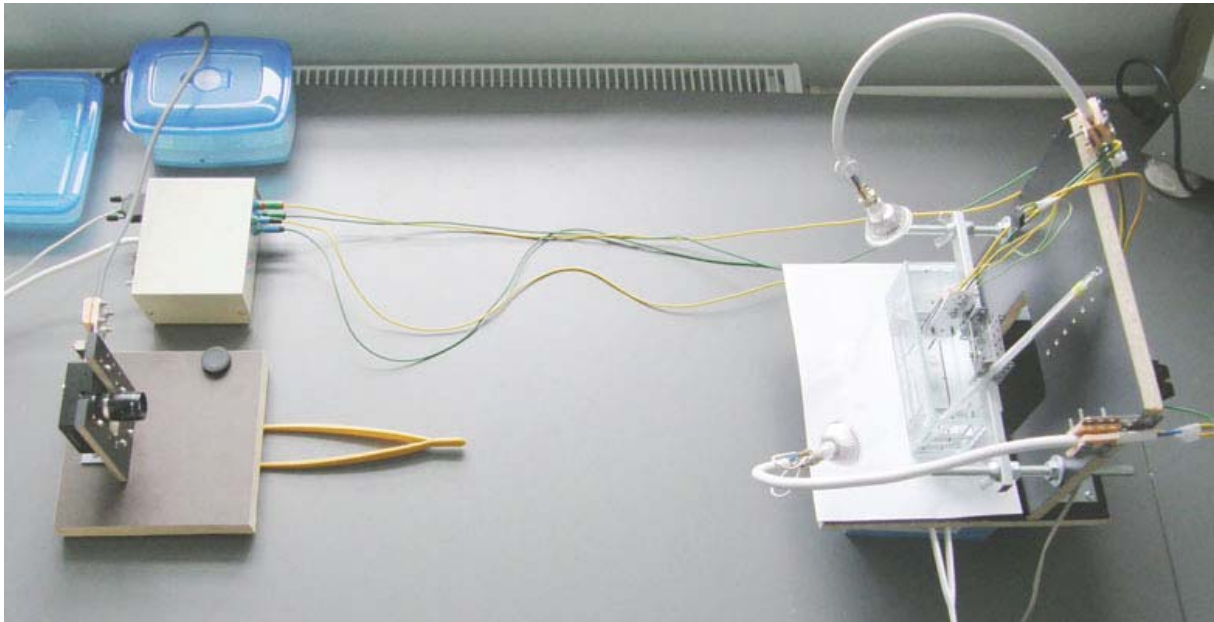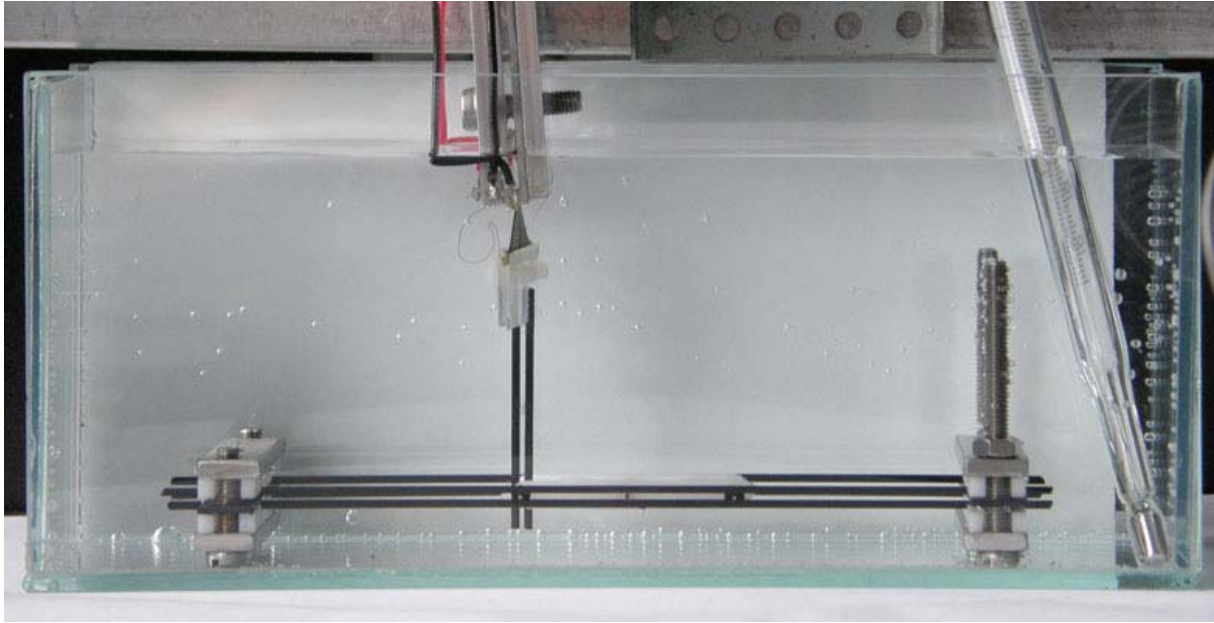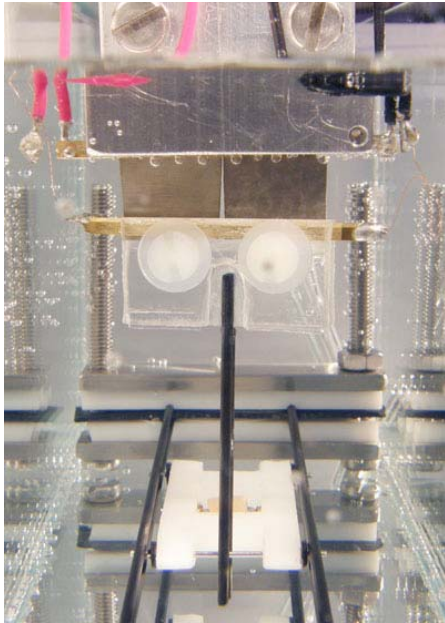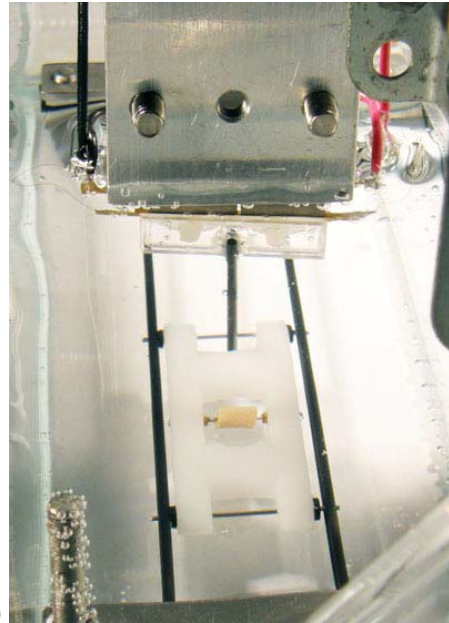It enabled us to capture **300** frames per second at **320x160** resolution and in **8 bit grayscale** mode.

