Exemplar®

Smart CCD Spectrometer
User Manual

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1. Introduction

The Exemplar® is the next step in the evolution of miniature CCD spectrometers. It is the first smart spectrometer featuring on board data processing, USB 3.0 communication, and temperature compensation. The Exemplar is also optimized for multi-channel operation featuring ultra-low trigger delay, ultra-low gate jitter, and super speed data transfer. Additionally, the Exemplar features a 2048 element detector and a built-in 16-bit digitizer with a >2.0 MHz readout speed.

2. Exemplar Spectral Acquisition Modes

There are three spectral acquisition modes as described below.

2.1. Normal Scan Mode

In this acquisition mode, the spectrometer acquires data which is received by the PC/Software through the USB. The user can then perform post data manipulation such as averaging, smoothing, and dark compensation. Continuous spectra acquisition is possible in normal scan mode. At an integration time of 1.0ms the maximum frame rate is less than 500 spectra per second in this mode.

2.2. Smart Scan Mode

Smart Scan allows for data manipulation to take place in the Exemplar's on-board processor including averaging, smoothing, and dark compensation, in that order. The user has the ability to send a command with flags for each of the methods. The internal data processing engine can handle any combination of these methods.

Table 1 details the frame rate at different combinations of methods at an integration time of 1ms.

Processing	Estimated Time Needed
Smoothing	23.5 (ms)
Dark Compensation	7.2 (ms)
Averaging N Time	$T = 4.55(ms) \times N + 8.13$ (ms)

2.3. Burst Scan Mode

This is the fastest spectral acquisition mode. After a burst mode, spectral acquisition command is received, and the internal spectral acquisition engine will continuously send the spectra back to the PC until the preset number of spectra is reached. In this mode the minimum integration time must be set to 1050us, as the events of signal integration and spectral readout plus sending of data are processed simultaneously. There is no time gap between the consecutive integration periods, which enables this spectrometer to be a suitable device for time-of-flight event capturing.

3. Specifications

See product data sheets for specifications for the Exemplar model BRC115P-V and BRC115P-U (model LS)

4. Check Contents

Before installation please check your system contents. They may include:

- Exemplar™ Spectrometer unit
- USB 3.0 Cable
- AUX Port Cable
- BWSpec4™ software on a USB Drive

| Exemplar™ Spectrometer | USB 3.0 Cable | Aux Port Cable |

Software USB Drive

5. Installation

Software / Hardware Installation:

There is a BWSpec installation guide located on your USB drive. Refer to this guide for full installation instructions

6. Operating Software BWSpec Quick Start Guide

6.1. Getting to Know BWSpec Graphic User Interface

The BWSpec operating software has a graphic user interface which consists of a menu bar, quick access bar, graphic area, message bar and control panel.
Reference the BWSpec4TM user manual located on your USB drive for more information on how the software works.

6.2. Quick Start

1. Run BWSpec from the shortcut icon that will have been placed on your desktop after installation.

2. From the toolbar, select "Acquire Continuously"

3. Aim the spectrometer's SMA port (light input) towards a broadband light source; for example a tungsten bulb, light bulb, or overhead lights.

4. You should see a spectral response being displayed in the BWSpec4TM software window. The spectral response will change if the integration time is adjusted from the toolbar.
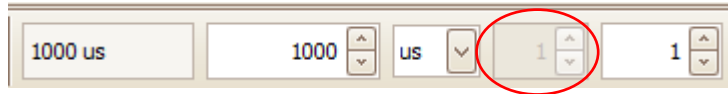
Exemplar®
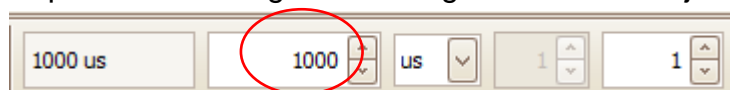
Note: There are different ways in which light can be directed into the spectrometer's SMA port and different light sources which can be used.

For more information on these types of setups, please visit our website: www.bwtek.com.

Multiplier Function
When using the Exemplar spectrometer, the "Multiplier" function is not available and will be greyed out:

7. Auxiliary Port Function

Exemplar is capable of monitoring and controlling both digital and analog signals through the auxiliary port on the side of the spectrometer. See Appendix C for a table containing the description and function details for each pin of the auxiliary port. These standard functions are accessible through SDK. Moreover, if the customer wants to create their own input/output correlations, B&W Tek can configure a customized pin definition.

7.1. External Trigger Function

The Exemplar has a built in external trigger option. External triggering of the spectrometer can be achieved by using the 12 pin connector located at the rear panel of the spectrometer and its associated pins. Make sure that the external trigger checkbox under the "Acquire Control" menu in BWSpec is checked before the spectrometer can be ready to respond to an external trigger. The typical time delay between arrival of a falling edge and the start of a new integration time is less than 35ns. Within the specified short delay, the spectrometer will begin a new integration period and will last for a complete integration cycle (Ex: 1 scan with 10 averages requires only 10 pulse). The supplied trigger signal is required to be a TTL compatible pulse with an optimal width of 30~100us. The trigger is falling edge effective. The maximum trigger signal voltage should not exceed +5.5 V DC. To disable the external trigger mode, check off the option in the checkbox under the "Acquire Control" menu.

