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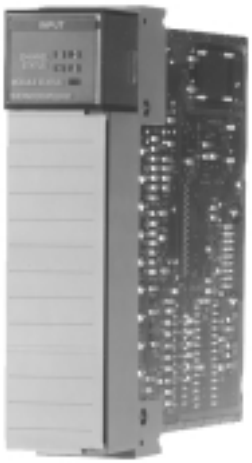
Technical Data

SLC 500™ Thermocouple/mV Input Module

(Catalog No. 1746-NT4, -NT8, -INT4)



1746 Thermocouple/mV input modules expand the control capabilities of your SLC 500 fixed or modular system by allowing you to directly interface with any of 10 types of thermocouple temperature sensors and millivolt sensors such as strain gages. This greatly enhances the flexibility of SLC 500 applications by eliminating the need for expensive thermocouple transmitters, providing a more economical means of addressing process applications in industries requiring temperature measurement and control. It also provides the capability for accepting millivolt signals that are not within the application window of standard analog modules. A choice of modules is available including the four-channel NT4, the eight-channel NT8, and the four-channel isolated INT4.

1746 thermocouple modules provide channel configuration flexibility that allows you to define the operational characteristics for each input channel on the module via your ladder logic programming. There are no hardware DIP switches to set. Each of the module's channels is configured using your ladder program and may be dynamically reconfigured without handling the hardware. Each module performs on-board scaling to engineering units. You can specify thermocouple or millivolt operation, temperature resolution in degrees or tenths of degrees Celsius or Fahrenheit, or format conversion of the input data to proportional or scaled for PID.

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Features and Benefits

1746-NT4 and 1746-NT8 modules provide a choice of four filter frequencies, permitting you to select input noise filtering appropriate to the application and surrounding environment. Either or both 50 Hz and 60 Hz noise can be filtered from the input signal for greater noise rejection and resolution. The 250 Hz filter provides minimum noise rejection and is best suited for millivolt applications where response to step changes are required.

All modules provide cold-junction temperature compensation (CJC), fully integrated into the removable terminal block, as a means of retaining thermocouple input signal accuracy. Two thermistor assemblies located at each end of the terminal block measure and compensate for the absolute temperature of the reference junction.

1746-NT4 and 1746-NT8 modules require no user calibration. Each of the 1746-NT4 module's channels undergoes a calibration cycle at power-up, on channel configuration, or on your command to compensate for module component drift. Each of the 1746-NT8 module's channels undergoes a calibration cycle when a new filter frequency is selected and every two minutes thereafter. Autocalibration guarantees module accuracy and saves valuable time.

All modules provide fault diagnostics to check for open circuits or out-of-range values, then indicate operational problems on status LEDs. Channel status LEDs and diagnostic bits signal if input channel data is out of range or if an open-circuit condition is present. Channel configuration validity is also checked. In addition, a module status LED differentiates recoverable channel errors from more serious module-related problems, saving you troubleshooting time.

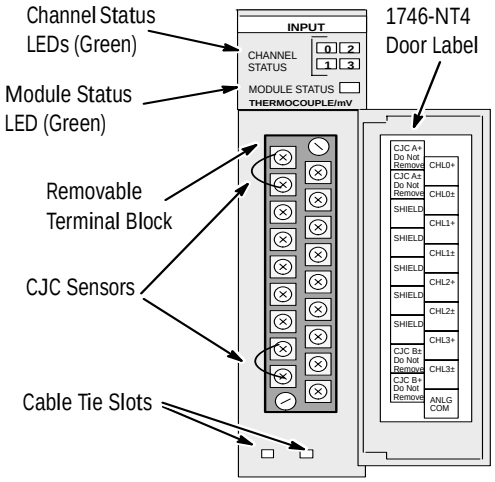
The 1746-INT4 module provides 1000V channel-to-channel isolation making it ideal for grounded thermocouple applications.

What's Inside **Page**

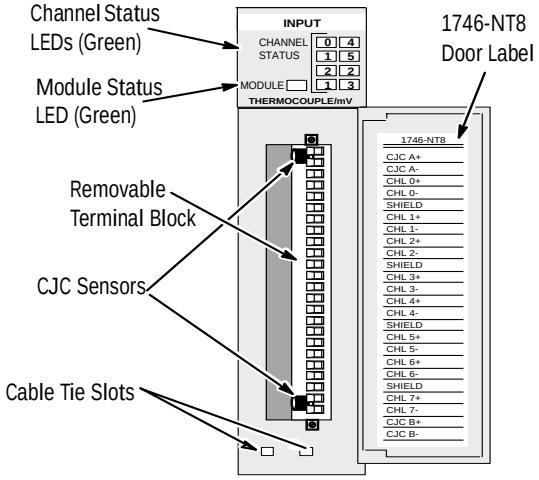
Hardware Overview

1746 thermocouple input modules fit into any single slot, except the processor slot of an SLC 500 modular system or an SLC 500 fixed system expansion chassis. They are Class 1[1] modules (use 8 input and 8 output words) with inputs multiplexed into a single A/D converter. They interface with thermocouple types J, K, T, E, R, S, B, and N, and support direct ±50 mV and ±100 mV analog input signals. The 1746-INT4 also supports C and D thermocouple types.

All modules contain a removable terminal block providing connection for thermocouple or DC millivolt analog input devices. There are also two cold-junction compensation (CJC) sensors used to compensate for offset voltages introduced into the thermocouple input signal as a result of the cold-junction, i.e., where the thermocouple wires connect to the module wiring terminal. There are no output channels on the module. Module configuration is done via your ladder program. There are no DIP switches.



1746-NT4 and 1746-INT4



1746-NT8

Hardware Features

Hardware	Function
Channel Status LED Indicators	Displays operating and fault status of each channel.
Module Status LED	Displays module operating and fault status
Side Label (Nameplate)	Provides module information
Removable Terminal Block	Provides physical connection to input devices. It is color coded green.
CJC Sensors	Compensate for offset voltages due to cold junction
Door Label	Permits easy terminal identification
Cable Tie Slots	Secure and route wiring from module
Self-Locking Tabs	Secure module in chassis slot

[1]Requires use of Block Transfer in a remote configuration.

