

Port City Instruments, LLC
SINGLE-LINE SPECTROSCOPY SOLUTIONS

PCI-FPGA-1B

User Guide

Rev 1.0 (Nov. 2012)



Port City Instruments, LLC

8209 Market Street, Suite A271 ❖ Wilmington, NC 28411
(Tel) 866-456-2488 ❖ (Web) www.portcityinstruments.com

Copyright © 2012 Port City Instruments, LLC. All Rights Reserved.

This document may not be copied, disclosed, transferred, or modified without the prior written consent of Port City Instruments, LLC. Port City Instruments, LLC assumes no responsibility or liability for any errors or inaccuracies that may appear in this manual. Port City Instruments, LLC reserves the right to modify the products and product specifications described in this manual without advance notice.

Port City Instruments, LLC is not responsible for any direct, indirect, or consequential damage or liability caused by improper use of this manual or the product.

Trademarks

The trademarks, logos, and service marks displayed in this manual are the property of Port City Instruments, LLC or other third parties. Users are not permitted to use these marks without the prior written consent of the company.

All other trademarks mentioned in this document are the property of their respective owners.

Document Change History

Rev #	Date	Changes
1.0	November, 2012	Initial Release (for Rev B PCI-FPGA-1A board).

Contents

1	INTRODUCTION	1
1.1	COMPANY OVERVIEW	1
1.2	PRODUCT OVERVIEW	1
2	SOFTWARE INSTALLATION	2
2.1	FLASH PROGRAMMING	2
2.1.0	<i>Location of the software and instructions</i>	2
2.1.1	<i>Installing the software</i>	2
2.1.2	<i>Onboard flash parameters</i>	2
3	CONNECTOR DESCRIPTIONS	4
3.1	POWER (REAR PANEL).....	4
3.2	USB (REAR PANEL)	4
3.3	TEMPERATURE SENSOR INPUTS (REAR PANEL).....	4
3.4	TIME CONSTANT SELECTION (REAR PANEL).....	5
3.5	DETECTOR INPUTS (FRONT PANEL).....	5
3.6	LASER DRIVE (FRONT PANEL)	6
3.7	SPECTRUM OUTPUTS (FRONT PANEL).....	7
3.8	TRIGGER OUTPUTS (FRONT PANEL)	7
3.9	TEMPERATURE SENSOR OUTPUTS (FRONT PANEL).....	7
3.10	PRESSURE SENSOR I/O (FRONT PANEL).....	8
APPENDIX A:	CONVERSIONS	9
A.1	SENSOR CONVERSIONS	9
	PRESSURE SENSOR CONVERSIONS (ABSOLUTE P SENSORS)	9
	PRTD CONVERSION	9

1 Introduction

1.1 Company overview

Port City Instruments, LLC provides scientific and engineering instrumentation and support services for industrial, university and government researchers working in the fields of single-line spectroscopy for gas detection. Products include tunable diode laser spectrometer controllers (board level and packaged), custom research-grade laser hygrometers and other laser-based gas sensors, and accessory boards for thermal control and pressure sensor conditioning. The company is located in Wilmington, North Carolina, USA.

1.2 Product overview

The PCI-FPGA-1B module contains our PCI-FPGA-1A spectrometer controller board and provides easy connections to the board's functions. This module is cable-compatible with the PCI-FPGA-1C data acquisition and display module, which can be used for real time graphical display and logging of spectra produced by -1B module.

This manual describes the signal connections to/from the -1B module only. Please consult the PCI-FPGA-1A user manual (included, or available for download from our website) for full descriptions of the circuit board and functions of the various jumpers and options accessible directly on the controller board. The default setup is for a DFB laser and InGaAs detector (2.5V reverse biased).



Figure 1. Front panel containing detector input connections, laser drive output, and outputs for spectra, triggers, temperature and pressure signals.



Figure 2. Back panel containing a DIP switch for time constant selection, USB type B port for flash programming, and screw terminals for power input and temperature sensor inputs.

2 Software Installation

2.1 Flash Programming

Before the system can be used you must install the flash programming software as described in the PCI-FPGA-1A manual.

2.1.0 Location of the software and instructions

Software to program the on-board flash, as well as user manuals for both the -1A and -1B modules are available for download from our website at:

<http://www.portcityinstruments.com/downloads>

Download the following files from the website link above:

- The flash programming software (PCI_FPGA_Install.zip)
- -1A User Manual (PCI_FPGA_1A_UserGuide_RevB.PDF)
- -1B User Manual (PCI_FPGA_1B_UserGuide_RevB.PDF).

