Thermal II sensors and actuators

Beam position sensor (And Beam Steering Servo)

Purpose: to maintain write laser beam pointing on the optical axis, and properly positioned in the light valve for best performance. The sensor, and associated actuator, is required because the write laser will wander as a function of temperature gradients and stresses in the head as things are switched on and off.

Method: A piece of the write beam is taken from the edge, where it is un-useable for pixels. This beam is attenuated and projected onto a split detector. An error signal is generated based on how much light falls on each side of the split detector. A PID (proportional integral derivative) servo control lop is used to minimize the error signal.

Why different than Thermal? Thermal 1.0/1.7 did some slight clipping of the beam (depending on the beam width). The tighter beam effected the servo control parameters, with the risk of some dead band. The detectors had a risk of burning. The detectors were signal sourced and actually only made for Creo. The detectors were expensive.

Beam Steering Actuator:

Thermal Rod: Resistive element (60 ohms) stuck on thin aluminum piece. Current added creates heat that gives expansion of the "rod" which pivots the first reflecting mirror, providing the steering function. No current gives cooling which causes contraction of the rod.

Challenges: The heating/cooling is not symmetrical. Therefore optimal control of the servo is different for each half of the cycle. It is difficult to have both a quick settling time and sufficiently damped operation. The thermal rod is also sensitive to air currents.

Future improvements: Split the heating and cooling into independent control loops. Model and properly optimize each loop.

Beam Position Sensor – Excessive detail

The BPS consists of a metal aperture, a right angle prism, an ND3.0 metallic filter and a split silicon sensor with a an appropriate electronic circuit. The metal aperture is 1.6mm by 3.5mm and is centered 1.6mm from the edge of the piece of metal. The right angle prism is glued to the metal, so that the light is bent 90 degrees to the side of the write beam.

The beam is filtered down to 0.1% of the original power (i.e. ND 3.0) by a metallic filter placed in front of a circuit board containing a Hamamatsu S5870 split silicon sensor. This

sensor contains two common cathode 5mm by 10mm sensors, separated by 35um. An amplifier is used to convert the sensors currents to a voltage, which is then level shifted on the board to be between –2.5V and 2.5V, to be compatible with the ADC's on the T2HC board.

M8 Sensor

Purpose: To provide real time control of the write laser level during a plot. Not intended to be a long time stable sensor, and only samples a portion of the write beam width. All pixels are turned on during the clamp time for power sampling by the M8 sensor and servoing of the write laser. This is a low bandwidth servo, with one or two samples per drum rotation. The light valve has some throughput issues related to write beam and number of on and off pixels, which is why it was necessary to place the sensor downstream such that it could compensate for these effects. The M8 sensor is calibrated to the "master" beam balance sensor between plots.

M8 Sensor – Excessive detail

The M8 mirror reflects the write beam from the light valve 90 degrees towards the focus block. A power sensor, the M8 sensor, is behind this mirror. The mirror has a dielectric coating that allows 0.5% of the beam to be transmitted. A tunnel is behind the mirror, which is necessary to prevent reflections coming back from the plate having an effect on the measured power. Another filter, a metallic ND 1.4 filter (4% transmission), is placed at the end of the tunnel, directly in front of a circuit containing a Mamamatsu S5170 silicon sensor. This filter is required to drop the signal to an appropriate level, and is metallic since this type of filter attenuates light over a much larger angle than dielectric filters. A separate filter is also used since dielectric coatings are not stable for coatings with transmissions much less than 0.5%. An amplifier is used to convert the sensors' output current to a voltage, which is then level shifted on the board to be between –2.5V. and 2.5V, to be compatible with the ADC's on the HC board.

At the plane of the sensor, the beam is roughly 20mm wide, while the sensor is 10 mm wide, so roughly half of the beam is measured. The sensor is roughly centered, horizontally and vertically, in the beam. Since the sensor is located before the order blockers and before the order blockers and before full separation of the orders, this sensor should not be used to measure contrast ratio. The spot full and spot off measurements tend to differ by less than 5%.

Beam Balance Sensor:

Purpose: To provide overall power levels, both for pixels on and off, and thus also contrast. To "flatten" the beam such that there is equal energy for every pixel pair (plus, possibly slope and curve correction).

Challenge: To achieve the incredible accuracy required, at low cost and high reliability. For example, we are trying to match the accuracy of some very good laser power meters that cost over $3000 U.S. We also need this accuracy over a tremendous range of power from low power all pixels off to high power all pixels on. In fact, we were unable our requirements under the highest power conditions, with waste heat causing drift of the sensor. To keep the maximum power on the sensor down, we use a trick of determining full power levels by breaking the on pixels into groups and summing.

Shutter: The beam balance sensor must be moved in and out of the write beam. A bi-stable shutter is used. With current only needed to have the shutter change state, we avoid an asymmetric heat load that would distort the optical path.

Beam Balance Sensor – Excessive detail

The Beam Balance Sensor (BBS) is located on the shutter, between the fixed and moving lens tubes. This sensor is much like the Beam Balance Sensor on Thermal 1. A custom UDT photocell, is placed behind a OD 4.1 filter. This filter is angled at roughly down 1 degrees, so that when the shutter is closed, the reflected beam does not get reflected directly back to the M8 mirror, and thus back along the write beam path.

The filter is a two-part laminate. A dielectric filter, with a transmission of 1% coated on a piece of borofloat glass, and this laminated, dielectric side up, to a piece of Schott BG28 coloured glass, which attenuates the remaining beam by a bit more, 99%. It is important to understand the difference between these two filter types. A dielectric filter is designed for a specific range of wavelengths of light. When the filter is rotated, the effective wavelength of the light changes, so t a given wavelength, a dielectric filter is limited to a typically small optical incidence angle. For this reason, the filter laminate is place dielectric side out, so that roughly 99% of the incident light in this case, is reflected away from the shutter. The coloured glass, on the other hand, attenuates the beam by absorption. For this reason, the coloured glass is placed on the inside of the shutter sensor. If it were exposed to the full beam, it would likely crack. Please be warned that even 1% of the full beam will cause the coloured glass filter to heat up, which has the unfortunate consequences of changing the filters properties. Thus it is not advisable to shine the full beam power on the BBS for a long period of time.

The sensor has an active area of 12mm by 12mm, while for a 2400 dpi head, the beam is roughly 5mm by 10mm high at the sensor. The sensor output current is sent to the autofocus actuator PCB, where there is an amplifier with switchable gains. This signal is then level shifted to be between –2.5V and 2.5V to be compatible with the ADC's on the HC board.