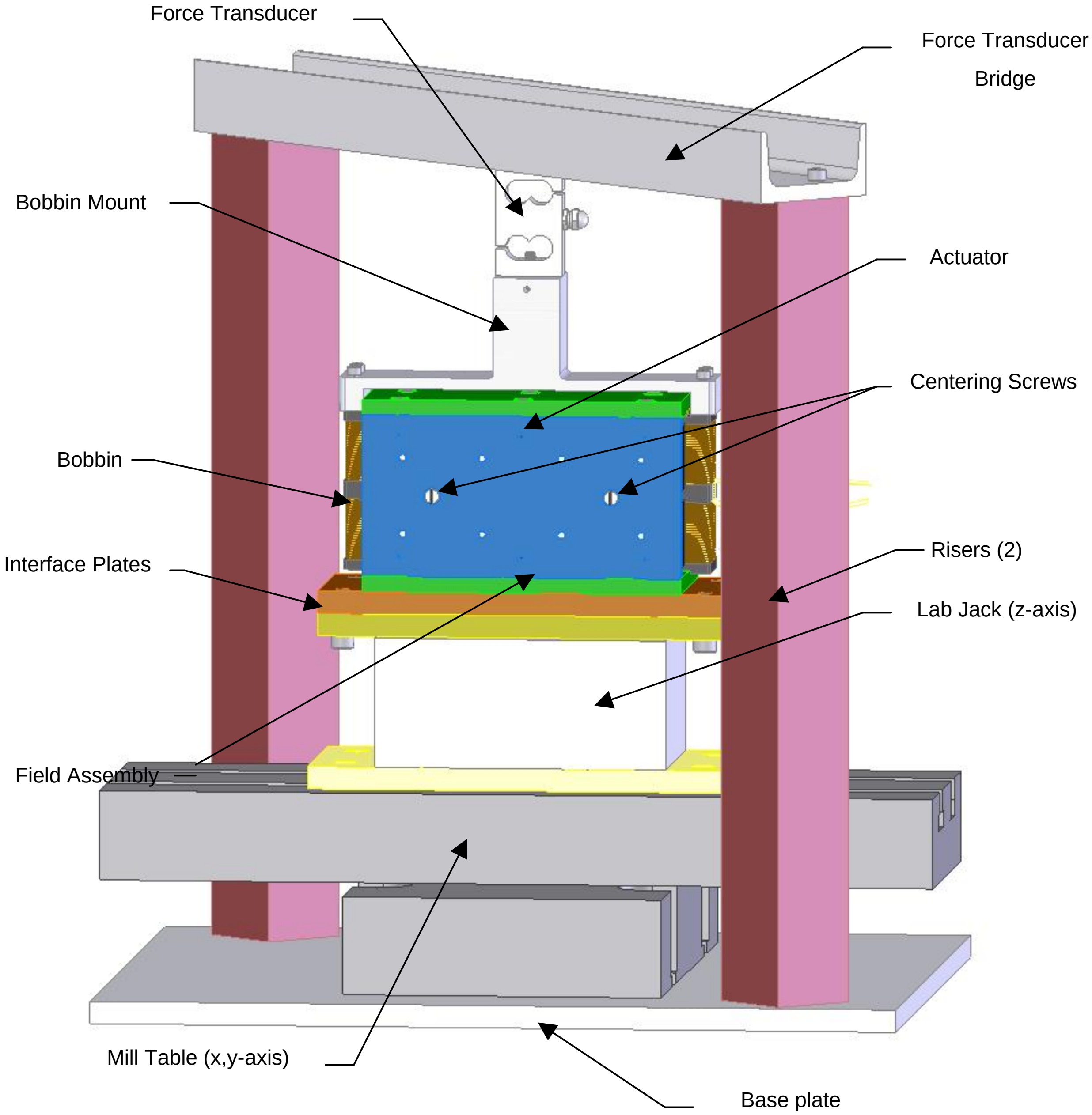
Actuator Test Stand

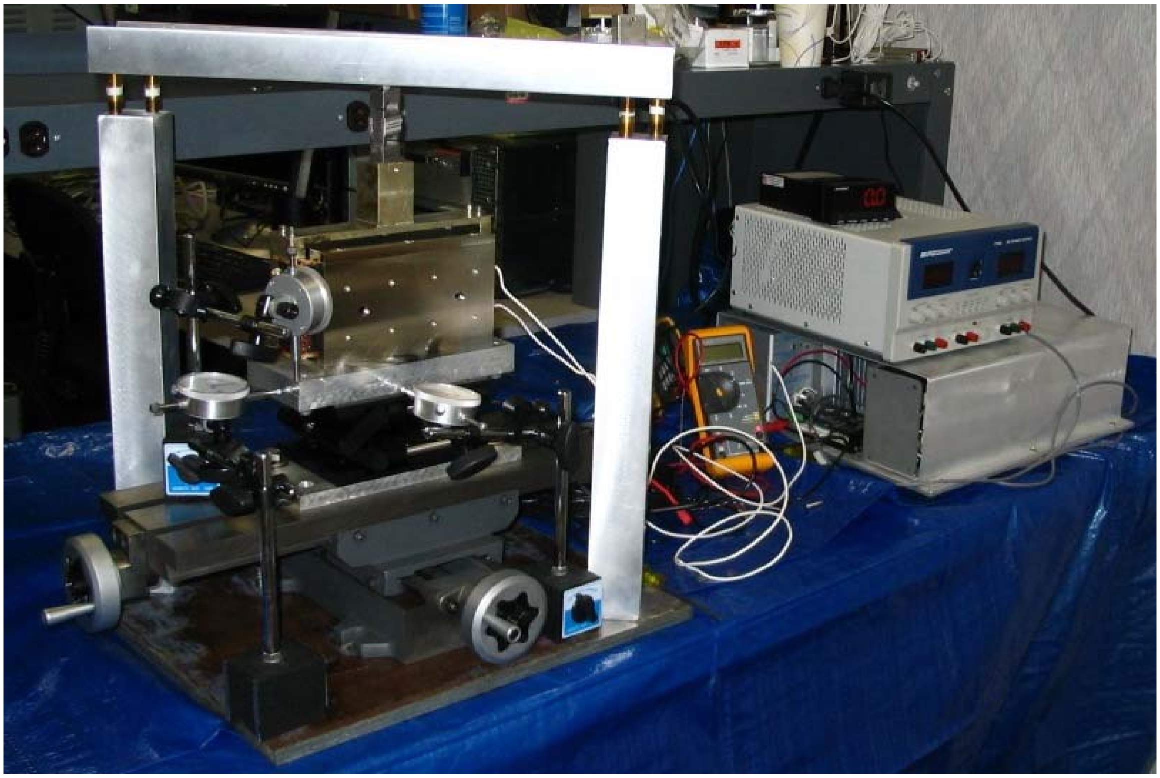
The figure below is a CAD model of the LIGO actuator test stand.



Aluminum channel (Force Transducer Bridge) is mounted on top of two square tube Risers which are in turn anchored to a base plate. The bobbin is attached to a force transducer through a bobbin mount and subsequently to the Aluminum channel. This arrangement fixes the bobbin at a known position (nominally 0,0,0). The mill table-lab jack combination positions the field assembly in the x, y and z axes respectively.