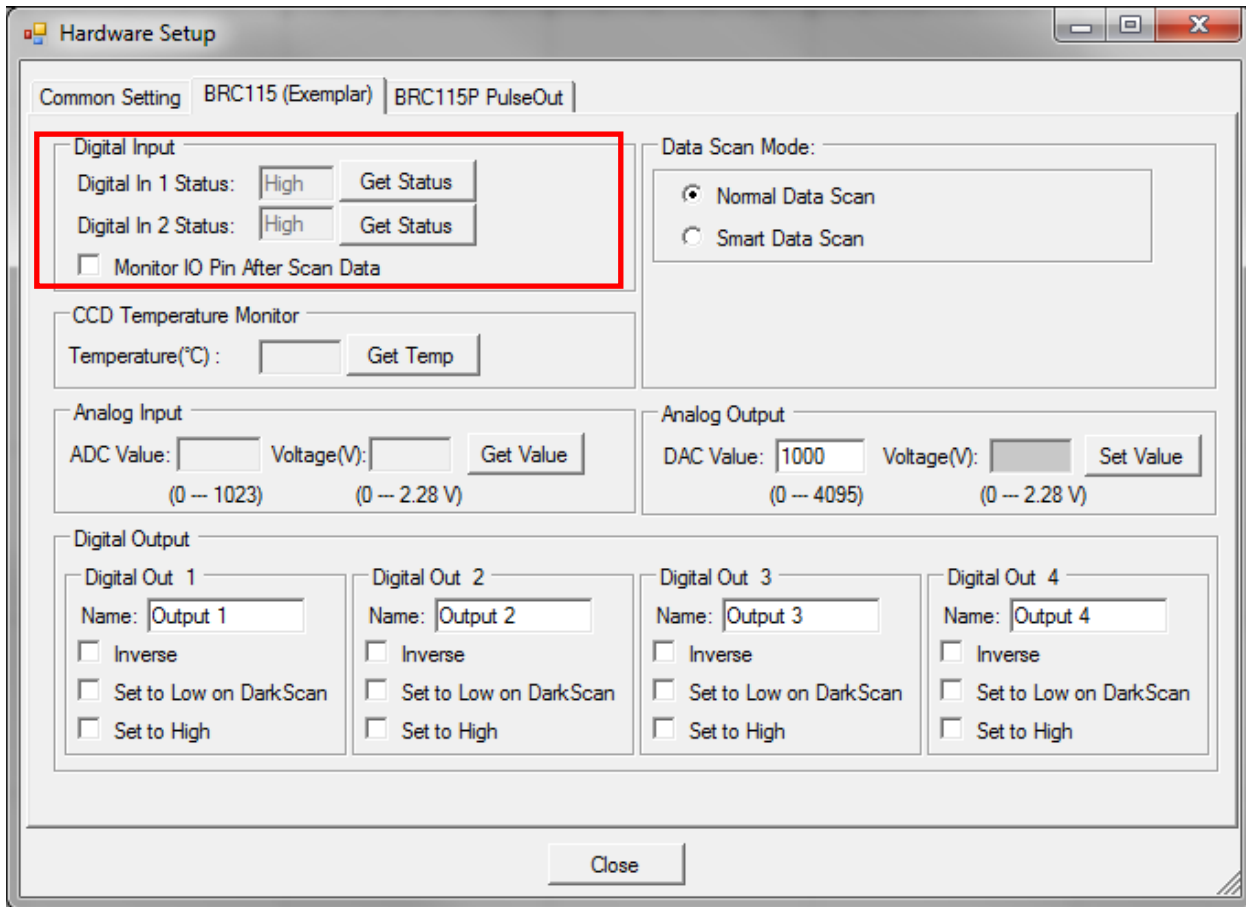Go to **Appendix C – Aux Port** for pins assignments

8. Hardware Setup

The Exemplar allows for advanced hardware control features which can be found by following the path below.
Menu Bar → Setup → Hardware Setup
Click on the "BRC115 (Exemplar)" tab

8.1. Digital Input Section:

The **"Get Status"** button will return a 'High' or 'Low' value depending on the TTL Digital Signal being applied to the 'Digital In 1' and 'Digital In 2' pins.

