ZEPTO Quadrupole

Mechanical drive requirements

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STFC – Tuneable permanent magnet quadrupole project
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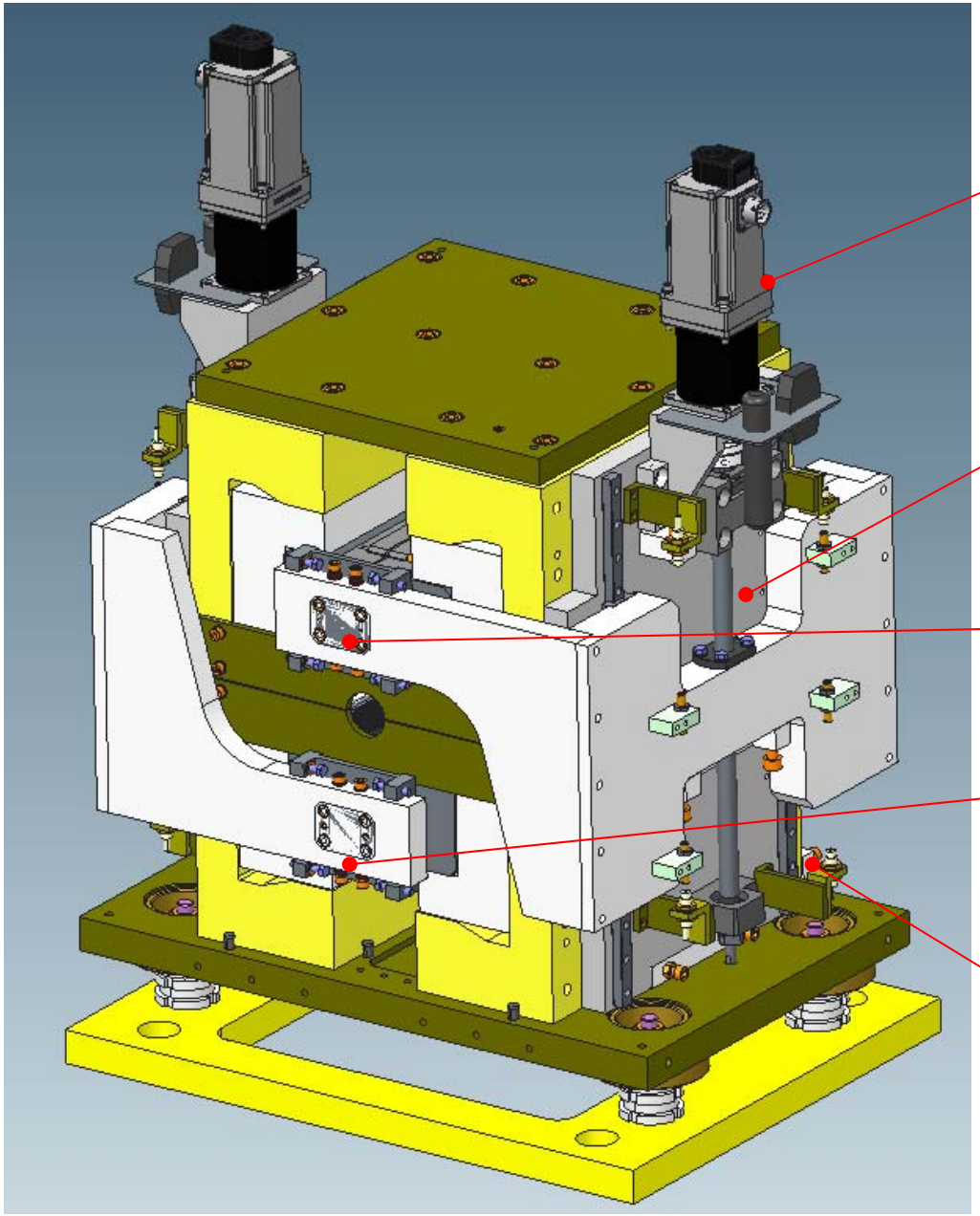
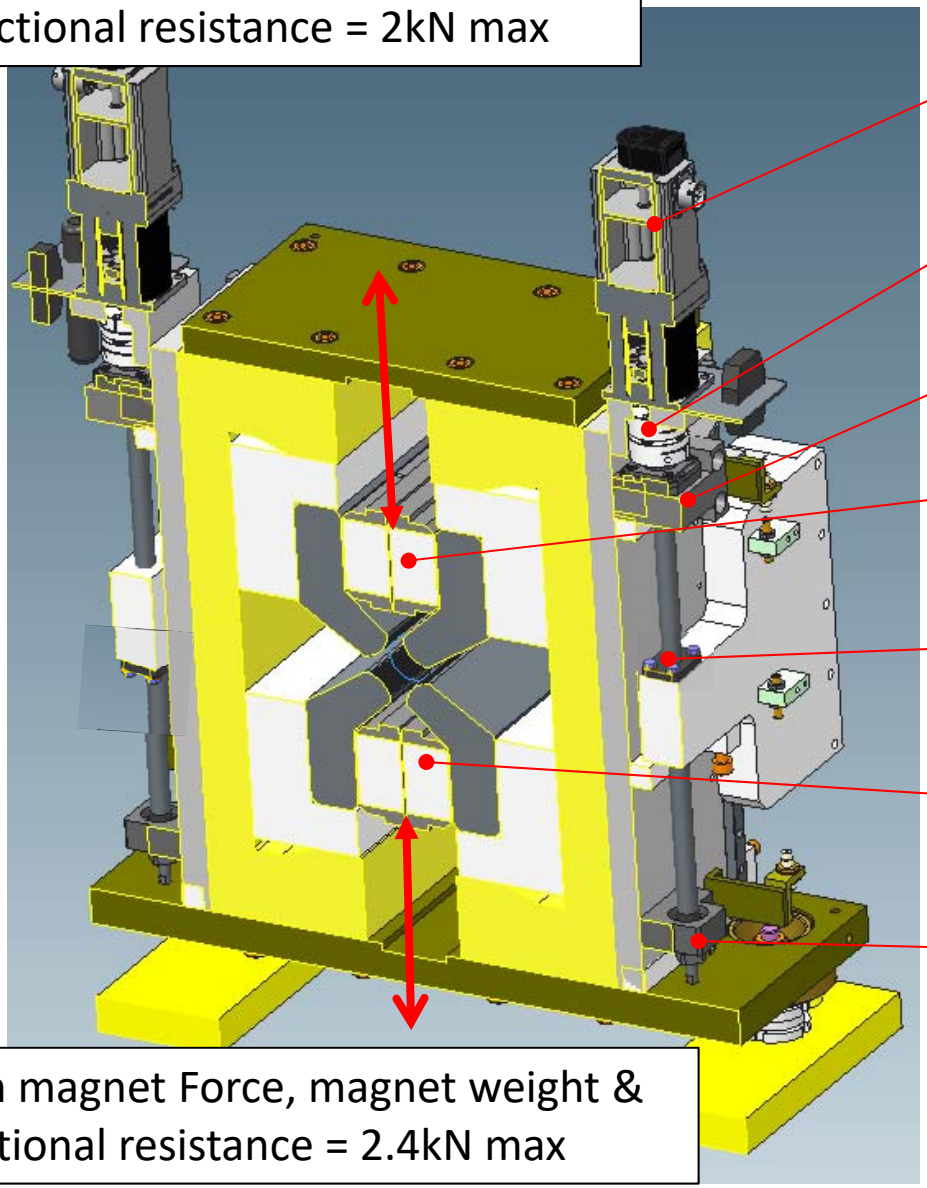
Application