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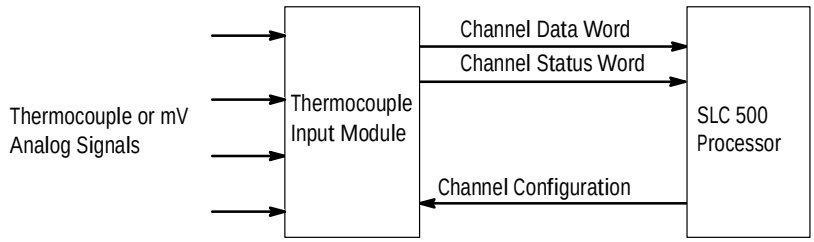
Module Operation

All 1746 thermocouple modules have similar operating characteristics. At powerup, the thermocouple module performs checks of its internal circuits, memory, and basic functions. During this time, the module status LED remains off. If no faults are found during the power-up diagnostics, the module status LED is turned on.

After powerup checks are complete, the thermocouple module waits for valid channel configuration data from your SLC™ ladder logic program (channel status LEDs off). After configuration data is written to one or more channel configuration words and the module has done one conversion for each configured channel, the channel status LED goes on, and the thermocouple module continuously converts the thermocouple or millivolt input to a value within the range you selected for the enabled channels (See 1746-NT4, 1746-INT4 and 1746-NT8 Thermocouple Modules Channel Data Word Format on page 11.).



Each time a channel is read by the module, that data value is tested by the module for an under/over-range or open circuit condition. If such a condition is detected, an error bit is set in the channel status word and the appropriate channel LED blinks.

The SLC processor reads the converted thermocouple or millivolt data from the module at the end of the program scan, or when commanded by the ladder program. The processor and thermocouple module determine that the backplane data transfer was made without error, and the data is used in your ladder program.

Calibration

1746 thermocouple modules are initially calibrated at the factory. 1746-NT4 and 1746-NT8 modules also have an autocalibration function. Autocalibration compensates for offset and gain drift of the analog circuitry caused by temperature change within the module. An internal, high-precision, low-drift voltage reference and system ground are used for this purpose. Each of the 1746-NT4 channels undergoes a calibration cycle at powerup, on channel configuration or on your command.

1746-NT8 auto-calibration occurs immediately following configuration of a previously unselected filter frequency and generally every two minutes for all selected filter frequencies of the system. No external, user-supplied device is required for autocalibration of the modules.

Compatibility with Controllers and Thermocouple Sensors

1746 thermocouple modules are fully compatible with all SLC 500 fixed and modular controllers. They are compatible with all type J, K, T, E, R, S, B, and N thermocouple sensors and extension wire. The 1746-INT4 is also compatible with type C and D thermocouples.

The NT4 and INT4 use the National Bureau of Standards (NBS) Monograph 125 and 161 (14 AWG Type N) based on IPTS-68 for thermocouple temperature linearization. The NT8 uses NIST ITS-90 standard for thermocouple temperature linearization.

The following tables define thermocouple types and their associated temperature ranges and also list the millivolt analog input signal ranges that the modules will support.

Thermocouple Temperature Ranges

Type	°C Temperature Range	°F Temperature Range
J	-210°C to 760°C	-346°F to 1400°F
K	-270°C to 1370°C	-454°F to 2498°F
T	-270°C to 400°C	-454°F to 752°F
B	300°C to 1820°C	572°F to 3308°F
E	-270°C to 1000°C	-454°F to 1832°F
R	0°C to 1768°C	32°F to 3214°F
S	0°C to 1768°C	32°F to 3214°F
N	0°C to 1300°C	32°F to 2372°F
C(1)	0°C to 2317°C	32°F to 4201°F
D(1)	0°C to 2317°C	32°F to 4201°F
CJC Sensor	0°C to 85°C	32°F to 185°F

(1) Thermocouple type only available with 1746-INT4 module.

When configured for millivolt analog inputs, the modules convert the analog values directly into digital values. The modules assume that the mV input signal is already linear.

Millivolt Input Ranges

Millivolt Input Type	Range
±50 mV	-50 mV dc to +50 mV dc
±100 mV	-100 mV dc to +100 mV dc

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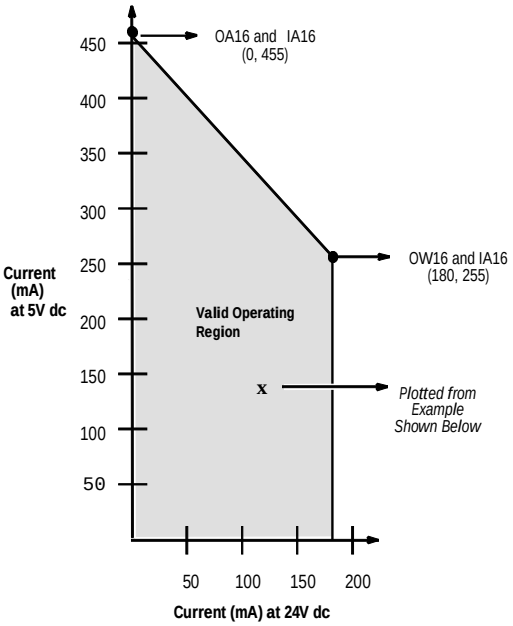
Compatibility in a Fixed Expansion Chassis

The following chart depicts the range of current combinations supported by the fixed I/O expansion chassis. To use it, find the backplane current draw and operating voltage for both modules being used in the chassis. These specifications are found in the table alongside the chart.

Next, plot each of the currents on the chart below. If the point of intersection falls within the operating region, the combination is valid. If not, the combination cannot be used in a 2-slot, fixed I/O chassis.



Example: Plot IN16 and NIO4V
IN16 = 0.085 at 5V dc and 0A at 24V dc
NIO4V = 0.055A at 5V dc and 0.115A at 24V dc

1. Add current draws of both modules at 5V dc to get 0.14 (140mA)
2. Plot this point on the chart above (140mA at 5V dc).
3. Add current draws of both modules at 24V dc to get 0.115A (115mA)
4. Plot current draw at 24V dc (115mA at 24V dc)
5. Note the point of intersection on the chart above (marked x). This combination falls within the valid operating region for the fixed I/O chassis.

Important: The1746-NO4I and 1746-NO4V analog output modules may require an external power supply.

