

# DT9828

## USB Powered Thermocouple Measurement Module

### Key Features:

- 8 differential analog inputs for thermocouple or voltage 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
- Four, isolated, TTL digital inputs; you can read the status of the digital input port in the analog input stream
- Four, isolated, open-collector digital outputs
- $\pm 500$  V galvanic isolation to the computer
- Powered by USB bus; no external power supply required
- Includes QuickDAQ 2013 application software to acquire, analyze and display data

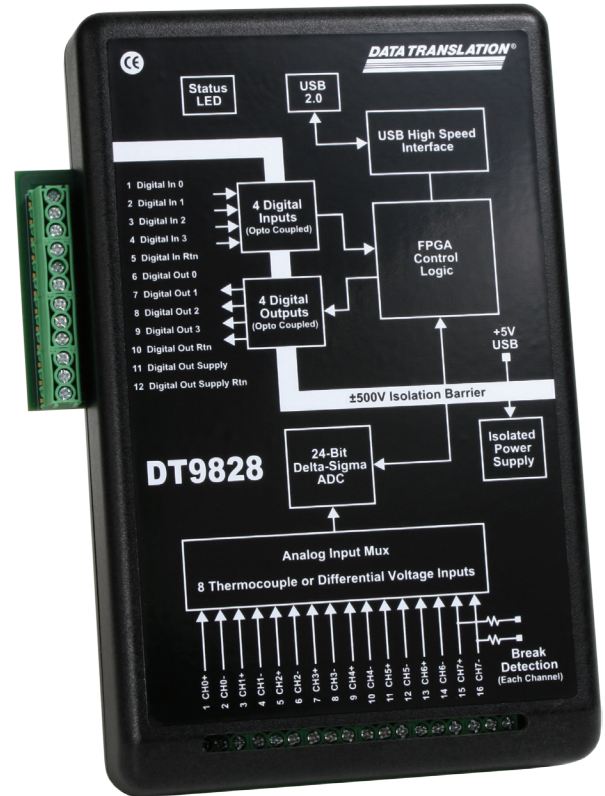
### Analog Input Channels

The DT9828 module supports eight differential analog input channels that can be used for thermocouple or voltage measurements, with an input range of  $\pm 156$  mV and input resolution of 24-bits. The following thermocouple types can be attached to each analog input channel: J, K, T, B, E, N, R, and/or S. 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 (2498° 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 (3182° F)
S	-50° C (-58° F)	1768° C (3182° F)

The DT9828 module can acquire data from a single analog input channel or from a group of analog input channels.



**Figure 1: The DT9828 design sets the accuracy benchmark for thermocouple measurements. Combined with the included QuickDAQ 2013 ready-to-measure application software, the DT9828 is a powerful temperature data logger.**

### Specifying a Single Channel

To acquire data from a single analog input channel, specify the channel for a single-value analog input operation using software. A single channel can also be specified using the analog input channel list.

### Specifying One or More Channels

Data can be read from one or more analog input channels using an analog input channel list. The channels in the list can be grouped sequentially (starting either with 0 or with any other analog input channel) or randomly. A single channel or the same channel can be specified more than once in the list.

Using software, specify the analog input channels in the order you want to sample them. Up to 1024 entries can be entered in the channel list. For the DT9828, channels 0 to 7 correspond to the analog input channels and channel 8 corresponds to the digital input port.

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. The channels are read in order from the first entry to the last entry in the channel list.

## 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.

## Open Thermocouple Detection

A 10 M $\Omega$  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 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

DT9828 module supports single-value and continuous scan conversion modes.