Monitor IO Pin After Scan: when enabled the Status of the 'Digital In 1' and 'Digital In 2' pins will be updated after each scan. The Digital In 1 Status and Digital In 2 Status will be displayed below the graph in the main BWSpec Window.   Statuses will appear after the first acquisition. Location will vary depending on the size of the main BWSpec window.
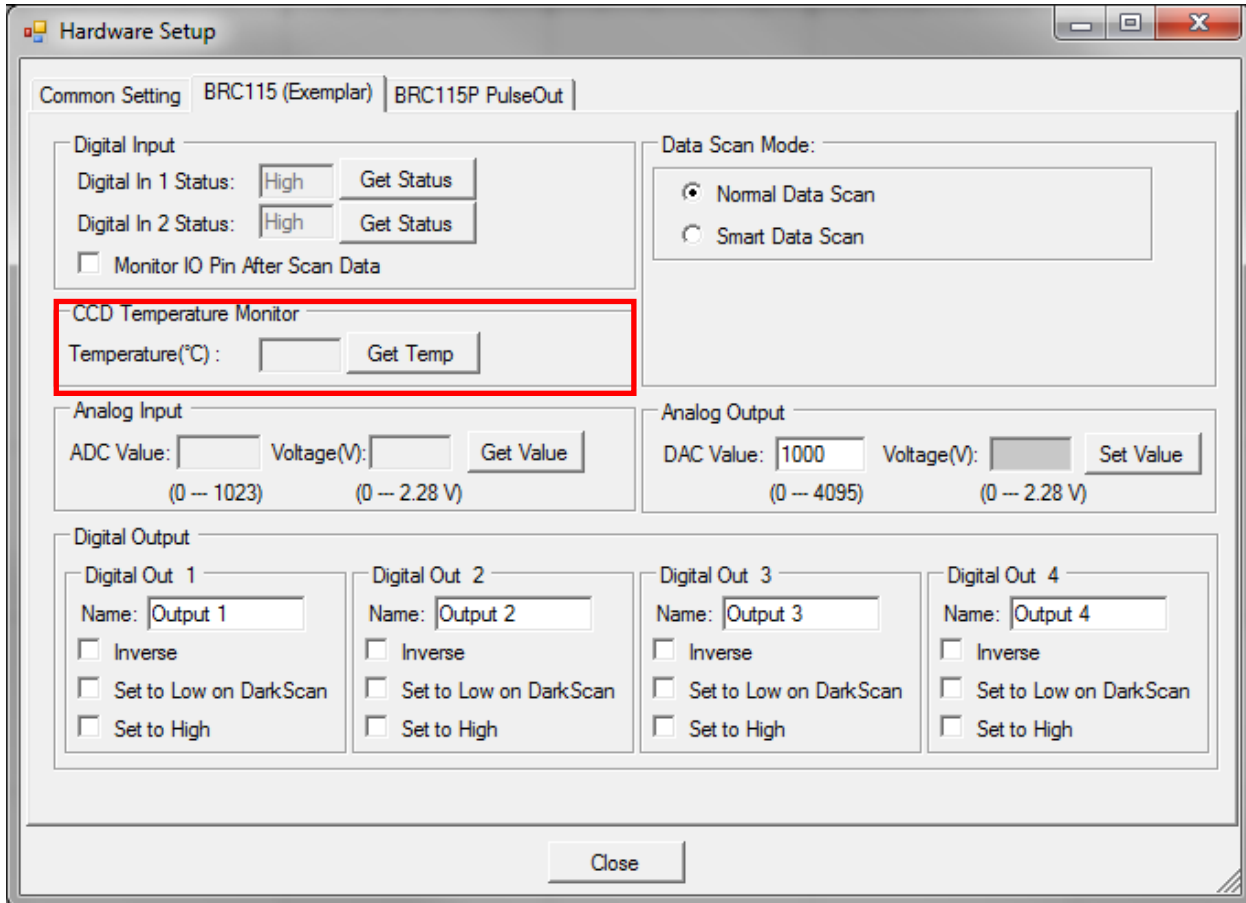
"Full Screen" Window Display
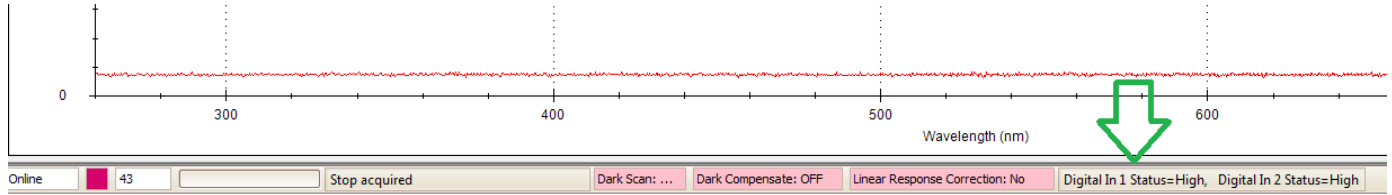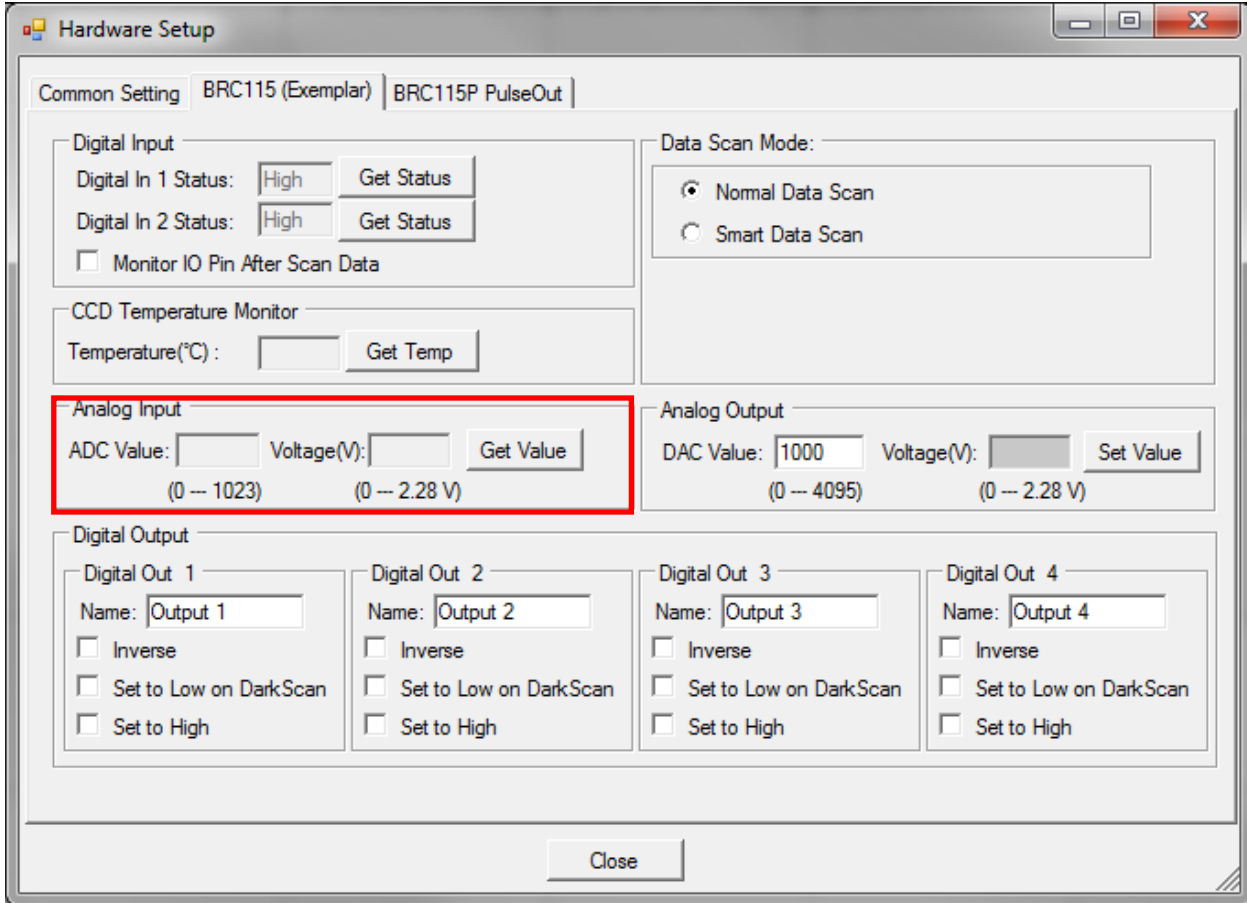

"Reduced"/"Minimized" Window Display
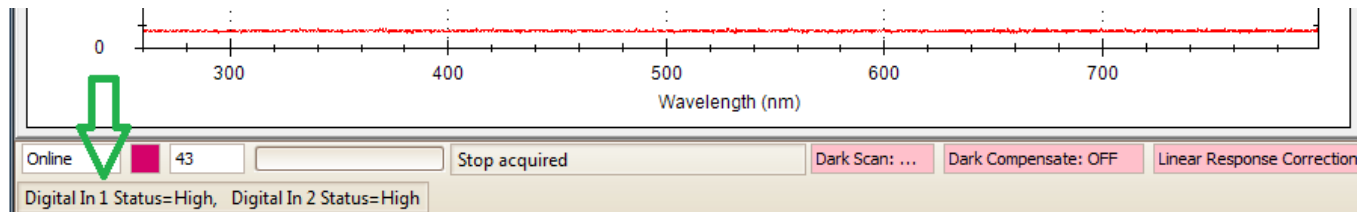
8.2. Temperature Monitor Section:

The **"Get Temp"** button will return the temperature of the PCB, which is also the CCD sensor reference temperature.
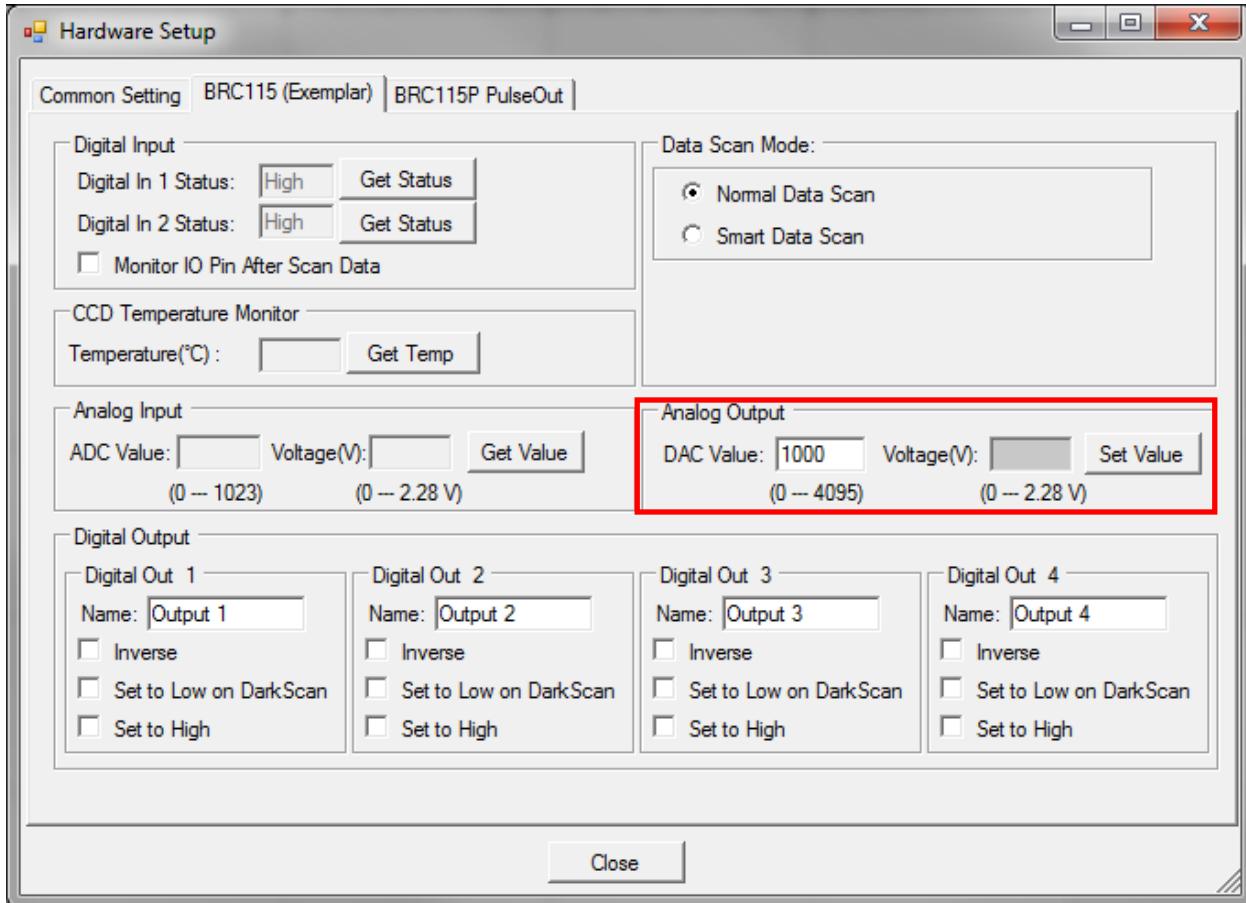
8.3. Analog Input Section:

ADC Value: will return the digital value of the analog signal applied to the "Analog Input" pin.
*ADC Value = (Voltage / 2.28) * 1024*

Voltage (V): will return the analog voltage value of the analog signal applied to the "Analog Input" pin.
*Voltage = (ADC value / 1024) * 2.28*

(Reference the "Auxiliary Port Function" section in this user manual)
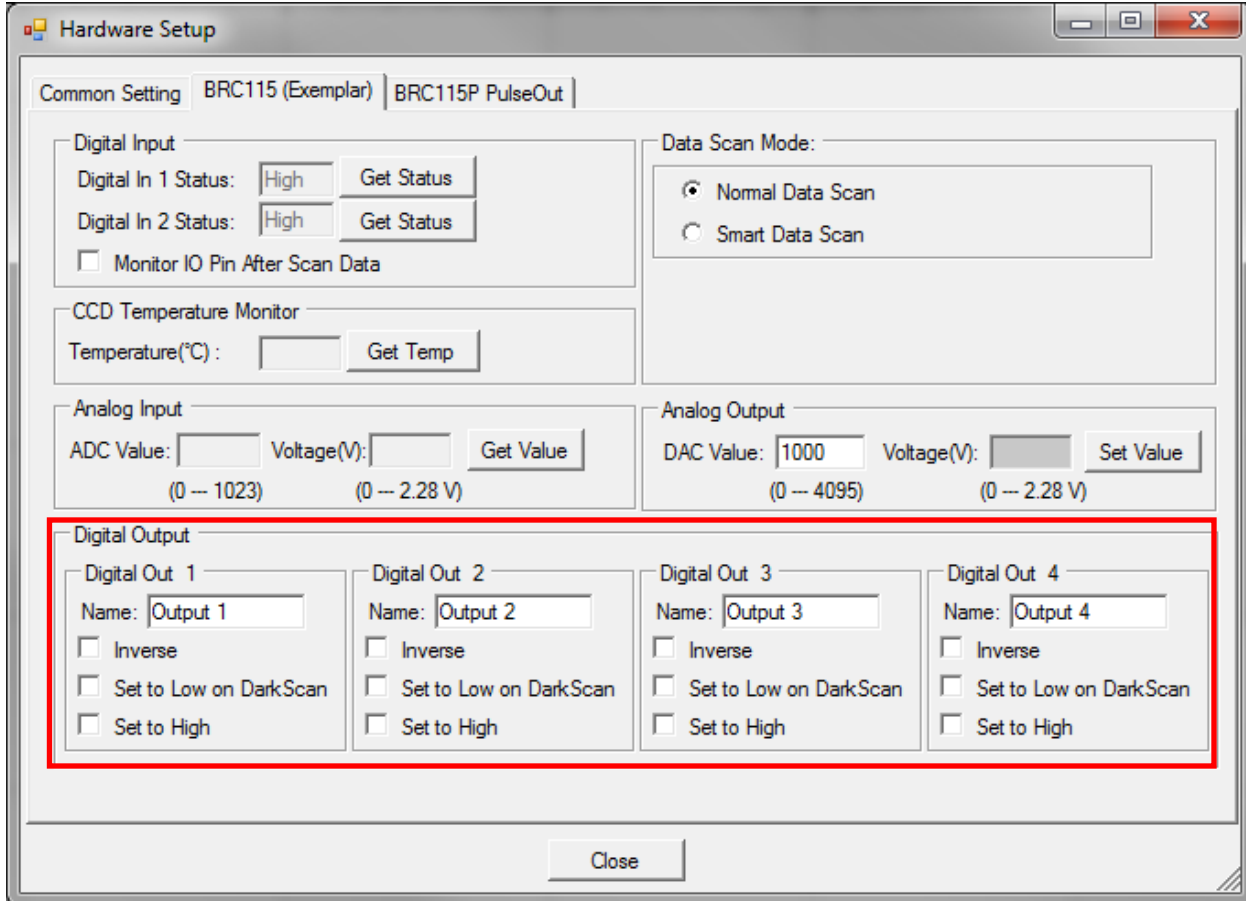
8.4. Analog Output Section:

DAC Value: can be set to a 12-bit digital signal range from 0 – 4095 when the "Set Value" button is pressed. This will output a voltage range of 0 – 2.28 volts to the "Analog Output" pin.
*Voltage = (DAC value / 4096) * 2.28*

(Reference the "Auxiliary Port Function" section in this user manual)

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8.5. Digital Output Section:

"Digital Out 1" – "Digital Out 4" sections relate to the corresponding "Digital Out #" pin on the Auxiliary Port.

