Danville Signal Processing, Inc.

dspInstrument spDAQ

Two Channel Sound & Vibration Front End

USB Bus Powered

User Manual

Version 1.00

Danville Signal Processing, Inc.
dspInstrument™ spDAQ™ User Manual

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Overview

The dspInstrument spDAQ is a high performance two-channel sound and vibration measurement front end that supports IEPE accelerometers and measurement microphones. It is used with a third party measurement software application to create an analyzer or signal generator with excellent dynamic range and distortion characteristics and supports sample rates as high as 192kHz.

It is bus powered via USB 3 from a modern Windows computer using USB Audio Class 2 as its streaming protocol. A Microsoft Windows driver with ASIO support is included. This ensures jitter free performance at sample rates of 192k, 96k and 48k with full 32 bit depth. The control functions of the dspInstrument spDAQ are managed by a standalone Windows application provided by Danville Signal or may be integrated directly into the third party software Analyzer/Generator application. If you are an OEM or software provider, we can help you optimize integration of the dspInstrument spDAQ into your product.

The dspInstrument spDAQ will run warm. This is a direct consequence of having industry leading signal to noise and dynamic range performance. We opted to trade off current consumption to achieve this result.

The dspInstrument spDAQ includes stepped programmable gain amplifiers and attenuators to optimize measurement range in a stable consistent manner.

The dspInstrument spDAQ has support for TEDS (IEEE 1451.4) Class 1 devices. This is the interface used by IEPE powered sensors such as accelerometers, force transducers and measurement microphones.

Most customers of the dspInstrument spDAQ will be using the product as a complete standalone instrument. However, you can also purchase PCB assemblies for integration into a larger hardware platform. You may also be interested in a similar product, the dspInstrument spDAQb that uses balanced audio inputs and outputs for analog I/O.

Hardware Description

Input Channels

The dspInstrument spDAQ has two independent channels with individually selectable parameters.

Inputs use BNC connections and are configured for Voltage, IEPE biasing, or TEDS.

Voltage Mode makes the dspInstrument spDAQ operate as a calibrated audio analyzer front end. This mode might be used for sensors with external signal conditioning.

IEPE (CCP) Mode is commonly used with accelerators and measurement microphone preamplifiers in sound and vibration applications. The bias current is 4mA. When using an IEPE sensor, the bias voltage will typically be in the range of 8-12 volts DC. This allows the dspInstrument spDAQ to test for cable/sensor shorts or opens, since an open condition will be about 24V and a short will be near zero volts.

Many IEPE based microphones and accelerometers support TEDS (IEEE 1451.4) operating in class 1 mode. The dspInstrument spDAQ has a TEDS interface. Danville has a companion Control App that reads TEDS header information and supports TEDS templates 25 (accelerometers) and 27 (microphones). Each input has a programmable gain amplifier that has 8 selections, switchable in binary (6dB) steps. The maximum input level is 10V peak in the x1 PGA setting. The actual full scale voltage is a little higher than this to leave room for calibration and ensures that whole specified range remains linear. The PGA allows most sensors to interface directly without additional amplification.

Output Channels

The dspInstrument spDAQ has two channels of audio outputs. The primary output is available on the front panel using a BNC connector. This is normally the only output required in most measurement scenarios. Both channels are available via a 3.5mm phone jack on the back panel.

Each output has a programmable attenuator that has 4 selections, switchable in x4 (12dB) steps. The maximum output level is 10V peak in the x1 setting. The actual full scale voltage is a little higher than this to leave room for calibration and ensures that whole specified range remains linear. The attenuators are switched in pairs so both outputs always operate in the same full scale range.

Digital I/O

The dspInstrument spDAQ has three opto-isolated inputs and three opto-isolated outputs that are available on RJ45 connectors on the back panel. The wiring uses standard Ethernet cable conventions so that off-the-shelf CAT6 cables can be used. Since each input or output uses one pair of wires, the remaining pair provides +5V and Ground. The 5V is available after the USB is enumerated and is essentially switched USB VBUS. Keep in mind that if you use the 5V or Ground connections, your interface will no longer be isolated. The digital I/O can be tested with the Danville Control App program, but these ports need to be integrated into a third party signal processing application to be useful.

Connections

RJ45 Pin	Color TIA568B	Input	Output
1	Orange/White	In 0 C	Out 0 C
2	Orange	In 0 E	Out 0 E
3	Green/White	In 1 C	Out 1 C
6	Green	In 1 E	Out 1 E
4	Blue	In 2 E	Out 2 E
5	Blue/White	In 2 C	Out 2 C
7	Brown/White	5V	5V
8	Brown	GND	GND

Most CAT6 cables follow the TIA568B convention, but some use TIA568A which substitutes the orange and green pairs.

