NI-9145 Expansion Chassis Configuration

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Contents

CG Purpose

This document contains information about accessing all of the functionality of the C Series modules using vendor extensions to the object dictionary on the EtherCAT expansion chassis.

Using the chassis with an EtherCAT Third-Party Master

When using a third-party master, you can access all of the functionality of the C Series modules using vendor extensions to the object dictionary. Each module installed in the chassis has its own object dictionary that you can use to configure the module.

If your master software supports ADS over EtherCAT (AoE) services, you can address the module directly. If your master software does not support AoE services, you can still configure your module using NI vendor extensions and CAN over EtherCAT (CoE).

Using AoE/SDO

AoE protocol allows you to specify the destination port or address of the SDO request. An address of 0 indicates the chassis. Addresses 1 through 8 route the SDO request to the object dictionary of the module in the addressed slot. If no module is installed in the addressed slot, the request fails. SDOInfo and SDO requests work with module object dictionaries over AoE similar to the chassis main object dictionary.

> **Tip** Depending on the master software interface, you may be required to add 1,000 to the slot number to create a valid AoE address.

Related reference

- Vendor Extensions to the Object Dictionary

Using CoE/SDO

CoE protocol does not have a destination port or address. When using CoE protocol, the chassis provides an object dictionary entry that allows addressing support. Prior to sending an SDOInfo or SDO request, the application writes an address of 1 through 8 to the object dictionary index 0x5FFF, subindex 0. Once the address is written, SDO transactions are sent to the object dictionary of the module in the addressed slot. If no module is installed in the addressed slot, the request fails.

After the module-specific SDOInfo and SDO requests are complete, the application writes 0 to the module object dictionary index 0x5FFF, subindex 0 to return control to the chassis main object dictionary.

Related reference

- Vendor Extensions to the Object Dictionary

Vendor Extensions to the Object Dictionary

Most object dictionary entries are defined by the EtherCAT and CANOpen specifications for modular slave devices. The chassis and the C Series modules have vendor extensions to those specifications.

> **Note** Visit ni.com/manuals to access the NI 951x C Series modules object dictionary.

> **Note** Most object dictionary entries are set to usable defaults during the transition from INIT to PRE-OP of the chassis. NI recommends writing down the object dictionary default values, in case you need to revert to them, before you begin to overwrite them with new values prior to the transition to SAFE-OP.

The following table lists common C Series module vendor extensions.

> **Note** Each module has its own extensions, which may vary from the information listed in the following table. Also, any given object dictionary index may have a different meaning, depending on the module you are

using. Refer to the C Series module sections for more information about the specific module extensions.

Vendor Extension	Index	Sub	Type	R/W	Description
NI 914**x**	0x3001	0	ARR:U32	—	Timing overrides. Provides additional control over the timing of the chassis.
	—	1	—	R/W	Minimum free-run cycle time in nanoseconds. Set to 0 to operate at the minimum cycle. Set to 1,000,000 for a 1 mS cycle (1 kHz).
	—	2	—	R/W	Disables multiple scans. Setting the field to 1 disables multiple-scan ability, regardless of whether a module has enough time during the cycle to acquire more than one set of data. This is useful when analyzing the module acquisition timing.
	0x5FFF	0	U32	R/W	Slot address override. Enter the slot number of the module to address CoE requests to the object dictionary of the module. Set to 0 to cancel the slot address override.
C Series Module	0x2000	0	U32	R	C Series Vendor ID (For C Series modules, equals 0x1093)
	0x2001	0..N	ARR:	R/W	▪ Scan or command list ▪ Channel direction control ▪ Mode selection
	0x2002	0	U32	R/W	▪ Error status ▪ Unipolar/bipolar control ▪ Module configuration command ▪ Module conversion rate control
	0x2003	0	U32	R/W	Error acknowledgment or status
	0x2005	0	U8	R/W	▪ Refresh period ▪ Conversion format
	0x2100	0..N	ARR:	R	Calibration data

Vendor Extension	Index	Sub	Type	R/W	Description
	0x3002	0	U32	R	Number of scans. This index reports the number of conversions the module makes during the cycle. If disable multiple scans is selected, the number of scans is always 1.
	0x4000 … 0x47FF	—	—	R/W	Safe data values that mirror the PDO data in 0x6000…0x67FF.
	0x4800 … 0x4FFF	—	—	R/W	Safe control values that mirror the SDO data in 0x2000…0x27FF.

Table 1. Module Vendor Extensions

NI 9201/9221

The following table lists the vendor configuration extensions for the NI 9201/9221.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	—	Scan List = 9
	1		R	Channels to Convert = <1..8>, default = 8
	2..9		R/W	Channel Code
0x2002	0	U32	R/W	Fast Convert = 0/1, default = 1 (fast)
0x2100	0	ARR:U32	—	Calibration = 32
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	...		—	—
	15		R	Ch7 Offset
	16		R	Ch7 Gain
	17		R	External Calibration, Ch0 Offset
	...		—	—

Table 2. NI 9201/9221 Vendor Configuration Extensions

NI 9201/9221 Scan List

The scan list channel codes consist of two-bit fields in a 32-bit entry.

Bits	Field
31..24	= 0
23..16	Data Offset[**t**]
15..8	= 0
7..0	Convert Flag[**t**+2]

Table 3. NI 9201/9221 Scan List Format

Bits <23..16> describe the data offset to store a conversion at time **t**, and bits <7..0> describe the conversion control code that takes effect two conversions in the future, at time **t**+2. For the NI 9201/9221, this conversion code is a bit flag where bit 0 represents a conversion on channel 0, through bit 7 for channel 7.

For example, the scan list entry 0x00010008 indicates this scan stores at address 1, and the conversion two in the future is channel 3 (bit 3 set = 8).

Index	Sub	Type	Value
0x2001	0	ARR:U32	9
	1		8
	2		0x00000004
	3		0x00010008
	4		0x00020010
	5		0x00030020
	6		0x00040040
	7		0x00050080
	8		0x00060001
	9		0x00070002

Table 4. NI 9201/9221 Default Scan List

NI 9201/9221 Calibration Data

The NI 9201/9221 modules have eight channels with a nominal range of ±10.53 V and ±62.5 V, respectively. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	nV/LSB
Offset	Signed	nV

Table 10. NI 9221/9201 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data.

Figure 1. NI 9201/9221 Corrected Data Equation

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\} - \left\{Offset\left(nV\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\}$$

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\} - \left\{Offset\left(nV\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\}$$

NI 9203

The following table lists the vendor configuration extensions for the NI 9203.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	—	Scan List = 9
	1		R	Channels to Convert = <1..8>, default = 8
	2..9		R/W	Channel Code
0x2002	0	U32	R/W	Unipolar Channel Mask
0x2100	0	ARR:U32	—	Calibration = 36
	1		R	Bipolar Offset
	2		R	Ch0 Bipolar Gain
	3		R	Ch1 Gain

Index	Sub	Type	R/W	Description
	...		—	—
	9		R	Ch7 Gain
	10		R	Unipolar Offset
	11		R	Ch0 Unipolar Gain
	...		—	—
	19	R	R	External Calibration, Bipolar Gain
	...		—	—

Table 6. NI 9203 Vendor Configuration Extensions

NI 9203 Scan List

The scan list channel codes consist of three bit fields in a 32-bit entry.

Bits	Field
31..24	= 0
23..16	Data Offset[**t**]
15..4	= 0
3	Bipolar = 0, Unipolar = 1
2..0	Channel Code[**t**+2]

Table 7. NI 9203 Scan List Format

Bits <23..16> describe the data offset to store a conversion at time **t**, and bits <3..0> describe the conversion control code that will take effect two conversions in the future, at time **t**+2. On the NI 9203, bit 3 determines whether the result is bipolar (signed) or unipolar (unsigned), and bits <2..0> are the channel number reversed.

Channel	Reversed Bits
0 = 0b000	0b000 = 0
1 = 0b001	0b100 = 4
2 = 0b010	0b010 = 2
3 = 0b011	0b110 = 6
4 = 0b100	0b001 = 1
5 = 0b101	0b101 = 5
6 = 0b110	0b011 = 3

Channel	Reversed Bits
7 = 0b111	0b111 = 7

Table 8. NI 9203 Channels/Reversed Bits

For example, the scan list entry 0x00010006 indicates that this scan gets stored at address 1, and that conversion two is a bipolar channel 3 (3 reversed = 6).

Index	Sub	Type	Value
0x2001	0	ARR:U32	9
	1		8
	2		0x00000002
	3		0x00010006
	4		0x00020001
	5		0x00030005
	6		0x00040003
	7		0x00050007
	8		0x00060000
	9		0x00070004

Table 9. NI 9203 Scan List Format

NI 9203 Calibration Data

The NI 9203 has eight channels each with two modes. Each channel can have a nominal unipolar input range of 0 mA to 20 mA or bipolar ±20 mA. Each channel has an associated LSB weight, which is the number of amps per bit, and an offset, which is the number of amps per bit measured when the inputs are open.

Note LSB weight is referred to as gain in the object dictionary.

The difference in offset from channel to channel is negligible.

The calibration data gives one offset and eight gains for each mode, for a total of 2 offsets and 16 gains. All channels in a given mode use the same offset. The host can then take these constants and adjust the raw data into calibrated data.

The calibration data is stored in a U32 array, though each offset should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pA/LSB
Offset	Signed	pA

Table 10. NI 9203 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data.

