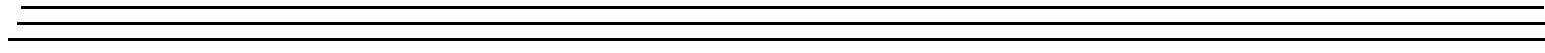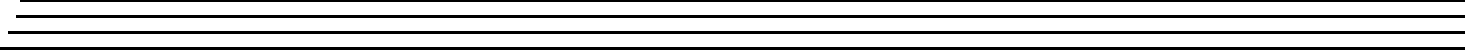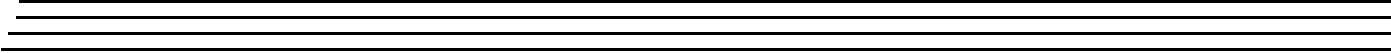DATA TRANSLATION®
A MEASUREMENT COMPUTING COMPANY

DT9828 User's Manual

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Radio and Television Interference

This equipment has been tested and found to comply with CISPR EN55022 Class A and EN61000-6-1 requirements and also with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

Changes or modifications to this equipment not expressly approved by Data Translation could void your authority to operate the equipment under Part 15 of the FCC Rules.

Note: This product was verified to meet FCC requirements under test conditions that included use of shielded cables and connectors between system components. It is important that you use shielded cables and connectors to reduce the possibility of causing interference to radio, television, and other electronic devices.

Canadian Department of Communications Statement

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de la class A prescrites dans le Règlement sur le brouillage radioélectrique édicté par le Ministère des Communications du Canada.

Table of Contents

About this Manual

The first part of this manual describes how to install and set up your DT9828 module and device driver, and verify that your module is working properly.

The second part of this manual describes the features of the DT9828 module, the capabilities of the DT9828 Device Driver, and how to program the DT9828 module using the DT-Open Layers for .NET Class Library™ software. Troubleshooting and calibration information is also provided.

Note: For information on checking system requirements, installing the software, and viewing the documentation, refer to the README file on the OMNI CD.

For more information on the class library, refer to the *DT-Open Layers for .NET Class Library User's Manual*. If you are using the DataAcq SDK or a software application to program your device, refer to the documentation for that software for more information.

Intended Audience

This document is intended for engineers, scientists, technicians, or others responsible for using and/or programming the DT9828 module for data acquisition operations in the Microsoft® Windows® XP, or Windows Vista®, Windows 7, or Windows 8 operating system. It is assumed that you have some familiarity with data acquisition principles and that you understand your application.

How this Manual is Organized

The manual is organized as follows:

- Chapter 1, "Overview," describes the major features of the DT9828 module, as well as the supported software and accessories for the modules.

- Chapter 2, "Installing a Module," describes how to install the DT9828 module.

- Chapter 3, "Wiring Signals," describes how to wire signals to a DT9828 module.

- Chapter 4, "Verifying the Operation of a Module," describes how to verify the operation of the DT9828 module with the QuickDAQ application.

- Chapter 5, "Principles of Operation," describes all of the features of the DT9828 module and how to use them in your application.

- Chapter 6, "Supported Device Driver Capabilities," lists the data acquisition subsystems and the associated features accessible using the DT9828 Series Device Driver.

- Chapter 7, "Calibration," describes how to calibrate the analog input circuitry of the DT9828 module.

- Chapter 8, "Troubleshooting," provides information that you can use to resolve problems with the DT9828 module and the device driver, should they occur.

- Appendix A, "Specifications," lists the specifications of the modules.

- Appendix B, "Pin Assignments and LED Status Indicators," shows the pin assignments for the connectors and screw terminals on the modules, and describes the LEDs on the modules.

- An index completes this manual.

Conventions Used in this Manual

The following conventions are used in this manual:

- Notes provide useful information or information that requires special emphasis, cautions provide information to help you avoid losing data or damaging your equipment, and warnings provide information to help you avoid catastrophic damage to yourself or your equipment.

- Items that you select or type are shown in **bold**.

Related Information

Refer to the following documents for more information on using the DT9828 module:

- *Benefits of the Universal Serial Bus for Data Acquisition.* This white paper describes why USB is an attractive alternative for data acquisition. It is available on the Data Translation web site (www.mccdaq.com).

- *QuickDAQ User's Manual* (UM-24774). This manual describes how to create a QuickDAQ application to acquire and analyze data from DT-Open Layers data acquisition devices.

- *DT-Open Layers for .NET User's Manual* (UM-22161). For programmers who are developing their own application programs using Visual C# or Visual Basic .NET, this manual describes how to use the DT-Open Layers for .NET Class Library to access the capabilities of Data Translation data acquisition devices.

- *DataAcq SDK User's Manual* (UM-18326). For programmers who are developing their own application programs using the Microsoft C compiler, this manual describes how to use the DT-Open Layers DataAcq SDK™ to access the capabilities of Data Translation data acquisition devices.

- *DAQ Adaptor for MATLAB* (UM-22024). This document describes how to use Data Translation's DAQ Adaptor to provide an interface between the MATLAB Data Acquisition subsystem from The MathWorks and Data Translation's DT-Open Layers architecture.

- *LV-Link Online Help*. This help file describes how to use LV-Link™ with the LabVIEW™ graphical programming language to access the capabilities of Data Translation data acquisition devices.

- Microsoft Windows XP, Windows Vista, Windows 7, or Windows 8 documentation.

- USB web site (http://www.usb.org).

- *Omega Complete Temperature Measurement Handbook and Encyclopedia®.* This document, published by Omega Engineering, provides information on how to linearize voltage values into temperature readings for various thermocouple types.

Where To Get Help

Should you run into problems installing or using a DT9828 module, the Data Translation Technical Support Department is available to provide technical assistance. Refer to Chapter 8 for more information. If you are outside the United States or Canada, call your local distributor, whose number is listed on our web site (www.mccdaq.com).

1

Overview

Features

The DT9828, shown in Figure 1, is a low-cost thermocouple and voltage input module for the version 1.1, 2.0, or 3.0 of the Universal Serial Bus (USB).
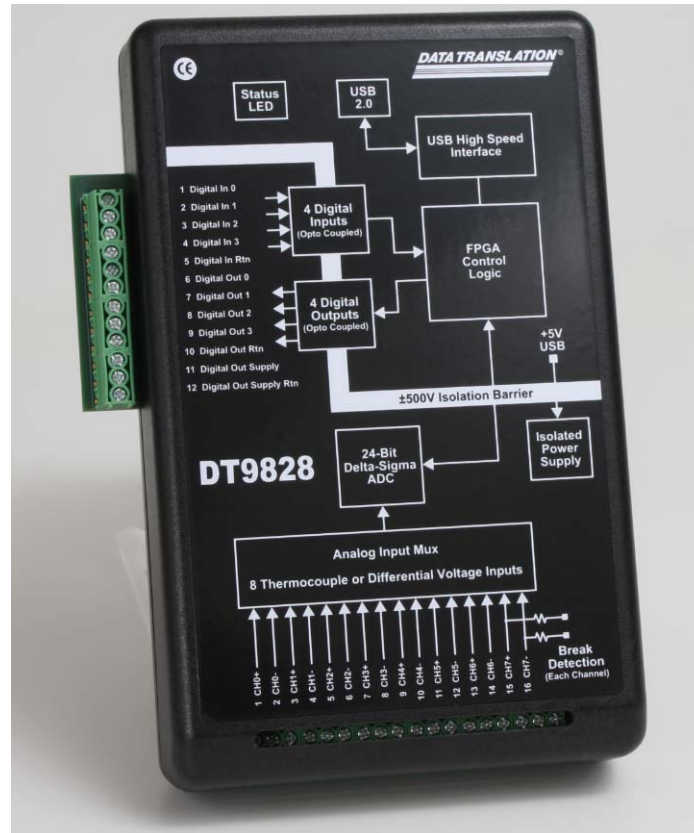
Figure 1: DT9828 Thermocouple and Voltage Module

The key features of the DT9828 module are as follows:

• 8 differential analog inputs for thermocouple or voltage input measurements

• Support for B, E, J, K, N, R, S, and T thermocouple types

• One cold junction compensation (CJC) circuit for all thermocouple inputs

• Open thermocouple detection

• Input resolution of 24 bits

• Analog throughput of up to 600 Samples/s

• Input voltage range of ±156.25 mV

• Four, isolated, TTL, 12 V and 24 V digital inputs; you can read the status of the digital input port in the analog input stream

• Four, isolated, open-collector digital outputs

- ±500 V galvanic isolation to the computer

- Powered by USB bus; no external power supply required

- A software calibration utility is provided for calibrating the analog input subsystem

Supported Software

The following software is available for use with DT9828 module and is shipped on the Data Acquisition OMNI CD:

- **DT9828 Series Device Driver** – The device driver allows you to use a DT9828 module with any of the supported software packages or utilities. Refer to Chapter 2 starting on page 23 for more information on loading and configuring the device driver.

- **DT9828 Series Calibration Utility** – The DT9828 Series Calibration Utility allows you to calibrate the analog input circuitry of the DT9828 module. Refer to Chapter 8 starting on page 89 for more information on this utility.

- **QuickDAQ Base Version** – The base version of QuickDAQ is free-of-charge and allows you to acquire and analyze data from all Data Translation USB and Ethernet devices, except the DT9841 Series, DT9817, DT9835, and DT9853/54. Using the base version of QuickDAQ, you can perform the following functions:

  - Discover and select your devices.

  - Configure all input channel settings for the attached sensors.

  - Load/save multiple hardware configurations.

  - Generate output stimuli (fixed waveforms, swept sine waves, or noise signals).

  - On each supported data acquisition device, acquire data from all channels supported in the input channel list.

  - Choose to acquire data continuously or for a specified duration.

  - Choose software or triggered acquisition.

  - Log acquired data to disk in an .hpf file.

  - Display acquired data during acquisition in either a digital display using the Channel Display window or as a waveform in the Channel Plot window.

  - Choose linear or logarithmic scaling for the horizontal and vertical axes.

  - View statistics about the acquired data, including the minimum, maximum, delta, and mean values and the standard deviation in the Statistics window.

  - Export time data to a .csv or .txt file; you can open the recorded data in Microsoft Excel® for further analysis.

  - Read a previously recorded .hpf data file.

  - Customize many aspects of the acquisition, display, and recording functions to suit your needs, including the acquisition duration, sampling frequency, trigger settings, filter type, and temperature units to use.

- **QuickDAQ FFT Analysis Option** – When enabled with a purchased license key, the QuickDAQ FFT Analysis option includes all the features of the QuickDAQ Base version plus basic FFT analysis features, including the following:

  - The ability to switch between the Data Logger time-based interface and the FFT Analyzer block/average-based interface.

  - Supports software, freerun, or triggered acquisition with accept and reject controls for impact testing applications.

  - Allows you to perform single-channel FFT (Fast Fourier Transform) operations, including AutoSpectrum, Spectrum, and Power Spectral Density, on the acquired analog input data. You can configure a number of parameters for the FFT, including the FFT size, windowing type, averaging type, integration type, and so on.

  - Allows you to display frequency-domain data as amplitude or phase.

  - Supports dB or linear scaling with RMS (root mean squared), peak, and peak-to-peak scaling options

  - Supports linear or exponential averaging with RMS, vector, and peak hold averaging options.

  - Supports windowed time channels.

  - Supports the following response window types: Hanning, Hamming, Bartlett, Blackman, Blackman Harris, and Flat top.

  - Supports the ability to lock the waveform output to the analysis frame time.

  - Allows you to configure and view dynamic performance statistics, including the input below full-scale (IBF), total harmonic distortion (THD), spurious free dynamic range (SFDR), signal-to-noise and distortion ratio (SINAD), signal-to-noise ratio (SNR), and the effective number of bits (ENOB), for selected time-domain channels in the Statistics window.

  - Supports digital IIR (infinite impulse response) filters.

- **QuickDAQ Advanced FFT Analysis Option** – When enabled with a purchased software license, the QuickDAQ Advanced FFT Analysis option includes all the features of the QuickDAQ Base version with the FFT Analysis option plus advanced FFT features, including the following:

  - Allows you to designate a channel as a Reference or Response channel.

  - Allows you to perform two-channel FFT analysis functions, including Frequency Response Functions (Inertance, Mobility, Compliance, Apparent Mass, Impedance, Dynamic Stiffness, or custom FRF) with H1, H2, or H3 estimator types, Cross-Spectrum, Cross Power Spectral Density, Coherence, and Coherent Output Power.

  - Supports the Exponential response window type.

  - Supports the following reference window types: Hanning, Hamming, Bartlett, Blackman, Blackman Harris, FlatTop, Exponential, Force, and Cosine Taper windows.

  - Supports real, imaginary, and Nyquist display functions.

  - Allows you to save data in the .uff file format.

- **Quick DataAcq application** – The Quick DataAcq application provides a quick way to get up and running using a DT9828 module. Using this application, you can verify key features of the modules, display data on the screen, and save data to disk.

- **DT-Open Layers for .NET Class Library** – Use this class library if you want to use Visual C# or Visual Basic for .NET to develop your own application software for a DT9828 module using Visual Studio 2003-2012; the class library complies with the DT-Open Layers standard.

- **DataAcq SDK** – Use the Data Acq SDK if you want to use Visual Studio 6.0 and Microsoft C or C++ to develop your own application software for the DT9828 module using Windows XP, Windows Vista, Windows 7, or Windows 8; the DataAcq SDK complies with the DT-Open Layers standard.

- **DAQ Adaptor for MATLAB** – Data Translation's DAQ Adaptor provides an interface between the MATLAB Data Acquisition (DAQ) subsystem from The MathWorks and Data Translation's DT-Open Layers architecture.

- **LV-Link** – LV-Link allows you to access the capabilities of a DT9828 module from the LabVIEW graphical programming language.

Refer to the Data Translation web site (www.mccdaq.com) for information about selecting the right software package for your needs.

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Accessories

One EP365 cable is shipped with each DT9828 module. The EP365 is a 1.83-meter, USB cable that connects the USB connector of the module to the USB connector on the host computer. If you want to buy additional USB cables, EP365 is available as an accessory product for the DT9828 module.

Getting Started Procedure

The flow diagram shown in Figure 2 illustrates the steps needed to get started using the DT9828 module. This diagram is repeated in each Getting Started chapter; the shaded area in the diagram shows you where you are in the procedure.

Install the Module
(see Chapter 2 starting on page 23)

Wire Signals
(see Chapter 3 starting on page 33)

Verify the Operation of the Module
(see Chapter 4 starting on page 43)
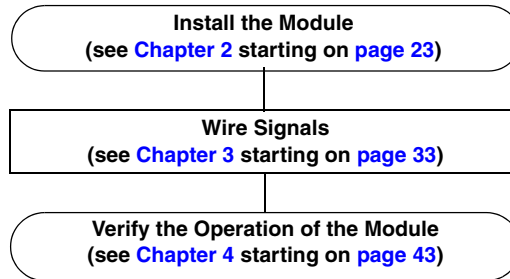
Figure 2: Getting Started Flow Diagram

Part 1: Getting Started

2

Installing a Module

Install the Module
(this chapter)

Wire Signals
(see Chapter 3 starting on page 33)

Verify the Operation of the Module
(see Chapter 4 starting on page 43)

Unpacking

Open the shipping box and verify that the following items are present:

• DT9828 module

• EP365 USB cable

• Data Acquisition OMNI CD

If an item is missing or damaged, contact Data Translation. If you are in the United States, call the Customer Service Department at (508) 946-5100. An application engineer will guide you through the appropriate steps for replacing missing or damaged items. If you are located outside the United States, call your local distributor, listed on Data Translation's web site (www.mccdaq.com).

System Requirements

For reliable operation, ensure that your computer meets the following system requirements:

- Processor: Pentium 4/M or equivalent

- RAM: 1 GB

- Screen Resolution: 1024 x 768 pixels

- Operating System: Windows 8, Windows 7, Windows Vista (32- and 64-bit), or
  Windows XP SP3 (32-bit)

- Disk Space: 4 GB

Attaching Modules to the Computer

You can attach a DT9828 module to the host computer in one of two ways:

- Connect directly to a USB port of the host computer, described on this page. Use this method if one or two modules are sufficient for your application.

- Connect to one or more self-powered USB hubs, described on page 28. Use this method if your application requires more modules than the USB ports on the host computer.

You **must** install the device driver before connecting a DT9828 module to the host computer.