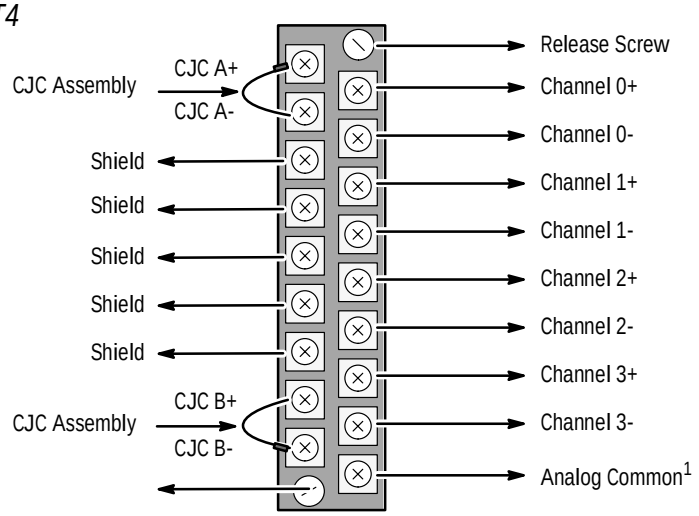
Module Current Draw - Power Supply Loading					
I/O Module	**5V**	**24V**	**I/O Module**	**5V**	**24V**
BAS	.150	.040	KE	.150	.040
BASn	.150	.125	KEn	.150	.125
DCM	.360	.000	NI4	.025	.085
FIO4I	.055	.150	NI8	.200	.100
FIO4V	.055	.120	NIO4I	.055	.145
HS	.300	.000	NIO4V	.055	.115
HSTP1	.200	.000	NO4I	.055	.195
IA4	.035	.000	NO4V	.055	.145
IA8	.050	.000	NR4	.050	.050
IA16	.085	.000	NT4	.060	.040
IB8	.050	.000	OA16	.370	.000
IB16	.085	.000	OA8	.185	.000
IB32	.106	.000	OAP12	.370	.000
IC16	.085	.000	OB8	.135	.000
IG16	.140	.000	OB16	.280	.000
IH16	.085	.000	OB16E	.135	.000
IM4	.035	.000	OB32	.452	.000
IM8	.050	.000	OBP8	.135	.000
IM16	.085	.000	OBP16	.250	.000
IN16	.085	.000	OG16	.180	.000
IO4	.030	.025	OV8	.135	.000
IO8	.060	.045	OV16	.270	.000
IO12	.090	.070	OV32	.452	.000
ITB16	.085	.000	OVP16	.250	.000
ITV16	.085	.000	OW16	.170	.180
IV8	.050	.000	OW4	.045	.045
IV16	.085	.000	OW8	.085	.090
IV32	.106	.000	OX8	.085	.090

IMPORTANT There are certain conditions that affect the compatibility characteristics of the BASIC module (BAS) and the DH-485/RS-232C module (KE)

Module Wiring

1746-NT4 and 1746-INT4 modules contain a green, 18-position, removable terminal block.

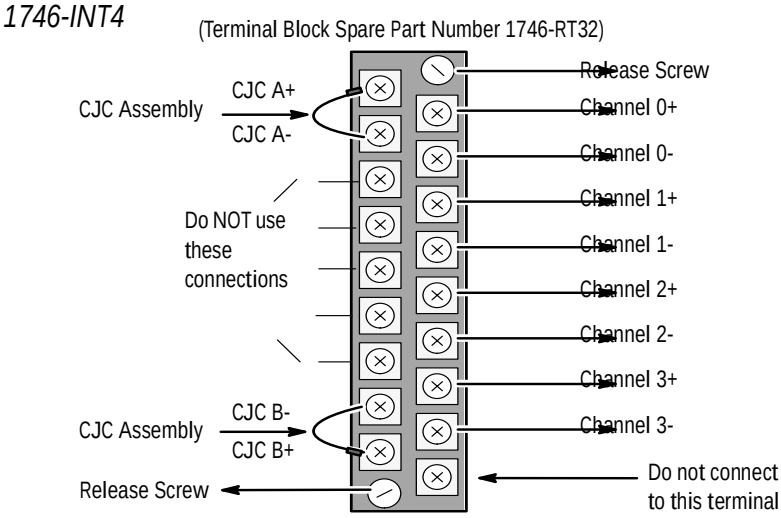
1746-NT4



(Terminal Block Spare Part Number 1746-RT32)

1. Refer to the Thermocouple/mV Input Module User Manual (publication 1746-6.6.1) for the appropriate use of this new Analog Common terminal when using this module with multiple grounded or exposed thermocouples.

1746-INT4



NOTE The 1746-INT4 module requires a ferrite collar around input wiring for CE compliance. Use Fair Rite Inc. part no. 0443164151.

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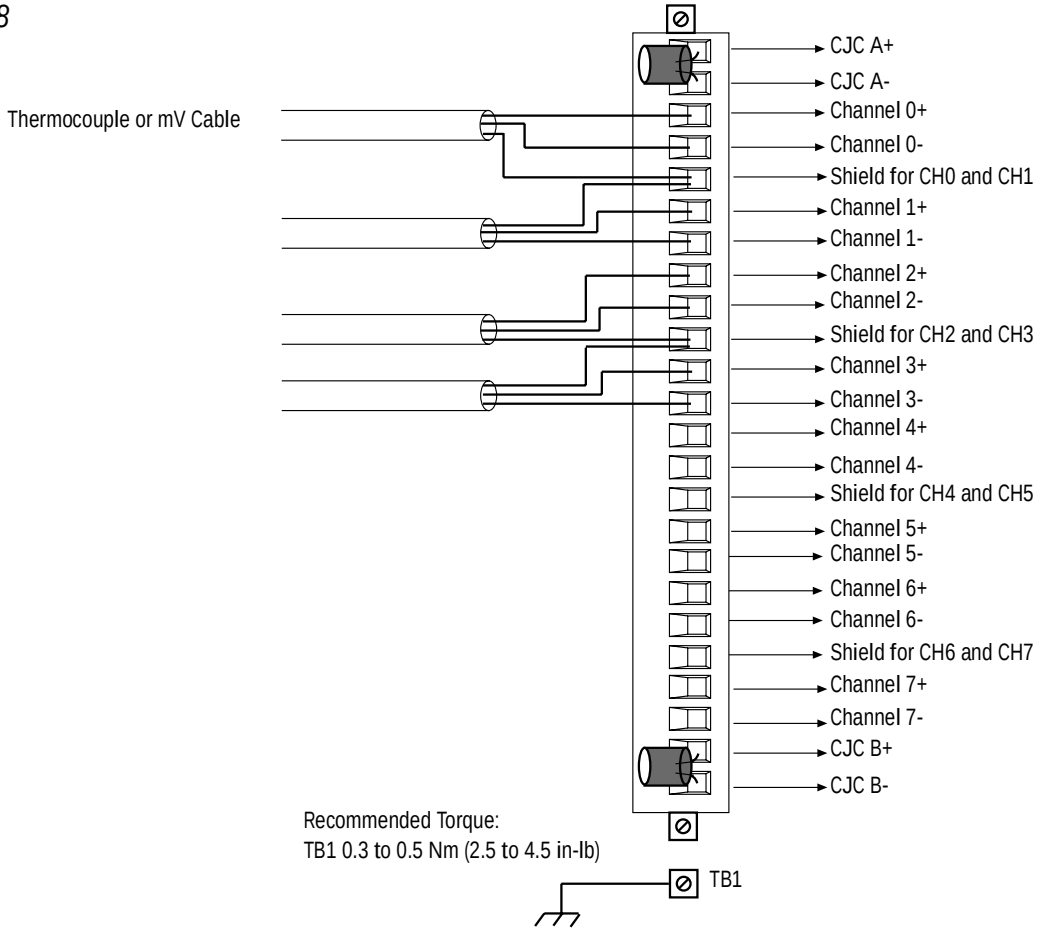
1746-NT8