(Reference the "Auxiliary Port Function" section in this user manual)

- **"Name:"** field can be renamed to an application appropriate function, which will be displayed under the "Acquire Control" section the BWSpec 4 main window.
- **Inverse Checkbox:** When activated, inverts the output status.
- **Set to Low on Dark Scan:** This will output the configured signal through the corresponding digital out pin when a dark scan is taken in BWSpec. (For example, you could use this to close an external shutter)
- **Set to High**: By default the output signals are set to LOW. When checked, the output is set to HIGH through the corresponding digital out pin. When enabled the checkbox
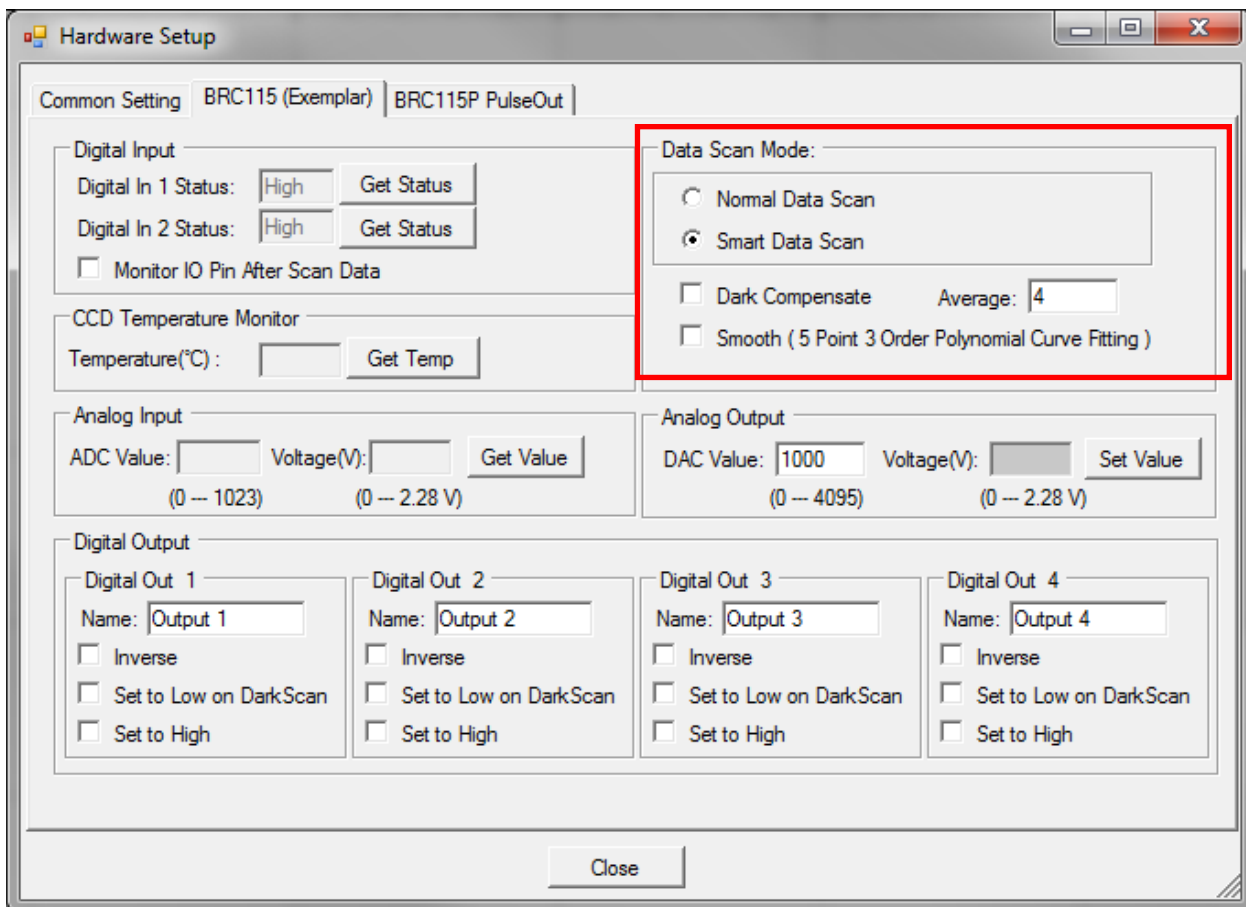
status will also be reflected under the "Acquire Control" section the BWSpec4 main window.

Reference the following "Truth Table" for output signal configurations.

Truth Table:

Inverse Check Box	Set to High Check Box	Output (0 = LOW, 1 = HIGH)
0	0	0
0	1	1
1	0	1
1	1	0

8.6. Data Scan Mode Section:

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The Exemplar has three data scan modes, **Normal Scan, Smart Scan** and **Burst Scan**.

8.6.1. Normal Data Scan

"Normal Data Scan", when selected, allows the spectrometer to acquire and transmit data. Data manipulation is then accomplished on the software/computer. Averaging, smoothing and dark compensation can be acquired and controlled here, for example.

8.6.2. Smart Data Scan:

"Smart Data Scan" allows for data manipulation to take place inside the spectrometer allowing for smart spectra acquisition. Smart scan features are:

- **Dark Compensate:** This will automatically adjust the baseline of the spectrometer so that the dark current is automatically removed from the collected data.
- **Average:** X number of scans will be taken at the given integration time and the average of all of these scans will be displayed in BWSpec. Hardware averages are limited to a maximum of 255 scans.
- **Smooth:** Smoothing will be applied to all data outputted to BWSpec.

8.6.3. Burst Data Scan

Burst mode allows for the fastest data acquisition possible in the spectrometer by limiting overhead processing from data transfer to the computer and saving data. In burst mode, the spectrometer will continuously acquire and transfer data to the PC without a time gap between successive spectra.

Burst mode is located under the Timeline plugin:

- **Enable the Timeline plugin-**
    Menu Bar --> Plug-in --> Plug-in Manager
    Locate the "Timeline Plug-in" and enable the Check box.
    Click "OK" to enable.