Note: The DT9828 module is a low-power device (using less than 500 mA); therefore, it does not require an external power supply.

Connecting Directly to the USB Ports

To connect a DT9828 module directly to a USB port on your computer, do the following:

1. Attach one end of the EP365 (USB) cable, which is shipped with the module, to the USB port on the module.

2. Attach the other end of the EP365 cable to one of the USB ports on the host computer. Figure 3 shows the USB port on the DT9828 module.
The operating system automatically detects the USB device and starts the Found New Hardware wizard.

The USB LED is green when the module is powered and blinks amber when the module is acquiring data.
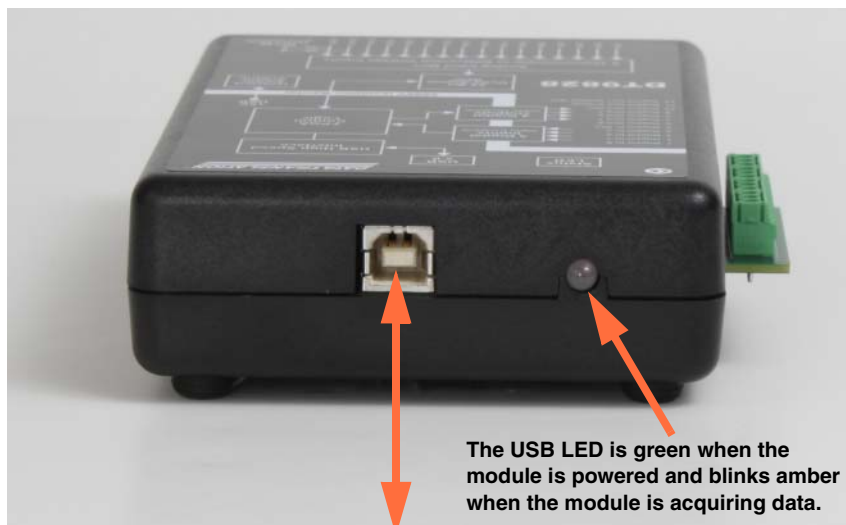
Attach the USB cable (EP365) here.
Plug the other end into a USB port of your host computer.

Figure 3: Attaching the Module to the Host Computer

3. *For Windows Vista*:

   a. Click **Locate and install driver software (recommended**).
   The popup message "Windows needs your permission to continue" appears.

   b. Click **Continue**.
   The Windows Security dialog box appears.

   c. Click **Install this driver software anyway**.

   For Windows XP:

   a. Click **Next** and/or **Finish** as required in the wizard.
   Once the firmware is loaded, the wizard restarts to initiate the firmware to accept commands.

   b. Click **Next** and/or **Finish** again.

Note: Windows 7 and Windows 8 find the device automatically.

---

4. Repeat these steps to attach another DT9828 module to the host computer, if desired.

Note: You can unplug a module, and then plug it in again, if you wish, without causing damage. This process is called hot-swapping.

Your application may take a few seconds to recognize a module once it is plugged back in.

Once you have connected your module to the host computer, power is turned on to the module when your application program opens the module. The LED on the module, shown in , turns green to indicate that power is turned on. Power is turned off to the module when your application program terminates its connection to the module.

Connecting to an Expansion Hub

Expansion hubs are powered by their own external power supply. The practical number of DT9828 modules that you can connect to a single USB port depends on the throughput you want to achieve.

Note: The bandwidth of the USB Ver. 1.1 bus is 12 Mbits/second. Each DT9828 module running at full speed (600 kHz multiplexed) requires 4800 bytes/s or 39.6 kbits/s of this bandwidth. Keep this in mind when determining how many modules to connect.

To connect multiple DT9828 modules to an expansion hub, do the following:

1. Attach one end of the USB cable to the module and the other end of the USB cable to an expansion hub.

2. Connect the power supply for the expansion hub to an external power supply.

3. Connect the hub to the USB port on the host computer using another USB cable.
   The operating system automatically detects the USB device and starts the Found New Hardware wizard.

4. *For Windows Vista*:

   a. Click **Locate and install driver software (recommended)**.
      The popup message "Windows needs your permission to continue" appears.

   b. Click **Continue**.
      The Windows Security dialog box appears.

   c. Click **Install this driver software anyway**.

   For Windows XP:

   a. Click **Next** and/or **Finish** as required in the wizard.
      Once the firmware is loaded, the wizard restarts to initiate the firmware to accept commands.

   b. Click **Next** and/or **Finish** again.

Note: Windows 7 and Windows 8 find the device automatically.

---

5. Repeat these steps until you have attached the number of hubs and modules that you desire. Refer to Figure 4.
   The operating system automatically detects the USB devices as they are installed.
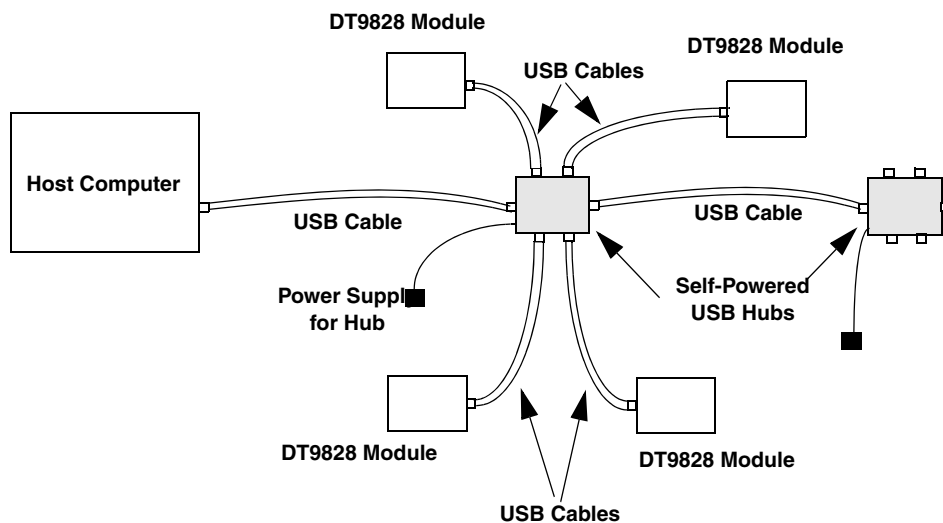
Figure 4: Attaching Multiple Modules Using Expansion Hubs

Note: You can unplug a module, and then plug it in again, if you wish, without causing damage. This process is called hot-swapping.

Your application may take a few seconds to recognize a module once it is plugged back in.

Once you have connected your module to the host computer, power is turned on to the module when your application program opens the module. The LED on the module, shown in Figure 3 on page 27, turns green to indicate that power is turned on. Power is turned off to the module when your application program terminates its connection to the module.

Configuring the Device Driver

> **Note:** In Windows 7, Windows 8, and Vista, you must have administrator privileges to run the Open Layers Control Panel. When you double-click the Open Layers Control Panel icon, you may see the Program Compatibility Assistant. If you do, select **Open the control panel using recommended settings**. You may also see a Windows message asking you if you want to run the Open Layers Control Panel as a "legacy CPL elevated." If you get this message, click **Yes**.
>
> If you do not get this message and have trouble making changes in the Open Layers Control Panel, right click the DTOLCPL.CPL file and select **Run as administrator**. By default, this file is installed in the following location:
>
> Windows 7, Windows 8, and Vista (32-bit)
> C:\Windows\System32\Dtolcpl.cpl
>
> Windows 7, Windows 8, and Vista (64-bit)
> C:\Windows\SysWOW64\Dtolcpl.cpl

To configure the DT9828 Series Device Driver, do the following:

1. If you have not already done so, power up the host computer and all peripherals.

2. From the Windows Control Panel, double-click the **Open Layers Control Panel** icon. *The Data Acquisition Control Panel dialog box appears.*

3. Click the DT9828 module that you want to configure.

4. If you want to rename the module, click **Edit Name**.

5. Enter a new name for the module, and then click **OK**.

> **Note:** This name is used to identify the module in all subsequent applications.

6. When you are finished configuring the module, click **Close**.

7. Repeat steps 3 to 6 for the other modules that you want to configure.

8. Close the Control Panel.

3

Wiring Signals

```
        ╭─────────────────────────────────╮
        │       Install the Module        │
        │ (see Chapter 2 starting on page 23) │
        ╰─────────────────────────────────╯
                        │
        ┌─────────────────────────────────┐
        │          Wire Signals           │
        │         (this chapter)          │
        └─────────────────────────────────┘
                        │
        ╭─────────────────────────────────╮
        │  Verify the Operation of the Module │
        │ (see Chapter 4 starting on page 43) │
        ╰─────────────────────────────────╯
```

Note: If you are using thermocouples with the DT9828 module, it is recommended that you run the DT9828 Series Calibration Utility prior to using the module. Refer to Chapter 8 starting on page 89 for instructions.

General Wiring Recommendations

Keep the following recommendations in mind when wiring signals to a DT9828 module:

- Separate power and signal lines by using physically different wiring paths or conduits.

- To avoid noise, do not locate the instrument and cabling next to sources that produce high electromagnetic fields, such as large electric motors, power lines, solenoids, and electric arcs, unless the signals are enclosed in a mumetal shield.

- Locate the DT9828 module as far away as possible from sources of high or low temperatures or strong air currents, such as fans.

- Prevent electrostatic discharge to the I/O while the instrument is operational.

- When wiring thermocouples, use a wire insulation strip length of 0.197 inches (5 mm).

- Use 16 AWG to 26 AWG shielded wire for maximum rejection of electrical interference.

Note: The DT9828 module requires a warm-up time of 10 minutes for the analog circuitry to stabilize.

Connecting Thermocouple Inputs

DT9828 modules support up to eight, differential thermocouple channels. You connect thermocouple signals to the Analog Input screw terminal block (TB1) of the module. Figure 5 shows the layout of the DT9828 module.

Analog Input Screw Terminal Block (TB1)
Insert wires through the side and screw from the top.

Side View
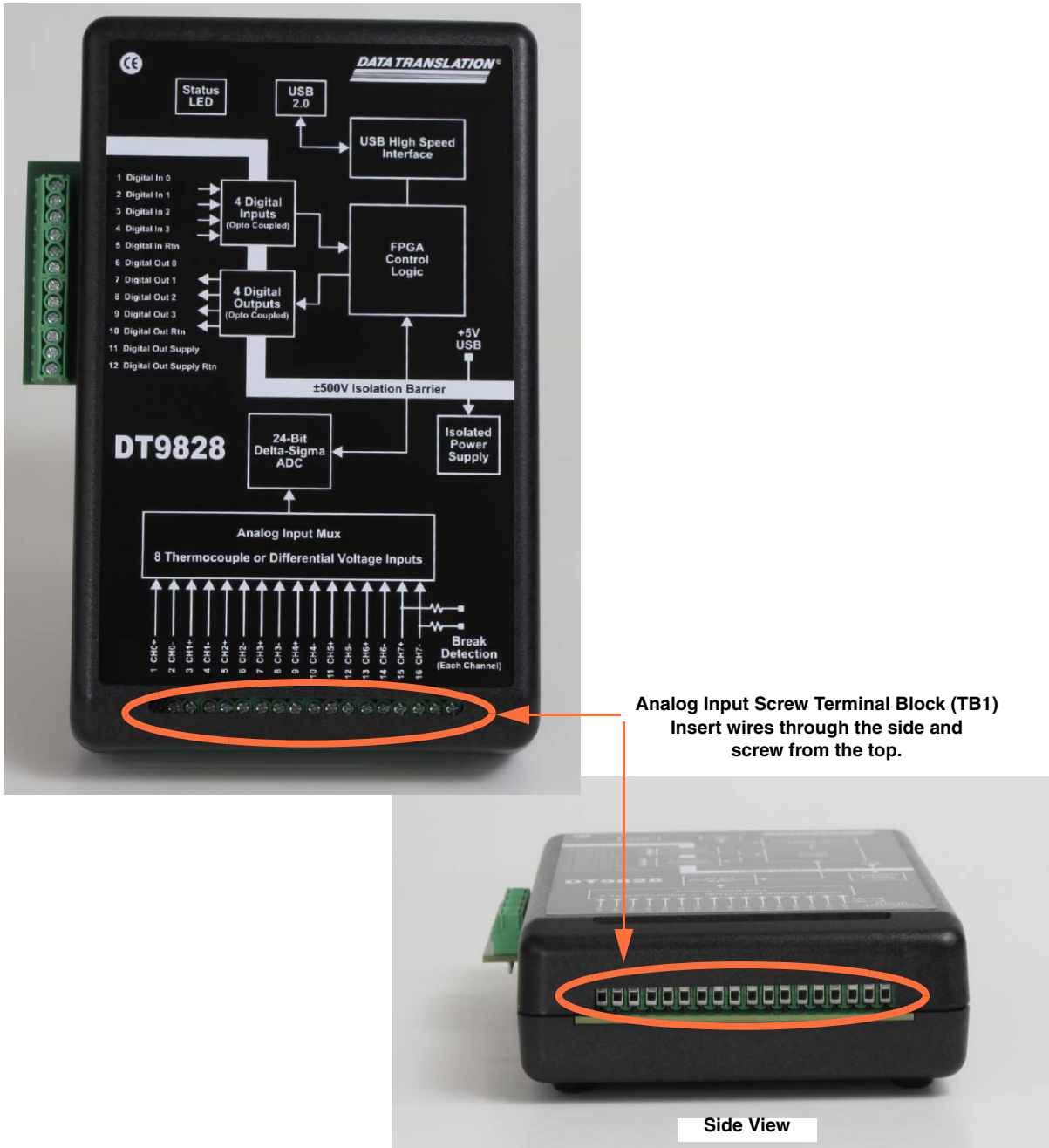
Figure 5: Analog Input Screw Terminal Block (TB1) on the DT9828 Module

Figure 6 shows how to connect a thermocouple input to a DT9828 module.
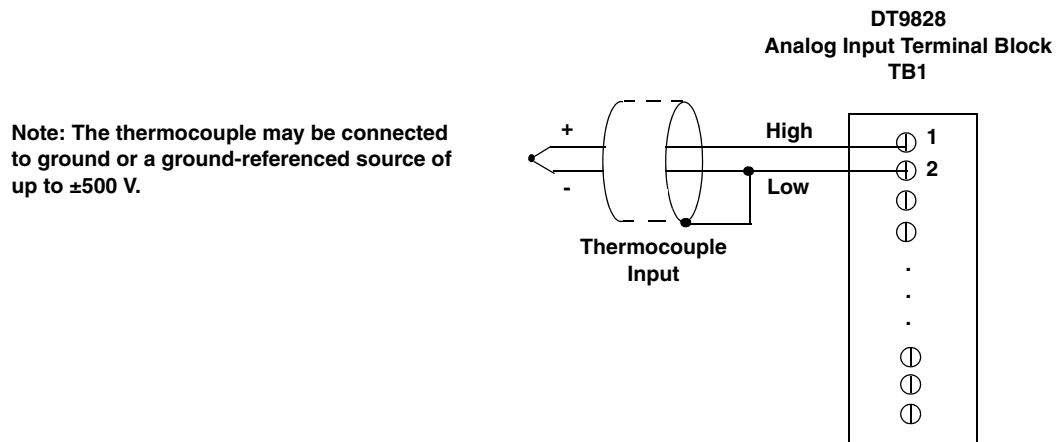
Figure 6: Connecting Thermocouple Inputs (Shown for Analog Input Channel 0)

Note: One cold-junction compensation (CJC) circuit is provided for all thermocouple input channels. The software reads the value of the CJC input and applies it to the value of the thermocouple input to correct for errors based on the specified thermocouple type.

The output of the channel goes to positive, full-scale if an open circuit is detected at the input.

Connecting Voltage Input Signals

DT9828 modules support up to eight, differential voltage input channels. You connect voltage input signals to the Analog Input screw terminal block (TB1) of the module (see Figure 5 on page 36 for the DT9828).

Figure 7 illustrates how to connect a floating signal source to a DT9828 module. (A floating signal source is a voltage source that has no connection with earth ground.)