Figure 1. A view of the system setup. The camera and current amplifier are on the left and stage for the IPMC sheet and platform is on the right.

Figure 2. A close-up of the IPMC sheet and platform from front (a) left (b) and right (c)

Dimensions of the free IPMC piece : 7*20mm
Length of the elongation : 40mm
Mass of the platform : 1.95g
Temperature in the pool : 33°C.

Experiment details

During one episode a sinusoidal voltage was applied to IPMC for 60 s.
For each episode a frequency and amplitude was picked randomly.
Frequencies ranged from 0.1Hz to 10Hz.
Amplitudes 0.50V and 1.00V where tried.
There was 1000 of such consecutive episodes. The experiment takes 20 hours to complete.
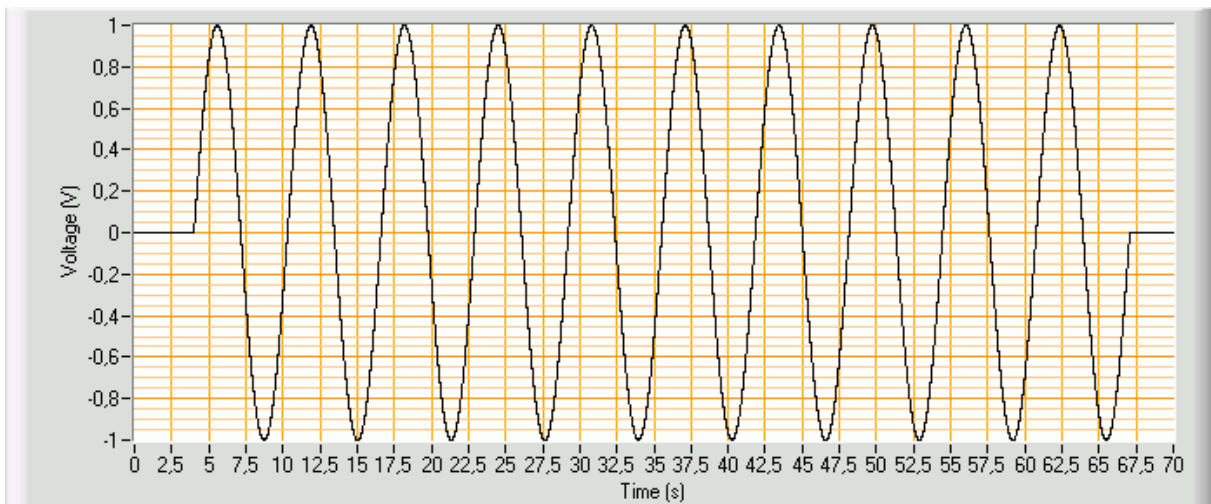

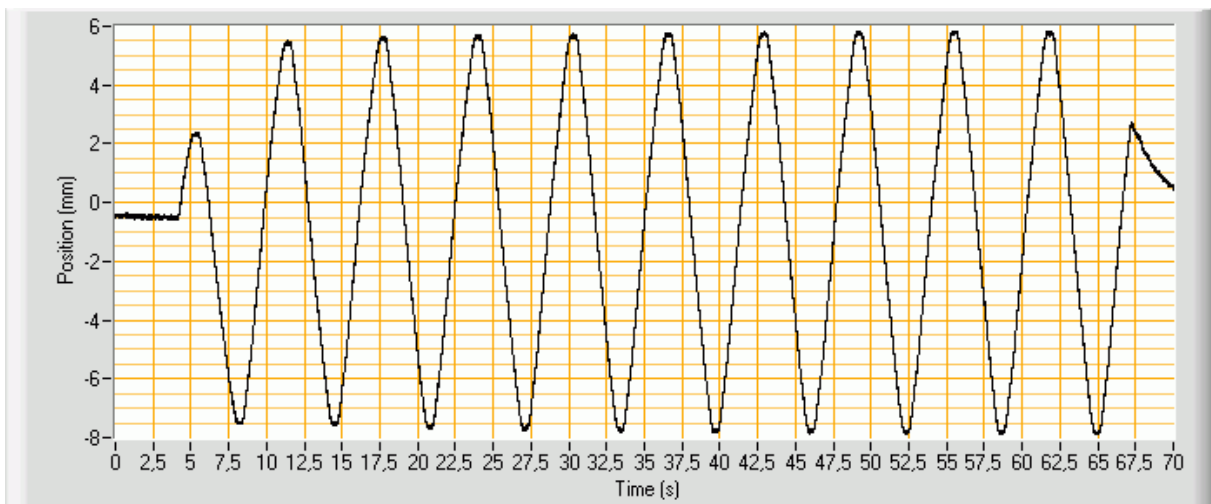Figure 3. A sample input signal (frequency 0.158562Hz).

