# Crystal Technology, Inc.

## Single Channel AOTF Controller Integration Guide

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| Revision History | | | |
|---|---|---|---|
| **Revision** | **Date** | **Who** | **Comments** |
| 1.0 | 2009/01/05 | Dale Gifford | Genesis.<br>Derived from Single Channel Technical Specifications. |
| 1.1 | 2010/08/10 | Dale Gifford | Updated logo, fixed typos. Release 2010-08. |

  

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# 1. Introduction

## 1.1. Purpose

This document is a guide for how to integrate the *Single Channel Acousto-Optic Tunable Filter (AOTF) Controller* into host environments. The *Single Channel AOTF Controller* provides a Direct Digital Synthesis (DDS) chip with the ability to adjust the DDS to a separate frequency from 20Mhz to 200Mhz. The *Single Channel AOTF Controller* communicates with a desktop or notebook PC or PDA environment via an RS232 serial interface, a USB interface, or a Bluetooth interface.

## 1.2. Compatibility

The *AOTF Controller* is compatible with the following standards:

- Electronic Industries Association RS232 communication standard (EIA232). www.eia.org.
- Universal Serial Bus standard (USB). www.usb.org.
- Bluetooth Specification, Bluetooth Special Interest Group (SIG), www.bluetooth.org.

## 1.3. 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.
- 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.
- AOTF Controllers and Light Intensity Tracking, Revision 1.2, 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.

### 1.4. 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. *AOTF Controller* Architecture Overview

The *AOTF Controller* is composed of these two separate PCB assemblies:

- The *AOTF Controller* PCB
- The *Temperature Sensor Board* PCB

To accommodate various applications, the *Single Channel AOTF Controller* contains all of the components for interfacing to various host environments, including both analog and digital interfaces. The *Temperature Sensor Board* is a separate PCB that travels with the AOTF Crystal. The *AOTF Controller PCB* contains the DDS chip, microcontroller, Amplitude Modulation, FSK, and Blanking control. The *Temperature Sensor Board* contains a temperature sensing circuit and a serial EEPROM that identifies the AOTF Crystal.

The architecture of the two board design is shown in *Figure 1, on page 4*, and a typical system that utilizes the *AOTF Controller* is shown in *Figure 2*, on *page 5*.

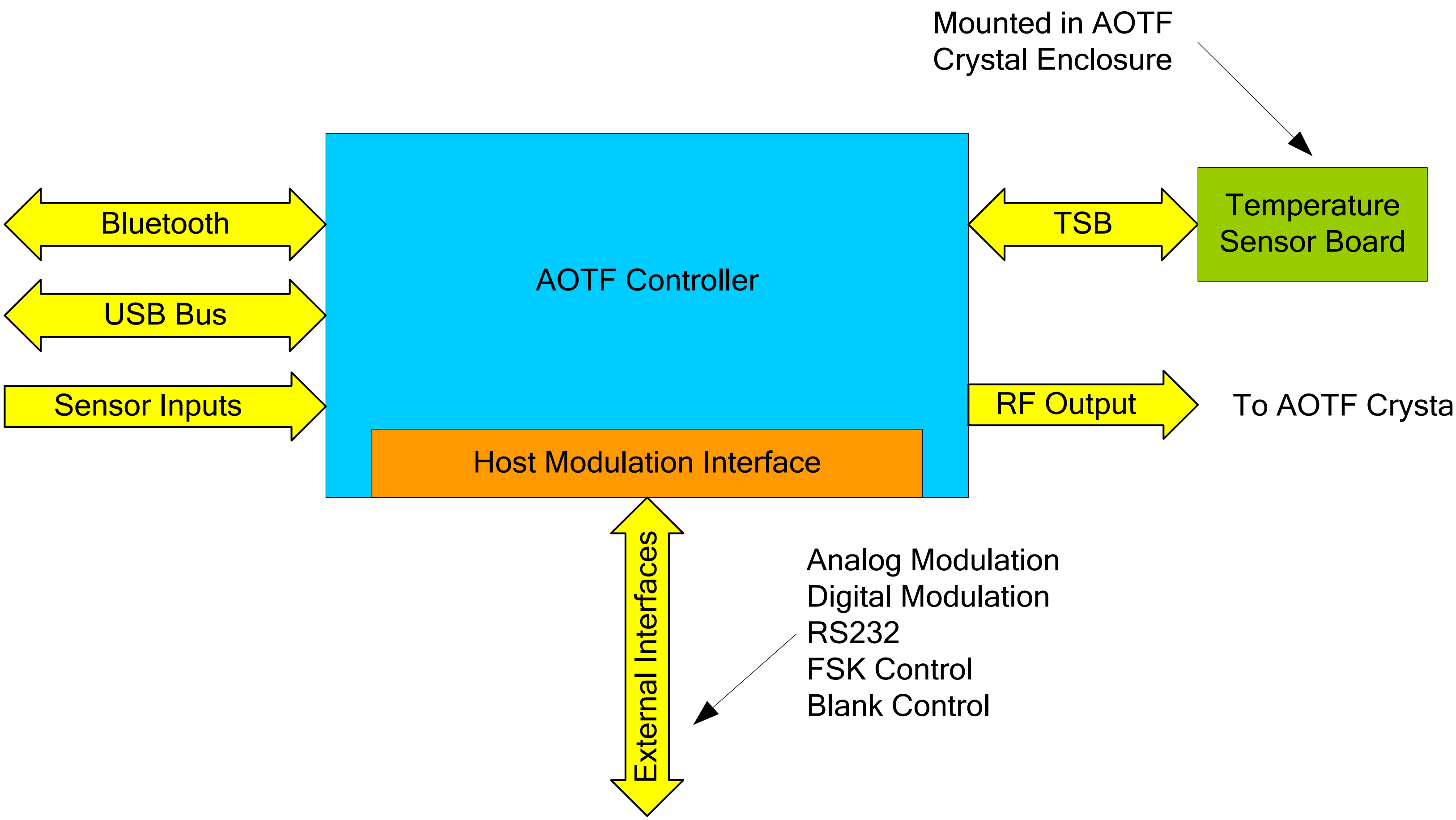


**Figure 1: AOTF Controller and Temperature Sensor Board**

  