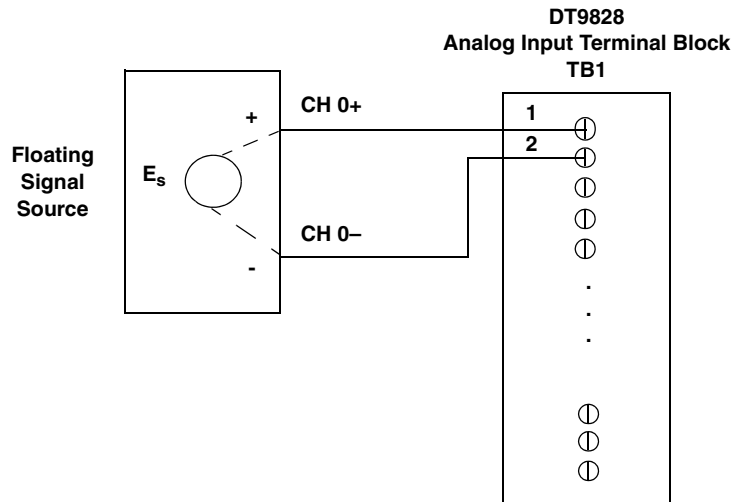**Figure 7: Connecting Differential Voltage Inputs (Shown for Analog Input Channel 0)**

Figure 8 illustrates how to connect a grounded (nonfloating) signal source to a DT9828 module.
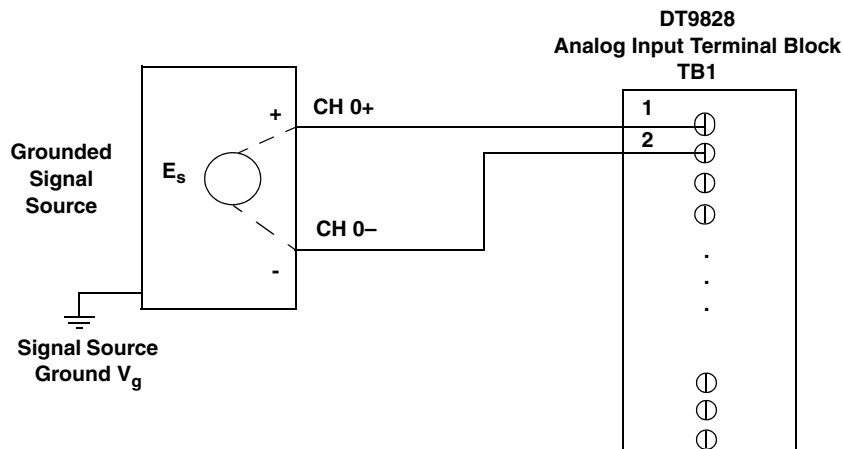
Figure 8: Connecting Differential Voltage Inputs from a Grounded Signal Source (Shown for Analog Input Channel 0)

Connecting Current Loop Inputs

You connect current loop inputs to the Analog Input screw terminal block (TB1) of the DT9828 module (see Figure 5 on page 36 for the DT9828).

Figure 9 shows how to connect a current loop input to a DT9828 module.

DT9828
Analog Input Terminal Block
TB1

CH 0+

4 to 20 mA

CH 0–

User-installed resistor

The user-installed resistor connects the high side of the channel to the low side of the corresponding channel, thereby acting as a shunt.

If, for example, you add a 1 Ω resistor, and then connect a 4 to 20 mA current loop input to channel 0, the input range is converted to 4 mV to 20 mV.

Be sure to choose a resistor such that the voltage developed across it remains within the ±156.25 mV input range of the DT9828.

Figure 9: Connecting Current Inputs (Shown for Analog Input Channel 0)

Connecting Digital Input Signals

DT9828 modules support up to four, isolated, TTL, 12 V and 24 V digital input lines. You connect digital input signals to the Digital I/O screw terminal (TB2) on the module, shown in Figure 10.

Digital I/O Screw Terminal Block (TB2)
Insert wires through the side and
screw from the top.

Figure 10: Digital I/O Screw Terminal Block (TB2) on the DT9828 Module

Figure 11 shows how to connect digital input signals (lines 0 and 1, in this case) to a DT9828 module.
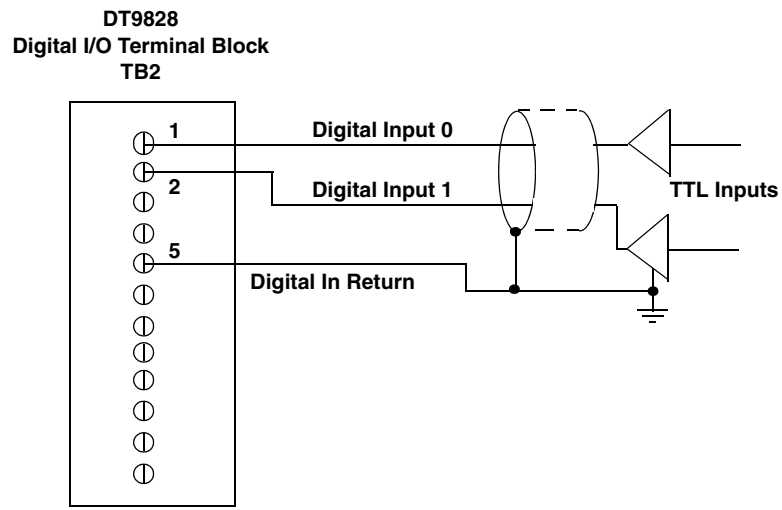

Figure 11: Connecting Digital Inputs (Shown for Digital Input Lines 0 and 1)

Connecting Digital Output Signals

The DT9828 module provides four open-collector digital outputs and a common return that are isolated from the analog input circuitry, USB ground, and digital input ground. The open collector outputs have a drive capability of 2 mA maximum and can control circuitry that is powered from an external supply.

Digital I/O terminal block TB2 on the DT9828, shown in Figure 10 on page 40, provides screw terminals for connecting an external supply (in the 3.3 VDC to 30 VDC range) and an external supply return.

Each open collector output has a weak pull-up resistor of 100 kΩ to the External Supply terminal of the screw terminal block TB2. Connecting a 3.3 V to 5 V supply provides outputs that are capable of driving TTL-level logic.

Figure 12 shows an example of connecting an open-collector digital output on the DT9828 module to an external supply and logic gate.
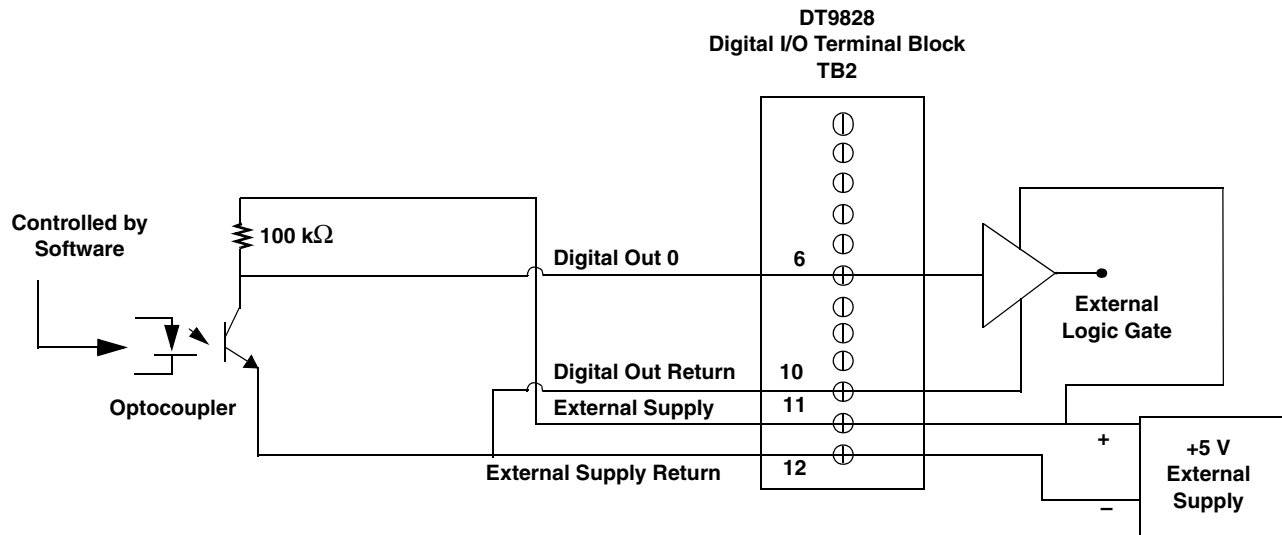
Figure 12: An Example of Connecting an Open-Collector Digital Output of a DT9828 Module to an External Supply and Logic Gate (Shown for Digital Output Line 0)

4

Verifying the Operation of a Module

Install the Module
(see **Chapter 2** starting on **page 23**)

Wire Signals
(see **Chapter 3** starting on **page 33**)

Verify the Operation of the Module
(this chapter)

QuickDAQ allows you to acquire and analyze data from all Data Translation USB and Ethernet devices, except the DT9841 Series, DT9817, DT9835, and DT9853/54. This chapter describes how to verify the operation of a DT9828 module using the QuickDAQ base version.

Selecting the Device

To get started with your DT9828 module and the QuickDAQ application, follow these steps:

1. Connect the DT9828 module to the USB port of your computer, and connect your thermocouples or voltage inputs to the module.

2. Start the QuickDAQ application.
   The Device Selection window appears.
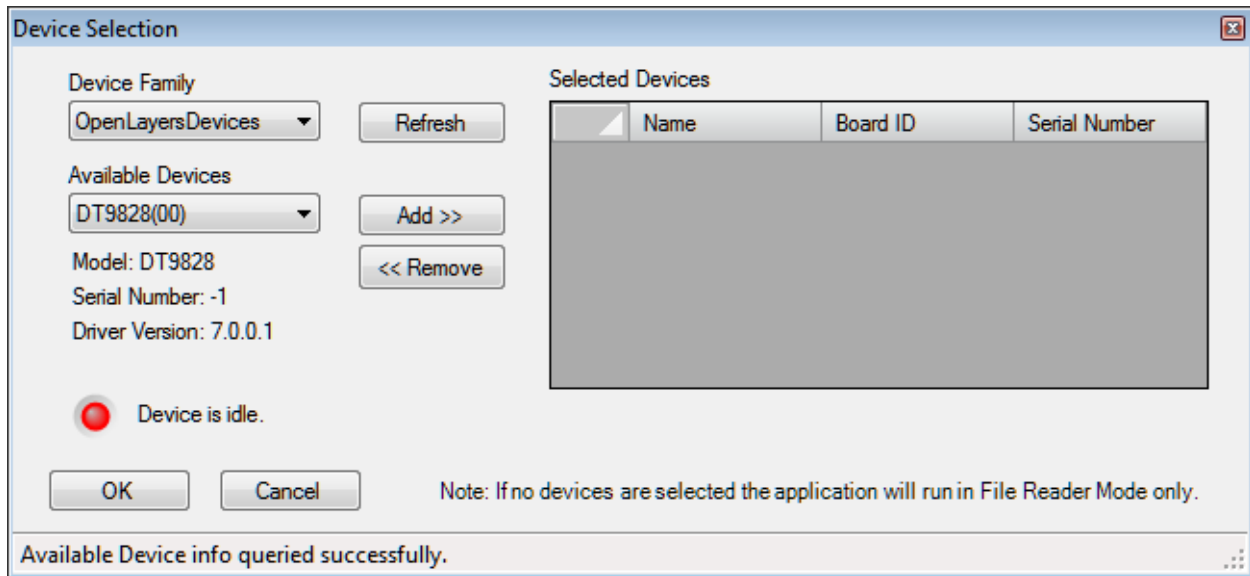

3. For the Device Family selection, select **OpenLayersDevices**.
   By default, the application "discovers" all devices that are available for the specified device family and displays the module name for the USB devices in the drop-down list. If you want to refresh this list to determine if other devices are available, click **Refresh**.

4. Select the module name for the module that you want to use from the list of Available Devices, and click **Add**.
   Information about the device, including the model number, serial number, firmware version, driver version, and scanning status is displayed.
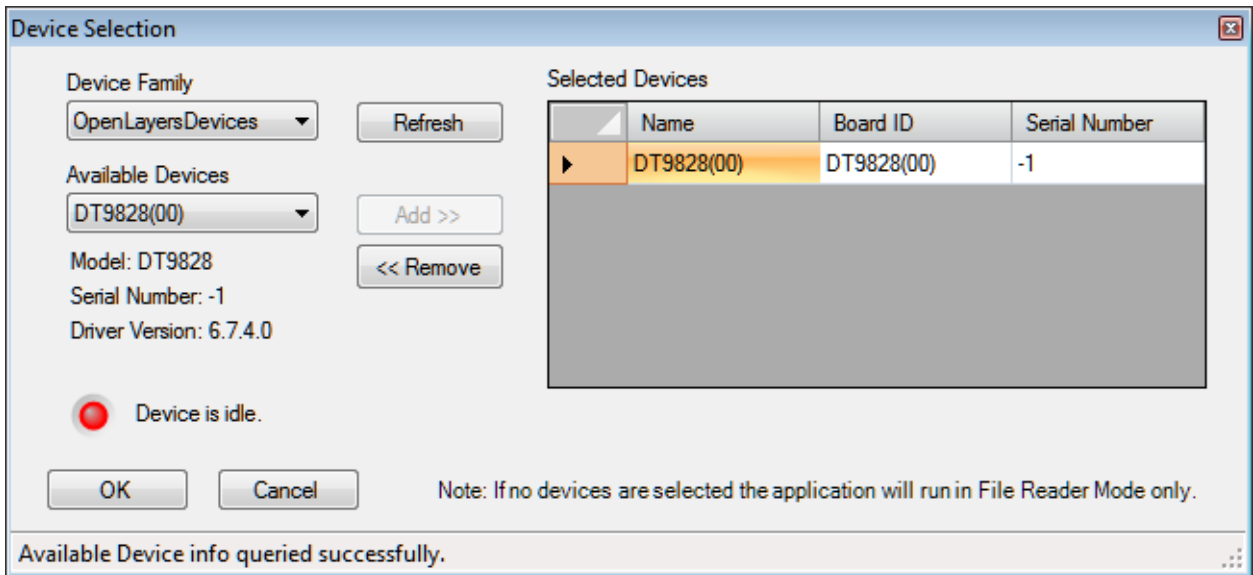
5. (Optional) If you want to remove a device from list of selected devices, click the Row Selector button for the device, and then click **Remove**.