Figure 2. NI 9203 Corrected Data Equation

$$I_{corrected}\left(I_{raw}\right) = \left(I_{raw}\right)LSB_{weight} - I_{offset}$$

$$I_{corrected}\left(I_{raw}\right) = \left(I_{raw}\right)LSB_{weight} - I_{offset}$$

Term	Units	Definition
$I_{corrected}$	pA	Calibrated current
I_{raw}	bits	Raw code from the NI 9203
LSB_{weight}	pA/bit	Amount of pA in one bit
I_{offset}	pA	Offset at 0 mA

Table 11. NI 9203 Calibration Equation Information

NI 9205/9206

The following table lists the vendor configuration extensions for the NI 9205/9206.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	—	Scan List = 33
	1		R	Channels to Convert = <1..32>, default = 32
	2..33		R/W	Channel Code
0x2100	0	ARR:U32	—	Calibration = 24
	1		R	Coeff3
	2		R	Coeff2
	3		R	Coeff1
	4		R	Coeff0
	5		R	10 V Offset

Index	Sub	Type	R/W	Description
	6		R	10 V Gain
	7		R	5 V Offset
	...		—	—
	13		R	User Calibration, Coeff 3
	...		—	—

Table 12. NI 9205/9206 Vendor Configuration Extensions

NI 9205/9206 Scan List

The scan list channel codes consist of eight bit fields in a 32-bit entry.

Bits	Field
31..24	= 0
23..16	Data Offset[**t**]
15..0	Conversion Code[**t**+2]

Table 13. Scan List Format

Bits <23..16> describe the data offset to store a conversion at time **t**, and bits <15..0> describe a complex conversion control code that takes effect two conversions in the future, at time **t**+2. The following table lists the conversion code NI 9205/9206.

Bits	Field
15..13	001 = Read AI
12..11	Bank: ▪ 01 = Channels <0..15> ▪ 10 = Channels <16..31>
10..8	Channel LSB = <0..7>
7..6	00 = Cal Pos Ref5V
5..4	▪ 00 = NRSE ▪ 11 = Cal Neg AI GND RSE or DIFF
3..2	Mode: ▪ 01 = DIFF

Bits	Field
	▪ 10 = Single-End A (Ch. <0..7>, <16..23>) ▪ 11 = Single-End B (Ch. <8..15>, <24..31>)
1..0	▪ 00 = ±10 V ▪ 01 = ±5 V ▪ 10 = ±1 V ▪ 11 = ±200 mV

Table 14. NI 9205/9206 Conversion Code

Index	Sub	Type	Value	Sub	Value
0x2001	0	ARR:U32	33	—	—
	1		32	—	—
	2		0x00002A38	18	0x00103238
	3		0x00012B38	19	0x00113338
	4		0x00022C38	20	0x00123438
	5		0x00032D38	21	0x00133538
	6		0x00042E38	22	0x00143638
	7		0x00052F38	23	0x00153738
	8		0x0006283C	24	0x0016303C
	9		0x0007293C	25	0x0017313C
	10		0x00082A3C	26	0x0018323C
	11		0x00092B3C	27	0x0019333C
	12		0x000A2C3C	28	0x001A343C
	13		0x000B2D3C	29	0x001B353C
	14		0x000C2E3C	30	0x001C363C
	15		0x000D2F3C	31	0x001D373C
	16		0x000E3038	32	0x001E2838
	17		0x000F3138	33	0x001F2938

Table 15. NI 9205/9206 Scan List Format

NI 9205/9206 Calibration Data

The NI 9205/9206 uses a quadratic formula for conversion from 16-bit raw data to calibrated data.

The NI 9205/9206 EEPROM provides overall polynomial values a3-a0 along with gain and offset values for each voltage range. Complete the following procedure to convert 16-bit raw data to calibrated data.

1. Convert the 32-bit hex values to 64-bit floating point format for use in the calibration formula.
2. Select the 32-bit gain value for a particular range.
3. Select the 32-bit offset value (to be interpreted as a signed int) for a particular range.
4. Use the above final coefficients and complete the following steps in the quadratic equation to convert raw 16-bit data into scaled volts:
   where f64(**x**) typecasts the value to a floating point:
   1. a0 = (f64(a0) × rangeGain) + rangeOffset
   2. a1 = f64(a1) × rangeGain
   3. a2 = f64(a2) × rangeGain
   4. a3 = f64(a3) × rangeGain
5. Use the following formula with a3-a0 to obtain the scaled 16-bit value in volts, where x = signed un-scaled 16-bit data read from device:
   Scaled 16-bit signed data in volts = $a3 \times \mathbf{x}^3 + a2 \times \mathbf{x}^2 + a1 \times \mathbf{x} + a0$

Refer to the NI 9201/9221 section for information about how to decode the raw data using only the offset and gain values.

NI 9207

The following table lists the vendor configuration extensions for the NI 9207.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	—	Scan List =17
	1		R	Channels to Convert = <1..16>, default = 16

Index	Sub	Type	R/W	Description
	2..17		R/W	Channel Code
0x2002	0	U32	R/W	Conversion Speed Control = 0 or 1, default = 0

Table 16. NI 9207 Vendor Configuration Extensions

NI 9207 Conversion Speed Control

The NI 9207 converts at two pre-defined rates, as specified in the Speed Control field.

> **Note** The conversion rate assumes that the scan lists contains 16 channels.

Speed Control	Meaning	Conversion Rate
0	High Accuracy	62.5 ms/channel (1 s total)
1	High Speed	1.92 ms/channel (30.72 ms total)

Table 17. NI 9207 Conversion Speed Control

NI 9207 Scan List

The scan list is a simple, ordered list of channels to convert. The NI 9207 has a total of 16 measurable channels.

Index	Sub	Type	Value
0x2001	0	ARR:U32	17
	1		16
	2		0
	3		1
	...		...
	17		15

Table 18. NI 9207 Scan List Format

NI 9207 Calibration Data

Calibration data is set by the device driver during initialization and the calibration conversion is performed on the module ADC.

NI 9208

The following table lists the vendor configuration extensions for the NI 9208.

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	—	Scan List = 17
	1		R	Channels to Convert = <1..16>, default = 16
	2..17		R/W	Channel Code
0x2002	0	U32	R/W	Conversion Speed Control = 0 or 1, default = 0

Table 19. NI 9208 Vendor Configuration Extensions

NI 9208 Conversion Speed Control

The NI 9208 converts at two pre-defined rates, as specified in the Speed Control field.

Note The conversion rate assumes that the scan list contains 16 channels.

Speed Control	Meaning	Conversion Rate
0	High Resolution	62.5 ms/channel (1 s total)
1	High Speed	1.92 ms/channel (30.72 ms total)

Table 20. NI 9208 Conversion Speed Control

NI 9208 Scan List

The scan list is a simple, ordered list of channels to convert. The NI 9208 has a total of 16 measurable channels.

Index	Sub	Type	Value
0x2001	0	ARR:U32	17

Index	Sub	Type	Value
	1		16
	2		0
	3		1
	...		...
	17		15

Table 21. NI 9208 Scan List Format

NI 9208 Calibration Data

Calibration data is set by the device driver during initialization and the calibration conversion is performed on the module ADC.

NI 9209

The following table lists the vendor configuration extensions for the NI 9209.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	-	Scan List = 33
	1		R	Channels to Convert = <1..32>, default = 32
	2..33		R/W	Channel Code
0x2002	0	U32	R/W	Conversion Speed Control = 0 or 1, default = 0

Table 49. NI 9209 Vendor Configuration Extensions

NI 9209 Conversion Speed Control

The NI 9209 converts at two pre-defined rates, as specified in the Speed Control field.

Speed Control	Meaning	Conversion Rate
0	High Resolution	52 ms/channel
1	High Speed	2 ms/channel

Table 50. NI 9209 Conversion Speed Control

NI 9209 Scan List

The scan list channel codes consist of eight bit fields in a 32-bit entry.

Bits	Field
31..6	Reserved
5	Mode: ▪ 0 = DIFF ▪ 1 = RSE
4..0	Channel number = <0..31>

Table 51. NI 9209 Channel Code

Index	Sub	Type	Value
0x2001	0	ARR:U32	33
	1		32
	2		0x20 | 0x00
	3		0x20 | 0x01
	...		...
	33		0x20 | 0x1F

Table 53. NI 9209 Default Scan List

NI 9209 Calibration Data

Calibration data is set up by driver during initialization, and the calibration conversion is performed on the module ADC itself. The calibration tables are not required.

Use the following equation to scale the calibrated ADC codes into voltages for the NI 9209:

Figure 3. NI 9209 Voltage Scaling Equation

$$V_{corrected}\left(R_{raw}\right) = V_{raw}\left(bits\right) \times 1.2398514\left(\frac{\mu V}{bits}\right) \times 10^{-6}\left(\frac{V}{\mu V}\right)$$

$$V_{corrected}\left(R_{raw}\right) = V_{raw}\left(bits\right) \times 1.2398514\left(\frac{\mu V}{bits}\right) \times 10^{-6}\left(\frac{V}{\mu V}\right)$$

where $V_{corrected}$ represents the calibrated voltage value and V_{raw} represents the data returned by the NI 9209 in bits.

NI 9211

The following table lists the vendor configuration extensions for the NI 9211.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	—	Scan List = 7
	1		R	Channels to Convert = <1..6>, default = 6
	2..7		R/W	Channel Number

Table 26. NI 9211 Vendor Configuration Extensions

NI 9211 Scan List

The scan list is a simple, ordered list of channels to convert. The NI 9211 has a total of six measurable channels.

- <0..3>: four input channels (always measured in a ±80 mV range)
- 4: one cold junction channel (always measured in a ±2.5 V range)
- 5: one auto zero channel (always measured in a ±80 mV range)

Index	Sub	Type	Value
0x2001	0	ARR:U32	7
	1		6
	2		0
	3		1
	...		...
	7		5

Table 27. NI 9211 Scan List Format

NI 9211 Calibration Data

Calibration data is set by the device driver during initialization and the calibration conversion is performed on the module ADC.