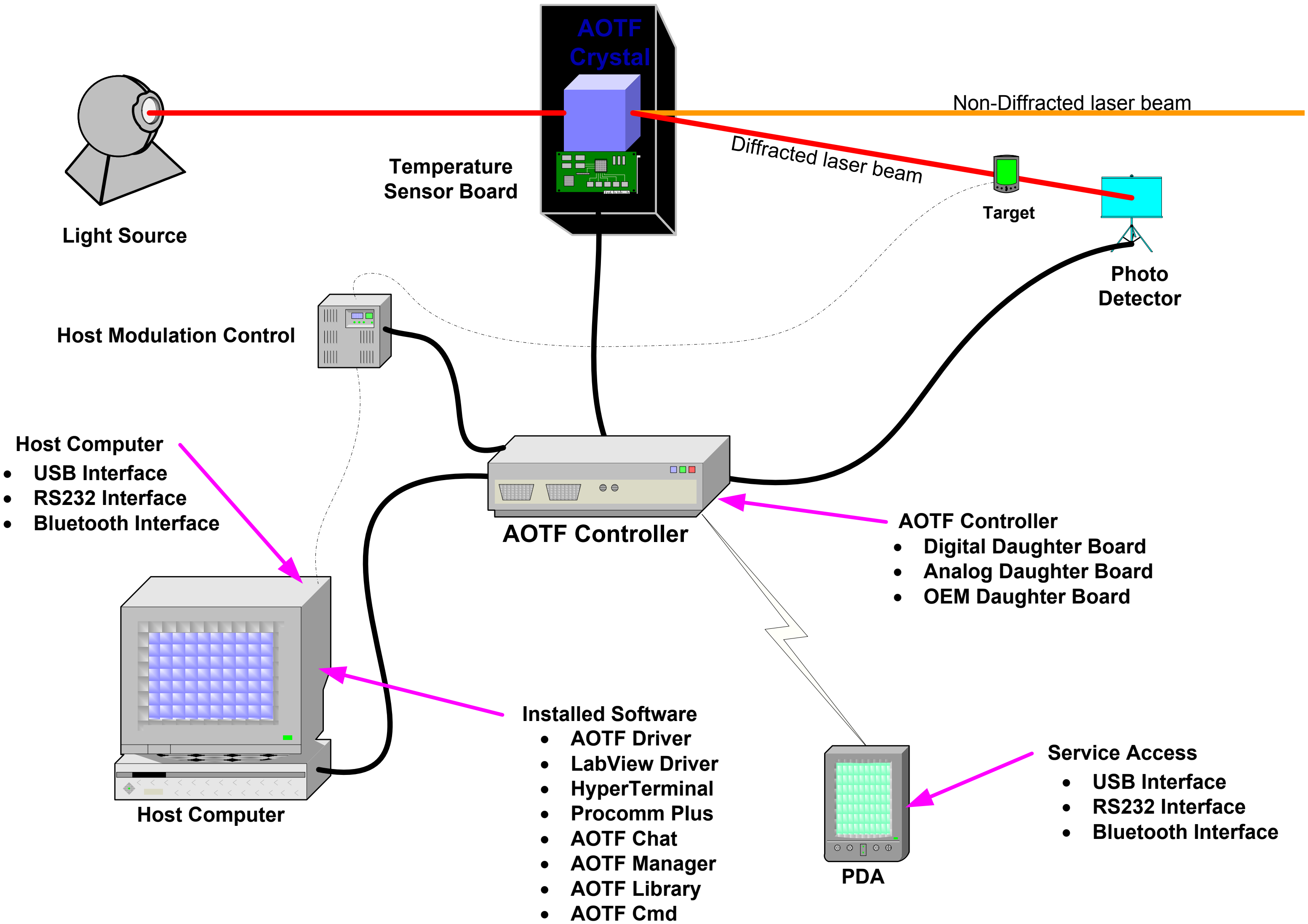


**Figure 2: Typical System Utilizing the AOTF Controller**

## 2.1. AOTF Controller Architecture

A simplified block diagram of the *AOTF Controller* is shown in *Figure 3 on page 7*. The *AOTF Controller* consists of the following major architectural blocks:

- **Modulation Interface**
  The Modulation Interface provides the connection to the host environment. The primary functions are host modulation input conversion and profile selection.

- **Analog to Digital Converter (ADC)**
  The ADC provides the ability for the Microcontroller to read the temperature of the AOTF Crystal and the power from the Optical Power Sensor. The Microcontroller uses the information to implement temperature compensation and light intensity algorithms.

- **Microcontroller**
  The microcontroller executes the firmware that implements the AOTF functions such as RS232 communication, USB communication, and DDS control.

- **Direct Digital Synthesis (DDS)**
  The DDS chips synthesize the RF frequency and create the RF signal that will be modulated and amplified for driving the AOTF Crystal.

- **Modulator**
  The Modulator combines the modulation input from the host environment with the output from the DDS to produce the RF signal that will drive the AOTF Crystal.

