



PORTLAND TOOL & DIE

PIO-9216A

I²S and serial audio interface
User's Guide



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Summary

The Portland Tool & Die PIO-9216A is a versatile interface for connecting to devices with an I²S serial data interface. It provides for simple configuration of all parameters including data and clock direction, clock rates, data frame parameters and logic levels. The PIO-9216A translates I²S data to S/PDIF and easily interfaces directly with a computer via USB for both audio and control signals.

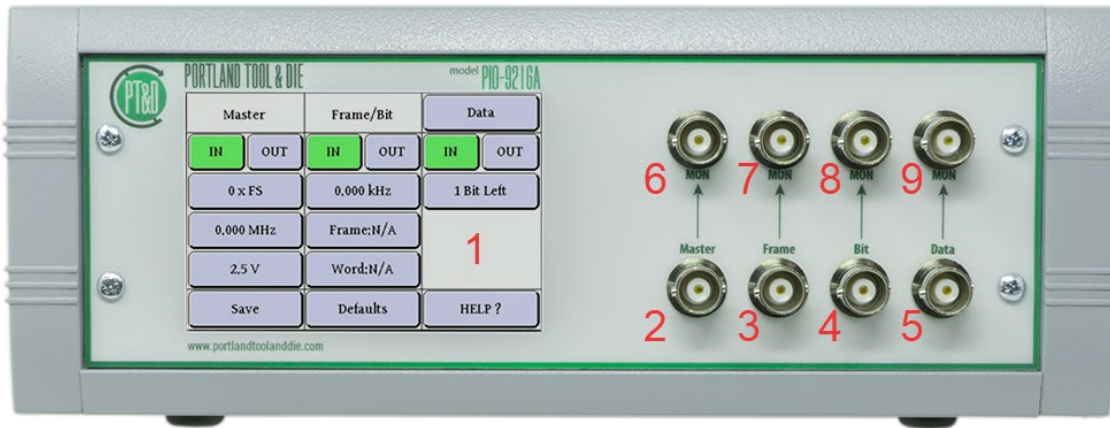
The instrument can be easily configured via its touchscreen interface or via a convenient command line utility. All data is transported strictly in the digital domain and bit-for-bit transport is an available option.

Table of Contents

- Summary..... 2**
- PIO-9216A Hardware 5**
- Configuring the PIO-9216A instrument via the touchscreen display..... 6**
- Main Menu..... 6
- Master Clock Parameters 6
 - IN – OUT Selection6*
 - N x FS Setting7*
 - Master Clock Frequency.....7*
 - Logic Level.....7*
- Frame/Bit Parameters 7
 - IN – OUT Selection7*
 - Sample Rate.....7*
 - Frame Width.....7*
 - Sample Word Width.....7*
- Data Settings Menu 8
 - Data Settings.....8*
 - IN – OUT Selection8*
 - 1 Bit Left.....8*
- Save, Defaults and About..... 8
- I2S Bus Configuration 9**
- TDM 2-channel Configuration 9**
- I2S and TDM bus signal frequency relationships..... 10**
- Configuring the PIO-9216A via the USB interface 11**
- Installing the Microsoft Windows support software..... 11
- Using the pioutil.exe..... 11
- Connection to 3rd party test equipment 12**
- Via USB..... 12
- Via SPDIF..... 12
- A note on sample rate and bit depth..... 12
- Use with Listen, Inc. SoundCheck 13**
- Directly via USB..... 13
 - First, create a hardware channel..... 13*

| | |
|--|-----------|
| <i>Second, setup input and output signal channels.....</i> | <i>14</i> |
| Via an existing audio interface using SPDIF | 15 |
| <i>Advantages of using an existing audio interface with a SPDIF input.....</i> | <i>15</i> |
| PIO-9216A Specifications | 16 |
| Master Clock | 16 |
| Bit/Frame Clock..... | 16 |
| Data Terminal | 16 |
| Host Interface..... | 16 |
| Physical..... | 16 |
| Support and Contact Information | 16 |