NI 9212

The following table lists the vendor configuration extensions for the NI 9212.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Conversion Speed Control = 2, 8, 9 or 15, default = 15
0x2003	0	ARR:U32	R	Open Thermocouple Status (also as 8-bit PDO)

Table 36. NI 9212 Vendor Configuration Extensions

NI 9212 Conversion Speed Control

The NI 9212 converts at four pre-defined rates, as specified in the Speed Control field.

Note The conversion rate assumes that 40 channels are in the scan list.

Speed Control	Meaning	Conversion Rate
2 (0x02)	High Speed	10.39 ms/module
8 (0x08)	Best 60 Hz Rejection	138 ms/module
9 (0x09)	Best 50 Hz Rejection	117.49 ms/module
15 (0x0F)	High Resolution	548.2 ms/module

Table 29. NI 9212 Conversion Speed Control

NI 9212 Status

The following table lists the error/status field definitions.

Bits	Field
31..8	Reserved
7..0	The latest detected open thermocouple status. Each channel takes one bit.

Table 37. NI 9212 Open Thermocouple Status Code

NI 9212 Calibration Data

Calibration data is set up by the driver during initialization. The calibration conversion is performed on the module ADC itself. The third-party user does not need to check the index 0x2100 to calibrate the data manually.

Use the following equation to calculate raw voltage for the cold-junction compensation (CJC):

Figure 19. NI 9212 CJC Raw Voltage Equation

$$V_{CJCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times Bit_{CJC}$$

$$V_{CJCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times Bit_{CJC}$$

where $V_{CJCvoltage}$ represents raw CJC voltage and Bit_{CJC} represents binary bits for the CJC

Use the following equation to calculate raw voltage for the thermocouple (TC):

Figure 5. NI 9212 TC Raw Voltage Equation

$$V_{TCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times Bit_{TC}\ V_{TCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times Bit_{TC}$$

where $V_{TCvoltage}$ represents raw TC voltage and Bit_{TC} represents binary bits for the TC

After calculating the CJC and the TC voltage, use the NI 9212 Getting Started example, which is located in the LabVIEW\examples\CompactRIO\Module Specific directory, to calculate the resistance of the TC and the CJC temperature in degrees Celsius.

NI 9213

The following table lists the vendor configuration extensions for the NI 9213.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	—	Scan List = 16
	1		R	Channels to Convert = <1..18>, default = 18
	2..19		R/W	Channel Code
0x2002	0	U32	R/W	Channel Speed Control = 2 or 15, default = 2

Index	Sub	Type	R/W	Description
0x2003	0	U32	R	Common Mode Range Error Detection Status (also as 8-bit PDO)

Table 31. NI 9213 Vendor Configuration Extensions

NI 9213 Conversion Speed Control

The NI 9213 converts at two pre-defined rates, as specified by the Speed Control field.

Note The conversion rate assumes that 18 channels are in the scan list.

Speed Control	Meaning	Conversion Rate
2 (0x02)	High Accuracy	55 ms/channel (.99 s total)
15 (0x0F)	High Speed	740 µs/channel (12.32 ms total)

Table 32. NI 9213 Conversion Speed Control

NI 9213 Common Mode Error/Status

The following tables define the error/status field for the NI 9213.

Bits	Field
31..16	Reserved
15..0	The most recently detected open thermocouple status. Each channel takes one bit.

Table 33. NI 9213 Open Thermocouple Status Code

Bits	Field
31..16	Reserved
15..0	The most recently detected common mode voltage error. Each channel takes one bit.

Table 34. NI 9213 Common Mode Voltage Error Code

NI 9213 Scan List

The scan list is a simple list of channels to convert, in order. The NI 9213 has eighteen total channels that can be measured:

- <0..15>: 16 thermocouple channels (always measured in a ±78.125 mV range)
- 16: one cold junction channel (always measured in a ±2.5 V range)
- 17: one auto-zero channel (always measured in a ±78.125 mV range)

Index	Sub	Type	Value
0x2001	0	ARR:U32	19
	1		18
	2		0
	3		1
	...		...
	18		16
	19		17

Table 35. NI 9213 Scan List Format

NI 9213 Calibration Data

Calibration data is set up by the driver during initialization. The calibration conversion is performed on the module ADC itself. The third-party user does not need to check the index 0x2100 to calibrate the data manually.

Use the following equation to calculate raw voltage for the cold-junction compensation (CJC):

Figure 6. NI 9213 CJC Raw Voltage Equation

$$V_{CJCvoltage} = \frac{(78.125\ \text{mV} + 78.125\ \text{mV})}{2^{24}} \times Bit_{CJC}$$

$$V_{CJCvoltage} = \frac{(78.125\ \text{mV} + 78.125\ \text{mV})}{2^{24}} \times Bit_{CJC}$$

where $V_{CJCvoltage}$ represents raw CJC voltage and Bit_{CJC} represents binary bits for the CJC.

Use the following equation to calculate raw voltage for the thermocouple (TC):

Figure 7. NI 9213 TC Raw Voltage Equation

$$V_{TCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times \left(Bit_{TC} - Bit_{autozero}\right)$$

$$V_{TCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times \left(Bit_{TC} - Bit_{autozero}\right)$$

where

- $V_{TCvoltage}$ represents raw TC voltage
- Bit_{TC} represents binary bits for the TC
- $Bit_{autozero}$ represents binary bits returned by the autozero channel

Use the following equation to calculate the resistance of the thermistor:

Figure 8. NI 9213 Thermistor Resistance Equation

$$R = \left(10000 \times 32 \times V_{CJCvoltage}\right) \div \left(2.5 - 32 \times V_{CJCvoltage}\right)$$

$$R = \left(10000 \times 32 \times V_{CJCvoltage}\right) \div \left(2.5 - 32 \times V_{CJCvoltage}\right)$$

where R represents the resistance of the thermistor and $V_{CJCvoltage}$ = raw CJC voltage.

Use the following equation to calculate the CJC temperature:

Figure 9. NI 9213 CJC Temperature Equation

$$T = \left\{1 \div \left[A + B\left(\ln\left(R\right)\right) + C(\ln(R))^{3}\right]\right\} - \left(273.15 + Offset\right)$$

$$T = \left\{1 \div \left[A + B\left(\ln\left(R\right)\right) + C(\ln(R))^{3}\right]\right\} - \left(273.15 + Offset\right)$$

where

- T represents the temperature in degrees Celsius
- R represents the resistance of the thermistor
- A is 1.2873851×10^{-3}
- B is 2.3575235×10^{-4}
- C is 9.4978060×10^{-8}
- Offset represents the offset constant, which the constant is the typical temperature gradient between the CJC sensor and the TC cold junction

NI 9214

The following table lists the vendor configuration extensions for the NI 9214.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	—	Scan List = 21
	1		R	Channels to Convert = <1..20>, default = 20
	2..21		R/W	Channel Code
0x2002	0	U32	R/W	Conversion Speed Control/Open Thermocouple Detection
0x2003	0	U32	R	Common Mode Range Error Detection Status (also as 8-bit PDO)

Table 36. NI 9214 Vendor Configuration Extensions

NI 9214 Conversion Speed Control/Open Thermocouple Detection (0x2002)

The NI 9214 converts at two pre-defined rates, as specified in the Speed Control field. The conversion rate assumes that 20 channels are in the scan list. The NI 9214 can also enable/disable open thermocouple detection.

Bits	Field
31..5	Reserved
4	Open Thermocouple Detection: ▪ 0x10: Enable ▪ 0x00: Disable
3..0	Conversion Speed Control: ▪ 0x02: High Accuracy, 52 ms/channel (1.04 s total) ▪ 0x0F: High Speed, 735 µs/channel (14.7 ms total)

Table 37. NI 9214 Conversion Speed Control/Open Thermocouple Detection

NI 9214 Common Mode Error/Status (0x2003)

The following tables describe the error/status field for the NI 9214.

Bits	Field
31..6	Reserved
15..0	The most recently detected open thermocouple status. Each channel takes one bit.

Table 38. NI 9214 Open Thermocouple Status Code

Bits	Field
31..6	Reserved
15..0	The most recently detected common mode voltage error. Each channel takes one bit.

Table 39. NI 9214 Common Mode Voltage Error Code

NI 9214 Scan List

The scan list is a simple list of channels to convert, in order. The NI 9214 has 20 total channels that can be measured:

- 0..15: 16 thermocouple channels (always measured in a ±78.125 mV range)
- 16: One auto-zero channel (always measured in a ±78.125 mV range)
- 17: Cold junction channel 0 (always measured in a ±2.5 V range)
- 18: Cold junction channel 1 (always measured in a ±2.5 V range)
- 19: Cold junction channel 2 (always measured in a ±2.5 V range)

Index	Sub	Type	Value
0x2001	0	ARR:U32	21
	1		20
	2		0
	3		1
	...		—
	20		18
	21		19

Table 40. NI 9214 Vendor Configuration Extensions

NI 9214 Calibration Data

Calibration data is set up by the driver during initialization. The calibration conversion is performed on the module ADC itself. The third-party user does not need to check the index 0x2100 to calibrate the data manually.

Use the following equation to calculate raw voltage for the cold-junction compensation (CJC):

Figure 10. NI 9214 CJC Raw Voltage Equation

$$V_{CJCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times Bit_{CJC}$$

$$V_{CJCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times Bit_{CJC}$$

where $V_{CJCvoltage}$ represents raw CJC voltage and Bit_{CJC} represents binary bits for the CJC.

Use the following equation to calculate raw voltage for the thermocouple (TC):

Figure 11. NI 9214 TC Raw Voltage Equation

$$V_{TCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times Bit_{TC} \quad V_{TCvoltage} = \frac{(78.125\ mV + 78.125\ mV)}{2^{24}} \times Bit_{TC}$$

where $V_{TCvoltage}$ represents raw TC voltage and Bit_{TC} represents binary bits for the TC.