- **Open Timeline from the menu-**
   Menu Bar --> Tools --> Timeline --> Timeline (Equal Integration Time)

Notes:

- Burst Mode will only work with the set integration time >= 1050us, multiplier = 1 and averaging = 1 (1050us, or 1.05ms, is the minimum integration time allowed in burst mode). If the integration time is set to a lower setting, the integration time will be automatically updated to 1050us in burst data scan.
- The highest number of scans the spectrometer can acquire is 16,000.
- Smart data scan cannot be used in conjunction with burst mode.
- "Time Average" from the main BWSpec window will have no effect when acquiring data.
- "Multiplier" from the main BWSpec window will have no effect when acquiring data.

8.6.3.1. Setup
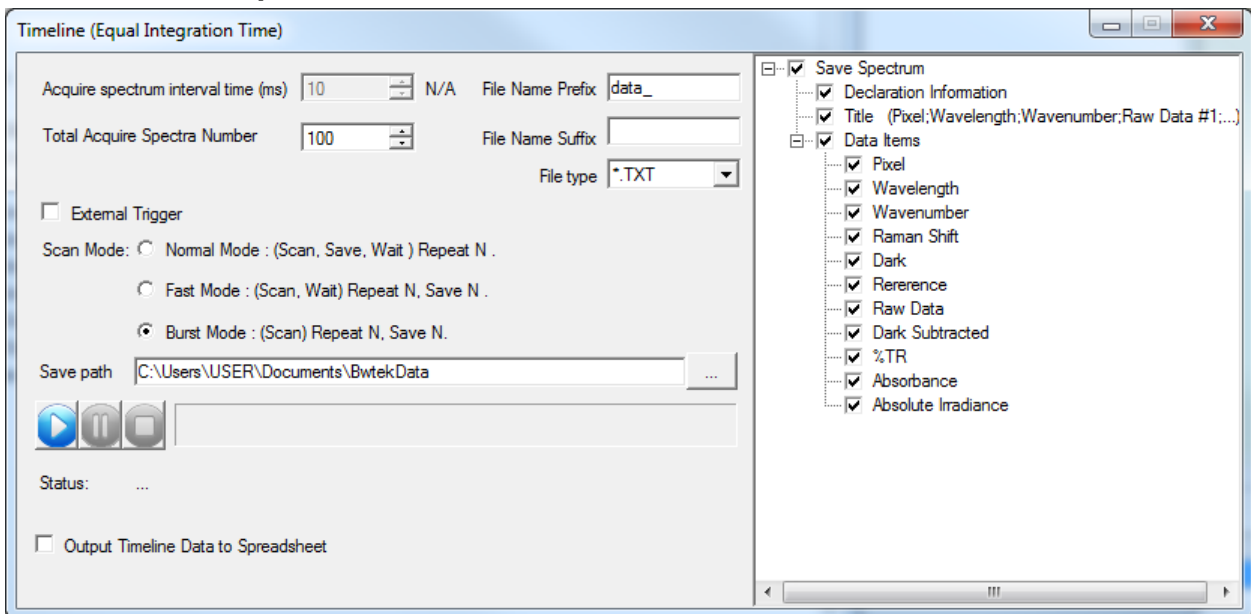
- **Total Acquire Spectra Number:** This sets the number of scans to be performed by the spectrometer.
- **File Name Prefix:** This sets the prefix for the saved spectra
- **File Name Suffix:** This sets the suffix for the saved spectra
- **File type:** This sets the saved file type for the saved spectra.
  Options: .txt, .csv, .BWRam, .SPC
- **Save path:** This sets the location where the data will be saved once complete.
- The right side of the window allows the user to select what specific data is to be saved.

- These control the progress of the burst mode. Press the 'Play' button to begin acquiring.
- **Output Timeline Data to Spreadsheet:** This outputs the saved data to an Excel Spreadsheet.

Notes

1. You must have **MS Excel** installed on your computer for this feature to work.
2. **DO NOT click** on the excel worksheet while it is being written. This will disrupt the output process and you will lose the data.
3. For outputting to Excel, you are **limited by the maximum number of columns (6)** for the number of scan you can have outputted.

8.7. Pulse Output, BRC115P PulseOut
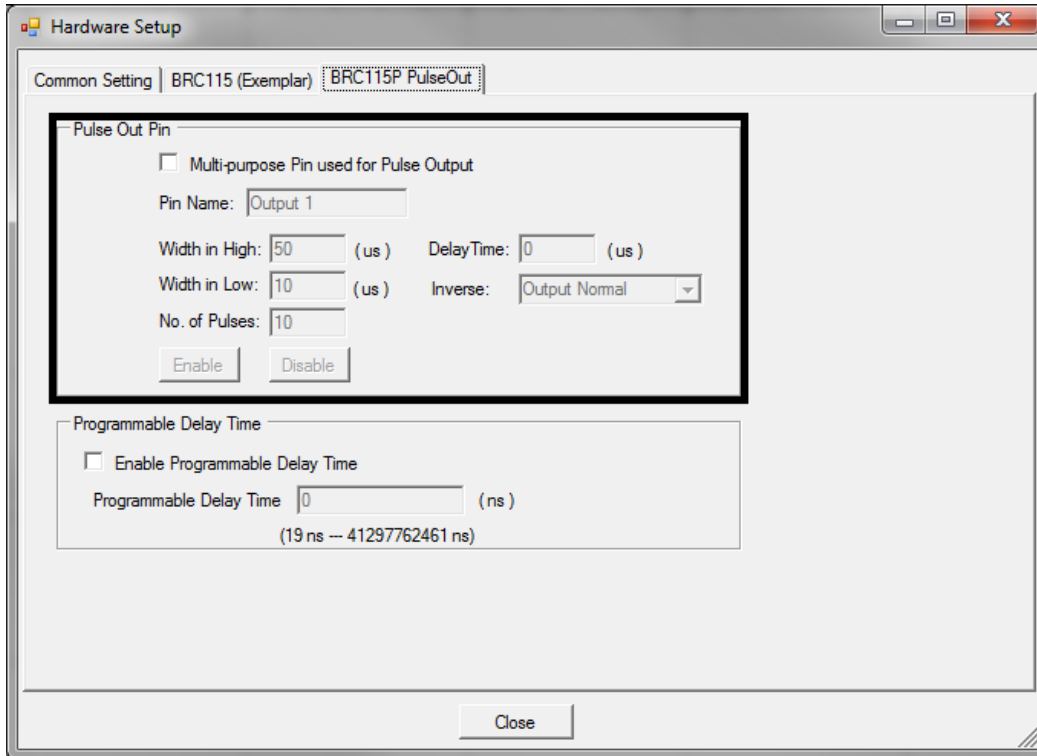
Pulse Chain Output function generates a user configured pulse chain while the spectrometer is integrating.

