<Synchrochord>

The first bowed instrument robot we designed was <Hurdy>, an automated hurdy gurdy, built between 2004 and 2007. The building of that robot had many problems and our attempts to solve these have lead to many new ideas and experiments regarding acoustic sound production from bowed strings. Between 2008 and 2010 we worked very hard on our <Aeio> robot, where we used only two phase electromagnetic excitation of the twelve strings. Although <Aeio> works pretty well, it can not serve as a realistic replacement of the cello as we first envisaged it. The pretty slow build-up of sound was the main problem. The cause being the problematic coupling of the magnetic field to the string material. Thus we went on experimenting with bowing mechanisms until we discovered that it is possible to excite the string mechanically synchronous with the frequency to which it is tuned. For such an approach to work well, we need a very precize synchronous motor with a very high speed. Change of speed ought to be very fast, thus necessitating a low inertia motor as well as a fast braking mechanism. Needless to say, but the motor should also run as quietly as possible. To relax the high speed requirement a bit, we designed a wheel mounted on the motor axis with ten plectrums around the circumference. Thus for every single rotation of the spindle, the string will be plucked ten times. Follows that in order to excite a string tuned to 880Hz, we need a rotational frequency of 88Hz. Or, stated in rotations per minute: 5280 rpm. The motor type ought to be a synchronous reluctance motor, since this type has no slip and can be frequency controlled with high precision. Fortunately we could dig up a suitable precision motor made by Eastern Air Devices. It's a spare part, custom made for an American military airplane.
Since the tuning of the string is very critical, we did strive at making the robot autotuning. Such a mechanism entails yet another motor specification problem. The tension on the string obtainable from the motor ought to be at least 600N. Such force values indicate the use of some kind of gears as well as a motor with slow speed and very high starting torque. This brought another type of motor we had on our shelves into sight: a General Electric synchronous inductor motor. Its torque is specified as 150 Oz.In., the anachronistic imperial equivalent of 1.059 Nm in standard SI units. This motor is used to drive, via an intermediate 1:10 dented wheel construction, a worm gear without backlash, the large wheel being connected to the 12 mm take up spindle for the string. The reduction ratio of the worm gear is 1:4. The maximum force we have available to excert on the string now is 6.6 kN. We estimate that the sum of losses suppers up more than half of this force. Designing an autotune mechanism means that we also need to provide a sensor to measure the string pitch accurately. For strings made of ferromagnetic material, an inductive sensor can be used, but if we want to use other types of strings, either optical sensing or a contact microphone is needed. During the tuning procedure, the string has to be excited. Either the motor-exciter has to run at its lowest possible speed, just plucking the string at its free resonant frequency, or we can use the build-in feedback mechanism if ferromagnetic strings are used. As an electromagnetic string exciter, we used a synchronous shorted cage motor from which we removed the rotor completely. The string comes to run through the circular hole left open now. An extra bonus of this autotune approach is that it now becomes possible to apply vibrato on the string sound during normal operation. However, this makes it essential that the processor steering the string exciter and the processor called in for the autotuning mechanism talk to each other..

Musically <Synchrochord> sounds quite a bit like a mediaeval Tromba Marina. A bit harsh in sound at times. The historical trumpet marine however, did not have any frets and its sounds were restricted to the high overtone series of the single gut string. On our instrument, not that many overtones can be produced due the the fixed position of the exciter with respect to the sounding string length. The fingered vibrato on this instrument came out to be very usefull. On large interval jumps its behaviour is a bit sluggish due to motor inertia and thus the instrument is best suited for relatively slow moving string bass parts.