- **Amplifier**
  The provides the final amplification for RF Output.

  

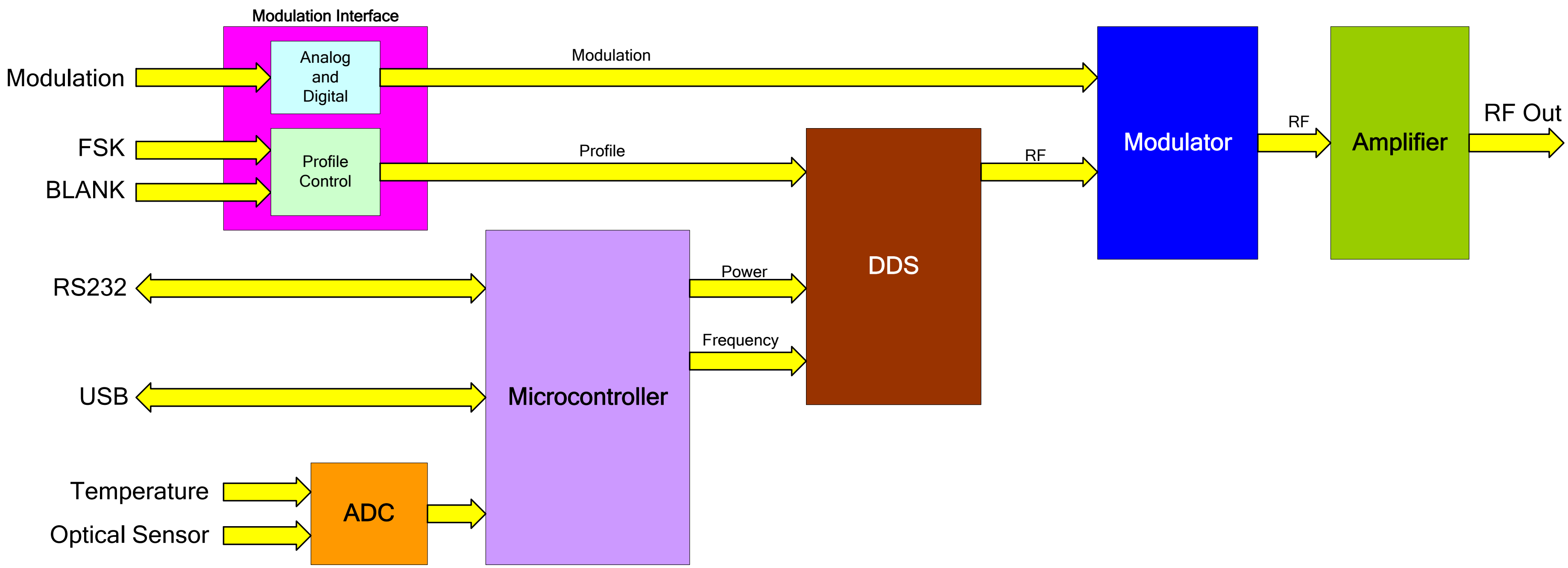


**Figure 3: AOTF Controller Block Diagram**

### *2.2. Temperature Sensor Board*

The *Temperature Sensor Board* (TSB) provides two functions:

- Temperature sensing capability at the AOTF Crystal.
- AOTF Crystal Identification and calibration.

The TSB is mounted in the enclosure that contains the AOTF Crystal. The temperature sensing element is mounted such that it is in contact with the AOTF Crystal, to provide an accurate temperature reading of the AOTF Crystal. *Figure 4 on page 8* shows a block diagram of the *Temperature Sensor Board*.

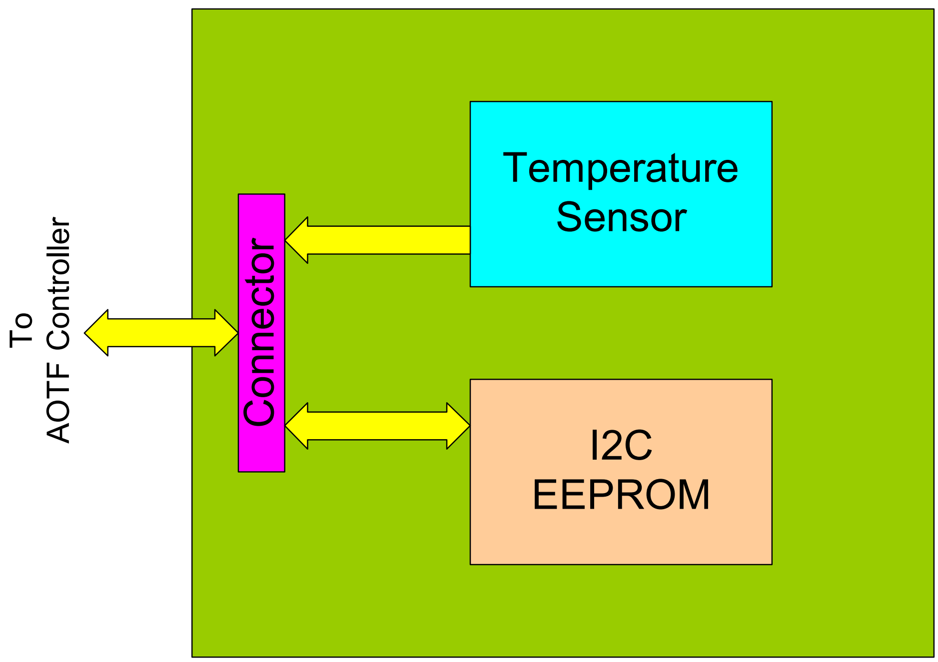


**Figure 4: Temperature Sensor Board (TSB)**

The TSB is connected to the *AOTF Controller* via the Temperature Sensor Connector on the front panel of the *AOTF Controller*. See *Section 3.5*, on *page 22* for a description of the Temperature Sensor Board Connector.