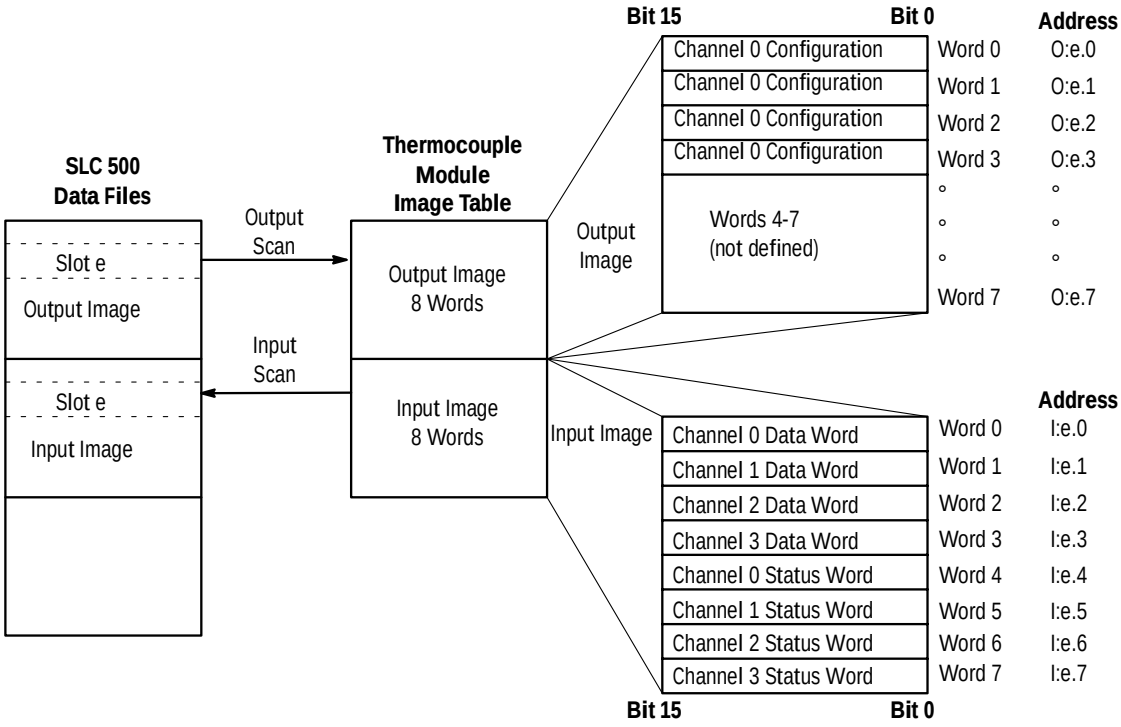


Cold-Junction Compensation (CJC)

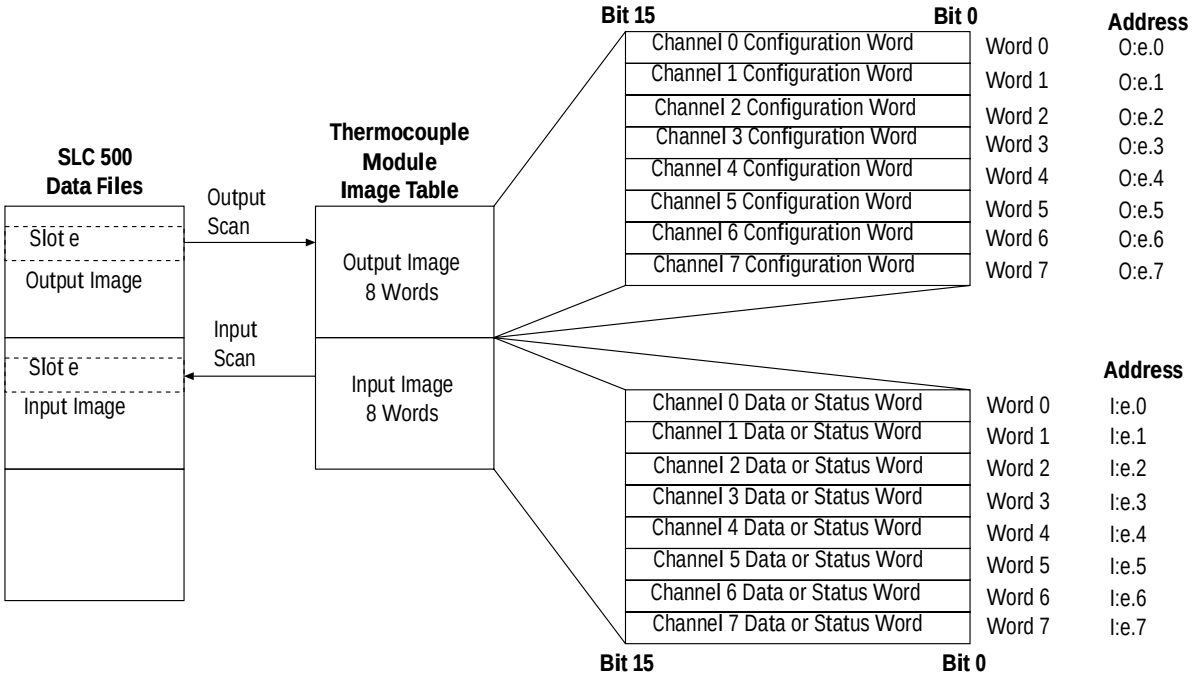
To obtain accurate readings from each of the channels, the cold junction temperature (temperature at the module's terminal junction between the thermocouple wire and the input channel) must be compensated for. Two cold-junction compensating thermistors have been integrated in the removable terminal block for all 1746 modules to accomplish this function and maintain high system accuracy.

Module Addressing

The following memory map shows you how the output and input image tables are defined for the NT4 and INT4 thermocouple modules.



The following memory map shows you how the output and input image tables are defined for the NT8 thermocouple module.



