LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

-LIGO-

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HEPI Electronics Requirements		
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1 System Overview

The Hydraulic External Pre-isolator (HEPI) system and associated hydraulic pump control system are used in the seismic noise remediation effort at the LIGO observatories. The HEPI system responds to a blend of position and velocity sensor inputs and produces the needed output signals to attenuate seismic ground noise induced motion of the LIGO optics. The hydraulic pump control system maintains a constant differential pressure across the HEPI hydraulic control valves by sensing differential pressure and supplying a control signal to the hydraulic pump motor controller. This document differentiates slightly between the HEPI system and the hydraulic pump control system, but in reality, the pump control system is an integral part of HEPI.

In all cases the electronics design shall be in conformance with the revised LIGO RFI mitigation practices.

1.1 HEPI System Diagram

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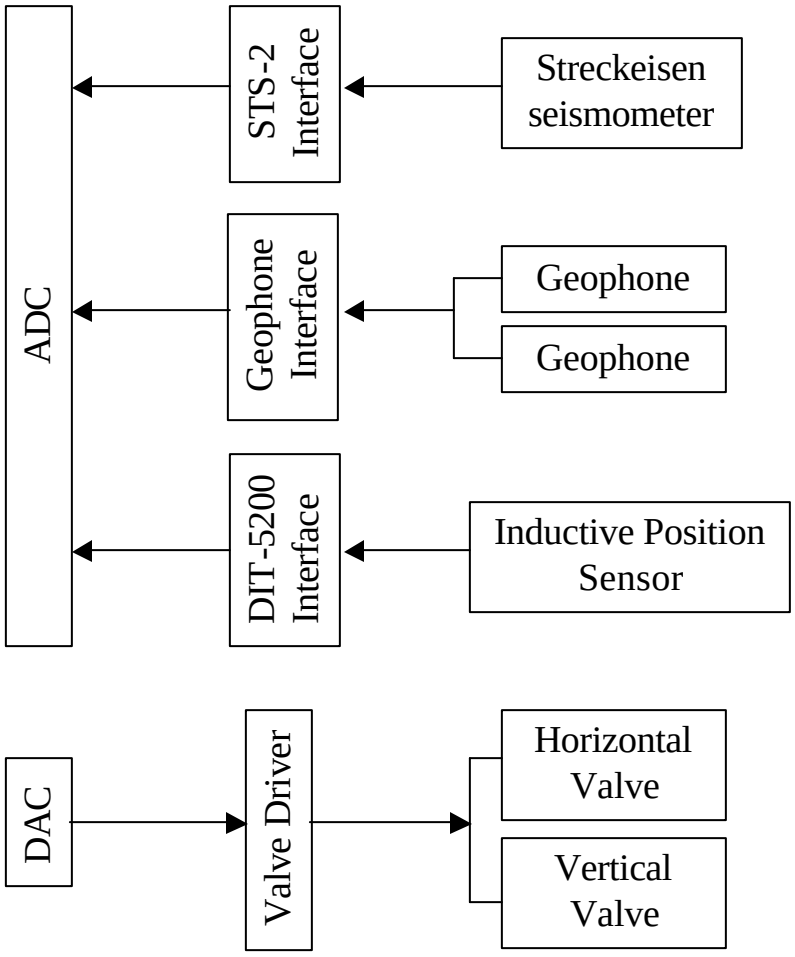