  

# 3. Connectors

The front panel of the *AOTF Controller* is shown in *Figure 5 on page 10*. The front panel elements are:

- **+12VDC Power Input**
  This is the power supply input. Connect a +12VDC @ 1 Amp. See *Section 3.1,Power Supply Connector, on page 11* for more details.

- **Host Modulation**
  This is the connector where the host provides the amplitude modulation, either analog or digital. See *Section 3.2, Host Modulation Connector, on page 12* for more details.

- **Optical Power Sensor Input**
  This is the Optical Power Sensor Input. Connect an Optical Power Meter to this input for use with firmware algorithms such as peak diffracted light efficiency optimizations and light intensity tracking. The input impedance is 100K Ohms and the maximum input voltage is 3.3V. See *Section 3.3, Optical Power Sensor Connector, on page 20* for more details.

- **Host USB Interface**
  This is the USB connection for host communication. Software applications on the host can use the USB for communication. See *Section 3.4, USB Connector, on page 21* for more details.

- **Temperature Sensor Input**
  This is the connection to the Temperature Sensor Board (TSB). The TSB is located in the housing with the AOTF Crystal and contains the temperature sensor and the calibration EEPROM. The EEPROM contains important calibration information related to the AOTF Crystal. See *Section 3.5, Temperature Sensor Board Connector, on page 22* for more details.

- **Power ON LED**
  The Power ON LED should be ON and Green when the *AOTF Controller* is operating. If the LED is OFF then the +12VDC input is not present or has failed.

- **RF Output**
  The RF Output provides the signal to the AOTF Crystal. See *Section 3.6, RF Output Connector, on page 23* for more details.

  

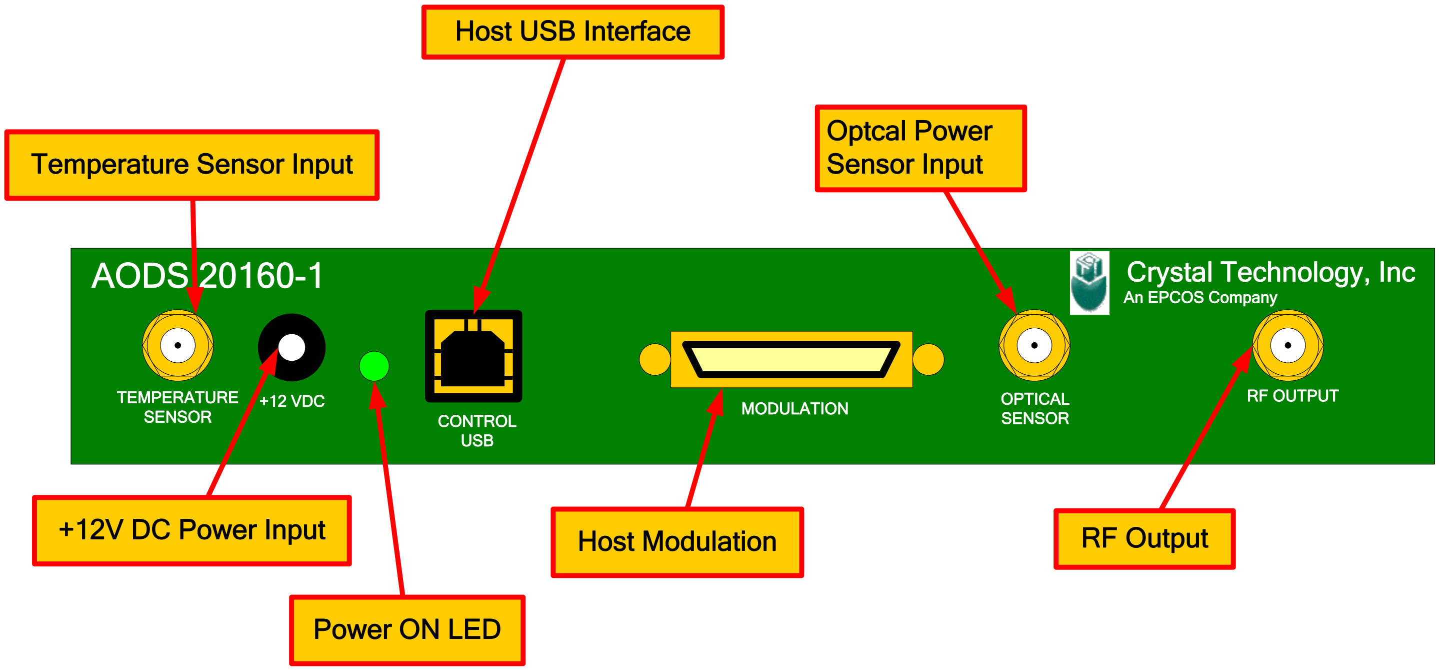


**Figure 5: Front Panel**

### *3.1. Power Supply Connector*

The Power Supply Connector is a circular right angle PCB mounted connector.

| Power Supply Connector | | |
|---|---|---|
| **Pin** | **Direction** | **Description** |
| 1 (center) | - | +12VDC @ 1 Amps |
| 2 (shield) | - | GND |

**Table 1: Power Supply Connector**

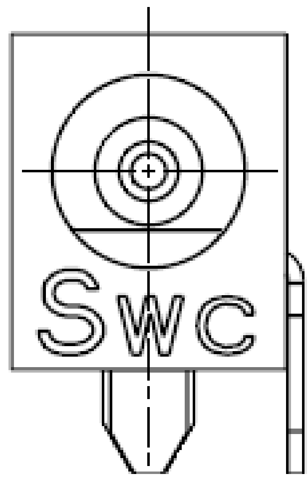


**Figure 6: Power Supply Connector**

### *3.2. Host Modulation Connector*

The Host Modulation connector, as viewed looking at the front of the *AOTF Controller* is shown in *Figure 7*.