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Channel Configuration (Output Image)

Once the module has been installed, each channel on the module can be configured to establish the way the channel operates. You configure the channel by entering bit values into the configuration word using your programming software. Channels 0-3 on the NT4 module are configured by entering bit values into output words 0-3 respectively. Output words 4-7 are not used.

You can configure the following parameters:

Module	Parameter	Select one of these
INT4, NT4, NT8	Thermocouple Type	J, K, T, E, R, S, B, or N (plus C or D for INT4 module only)
INT4, NT4, NT8	Millivolt Type	±50 mV or ±100 mV
INT4, NT4, NT8	Temperature Units	°C or °F
INT4, NT4, NT8	Data Format	1.0 degrees or 0.1 degrees 0.1 mV or 0.01 mV scaled-for-PID or proportional counts
NT4, NT8	Filter Frequency	10 Hz, 50 Hz, 60 Hz, or 250 Hz
INT4, NT4, NT8	Open Circuit Failure	Zero, upscale, or downscale
NT8	Input Image Type	Data Word or Status Word module

The format of the data that the module sends back to the SLC processor depends on how the bits are set in the configuration word. Specific bit fields represent various channel characteristics. Each of these characteristics can be modified from its powerup default setting at installation or dynamically redefined while the module is operating.

Specific bit settings are discussed in the *Thermocouple/mV Input Module User Manual* for your thermocouple module. The tables on the next page define the data and display formats and the resolutions that can be represented for each input type.

In these tables:

- **Engineering Units** provide the input value directly in °C, °F, or millivolts.
- **Scaled-for-PID** provides a data format directly compatible with the SLC 5/02™ and later processors PID algorithm.
- **Proportional Counts** provide the greatest possible resolution but require manual conversion to engineering units.

1746-NT4, 1746-INT4 and 1746-NT8 Thermocouple Modules Channel Data Word Format

Input Type	Data Format					
	Engineering Units (in Degrees)		Engineering Units (in tenths of a Degree)		Scaled-for-PID	Proportional Counts
	° Celsius	° Fahrenheit	° Celsius	° Fahrenheit		
J	-210 to 760	-346 to 1400	-2100 to 7600	-3460 to 14000	0 to 16383	-32768 to 32767
K	-270 to 1370	-454 to 2498	-2700 to 13700	-4540 to 24980	0 to 16383	-32768 to 32767
T	-270 to 400	-454 to 752	-2700 to 4000	-4540 to 7520	0 to 16383	-32768 to 32767
E	-270 to 1000	-454 to 1832	-2700 to 10000	-4540 to 18320	0 to 16383	-32768 to 32767
R	0 to 1768	32 to 3214	0 to 17680	320 to 32140	0 to 16383	-32768 to 32767
S	0 to 1768	32 to 3214	0 to 17680	320 to 32140	0 to 16383	-32768 to 32767
B	300 to 1820	572 to 3308	3000 to 18200	5720 to 32767(1)	0 to 16383	-32768 to 32767
N	0 to 1300	32 to 2372	0 to 13000	320 to 23720	0 to 16383	-32768 to 32767
C (1746-INT4)	0 to 2317	32 to 4201	0 to 23170	320 to 32767	0 to 16383	-32768 to +32767
D (1746-INT4)	0 to 2317	32 to 4201	0 to 23170	320 to 32767	0 to 16383	-32768 to +32767
±50 mV (2)	-500 to 500		-5000 to 5000		0 to 16383	-32768 to 32767
±100 mV (2)	-1000 to 1000		-10000 to 10000		0 to 16383	-32768 to 32767
CJC Sensor (1746-NT4,-INT4)	0 to 85	32 to 185	0 to 850	32 to 1850	0 to 16383	-32768 to 32767
CJC Sensor (1746-NT8)	-25 to +105	-13 to +221	-250 to +1050	-130 to +2210	0 to +16383	-32768 to +32767

(1) Type B thermocouple cannot be represented in tenths of a degree Fahrenheit engineering units above 3276.7°F.

(2) When millivolts are selected, the temperature setting is ignored. Analog input data is the same for either °C or °F selection.

1746-NT4 1746-INT4 and 1746-NT8 Thermocouple Modules - Channel Data Word Resolution (thermocouples and millivolt sensors)

Input Type	Data Format							
	Engineering Units (in Degrees)		Engineering Units (in tenths of a Degree)		Scaled-for-PID		Proportional Counts	
	° Celsius	° Fahrenheit	° Celsius	° Fahrenheit	° Celsius	° Fahrenheit	° Celsius	° Fahrenheit
J	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0592°C/step	0.1066°F/step	0.0148°C/step	0.0266°F/step
K	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1001°C/step	0.1802°F/step	0.0250°C/step	0.0450°F/step
T	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0409°C/step	0.0736°F/step	0.0102 °C/step	0.0184°F/step
E	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0775°C/step	0.1395°F/step	0.0194°C/step	0.0349°F/step
R	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1079°C/step	0.1942°F/step	0.0270°C/step	0.0486°F/step
S	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1079°C/step	0.1942°F/step	0.0270°C/step	0.0486°F/step
B	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0928°C/step	0.1670°F/step	0.0232°C/step	0.0417°F/step
N	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0793°C/step	0.1428°F/step	0.0198°C/step	0.0357°F/step
C (1746-INT4)	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1414°C/step	0.0564°C/step	0.0353°C/step	0.0641°C/step
D (1746-INT4)	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1414°C/step	0.0564°C/step	0.0353°C/step	0.0641°C/step
±50 mV(1)	0.1 mV/step		0.01 mV/step		6.104 µV/step		1.526 µV/step	
±100 mV	0.1 mV/step		0.01 mV/step		12.21 µV/step		3.052 µV/step	
CJC Sensor (1746-NT4)	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0052°C/step	0.0093°F/step	0.0013°C/step	0.0023°F/step
CJC Sensor (1746-NT8)	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0079³C/step	0.0143°F/step	0.0020°C/step	0.0036°F/step

(1) When millivolts are selected, the temperature setting is ignored. Analog input data is the same for either °C or °F selection.

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Channel Data and Status (Input Image)

1746-NT4 and INT4 input words 0-3 (data words) hold the input data that represent the temperature value of thermocouple analog inputs for channels 0-3 respectively. This data word is valid only when the channel is enabled and there are no channel errors.

Input words 4-7 (status words) contain the status of channels 0-3 respectively. The status bits for a particular channel reflect the configuration settings that you have entered into the output image configuration word for that channel, as well as providing information about the channel's operational state. To receive valid status information, the channel must be enabled and the channel must have processed any configuration changes that may have been made to the configuration word.The 1746-NT8 channel configuration word must be configured to select either data or status information in the input image.

