# Crystal Technology, Inc.

## AOTF Controllers and Light Intensity Tracking

**Revision 1.2**

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| Revision History | | | |
|---|---|---|---|
| **Revision** | **Date** | **Who** | **Comments** |
| 1.0 | 2008/12/01 | Dale Gifford | Genesis. |
| 1.1 | 2008/12/05 | Dale Gifford | Release 2008-12-05 |
| 1.2 | 2010/08/10 | Dale Gifford | Updated logo, fixed typos. Release 2010-08. |

**Table 1: Revision History**

  

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# 1. Introduction

## 1.1. Purpose

This document contains information about using Crystal Technology's *Acousto-Optic Tunable Filter (AOTF) Controllers* in environments that utilize Light Intensity Tracking. This document provides guidelines for configuring and operating *AOTF Controllers* in a Light Intensity Tracking mode of operation.

## 1.2. Related Documents

The following references may be useful in fully understanding and utilizing the *AOTF Controller*:

- Octal Channel AOTF Controller Integration Guide, Revision 1.1, 2010/08/10, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- Quad Channel AOTF Controller Integration Guide, Revision 1.1, 2010/08/10, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- Single Channel AOTF Controller Integration Guide, Revision 1.1, 2010/08/10, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AOTF Controller Command Reference, Revision 1.3, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AOTF Controllers and Temperature Compensation, Revision 1.2, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AOTF Controllers and FSK Operation, Revision 1.3, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AotfManager User's Guide, Revision 1.1, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.
- AotfCmd User's Guide, Revision 1.1, www.CrystalTechnology.com, Crystal Technology, Inc. 1040 East Meadow Circle, Palo Alto, CA 94303-4230.

## 1.3. Notation

- Numbers with an "h" suffix or "0x" prefix are hexadecimal. All other numbers are decimal.
- Register and bit names ending in "**[#]**" and "**[#:#]**" signify selection of a subset of the register (e.g. **I2CS[0]** represents bit 0 of the **I2CS** register, and **I2CS[5:3]** represents bit 5 through 3 of the **I2CS** register).
- Signal names ending with '#' (e.g. **INT0#**) indicates an active low signal.

  

- N/A is an abbreviation for Not Applicable.
- Register bits are either set (1) or cleared (0).

  

## 2. Light Intensity Tracking

Light Intensity Tracking is the process of adjusting the RF Frequency output of the AOTF Controller to maintain optimum diffracted light intensity. The diffracted light intensity is a function of the RF Frequency injected into the AOTF Crystal. The optimum frequency varies with the temperature of the AOTF Crystal, so it becomes important to compensate for changes in the temperature of the AOTF Crystal by adjusting the RF Frequency. The compensation algorithm can be based on measuring the light intensity directly or by measuring the temperature of the AOTF crystal. This document contains information about using Crystal Technology's *Acousto-Optic Tunable Filter (AOTF) Controllers* in environments that utilize Light Intensity Compensation. This document provides guidelines for configuring and operating AOTF Controllers in a Light Intensity Compensation mode of operation.

All host environments are not identical, and there is more than one way a host environment might deal with variations in AOTF Crystal temperature. To facilitate these various host environments *AOTF Controllers* have algorithms embedded in the firmware that can be utilized in different temperature compensation schemes.

Light Intensity Tracking Adjustments are divided into two modes of operation:

- **<u>Auto</u>**
  Auto Light Intensity Tracking uses an interval timer to periodically make adjustments to the frequency. Each interval period the frequency is adjusted to maximize the Peak Light Intensity.
- **<u>Manual</u>**
  Manual Light Intensity Tracking only performs adjustments when the host invokes the adjustment command. This is to allow the host the ability to decide when frequency adjustments can be tolerated.