PIO-9216A Hardware



1. Touchscreen display
2. Master Clock I/O Connector
3. Frame Clock I/O Connector
4. Bit Clock I/O Connector
5. Data I/O Connector
6. Master Clock Monitor Out
7. Frame Clock Monitor Out
8. Bit Clock Monitor Out
9. Data Monitor Out



1. Power switch
2. Instrument DC power input
3. USB interface
4. SPDIF/AES3 input
5. SPDIF/AES3 output
6. Chassis ground connector

Configuring the PIO-9216A instrument via the touchscreen display

The instrument's touchscreen display allows all instrument parameters to be controlled and displays the value for all parameters. To configure:

Main Menu

| Master | | Frame/Bit | | Data | |
|-----------|-----------|------------|-----|------|-----|
| IN | OUT | IN | OUT | IN | OUT |
| 0 x FS | 0,000 kHz | 1 Bit Left | | | |
| 0,000 MHz | Frame:N/A | | | | |
| 2,5 V | Word:N/A | | | | |
| Save | Defaults | HELP ? | | | |

From the main menu you can set the configuration of each I/O port on the instrument including the direction, clock parameters and data format parameters.

When operating the instrument via the touchscreen the best practice is to start at the top left of the menu and proceed down and to the right. That is, first set the master clock parameters, the Frame/Bit clock parameters and finally the Data parameters.

Master Clock Parameters

The Master clock column on the touchscreen UI controls the settings associated with the Master clock I/O connector. A master clock connection is not strictly required for an I²S connection. If your device does not require a master clock connection, these settings can be ignored.

The Master clock input is used internally to generate Frame and Bit clocks. If the Frame/Bit direction is set to OUT and Master clock is set to IN, the external system must provide a valid clock signal on the Master clock input. If the external system cannot supply the Master clock signal, set the Master clock direction to OUT to allow the PIO to use the internally generate the Frame/Bit clocks in this situation.

IN – OUT Selection

The IN /OUT selection sets whether the instrument transmits or receives the master clock signal.

N x FS Setting

The N x FS Setting displays or sets the ratio between the master clock and the frame (sample) clock. When the master clock is set to IN, N x FS is a display showing the ratio between the received master clock and the current Frame clock. When the master clock is set to OUT it is a control and should be set to the value required by the device being interfaced to.

Master Clock Frequency

The Master Clock Frequency can be set when the when the master clock is set to OUT and is a readout when it is set to IN.

Note – If the master clock is set to out and the frame clock frequency is changed, the master clock frequency will be adjusted such that it equals the N x FS parameter multiplied by the frame clock rate. Reciprocally if the master clock frequency is changed, the frame clock will be adjusted to match the new master clock frequency divided by the N x FS parameter.

Logic Level

The logic level sets the peak amplitude in volts of the master, frame, bit and data signals.

Note – When receiving data, the system is edge triggered at half the set logic level.

Frame/Bit Parameters

IN – OUT Selection

The IN/OUT selection determines whether the instrument is transmitting or receiving the frame and bit clocks.

Sample Rate

The sample rate or frame rate is set, when the clock direction is out, or displayed in this control.

Frame Width

This control sets the width of the audio data frame. There are two frames per sample.

Note – The bit clock rate is equal to the sample rate x frame width x 2.

Sample Word Width

This control sets the width of the audio sample.

Note – The Word Width cannot exceed the frame width.

Data Settings Menu

Data Settings

| | | |
|---------------------------|---------------|--------|
| ⏪Back | Data Settings | |
| Data | IN | OUT |
| Source (When Out) | USB | SPDIF |
| Direct Mode \Rightarrow | ON | OFF |
| | | |
| Save | Defaults | Help ? |

To access advanced controls related to the audio data, select the data button itself from the main menu.

Source Selection

This control determines whether the USB port or the SPDIF port is this source of audio data that is then transmitted via I²S.

