LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

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40 meter BPCU Electronics Requirements

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1 INTRODUCTION

This document describes the electronics requirements for the Beam Pointing Control Unit (BPCU) for the 40 meter interferometer. The BPCU will be necessary to control beam pointing and position once the 12 meter mode cleaner is installed. A block diagram of the BPCU is shown in the figure below

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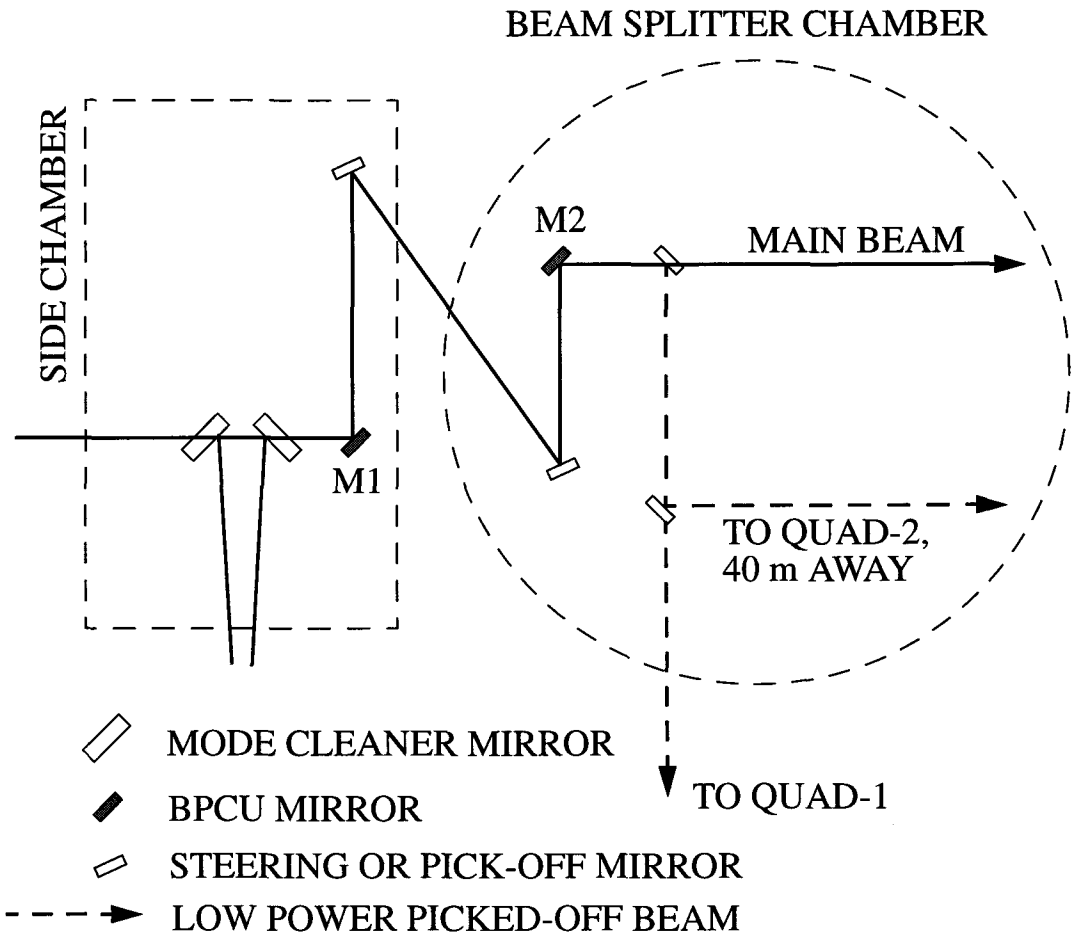

Figure 1: Conceptual Layout for BPCU

The design of the BPCU utilizes two servo controlled mirror mounts as actuators and quadrant photodiode detectors as sensors. The actuation mechanism for the mirrors are piezo-electric actuators mounted behind the mirrors and picomotors attached to mirror micrometers. A complete description of the BPCU can be found in LIGO document number T95000TBD.

A block diagram of the BPCU servo electronics is shown in the figure below.