To configure the *AOTF Controller* for Auto Light Intensity Tracking issue this command:

```
Track Auto -i 0 0 20
```

This will enable Auto Light Intensity Tracking for channel 0 every 20 seconds. To terminate the Auto Light Intensity Tracking issue the following command:

```
Track stop 0
```

To configure the *AOTF Controller* for Manual Light Intensity Tracking issue this command:

```
Track Manual -i 0
```

This will enable Manual Light Intensity Tracking for channel 0. No adjustments will be made until the following command is issued:

```
Track Adjust
```

To terminate the Manual Light Intensity Tracking issue the following command:

```
Track stop 0
```

  

# 3. Light Intensity Tracking Adjustments

Before Light Intensity Tracking Adjustments can begin it is necessary to peak the light intensity by following the procedure outlines in *Section 4, Peak Light Intensity, on page 13*. Once the Peak Light Intensity frequency has initially been determined, the Light Intensity Tracking algorithm can continually update the frequency to maintain the Peak Light Intensity.

Light Intensity Tracking Adjustments rely on the fact that the current frequency of the *AOTF Controller* is very near the frequency that originally provided the optimum Peak Light Intensity. The algorithm follows the following procedure:

- The current frequency is used as the starting point for a search for a 2% reduction in light intensity above and below the current frequency. These two frequencies define the frequency span used for searching for a new peak light intensity.

- Beginning from the 2% drop off frequency below the current frequency, up to the 2% drop off frequency above the current frequency, the spectrum is scanned for a new peak light intensity frequency.

**Example:**

The following example is using channel 0 for Light Intensity Tracking. The procedure outlined in *Section 4, Peak Light Intensity, on page 13*, will first be performed:

Configure the Light Intensity meter to receive the full intensity of the non-diffracted beam and issue the following command to calibrate the gain of the AtoD sensor input range:

```
Adc Peak 2
```

The ADC sensor input is now capable of reading the maximum light intensity without over driving the sensor input. Over driving the sensor input would flatten the AtoD conversion and make it impossible to detect the peak.

Configure the Light Intensity meter to receive the diffracted beam (or some portion of it). Issue the following command to have the AOTF Controller search the spectrum and locate the frequency that provides the maximum intensity of the diffracted beam:

```
Dds Peak 0 50 150
```

The start and stop frequencies in the above command can be narrowed if the peak frequency is known. The concept is to force the *AOTF Controller* to begin a frequency sweep with a wide enough span that the peak frequency will be within the span. A wide span takes longer and doesn’t really gain anything. If the peak frequency is unknown then the above span from 50MHz to 150MHz will most likely find the peak frequency after a couple of iterations of the algorithm.

  

Enable Auto Light Intensity Tracking with the following command:

```
Track Auto -i 0 0 20
```

Or enable Manual Light Intensity Tracking with the following command:

```
Track Manual -i 0
```

If using Manual Light Intensity Tracking an adjustment can be performed as often as necessary by issuing the following command:

```
Track Adjust
```

  

## 4. Peak Light Intensity

The Peak Light Intensity algorithms require a Light Intensity meter connected to the Light Intensity sensor input of the *AOTF Controller*. Configure the host environment as shown in *Figure 1*:

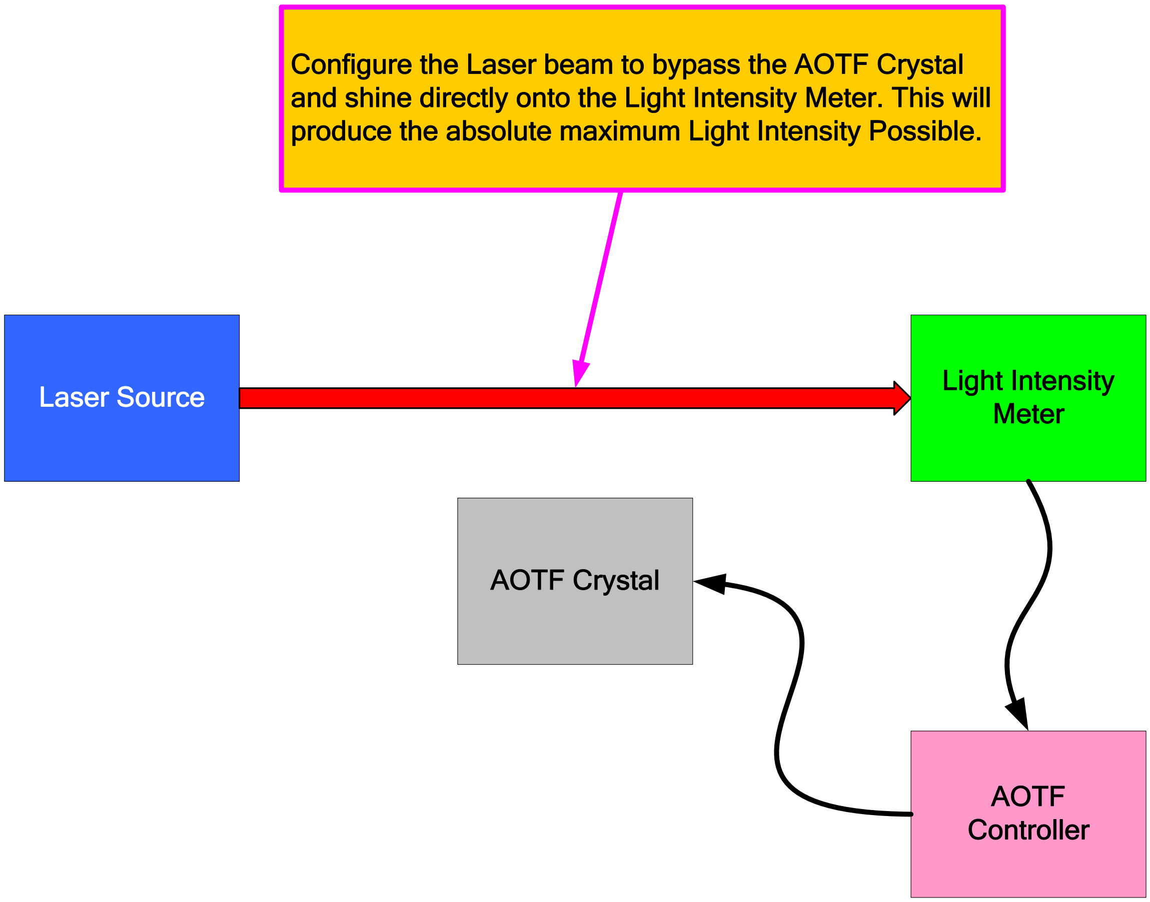


**Figure 1: Peak Light Intensity Calibration**

This phase of the Peak Light Intensity calibration should be performed with the modulation amplitude configured for maximum intensity. The modulation amplitude can be either Analog Modulation or Digital Modulation, depending on the configuration of the *AOTF Controller*. NOTE: It's possible to overdrive the AOTF Crystal, and the final phase of the Peak Light Intensity calibration will attempt to compensate for the overdrive. For now adjust the modulation for maximum intensity.

This configuration will allow the *AOTF Controller's* sensor input to be calibrated for the correct amount of gain to produce the optimum range for the sensor input. With the host environment correctly configured, issue this command:

```
Adc Peak 2
```

  

The “`Adc Peak`” command will adjust the gain of sensor input 2, which is the Light Intensity sensor input, for a full scale reading. This will make the full range f the ADC available for the next phase of the Peak Light Intensity algorithm.