6. Once you have added all the devices that you want to use with the application, click **OK**. *The latest state is saved and used when the application is next run, and the interface of the QuickDAQ application is displayed.*
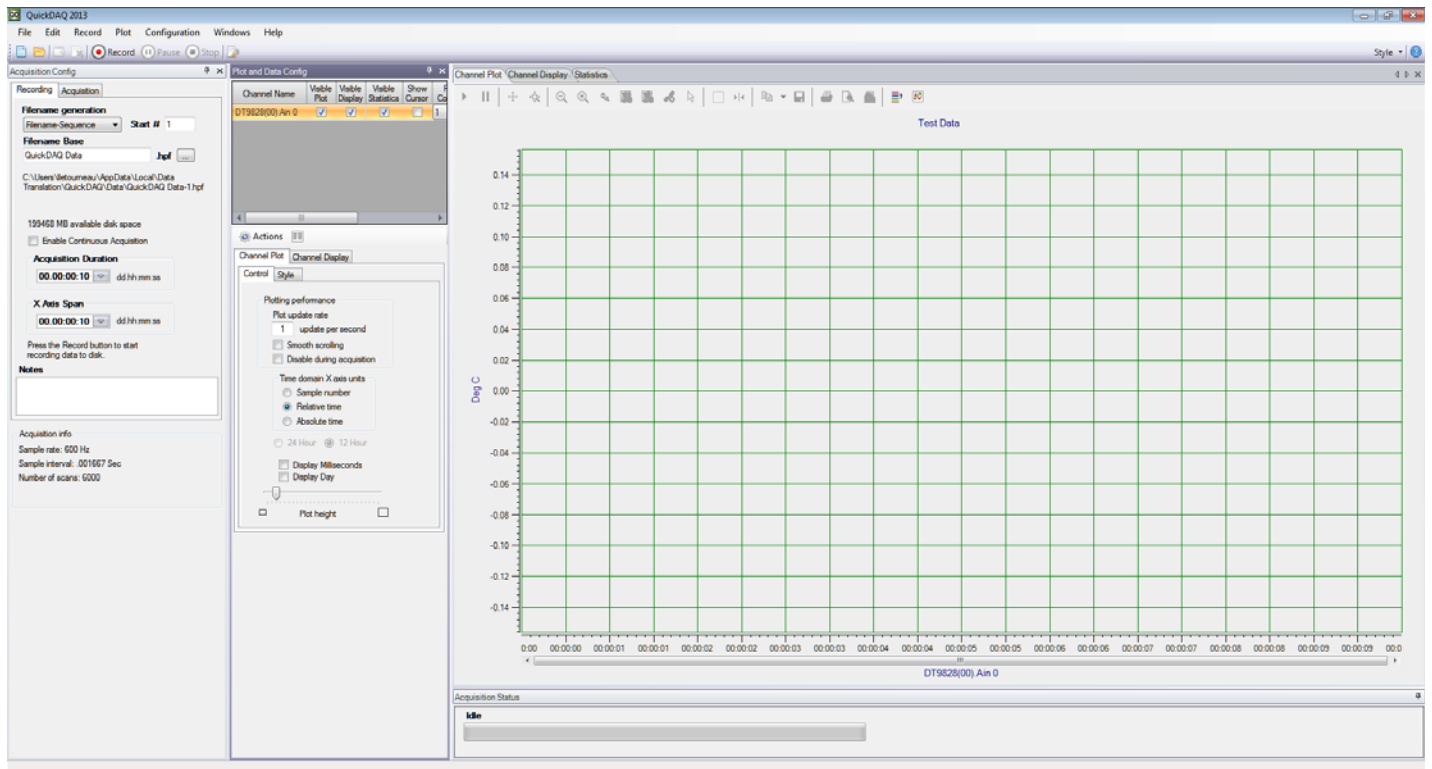
Thermocouple Measurement Example

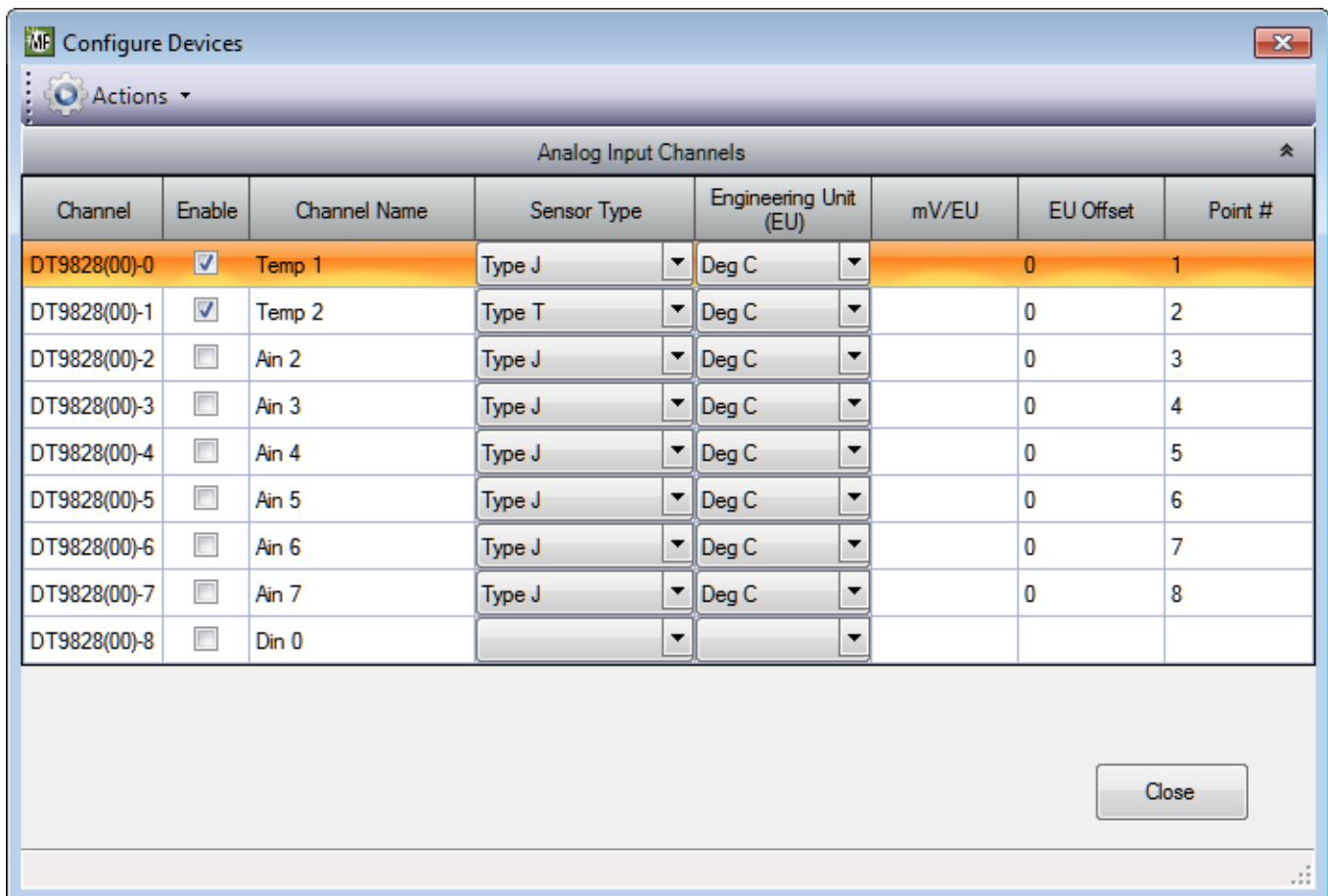The following steps describe how to use the QuickDAQ application to measure temperature from thermocouple inputs.

This example uses a type J thermocouple connected to analog input channel 0 and a type T thermocouple connected to analog input channel 1 of a DT9828 module.

Configure the Channels

Configure the channels as follows:

1. Configure each analog input channel by clicking the **Configuration** menu, and clicking **Input Channel Configuration**, or by clicking the **Input Channel Configuration** toolbar button ( ).

2. Enable analog input channels 0 and 1 by clicking the checkbox under the **Enable** column.

Channel	Enable	Channel Name	Sensor Type	Engineering Unit (EU)	mV/EU	EU Offset	Point #
DT9828(00)-0	☑	Temp 1	Type J ▼	Deg C ▼	0		1
DT9828(00)-1	☑	Temp 2	Type T ▼	Deg C ▼		0	2
DT9828(00)-2	☐	Ain 2	Type J ▼	Deg C ▼		0	3
DT9828(00)-3	☐	Ain 3	Type J ▼	Deg C ▼		0	4
DT9828(00)-4	☐	Ain 4	Type J ▼	Deg C ▼		0	5
DT9828(00)-5	☐	Ain 5	Type J ▼	Deg C ▼		0	6
DT9828(00)-6	☐	Ain 6	Type J ▼	Deg C ▼		0	7
DT9828(00)-7	☐	Ain 7	Type J ▼	Deg C ▼		0	8
DT9828(00)-8	☐	Din 0	▼	▼			

Configure Devices — Actions — Analog Input Channels — Close

3. Under the **Channel Name** column, enter a meaningful name for the channel.
   *For this example, enter **Temp 1** for analog input channel 0 and **Temp 2** for analog input channel 1.*

4. Under the **Sensor Type** column, select the sensor type for the channel.
   *For this example, set the sensor type for analog input channel 0 to **Type J** and the sensor type for analog input channel 1 to **Type T**.*

5. Under the **Engineering Units** column, **Deg C** is selected by default. If you want to change this setting, change the temperature units under the **Acquisition** tab.
   *In this example, **Deg C** is used.*

6. If you know the offset for your calibrated thermocouple, enter it under the **EU Offset** column.
   *For this example, leave **0** as the EU offset for the thermocouple.*

7. Leave the test point values for each channel unchanged.

8. Click **Close** to close the Channel Configuration dialog box.

## Configure the Parameters of the Acquisition Config Window

For this example, set the Acquisition Config parameters as follows:

1. Click the **Recording** tab.

2. For **Filename**, enter a meaningful name for the data file.
   *In this example, **LogData.hpf** is used.*

3. Leave the **Enable Continuous Acquisition** checkbox unchecked.

4. For **Acquisition Duration**, select **10 seconds** as the time to acquire the measurement data.
   The amount of available disk space is shown; in addition, the number of scans in the Acquisition Info area is updated based on the acquisition duration that is selected.

5. For **X Axis Span**, leave **10 seconds** as the span for the x-axis.

6. Click the **Acquisition** tab.
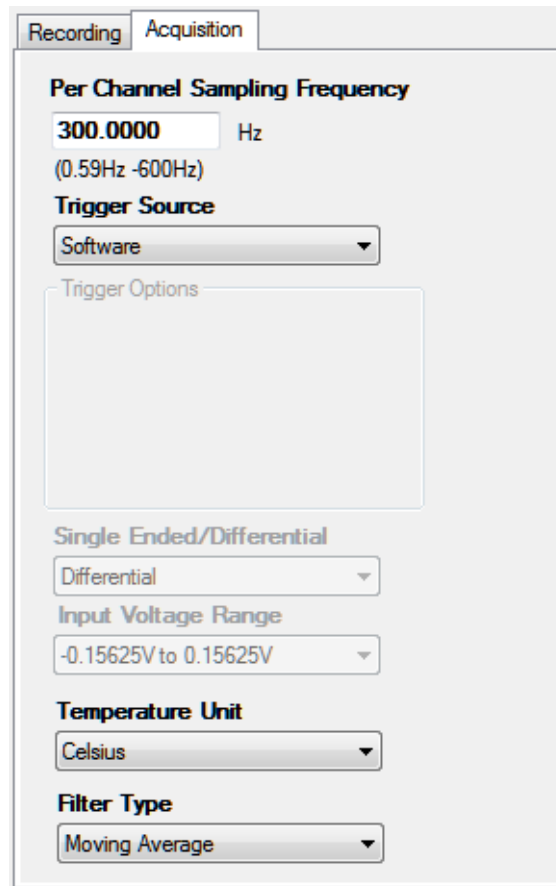
7. For this example, ensure that the following settings are used:

   – **Per Channel Sampling Frequency:** 300 Hz

   – **Trigger Source:** Software

   – **Temperature Unit:** Celsius

   – **Filter type:** Moving Average

8. If desired, hide the **Acquisition Config** window by clicking the **Auto-Hide** pin (📌) in the top, right corner of the window.

Configure the Appearance of the Channel Plot Window

Configure the appearance of the Channel Plot window as follows:

1. In the **Plot and Data Config** window, set up the following parameters:

   a. Ensure that the **Visible Plot** column is checked for both enabled channels.

   b. Leave the **Show Cursor** column unchecked for all three enabled channels.

   c. Under **Plot Column**, use the default plot column setting of 1 for both enabled channels.

   d. Under the **Signal Group** column, select **A** for both thermocouple channels.

   e. Under the **Color** column, assign a unique color to each trace.
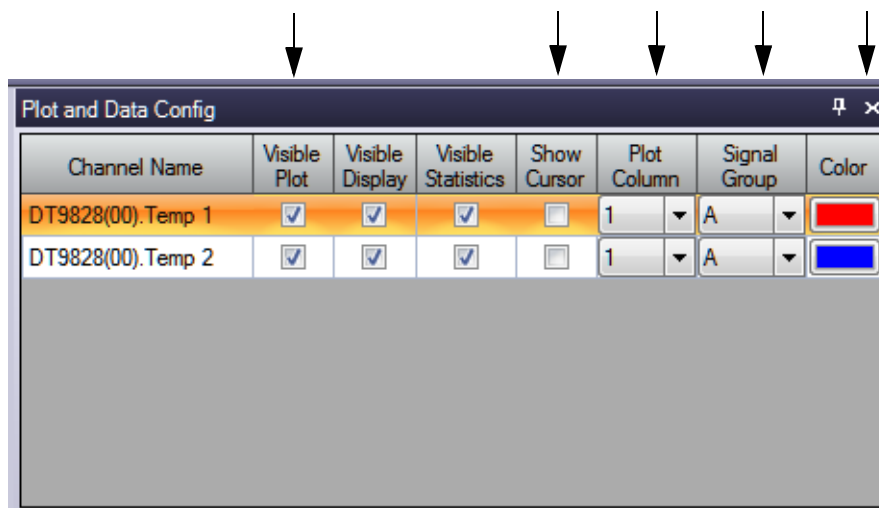
2. In the display area, click the tab for the **Channel Plot** window.

3. Click the **Show Legend** control ([icon]) on the toolbar.

4. Change the text for the label on the x-axis, by doing the following:

   a. Right-click on the label.

   b. Select **Edit Label**.

   c. Enter the following text: **Thermocouple Channels.**
      The Channel Plot window should appear as follows:
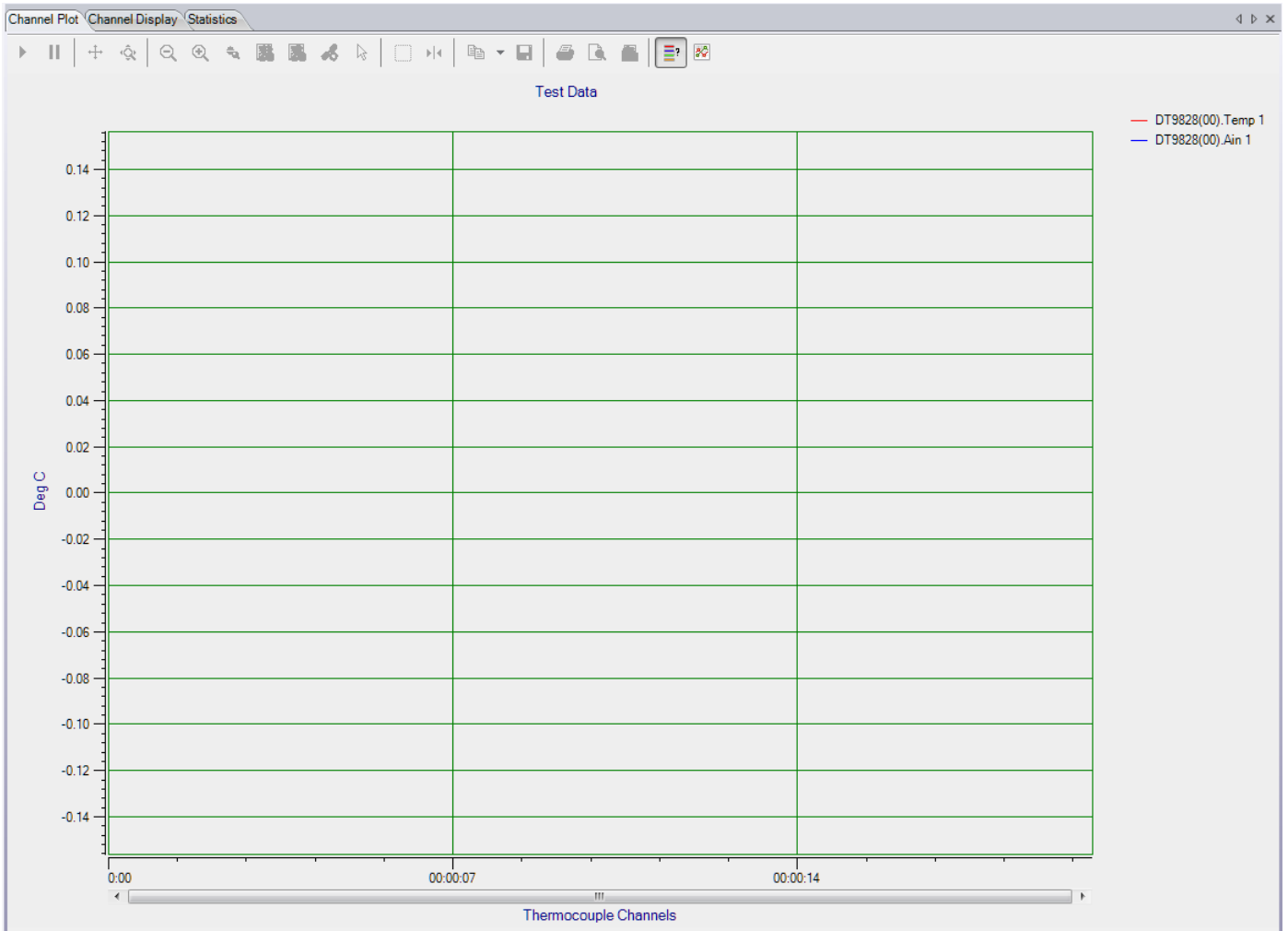
Configure the Appearance of the Channel Display Window

Configure the appearance of the Channel Display window as follows:

1. Ensure that the **Visible Display** column in the **Plot and Data Config** window is checked for both enabled channels.
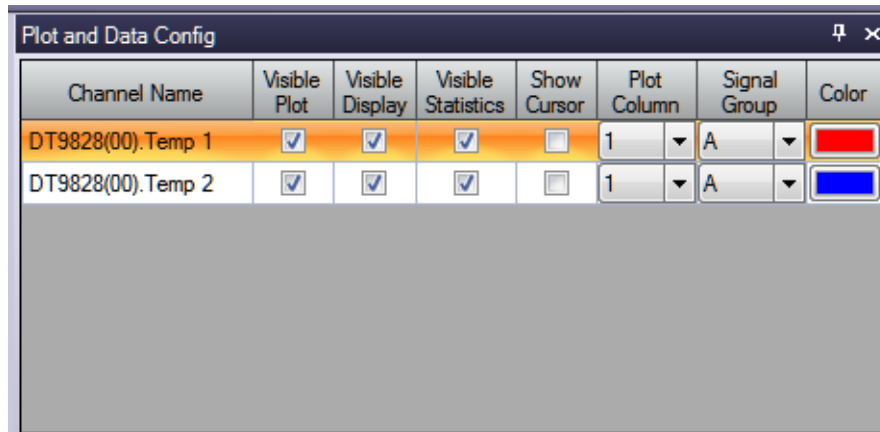
2. Click the **Channel Display - Control** tab, and select the **Hide Unused Channels** checkbox so that only analog input channels 0 and 1 are displayed.
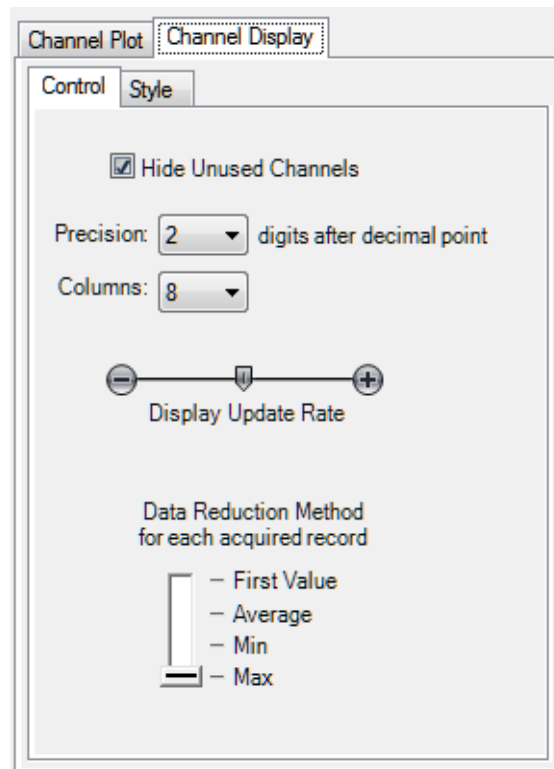
3. For the Data Reduction Method, select **Max** so that the maximum value of the most recent buffer is displayed for each channel.

4. Leave the default values for the remaining parameters:
   – Precision = 2
   – Columns = 8
   – Display Update rate = middle of slider bar

Configure the Appearance of the Statistics Window

Configure the appearance of the Statistics window as follows:

1. Ensure that the **Visible Statistics** column in the **Plot and Data Config** window is checked for both channels:
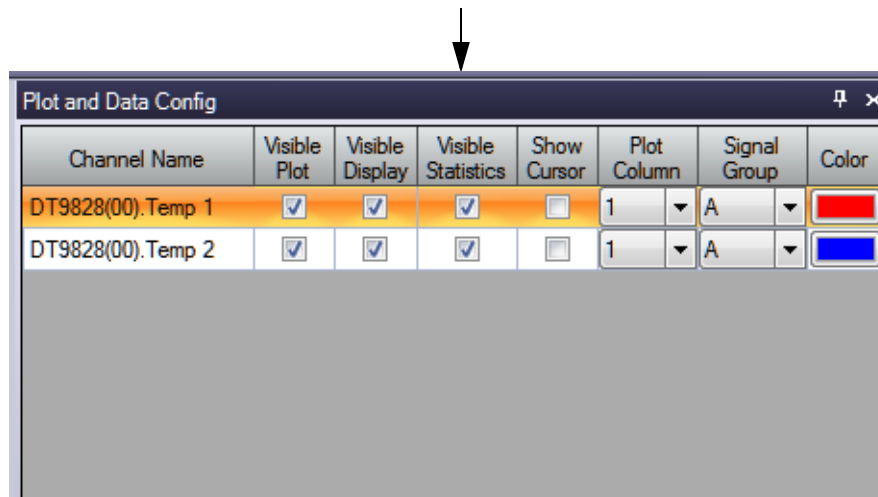
2. If desired, hide the **Plot and Data Config** window by clicking the **Auto-Hide** pin (⊞) in the top, right corner of the window.

Position the Windows

If you want see the data that is displayed in the Channel Display, Channel Plot, and Statistics windows at once, you need to move the windows to different locations in the display area.

In the following example, the Channel Display window is located at the top of the display area, the Channel Plot window is located in the middle of the display area, and the Statistics window is located at the bottom of the display area:
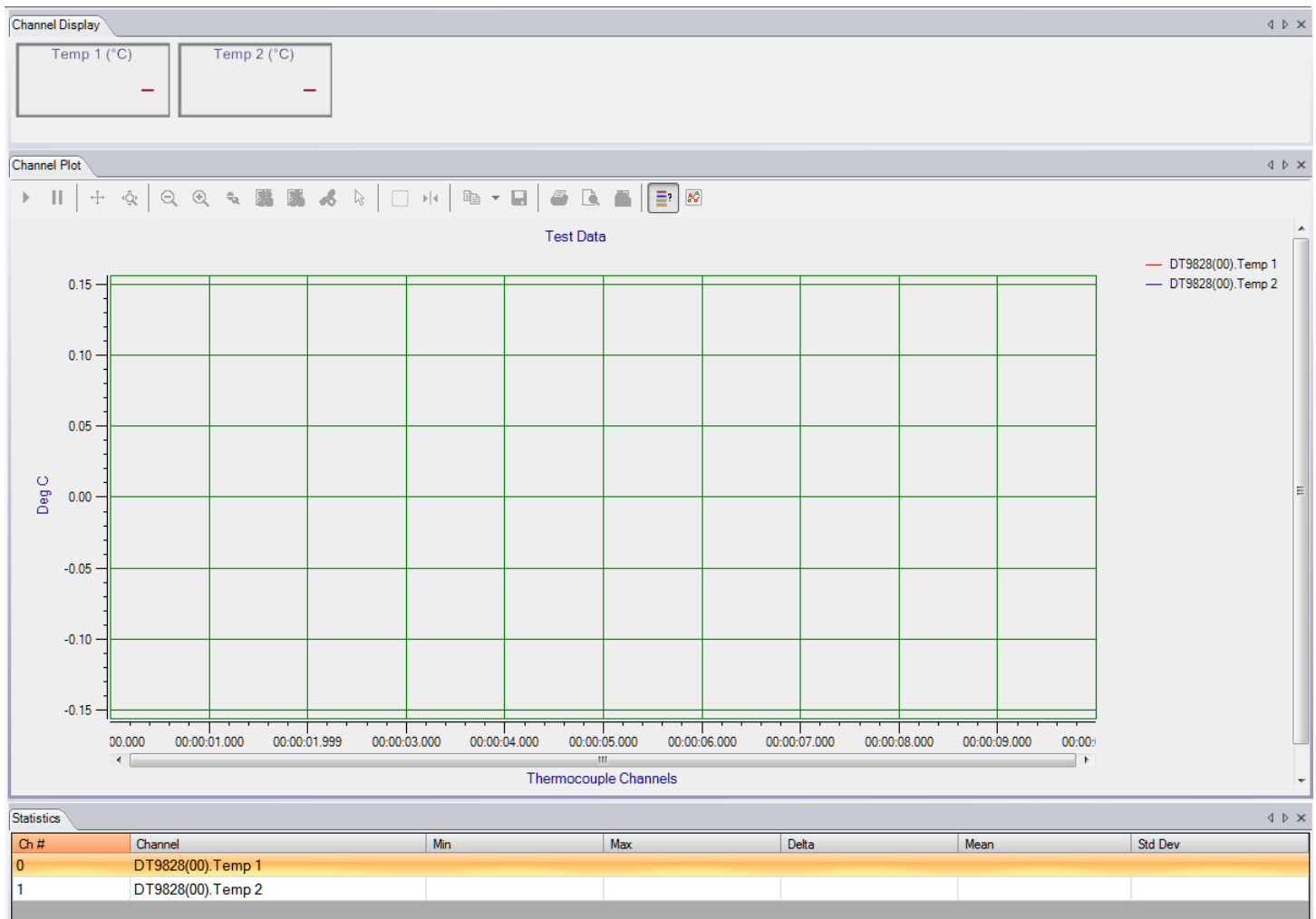
Perform the following steps to position the Channel Display window at the top of the display area, the Channel Plot window in the middle of the display area, and the Statistics window at the bottom of the display area:

1. Click the tab for the **Statistics** window, drag the window toward the middle of the display area, move the mouse over the guide on the bottom of the guide diamond, and then release the mouse button.
   The Statistics window is now placed at the bottom of the display area.

2. Click the tab for the **Channel Plot** window, drag the window toward the middle of the display area, move the mouse over the guide on the bottom of the guide diamond, and then release the mouse button.
   The Channel Plot window is now placed in the middle of the display area, revealing the Channel Display window at the top of the display area.

3. Resize each window, as desired.

Start the Measurement

Once you have configured the channels and the display area, start acquisition and log data to disk by clicking the **Record** toolbar button (⏺ Record).
Results similar to the following are displayed in the display area.

Ch #	Channel	Min	Max	Delta	Mean	Std Dev
0	DT9828(00).Temp 1	26.6815567	28.83251572	2.15095901	27.84974487	0.63496815
1	DT9828(00).Temp 2	26.78201866	29.43671608	2.65469742	27.9762827	1.01170094
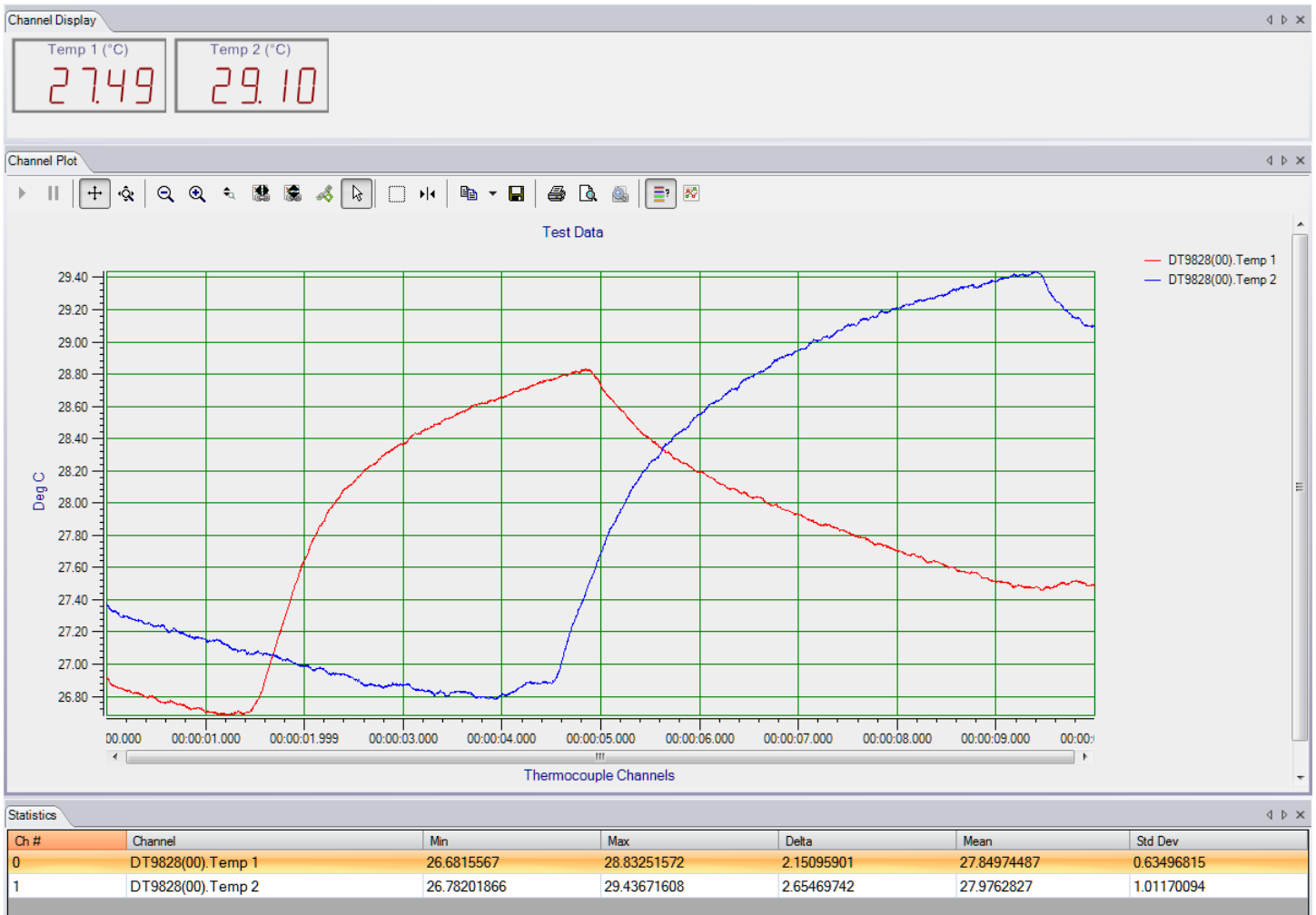
If desired, you can view the data in Excel by clicking the **Open Current Data in Excel** toolbar button (📊).

Part 2: Using Your Module

5

Principles of Operation

Block Diagram

Figure 13 shows a block diagram of the DT9828 module.

**+/- 500 V
Isolation Barrier**

Isolated Power ← DC/DC ← 5 V DC USB

○ Status LED

16 Pos Term Block

FPGA

EEPROM

MUX
8:1 Differential

24-Bit Delta-Sigma ADC

ADC Controls

Bus Interface and Control Registers

USB High Speed Interface

USB 2.0

8 Thermocouple or Differential Voltage Inputs →

MUX Controls

Break Detection on each channel

CJ Sensor → FPGA

Digital In (Opto Coupled) x 4

Digital Out (Opto Coupled) x 4

12 Pos Term Block

4 Digital Inputs

4 Digital Outputs

**Digital Output Return
Digital Output Supply**

Figure 13: Block Diagram of the DT9828 Module

Analog Input Features

This section describes the features of the analog input (A/D) subsystem, including the following:

- Analog input channels, described next
- Cold junction compensation, described on page 62
- Open thermocouple detection, described on page 63
- Input ranges and gains, described on page 63
- Input resolution, described on page 64
- A/D sample clock sources, described on page 64
- Triggers, described on page 65
- Analog input conversion modes, described on page 66
- Filtering, described on page 67
- Data format, described on page 68
- Error conditions, described on page 68

Analog Input Channels

The DT9828 module supports eight differential analog input channels. Using software, you configure each analog input channel independently for either a voltage input or one of the following thermocouple types: J, K, T, B, E, N, R, and/or S. Refer to Chapter 3 starting on page 33 for information on wiring signals to the screw terminals on the module.

Table 1 lists the supported measurement range for each thermocouple type.

Table 1: Supported Measurement Range for Each Thermocouple Type

Thermocouple Type	Supported Measurement Range	
	Minimum	**Maximum**
J	–210° C (–346° F)	1200° C (2192° F)
K	–200° C (–328° F)	1372° C (2502° F)
T	–200° C (–328° F)	400° C (752° F)
B	250° C (482° F)	1820° C (3308° F)
E	–200° C (–328° F)	1000° C (1832° F)
N	–200° C (–328° F)	1300° C (2372° F)
R	–50° C (–58° F)	1768° C (3214° F)
S	–50° C (–58° F)	1768° C (3214° F)

Refer to page 98 for the thermocouple accuracy of thermocouple channels over the dynamic range of the instrument.

The DT9828 module can acquire data from a single analog input channel or from a group of analog input channels. Analog input channels are numbered 0 to 7. The following subsections describe how to specify the channels.

Specifying a Single Channel

The simplest way to acquire data from a single analog input channel is to specify the channel for a single-value analog input operation using software; refer to page 66 for more information on single-value operations.