Since the digital I/O is provided with opto-couplers, current is limited. This means mating circuits will need to interface with minimal current requirements, The rationale for this choice is to avoid noise and ground loops from external equipment.

Installation

USB & Computer Requirements

The dspInstrument spDAQ is bus powered by the USB interface on the supporting computer.

From its inception, the dspInstrument spDAQ has always assumed a good performing mating computer. We recommend an Intel I7 or I9 based or similar AMD based computer system, running Microsoft Windows 10 or 11. If you use a portable computer, we suggest a gaming laptop.

In all cases, you need to use a USB3 port and USB3 cable which includes the USB3 B connector. The reason for this is that USB3 cables have larger gauge wire for the power connections and this is necessary to deliver sufficient current to the dspInstrument spDAQ.

Device Drivers & Control Software

The dspInstrument spDAQ uses device drivers licensed by Ploytec GmbH. This USB driver supports sample rates of 192k, 96k and 48k with ASIO. A MIDI interface is used for control.

Danville also provides a Control App that is used to configure the dspInstrument spDAQ. This application supplements third party signal processing applications to select input operating modes, gain and attenuators settings, and also functions as a TEDS reader. In some cases, these features will be integrated directly into the signal processing application and therefore the Control App will not be required.

Installation Steps

Installation is straightforward.

Step 1:

Install Microsoft Visual C++ Redistributable (x64).

Chances are you already have this component on your computer. If it asks you to Modify Setup, it is already installed and you can close. Otherwise, it will install and you will need to restart your computer.

Step 2:

Install Danville_Signal_UAC2 Drivers.
This installs the Ploytec drivers. After installing, you will need to restart your computer.

Step 3:

Copy dspInstrument_spDAQ.exe and the companion DLL to a convenient folder. Create a shortcut if you like.

Specifications

General	
Sampling Rate	48kHz, 96kHz, 192kHz
Sampling Precision	24 bit
Inputs	
Input Voltage (full scale)	±10 V (7.07 V_{RMS})
Input Gain Settings	x1, x2, x4, x8, x16, x32, x64, x128 (independent for each channel)
Input Voltage Ranges	±10V, ±5V, ±2.5V, ±1.25V, ±625mV, ±312.5mV, ±156.25mV, ±78.125mV
Input Channels	2
Connector	BNC
Input Impedance	1 Meg Ohm
Input Selection	Voltage, IEPE (CCP), TEDS, Off
Frequency Response	1 Hz to 88 kHz (-1dB) @ 192k 1 Hz to 44 kHz (-1dB) @ 96k 1 Hz to 22 kHz (-1dB) @ 48k
Low Frequency Cutoff	0.5 Hz (-3dB)
Total Harmonic Distortion (THD)	< 0.002% (1.0 V_{RMS} signal level, 2.5 V gain)
Spurious Free Dynamic Range	> 95 dB
Noise Floor (terminated inputs)	< -110 dBV_{RMS}
Channel Separation	> 90 dB
Input Voltage Protection	Up to ±30 V
Outputs	
Output Voltage (full scale)	±10 V (7.07 V_{RMS})
Output Attenuator	x1, x$^1/_4$, x$^1/_{16}$, x$^1/_{64}$
Output Voltage Ranges	±10V, ±2.5, ±625mV, ±156mV
Output Channels	2 (1 on front panel)
Connectors	BNC (front panel, mono), 3.5mm phone Jack
Frequency Response	1 Hz to 88 kHz (±1dB) 1 Hz to 44 kHz (±1dB) 1 Hz to 22 kHz (±1dB)
Digital I/O	
Connector	RJ45
Interface	
Drivers Windows 10, 11 (x32 and x64)	MME (Windows Multimedia Extensions) ASIO (Steinberg Audio Stream Input/Output)
PC Interface	USB 3 B Connector (requires USB 3 cable)
Operating Power	USB 3 Bus Power (650ma at 5V)
Misc	
Operating Temperature Range	0 to 50 °C
Dimensions	140 x 77 x 26 mm, 5.5″ x 3″ x 1″
Weight	0.250 kg, 9 oz

dspInstrument spDAQ Control

Overview

The dspInstrument spDAQ Control App (Version 2.x.x) supplements the third party Analyzer/Generator application that you are running to complete your measurement system. The main purpose of this program is to select the desired operating modes and gain/level configurations of the dspInstrument spDAQ. This application is written in Microsoft Visual C with source code available for third party software providers who may wish to more tightly integrate the dspInstrument into their programs.

There are four operating sections in the program.