After calculating the CJC and TC voltage, use the NI 9214 Getting Started example located in the LabVIEW\examples\CompactRIO\Module Specific directory to calculate the resistance of the thermistor and the CJC temperature in degrees Celsius.

NI 9215

The following table lists the vendor configuration extensions for the NI 9215.

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	...		—	—

Index	Sub	Type	R/W	Description
	7		R	Ch3 Offset
	8		R	Ch3 Gain
	9		R	External Calibration, Ch0 Offset
	...		—	—

Table 102. NI 9215 Vendor Configuration Extensions

NI 9215 Calibration Data

The NI 9215 has four channels with a nominal range of ±10.4 V. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The NI 9215 EEPROM stores these two constants for each channel. The host can then take these constants and adjust the raw data into calibrated data.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	nV/LSB
Offset	Signed	nV

Table 103. NI 9215 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data.

Figure 18. NI 9215 Corrected Data Equation

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\} - \left\{Offset\left(nV\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\}$$

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\} - \left\{Offset\left(nV\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\}$$

where $V_{corrected}$ represents the calibrated voltage value and V_{raw} represents data returned by the NI 9215 in bits.

NI 9216/9226

The following table lists the vendor configuration extensions for the NI 9216/9226.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	-	Scan List = 9
	1		R	Channels to Convert = <1..8>, default = 8
	2..9		R/W	Channel Code
0x2002	0	U32	R/W	Conversion Speed Control = 2 or 31, default = 31
0x2100	0	ARR:U32	-	Calibration = 32
	1		-	Ch0 Offset
	2		-	Ch0 Gain
	3		-	Ch1 Offset
	...		-	-
	16		R	Ch7 Gain
	17		-	External Ch0 Offset
	...		-	-

Table 49. NI 9216/9226 Vendor Configuration Extensions

NI 9216/9226 Conversion Speed Control

The NI 9216/9226 converts at two pre-defined rates, as specified in the Speed Control field.

Note The conversion rate assumes that eight channels are in the scan list.

Speed Control	Meaning	Conversion Rate
31 (0x1F)	High Accuracy	200 ms/channel (1600 ms total)
2 (0x02)	High Speed	2.5 ms/channel (20 ms total)

Table 50. NI 9216/9226 Conversion Speed Control

NI 9216/9226 Scan List

The scan list channel codes consist of eight bit fields in a 32-bit entry.

Bits	Field
31..16	Reserved
15..8	Data Offset[t]
7..0	Convert Code [**t**+1]

Table 51. NI 9216/9226 Channel Code

Bits <15..8> describe the data offset to store a conversion at time **t**, and bits <7..0> describe the conversion control codes that take effect one conversion in the future, at time **t**+1. The conversion code is listed in the following table.

Bits	Field
7..3	Reserved
2..0	Channel number

Table 52. NI 9216/9226 Conversion Code

For example, the scan list entry 0x0000000102 indicates this scan stores at address 1, and the next conversion is channel 2.

Index	Sub	Type	Value
0x2001	0	ARR:U32	9
	1		8
	2		0x0000 | 0x01
	3		0x0100 | 0x02
	...		...
	9		0x0700 | 0x00

Table 53. NI 9216/9226 Default Scan List

NI 9216/9226 Calibration Data

The NI 9216/9226 has eight RTD channels that can measure 100 Ω/1000 Ω RTD in 3-wire and 4-wire mode. There is a 1 mA excitation current source per channel for NI 9216 and 0.1 mA excitation current source per channel for NI 9226. The resistance range specified in the manual is 0 Ω to 400 Ω for NI 9216 and 0 Ω to 4000 Ω for NI 9226. This range is tested and covers the temperature range of -200 °C to 850 °C for the standard platinum RTD. The channel does not read negative resistance.

Each channel has an associated LSB weight, which is the number of ohms per bit, and an offset, which is the number of ohms per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pΩ/LSB
Offset	Signed	mΩ

Table 54. NI 9216/9226 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data:

Figure 13. NI 9216/9226 Corrected Data Equation

$$R_{corrected}\left(R_{raw}\right) = R_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{p\Omega}{bits}\right) \times 10^{-12}\left(\frac{\Omega}{p\Omega}\right)\right\} - Offset\left(\mu\Omega\right) \times 10^{-6}\left(\frac{\Omega}{\mu\Omega}\right)$$

$$R_{corrected}\left(R_{raw}\right) = R_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{p\Omega}{bits}\right) \times 10^{-12}\left(\frac{\Omega}{p\Omega}\right)\right\} - Offset\left(\mu\Omega\right) \times 10^{-6}\left(\frac{\Omega}{\mu\Omega}\right)$$

where R_{raw} represents data returned by the NI 9216/9226 in bits and $R_{corrected}$ represents calibrated resistance reading.

NI 9217

The following table lists the vendor configuration extensions for the NI 9217.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	-	Scan List = 5
	1		R	Channels to Convert = <1..4>, default = 4

Index	Sub	Type	R/W	Description
	2..5		R/W	Channel Code
0x2002	0	U32	R/W	Conversion Speed Control = 2 or 31, default = 31
0x2100	0	ARR:U32	-	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		-	-
	8		R	Ch3 Gain
	9		R	External Ch0 Offset
	...		-	-

Table 49. NI 9217 Vendor Configuration Extensions

NI 9217 Conversion Speed Control

The NI 9217 converts at two pre-defined rates, as specified in the Speed Control field.

Note The conversion rate assumes that four channels are in the scan list.

Speed Control	Meaning	Conversion Rate
31 (0x1F)	High Accuracy	200 ms/channel (800 ms total)
2 (0x02)	High Speed	2.5 ms/channel (10 ms total)

Table 50. NI 9217 Conversion Speed Control

NI 9217 Scan List

The scan list channel codes consist of eight bit fields in a 32-bit entry.

Bits	Field
31..16	Reserved
15..8	Data Offset[t]

Bits	Field
7..0	Convert Code [**t**+1]

Table 51. NI 9217 Channel Code

Bits <15..8> describe the data offset to store a conversion at time **t**, and bits <7..0> describe the conversion control codes that take effect one conversion in the future, at time **t**+1. The conversion code is listed in the following table.

Bits	Field
7..3	Conversion rate: ▪ 0b11111 = 31, High-Accuracy ▪ 0b00010 = 2, High-Speed
2..1	Channel number
0	Reserved

Table 52. NI 9217 Conversion Code

Note The conversion rate for every channel must match the value of the conversion speed control in 0x2002.

For example, the scan list entry 0x00000001FC indicates this scan stores at address 1, and the next conversion is channel 2 at high accuracy.

<table>
<tr><th>Index</th><th>Sub</th><th>Type</th><th>Value</th></tr>
<tr><td rowspan="6">0x2001</td><td>0</td><td rowspan="6">ARR:U32</td><td>5</td></tr>
<tr><td>1</td><td>4</td></tr>
<tr><td>2</td><td>0x0000 | 0xF8 | 0x02</td></tr>
<tr><td>3</td><td>0x0100 | 0xF8 | 0x04</td></tr>
<tr><td>4</td><td>0x0200 | 0xF8 | 0x06</td></tr>
<tr><td>5</td><td>0x0300 | 0xF8 | 0x00</td></tr>
</table>

Table 53. NI 9217 Scan List Format

NI 9217 Calibration Data

The NI 9217 has four RTD channels that can measure 100 Ω RTD in 3-wire and 4-wire mode. There is a 1 mA excitation current source per channel and the module range is -500 Ω to 500 Ω. The resistance range specified in the manual is 0 Ω to 400 Ω. This range is tested and covers the temperature range of -200 °C to 850 °C for the standard platinum RTD. The channel does not read negative resistance.

Each channel has an associated LSB weight, which is the number of ohms per bit, and an offset, which is the number of ohms per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pΩ/LSB
Offset	Signed	mΩ

Table 54. NI 9217 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data:

Figure 14. NI 9217 Corrected Data Equation

$$R_{corrected}\left(R_{raw}\right) = R_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{p\Omega}{bits}\right) \times 10^{-12}\left(\frac{\Omega}{p\Omega}\right)\right\} - Offset\left(\mu\Omega\right) \times 10^{-6}\left(\frac{\Omega}{\mu\Omega}\right)$$

$$R_{corrected}\left(R_{raw}\right) = R_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{p\Omega}{bits}\right) \times 10^{-12}\left(\frac{\Omega}{p\Omega}\right)\right\} - Offset\left(\mu\Omega\right) \times 10^{-6}\left(\frac{\Omega}{\mu\Omega}\right)$$

where R_{raw} represents data returned by the NI 9217 in bits and $R_{corrected}$ represents calibrated resistance reading.

NI 9218

The following table lists the vendor configuration extensions for the NI 9218.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure Module, default = 0x00010106
0x2100	0	ARR:U32	—	Calibration = 48
	1		R	Ch0 60 V Gain
	2		R	Ch0 16 V Offset
	3		R	Ch0 16 V Gain
	4		R	Ch0 60 mV Offset
	5		R	Ch0 60 mV Gain
	6		R	Ch0 5 V Offset
	7		R	Ch0 5 V Gain
	8		R	Ch0 20 mA Offset
	9		R	Ch0 20 mA Gain
	10		R	Ch0 22 mV/V Offset
	11		R	Ch0 22 mV/V Gain
	12		R	External Ch0 Offset
	...		—	—

Table 55. NI 9218 Vendor Configuration Extensions

NI 9218 Configuration Mode

This module is set to maximum speed and configured for full-bridge mode for all channels by default.

Bits	Field	Description
31..22	Reserved	—
21	Offset Cal Enable <ch1>	Controls the offset calibration mode. Offset calibration mode disconnects both signal input pins and forces the channel inputs to zero volts, enabling measurement of the channel offset voltage. A logic 1 in any bit enables offset calibration for the channel, while a logic 0 disables the offset calibration.
20	Shunt Cal Enable <ch1>	Controls the shunt calibration switch for each of the two channels. A logic 1 in any bit closes the switch for the respective channel, while a logic 0 opens the switch.
19..16	Module Mode Setting <ch1>	Saves the module mode calibration information for the channel.