Figure 4. Corresponding output signal.

Please note that on fig. 4 the position of the platform does not a pure harmonic oscillation. It may be an indication of nonlinear behavior of IPMC.

Results

Frequency response of the system was measured. However as a complex material the readings depended on both time and voltage (amplitude). Readings where were taken in case of 4 different conditions: in case of voltages 0.5V or 1V and for the first 10 hours and for the second half of the experiment.
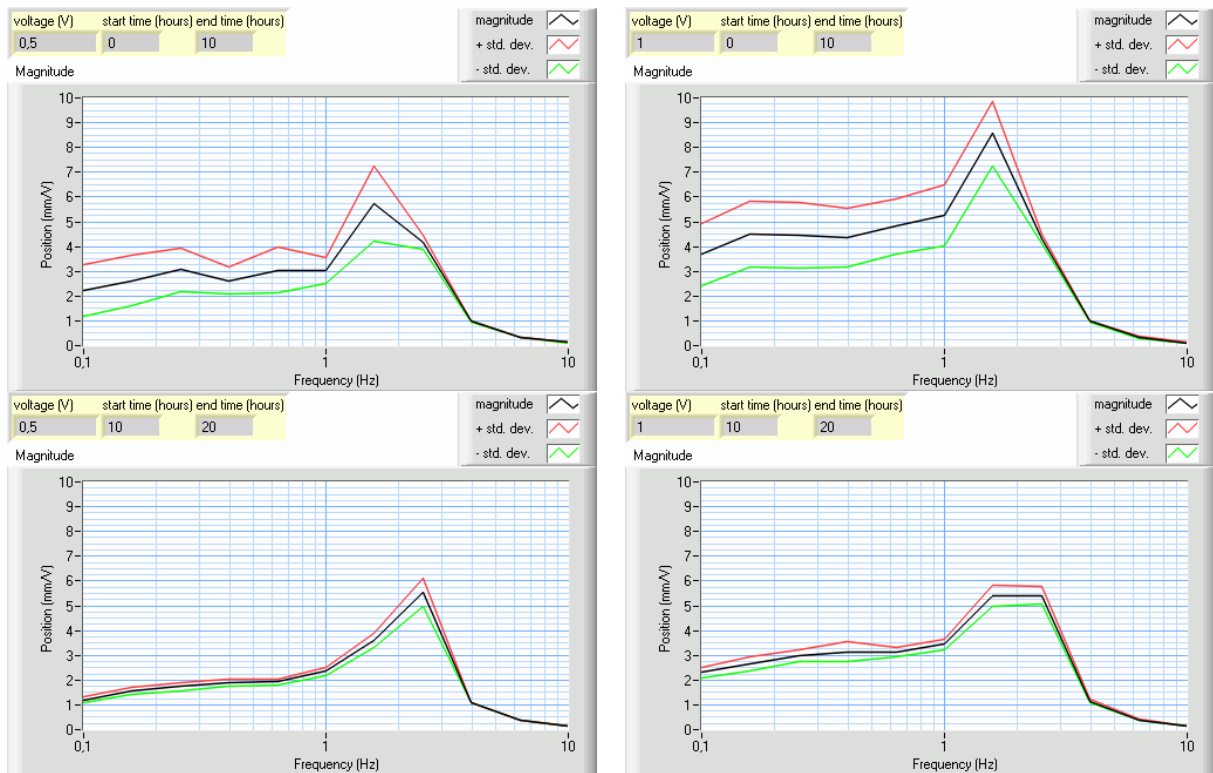
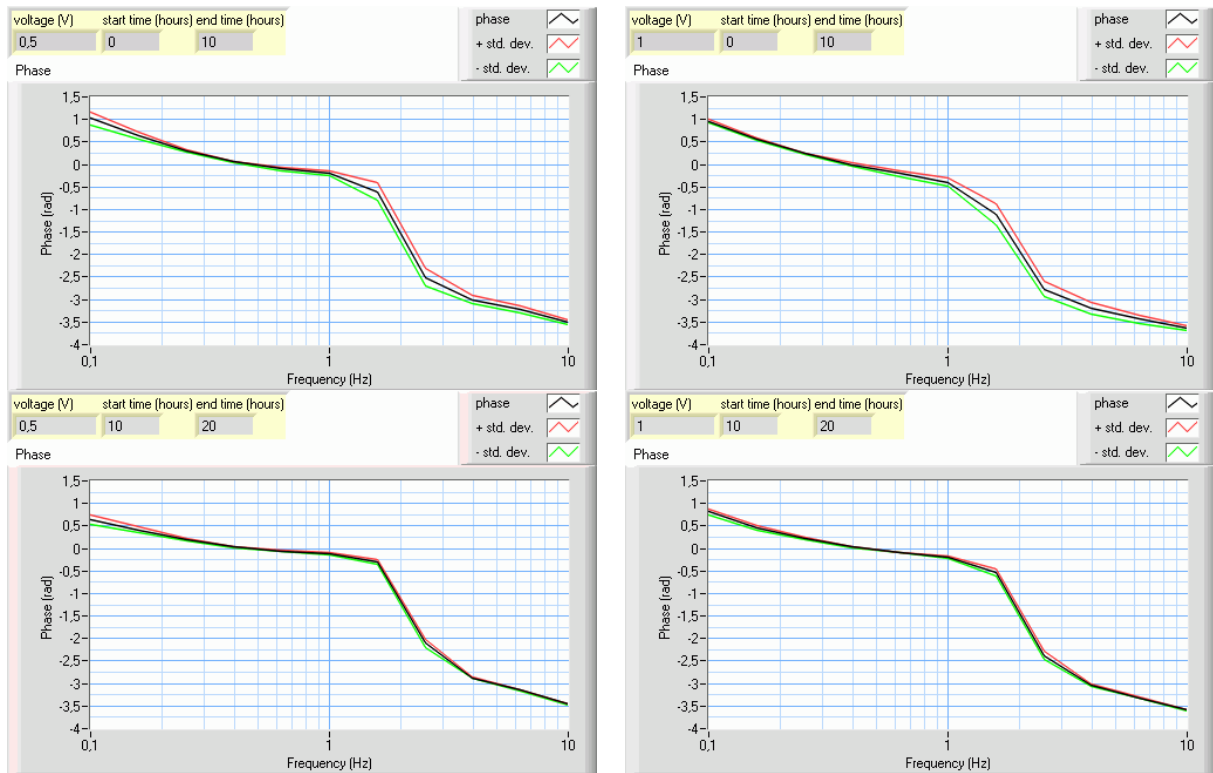The conditions are defined on top of each graph.

Figure 5. Magnitude

Figure 6. Phase

Conclusion

IPMC is a nonlinear time variant system.
   a) If you apply sinusoidal input you do not get sinusoidal output. (see fig. 3 and 4),
   b) Frequency responses (namely magnitude part and more precisely low frequency region) differ in case of different voltages (please compare left and right graphs on figure 5).
   c) After 10 hour of work it behaves differently (more stable) than before (please compare top and bottom graphs on figure 5).

Time invariance can be defeated by letting the IPMC to worm up for some (long) time.
The fact that output is not always proportional with input is a much more serious problem.

The phase spectrum does not seem to depend on neither time nor voltage.

I think there is pole/eigenfrequency of the system near 2Hz. This conclusion is also in concordance with other experiments not discussed here.