- **Multi-Purpose Pin Used for Pulse Output:** activates this function to be used for the multi-purpose pin. (See section 7 for pin definitions.)
- **Pin Name:** User defined name to easily identify function enable/disable under "Acquire Control" in the spectrometer control panel.
- **Width in High:** Period of time where pulse signal is a TTL high (5V) during 1 period (low if output inverse).
- **Width in Low:** Period of time where pulse signal is a TTL low (0V) during 1 period (high if output inverse).
- **No. of Pulses:** Determines the number of pulses the spectrometer should send out during a scan.
- **Delay Time:** Determines period of time before first pulse is generated.
- **Inverse:** Allows ability to invert the output signal.

Notes:

- Click "Enable" to send parameters to the spectrometer before taking a measurement.
- "Width in High", "Width in Low", and "Number of Pulses" are limited to total integration time. Set desired integration time before setting parameters for pulse output. Equation is as follows:

  Pulse Time=(Width in High + Width in Low)*No. of Pulses

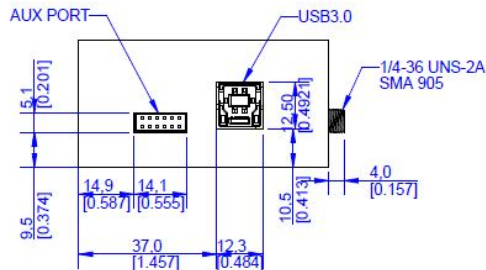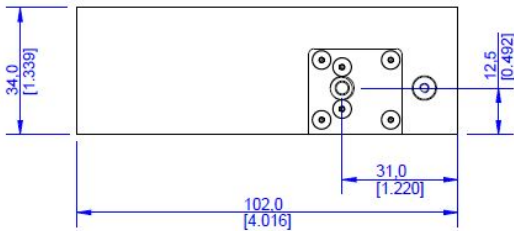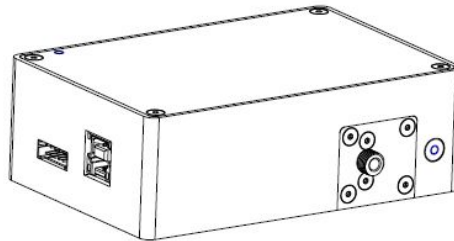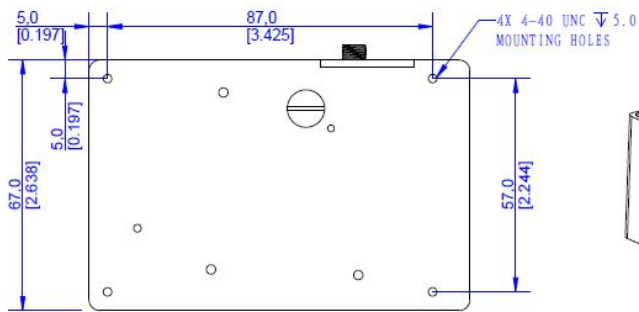- Output 1 from digital output (section 8.4) will be disabled while pulse output is activated.

8.8. Programmable Delay Time
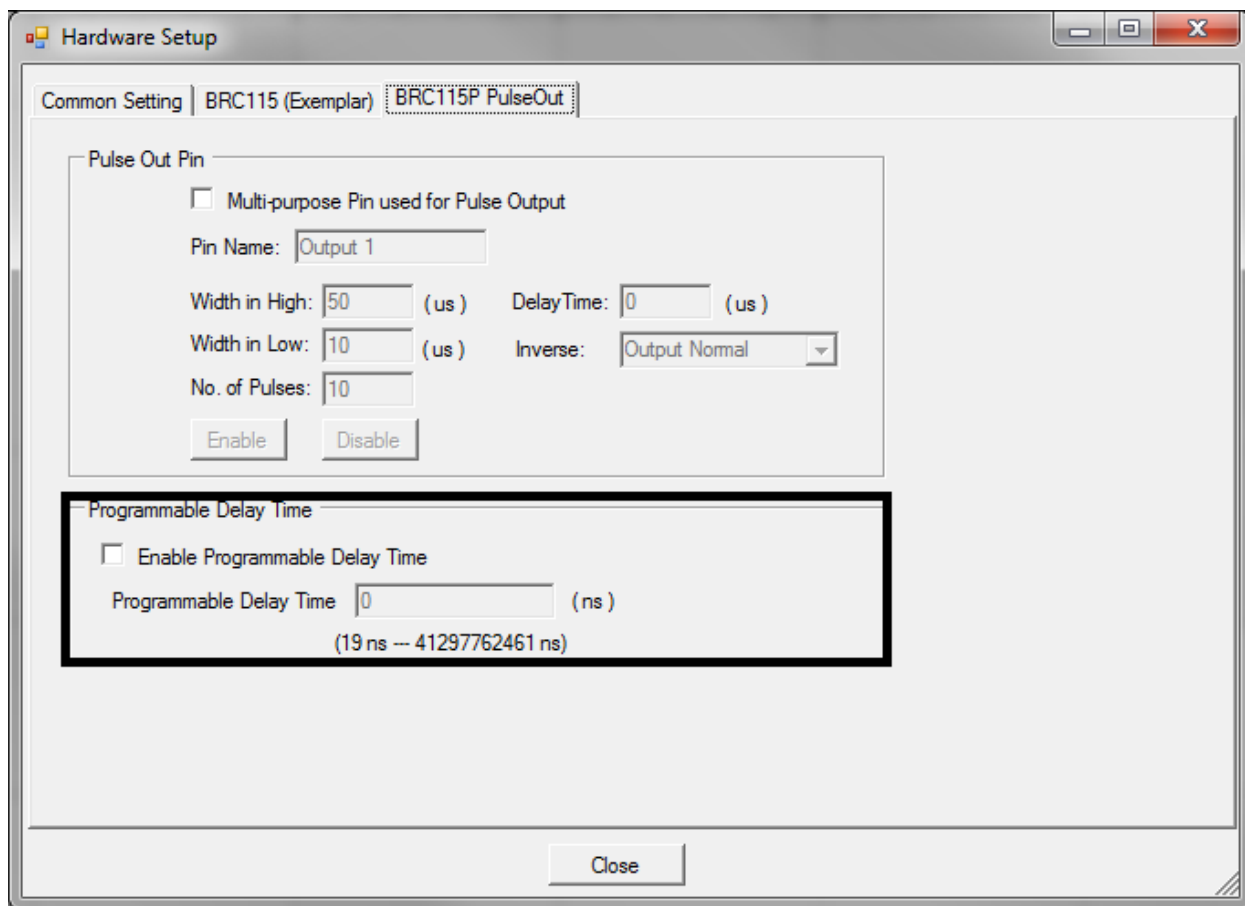
"Programamable Delay Time" adds a user defined external trigger delay between when a scan event is initiated and when the actual scan begins. BRC115P spectrometers can be programmed to have a external trigger delay between 19ns and 41297762461ns (~41 seconds).