Centering screws are used to verify the position of the bobbin in the field assembly prior to testing. The screws are removed once the 0,0,0 position is set.

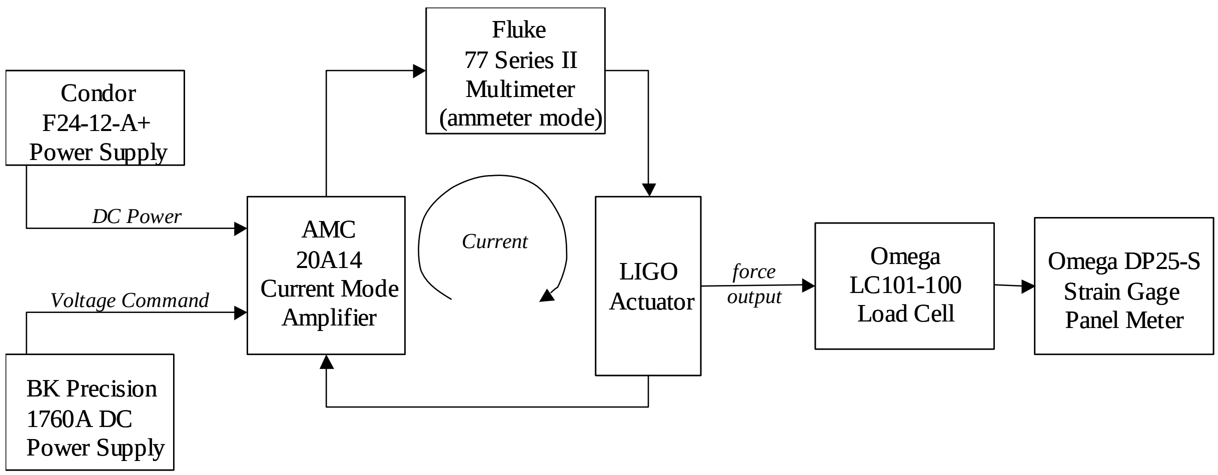
The following figure shows a large actuator mounted in the test stand. Also shown in the picture are dial indicators for measuring travel in the x, y, and z axes, a DVM, DC power supply, force transducer LED and the amplifier for driving the actuators.