Direct Mode – ON / OFF

The instrument uses an internal sample rate converter to translate between the I²S data stream and the USB and SPDIF data interface. In practical use this means that it is not necessary to exactly match sample rates between the host system and the I²S device. However, if a bit-for-bit translation between I²S and SPDIF is desired, it can be achieved by enabling Direct Mode. The Master and Frame/Bit Clocks must be set to OUT before Direct Mode can be enabled.

Note – Bit exact data transport is only available via the SPDIF audio interface.

IN – OUT Selection

This controls whether the instrument receives or transmits audio data on the data I/O terminal.

1 Bit Left

This control sets the number of bit periods between the start of frame and the first data bit.

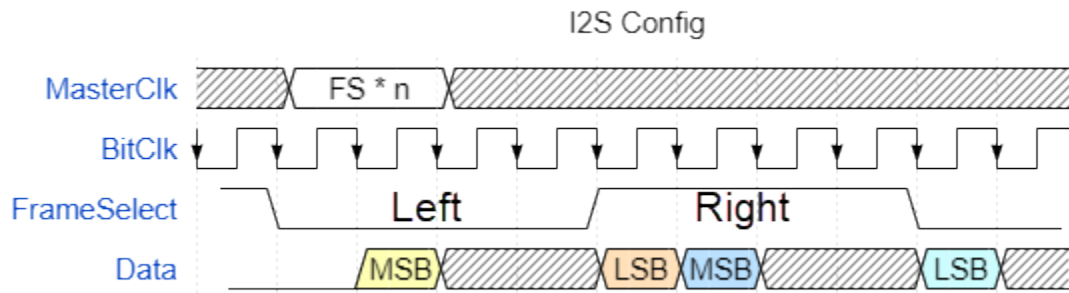
The default is set for I²S data where the data starts one 1-bit period after the start of the frame.

Save, Defaults and About

The Save button will save the current instrument settings to non-volatile memory. The Defaults button restores the factory default settings. The About button displays the instruments own Bluetooth address, firmware version and other information.

I2S Bus Configuration

The following diagram shows the I2S bus signals.



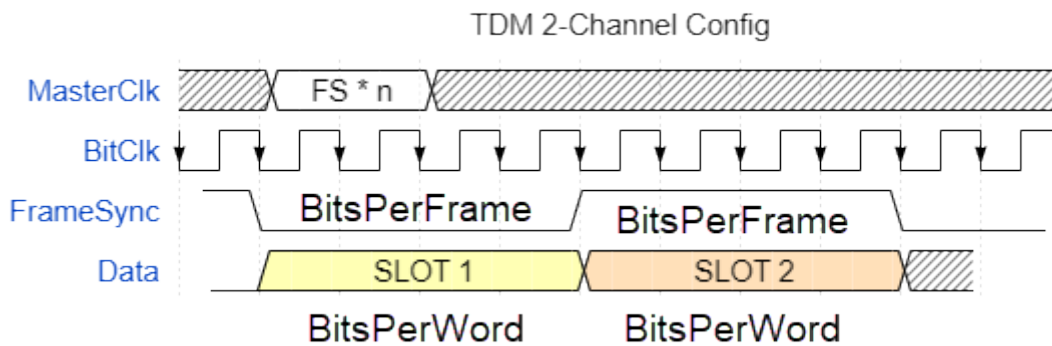
The signals on the I2S bus change state on the falling edge of the Bit clock and are sampled on the rising edge of the Bit clock.

To enable I2S mode, set the Data offset to be "1 bit left". This accounts for the 1 Bit clock delay between the falling edge of FrameSelect signal and the first (MSB) bit of the left audio sample.

TDM 2-channel Configuration

There PIO can transmit 2-channel left-justified TDM data and it can receive left or right justified 2-channel TDM data.

The following diagram shows the supported TDM bus format.



The BitsPerWord must always be \leq BitsPerFrame.

If the PIO DATA is set to OUT, then the data will be transmitted left-justified with MSB first. If the PIO DATA is set to IN, then the external system must send the data either left-or right justified with the MSB first.

I2S and TDM bus signal frequency relationships

Because I2S is defined to carry 2 channels and the PIO TMD mode can only support 2 channels of audio, the bus clock calculations are the same for both I2S and TDM mode.