Figure 1: HEPI Sensor and Actuators

1.2 Hydraulic Pump Control Servo

For reference, the major components to the pump servo are shown in fig. 2

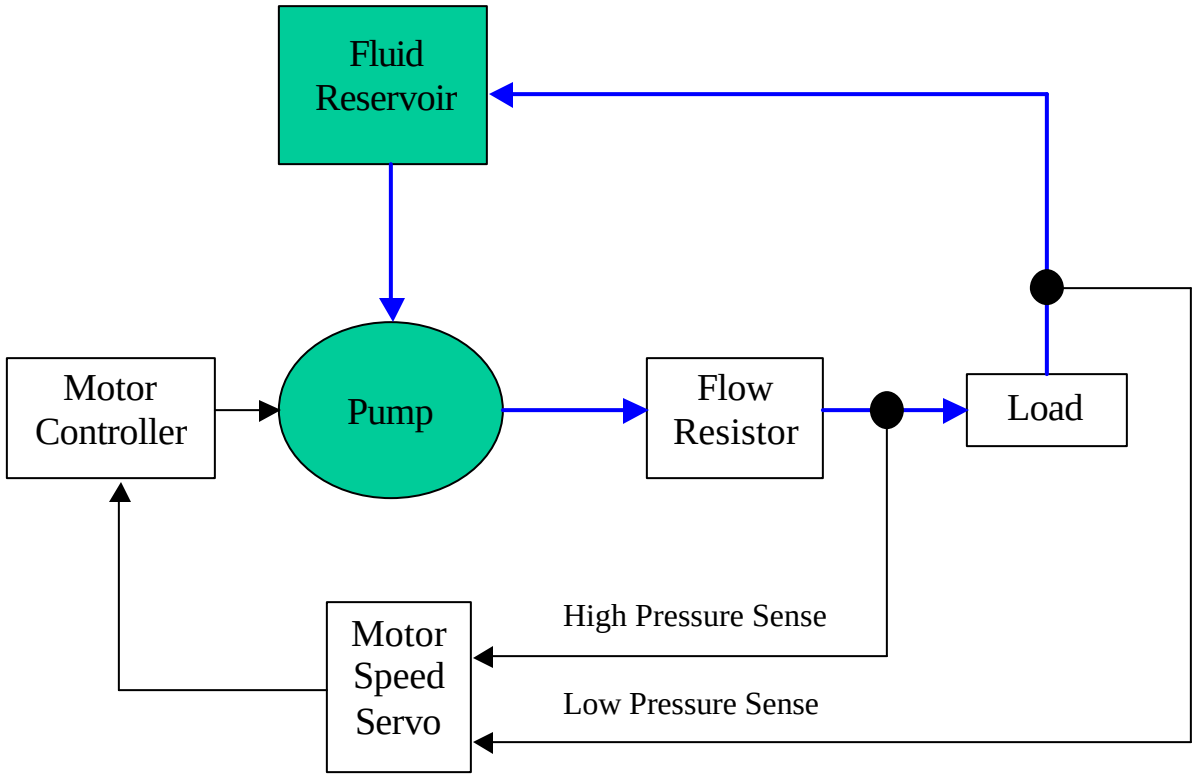

Figure 2 Pump Servo Overview

2 Sensor Interface Electronic Requirements

The sensors for the HEPI system have already been chosen. A summary of the interface electronics requirements is given in the following sections

2.1 Displacement Sensor

The displacement sensors used are Kaman Instrumentation DIT-5200 dual channel transducers with 20N sensor heads. The sensor electronics are contained in a small enclosure located within 5 feet of the sensor heads. Table 1 shows the physical characteristics of the interface

Table 1

Output voltage	+/- 10 V
Range	+/- 1.27 mm
Signal Bandwidth	20 kHz
Noise Floor	4uV/vHz
Output Connector	ITT Cannon MDM-9SL2P
Connector Pin 1	+15 V @ 40 mA
Connector Pin 2	-15 V @ 40 mA
Connector Pin 3	Power Supply Common
Connector Pin 4	+X Out

Connector Pin 5	-X Out
Connector Pin 6	+Y Out
Connector Pin 7	-Y Out
Connector Pin 8	Not Used
Connector Pin 9	Not Used

2.1.1 Position Sensor interface electronics requirements:

1. Provide a compatible differential interface - conforming to LIGO RFI directives - for 4 dual channel position sensor modules
2. Provide **750 Hz** anti-aliasing filters consisting of a **0.1dB ripple 4 pole Chebyshev response**
3. Provide signal whitening consisting of a **zero at 0.1 Hz** and a **pole at 1 Hz**
4. The electronics input referred noise must be less than **400nV/vHz**
5. At this time, the system gains are known well enough not to require the added complexity of jumper selectable gain settings
6. Provide proper physical and electrical interfacing to ADC inputs
7. Provide DAQ interface for all outputs

2.2 Geophones

The geophones are a model L4C (vendor unknown, Mark Products?). There are 2 geophones per pier.

2.2.1 Geophone interface electronics requirements:

1. Receive the coil outputs from a total of 8 geophones (4 pairs)
2. Provide local (within 6 feet or so) pre-amplification suitable for transmitting the geophone outputs differentially to a remote rack 100 feet or so away
3. Provide **750 Hz** anti-aliasing filters consisting of a **0.1dB ripple 4 pole Chebyshev response** for each channel
4. Provide proper physical and electrical interfacing to ADC inputs
5. No signal whitening needed
6. Provide local access to coil test inputs on the geophone through the field pre-amplifier box
7. Provide DAQ interface for all outputs

2.3 Seismometer

The seismometer used is a Streckeisen model STS-2 tri-axial seismometer. The unit comes with a 'host box' that provides access to the power, signal and control lines of the STS-2. Refer to the STS-2 manual for connection data.