### Single-Value Operations

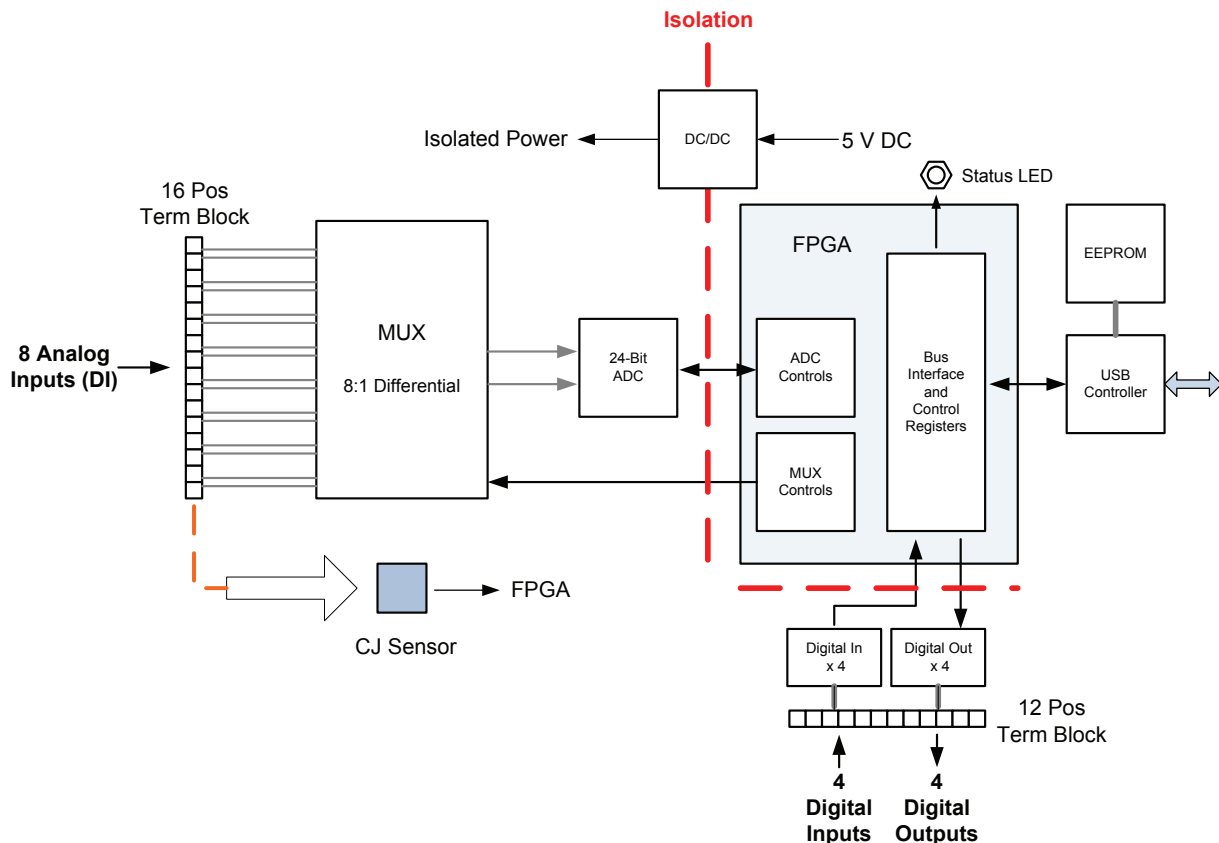
For single-value specify the analog input channel that you want to use using software. The module acquires the data from the specified channel and returns the data immediately.

For single-value operations, a clock frequency, trigger source, scan mode, or buffer cannot be specified. Single-value operations stop automatically when finished.

### Continuous Scan Mode

Continuous scan mode takes full advantage of the capabilities of the DT9828 module. A channel list, sampling frequency, start trigger, and buffer can be specified using software. Up to 1024 entries can be entered in the channel list. Using software, specify the channels you want to sample.

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, a scan can be stopped 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.

## Filtering

The DT9828 module multiplexes all enabled channels to a single 24-bit Delta-Sigma analog-to-digital converter (ADC). The overall throughput rate is programmable to up to 600 Samples/s. The throughput rate determines the ADC data rate, internal filter response, and noise. 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 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 a thermocouple type of None is selected 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, is returned. In normal operation, one, 32-bit floating-point value is returned for each enabled channel. If the digital input port is in the channel list, that 4-bit value (value 0 to 15) is returned as float. Note: The Input FIFO stores up to 1024, 4-bit samples.

## Digital Input Lines

The DT9828 module features four, isolated digital input lines. The digital inputs have a common ground (Digital Input Return) that is isolated from USB, analog, and digital grounds. The response time of the digital inputs is less than 100  $\mu$ s.