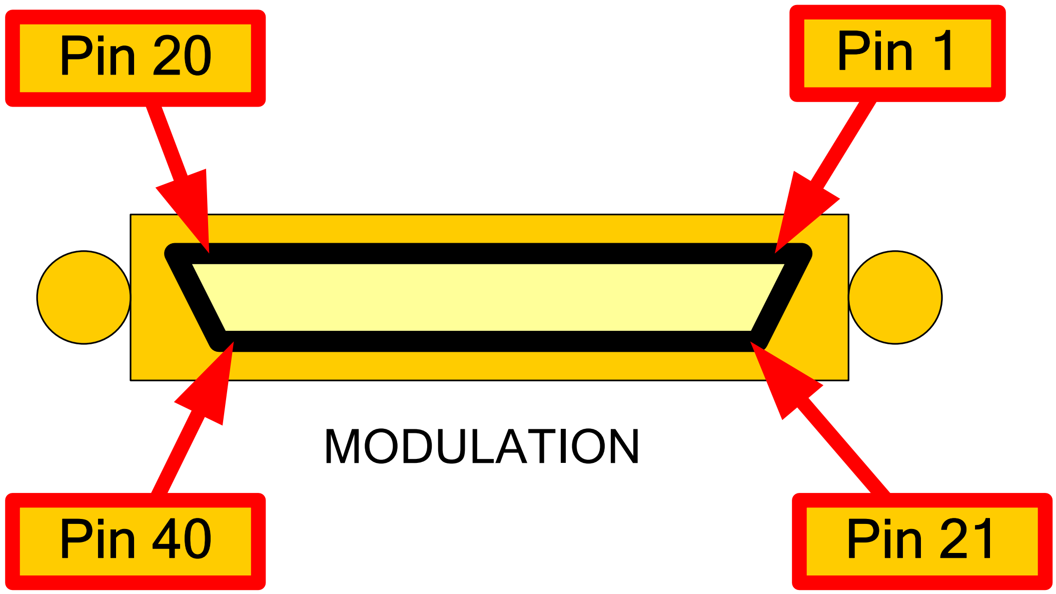


**Figure 7: Analog Modulation Connector**

The pin assignments for the Host Modulation connector are outlined in *Table 2*.

| Host Modulation | | | |
|---|---|---|---|
| **Pin** | **Direction** | **Name** | **Description** |
| 1 | IN/OUT | VCC12 | VCC12 is connected directly to the +12VDC power supply. These VCC24 pins can be used to supply power to the AOTF Controller instead of supplying power through the +12VDC connector. Alternatively, these VCC12 pins can supply a small amount of power to drive interface circuits, such as the Application Specific Adaptors. |
| 2 | IN/OUT | VCC12 | |
| 3 | - | GND | Ground Reference. |
| 4 | IN/OUT | ONEWIRE | The ONEWIRE signal provides access to the One Wire EEPROM located on the daughter board. |
| 5 | OUT | TXD | Serial Transmit Data. The serial signals are jumper configurable for either RS232 or CMOS 3.3V level signals. |
| 6 | OUT | RTS | Serial Request To Send. The serial signals are jumper configurable for either RS232 or CMOS 3.3V level signals. |
| 7 | - | GND | Ground Reference. |
| 8 | IN/OUT | SDA | I2C Data provides the host with access to the I2C bus on the AOTF Controller. The I2C signals are CMOS 3.3V level signals. |
| 9 | IN | RESET# | Provides the host with a mechanism for resetting the interface logic. Active low, CMOS 3.3V. |
| 10 | IN | BLANK- | The BLANK+/- are an LVDS pair that provide the host with the ability select one of four profiles. |
| 11 | - | GND | Ground Reference. |
| 12 | IN | FSK- | The FSK+/- are an LVDS pair that provide the host with the ability select one of four profiles. |
| 13 | IN | CHIRP- | The CHIRP+/- are an LVDS pair that provide the host with the ability to initiate frequency chirps. |
| 14 | | Not Used | Not Used. |
| 15 | IN | ANALOG- | The ANALOG+/- signals provide a differential analog modulation input for the host environment. The analog voltage can swing from 0V to +10V. The input impedance is 4.3K Ohm. |
| 16 | | Not Used | Not Used. |
| 17 | | Not Used | |
| 18 | | Not Used | |