Module Diagnostics

1746 thermocouple modules perform operations at two levels:

- module-level operation
- channel-level operation

Module-level operation includes functions such as powerup configuration and communication with the SLC processor.

Channel-level operation describes channel-related functions, such as data conversion and open-circuit detection.

Internal diagnostics are performed at both levels of operation and any error conditions detected are immediately indicated by the module's LEDs.

PowerUp Diagnostics

At module powerup, a series of internal diagnostic tests is performed automatically. If any test fails, a module error results and the status LED remains off.

Channel Diagnostics

When a channel is enabled, a diagnostic check is performed to verify that the channel has been properly configured. In addition, the channel is tested for out-of-range and open-circuit faults on every scan. If the channel is configured for thermocouple input or CJC input, the CJC sensors are also checked for open circuits.

A failure of any channel diagnostic test causes the faulted channel LED to blink. All channel faults are indicated in bits 12 through 15 of the channel's status word. Channel faults are self-clearing, and the channel LED will stop blinking and resume steady illumination when the fault conditions are removed.

Terms and Abbreviations

Listed below are definitions of some of the terms and abbreviations used in the specification tables.

A/D - Refers to the analog to digital converter inherent to the thermocouple input module. The converter produces a digital value whose magnitude is proportional to the instantaneous magnitude of an analog input signal.

channel - Refers to one of four (1746-NT4, -INT4) or eight (1746-NT8), small-signal analog input interfaces available on the module's terminal block. Each channel is configured for connection to a thermocouple or DC millivolt (mV) input device, and has its own diagnostic status word.

CJC - (Cold-Junction Compensation) The means by which the module compensates for the offset voltage error introduced by the temperature at the junction between the thermocouple lead wire and the input terminal block (the cold junction).

common mode rejection ratio - The ratio of a device's differential voltage gain to common mode voltage gain. Expressed in dB, CMRR is a comparative measure of a device's ability to reject interference caused by a voltage common to its input terminals relative to ground. CMRR=20 Log_{10} (V1/V2)

cut-off frequency - The frequency at which the input signal is attenuated 3dB by the digital filter. Frequency components of the input signal below the cut-off frequency are passed with under 3dB of attenuation.

data word - A 16-bit integer that represents the value of the analog input channel. The channel data word is valid only when the channel is enabled and there are no channel errors. When the channel is disabled, the channel data word is cleared (0).

dB - (decibel) A logarithmic measure of the ratio of two signal levels.

digital filter - A low-pass noise filter incorporated into the A/D converter. The digital filter provides a very steep roll-off above its cut-off frequency, which provides high frequency noise rejection.

filter frequency - The user-selectable first-notch frequency for the A/D converter's digital filter. The digital filter provides high noise rejection at this frequency.

LSB - (Least Significant Bit) Refers to a data increment defined as the full scale range divided by the resolution. The bit that represents the smallest value within a string of bits.

normal mode rejection - (differential mode rejection) A logarithmic measure in dB, of a device's ability to reject noise signals between or among circuit signal conductors, but not between equipment grounding conductor or signal reference structure and the signal conductors.

resolution - The smallest detectable change in a measurement, typically expressed in engineering units (e.g., 0.1°C) or as a number of bits. For example, a 12-bit system has 4,096 possible output states. It can therefore measure 1 part in 4096.

step response - The time required for the analog input signal to reach 100% of its expected final value.

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Specifications

Electrical Specifications

Specification	1746-NT4	1746-NT8	1746-INT4
Backplane Current Consumption	60 mA at 5V dc; 40 mA at 24V dc	120 mA at 5V dc; 70 mA at 24V dc	110 mA at 5V dc; 85 mA at 24V dc
Backplane Power Consumption	0.8W maximum (0.3W at 5V dc, 0.5W at 24V dc)	2.28W maximum (0.6W at 5V dc, 1.68W at 24V dc)	0.6W maximum (0.55W at 5V dc, 2W at 24V dc)
Number of Channels	4 (backplane isolated)	8 (backplane isolated)	4 (backplane and channel-to-channel isolated)
I/O Chassis Location	Any I/O module slot except slot 0		
A/D Conversion Method	Sigma-Delta Modulation		
Input Filtering	Low pass digital filter with programmable notch (filter) frequencies (at 10 Hz, 50 Hz, 60 Hz, and250 Hz)		low pass digital filter corner frequency
Normal Mode Rejection (between [+] input and [-] input)	Greater than 100 dB at 50/60 Hz (10 Hz, 50 Hz filter frequencies)		Greater than 50 dB at 50 Hz, greater than 60 dB at 60 Hz
Common Mode Rejection (between inputs and chassis ground)	Greater than 150 dB at 50/60 Hz (10 Hz, 50 Hz filter frequencies)	Greater than 100 dB at 50/60 Hz (10 Hz, 50 Hz filter frequencies)	Greater than 120 dB at 50/60 Hz (with 1K ohm imbalance)
Input Filter Cut-Off Frequencies	2.62 Hz at 10 Hz filter frequency 13.1 Hz at 50 Hz filter frequency 15.72 Hz at 60 Hz filter frequency 65.5 Hz at 250 Hz filter frequency		8 Hz
Calibration	Module autocalibrates at power-up and whenever a channel is enabled.	Module auto-calibrates at power-up with filter frequency change and approximately every two minutes afterward	calibration via Ladder Program once yearly, if required
Isolation	500V dc transient between inputs and chassis ground, and between inputs and backplane. 2V dc continuous between channels (Series B or later).	500V dc transient between inputs and chassis ground and between inputs and backplane. 12.5V dc continuous between channels.	1000V transient or 150 VAC continuous, channel-to-channel or channel-to-backplane

Physical Specifications

Specification	1746-NT4	1746-NT8	1746-INT4
LED Indicators	5, green status indicators, one for each of 4 channels and one for module status	9 green status indicators, one for each of 8 channels and one for module status.	5 green status indicators, one for each of 4 channels and one for module status.
Module ID Code	3510	3533	3515
Recommended Cable: for thermocouple inputs... for mV inputs...	Appropriate shielded twisted pair thermocouple extension wire[1] Belden #8761 or equivalent	Appropriate shielded twisted pair thermocouple extension wire[1] Belden #8761 or equivalent	Appropriate shielded twisted pair thermocouple extension wire. Alpha 5121 or equivalent
Maximum Wire Size	Two 14 AWG wires per terminal	One 14 AWG wire or two 22 AWG wires per terminal	Two 14 AWG wires per terminal
Maximum Cable Impedance	25Ω maximum loop impedance, for <1LSB error		150Ω maximum loop impedance for <1LSB error
Terminal Strip	Removable, Allen-Bradley spare part Catalog Number 1746-RT32	Removable, 24 pin Phoenix, Allen-Bradley Catalog Number TBD.	Removable, Allen-Bradley spare part Catalog Number 1746-RT32

[1] Refer to the thermocouple manufacturer for the correct extension wire.