Using software, specify the digital input line that you want to read in single-value digital I/O operation. 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 k $\Omega$  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. 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).

## Digital I/O 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. 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.
- 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. For the DT9828, enter the digital input port as channel 8 in the analog input channel list. The A/D sample clock paces the reading of the digital input port (as well as the acquisition of the analog input channels).

## System Temperature Error

Table 2 lists the typical accuracy errors and Table 3 lists the maximum accuracy errors of the DT9828 for each thermocouple type at several thermocouple measurement values.

The values in Table 2 are the typical errors expected when the module is operating at 23° C ±5° C ambient.

**Table 2: Typical Thermocouple Measurement Accuracy of the DT9828 at 23° C ±5° C**

Thermocouple Temp.	Thermocouple Type <sup>1</sup>							
	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	±0.1° C	±0.06° C	±0.58° C	±0.6° C	—	±0.13° C
100° C	±0.1° C	±0.1° 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	±0.2° C	—	±0.17° C	±0.4° C	±0.37° C	±0.65° C	±0.2° C
700° C	±0.24° C	±0.24° C	—	±0.23° C	±0.43° C	±0.4° 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	±0.3° 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	±0.5° C	±0.46° C	—

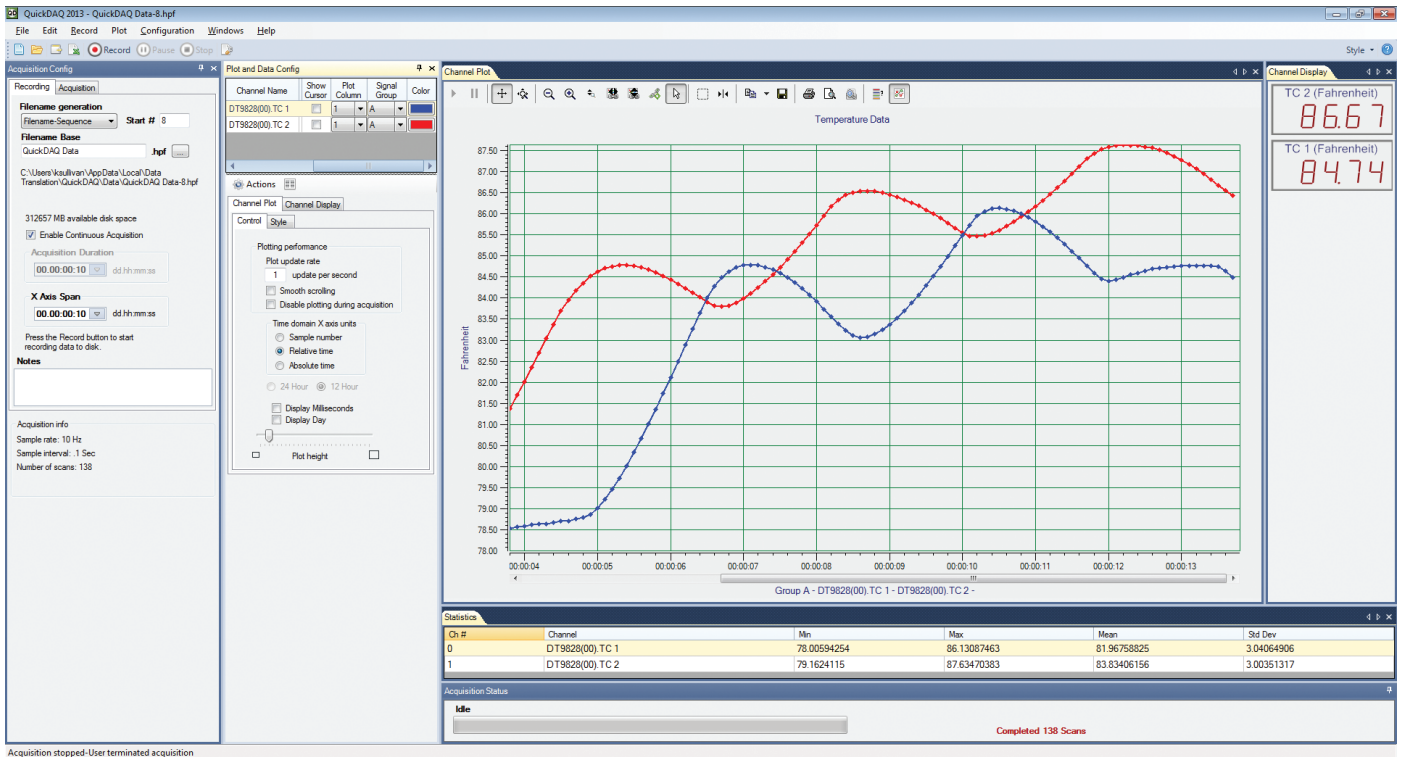
The values in Table 3 are the maximum errors expected when operating the module over the full specified temperature range of 0° C to 50° C.