Bits	Field	Description
15..14	Reserved	—
13	Offset Cal Enable <ch0>	Controls the offset calibration mode. Offset calibration mode disconnects both signal input pins and forces the channel inputs to zero volts, enabling measurement of the channel offset voltage. A logic 1 in any bit enables offset calibration for the channel, while a logic 0 disables the offset calibration.
12	Shunt Cal Enable <ch0>	Controls the shunt calibration switch for each of the two channels. A logic 1 in any bit closes the switch for the respective channel, while a logic 0 opens the switch.
11..8	Module Mode Setting <ch0>	Saves the module mode calibration information for the channel.
7	Reserved	—
6..2	Clock Divisor	The NI 9218 divides the clock source by this value and uses it as the oversample clock of the converter. The data rate is equal to 1/256 times this oversample clock frequency.
1..0	Clock Source	—

Table 56. NI 9218 Scan List Format

This module has the following modes for each channel.

Mode	Index
16 V	1
5 V	2
16 V with Power Sensor	3
60 V	4
65 mV	5
65 mV with Power Sensor	6
20 mA	7
20 mA with Power Sensor	8
22 mV/V Bridge, 2 V Ex.	9
22 mV/V Bridge, 3.3 V Ex.	10

Table 57. NI 9218 Modes

NI 9218 Example Data Rates

Example data rates use a 13.1072 MHz clock source.

Data Rate	Clock Divisor	Clock Source	Oversample Clock Rate
51.2 kS/s	1	10	13.1072 MHz
25.6 kS/s	2	10	6.5536 MHz
17.067 kS/s	3	10	4.3691 MHz
...	...	...	...
1.652 kS/s	31	10	422.8129 kHz

Table 58. NI 9218 Example Data Rates

NI 9218 Calibration Data

The NI 9218 has two channels. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

Note LSB weight is referred to as gain in the object dictionary.

The following table shows the scan list format for each mode.

Coefficient	Representation	Units
60 V LSB Weight	Unsigned	pV/LSB
60 V Offset	Signed	nV
16 V LSB Weight	Unsigned	pV/LSB
16 V Offset	Signed	nV
65 mV LSB Weight	Unsigned	fV/LSB
65 mV Offset	Signed	nV
5 V LSB Weight	Unsigned	pV/LSB
5 V Offset	Signed	nV
20 mA LSB Weight	Unsigned	fA/LSB
20 mA Offset	Signed	nV
22 mV/V LSB Weight	Unsigned	fV/V/LSB

Coefficient	Representation	Units
22 mV/V Offset	Signed	nV

Table 59. NI 9218 Scan List Format

Use the calibration coefficients with the following equation to generate corrected data.

Figure 15. NI 9218 Corrected Data Equation

$y = mx - b$ $y = mx - b$

where

- y represents the calibrated data for the voltage, current, or bridge
- m represents the ADC data
- x represents raw data for the voltage, current, or bridge
- b represents the offset value

NI 9219

The following table lists the vendor configuration extensions for the NI 9219.

Index	Sub	Type	R/W	Description
0x2001	0	ARR:U32	—	Command List = 33
	1		R	Command Count = <1..32>, default = 32
	2..33		R/W	Configuration Command
0x2002	1	ARR:U32	R	Error Status
0x2005	0	U32	R/W	ADC Format
0x2100	0	ARR:U32		Calibration = 168
	1		R	Ch0 60 V Offset
	2		R	Ch0 60 V Gain
	3		R	Ch0 15 V Offset
	...		—	—
	42		R	Ch0 Full-Bridge 7.8 mV/V Gain
	43		R	Ch1 60 V Offset
	...		—	—
0x2101	0	ARR:U32		External Calibration = 168

Index	Sub	Type	R/W	Description
	1	—	R	Ch0 60 V Offset
...	...	...	...	...

Table 60. NI 9219 Vendor Configuration Extensions

NI 9219 ADC Format

The NI 9219 converts at different rates, and can specify different data formatting styles. This is determined by both the ADC Format field and corresponding fields in the setup commands. The following table describes the ADC Format field.

Bits	Field
31..24	Reserved
23..16	Conversion speed in multiples of 10 mS
15..8	Reserved
7..0	ADC Data Formatting

Table 61. NI 9219 ADC Format

Standard values for ADC Format are:

- 0x0001000F, High Speed
- 0x000B000F, Best 60 Hz rejection
- 0x000D000F, Best 50 Hz rejection
- 0x0032000F, High Resolution

NI 9219 Error Status

Caution Configuring all the channels in full-bridge mode shorts the channels and results in the firmware setting all the bits in the lower nibble.

When a channel over-current condition occurs on any of the channels of the NI 9219 (such as, configure channels in 4-wire resistance mode and do not connect a resistor to the channel), the firmware sets a bit in the lower nibble indicating the presence of this condition (LSB = ch0).

Errors are internally acknowledged on the cycle after the error is reported.

NI 9219 Calibration Data

The NI 9219 has four channels which each have 21 different operating modes and ranges. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

Note LSB weight is referred to as gain in the object dictionary.

The following table lists the operating modes and ranges, in the order they are defined in the calibration table for each channel.

Entry Number	Mode	Range
1	Voltage	±60 V
2		±15 V
3		±4 V
4		±1 V
5		±125 mV
6	Current	±25 mA
7	4-Wire Resistance	10 kΩ
8		1 kΩ
9	2-Wire Resistance	10 kΩ
10		1 kΩ
11	Thermocouple	—
12	4-Wire RTD	Pt1000
13		Pt100
14	3-Wire RTD	Pt1000
15		Pt100
16	Quarter-Bridge	350 Ω
17		120 Ω
18	Half-Bridge	±500 mV/V
19	Reserved	—
20	Full-Bridge	±62.5 mV/V

Entry Number	Mode	Range
21		±7.8 mV/V

Table 62. NI 9219 Channel Calibration

The calibration data is stored in a U32 array, though each offset field should be interpreted as a signed value.

Coefficient	Representation
LSB Weight	Unsigned
Offset	Signed

Table 63. NI 9219 Calibration Data

The NI 9219 returns calibrated 24-bit (padded to 32-bits) AI data for all modes and ranges.

Use the following formula to convert raw data into engineering units.

Figure 16. NI 9219 Engineering Units Equation

$y = mx + b$ $y = mx + b$

where b represents offset based on range of the device: such as, -60 for ±60 V voltage measurement range and m represents gain full-range/(2^{24}): such as, 120/(2^{24}) for ±60 V voltage measurement range.

NI 9219 Configuration Commands

There are eight configuration commands for the NI 9219. Eight configuration commands must be sent for each of the four channels, even if you are only using a subset of the four channels. Each of the eight configuration commands is 1 Byte. Each configuration command is followed by a data Byte, then by a CRC value, which is 1 Byte. Therefore, 3 Bytes × 8 commands × 4 channels = 96 command bytes (held in 32 entries in the object dictionary).

Data in the object dictionary is held in LSB format, so the value 0x12345678 is represented in memory as the series of bytes 0x78, 0x56, 0x34, 0x12. The following table shows the command word format.

Bits	Field
31..24	Reserved

Bits	Field
23..16	CRC
15..8	Configuration Data
7..0	Configuration Command

Table 64. NI 9219 Command Word Format

NI 9219 CRC Calculation

```
U8 crcShiftReg = 0;
   for ( x = 0 ; x < 8 ; ++x )
   {
      dataBool = ((0x80>>x) & configCommand) != 0;
      shiftBool = (0x01 & crcShiftReg) != 0;
      crcShiftReg /= 2;
      if (dataBool != shiftBool)
         crcShiftReg ^= 0x8C;
   }
   for ( x = 0 ; x < 8 ; ++x )
   {
dataBool = ((0x80>>x) & configData) != 0;
      shiftBool = (0x01 & crcShiftReg) != 0;
      crcShiftReg /= 2;
      if (dataBool != shiftBool)
         crcShiftReg ^= 0x8C;
   }
   crcShiftReg = crcShiftReg << 1;
   return crcShiftReg;
```

NI 9219 Configuration Command

You must configure the conversion time, mode, range, and calibration gain/offset values for each channel on the NI 9219, regardless of whether you are using that channel.

Note You must first send calibration gain and offset values in MSB format. The conversion time value must be the same across all channels.

Bits	Field	Description
7..6	Channel Number, <0..3>	—
5	0	—

Bits	Field	Description	
4..0	Configuration Type	Configuration Type values:	
		Conversion Time	0x1F
		Mode & Range	0x01
		Calibration Offset 2 (LSB)	0x06
		Calibration Offset 1	0x05
		Calibration Offset 0 (MSB)	0x04
		Calibration Gain 2 (LSB)	0x0A
		Calibration Gain 1	0x09
		Calibration Gain 0 (MSB)	0x08

Table 65. NI 9219 Scan List Format

NI 9219 Configuration Data

Configuration Value	Maximum Frequency	Conversion Time	Description
0x01	100 Hz/50 Hz (TC)	10 ms/20 ms (TC)	High Speed
0x08	9.09 Hz/8.33 Hz (TC)	110 ms/120 ms (TC)	Best 60 Hz Rejection
0x09	7.69 Hz/7.14 Hz (TC)	130 ms/140 ms (TC)	Best 50 Hz Rejection
0x0F	2 Hz/1.96 Hz (TC)	500 ms/510 ms (TC)	High Resolution

Table 66. NI 9219 Type Conversion Time

Note When any AI data channel is configured for Thermocouple, ADC conversion time increases by 10 ms for all channels. Refer to the preceding table to determine the maximum frequency for various ACD timing configurations. The TC mode/range configuration code is 0x0A.