- The quadrupole contains two independently driven permanent magnet assemblies
- Each permanent magnet is precisely raised and lowered via a preloaded precision ground ball screw driven through a geared stepper drive
- Linear rails provide the guidance for the movement of the magnets and bear the horizontal forces
- The ball screw bears the vertically magnet forces and any frictional forces from the guidance rails
- The gearing in the drive system is high enough to prevent any back drive in the event of a power loss. A brake is not required. During start-up, the output torque from the gearbox is 13.6Nm.
- A rotary encoder to monitor the motor movements is installed on the back of the motor
- Each motor will be driven in open loop control
- Operating conditions:
  1. Normal operation. Magnets move in a synchronised movement , towards each other, or away from each other.
  2. Tuning operation. Magnets are moved separately to optimise the magnetic field quality. this expected over a short distance ~ 1 mm maximum.
- Motors will rotate in opposite directions to bring magnets together or spaced apart
- Current drawn by motors to be restricted to 2A to prevent mechanical damage
- The drive positioning accuracy required is to be better than 10 microns
- The duty cycle is low; the magnets are moved very occasionally, no more than once a day
- The travel range is a minimum 90mm and linear speed is ~ 1mm/sec
- The axial load varies with the position of the magnets. When the magnets are inserted, the direction of the load acts towards the centre. The load direction switches at about the 1/3 travel distance, see page 5