The 'host box' provides three differential outputs. The characteristics are:

- True differential outputs for X, Y and Z
- Sensitivity of 2.75 V/m/sec
- Predicted output of ~10 µV/**v**Hz during normal ground noise conditions

2.3.1 Seismometer interface electronics requirements:

1. Interface to the 'host box' for the STS-2
2. Provide power to the STS-2 through the 'host box' interface
3. Provide differential receivers for each of the 3 outputs from the 'host box'

4. Provide **750 Hz** anti-aliasing filters consisting of a **0.1dB ripple 4 pole Chebyshev response** for each of the 3 outputs
5. Provide proper physical and electrical interfacing to ADC inputs
6. Provide convenient front panel interface to the calibration coil inputs
7. Provide the following control functions:
   - Initialization of mass centering (AUTZ control input)
   - Selection of low-frequency corner period (PERSW control input)
   - Connection/disconnection of calibration lines (CALSW control input)
   - Monitor signal selection (position of raw sensor outputs (SIGSW control input)

8. Monitor mass position signals (UPOS, VPOS, WPOS)
9. Provide DAQ interface for all outputs

2.4 Pressure Sensor

The pressure sensors used to monitor the hydraulic fluid pressure in the pump station are Sensym ICT Inc model 19C. Two full-scale pressure sensors have been used. Either is fine for the pump station feedback control. The sensor characteristics are:

- 0.1 volts differentially across the bridge output for either 300 or 500 PSI full scale pressure input
- Excitation voltage for the bridge is 10 VDC
- Sensor output impedance is 25 kohm typical

2.4.1 Pressure sensor interface electronics requirements:

1. Provide differential interface for up to 5 sensors per pump station
2. Provide low noise bridge excitation for the pressure sensor
3. Provide anti-aliasing for ADC input
4. Based on the loose notion that the differential pressure must be kept within 0.1 PSI of the 70 PSI specification, the sensor readout electronics must have less than 20 µV/√Hz input referred noise.
5. The pump station servo is required to maintain 70 PSID +/- TBD PSI across the load
6. Provide DAQ interface for all outputs

2.5 Temperature Sensors for Pump Station

There is a need to monitor the temperature of the hydraulic pump and the load as a backup detection of fluid loss as well as general trend information. The AD590 current output temperature sensor on a custom circuit board mount was used in the prototype. The major features are:

- 1µA per K output
- 4 to 30 VDC power supply range
- +/- 0.5 deg C initial absolute accuracy
- Galvanically isolated from ground

2.5.1 Temperature sensor and interface electronics requirements

1. 0.1 degree temperature resolution
2. +/- 1 degree C absolute accuracy
3. Supply DC power to sensor
4. Provide DAQ interface for all outputs

3 Actuator Interface Electronic Requirements

There are 8 hydraulic valves per vacuum chamber to provide the required control authority. Each valve has two identical coils that can be connected in either a series or parallel configuration.

3.1 The coil parameters are:

- Resistance of 80 ohms at DC rising as ~$f^{1/2}$ at 10 Hz with ~45 degrees phase lead (skin effect)
- Coil inductance is not significant. The coil is dominated by the skin effect
- Output connector is a CF-3102-14S-2P which mates with a MS3106-14S 2P
- The maximum current rating for the coil is +/- 80 mA

3.2 The electronics requirements for the coil drivers are

1. Provide a means local to the valve to configure the windings in either a series or parallel configuration
2. Provide up to +/- 80 mA continuous current to each coil winding
3. Coil driver bandwidth is >80 Hz
4. Coil driver noise is TBD
5. There is no need for anti-image filtering
6. Provide the required physical and electrical interface to the DAC
7. Provide DAQ interface for all outputs

4 Pump Station Miscellaneous Requirements

The pump station has been envisioned as a stand-alone system. There is only a limited interface to the pump station. The existing pump station controller is described in **LIGO-T020193-00-C.** In the future, additional monitoring is desired for the parameters controlled by the pump servo. A planned upgrade to the Physics and Environmental Monitoring (PEM) system is a reasonable time to implement additional monitoring.

4.1 Pump station control and monitoring requirements

1. Supply a composite health status bit that alerts operators to a major malfunction such as:
   - Loss of fluid level
   - Pump over-temperature
   - High filter differential pressure
   - Out of regulation pressure band

2. A remote kill input that allows the pump station to be shut down from the control room