Configuration Value	Mode	Range
0x00	Voltage	60 V
0x01		15 V
0x02		3.75 V
0x03		1 V
0x04		125 mV
0x05	Current	25 mA
0x06	Resistance	10K 4w

Configuration Value	Mode	Range
0x07		1K 4w
0x08		10K 2w
0x09		1K 2w
0x0A	TC	TC
0x0B	RTD	Pt1000 4w
0x0C		Pt100 4w
0x0D		Pt1000 3w
0x0E		Pt100 3w
0x0F	Quarter-Bridge	350 Ω
0x10		120 Ω
0x11	Half-Bridge	1 V/V
0x13	Full-Bridge CJC	62.5 mV/V
0x14		7.8 mV/V
0x17		CJC range

Table 67. NI 9219 Mode and Range Type

NI 9219 Example Command Words Sequence

Note The order in which you send the commands is important.

Configuration 1: All Channels <ai0..ai3> for Voltage AI, ±15 V Range, High-Speed Mode (100 Hz Maximum Sample Rate).

Command Byte Value	Description
0x01	Mode and Range Configuration Byte - Channel 0
0x01	Data Byte
0x46	CRC value
0x1F	Conversion Time - Channel 0
0x01	Data Byte
0xC6	CRC value
0x04	Calibration Offset MSB - Channel 0
0x7F	Data Byte
0x54	CRC value

Command Byte Value	Description
0x05	Calibration Offset Byte 2 - Channel 0
0xFF	Data Byte
0xB6	CRC value
0x06	Calibration Offset LSB - Channel 0
0x85	Data Byte
0x56	CRC value
0x08	Calibration Gain MSB - Channel 0
0x6C	Data Byte
0x1E	CRC value
0x09	Calibration Gain Byte 2 - Channel 0
0xAA	Data Byte
0x4E	CRC value
0x0A	Calibration Gain LSB - Channel 0
0xC1	Data Byte
0x32	CRC value
0x41	Mode and Range Configuration Byte - Channel 1
0x01	Data Byte
0x64	CRC value
0x5F	Conversion Time - Channel 1
0x01	Data Byte
0xE4	CRC value
0x44	Calibration Offset MSB - Channel 1
0x7F	Data Byte
0x76	CRC value
0x45	Calibration Offset Byte 2 - Channel 1
0xFF	Data Byte
0x94	CRC value
0x46	Calibration Offset LSB - Channel 1
0x86	Data Byte
0xE0	CRC value
0x48	Calibration Gain MSB - Channel 1

Command Byte Value	Description
0x6C	Data Byte
0x3C	CRC value
0x49	Calibration Gain Byte 2 - Channel 1
0x76	Data Byte
0x50	CRC value
0x4A	Calibration Gain LSB - Channel 1
0x3C	Data Byte
0xF6	CRC value
0x81	Mode and Range Configuration Byte - Channel 2
0x01	Data Byte
0xCE	CRC value
0x9F	Conversion Time - Channel 2
0x01	Data Byte
0x4E	CRC value
0x84	Calibration Offset MSB - Channel 2
0x7F	Data Byte
0xDC	CRC value
0x85	Calibration Offset Byte 2 - Channel 2
0xFF	Data Byte
0x3E	CRC value
0x86	Calibration Offset LSB - Channel 2
0xC8	Data Byte
0xC2	CRC value
0x88	Calibration Gain MSB - Channel 2
0x6C	Data Byte
0x96	CRC value
0x89	Calibration Gain Byte 2 - Channel 2
0xB0	Data Byte
0xF4	CRC value
0x8A	Calibration Gain LSB - Channel 2
0x90	Data Byte

Command Byte Value	Description
0x5E	CRC value
0xC1	Mode and Range Configuration Byte - Channel 3
0x01	Data Byte
0xEC	CRC value
0xDF	Conversion Time - Channel 3
0x01	Data Byte
0x6C	CRC value
0xC4	Calibration Offset MSB - Channel 3
0x7F	Data Byte
0xFE	CRC value
0xC5	Calibration Offset Byte 2 - Channel 3
0xFF	Data Byte
0x1C	CRC value
0xC6	Calibration Offset LSB - Channel 3
0xD3	Data Byte
0xCA	CRC value
0xC8	Calibration Gain MSB - Channel 3
0x6C	Data Byte
0xB4	CRC value
0xC9	Calibration Gain Byte 2 - Channel 3
0xD8	Data Byte
0x56	CRC value
0xCA	Calibration Gain LSB - Channel 3
0x65	Data Byte
0xA0	CRC value

Table 68. NI 9219 Configuration 1: Command Bytes

NI 9220

The following table lists the vendor configuration extensions for the NI 9220.

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	—	Calibration = 64
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	32		R	Ch16 Gain
	33		R	User Calibration Ch0 Offset
	...		—	—

Table 102. NI 9220 Vendor Configuration Extensions

NI 9220 Calibration Data

The NI 9220 has 16 channels with a nominal range of ±10.5 V. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

Note LSB weight is referred to as gain in the object dictionary.

The NI 9220 EEPROM stores these two constants for each channel. The host can then take these constants and adjust the raw data into calibrated data.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pV/LSB
Offset	Signed	nV

Table 103. NI 9220 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data.

Figure 18. NI 9220 Corrected Data Equation

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{pV}{bits}\right) \times 10^{-12}\left(\frac{V}{pV}\right)\right\} - Offset\left(nV\right) \times 10^{-9}\left(\frac{V}{nV}\right)$$

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{pV}{bits}\right) \times 10^{-12}\left(\frac{V}{pV}\right)\right\} - Offset\left(nV\right) \times 10^{-9}\left(\frac{V}{nV}\right)$$

where $V_{corrected}$ represents the calibrated voltage value and V_{raw} represents the raw data returned by the NI 9220 in bits.

NI 9222/9223

The following table lists the vendor configuration extensions for the NI 9222/9223.

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	8		R	Ch3 Gain
	9		R	User Calibration Ch0 Offset
	...		—	—

Table 102. NI 9222/9223 Vendor Configuration Extensions

NI 9222/9223 Calibration Data

The NI 9222/9223 has four channels with a nominal range of ±10.6 V. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The NI 9222/9223 EEPROM stores these two constants for each channel. The host can then take these constants and adjust the raw data into calibrated data.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	nV/LSB
Offset	Signed	nV

Table 103. NI 9222/9223 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data.

Figure 18. NI 9222/9223 Corrected Data Equation

$$V_{corrected}(V_{raw}) = V_{raw}(bits) \times \left\{LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\} - Offset(nV) \times 10^{-9}\left(\frac{V}{nV}\right)$$

$$V_{corrected}(V_{raw}) = V_{raw}(bits) \times \left\{LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)\right\} - Offset(nV) \times 10^{-9}\left(\frac{V}{nV}\right)$$

where $V_{corrected}$ represents the calibrated voltage value and V_{raw} represents the raw data returned by the NI 9222/9223 in bits.

NI 9225

The following table lists the vendor configuration extensions for the NI 9225.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure ADC, default = 0x0A
0x2100	0	ARR:U32	—	Calibration = 12
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	6		R	Ch2 Gain
	7		R	External Ch0 Offset
	...		—	—

Table 73. NI 9225 Vendor Configuration Extensions

As a DSA module, the NI 9225 does not synchronize to other modules and free-runs at its own fixed rate.

NI 9227

The following table lists the vendor configuration extensions for the NI 9227.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure ADC, default = 0x0A
0x2100	0	ARR:U32	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	8		R	Ch3 Gain
	9		R	External Ch0 Offset
	...		—	—

Table 74. NI 9227 Vendor Configuration Extensions

As a DSA module, the NI 9227 does not synchronize to other modules and free-runs at its own fixed rate.

NI 9229/9239

The following table lists the vendor configuration extensions for the NI 9229/9239.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure ADC, default = 0x06
0x2100	0	ARR:U32	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	8		R	Ch3 Gain
	9		R	External Ch0 Offset
	...		—	—

Table 93. NI 9229/9239 Vendor Configuration Extensions

As a DSA module, the NI 9229/9239 does not synchronize to other modules and free-runs at its own fixed rate.

> **Note** The NI 9229/9239 does not have the turbo bit configuration byte.

NI 9229/9239 Calibration Data

The NI 9229/9239 have four channels with nominal ranges of ±10 V and ±60 V respectively. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pV/LSB
Offset	Signed	nV

Table 76. NI 9229/9239 Scan List Format

Use the calibration coefficients with the following equation to generate corrected data.

Figure 19. NI 9229/9239 Corrected Data Equation

$$V_{corrected} = Raw \times \left(LSB_{weight} \times 10^{-12}\right) - Offset \times 10^{-9}$$

$$V_{corrected} = Raw \times \left(LSB_{weight} \times 10^{-12}\right) - Offset \times 10^{-9}$$

where Raw represents raw data returned by the NI 9229/9239 and $V_{corrected}$ represents the corrected voltage value.

NI 9234

The following table lists the vendor configuration extensions for the NI 9234.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure Module, default = 0x06
0x2100	0	ARR:U32	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch0 Offset
	...		—	—
	8		R	Ch3 Gain
	9		R	External Ch0 Offset
	...		—	—

Table 77. NI 9234 Vendor Configuration Extensions

As a DSA module, the NI 9234 does not synchronize to other modules and free-runs at its own fixed rate.

NI 9234 Configure Module

The NI 9234 has multiple configuration fields. Configuration bits <15..8> control the channel mode, while bits <7..0> set the conversion rate.