MasterClk must be an integer multiple of the FrameSync signal. In many systems the Master clock is run at 256 times the FrameSync signal.

The BitClock frequency can be calculated by:

$$\text{BitClockFreq} = \text{FrameSyncFreq} * \text{BitsPerFrame} * \text{NumChannels}$$

Since the PIO always uses stereo data, the equation can be simplified to be:

$$\text{BitClockFreq} = \text{FrameSyncFreq} * \text{BitsPerFrame} * 2$$

For example, many systems use a 32 bit frame and 24 bit audio at 48 kHz sample rate. For this condition, the bit clock frequency will be 3.072 Mhz.

Configuring the PIO-9216A via the USB interface

Installing the Microsoft Windows support software

Please run PIO-9216A-Setup-vX-XX.exe, supplied with your instrument to automatically install the device driver required to control your instrument via USB.

Using the pioutil.exe

A Windows command shell program is also provided as an alternate to the touchscreen interface. This program allows all variable parameters of the instrument to be set.

PIO-9216A-Setup automatically installs pioutil.exe and creates a program shortcut under the Start menu. Once installed the program can be called from the command line as follows.

Usage: pioutil [<option> <value>] [<option> <value>] ...

Options:

| | | |
|-----|------------------------|--|
| /? | --help | Prints this information |
| /# | --instrument | Specific instrument # or serial number |
| /s | --save | Save settings into [filename] |
| /o | --open | Load settings from [filename] |
| /i | --identify | Identifies connected instruments |
| /l | --list | List current instrument settings |
| /r | --restore | Restore factory default settings |
| /sd | --save-defaults | Save current settings as power on defaults |
| /sc | --screen-capture | [filename] to save screen bitmap into |
| /md | --master-clk-direction | Master clock direction [in out] |
| /fm | --fs-multiplier | Sampling frequency multiplier |
| /mf | --master-frequency | Master clock frequency (Hz) |
| /fd | --frame-direction | Frame and bit direction [in out] |
| /fs | --sampling-frequency | Sampling frequency (Hz) |
| /fl | --frame-length | Frame length (bits) |
| /wl | --word-length | word length (bits) |
| /dd | --data-direction | Data direction [in out] |
| /do | --data-offset | Data offset from rising edge of FS (bits) |
| /ds | --data-source | Data source [USB SPDIF] |
| /dm | --direct-mode | Data direct mode [on off] |

Note - The command line utility does require the Microsoft .NET runtime installed. It can be downloaded from here: <http://www.microsoft.com/net/>

Connection to 3rd party test equipment

Via USB

Simply connect the USB interface on the instrument to an Apple Mac or Microsoft Windows PC. The audio portion of the instrument will appear as a line level input device and requires no driver installation.

Note - The instrument appears as two distinct USB devices. An audio device and a virtual com port. The audio device requires no drivers and will function immediately. The virtual com port requires a device driver to be installed but is only required if you wish to control the instrument remotely over USB. For command port installation instructions see the following page.

Via SPDIF

The SPDIF output is simultaneously active with the USB audio output. To use, simply connect to equipment with a SPDIF or AES3 input.

The SPDIF input must be selected as the audio source via the touchscreen or command line interface.

A note on sample rate and bit depth

Over USB, the PIO-9216A provides 24-bit, 48 kHz sample rate audio data regardless of the sample rate or bit depth of the I²S link. A very high-quality sample rate converter affects the translation between the I²S and USB audio interfaces.

If Direct Mode is enabled the SPDIF audio and I²S link sample rates are locked together, and no sample rate conversion takes place.