  

| Host Modulation | | | |
|---|---|---|---|
| **Pin** | **Direction** | **Name** | **Description** |
| 19 | IN | DIN0- | The DIN0+/- are an LVDS pair that provides the data for the digital modulation. |
| 20 | IN | CLK- | The CLK+/- are an LVDS pair that provides the clock for the digital modulation. |
| 21 | IN/OUT | VCC12 | VCC12 is connected directly to the +12VDC power supply. These VCC24 pins can be used to supply power to the AOTF Controller instead of supplying power through the +12VDC connector. Alternatively, these VCC12 pins can supply a small amount of power to drive interface circuits, such as the Application Specific Adaptors. |
| 22 | - | GND | Ground Reference. |
| 23 | - | GND | |
| 24 | - | GND | |
| 25 | IN | RXD | Serial Receive Data. The serial signals are jumper configurable for either RS232 or CMOS 3.3V level signals. |
| 26 | IN | CTS | Serial Clear To Send. The serial signals are jumper configurable for either RS232 or CMOS 3.3V level signals. |
| 27 | - | GND | Ground Reference. |
| 28 | IN/OUT | SCL | I2C Clock provides the host with access to the I2C bus on the AOTF Controller. The I2C signals are CMOS 3.3V level signals. |
| 29 | - | GND | Ground Reference. |
| 30 | IN | BLANK+ | The BLANK+/- are an LVDS pair that provide the host with the ability select one of four profiles. |
| 31 | - | GND | Ground Reference. |
| 32 | IN | FSK+ | The FSK+/- are an LVDS pair that provide the host with the ability select one of four profiles. |
| 33 | IN | CHIRP+ | The CHIRP+/- are an LVDS pair that provide the host with the ability to initiate frequency chirps. |
| 34 | | Not Used | Not Used. |
| 35 | IN | ANALOG+ | The ANALOG+/- signals provide a differential analog modulation input for the host environment. The analog voltage can swing from 0V to +10V. The input impedance is 4.3K Ohm. |
| 36 | | Not Used | Not Used. |

  

| Host Modulation | | | |
|---|---|---|---|
| **Pin** | **Direction** | **Name** | **Description** |
| 37 | | Not Used | |
| 38 | | Not Used | |
| 39 | IN | DIN0+ | The DIN0+/- are an LVDS pair that provides the data for the digital modulation. |
| 40 | IN | CLK+ | The CLK+/- are an LVDS pair that provides the clock for the digital modulation. |

**Table 2: Host Modulation Pin Assignment**

  

### *3.2.1. Analog Amplitude Modulation*

The ANALOG+/- signals form a differential pair that is used for analog control of the RF amplitude.

When ANALOG+ and ANALOG- have a relative difference of zero volts, the RF output is at zero. When ANALOG+ is at +10V greater than ANALOG- the RF output is at maximum. The maximum voltage for the differential pair is 10V. The minimum voltage for the differential pair is -5V.

The host environment could supply analog voltage in any of the following forms:

- **-5V to +5V**
  This provides a 10V range. The host environment would drive the ANALOG- and ANALOG+ signals with equal magnitude in opposite directions. When both signals are at 0V would be minimum RF output and when ANALOG- is at -5V and ANALOG+ is at 5V would be the maximum RF output.
- **0V to 10V**
  This provides a 10V range. The host environment would connect the ANALOG- signal to GND and drive the ANALOG+ signal with the 10V analog voltage, where 0V would be minimum RF output and 10V would be the maximum RF output.

*Figure 8* shows the analog RF amplitude modulation controls.

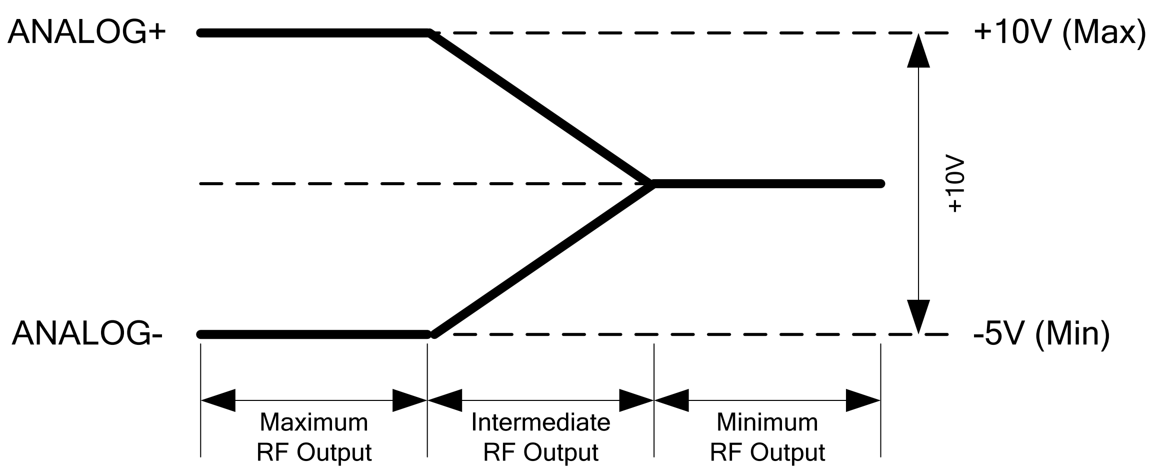


**Figure 8: Analog Amplitude Modulation Waveforms**

### 3.2.2. Digital Amplitude Modulation

The format of the Digital Modulation data is shown in *Figure 9*. The Digital Modulation format uses a serial data stream (DIN0) along with a clock (CLK).