Bits	Field	Description
15	Ch3 IEPE	IEPE Enable 3: When set, the relays of the corresponding channel are switched to IEPE operation. IEPE operations switches the AC/DC relay to AC mode and enables the IEPE relay to send the current to the IEPE sensor.
14	Ch3 AC/~DC	AC/~DC 3: Controls the AC/DC relay when IEPE is not selected. If IEPE is enabled, then these bits have no meaning as AC mode is always selected with an IEPE operation.
13	Ch2 IEPE	IEPE Enable 2: When set, the realys of the corresponding channel are switched to IEPE operation. IEPE operations switches the AC/DC relay to AC mode and enables the IEPE relay to send the current to the IEPE sensor.
12	Ch2 AC/~DC	AC/~DC 2: Controls the AC/DC relay when IEPE is not selected. If IEPE is enabled, these bits have no meaning as AC mode is always selected with an IEPE operation.
11	Ch1 IEPE	IEPE Enable 1: When set, the relays of the corresponding channel are switched to IEPE operation. IEPE operations switches the AC/DC relay to AC mode and enables the IEPE relay to send the current to the IEPE sensor.

Bits	Field	Description
10	Ch1 AC/~DC	AC/~DC 1: Controls the AC/DC relay when IEPE is not selected. If IEPE is enabled, then these bits have no meaning as AC mode is always selected with an IEPE operation.
9	Ch0 IEPE	IEPE Enable 0: When set, the relays of the corresponding channel are switched to IEPE operation. IEPE operations switches the AC/DC relay to AC mode and enables the IEPE relay to send the current to the IEPE sensor.
8	Ch0 AC/~DC	AC/~DC 0: Controls the AC/DC relay when IEPE is not selected. If IEPE is enabled, then these bits have no meaning as AC mode is always selected with an IEPE operation.
7	Reserved	—
6..2	Clock Divisor	Clock Divisor: The NI 9234 divides the clock source (internal or external) by this value and uses it as the oversample clock of the converter. The data rate is equal to 1/256 times this oversample clock frequency. Valid values for Clock Divisor are from 1 to 31, and the final divided clock must be between 100 KHz and 12.8 MHz.
1..0	Clock Source	0b00 = 0: The OCLK pin is used as the oversample clock source. 0b01 = 1: The 12.8 MHz internal clock is used as the clock source and this 12.8 MHz is driven onto the OCLK pin. 0b10 = 2: The internal clock is used but not driven onto OCLK pin. This is the required clock setting. 0b11 = 3: Reserved.

Table 94. NI 9234 Scan List Format

NI 9234 Example Data Rates

The example data rates use a 12.8 MHz clock source.

Data Rate	Clock Divisor	Clock Source	Rate Byte	Oversample Clock Rate
50.000 kS/s	00001	10	0x06	12.80 MHz
25.000 kS/s	00010	10	0x0A	6.40 MHz
16.667 kS/s	00011	10	0x0E	4.27 MHz
12.500 kS/s	00100	10	0x12	3.20 MHz
10.000 kS/s	00101	10	0x16	2.56 MHz
6.250 kS/s	01000	10	0x22	1.60 MHz

Data Rate	Clock Divisor	Clock Source	Rate Byte	Oversample Clock Rate
5.000 kS/s	01010	10	0x2A	1.28 MHz

Table 95. NI 9234 Example Data Rates

NI 9234 Calibration Data

The NI 9234 has four channels with a nominal range of ±5 V. Each channel has an associated AC or DC input mode; an optional IEPE excitation; an associated LSB weight, which is the number of volts per bit; and an offset, which is the volts per bit measured with the inputs grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pV/LSB
Offset	Signed	nV

Table 80. NI 9234 Scan List Format

Use the calibration coefficients with the following equation to generate corrected data.

Figure 20. NI 9234 Corrected Data Equation

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{pV}{bits}\right) \times 10^{-12}\left(\frac{V}{pV}\right)\right\} - Offset\left(pV\right) \times 10^{-9}\left(\frac{V}{nV}\right)$$

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{pV}{bits}\right) \times 10^{-12}\left(\frac{V}{pV}\right)\right\} - Offset\left(pV\right) \times 10^{-9}\left(\frac{V}{nV}\right)$$

where V_{raw} represents data returned by the NI 9234 in bits and $V_{corrected}$ represents the corrected voltage value.

NI 9235

The following table lists the vendor configuration extensions for the NI 9235.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure ADC, default = 0xCE00

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	-	Calibration = 48
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch0 Shunt
	4		R	Ch1 Offset
	...		—	—
	24		R	Ch7 Shunt
	25		R	External Ch0 Offset
	...		—	—

Table 81. NI 9235 Vendor Configuration Extensions

The NI 9235 is a DSA module and as such does not synchronize with other modules but free-runs at its own fixed rate.

Configure ADC

The NI 9235 (like the other DSA modules) can convert at various rates, controlled by the fields in the ADC conversion command.

Bits	Field	Description
15..10	Clock Divisor	The clock source (internal or external) is divided by one half of this value and used as the oversample clock converter. Valid values are from 2 to 63, but the final divided clock must be between 502 kHz and 5.12 MHz. This means that only values from 5 to 51 (representing the divisors 2.5 to 25.5) are valid when using the 12.8 MHz internal clock source.
9..8	Clock Source	0b00 = 0: The OCLK pin is used as the oversample clock source. 0b01 = 1: The 12.8 MHz internal clock is used as the clock source and this 12.8 MHz is driven onto the OCLK pin. 0b10 = 2: The internal clock is used but not driven onto OCLK pin. This is the required clock setting. 0b11 = 3: Reserved.
7..0	Shunt Cal Enable <ch7..ch0>	Controls the shunt calibration switch for each of the eight channels. A logic 1 in any bit closes the switch for the respective channel, while a logic 0

Bits	Field	Description
		opens the switch. Refer to the following table for example data rates using a 12.8 MHz clock source (and using 0x00 in the shunt cal enable bits).

Table 82. NI 9235 Scan List Format

Data Rate	Clock Divisor	Clock Source	Configure ADC	Oversample Clock Rate
10.000 kS/s	000101	10	0x1600	5.12 MHz
8.333 kS/s	000110	10	0x1A00	4.27 MHz
7.143 kS/s	000111	10	0x1E00	3.66 MHz
2.500 kS/s	010100	10	0x5200	1.28 MHz
1.613 kS/s	011111	10	0x7E00	825.8 kHz
1.250 kS/s	101000	10	0xA200	640.0 kHz
0.980 kS/s	110011	10	0xCE00	502.0 kHz

Table 83. NI 9235 Example Data Rates

NI 9235 Calibration Data

The NI 9235 has eight input channels for measuring strain. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

Note LSB weight is referred to as gain in the object dictionary.

There is also a shunt measurement value which is not used during normal operation. The calibration data is stored in an U32 array, though each offset field (subindex 1, 4, 7, etc.) should be interpreted as a signed value.

Coefficient	Representation
LSB Weight	Unsigned
Offset	Signed
Shunt	Signed

Table 84. NI 9235 Calibration Coefficients

The calibration coefficients are used with the following equation to generate corrected data.

Figure 23. NI 9235 Corrected Data Equation

$$\text{Nominal}\left(\frac{V}{V}\right) = \text{Binary}_{\text{Data}} \times \text{LSB}_{\text{Weight}} \times 1e - 13 - \text{Offset} \times 1e - 7$$
$$\text{Nominal}\left(\frac{V}{V}\right) = \text{Binary}_{\text{Data}} \times \text{LSB}_{\text{Weight}} \times 1e - 13 - \text{Offset} \times 1e - 7$$

The resultant calibrated reading is a ratio between the bridge input voltage and the excitation voltage, termed V_r. However, typical quarter-bridge measurements are denominated in strain, which require not only conversion in the strain equation, but also the acquisition and use of an unstrained measurement. The strain equation is:

Figure 22. NI 9235 Strain Equation

$$\text{strain}(e) = \frac{-4(V_{r-st} - V_{r-unst})}{GF \quad [(1+2) \quad (V_{r-st} - V_{r-unst})]} \; \text{strain}(e) = \frac{-4(V_{r-st} - V_{r-unst})}{GF \quad [(1+2) \quad (V_{r-st} - V_{r-unst})]}$$

where V_{r-st} and V_{r-unst} are the strained and unstrained readings, respectively from the module.

NI 9236

The following table lists the vendor configuration extensions for the NI 9236.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure ADC, default = 0xCE00
0x2100	0	ARR:U32	...	Calibration = 48
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch0 Shunt
	4		R	Ch1 Offset
	...		—	—
	24		R	Ch7 Shunt
	25		R	External Ch0 Offset
	...		—	—

Table 85. NI 9236 Vendor Configuration Extensions

The NI 9236 is a DSA module and as such it does not synchronize with other modules but free-runs at its own fixed rate.

Configure ADC

The NI 9236 (like the other DSA modules) can convert at various rates, controlled by the fields in the ADC conversion command.

Bits	Field	Description
15..10	Clock Divisor	The clock source (internal or external) is divided by one half of this value and used as the oversample clock of the converter. Valid values are from 2 to 63, but the final divided clock must be between 502 kHz and 5.12 MHz. This means that only values from 5 to 51 (representing the divisors 2.5 to 25.5) are valid when using the 12.8 MHz internal clock source.
9..8	Clock Source	0b00 = 0: The OCLK pin is used as the oversample clock source. 0b01 = 1: The 12.8 MHz internal clock is used as the clock source and this 12.8 MHz is driven onto the OCLK pin. 0b10 = 2: The internal clock is used but not driven onto OCLK pin. This is the required clock setting. 0b11 = 3: Reserved.
7..0	Shunt Cal Enable <ch7..ch0>	Controls the shunt calibration switch for each of the eight channels. A logic 1 in any bit closes the switch for the respective channel, while a logic 0 opens the switch.