Geared stepper motor drive
Ballscrew
Top magnet
Bottom magnet
Guide rail(s) for magnet(s)

Top magnet force, magnet weight & rail frictional resistance = 2kN max



Geared stepper motor drive

Coupling

Bearing support for ballscrew

Top magnet

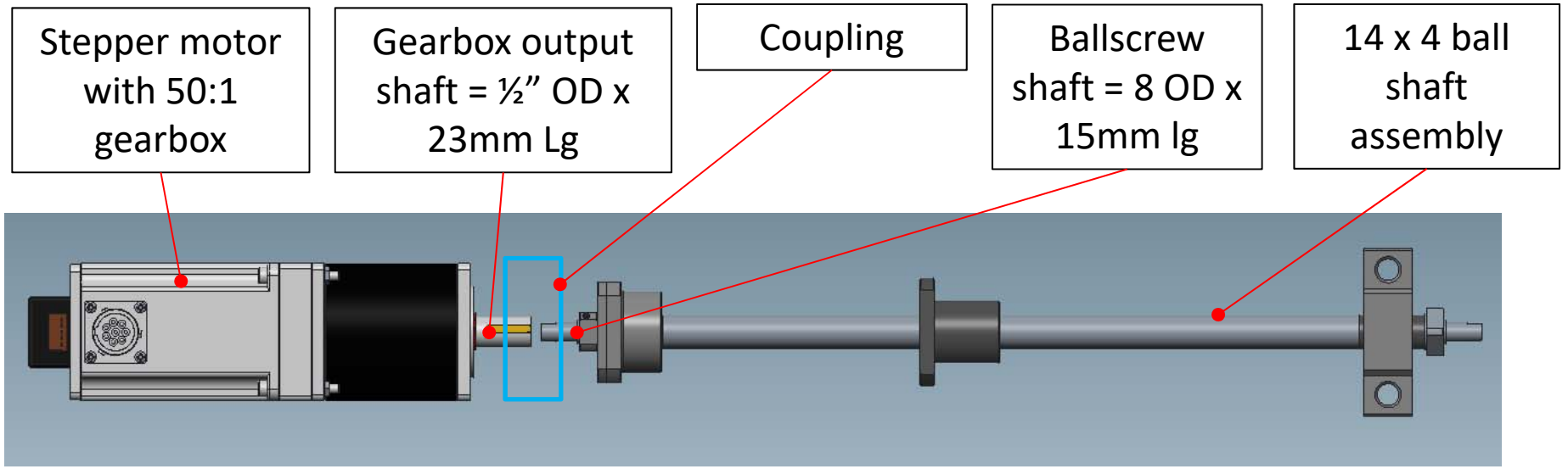
RH thread ball screw and flanged nut assy

Bottom magnet

Bearing support for ballscrew

Travel of each magnet = 90mm

Bottom magnet Force, magnet weight & rail frictional resistance = 2.4kN max



Magnet forces

Displacement	Total vertical force per carriage / N
0	39.988
10	-375.56
20	-909.8
30	-1015.2
40	499.72
50	703.44
60	1930.08
70	1851.04
80	1022.68
90	2.36

These are overestimated, likely by ~5% due to changes in the model to allow simpler and more reliable calculation