The host transfers Digital Modulation data to the *AOTF Controller* by using a sequence of 17 clocks as shown in *Figure 9*. Each rising edge of the CLK signal is used as a chip select for the DAC chips, and each negative edge of the CLK signal provides a data bit. Each of the negative edges transfers a bit of data as shown in *Table 3*.

| Digital Modulation | | |
|---|---|---|
| **CLK #** | **Positive Edge** | **Negative Edge** |
| 0 | 1<br>Indicates no transfer. | Ignored |
| 1 | 0<br>Indicates a transfer is starting. | BLANK<br>Profile Select 1 |
| 2 | 0<br>Indicates a transfer in progress. | FSK<br>Profile Select 0 |
| 2 | 0<br>Indicates a transfer in progress. | DAC Data bit 14, MSB |
| 3 | 0<br>Indicates a transfer in progress. | DAC Data bit 13 |
| 4 | 0<br>Indicates a transfer in progress. | DAC Data bit 12 |
| 5 | 0<br>Indicates a transfer in progress. | DAC Data bit 11 |
| 6 | 0<br>Indicates a transfer in progress. | DAC Data bit 10 |
| 7 | 0<br>Indicates a transfer in progress. | DAC Data bit 9 |
| 8 | 0<br>Indicates a transfer in progress. | DAC Data bit 8 |
| 9 | 0<br>Indicates a transfer in progress. | DAC Data bit 7 |
| 10 | 0<br>Indicates a transfer in progress. | DAC Data bit 6 |

  

| Digital Modulation | | |
|---|---|---|
| **CLK #** | **Positive Edge** | **Negative Edge** |
| 11 | 0<br>Indicates a transfer in progress. | DAC Data bit 5 |
| 12 | 0<br>Indicates a transfer in progress. | DAC Data bit 4 |
| 13 | 0<br>Indicates a transfer in progress. | DAC Data bit 3 |
| 14 | 0<br>Indicates a transfer in progress. | DAC Data bit 2 |
| 15 | 0<br>Indicates a transfer in progress. | DAC Data bit 1 |
| 16 | 0<br>Indicates a transfer in progress. | DAC Data bit 0 |
| 17 | 0<br>Indicates the end of a transfer. | Ignored |

**Table 3: Digital Modulation**

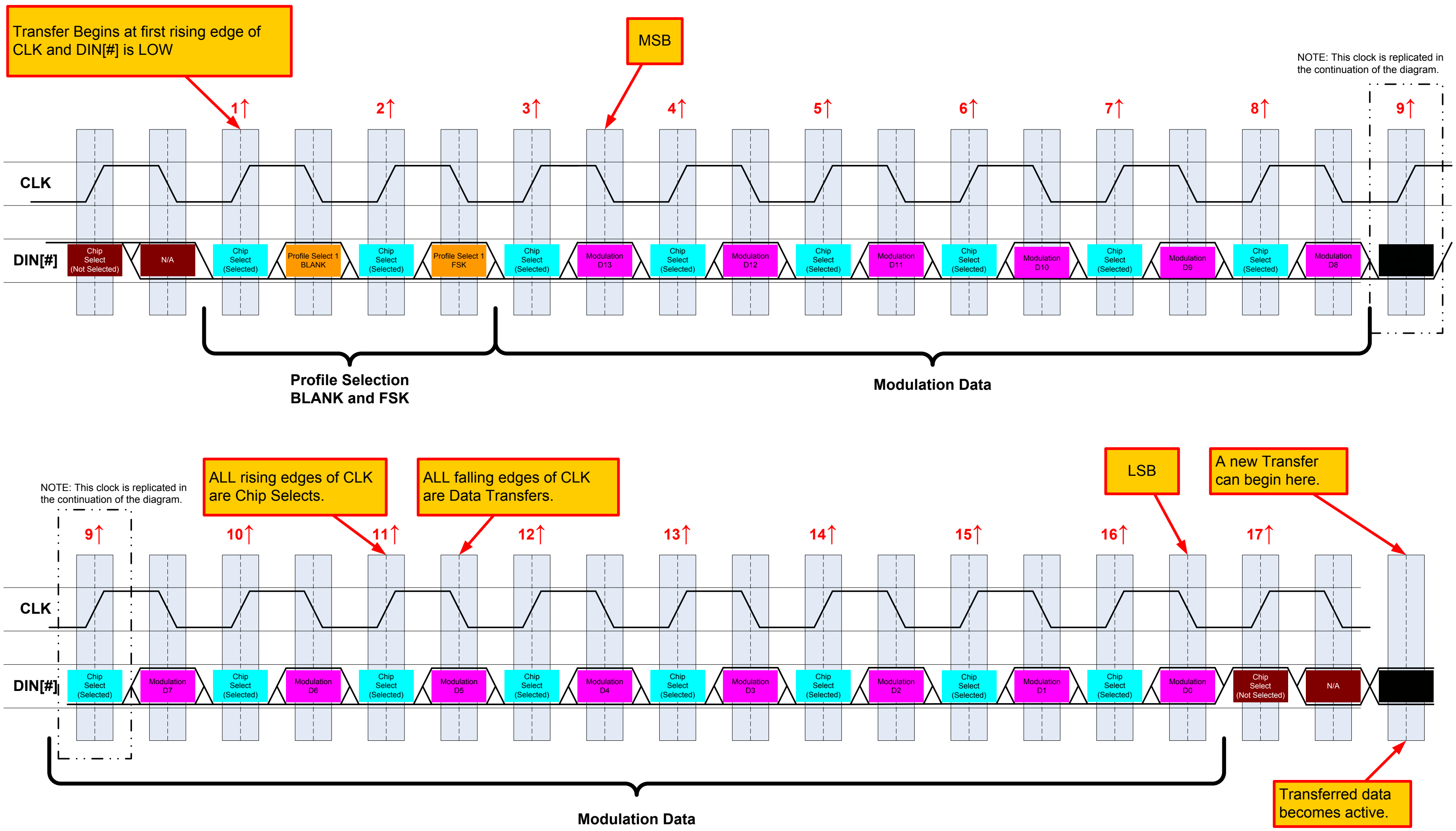


**Figure 9: Digital Modulation Format**

### 3.3. Optical Power Sensor Connector

The Light Power Sensor Connector is a right angle PCB Mount SMA Coax connector.