2.1.1 Installing the software

Install the flash programming software, following the instructions in the -1A manual or the Quick Start Guide included in the original shipment. Unzip the flash programming files into any folder on your hard drive and double click the **PCI-FPGA_setup.exe** file to complete the installation. Skip any messages about certificates and the the control program will appear in the Windows START menu with the filename **PCI_FPGA-1 Controller**. This can be copied to the desktop for easier access by right clicking on the filename under the START menu, and selecting Send To > Desktop (Create Icon).

The -1A manual contains details of the controller board inside the -1B module and how to configure the board for a specific combination of laser and detector.

2.1.2 Onboard flash parameters

The onboard flash stores parameters that control the laser scan current:

- scan waveform definition
- 1f modulation amplitude
- length of a laser off pulse at the start of the laser scan

It also stores the 2f demodulator settings

- Phase
- Gain
- Offset
- Internal filter bandwidth

By default, the flash is configured with typical settings for a DFB laser and moderate signal amplitudes.

Be sure to configure the flash properly for your specific laser before continuing, and follow the procedures described in the -1A board manual to ensure that the jumpers are set correctly and all parameters are safe for your laser, in particular the laser current scan as applying currents that are too high can permanently damage or destroy a laser!



Double Check Parameters Are Safe for Your Laser

Lasers can be permanently damaged or destroyed by applying currents that are too high. Triple check the parameters for you laser current scan.

The default board settings are found in the PCI-FPGA-1A User Guide in Section 4: Hardware Description.

3 Connector Descriptions

3.1 Power (rear panel)

Observe the polarity as indicated on the panel label as reversing the connections can permanently damage the controller board inside, or to a connected laser.

For optimum results always power the module with a clean and stable 5.0V power source as the integrity of the output signals can be impacted if a noisy or unstable supply is used.

Apply +5.0 VDC (-0.1V, +0.2V) power to the screw terminal connector on the rear of the module. Current draw is approximately 150 mA without a laser connection.

NOTE: All screw terminal blocks can be removed for easier access using the two screws at either side of the connector block.

3.2 USB (rear panel)

A standard type B USB port is provided on the rear panel for connection to a PC for flash programming.

NOTE: If you have not already installed the driver for the control board's UART, please follow the instructions in the PCI-FPGA-1A manual and configure the laser scan parameters and 2f demodulator parameters prior to connecting a laser to the system.

A compatible USB cable is included with the module. It will mate to any type A USB port on a PC.

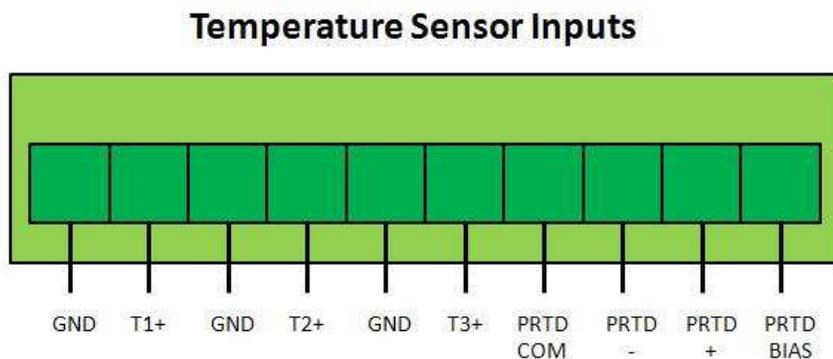
Note: a type A USB connector is the thin, rectangular port commonly used on desktop and laptop PCs; type B is the "D" shaped connector on the rear of the -1B module.

3.3 Temperature Sensor Inputs (rear panel)

Thermistor and PRTD inputs are provided on standard screw terminals via a 10-pin terminal block on the rear panel.

As indicated by the labels below the terminal block, the thermistor inputs are in pairs from left to right, with the rightmost four locations reserved for a 4-wire PRTD.

Although thermistors have no inherent polarity, the control board ties one side of the thermistor to ground (the leftmost terminal of each pair).



Refer to the diagram above for details, and always ensure that stripped wires are inserted fully and tightened down properly.