**Table 3: Typical Thermocouple Measurement Accuracy of the DT9828 at 0° C to 50° C**

Thermocouple Temp.	Thermocouple Type <sup>1</sup>							
	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	±1.0° C	±0.99° C	—	±0.33° C
300° C	±0.34° C	±0.41° C	±0.34° C	±0.3° C	±0.89° C	±0.85° C	±2.28° C	±0.39° C
500° C	±0.45° C	±0.48° C	—	±0.4° 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	±0.6° 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	±0.8° C
1400° C	—	—	—	—	±1.21° C	±1.11° C	±1.04° C	—

<sup>1</sup> 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 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.



## Software Options

There are many software choices available for application development, from ready-to-measure applications to programming environments.

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

- **DT9828 Device Driver** –The device driver allows you to use a DT9828 module with any of the supported software packages or utilities.
- **DT9828 Calibration Utility** – This utility allows you to calibrate the analog input circuitry of a DT9828 module.
- **QuickDAQ 2013** – This application allows you to acquire and analyze data from all Data Translation USB and Ethernet devices, except the DT9841 Series, DT9817, DT9835, and DT9853/54.

QuickDAQ lets you perform the following functions:

- Discover and select your devices.
- Configure all input channel settings for the attached sensor, such as the enable state, input range, and engineering units for the sensor.
- Load/save multiple hardware configurations.
- On each device, acquire data from all channels supported in the input channel list.
- Log acquired data to disk.
- Display acquired data during acquisition in either a digital display using the Channel Display window or as a waveform using the Channel Plot window.

- Display statistics about the acquired data in the Statistics window.
- Open recorded data in Excel for further analysis.
- Customize many aspects of the acquisition, display, and recording functions to suit your needs, including the clock frequency and the trigger settings.

You can use QuickDAQ in one of two modes: Acquisition mode, which allows you to acquire data, or File Reader mode, which allows you to view a previously recorded data file. Refer to the documentation for QuickDAQ 2013 for detailed information about the application.

- **Quick DataAcq** application – The Quick DataAcq application provides a quick way to get up and running using a DT9828 module. Using this application, verify key features of the module, 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 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 to use Visual Studio 6.0 and Microsoft® C or C++ to develop application software for a DT9828 module using Windows® XP/Vista/7/8; 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) toolbox from The MathWorks™ and Data Translation’s DT-Open Layers architecture.
- **LV-Link** – Data Translation’s LV-Link is a library of VIs that enable LabVIEW™ programmers to access the data acquisition features of DT-Open Layers compliant USB and PCI devices.

### **Cross-Series Compatibility Saves Programming Time, Protects Your Investment**

Virtually all Data Translation data acquisition modules, including the DT9828, are compatible with the DT-Open Layers® software standard. This means any application developed with one of Data Translation’s software products can easily be upgrade to a new Data Translation module with little to no reprogramming needed.

### **Ordering Summary**

All Data Translation hardware products are covered by a 1-year warranty. For pricing information, please visit our website or contact your local reseller.

#### **HARDWARE**

- DT9828
- DT9828-OEM

#### **FREE SOFTWARE**

The following software is available as a free download from our website:

- **quickDAQ 2013**
- **DAQ Adaptor for MATLAB** – Access the analyzation and visualization tools of MATLAB®.
- **LV-Link** – Access the power of Data Translation boards through LabVIEW™.