Use with Listen, Inc. SoundCheck

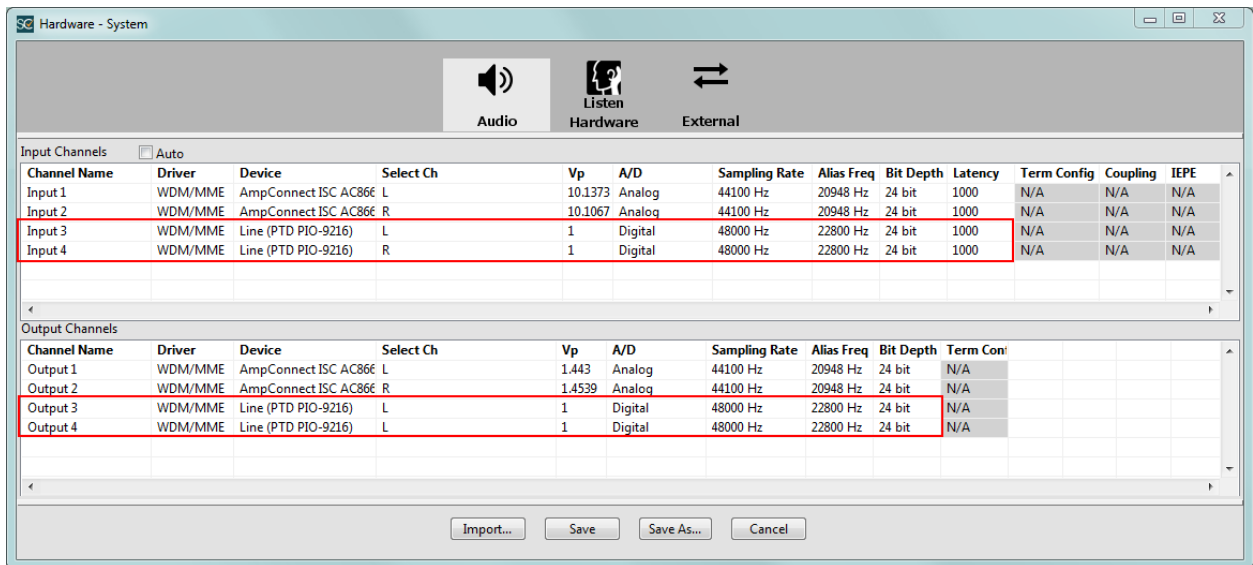
The PIO-9216A integrates directly with Listen, Inc.'s SoundCheck audio measurement system via USB or the SPDIF input of a professional audio interface. Instructions for both are provided below:

Directly via USB

First, create a hardware channel

Since the PIO-9216A appears as a normal Windows audio device when connected via USB to use it with SoundCheck you simply configure it as any other WDM audio device. Simply follow these steps:

1. With your PIO-9216A connected and powered on start SoundCheck.
2. From the main menu open Setup and then Hardware...
3. Add input and output hardware channels.
4. The PIO-9216A uses the WDM driver, operates at 48 kHz sample rate and supports 24-bit audio. Typical input and output channel configurations are:

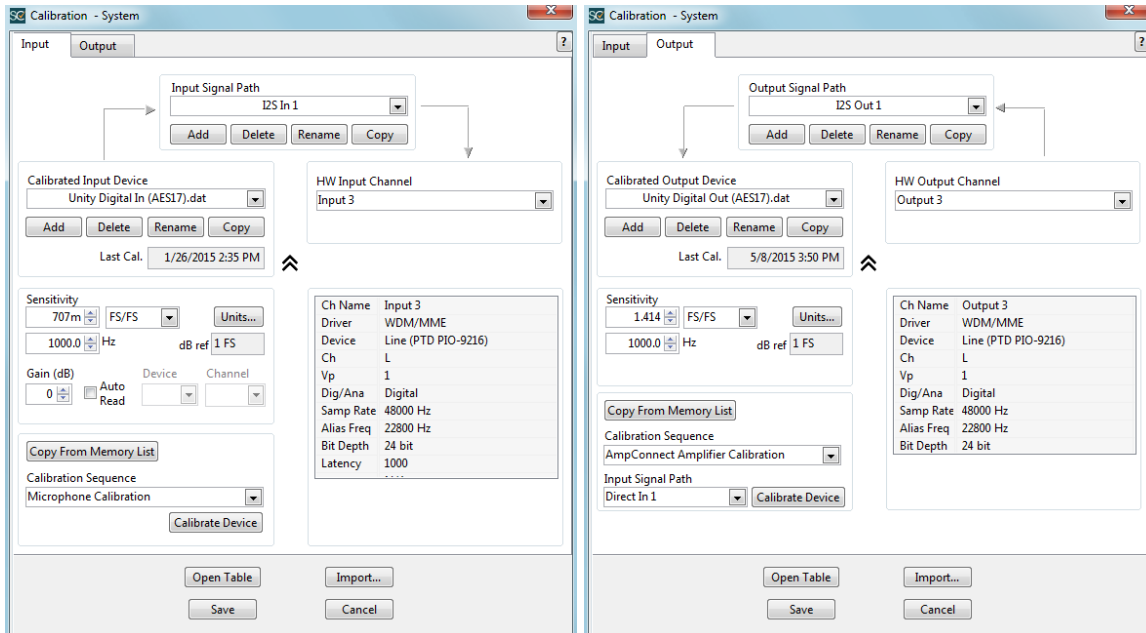


5. Save your changes.

Second, setup input and output signal channels

Once the hardware channel is setup we need to add an input signal channel to the calibration table. To do so, simply follow these steps:

1. From the main menu open Setup and then Calibration...
2. Add input and output signal paths.



Note: If you wish your input and output units to be scaled according to AES17 then add new input and output calibrated devices with sensitivities of 0.707 (-3.01 dB) FS/FS for the input and 1.414 (+3.01 dB) FS/FS for the output.

3. Save your changes.

Via an existing audio interface using SPDIF

The SPDIF input and output of the PIO-9216A can also be connected to the SPDIF I/O of an audio interface such as an RME Multiface or Fireface, Digital Audio Labs Card Deluxe, Lynx Studio Lynx Two or Aurora that is already supported by and interfaced to SoundCheck.

In this case the actual input would appear to originate from the audio interface, and you would follow the steps specific for that device to add the hardware channel.

Advantages of using an existing audio interface with a SPDIF input

There are two configuration scenarios where it is useful to use the SPDIF input of a professional audio interface rather than the USB output of the PIO-9216A. These include:

1. ASIO Driver - By using, for example, the digital input of an RME Fireface UC or UCX the audio signal is delivered to SoundCheck via an ASIO driver with the practical benefit of deterministic and consistent delay. In addition, ASIO bypasses the Windows mixer, which allows full 24-bit audio under Windows XP and eliminates the concern that gain may be applied to the signal under Windows 7.
2. Reference microphone measurement - If you wish to measure one microphone by comparing it to another, the simplest solution is to connect the PIO-9216A to the same input device as the reference microphone. Further, if you then slave the sample clock of the audio interface to the SPDIF output of the PIO-9216A then both the MEMS digital microphone and the reference microphone will be sampled synchronously, the is useful for the Log Time Selective Response measurement.

PIO-9216A Specifications

| | |
|--|--|
| <p>Master Clock Direction: In or Out Range: 0.08 to 50 MHz NxFs: 8 to 12,500 Vin/out: 1.2 to 5.5 V</p> | <p>Bit/Frame Clock Direction: In or Out FS Range: 4 to 216 kHz Bit Range: 128 kHz to 6.912 MHz Frame width: 8 to 32 bits Word width: 8 to 24 bits Vin/out: 1.2 to 5.5 V</p> |
| <p>Data Terminal Direction: In or Out Channels: Mono or Stereo Justification: Left or Right Offset: 0 to 7 bits relative to start of frame Vin/out: 1.2 to 5.5 V</p> | |
| <p>Host Interface USB Audio 24 bit, 48 kHz sample rate SPDIF/AES Digital Audio – 22 to 192 kHz in bit exact mode – 48 kHz via sample rate conversion</p> | <p>Physical 86 x 271 x 211 mm H x W x D 1.6 kg 12VDC, 24W power input (Universal 100-240 VAC / 50 – 60 Hz power supply included)</p> |

Support and Contact Information

Sold and distributed world-wide exclusively by:

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