For a 4-wire PRTD it is customary to connect the COM and (-) lines together, and the BIAS and (+) lines together, if the PRTD element has only two leads.

3.4 Time Constant Selection (rear panel)

A 4-position DIP switch allows you to select one of four demodulator output time constants (values in ms are indicated on the panel).

Push the desired DIP switch upwards to select that time constant value.

NOTE: These time constants are additive so that higher time constants are possible by selecting more than one switch.

For example, if the 4.1 ms and 1.9 ms switches are both turned "ON", the time constant will be 6.0 ms.

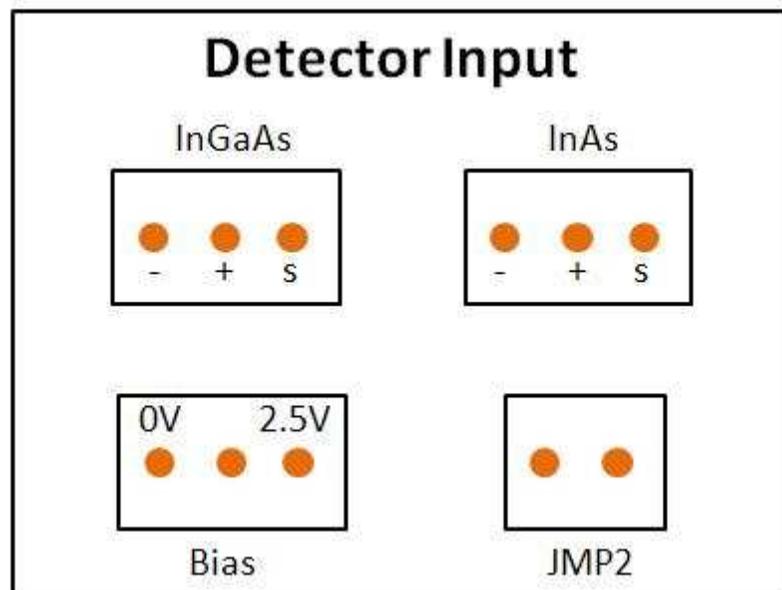
Refer to the -1A manual for implementation of a custom time constant value. This requires soldering a capacitor onto a blank space on the circuit board and turning all of the DIP switches to the OFF (down) position.

3.5 Detector Inputs (front panel)

The -1B module is compatible with both InGaAs (0.7 to 2.6 μm) and InAs (1.0 - 3.8 μm) detectors.

It is also possible to use certain TE-cooled HgCdTe detectors to cover wavelengths out to $>12 \mu\text{m}$ via connection to the InAs detector input. In particular, the TE-cooled detectors from Vigo (<http://www.vigo.com.pl/index.php/en>) are compatible with this controller board.

Detector connections are made via the 0.1" headers on the front panel. Refer to the diagram to the right for correct polarity for each detector (and use of a shield if using a shielded cable). "-" indicates the detector cathode, "+" the detector anode, and "s" is the shield connection. A shunt should be placed on the two leftmost pins of the Bias block for InAs/HgCdTe detectors, (0V bias) and on the rightmost two pins for InGaAs detectors (2.5V reverse bias).



The Bias and JMP connectors are for shunts (shorting plugs) and should be configured as in the following table.

NOTE: A shunt **must** be installed on one of the two Bias positions.

InGaAs Detector	InAs and HgCdTe Detectors
Bias shunt on 2.5V side	Bias shunt on 0V side
JMP2 open (no shunt)	JMP2 shunt installed (shorted)

InGaAs detectors are operated with 2.5V reverse bias, while InAs and HgCdTe detectors are operated with zero reverse bias.

For InGaAs detectors: JMP2 should be open (no shunt installed)

For InAs and HgCdTe detectors: JMP2 should be shorted (shunt installed)

Refer to the -1A manual for additional details on the detector input connections.

An access hole is provided on the front panel for the preamp gain adjustment. Adjust this for an on-scale signal for the DC spectrum output once the laser has been aligned to the detector. The 2f gain is set in software (see -1A manual for details).

3.6 Laser Drive (front panel)

A BNC connector (**center pin = laser anode, outer contact = laser cathode**) is provided for the laser drive signal, and is located adjacent to a toggle switch which must be in the ON (up) position to allow current to flow through the laser.