Appendix A: Dimensional Drawing - BRC115P-V
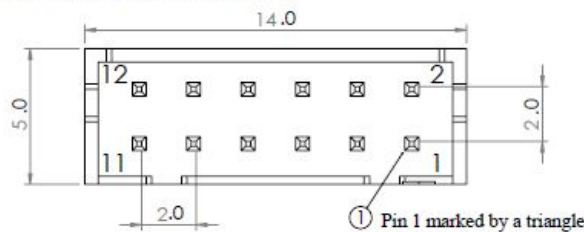
Appendix B: Dimensional Drawing - BRC115P-U

Appendix C: Auxilary Port Pin Assignments
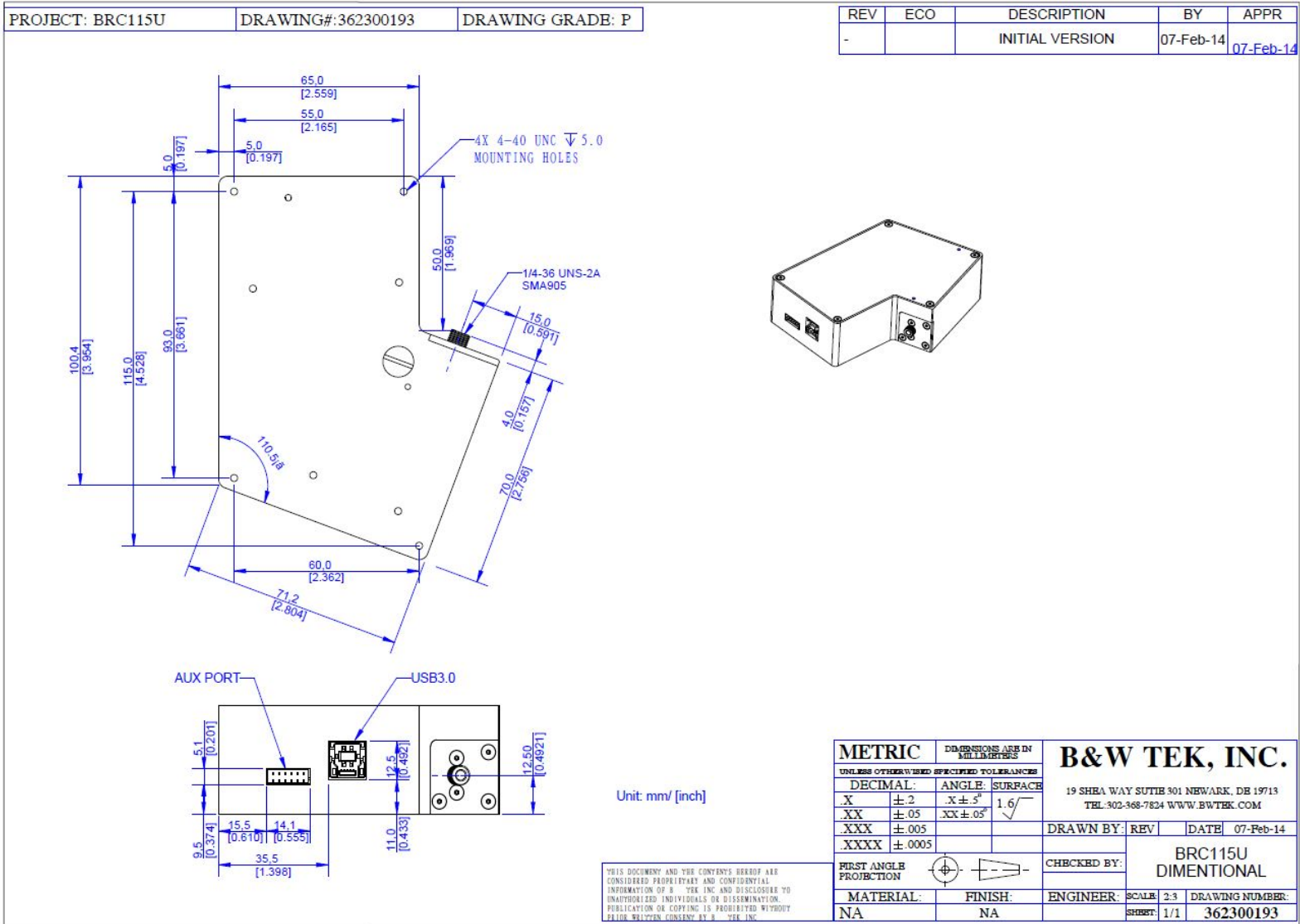
Table 1. Auxiliary Port Pin Assignments

Pin	IO	Description	Comment	Suggested Wire Color
1	Input	Device Reset	Microcontroller hardware rest input and low level active. The minimum level low width is 1 ms and minimum level high width is 5ms to guarantee proper reset function. Input high level 3.3 V with internal 10 kohm pull-up resistor.	Red
2	Output	Digital Out 2	TTL OUTPUT 2. TTL 5 V compatible, standard high level output current 20 mA, standard low level input current 20 mA.	Brown
3	Output	Digital Out 1 / Pulse Chain Output	TTL OUTPUT 1. TTL 5 V compatible, standard high level output current 20 mA, standard low level input current 20 mA. Pin also used for Pulse Chain Ouput function.	Yellow
4	Input	Digital In 2	TTL INPUT 2. TTL 5 V compatible, standard high level input current 20 mA, standard low level output current 20 mA. Internal 10 kohm pull-up resistor available.	Green
5	Input	Digital In 1	TTL INPUT 1. TTL 5 V compatible, standard high level input current 20 mA, standard low level output current 20 mA. . Internal 10 kohm pull-up resistor available.	Orange
6	Input / Output	Ground	Ground	Black
7	Output	Analog Output	12-bit resolution DAC using resistor ladder method. The analog output range is 0 ~2.28 V.	Yellow
8	Input	External trigger	External trigger pulse input. TTL 5 V compatible. Falling edge effective. Recommended level low width is 30~100 us. Internal 10 kohm pull-up resistor available.	Red
9	Ground	Ground	Ground	Black
10	Input	Analog Input	10-bit resolution ADC using successive approximation method. The analog input range is 0 ~ 2.28 V.	Brown
11	Output	Digital Out 3	TTL OUTPUT 3. TTL 5 V compatible, standard high level output current 20 mA, standard low level input current 20 mA.	Green
12	Output	Digital Out 4	TTL OUTPUT 4. TTL 5 V compatible, standard high level output current 20 mA, standard low level input current 20 mA.	Orange

Figure 1. Spectrometer Connector Dimension

① Pin 1 marked by a triangle