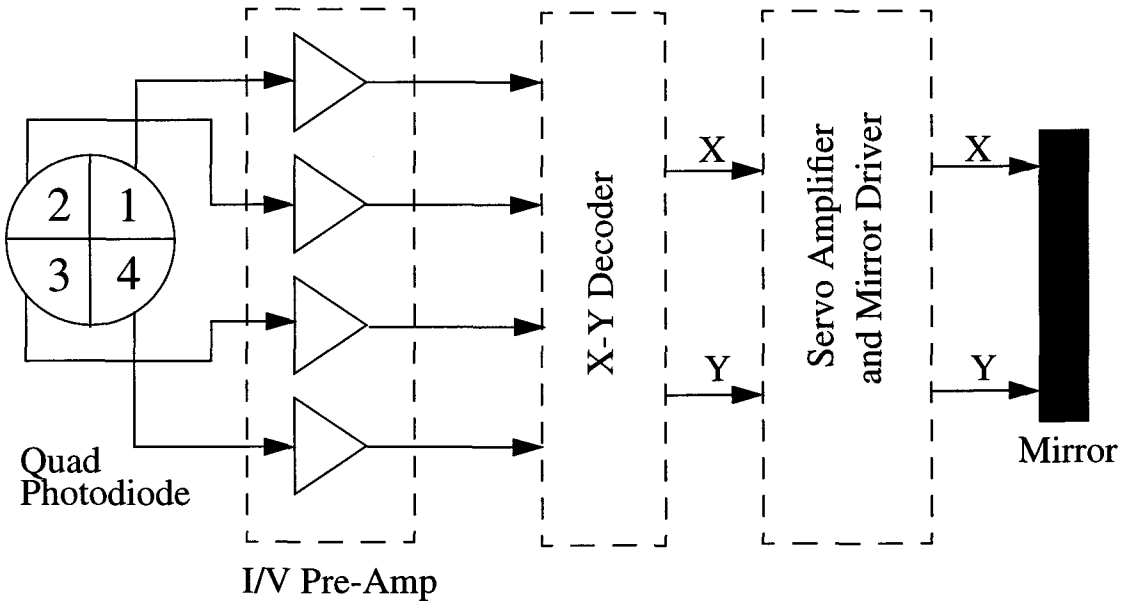

Figure 2: BPCU Servo Electronics

2 REQUIREMENTS

2.1. Quad Photodiode Electronics (I/V Pre-amp)

The output of each segment of the quad photodiode is a current whose magnitude is linearly dependent of the incident light power on the segment. The maximum operating power for the photodiode shall be less than 1 milliwatt. The sensitivity of each segment is given by:

$$I_{out} = 0.25\frac{mA}{mwatt}$$

2.1.1. Gain

The gain of each of the four channels of the preamplifier shall be $46 \pm 0.46\frac{Volts}{mAmp}$. The differential (i.e. channel to channel variations) shall be less than 1% for ambient temperature changes of +/-5 degrees C.

2.1.2. Output Noise Voltage

The output referred noise voltage of each channel shall be less than $40\frac{nV}{\sqrt{Hz}}$ for frequencies from 100 to 10 KHz.

2.1.3. Output Drive Capability

Each channel shall be capable of driving a minimum of 150 feet of shielded twisted pair cable terminated in 1 Kohms to 10 volts without oscillation. Performance shall not be degraded for frequencies less than 10 KHz.

2.1.4. Frequency Response

The full scale (large signal) frequency response of the circuit shall be better than 100 KHz. Gain and phase shall be flat to better than 1 dB and 5 degrees, respectively over this frequency range.

2.1.5. Temperature Sensitivity

The temperature coefficient for gain shall be less than 200 ppm/C.

2.2. X-Y Decoder

2.2.1. Transfer Function

The transfer function for the X position output shall be

$$X = (Q1 + Q4) - (Q2 + Q3)$$

and the transfer function for the Y position output shall be

$$Y = (Q1 + Q2) - (Q3 + Q4)$$

The accuracy of the calculation shall be better than 0.5%.

2.2.2. Input Impedance

The input impedance of each input of the decoder shall be 1 Kohm.

2.2.3. Frequency Response

The full scale (large signal) frequency response of the circuit shall be better than 100 KHz. Gain and phase shall be flat to better than 1 dB and 5 degrees, respectively over this frequency range.

2.2.4. Temperature Sensitivity

The differential drift for gain shall be less than 1000 ppm/C.

2.2.5. Output Noise Voltage

The output referred noise voltage of each channel shall be less than $100\frac{nV}{\sqrt{H}}$ for frequencies from 100 to 10 KHz.

2.3. Servo Amplifier and Mirror Driver

2.3.1. Transfer Function

The BPCU actually requires two separate servo amplifiers, one for each mirror. The difference in each of these units is in the DC gain. The nominal DC gain of one unit is 300 (49.5 dB) and the other requires a gain of 6000 (75.6 dB) at DC. Each unit shall have the capability of adjusting the gain 2 decades above and below the nominal DC gain.

A gain inversion switch shall be provided.

Both units shall have a single pole low pass filter response with the pole frequency at 0.1 Hz +/- 10%.

2.3.2. Output Noise Voltage

The output referred noise voltage of each channel shall be less than $300\frac{\mu V}{\sqrt{Hz}}$ for frequencies from 100 to 10 KHz and less than $0.5\frac{V}{\sqrt{Hz}}$ at 0.1 Hz. All line related or spurious spikes in this range shall be less than 1 milli-volt rms.

2.3.3. Output Voltage and Drive Capability

Each channel shall be capable of driving a minimum of 100 feet of shielded twisted pair cable terminated in 0.75 uF (the capacitance of the piezo actuator) without oscillation. The operating voltage range for the circuit is from 0 to 150 volts. The nominal output voltage for a 0 volt input shall be 75 volts.

2.3.4. Temperature Sensitivity

The temperature coefficient for gain shall be less than TBD ppm/C. DC offset stability shall be better than +/- 1% at 20 C, -5 C +20 C.

2.3.5. Indicators, Monitors and Controls

2.3.5.1 Gain Adjustment

2 decades of gain selection above and below the nominal gain shall be provided by a front panel switch. A fine adjustment pot (front panel) shall be provided for 100% adjustment of the gain in the selected decade.

2.3.5.2 DC Drift

The total DC drift at the output shall be less than 250 mV for ambient temperature changes of +/- 5 degrees C.

2.3.5.3 Output Voltage Indicators

Some type of output voltage indicator in the form of a front panel meter, LED or bar display shall be provided for each channel.

2.3.5.4 Output Voltage Monitors

Buffered output voltage monitors shall be provided for each channel. The scaling for the monitors is TBD.

2.4. Pico Motor Controls

A complete description of the operation of the pico motor actuators can be found in the application note provided with the pico motor manual. The BPCU controls shall provide for the control of the pico motors via an operator display. The operator shall be able to control the rate, direction and number of steps for the pico motor. It is not envisioned that the initial BPCU controls will utilize automatic centering software or algorithms, but the possiblity of this future enhancement to the system shall not be precluded by the design.