Testing the Actuator

The figure below shows a block diagram representation of the testing procedure. Each actuator is tested using an AMC 20A14 amplifier operating in current mode, which is capable of supplying a continuous current of ±10A with a voltage source between 40 to 140 VDC. To provide the power source to the amplifier, two Condor F24-12-A+ DC power supplies are connected in series, each capable of generating 28 VDC at 10A. The current output in the test circuit is proportional to the voltage input to the amplifier and is calibrated to 0.48 A/V. To control the current output of the amplifier, a BK Precision 1760A DC power supply is used as the voltage input. Current is monitored using a Fluke 77 Series II multimeter. The multimeter functions as an ammeter and is connected in series between the amplifier and the actuator, capable of current measurement up to 10A. The accuracy of the current measurement is 0.1 A.

The force output of the actuator is measured using an Omega LC101-100 load cell, capable of measuring up to 100 lbs in tension or compression. The load cell measurement is displayed using an Omega DP25-S strain gage meter, calibrated to an accuracy of 0.1 lbs.



The process for the test procedure is as follows. Before testing, the resistance of the coil is measured to verify proper conductivity. The ambient air temperature is also recorded. With the actuator centered in its housing, the current supplied to the actuator is increased until the maximum specified force output is measured by the load cell.

The load cell is mounted above the actuator, as previously shown. A force that is exerted upward by the actuator will load the transducer in compression. This direction is defined as the positive load. To distinguish the two leads of the actuator, one lead is connected to the ammeter and the other to the low side of the amplifier current output. The high side of the amplifier current output connects directly to the ammeter. With a positive voltage applied to the amplifier, if the resulting force causes a compressive load on the transducer, the actuator lead connected to the ammeter is labeled positive. Otherwise the lead connected to the low side of the amplifier is labeled positive.

Actuator stroke is verified by moving the field assembly in the x, y, and z directions. The z-axis corresponds to vertical movement of the field assembly, whereas the x-axis corresponds to longitudinal movement and the y-axis is associated with transverse movement of the field assembly. The mill table provides x- and y-axis travel, and a lab jack moves the unit in the z-direction. Dial indicators are used to measure the traversed distance along each axis, which allows the test operator to work through any backlash by monitoring the reading of each indicator. The dial indicators are accurate to 0.001 inches.

Eight positions are tested in addition to the centered position. These positions are located at ±0.040 inches in the x-, y-, and z-axes, which corresponds to the 8 corners of an imaginary cube encompassing the stroke limits of each actuator. Once these 8 positions are measured, the polarity of the voltage command to the amplifier is reversed, which will reverse the direction of the force exerted by the actuator. The process of measuring the force output at each of the 8 extremes is repeated for this new polarity configuration and recorded.

Throughout testing, current and force output are monitored closely. While traversing the field assembly between tests, the load cell output is monitored. Any changes to the load cell output can only be attributable to mechanical interference between the housing and field assembly. During testing, current is visually monitored to ensure it increases linearly with the load cell output. If mechanical interference occurs, current will increase sharply with little change in force output. Constant visual verification is used to prevent damage to the field assembly during testing.

The resistance and ambient temperature measurements, along with the current measurements are recorded in a test sheet for each actuator. The test sheet is dated and initialized by the technician. The actuator's force constant (force/current) is computed and recorded in the test sheet. In addition, each actuator's predicted max steady state power and temperature (P_{max} and T_{max}) at the continuous force, based on an assumed thermal resistance, are also computed and recorded in the test sheet. The equations used to compute these are as follows:

$$T_{\max} = \frac{234.5\,\phi_{total}\;i^2\;R_{amb}}{234.5 + T_{amb} - \phi_{total} * i^2 * R_{amb}}$$

$$P_{\max} = i^2 * \frac{(234.5 + T_{\max})}{(234.5 + T_{amb})}\,R_{amb}$$

Where

- ϕ_{total} is the total thermal resistance from the coil bobbin mounting interface to ambient. This is 1.8 W/C for the large actuator and 4.1 W/C for the small actuator.
- i is the current needed to achieve the continuous force output in amps
- T_{amb} is the ambient temperature in Celsius
- R_{amb} is the coil resistance at the ambient temperature in ohms