Environmental Specifications

Specification	1746-NT4		1746-NT8	1746-INT4
Operating Temperature	0°C to 60°C (32°F to 140°F)			
Storage Temperature	–40°C to +85°C (–40°F to +185°F)			
Relative Humidity	5% to 95% (without condensation)			
Certification (when product or packaging is marked)	Series A or higher: • UL listed • CSA approved	Series B or higher: • UL listed • CSA approved CE compliant for all applicable directives	• UL listed • CSA approved CE compliant for all applicable directives	• UL listed • CSA approved CE compliant for all applicable directives
Hazardous Environment Classification	Class 1 Division 2 by UL/CSA		Class 1 Division 2 by UL/CUL	Class 1 Division 2 by CSA only

Input Specifications

Type of Input (Selectable)	Thermocouple Type J	-210°C to 760°C	-346°F to 1400°F
	Thermocouple Type K	-270°C to 1370°C	-454°F to 2498°F
	Thermocouple Type T	-270°C to 400°C	-454°F to 752°F
	Thermocouple Type E	-270°C to 1000°C	-454°F to 1832°F
	Thermocouple Type R	0°C to 1768°C	32°F to 3214°F
	Thermocouple Type S	0°C to 1768°C	32°F to 3214°F
	Thermocouple Type B	300°C to 1820°C	572°F to 3308°F
	Thermocouple Type N	0°C to 1300°C	32°F to 2372°F
	Thermocouple Type C	0°C to 2317°C	32°F to 4201°F (1746-INT4 only)
	Thermocouple Type D	0°C to 2317°C	32°F to 4201°F(1746-INT4 only)
	Millivolt (-50 mV dc to +50 mV dc)		
	Millivolt (-100 mV dc to +100 mV dc)		

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Input Specifications

Specification	1746-NT4	1746-NT8	1746-INT4
Thermocouple Linearization	IPTS-68 standard, NBS MN-125, NBS MN-161	NIST ITS-90 standard	IPTS-68 standard, NBS MN-125, NBS MN-161
Cold-Junction Compensation	Accuracy ±1.5°C, 0°C to 85°C (32°F to 185°F)	Accuracy ±1.72°C, -25°C to +105°C	Accuracy ±1.5°C, 0° to 70°C (32°F to 158°F)
Input Impedance	Greater than 10 MΩ		
Temperature Scale (Selectable)	°C or °F and 0.1°C or 0.1°F		
DC Millivolt Scale (Selectable)	0.1 mV or 0.01 mV		
Open Circuit Detection Leakage Current	12 nA maximum	NA	20 nA typical
Open Circuit Detection Method	Upscale, downscale, or zero	Upscale, downscale, zero, or disabled	Upscale, downscale, or zero
Time to Detect Open Circuit	500 msec or 1 module update time, whichever is greater	One channel cycle time	5 seconds, typical
Input Step Response	See Channel Step Response(1746-NT4 and -NT8) on page 16.	0 to 95% in 400 msec (10 Hz)	0 to 99.9% in 600 ms (worst case)
Display Resolution	See 1746-NT4, 1746-INT4 and 1746-NT8 Thermocouple Modules Channel Data Word Format on page 11.		
Overall Module Accuracy at 25°C (77°F)	See 1746-NT4 Module Accuracy Table on page 19.		
Overall Module Drift	See 1746-NT4 Module Accuracy Table on page 19.		
Module Update Time (See page 17.)	The sum of all enabled channel's sample time plus one CJC update time.	Dependent on enabled channels (see Update Time Table.)	Less than 500 ms
Channel Turn-On Time, Reconfiguration Time	Requires up to one module update time plus one of the following: • 250 Hz Filter =82 milliseconds • 60 Hz Filter =196 milliseconds • 50 Hz Filter =226 milliseconds • 10 Hz Filter =946 milliseconds	One module update time plus 890 usec per newly configured channel (plus auto-calibration time if filter frequency is new to module).	One module update time plus 400 msec.
Channel Turn-Off Time (See page 17.)	Requires up to one module update time		

Channel Step Response(1746-NT4 and -NT8)

The channel filter frequency determines the channel's step response. The step response is time required for the analog input signal to reach 100% of its expected final value. This means that if an input signal changes faster than the channel step response, a portion of that signal will be attenuated by the channel filter.

The following table shows the available filter frequencies, cut-off frequency, and step response in ms for each filter frequency for 1746-NT4 and 1746-NT8 thermocouple modules.

Filter Frequency	Cut-Off Frequency	1746-NT4	1746-NT8
10 Hz	2.62	300	400
50 Hz	13.1	60	80
60 Hz	15.72	50	66.7
250 Hz	65.5	12	16

Module Update Time (1746-NT4 and - NT8)

The thermocouple module update time is defined as the time required for the module to sample and convert the input signals of all enabled input channels and make the resulting data values available to the SLC processor. It can be calculated by adding the the sum of all enabled channel sample times, plus a CJC update time.

The following table shows the channel sampling times for each filter frequency. It also gives the CJC update time.

Channel Sampling Time for Each Filter Frequency (all values ±1 msec)

Module Type	CJC Update Time	Channel Sampling Time			
		250 Hz Filter	60 Hz Filter	50 Hz Filter	10 Hz Filter
1746-NT4	14 msec	12 msec	50 msec	60 msec	300 msec
1746-NT8(1)	290 msec	66 msec	125 msec	140 msec	470 msec

(1) The sampling times for filter frequencies listed do not include a 45 msec open-circuit detection.

The *fastest module update time* occurs with the 1746-NT4 when only one channel with a 250 Hz filter frequency is enabled.

1746-NT4 Module update time (one channel, 250 Hz filter) =
12 msec + 14 msec = 26 msec

1746-NT8 Module Update Time (one channel, 250 Hz filter) =
290 msec + 66 msec = 356 msec

1746-NT4 Module update time (4 channels, 250 Hz filter) =
14 msec + (4 x 12 msec) = 62 msec

1746-NT8 Module update time (8 channels, 250 Hz filter) =
290 msec + (8 x 66 msec) = 818 msec

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Input Channel Characteristics (1746-INT4)

Each channel has an 8 Hz digital filter for input noise rejection, a multiplexer for processing cold-junction-compensation (CJC) values, and an analog-to-digital (A/D) converter to provide digital values for SLC processing.