I/O Configuration

I/O Configuration is the main operating menu in the application. It is used to configure the levels and operating mode of the each input and output. From the point of view of the Analyzer/Generator program, the only known data is digital conversations from the internal ADC or the digital levels sent to the DAC. This means that we need to tell the Analyzer/Generator program how to translate data converter levels to actual voltages that will be changing with each setting. These numbers are calculated automatically by the Control App and need to be entered into your Analyzer/Generator program.

Inputs

Inputs are independently adjustable in x2 steps with gains of 1 to 128 where full scale in the x1 position is 10.0 V_{PK}. If the input was set in the x2 position, full scale would be 5.00 V_{PK}, and so forth. The conversion is calculated based on the calibrated values stored in the dspInstrument spDAQ.

For example, if the instrument is operating in the x1 gain setting, the conversion would be SQRT(2)/10 = 0.14142 FS/V_{RMS} assuming that the actual full scale voltage is precisely 10.0 V_{PK} referenced to 1.00 V_{RMS}. The actual value will be a little different since the actual full scale voltage is a few percent higher that 10.00. A typical value will thus be lower (~0.1365 FS/V_{RMS}). In the x2 setting, this number will double.

There are four operating input modes for each input: Voltage, IEPE/CCP, TEDS, and GND. These are independent for each channel, but TEDS can only be selected in one channel at a time. If you select TEDS for a second channel, the previous channel will automatically toggle to IEPE/CCP mode. The assumption is that only IEPE/CCP sensors support TEDS.

Outputs

Outputs are adjustable in x4 steps with attenuation of 1 to 64 where full scale in the x1 position is 10.0 V_{PK}. If the output was set in the x4 position, full scale would be 2.50 V_{PK}, and so forth.

The conversion is similar to the inputs except that the numbers and units are essentially inverted. For example if full scale was exactly 10.0 V_{PK} the conversion would be 7.071 V_{RMS}/FS. Once again, the numbers will be a little higher (~7.328 V_{RMS}/FS) since actual full scale is a little higher than 10.0 V_{PK}

TEDS

The dspInstrument spDAQ includes a TEDS reader for accelerometers and measurement microphones. These devices are supported as TEDS template 25 & 27 devices. You can read manufacturer, serial number, and device sensitivity using this function.

Only one channel can read TEDS information at a time. Select the desired channel and the information will be updated automatically. If you are toggling channels, the alternate channel will be switched to IEPE/CCP mode. This will also change the mode in the I/O Configuration section.

If you encounter a sensor that doesn't report as expected, please let us know so we can address in the next software update. There are thousands of TEDS types now and more coming in the future.

Calibration

Calibration allows you to determine the correct conversions for the Analyzer/Generator program. This is discussed in finer detail in the next section of this manual.

Two sets of numbers are stored. The Lab Calibrated Values are generally only done using traceable external references on a periodic time interval, perhaps once a year. There is an alternate set of User Calibrated Values that are also available. Both sets function the same way. You can select which set is being used in the I/O Configuration Section of the program.

GPIO

The dspInstrument spDAQ includes three opto-isolated inputs and three opto-isolated outputs. The application is just a tester to verify that the interfaces are working properly. The GPIO feature is probably best used when integrated into the Analyzer/Generator program. For example, GPIO might be used for test sequencing or high level fault, good, low level fault signaling in a QC system.

Calibration Procedure

Overview

The dspInstrument spDAQ does not have any internal trimmers or adjustments, however there are small differences with respect to input sensitivity and output level. The calibration procedure is used to measure these differences and store the full scale/volt (inputs) or volt/full scale (outputs) conversion in internal nonvolatile memory. This defines the level where the internal ADC or DAC is at full scale in the x1 gain and attenuation settings.

The full scale voltage for both inputs and outputs is nominally $10V_{Pk}$, but is actually about 10.36 V_{Pk} ($17.3dBV_{RMS}$). This is to ensure that the measurement range is linear and that there is a little headroom for corrections.

Calibration is typically done using 1004 Hz, 1.000 V_{RMS} as the reference level or test signal in the x1 settings. 1004 Hz is a better reference than 1000 Hz in a digital system since it is relatively prime to the sample rate.

If we assume a full scale of $17.3dBV_{RMS}$ then

Output Scaling Factor $V_{RMS}/FS = 7.328$ // This is approximately 10.36/1.4142
Input Scaling Factor $FS/V_{RMS} = 0.1365$ // -17.3dBV

These numbers represent typical calibration levels that will be stored as 32 bit floating point numbers (IEEE-754) in the dspInstrument spDAQ.