You can also specify a single channel using the analog input channel list, described in the next section.

Specifying One or More Channels

You can read data from one or more analog input channels as well as the digital input port using an analog input channel list. Reading the digital input port (digital lines 0 to 3) using the analog input channel list is particularly useful when you want to correlate the timing of analog and digital events. Using software, you specify the input channels in the order that you want to sample them.

On the DT9828, you can enter up to 1024 entries in the channel list, where channels 0 to 7 correspond to the analog input channels and channel 8 corresponds to the digital input port. You can specify the channels in the list sequentially (starting either with 0 or with any other analog input channel) or randomly. You can also specify a single channel or the same channel more than once in the list.

The channels are read in order from the first entry to the last entry in the channel list. Refer to page 66 for more information on the supported conversion modes.

Cold Junction Compensation

One cold-junction compensation (CJC) circuit is provided for all thermocouple input channels. The software reads the value of the CJC input and applies it to the value of the thermocouple input to correct for errors based on the specified thermocouple type.

The conversion time for the CJC circuitry is 240 ms, typical. The software takes care of correlating the CJC measurements with the analog input measurements.

Note: When using the DT-Open Layers for .NET Class Library, the software provides the option of returning CJC values in the data stream. This option is seldom used, but is provided if you want to implement your own temperature conversion algorithms in software when using continuous operations. Refer to page 68 for more information on this feature.

Open Thermocouple Detection

A 10 MΩ pull-up resistor is provided on the high side input of each differential thermocouple channel for open thermocouple detection. When an open thermocouple is detected, a positive, full-scale input voltage is returned.

The software returns the value SENSOR_IS_OPEN (99999 decimal) for any channel that was configured for a thermocouple input and has either an open thermocouple or no thermocouple connected to it.

Input Ranges and Gains

The DT9828 module supports an input range of ±156.25 mV. In software, specify a gain of 1.

If a voltage is measured on the input that is outside of the range for the selected thermocouple type, the channel may be configured for the wrong type of thermocouple or something other than a thermocouple may be connected to the channel.

In addition, if the input voltage is less than the legal voltage range for the selected thermocouple type, the software returns the value TEMP_OUT_OF_RANGE_LOW (–88888 decimal). If the input voltage is greater than the legal voltage range for the selected thermocouple type, the software returns the value TEMP_OUT_OF_RANGE_HIGH (88888 decimal).

> **Note:** If you are continuously measuring from a properly configured thermocouple input channel and the thermocouple opens or becomes disconnected, the open thermocouple pull-up circuit causes the input voltage to rise to an out-of-range condition. The response times for detecting an open circuit is 20 ms.
>
> As the input voltage rises, you will receive the TEMP_OUT_OF_RANGE_HIGH (88888 decimal) value followed by the SENSOR_IS_OPEN (99999 decimal) value.

Input Resolution

The input resolution of the analog input subsystem on the DT9828 module is 24 bits.

A/D Sample Clock

The DT9828 module uses an internal A/D sample clock with a time base of 4.9152 MHz to pace analog input operations in continuous mode. This clock paces the acquisition of each channel in the channel list.

On the DT9828, the maximum total throughput is 600 Samples/s, and the minimum total throughput rate is 0.5865 Samples/s.

Using software, specify the channels that you want to sample in the channel list, and then set the desired sampling frequency. The software sets the sampling frequency to the closest possible value. You can use software to return the actual frequency that is used.

> **Note:** In QuickDAQ, you specify the per channel sampling frequency. In the DT-Open Layers Class Library and the Data Acq SDK, you specify the aggregate (total) sampling frequency.
>
> According to sampling theory (Nyquist Theorem), specify a frequency that is at least twice as fast as the input's highest frequency component. For example, to accurately sample a 20 Hz signal, specify a sampling frequency of at least 40 Hz. Doing so avoids an error condition called *aliasing*, in which high frequency input components erroneously appear as lower frequencies after sampling.

Table 2 shows examples of per channel data rates on the DT9828 module for selected throughput rates and number of input channels. Note that the digital input port is considered an additional channel when it is read in the analog input data stream.

Table 2: Example of Per Channel Data Rates for the DT9828 for Selected Throughput Rates

Number of Input Channels	Throughput Rate (Samples/s)[a]									
	600	300	200	120	100	60	40	10	6	1
1	600.00	300.00	200.00	120.00	100.00	60.00	40.00	10.00	6.00	1.00
2	300.00	150.00	100.00	60.00	50.00	30.00	20.00	5.00	3.00	0.50
3	200.00	100.00	66.67	40.00	33.33	20.00	13.33	3.33	2.00	0.33
4	150.00	75.00	50.00	30.00	25.00	15.00	10.00	2.50	1.50	0.25
5	120.00	60.00	40.00	24.00	20.00	12.00	8.00	2.00	1.20	0.20
6	100.00	50.00	33.33	20.00	16.67	10.00	6.67	1.67	1.00	0.17
7	85.71	42.86	28.57	17.14	14.29	8.57	5.71	1.43	0.86	0.14
8	75.00	37.50	25.00	15.00	12.50	7.50	5.00	1.25	0.75	0.13
9	66.67	33.33	22.22	13.33	11.11	6.66	4.44	1.11	0.67	0.11

a. The per channel data rates have been rounded to two digits. You can determine the actual rate through software.

The full set of throughput rates is calculated by applying the following formula:

$$ThroughputRate = \frac{600}{FS} \text{ Samples/s}$$

where,

FS is an integer, frequency-scaling factor that the driver uses. In this case, values for *FS* range from 1 to 1023. The software chooses the scaling factor that will yield the closest possible value to the sampling frequency that you specified.

You can determine the data rate per channel as follows:

$$DataRatePerChannel = \frac{ThroughputRate}{NumberOfChannels}$$

For example, to sample all eight thermocouple channels on the DT9828 module at the maximum rate, the data rate per channel is 600/8, or 75 Samples/s.

Input Trigger

The DT9828 module supports a software trigger event to start the analog input operation. A software trigger occurs when you start the analog input operation (the computer issues a write to the module to begin conversions). Using software, specify the trigger source as a software trigger.

Analog Input Conversion Modes

The DT9828 module supports single-value and continuous scan conversion modes. This section describes each of these conversion modes.

Single-Value Operations

Single-value operations are simpler to use than continuous operations. Using software, you specify the analog input channel (0 to 7) that you want to use. The module acquires the data from the specified channel and returns the data immediately.

For single-value operations, you cannot specify a clock frequency, trigger source, scan mode, or buffer. Single-value operations stop automatically when finished; you cannot stop a single-value operation.

Continuous Scan Mode

Continuous scan mode takes full advantage of the capabilities of the DT9828 module. You can specify a channel list, sampling frequency, start trigger, and buffer using software.

On the DT9828, you can enter up to 1024 entries in the channel list, where channels 0 to 7 correspond to the analog input channels and channel 8 corresponds to the digital input port. You can specify the channels in the list sequentially (starting either with 0 or with any other analog input channel) or randomly. You can also specify a single channel or the same channel more than once in the list.

When a software trigger (software command) is detected, the module cycles through the channel list, acquiring and converting the value for each entry in the list (this process is defined as the scan). The sampled data is placed in the allocated buffer(s). When the module gets to the end of the channel list, it wraps to the start of the channel list and repeats the process continuously until you stop the operation.

Using software, you can stop a scan by performing either an orderly stop or an abrupt stop. In an orderly stop, the module finishes acquiring the current buffer, stops all subsequent acquisition, and transfers the acquired data to host memory; any subsequent triggers are ignored. In an abrupt stop, the module stops acquiring samples immediately; the current buffer is not completely filled, it is returned to the application only partially filled, and any subsequent triggers are ignored.

The conversion rate is determined by the sampling frequency of the input sample clock; refer to for more information about the input sample clock.

To select continuous scan mode, use software to specify the following parameters:

- Specify the data flow as Continuous

- Specify the clock source as internal and specify the sampling frequency (refer to)

- Specify the trigger as a software trigger (refer to)

Figure 14 illustrates continuous scan mode with a channel list of three entries: channel 0 through channel 2. In this example, analog input data is acquired when a software trigger is detected.
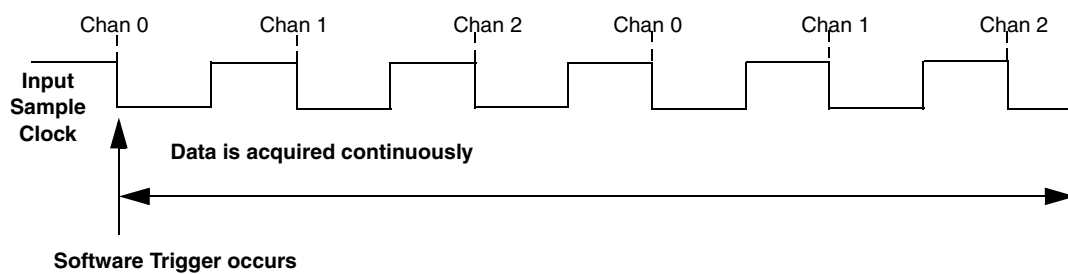

Figure 14: Continuous Scan Mode on the DT9828 Module

Note: The USB LED, shown in Figure 3 on page 27, blinks amber while the module is acquiring data.

Filtering

The DT9828 module multiplexes all enabled channels to a single 24-bit Delta-Sigma analog-to-digital converter (ADC).

The throughput rate determines the ADC data rate, internal filter response, and noise. On the DT9828 module, the overall throughput rate is programmable to up to 600 Samples/s. The Delta-Sigma ADC noise is inherently low at all sample rates, but sampling at lower rates yields lower noise. Additional noise filtering is implemented in software by a moving average filter, which may be enabled or disabled in software.

The software filtering options are described as follows:

- **Moving average** – (The default filter setting.) This filter type removes unwanted noise from your measurements and provides a compromise of filter functionality and response time. This filter can be used in any application.

  This low-pass filter takes the previous 16 samples, adds them together, and divides by 16.

- **None** – No filter (raw data). Use this option when you want to acquire fast thermocouple response times. The response time is determined by the ADC data rate. Higher throughput rates (data rates) yield faster response times, but the increased bandwidth also results in higher noise.

Data Format

If you specify a thermocouple type of None for a thermocouple input channel, a voltage measurement is selected and the instrument returns a voltage value. For all other thermocouple types, a temperature value, in degrees C, or one of the error constants, described on , is returned.

In normal operation, one, 32-bit floating-point value is returned for each enabled channel. If you enable the capability of returning CJC data in the data stream, described on , two floating-point values are returned in the data stream for each enabled analog input channel. The first value in the pair represents the temperature (or voltage) of the channel; the second value in the pair represents the CJC temperature (in degrees C) for that channel.

If the digital input port is in the channel list, that 4-bit value (value 0 to 15) is returned as float.

Error Conditions

The DT9828 module reports overrun errors by sending an overrun event to the application program. If this error condition occurs, the instrument stops acquiring and transferring data to the host computer. To avoid this error, try one or more of the following:

- Reduce the sample rate

- Close any other applications that are running

- Run the program on a faster computer

Additionally, the following constants may be reported to the host:

- 99999.0 – SENSOR_IS_OPEN, described on

- 88888.0 – TEMP_OUT_OF_RANGE_HIGH, described on

- –88888.0 – TEMP_OUT_OF_RANGE_LOW, described on

An additional error will be reported if an ESD (electrostatic discharge) spike causes an analog input channel to stop working. If the instrument is scanning when this occurs, scanning will stop and an error will be reported. To resume scanning, you must restart the scan. If the channel is functional, scanning will resume. If the channel is not functional, scanning will not resume and the error will be reported once again; contact Customer Service, as described on , to return the module to the factory.

Digital I/O Features

The DT9828 module provides four digital inputs and 4 digital outputs that you can use to control external equipment.

This section describes the following digital I/O features of the DT9828 module:

- Digital input lines, described on this page
- Digital output lines, described on this page
- Resolution, described on
- Operation modes, described on

Digital Input Lines

The DT9828 module features four, isolated, TTL-level, 12 V and 24 V digital input lines. On this module, the digital inputs have a common ground (Digital Input Return) that is isolated from USB, analog, and digital output grounds.

The response time of the digital inputs is less than 100 µs.

Using software, specify the digital input line that you want to read in single-value digital I/O operation. Refer to for more information about single-value operations.

A digital line is high if its value is 1; a digital line is low if its value is 0.

Digital Output Lines

The DT9828 module features four, isolated, open-collector digital output lines. The digital outputs have a common return that is isolated from the USB ground, analog input ground, and digital input ground.

Each digital output has a 100 kΩ pull-up resistor to the External Supply terminal on the digital I/O terminal block. You can connect an external supply in the 3.3 VDC to 30 VDC range to this terminal, and then connect the external supply return to the External Supply Return terminal on the digital I/O terminal block.

Using software, you can specify the digital I/O line that you want to set in a single-value digital I/O operation. Refer to for more information about single-value operations.

Setting a digital output line to 0 turns on the corresponding open collector output and pulls the output low. Setting a digital output line to 1 turns off the corresponding open collector; the output is pulled up to the external supply level.

On power up or reset of a DT9828 module, the digital output lines are set to 1 (open collectors are off; the outputs are pulled up to the external supply level).

Resolution

The digital input and digital output subsystems on the DT9828 module have a resolution of 4 bits.

Operation Modes

DT9828 modules support the following digital I/O operation modes:

- **Single-value operations** are the simplest to use but offer the least flexibility and efficiency. You use software to specify the digital I/O port and a gain of 1 (the gain is ignored). Data is then read from or written to all the digital I/O lines. For a single-value operation, you cannot specify a clock frequency or trigger source.

  Single-value operations stop automatically when finished; you cannot stop a single-value operation.

- **Continuous digital input** takes full advantage of the capabilities of the DT9828 module. You can specify a sampling frequency, conversion mode, trigger source, and buffer for the operation.

  Enter the digital input port as channel 8 in the analog input channel list. Refer to for more information on specifying channels.

  The A/D sample clock paces the reading of the digital input port (as well as the acquisition of the analog input channels); refer to for more information on the A/D sample clock.

Note: If the digital input port is in the channel list, that 4-bit value (value 0 to 15) is returned as float.

Supported Device Driver Capabilities

The DT9828 Series Device Driver provides support for the analog input (A/D) subsystem. For information on how to configure the device driver, refer to Chapter 2.

Table 3: DT9828 Subsystems

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Total Subsystems on Module	1	0	1	1	0	0	0

The tables in this chapter summarize the features available for use with the DT-Open Layers for .NET Class Library and the DT9828 module. The DT-Open Layers for .NET Class Library provides properties that return support information for specified subsystem capabilities.

The first row in each table lists the subsystem types. The first column in each table lists all possible subsystem capabilities. A description of each capability is followed by the property used to describe that capability in the DT-Open Layers for .NET Class Library.

Note: The following tables include the capabilities that can be queried. However, some capabilities may not be supported by your device. Blank fields represent unsupported options.

For more information, refer to the description of these properties in the DT-Open Layers for .NET Class Library online help or *DT-Open Layers for .NET Class Library User's Manual*.

Data Flow and Operation Options

Table 4: Data Flow and Operation Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Single-Value Operation Support **SupportsSingleValue**	Yes		Yes	Yes			
Simultaneous Single-Value Output Operations **SupportsSetSingleValues**							
Continuous Operation Support **SupportsContinuous**	Yes		Yes[a]				
Continuous Operation until Trigger **SupportsContinuousPreTrigger**							
Continuous Operation before & after Trigger **SupportsContinuousPrePostTrigger**							
Waveform Operations Using FIFO Only **SupportsWaveformModeOnly**							
Simultaneous Start List Support **SupportsSimultaneousStart**							
Supports Programmable Synchronization Modes **SupportsSynchronization**							
Synchronization Modes **SynchronizationMode**							
Interrupt Support **SupportsInterruptOnChange**							
FIFO Size, in Samples **FifoSize**	1024						
Muting and Unmuting the Output Voltage **SupportsMute**							
Auto-Calibrate Support **SupportsAutoCalibrate**							

a. The DIN subsystem supports continuous mode by allowing you to read the digital input port (all 4 digital input lines) using the analog input channel list.