Always keep this toggle switch in the OFF (down) position until a known, good laser drive waveform is confirmed. Laser current is applied to the laser only if the switch is ON (up).



Always Confirm Waveform Characteristics Before Connecting a Laser!

Reversing the polarity of the drive signal, or applying too much current to the laser, can damage or destroy the laser.

To confirm the characteristics of a programmed laser scan waveform:

1. Connect a 10 ohm, 1/2W resistor across the laser drive BNC connector.
2. Flip the laser ON/OFF toggle switch to the ON (up) position.
3. Use an oscilloscope to monitor the waveform across this 10 ohm dummy "laser", but **DO NOT GROUND** the negative (external shroud) of the BNC connector.

Instead, connect the scope probe negative lead to the 5V power supply ground, and use the positive scope probe to monitor the voltage at the (+) side of the test resistor (the end connected to the center pin of the BNC connector). The laser cathode is not grounded at the controller board, and grounding the (-) BNC connector point will shut off current to the laser.

With a proper laser scan waveform, there will be a ramp signal on **both** sides of the test 10 ohm load resistor connector (one higher in amplitude than the other). Always confirm that the laser scan waveform is appropriate for the laser being

used, and quantify the amplitude of the current ramp (observed voltage divided by 10 ohms) before connecting a laser to the system.

3.7 Spectrum Outputs (front panel)

The DC (laser power) and 2f spectra are output on two BNC connectors located on the front panel.

Connect these to an oscilloscope for real-time viewing of the spectra. Signals are in the 0-5V range, with common (ground reference) at 2.5V for the DC spectrum. The BNC shrouds are tied internally to the +5V power supply ground.

3.8 Trigger Outputs (front panel)

Separate triggers (0-3.3V low-voltage TTL) are provided for syncing to external data acquisition systems.

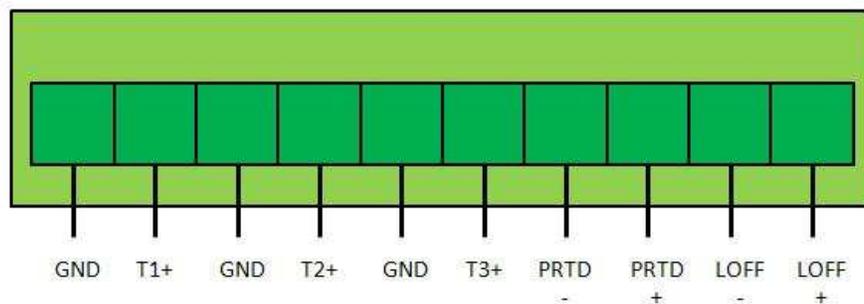
- "Trig-DC" is coincident with the start of the laser scan waveform.
- "Trig-2f" is coincident with the temporally-delayed 2f signal (see -1A manual).

Both triggers are approximately 110 μ s in duration. The time delay between these two trigger pulses is caused by the FPGA processing of the 2f signal. This varies with the bandwidth setting (which generally should not be changed from the default). See the -1A manual for additional details.

3.9 Temperature Sensor Outputs (front panel)

The thermistor and PRTD signals that are input on the rear panel connector (see Section 3.3) are output on this connector. Conversion of these voltages to resistance (and subsequently to temperature, based on the sensor's specifications) is described in the -1A manual and at the end of this manual (Appendix A).

Temperature Sensor Outputs



The rightmost two terminals are reserved for an external laser ON/OFF control input.

The LOFF signal is a digital or analog input signal (3.3V LVTTTL up to 5.0V TTL) used to disable the laser drive current exactly as is done with the toggle switch next to the laser drive output BNC.

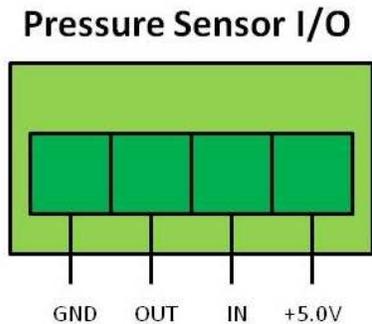
A positive signal here disables the laser drive, and a ground level signal enables the laser drive. If the laser drive toggle switch is placed in the OFF (down) position, external signal

input via the LOFF pins can be used for the same function. This way the laser ON/OFF function can be controlled by an external signal for situations where that is desired.