Once the actual calibration numbers are determined, they may be used directly by your application software (assuming tight integration by the software provider) or you can enter these values directly into your program. The dspInstrument spDAQ Control App recalculates the corrections when using other levels in the spDAQ. For example, V_{RMS}/FS for the x2 input range would double to 0.2730 with the typical values above.

Once we have established the reference calibration levels, frequency response measurements at each level confirm that the performance is consistent with all settings. These are not adjustable, but should meet the published specifications (page 5) since variations should be small. All the gain and attenuator setting resistors used for scaling are precision thin film types that have very good accuracy, temperature stability and long term drift characteristics.

Keep in mind that the dspInstrument spDAQ is not a generator or an analyzer. It is the front end to a software application that collectively makes the combination a generator or an analyzer. This means that an application program will be involved in the calibration process.

Procedure

Calibration relies on a trusted external reference, typically a calibrated precision DMM that is traceable to a standards organization such as NIST.

The companion dspInstrument spDAQ Control App has a tool that quickly determines the correct scaling factors for the dspInstrument spDAQ and stores these values into non volatile memory. The program also calculates the correct scaling factors for each range based on these calibration values, but keep in mind that these values are all referenced with the assumption that the attenuators and programmable gain amplifiers have perfect accuracy.

You have the option of overwriting the factory/calibration lab settings or using user defined alternate settings. You may then choose which calibration settings will be entered into your companion Analyzer/Generator software.

In this procedure, the output scaling is determined first. It is certainly possible to do the input scaling first, as long as you know the incoming level.

Calibration Connection

1. Connect the Reference DMM using a BNC T connector to the front panel Output and Channel 1 of the dspInstrument spDAQ. The dspInstrument spDAQ will be acting as the signal generator in conjunction with your Analyzer/Generator software application.

2. Set **Mode** to Voltage and **Gain** & **Attenuation** levels to x1 in the **I/O Configuration** Menu.

Adjusting the Output Scaling Factor

1. Go to the **Calibration** Menu. Determine whether you want to adjust **Lab Calibrated** values or **User Calibrated** values. The procedure is the same in both cases, but you will probably want to leave the lab settings alone. Click the Allow Changes Button in the desired section.

2. Adjust the **Reference Voltage**. We recommend this to be set to 1.000, but other levels are possible.

3. Set the generator program for a Scaling Factor that matches the current **Calibrated Value**. This might be about 7.32 V_{RMS}/Fs. If the **Calibrated Value** is not near this number, press **Reset Values.** Set the output level in the generator program to match the **Reference Level** (probably 1.000V). The generator frequency should be 1004 Hz.

4. Enter the measured voltage from the trusted reference in the Adjustment field and press **Update**. This will change the **Calibrated Value** that is stored in the dspInstrument spDAQ. Copy this number and enter it into the scaling factor of the generator program. It is very likely that the measured output from the trusted reference (Precision DMM) will be very close to the reference level. The process is recursive so you can repeat this step once more if needed.

5. Repeat the process for Channel 2 if desired. Output Channel 1 is on the front panel and also available from the tip of the 3.5mm phone jack. Channel 2 is generally not used and is available from the ring of the 3.5mm jack.

Adjusting the Input Scaling Factor

1. Set the **Reference Voltage** (Input Section) to the reading on the DMM. This will probably be 1.0000V.

2. Set the FFT Window to Flat or Rectangular in the Analyzer/Generator application. This ensures that the level at 1004 Hz is accurate. With this setting, you are likely to see spectral leakage, which you can ignore.

3. Read the level as referenced from **Full Scale Voltage**. This might be a percentage below 100% or the actual value using a linear voltage scale. The value will be about 0.138 FS/V_{RMS}. Enter this number in the **Adjustment** field and **Update**.

4. Repeat this procedure for the Channel 2.

Confirming Other Parameters

1. Set the Analyzer/Generator for a frequency sweep or multitones to confirm that the frequency response is flat over the desired frequency range. The input levels and output level are still set in the x1 positions.

2. Repeat the measurements with other levels. You will need to adjust the Input and Output Scaling accordingly in the Analyzer/Generator. These numbers are provided in the **I/O Configuration** Menu.

3. Change Mode to IEPE. Connect a 250 ohm resistor load to each input. The DC bias will be 10V which is 4mA * 250 ohm.

4. Go to the TEDS menu and read a known TEDS sensor.

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Danville Signal Processing products are warranted against defects in materials and workmanship. If Danville Signal Processing receives notice of such defects during the warranty period, Danville Signal Processing shall, at its option, either repair or replace hardware products, which prove to be defective.

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- Buyer-supplied software or interfacing;
- Unauthorized modification or misuse;
- Operation outside the environmental specification of the product;
- Improper site preparation and maintenance.

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