| Optical Power Sensor Connector | | |
|---|---|---|
| **Pin** | **Direction** | **Description** |
| 1 (center) | Input | Optical Power Sensor Input.<br>Input impedance is 100K Ohms.<br>Voltage should be proportional to light intensity.<br>Maximum Input voltage 3.3V. |
| 2 (shield) | - | GND |

**Table 4: Optical Power Sensor Connector**

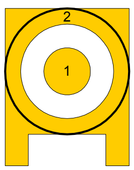


**Figure 10: Optical Power Sensor Connector**

The AtoD input circuitry has variable gain to accommodate differences in Optical Power Meter output levels. The gain is controlled by digitally controlled potentiometers that can be adjusted by the firmware of the AOTF Controller (the “adc gain” command).

The gain is adjustable according to the following formula:

$$A = (R1 + 100K – Rx) / (R2 + Rx)$$

Where:

A = Gain
R1 = 1K
R2 = 1K
Rx = Potentiometer resistance, which is between 0 and 100K in 256 increments. Each increment represents approximately 408 Ohms.

This gives an approximate gain range between 0.01 and 101. For unity gain Rx should be configured for 50K Ohms (use the command “adc gain 127”).

### 3.4. USB Connector

The USB Connector is a standard USB-B connector that the USB Specifications calls out for peripheral devices.

| USB Connector | | |
|---|---|---|
| **Pin** | **Direction** | **Description** |
| 1 | - | USB Power |
| 2 | Bidirectional | USBDM Differential Data Minus |
| 3 | Bidirectional | USBDP Differential Data Plus |
| 4 | - | GND |

**Table 5: USB Connector**

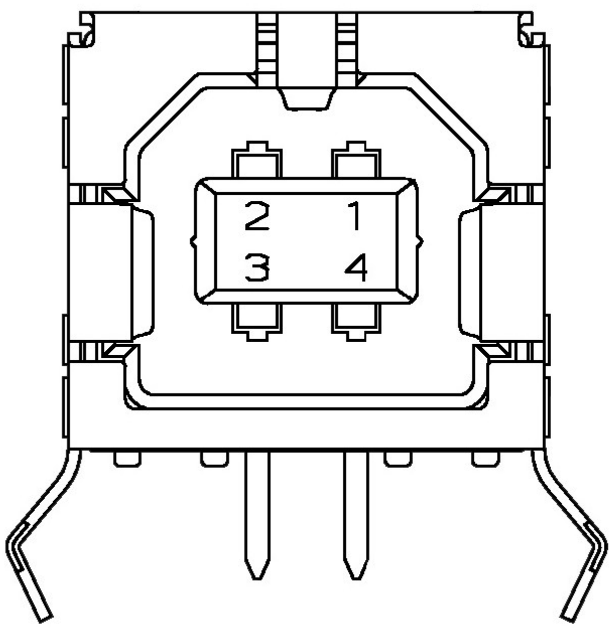


**Figure 11: USB Connector**

### *3.5. Temperature Sensor Board Connector*

The Temperature Sensor Board Connector is a panel mount circular DIN style.

| Temperature Sensor Board Connector | | |
|---|---|---|
| **Pin** | **Direction** | **Description** |
| Shield | - | GND |
| 1 | Input | Temperature output from LM60 |
| 2 | Bidir | I2C Data |
| 3 | Bidir | I2C Clock |
| 4 | - | VCC3.3 |

**Table 6: Temperature Sensor Connector**

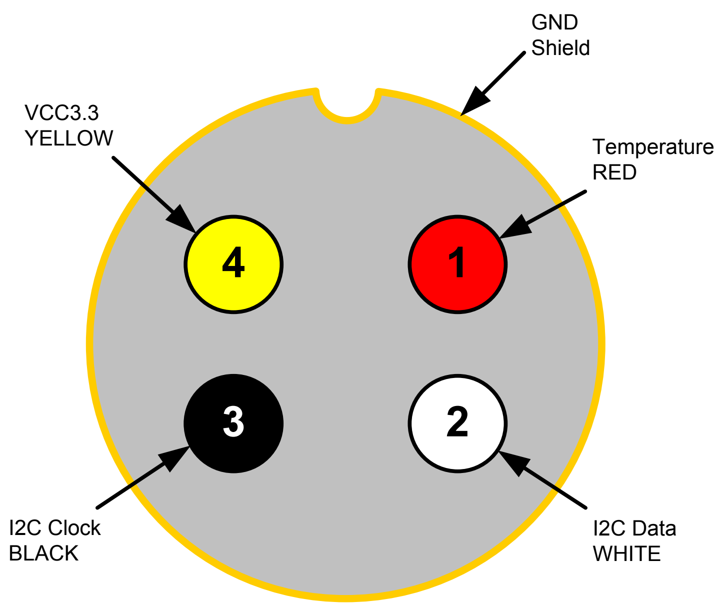


**Figure 12: Temperature Sensor Connector**

### 3.6. RF Output Connector

The RF Output Connector is a right angle PCB Mount SMA Coax connector.

| RF Output Connector | | |
|---|---|---|
| **Pin** | **Direction** | **Description** |
| 1 (center) | Output | RF Output.<br>50 Ohms impedance. |
| 2 (shield) | - | GND |

**Table 7: RF Output Connector**

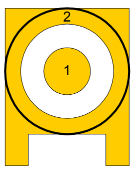


**Figure 13: RF Output Connector**