NOTE: When the laser drive toggle switch is in the ON (up) position, the laser drive may be passed to the laser independent of any input to LOFF above. Do not make connections to the LOFF pins if the toggle switch is used, and make sure the toggle switch is in the OFF (down) position if the LOFF external input is used.

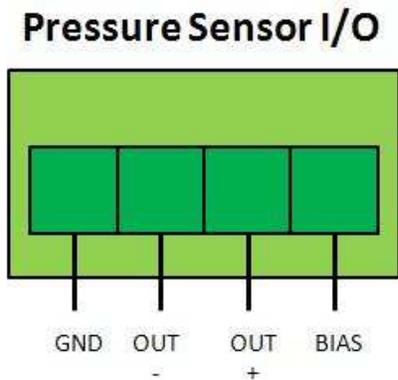
3.10 Pressure Sensor I/O (front panel)

The -1B module provides a 5.00V bias and front panel input connector for an amplified pressure sensor whose output is in the 0-5V range (the default configuration for the -1B module). These types of pressure sensors typically produce an output signal in the 0.25 to 4.75V, or 0.50 to 4.50V, with a 5.0V bias. The output voltage is generally ratiometric to the supply voltage, so the -1B module provides the stable 5.00V reference needed for these types of pressure sensors. Connections are as shown in the upper diagram.



Connect the pressure sensor's power input lead to the +5.0V pin and the return to the "GND" pin. The raw output voltage from the pressure sensor should be connected to the "IN" terminal, and the "OUT" terminal is this same signal after passing through an internal buffer circuit with a nominal gain of 1). You can either use the pressure sensor output directly in your application, or use the buffered output on the "OUT" terminal which provides some additional filtering of the signal.

The -1B module can also be ordered for use with common 0-100 mV output unamplified pressure sensors (eg. the Honeywell line of 19 mm sensors). These sensors have a large common mode voltage that is managed internally by the -1B module. Connections are as shown in the lower diagram. The -1B module provides a 10V bias signal to power the pressure sensor, which is the "BIAS" terminal. Power ground is provided on the "GND" terminal. The raw (0-100 mV) output of the pressure sensor is input to the -1B module via the "OUT -" and "OUT +" terminals. The amplified output of the pressure sensor (0 - 3.5V typically) is provided on the two "LOFF" pins (see section 3.9), which are then not available for the LOFF input function. The output is linear, but should be calibrated for any offset that may be present.



Specify at the time of order (or contact us if already received for instructions on how to convert this input terminal for an unamplified sensor) which type of pressure sensor will be used as there is some internal cable rerouting required to use 0-100 mV unamplified sensors. The default configuration is for the use of amplified pressure sensors having an output within the 0-5V range.

← Connections for unamplified pressure sensor

Appendix A: Conversions

A.1 Sensor conversions

Thermistor Conversion

$R_t = (22.49 * V_{in} - 7.0) / (2.8112 - V_{in})$, where R_t is the thermistor resistance in Kohm and V_{in} is the output voltage provided by the PCI-FPGA-1A board.

The useful range of thermistor resistances is between approximately 0.125 Kohm ($V_{in} = 0.325V$) to 488 Kohm ($V_{in} = 2.701V$). Outside of these ranges the change in V_{in} with respect to R_t is either very large (higher resistances), or very small (lower resistances).

For a typical 10 Kohm @ 25C thermistor with a beta value near 3900, this represents a temperature range of roughly -45C to +165C, with larger errors at the extremes of the range (especially the high temperature end where R_t is very small).

Make sure to use a thermistor with a resistance value within the above range for valid output values and, match it to the best performance over the full temperature range of the application.

Pressure sensor conversions (absolute P sensors)

Sensor	Conversion
Amplified sensor	No conversion. The board outputs the sensor voltage from the absolute pressure sensor with no amplification or scaling.
Unamplified 0 - 100 mV sensors	Linear output, 0 to $P_{max} = 0$ to V_{max} , where V_{max} is 3.5V (nominal) and P_{max} is the upper limit of the pressure sensor. Each pressure sensor should be calibrated with the board for precise determination of V_{max} and any DC offset that may be present.

PRTD conversion

$R_{prt} = 495.52 * V_{in}$, where R_{prt} is the resistance of the PRTD and V_{in} is the voltage output from the PCI-FPGA-1A board.

Conversion of R_{prt} to temperature can be accomplished using the appropriate calibration curve for the PRTD being used.