Buffering

Table 5: Buffering Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Buffer Support **SupportsBuffering**	Yes						
Single Buffer Wrap Mode Support **SupportsWrapSingle**							
Inprocess Buffer Flush Support **SupportsInProcessFlush**	Yes						

Triggered Scan Mode

Table 6: Triggered Scan Mode Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Triggered Scan Support **SupportsTriggeredScan**							
Maximum Number of CGL Scans per Trigger **MaxMultiScanCount**	1	0	0	0			
Maximum Retrigger Frequency **MaxRetriggerFreq**	0	0	0	0			
Minimum Retrigger Frequency **MinRetriggerFreq**	0	0	0	0			

Data Encoding

Table 7: Data Encoding Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Binary Encoding Support **SupportsBinaryEncoding**			Yes	Yes			
Twos Complement Support **SupportsTwosCompEncoding**							
Returns Floating-Point Values **ReturnsFloats**	Yes						

Channels

Table 8: Channel Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Number of Channels **NumberOfChannels**	8[a]	0	1	1			
SE Support **SupportsSingleEnded**							
SE Channels **MaxSingleEndedChannels**	0	0	0	0			
DI Support **SupportsDifferential**	Yes		Yes	Yes			
DI Channels **MaxDifferentialChannels**	8[a]	0	1	1			
Maximum Channel-Gain List Depth **CGLDepth**	1024[b]	0	0	0			
Simultaneous Sample-and-Hold Support **SupportsSimultaneousSampleHold**							
Channel-List Inhibit **SupportsChannelListInhibit**							
Support MultiSensor Inputs **SupportsMultiSensor**							
Bias Return Termination Resistor Support **SupportsInputTermination**							

a. Channels 0 to 7 correspond to the analog input channels and channel 8 corresponds to the digital input port (digital lines 0 to 3).
b. The channel list can include a maximum of 1024 entries and the entries do not have to be sequential.

Gain

Table 9: Gain Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Programmable Gain Support **SupportsProgrammableGain**							
Number of Gains **NumberOfSupportedGains**	1	0	0	0			
Gains Available **SupportedGains**	1						

Ranges

Table 10: Range Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Number of Voltage Ranges **NumberOfRanges**	1	0	0	0	0		0
Available Ranges **SupportedVoltageRanges**	±156.25 mV	0					

Resolution

Table 11: Resolution Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Software Programmable Resolution **SupportsSoftwareResolution**							
Number of Resolutions **NumberOfResolutions**	1		1	1			
Available Resolutions **SupportedResolutions**	24		4	4			

Current and Resistance Support

Table 12: Current and Resistance Support Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Current Support **SupportsCurrent**							
Current Output Support **SupportsCurrentOutput**							
Resistance Support **SupportsResistance**							
Software Programmable External Excitation Current Source for Resistance **SupportsExternalExcitationCurrentSrc**							
Software Programmable Internal Excitation Current Source **SupportsInternalExcitationCurrentSrc**							
Available Excitation Current Source Values **SupportedExcitationCurrentValues**							

Thermocouple, RTD, Thermistor Support

Table 13: Thermocouple, RTD, and Thermistor Support Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Thermocouple Support **SupportsThermocouple**	Yes						
RTD Support **SupportsRTD**							
Thermistor Support **SupportsThermistor**							
Voltage Converted to Temperature **SupportsTemperatureDataInStream**	Yes						
Supported Thermocouple Types **ThermocoupleType**	J, K, B, E, N, R, S, T						
Supports CJC Source Internally in Hardware **SupportsCjcSourceInternal**	Yes						
Supports CJC Channel **SupportsCjcSourceChannel**							
Available CJC Channels **CjcChannel**							
Supports Interleaved CJC Values in Data Stream **SupportsInterleavedCjcTemperaturesInStream**	Yes						
Supported RTD Types **RTDType**							
RTD R0 Coefficient **RtdR0**							
Supports Data Filters **SupportsTemperatureFilters**	Yes						
Temperature Filter Types **TemperatureFilterType**	Yes[a]						

a. Supports both Moving Average and Raw (none) filter types.

IEPE Support

Table 14: IEPE Support Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
IEPE Support **SupportsIEPE**							
Software Programmable AC Coupling **SupportsACCoupling**							
Software Programmable DC Coupling **SupportsDCCoupling**							
Software Programmable External Excitation Current Source **SupportsExternalExcitationCurrentSrc**							
Software Programmable Internal Excitation Current Source **SupportsInternalExcitationCurrentSrc**							
Available Excitation Current Source Values **SupportedExcitationCurrentValues**							

Bridge and Strain Gage Support

Table 15: Bridge and Strain Gage Support Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Bridge Support **SupportsBridge**							
Supported Bridge Configurations **BridgeConfiguration**							
Strain Gage Support **SupportsStrainGage**							
Supported Strain Gage Bridge Configurations **StrainGageBridgeConfiguration**							
External Excitation Voltage **SupportsExternalExcitationVoltage**							
Internal Excitation Voltage **SupportsInternalExcitationVoltage**							
Shunt Calibration **SupportsShuntCalibration**							
Voltage Excitation Per Channel **SupportedPerChannelVoltageExcitation**							
Minimum Excitation Voltage **MinExcitationVoltage**							
Maximum Excitation Voltage **MaxExcitationVoltage**							

Start Triggers

Table 16: Start Trigger Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Software Trigger Support **SupportsSoftwareTrigger**	Yes						
External Positive TTL Trigger Support **SupportsPosExternalTTLTrigger**							
External Negative TTL Trigger Support **SupportsNegExternalTTLTrigger**							
External Positive TTL Trigger Support for Single-Value Operations **SupportsSvPosExternalTTLTrigger**							
External Negative TTL Trigger Support for Single-Value Operations **SupportsSvNegExternalTTLTrigger**							
Positive Threshold Trigger Support **SupportsPosThresholdTrigger**							
Negative Threshold Trigger Support **SupportsNegThresholdTrigger**							
Digital Event Trigger Support **SupportsDigitalEventTrigger**							

Reference Triggers

Table 17: Reference Trigger Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
External Positive TTL Trigger Support **SupportsPosExternalTTLTrigger**							
External Negative TTL Trigger Support **SupportsNegExternalTTLTrigger**							
Positive Threshold Trigger Support **SupportsPosThresholdTrigger**							
Negative Threshold Trigger Support **SupportsNegThresholdTrigger**							
Digital Event Trigger Support **SupportsDigitalEventTrigger**							
Sync Bus Support **SupportsSyncBusTrigger**							
Analog Input Channels Supported for the Threshold Trigger **SupportedThresholdTriggerChannels**							
Post-Trigger Scan Count Support **SupportsPostTriggerScanCount**							

Clocks

Table 18: Clock Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Internal Clock Support **SupportsInternalClock**	Yes						
External Clock Support **SupportsExternalClock**							
Simultaneous Input/Output on a Single Clock Signal **SupportsSimultaneousClocking**							
Base Clock Frequency **BaseClockFrequency**	4.9152 MHz						0
Maximum Clock Divider **MaxExtClockDivider**	1.0						
Minimum Clock Divider **MinExtClockDivider**	1.0						
Maximum Frequency **MaxFrequency**	600 Hz						
Minimum Frequency **MinFrequency**	0.5865 Hz						

Counter/Timers

Table 19: Counter/Timer Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Cascading Support **SupportsCascading**							
Event Count Mode Support **SupportsCount**							
Generate Rate Mode Support **SupportsRateGenerate**							
One-Shot Mode Support **SupportsOneShot**							
Repetitive One-Shot Mode Support **SupportsOneShotRepeat**							
Up/Down Counting Mode Support **SupportsUpDown**							
Edge-to-Edge Measurement Mode Support **SupportsMeasure**							
Continuous Edge-to-Edge Measurement Mode Support **SupportsContinuousMeasure**							
High to Low Output Pulse Support **SupportsHighToLowPulse**							
Low to High Output Pulse Support **SupportsLowToHighPulse**							
Variable Pulse Width Support **SupportsVariablePulseWidth**							
None (internal) Gate Type Support **SupportsGateNone**							
High Level Gate Type Support **SupportsGateHighLevel**							
Low Level Gate Type Support **SupportsGateLowLevel**							
High Edge Gate Type Support **SupportsGateHighEdge**							
Low Edge Gate Type Support **SupportsGateLowEdge**							
Level Change Gate Type Support **SupportsGateLevel**							
Clock-Falling Edge Type **SupportsClockFalling**							
Clock-Rising Edge Type **SupportsClockRising**							
Gate-Falling Edge Type **SupportsGateFalling**							
Gate-Rising Edge Type **SupportsGateRising**							
Interrupt-Driven Operations **SupportsInterrupt**							

Tachometer

Table 20: Tachometer Options

DT9828	A/D	D/A	DIN	DOUT	C/T	TACH	QUAD
Tachometer Falling Edges **SupportsFallingEdge**							
Tachometer Rising Edges **SupportsRisingEdge**							
Tachometer Stale Data Flag **SupportsStaleDataFlag**							

7

Calibration

About Calibration

DT9828 modules are factory calibrated for voltage offset and gain. In addition, each channel of the module is factory calibrated for temperature using a thermocouple connected to a precisely measured temperature reference. This procedure establishes a CJC calibration coefficient for each analog input channel; these values are stored as factory calibration coefficients.

Factory calibration provides accurate temperature measurements; however, for utmost accuracy, it is recommended that you use the DT9828 Series Calibration Utility to recalibrate the module with the thermocouples you wish you to use. Thereafter, we recommend that you check, and if necessary, recalibrate the module every six months.

> **Note:** Ensure that you installed the DT9828 Series Device Driver prior to using the DT9828 Series Calibration Utility. Refer to Chapter 2 for more information.

This chapter describes how to use the DT9828 Series Calibration Utility to calibrate the analog input circuitry of the DT9828 module.

Running the Calibration Utility

Note: Ensure that you perform the calibration procedure after the module has been warmed up for 10 minutes.

To run the DT9828 Series Calibration Utility, do the following:

1. Click **Start** from the Task Bar.

2. Browse to **Programs | Data Translation, Inc | Calibration | DT9828 Series Calibration Utility**.
   The main menu appears.

3. Select the module to calibrate, and then click **OK**.

Calibrating the Voltage Offset and Gain

To calibrate the 24-bit A/D offset and A/D gain circuit on the DT9828 module, you must use a precision voltage standard, such as the Krohn-Hite Model 523 or equivalent, and a shorting plug.

Perform the following procedure to calibrate the voltage offset and gain on the DT9828:

1. Wire a shorting plug to analog input channel 0.

2. From the Voltage Calibration section of the dialog box, click **Run.**

3. Ensure that 0 V is applied to analog input channel 0, and then click **OK**.
   The voltage offset value is calibrated automatically.

4. Apply 140 mV to analog input channel 0, and then click **OK**.
   The voltage gain value is calibrated automatically.

Note: If you are not satisfied with the analog input calibration, you can load the factory default settings stored in the EEPROM by clicking **Restore Factory Settings**.

Calibrating the CJC

If you are using thermocouples, you must calibrate the CJC for each analog input channel using an accurate temperature input. For this purpose, it is recommended that you use a stirred calibration bath, such as the Hart Scientific 7320 or equivalent. The calibration bath that you select should have an accuracy of at least ±0.01° C. In addition, you must have a known, calibrated thermocouple (a type K thermocouple is recommended).

To calibrate the CJC, perform the following procedure:

1. Immerse one end of the thermocouple into the calibration bath.

2. Connect the other end of the thermocouple to the analog input channel that you want to use.

3. From the CJC Offset Calibration section of the dialog box, enter the following values:

   – Temp Target – The exact temperature of the calibration bath.

   – Thermocouple Type – The type of thermocouple that is connected to the analog input channel (Type B, Type E, Type J, Type K, Type N, Type R, Type S, or Type T).

   – Channel – The analog input channel (0 to 7) to which the thermocouple is connected.

   – Unit – The temperature unit of the CJC measurement (C, F, or K).

4. Click **Run**.

5. Ensure that you have connected your thermocouple to the appropriate channel, and set up the parameters properly, and then click **OK**.
   The temperature reading is returned along with the calibrated CJC offset value.

6. Repeat steps 1 through 5 for each of the remaining analog input channels.

7. When finished, click **Done** to close the DT9828 Series Calibration Utility.

Note: If you are not satisfied with the CJC calibration, you can load the factory default settings stored in the EEPROM by clicking **Restore Factory Settings**.

8

Troubleshooting

General Checklist

Should you experience problems using the DT9828 module, do the following:

1. Read all the documentation provided for your product, including any "Read This First" information.

2. Check the OMNI CD for any README files and ensure that you have used the latest installation and configuration information available.

3. Check that your system meets the requirements stated on page 26.

4. Check that you have installed your hardware properly using the instructions in Chapter 2.

5. Check that you have installed and configured the device driver properly using the instructions in Chapter 2.

6. Check that you have wired your signals properly using the instructions in Chapter 3.

7. Search the DT Knowledgebase in the Support section of the Data Translation web site (at www.mccdaq.com) for an answer to your problem.

8. Visit the product's page on the Data Translation web site for the latest tips, white papers, product documentation, and software fixes.

If you still experience problems, try using the information in Table 21 to isolate and solve the problem. If you cannot identify the problem, refer to page 92.

Table 21: Troubleshooting Problems

Symptom	Possible Cause	Possible Solution
Module is not recognized	You plugged the module into your computer before installing the device driver.	From the Control Panel > System > Hardware > Device Manager, uninstall any unknown devices (showing a yellow question mark). Then, install the USB device drivers, and reconnect your USB module to the computer.
Module does not respond.	The module configuration is incorrect.	Check the configuration of your device driver; see the instructions in Chapter 2.
	The module is damaged.	Contact Data Translation for technical support; refer to page 92.
Intermittent operation.	Loose connections or vibrations exist.	Check your wiring and tighten any loose connections or cushion vibration sources; see the instructions in Chapter 3.
	The module is overheating.	Check environmental and ambient temperature; consult the specifications on page 106 of this manual and the documentation provided by your computer manufacturer for more information.
	Electrical noise exists.	Check your wiring and either provide better shielding or reroute unshielded wiring; see the instructions in Chapter 3.

Table 21: Troubleshooting Problems (cont.)

Symptom	Possible Cause	Possible Solution
Device failure error reported.	The module cannot communicate with the Microsoft bus driver or a problem with the bus driver exists.	Check your cabling and wiring and tighten any loose connections; see the instructions in Chapter 3.
	The module was removed while an operation was being performed.	Ensure that your module is properly connected; see the instructions in Chapter 3.
Data appears to be invalid.	An open connection exists.	Check your wiring and fix any open connections; see the instructions in Chapter 3.
	A transducer is not connected to the channel being read.	Check the transducer connections; see the instructions in Chapter 3.
	The thermocouple or voltage input that you connected to the channel does not match the software configuration for that channel.	Check your wiring and ensure that what you specify in software matches your hardware configuration; see the instructions in Chapter 3.
	Your module may need recalibration.	The module is calibrated at the factory. Thereafter, yearly calibration is recommended. Use the DT9828 Series Calibration Utility, described on Chapter 7, or return your module to Data Translation for recalibration. For information on factory recalibration, contact Data Translation at 508-946-5100 (if you are in the USA) of call your local distributor (if you are located outside the USA); see our web site (www.mccdaq.com) for the name and telephone number of your nearest distributor.
USB 2.0 or 3.0 is not recognized.	Your operating system does not have the appropriate Service Pack installed.	Ensure that you load the appropriate Windows Service Pack (version 2 for Windows XP). If you are unsure of whether you are using USB 3.0, 2.0, or USB 1.1, run the Open Layers Control Panel applet, described on page 31.
	Standby mode is enabled on your PC.	For some PCs, you may need to disable standby mode on your system for proper USB 2.0 or 3.0 operation. Consult Microsoft for more information.

Technical Support

If you have difficulty using the DT9828 module, Data Translation's Technical Support Department is available to provide technical assistance.

To request technical support, to go our web site at http://www.mccdaq.com and click on the Support link.

When requesting technical support, be prepared to provide the following information:

- Your product serial number
- The hardware/software product you need help on
- The version of the OMNI CD you are using
- Your contract number, if applicable

If you are located outside the USA, contact your local distributor; see our web site (www.mccdaq.com) for the name and telephone number of your nearest distributor.

If Your Module Needs Factory Service

Most hardware models can be functionally tested, evaluated for repairs (if needed), and calibrated to factory specifications. An RMA # must be obtained from Application Engineering in advance of sending any product back to Measurement Computing. Customers outside the USA must contact their local distributor for a return procedure. Calibration certificates for most analog models can be obtained for a fee (certificate must be requested at time of RMA # assignment).