Alternatively, the AODS Controller application can accomplish the same command as shown in *Figure 2*:

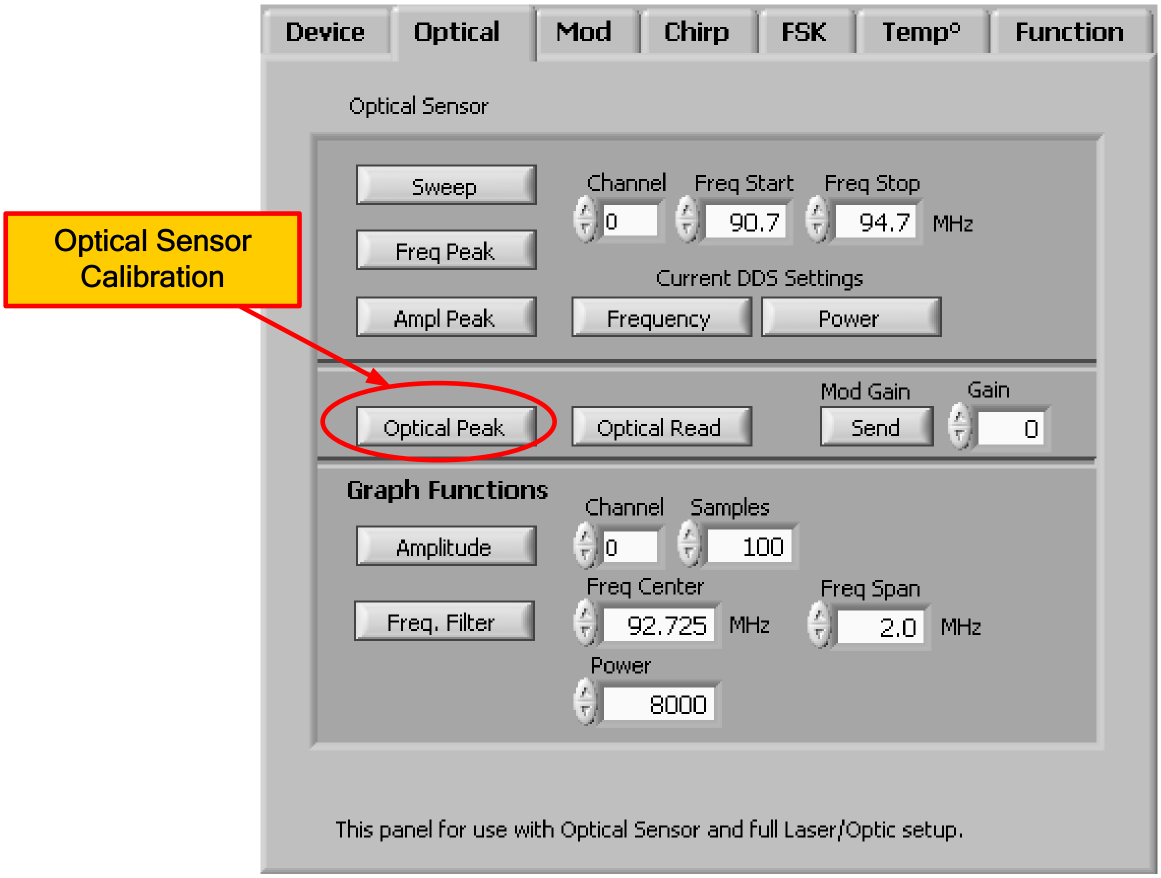


**Figure 2: ADC Optical Sensor Calibration**

  

Reconfigure the host environment as shown in *Figure 3*:

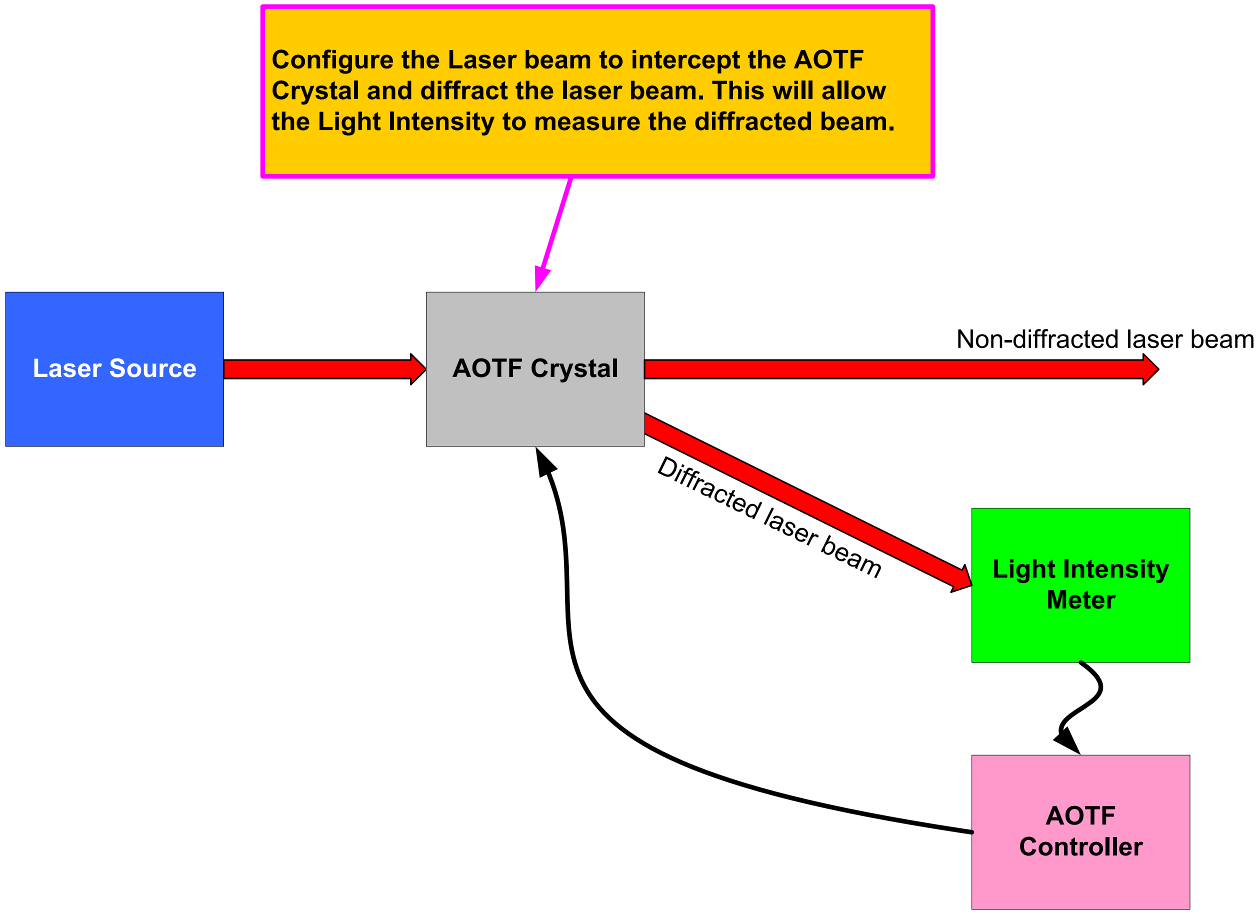


**Figure 3: Peak Light Intensity**

With the host environment configured like *Figure 3* issue this command:

```
Dds Peak 0 50 150
```

This will use channel 0 of the *AOTF Controller* to sweep through the RF spectrum from 50MHz to 150MHz and search for the Peak Light Intensity of the diffracted beam. When the algorithm completes the frequency of channel 0 will be positioned on the frequency that provided the Peak Light Intensity.

  

Alternatively, the AODS Controller application can accomplish the same command as shown in *Figure 2*:

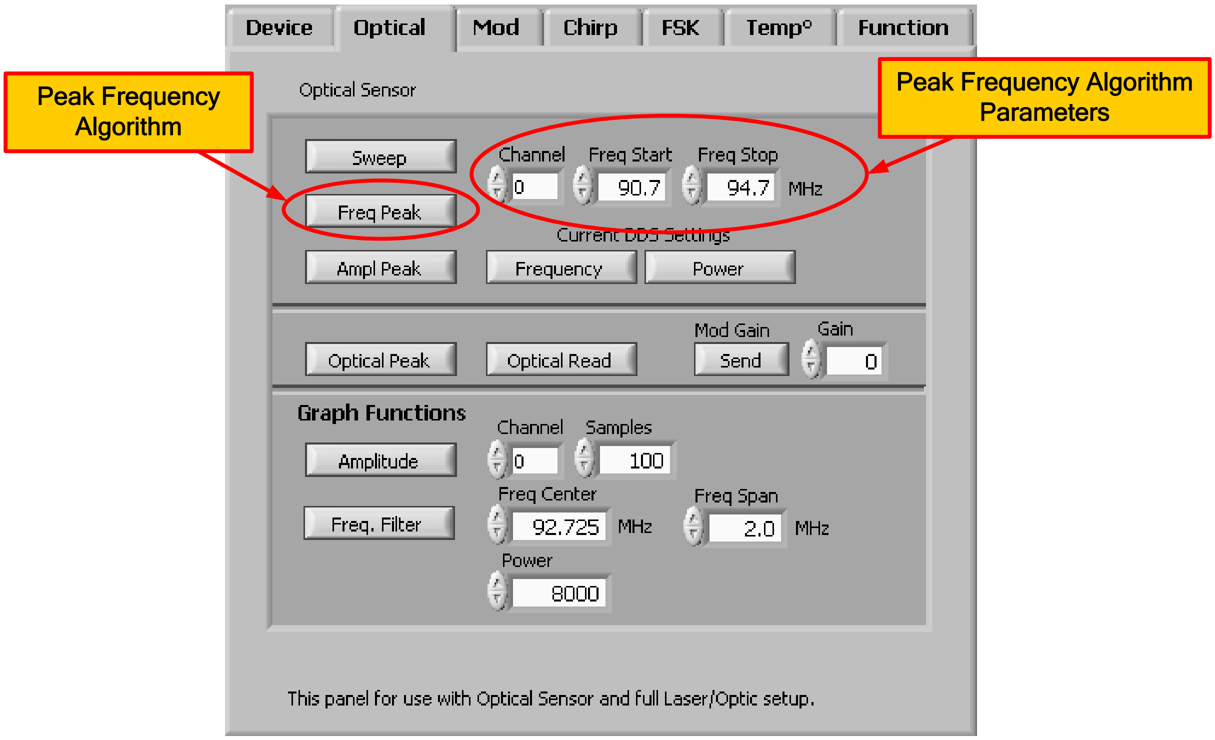


**Figure 4: Peak Frequency Algorithm**

Now that the Peak Frequency has been determined, the optimum modulation can be configured. It's possible to overdrive the AOTF Crystal, which results in less diffracted light as the modulation voltage increases beyond the optimum. There are two ways to optimize the modulation voltage:

- **Adjust the Modulation Voltage**
  This is accomplished by having the host environment reduce the modulation voltage to 0 and then slowly raising the modulation voltage to maximum while tracking the Peak Light Intensity on the light intensity meter. This calibration step requires that the host perform the modulation voltage adjustments while using the *AOTF Controller's* "`Adc Read`" command to track the light intensity meter sensor input and record the modulation voltage setting that results in the maximum light intensity. This is the preferred technique because it preserves the maximum range for the SIN wave generator, and allows the DDS chip to produce the best possible SIN wave with the most number of points along the SIN wave curve.

- **Adjust the Amplitude Scale Factor**
  The Amplitude Scale Factor (ASF) of the DDS chip can be adjusted to reduce the amplitude output, and thereby reducing the RF power output from the DDS chip. The ASF can be adjusted manually with the "`dds amplitude`" command. Alternatively the "`dds amppeak`" command can perform an automatic adjustment of the ASF to optimize the Peak Light Intensity. The "`dds amppeak`" command increments the ASF from 0 to the maximum and observes the light intensity sensor input. When the command completes the ASF will be set to the value that produced the maximum light intensity.

  