Channel Cut-off Frequency, Update Time, and Step Response

The channel cut-off frequency is defined as the point on the frequency response curve where frequency components of the input signal are passed with 3 dB of attenuation by the input filter. All frequency components above cut-off frequency are increasingly attenuated, as shown in the graph below. Cut-off frequency is also defined as the Normal Mode Rejection (NMR) in dB of attenuation at 50 Hz (European) or at 60 Hz (American).

We define module update time as the time required for the module to sample and convert channel input signals, multiplex them with the CJC reference value, and make the resulting values available to the SLC processor. It is typically 200 ms for multiplexing and 200 ms for sampling and converting.

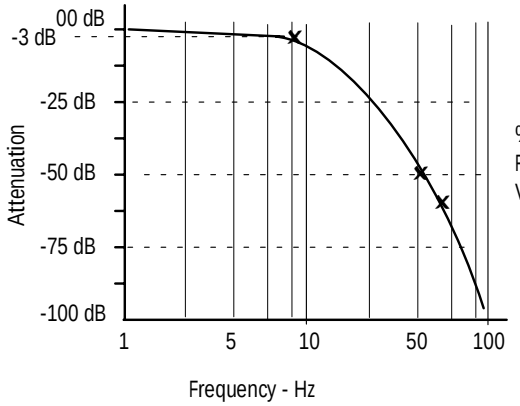
When sampling occurs after the signal reaches 99.9% of final value, the update time defines the minimum time (400 ms) for processing an input signal.

When sampling occurs just before the signal reaches 99.9% of final value, we define step response (worst-case) as the sum of the times required for the analog input signal to change from 0 to 99.9% of its expected final value (see graph). It includes the time required for

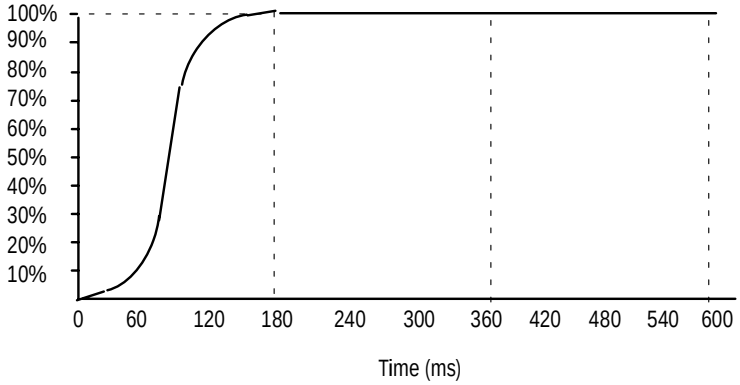
- input filter 180 ms
- CJC multiplexer 200 ms
- A/D converter 200 ms

This defines the maximum time required for processing an input signal.

Frequency Response of the 8 Hz Filter Converter



Step Response (worst case) for Filter, Multiplexer, and A/D



The following table summarizes the input channel characteristics:

Corner Frequency	50/60 Hz NMR	Filter Time	Update Time	Step Response (worst)
8 Hz	50-60 dB	180 ms	400 ms	600 ms

1746-NT4 Module Accuracy Table

Input Type	Maximum Error at 25°C	Maximum Error at 77°F	Temperature Drift (0°C-60°C)
J	±1.06°C	±1.91°F	±0.0193°C/°C, °F/°F
K	±1.72°C	±3.10°F	±0.0328°C/°C, °F/°F
T	±1.43°C	±2.57°F	±0.0202°C/°C, °F/°F
E	±0.72°C	±1.3°F	±0.0190°C/°C, °F/°F
S	±3.61°C	±6.5°F	±0.0530°C/°C, °F/°F
R	±3.59°C	±6.46°F	±0.0530°C/°C, °F/°F
B	±3.12°C	±5.62°F	±0.0457°C/°C, °F/°F
N	±1.39°C	±2.5°F	±0.0260°C/°C, °F/°F
±50 mV	±50 µV	±50 µV	±1.0 µV/°C, ±1.8 µV/°F
±100 mV	±50 µV	±50 µV	±1.5 µV/°C, ±2.7 µV/°F

1746-NT8 Module Accuracy Table

Input Type	Thermocouple Reference Point	Maximum Error at 25°C	Maximum Error at 77° F	Maximum Error at 0 to 60°C	Maximum Error at 32 to 140°F
J	+275°C (+527°F)	±1.4°C	±2.52°F	±3.0°C	±5.4°F
K	+550°C (+1022°F)	±1.5°C	±2.7°F	±3.0°C	±5.4°F
T	+65°C (+149°F)	±1.3°C	±2.34°F	±3.4°C	±6.12°F
E	+365°C (+689°F)	±1.0°C	±1.8°F	±2.5°C	±4.5°F
S	+885°C (+1625°F)	±3.6°C	±6.48°F	±6.5°C	±11.7°F
R	+885°C (+1625°F)	±3.4°C	±6.12°F	±7.2°C	±12.96°F
B	+1060°C (+1940°F)	±2.7°C	±4.86°F	±8.4°C	±15.12°F
N	+500°C (+932°F)	±1.3°C	±2.34°F	±3.0°C	±5.4°F
±50 mV		±30 µV	±30 µV	±120 µV	±120 µV
±100 mV		±30 µV	±30 µV	±120 µV	±120 µV

1746-INT4 Module Accuracy Table

Input Type	Maximum Error at 25°C	Maximum Error at 77°F	Temperature Drift (0°C-60°C)
J	±1.60°C	±2.88°F	±0.042°C/°C, °F/°F
K	±3.80°C	±6.84°F	±0.096°C/°C, °F/°F
T	±2.05°C	±3.69°F	±0.096°C/°C, °F/°F
E	±2.40°C	±4.32°F	±0.058°C/°C, °F/°F
S	±2.38°C	±4.29°F	±0.131°C/°C, °F/°F
R	±2.33°C	±4.02°F	±0.130°C/°C, °F/°F
B	±3.83°C	±6.90°F	±0.109°C/°C, °F/°F
N	±1.79°C	±3.23°F	±0.080°C/°C, °F/°F
C	±2.28°C	±4.11°F	±0.280°C/°C, °F/°F
D	±2.52°C	±4.54°F	±0.280°C/°C, °F/°F
±50 mV	±50 µV	±50 µV	±0.5µV/°C, ±50 ppm/°C
±100 mV	±50 µV	±50 µV	±0.5µV/°C, ±50 ppm/°C

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1746-TD002A-EN-P- April 2000
Supersedes Publication Number 1746-2.36 – March 1999

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