A

Specifications

Basic Module Specifications

Table 22 lists the basic specifications for the DT9828 module.

Table 22: Basic Module Specifications

Feature	Specifications
Number of analog input channels	8 Differential (0 to 7), Isolated
Number of digital input lines	4 Isolated, TTL, 12 V and 24 V digital inputs
Number of digital output lines	4 Isolated, open-collector digital outputs
Input functions	Thermocouples or voltage inputs
A/D converter type	High stability 24-bit Delta-Sigma; external multiplexer included

Data coding
  Analog input:
  Digital I/O:
	32-Bit floating point
	Binary

Thermocouple Specifications

Table 23 lists the specifications for thermocouple channels on the DT9828 module.

Table 23: Thermocouple Specifications

Feature	Specifications
Number of thermocouple channels	Up to 8 differential thermocouples
Thermocouple types (software-selectable)	J, K, T, B, E, N, R, S
A/D converter resolution	24 bits
Full-scale input range	±156.25 mV
Aggregate sample rate (throughput)	600 Samples/s maximum
Sampling mode	Multiplexed
Accuracy (for Type K thermocouples)	0.09° C typical; thermocouple at 25° C (see Table 24, Table 25, and Table 26 for complete specs)
Noise (for Type K thermocouples)	0.1° C peak to peak, typical, with moving average filter (see "Temperature Measurement Noise" on page 100 for more information)
DC differential input impedance	10 MΩ
Open thermocouple detect current	250 nA
Input common mode voltage	±500 V maximum
Differential input voltage	±10 V maximum (protection)
Common mode rejection @ 50 Hz and 60 Hz	120 dB
Warm-up time	10 minutes

System Temperature Error for the DT9828

Table 24 lists the typical accuracy errors and Table 25 lists the maximum accuracy errors of the DT9828 module for each thermocouple type at several thermocouple measurement values.

The values in Table 24 are the typical errors expected when the module is operating at 23° C ±5° C ambient. The values in Table 25 are the maximum errors expected when operating the module over the full specified temperature range of 0° C to 50° C.

Table 24: Typical Thermocouple Measurement Accuracy of the DT9828 at 23° C ±5° C

Thermocouple Temperature	Thermocouple Type[a]							
	J	K	T	E	S	R	B	N
−100° C	±0.06° C	±0.08° C	±0.08° C	±0.05° C	–	–	–	±0.13° C
0° C	±0.05° C	±0.08° C	±0.10° C	±0.06° C	±0.58° C	±0.60° C	–	±0.13° C
100° C	±0.10° C	±0.10° C	±0.09° C	±0.08° C	±0.43° C	±0.42° C	–	±0.12° C
300° C	±0.13° C	±0.18° C	±0.14° C	±0.12° C	±0.38° C	±0.36° C	±0.99° C	±0.16° C
500° C	±0.19° C	±0.20° C	–	±0.17° C	±0.40° C	±0.37° C	±0.65° C	±0.20° C
700° C	±0.24° C	±0.24° C	–	±0.23° C	±0.43° C	±0.40° C	±0.52° C	±0.25° C
900° C	±0.25° C	±0.34° C	–	±0.29° C	±0.46° C	±0.42° C	±0.47° C	±0.30° C
1100° C	±0.33° C	±0.38° C	–	–	±0.48° C	±0.44° C	±0.45° C	±0.36° C
1400° C	–	–	–	–	±0.54° C	±0.50° C	±0.46° C	–

a. **Conditions for accuracy measurements:**
   Module has been calibrated and warmed up for 10 minutes.
   Module is calibrated at 23° C.
   CJC offset is nulled using the CJC calibration process.
   The module is operated in a stable environment within the specified limits.
   Inclusive of CJC error and input offset, gain, linearity, and long-term stability errors.
   Exclusive of thermocouple errors.
   Exclusive of noise.
   Specifications are valid for 1 year from calibration.

Table 25: Maximum Thermocouple Measurement Accuracy of the DT9828 at 0° C to 50° C

Thermocouple Temperature	Thermocouple Type[a]							
	J	K	T	E	S	R	B	N
−100° C	±0.19° C	±0.23° C	±0.24° C	±0.16° C	–	–	–	±0.34° C
0° C	±0.19° C	±0.24° C	±0.26° C	±0.19° C	±1.34° C	±1.39° C	–	±0.33° C
100° C	±0.26° C	±0.27° C	±0.26° C	±0.23° C	±1.00° C	±0.99° C	–	±0.33° C
300° C	±0.34° C	±0.41° C	±0.34° C	±0.30° C	±0.89° C	±0.85° C	±2.28° C	±0.39° C
500° C	±0.45° C	±0.48° C	–	±0.40° C	±0.92° C	±0.86° C	±1.48° C	±0.47° C
700° C	±0.53° C	±0.57° C	–	±0.52° C	±0.98° C	±0.91° C	±1.19° C	±0.57° C
900° C	±0.60° C	±0.74° C	–	±0.64° C	±1.03° C	±0.95° C	±1.08° C	±0.67° C
1100° C	±0.75° C	±0.86° C	–	–	±1.08° C	±0.99° C	±1.03° C	±0.80° C
1400° C	–	–	–	–	±1.21° C	±1.11° C	±1.04° C	–

a. **Conditions for accuracy measurements:**

Module has been calibrated and warmed up for 10 minutes.

Module is calibrated at 23° C.

CJC offset is nulled using the CJC calibration process.

The module is operated in a stable environment within the specified limits.

Inclusive of CJC error and input offset, gain, linearity, and long-term stability errors.

Exclusive of thermocouple errors.

Exclusive of noise.

Specifications are valid for 1 year from calibration.

Temperature Measurement Noise

The total temperature measurement noise (short term variation) is the sum of the following two components:

- The equivalent temperature noise due to the noise of the analog input circuitry.

- The CJC sensor noise in degrees C.

The noise due to the analog input circuitry (volts) is converted to temperature by dividing the noise voltage by the sensitivity of the thermocouple type being used at the particular measurement temperature. Thermocouple sensitivities can be derived from commonly available NIST (National Institute of Standards and Technology) Thermocouple Reference Tables. The voltage noise from the analog input circuitry is a function of the programmed throughput rates and the software filter setting.

Table 26 provides the maximum expected voltage noise values for the DT9828. Also listed are the maximum expected CJC sensor temperature noise values for a selection of throughput rates.

Table 26: Input Voltage Noise and CJC Sensor Noise for the DT9828

Throughput (Samples/s)	Input Voltage Noise (μV pk-pk)		CJC Noise (Degrees C pk-pk)	
	Moving Average Filter	**No Filter**	**Moving Average Filter**	**No Filter**
600	3.0	12.0	0.01	0.025
100	1.5	4.0	0.01	0.025
60	1.0	3.0	0.01	0.025
10	0.5	1.0	0.01	0.025

Thermocouple Noise Calculation Example

Assume that you are using a type K thermocouple to measure a temperature of approximately 100°C, and the DT9828 module is configured to use a throughput rate of 600 Samples/s and the moving average filter. The steps to determine the maximum expected measurement noise are as follows:

1. Determine the CJC noise at the stated throughput rate and filter setting. From Table 26, the CJC noise is 0.01°C pk-pk for a throughput rate of 600 Samples/s and the moving average filter.

2. Determine the input voltage noise at the stated throughput rate and filter setting. From Table 26, the voltage noise is 3 μV pk-pk for a throughput rate of 600 Samples/s and the moving average filter.

3. Determine the sensitivity of the specified thermocouple type at the measurement temperature. From the NIST Thermocouple Reference Tables, the sensitivity of a Type K thermocouple at 100°C is 41.5 μV/°C.

4. Calculate the equivalent temperature noise by dividing the input voltage noise by the sensitivity of the thermocouple:

   3 µV pk-pk / 41.5 µV/°C = 0.072°C pk-pk

5. To determine the total noise, add the CJC sensor noise to the equivalent temperature noise of the input voltage noise. The total temperature noise is as follows:

   0.01°C pk-pk + 0.072°C pk-pk = 0.082°C pk-pk

Voltage Measurement Specifications

Table 27 lists the voltage measurement specifications for the analog input subsystem on the DT9828 module.

Table 27: Voltage Measurement Specifications

Feature	Specifications[a]
Number of voltage channels	Up to 8 differential voltage inputs
A/D converter resolution	24-bits
Full-scale input range	±156.25 mV
Aggregate sample rate	600 Samples/s maximum
Sampling mode	Multiplexed
DC differential input impedance	10 MΩ
Input bias current	250 nA
Input common mode voltage	±500 V maximum
Differential input voltage	±10 V maximum (protection)
Common mode rejection @ 50 Hz and 60 Hz	120 dB
Noise	3 µV pk-pk at maximum throughput (see Table 26 on page 100 for more information)
Input signal bandwidth, –3 dB	Total throughput rate x 2, in Hz (see "Input Signal Bandwidth of the DT9828" on page 103 for more information)
Offset error[b]	±20 µV
Gain error	±0.03% of reading
Linearity error	±2 µV maximum
Offset error tempco	±20 nV/°C
Gain error tempco	±0.0015% of reading/°C

a. **Conditions for specification:**
    Module is calibrated at 23 C.
    Values are typical for the module operated in a stable 23°C ±5°C environment.
    Valid for 1 year from calibration.
b. Voltage source impedance <= 50 ohms.

Input Signal Bandwidth of the DT9828

On the DT9828, the input signal bandwidth is determined by the Sigma-Delta ADC sample rate. Since the DT9828 is a multiplexed system, the input signal bandwidth is greater than the per channel sampling frequency. For the DT9828, you can derive the input signal bandwidth from the following equation:

–3 dB bandwidth (Hz) = total throughput x 2

As an example, if four channels are enabled at a per channel sampling frequency of 10 Hz, the input signal bandwidth is 80 Hz (40 Hz x 2).

For proper reconstruction of acquired signals, ensure that the per channel sampling frequency is set in accordance with the Nyquist criteria. That is, set the per channel sampling frequency to a minimum of twice the frequency of the signal to be acquired. As an example, if you wish to acquire a 5 Hz signal, set the per channel sampling frequency to a minimum of 10 Hz.

Digital I/O Specifications

Table 28 lists the specifications for the digital I/O subsystems on the DT9828 module.

Table 28: Digital I/O Specifications on the DT9828

Feature	DT9828 Specifications
Number of digital I/O lines	8 (4 in, 4 out)
Number of ports	2 (4 bits each)

Digital Inputs
   Input characteristics:
   Input type:
   Input high voltage:
   Input low voltage:
   Input voltage limits:
	
	Level-sensitive
	Optocoupler, 2.2 kΩ in series with LED
	2.0 V minimum
	0.8 V maximum
	-5 V to $+30$ V (relative to Digital Input Return)

Digital Outputs
   Output characteristics:
   Current sink capability:
   Output voltage range:
   V_{ext} range:
   Off state leakage:
	
	Open collector, 100 kΩ pull-up to V_{ext} input
	2 mA minimum, V_{CE} (sat) = 0.35 V maximum
	30 V maximum
	30 V maximum
	1 µA maximum

Interrupt on change	No
Inputs clocked with sample clock	Yes
Software I/O selectable	No

Isolation and Protection Specifications

Table 29 lists the isolation and protection specifications for the analog input subsystem on the DT9828 module.

Table 29: Isolation and Protection Specifications

Feature	Specifications

ESD protection per standard EN6100-4-2:2009 (see page 108 for more)
   Arc:
   Contact:
	
	8 kV
	4 kV

Isolation voltage from analog input and digital I/O to the host computer	±500 V operational

Power, Physical, and Environmental Specifications

Table 30 lists the power, physical, and environmental specifications for the DT9828 module.

Table 30: Power, Physical, and Environmental Specifications

Feature	Specifications
Power	+5 V ±5% from USB host; 200 mA maximum
Physical Dimensions (in enclosure)	Height: 1.472 inches (37.39 mm) Width: 4.175 inches (106.05 mm) Length: 6.030 inches (153.16 mm)
Weight (in enclosure)	6.95 oz (197 g)

Environmental
   Operating temperature range:
   Storage temperature range:
   Relative humidity:
	0° C to 55° C
	−25° C to 85° C
	To 95%, noncondensing

Terminal Block Specifications

Table 31 lists the screw terminal block specifications for the DT9828 module.

Table 31: Terminal Block Specifications

Feature	Specifications
Analog Input Screw Terminal Block (TB1)	16-Position Header: Phoenix Contact 1984756
Digital I/O Screw Terminal Block (TB2)	12-Position Header: Phoenix Contact 3.5 mm vertical, 1984714

Note: Phoenix Contact specifies a wire insulation strip length of 0.197 inches (5 mm) and a wire size of 26 AWG minimum and 16 AWG maximum.

Regulatory Specifications

DT9828 modules are CE-compliant. Table 32 lists the regulatory specifications for the DT9828 module.

Table 32: Regulatory Specifications

Feature	Specifications
Emissions (EMI)	FCC Part 15, Class A EN55011:2007 (Based on CISPR-11, 2003/A2, 2006)
Immunity	EN61326-1:2006 Electrical Equipment for Measurement, Control, and Laboratory Use EMC Requirements EN61000-4-2:2009 Electrostatic Discharge (ESD) 4 kV contact discharge, 8 kV air discharge, 4 kV horizontal and vertical coupling planes EN61000-4-3:2006 Radiated electromagnetic fields, 3 V/m, 80 to 1000 MHz; 3 V/m, 1.4 GHz to 2 GHz; 1 V/m, 2 GHz to 2.7 GHz EN61000-4-4:2004 Electrical Fast Transient/Burst (EFT) 1 kV on data cables EN61000-4-6:2009 Conducted immunity requirements, 3 Vrms on data cables 150 kHz to 80 MHz
RoHS (EU Directive 2002/95/EG)	Compliant (as of July 1st, 2006)

B

Pin Assignments and LED Status Indicators

Analog Input Screw Terminal Block (TB1)

Table 33 lists the screw terminal assignments of the 16-position Analog Input screw terminal block (TB1) on the DT9828 module.

Table 33: Analog Input Screw Terminal Block (TB1) on the DT9828 Module

Screw Terminal	Signal Description
1	Analog Input 0+
2	Analog Input 0–
3	Analog Input 1+
4	Analog Input 1–
5	Analog Input 2+
6	Analog Input 2–
7	Analog Input 3+
8	Analog Input 3–
9	Analog Input 4+
10	Analog Input 4–
11	Analog Input 5+
12	Analog Input 5–
13	Analog Input 6+
14	Analog Input 6–
15	Analog Input 7+
16	Analog Input 7–

Digital I/O Screw Terminal Block (TB2)

Table 34 lists the screw terminal assignments of the 12-position Digital I/O screw terminal block on the DT9828 module.

Table 34: Digital I/O Screw Terminal Block (TB2) on the DT9828 Module

Screw Terminal	Signal Description
1	Digital Input 0
2	Digital Input 1
3	Digital Input 2
4	Digital Input 3
5	Digital Input Return
6	Digital Output 0
7	Digital Output 1
8	Digital Output 2
9	Digital Output 3
10	Digital Output Return
11	Digital Output Supply[a]
12	Digital Output Supply Return

a. Supplies ranging from 3 VDC to 30 VDC are supported.

USB Connector

Figure 15 shows the orientation of the pins used by the USB connector on the DT9828 module.
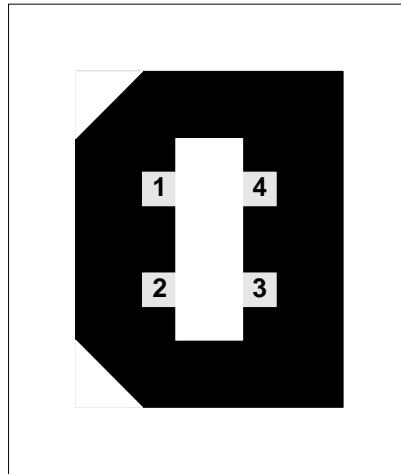
Figure 15: External USB Connector

Table 35 lists the pin assignments of the USB connector.

Table 35: J8 USB Connector Pin Assignments

Pin	Description
1	USB +5 V
2	USB Data –
3	USB Data +
4	USB Ground

LED Status Indicators

The DT9828 module has a single bi-color LED that indicates the status of the module, as described in Table 36.

Table 36: LED Status Indicators on the DT9828 Module

Color of the LED	Status Description
Green	Module is powered
Blinking amber	Module is acquiring data

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