Table 86. NI 9236 Scan List Format

Data Rate	Clock Divisor	Clock Source	Configure ADC	Oversample Clock Rate
10.000 kS/s	000101	10	0x1600	5.12 MHz
8.333 kS/s	000110	10	0x1A00	4.27 MHz
7.143 kS/s	000111	10	0x1E00	3.66 MHz
2.500 kS/s	010100	10	0x5200	1.28 MHz
1.613 kS/s	011111	10	0x7E00	825.8 kHz
1.250 kS/s	101000	10	0xA200	640.0 kHz
0.980 kS/s	110011	10	0xCE00	502.0 kHz

Table 87. NI 9236 Example Data Rates

NI 9236 Calibration Data

The NI 9236 has eight input channels for measuring strain. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

There is also a shunt measurement value which is not used during normal operation. The calibration data is stored in an U32 array, though each offset field (subindex 1, 4, 7, etc) should be interpreted as a signed value.

Coefficient	Representation
LSB Weight	Unsigned
Offset	Signed
Shunt	Signed

Table 88. NI 9236 Calibration Coefficients

The calibration coefficients are used with the following equation to generate corrected data.

Figure 23. NI 9236 Corrected Data Equation

$$\text{Nominal}\left(\frac{V}{V}\right) = \text{Binary}_{\text{Data}} \times \text{LSB}_{\text{Weight}} \times 1e-13 - \text{Offset} \times 1e-7$$

$$\text{Nominal}\left(\frac{V}{V}\right) = \text{Binary}_{\text{Data}} \times \text{LSB}_{\text{Weight}} \times 1e-13 - \text{Offset} \times 1e-7$$

The resultant calibrated reading is a ratio between the bridge input voltage and the excitation voltage, termed V_r. However, typical quarter-bridge measurements are denominated in strain, which require not only conversion in the strain equation, but also the acquisition and use of an unstrained measurement. The strain equation is:

Figure 24. NI 9236 Strain Equation

$$\text{strain}(e) = \frac{-4(V_{r\_st} - V_{r\_unst})}{GF \quad [(1+2) \quad (V_{r\_st} - V_{r\_unst})]}$$

$$\text{strain}(e) = \frac{-4(V_{r\_st} - V_{r\_unst})}{GF \quad [(1+2) \quad (V_{r\_st} - V_{r\_unst})]}$$

where V_{r_st} and V_{r_unst} are the strained and unstrained readings, respectively from the module.

NI 9237

The following table lists the vendor configuration extensions for the NI 9237.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure Module, default = 0x00060000
0x2100	0	ARR:U16	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	8		R	Ch3 Gain
	9		R	External Ch0 Offset
	...		—	—

Table 89. NI 9237 Vendor Configuration Extensions

As a DSA module, the NI 9237 does not synchronize to other modules and free-runs at its own fixed rate.

NI 9237 Configure Module

This module is set to maximum speed and configured for full-bridge mode for all channels by default.

Bits	Field	Description
31..23	Reserved	—
22..18	Clock Divisor	The NI 9237 divides the clock source (internal or external) by this value and uses it as the oversample clock of the converter. The data rate is equal to 1/256 times this oversample clock frequency. The final data rate must be between 391 kS/s and 52.734 kS/s. This means that while all values from 1 to 31 are within the specified operating range when using the 12.8 MHz internal clock source, for external clock sources of more than 13.5 MHz or less than 3.1 MHz the valid divisors are limited to those that provide data rates within the specified range.
17..16	Clock Source	—

Bits	Field	Description
15..12	Shunt Cal Enable <ch3..ch0>	Controls the shunt calibration switch for each of the four channels. A logic 1 in any bit closes the switch for the respective channel, while a logic 0 opens the switch.
11..8	Half-Bridge Enable <ch3..ch0>	Controls the half-bridge completion option for each channel. Enabling half-bridge completion for a channel disconnects the negative signal input pin from the rest of the circuit, and uses an internal voltage equal to the midpoint of the excitation voltage as the negative input to the rest of the circuit. A logic 1 in any bit enables half-bridge completion for the respective channel, while a logic 0 disables it.
7	Reserved	—
6..4	Excitation	Sets the excitation voltage setting. All channels share the same excitation voltage. 0b000 = 0: 2.5 V, The OCLK pin is used as the oversample clock source. 0b001 = 1: 3.3 V, The 12.8 MHz internal clock is used as the clock source and this 12.8 MHz is driven onto the OCLK pin. 0b010 = 2: 5.0 V, The internal clock is used but not driven onto OCLK pin. Currently, this is the required clock setting. 0b011 = 3: 10.0 V, Reserved. 0b1xx = 4..7: External Excitation.
3..0	Offset Cal Enable <ch3..ch0>	Controls the offset calibration mode. Offset calibration mode disconnects both signal input pins and forces the channel inputs to zero volts, enabling measurement of the channel offset voltage. A logic 1 in any bit enables offset calibration for the respective channel, while a logic 0 disables it.

Table 90. NI 9237 Scan List Format

NI 9237 Example Data Rates

Example data rates use a 12.8 MHz clock source.

Data Rate	Clock Divisor	Clock Source	Rate Byte	Oversample Clock Rate
50.000 kS/s	00001	10	0x06	12.80 MHz
25.000 kS/s	00010	10	0x0A	6.40 MHz
16.667 kS/s	00011	10	0x0E	4.27 MHz
12.500 kS/s	00100	10	0x12	3.20 MHz
10.000 kS/s	00101	10	0x16	2.56 MHz

Data Rate	Clock Divisor	Clock Source	Rate Byte	Oversample Clock Rate
6.250 kS/s	01000	10	0x22	1.60 MHz
5.000 kS/s	01010	10	0x2A	1.28 MHz
3.333 kS/s	01111	10	0x3E	853.3 KHz
2.500 kS/s	10100	10	0x52	640.0 KHz
2.000 kS/s	11001	10	0x66	512.0 KHz

Table 91. NI 9237 Example Data Rates

NI 9237 Calibration Data

The NI 9237 has four channels. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

Note LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U16 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	0.1 pV/LSB
Offset	Signed	10 nV

Table 92. NI 9237 Scan List Format

Use the calibration coefficients with the following equation to generate corrected data.

Figure 25. NI 9237 Corrected Data Equation

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{pV}{bits}\right) \times 10^{-13}\left(\frac{V}{pV}\right)\right\} - Offset\left(nV\right) \times 10^{-8}\left(\frac{V}{nV}\right)$$

$$V_{corrected}\left(V_{raw}\right) = V_{raw}\left(bits\right) \times \left\{LSB_{weight}\left(\frac{pV}{bits}\right) \times 10^{-13}\left(\frac{V}{pV}\right)\right\} - Offset\left(nV\right) \times 10^{-8}\left(\frac{V}{nV}\right)$$

where V_{raw} represents data returned by the NI 9237 in bits and $V_{corrected}$ represents the corrected voltage value.

NI 9242/9244

The following table lists the vendor configuration extensions for the NI 9242/9244.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R/W	Configure ADC, default = 0x6
0x2100	0	ARR:U16	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	8		R	Ch3 Gain
	9		R	User Calibration Ch0 Offset
	...		—	—

Table 93. NI 9242/9244 Vendor Configuration Extensions

As a DSA module, the NI 9242/9244 does not synchronize to other modules and free-runs at its own fixed rate.

NI 9242/9244 Configure ADC

The NI 9242/9244 converts at various rates, controlled by the field in the ADC conversion command.

Bits	Field	Description
7	Reserved	—
6..2	Clock Divisor	The NI 9242/9244 divides the clock source by this value and uses it as the oversample clock of the converter. The data rate is equal to 1/256 times this oversample clock frequency. Valid values for Clock Divisor are from 1 to 31.
1..0	Clock Source = 2	0b00 = 0: The OCLK pin is used as the oversample clock source. 0b01 = 1: The 12.8 MHz internal clock is used as the clock source and this 12.8 MHz is driven onto the OCLK pin. 0b10 = 2: The internal clock is used but not driven onto OCLK pin. Currently, this is the required clock setting.

Bits	Field	Description
		0b11 = 3: Reserved.

Table 94. NI 9242/9244 Scan List Format

NI 9242/9244 Example Data Rates

The following table lists the example data rates for the NI 9242/9244. These example data rates use a 12.8 MHz clock source.

Data Rate	Clock Divisor	Clock Source	Rate Byte	Oversample Clock Rate
50.000 kS/s	00001	10	0x06	12.80 MHz
25.000 kS/s	00010	10	0x0A	6.40 MHz
12.500 kS/s	00100	10	0x12	3.20 MHz
10.000 kS/s	00101	10	0x16	2.56 MHz
6.250 kS/s	01000	10	0x22	1.60 MHz
5.000 kS/s	01010	10	0x2A	1.28 MHz
3.333 kS/s	01111	10	0x3E	853 KHz
3.125 kS/s	10000	10	0x42	800 KHz
2.500 kS/s	10100	10	0x52	640 KHz
2.000 kS/s	11001	10	0x66	512 KHz

Table 95. NI 9242/9244 Example Data Rates

NI 9242/9244 Calibration Data

The NI 9242/9244 have four channels with nominal ranges of ±500 V and ±997.5 V respectively. Calibration data is set up by the driver during initialization. The calibration conversion is performed on the module ADC itself, by applying the gain and offset constants in the following equation. You do not need to check the index 0x2100 to calibrate the data manually.

Figure 26. NI 9242/9244 Calibration Conversion Equation

$y = mx - b$ $y = mx - b$

where

- y represents the calibrated ADC codes

- m represents the gain value
- x represents ADC data
- b represents the offset value

Use the following equation to scale the calibrated ADC codes into voltages for NI 9242.

Figure 27. NI 9242 Voltage Scaling Equation

$$V_{corrected} = V_{raw}(bits) \times 59605\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)$$

$$V_{corrected} = V_{raw}(bits) \times 59605\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)$$

Use the following equation to scale the calibrated ADC codes into voltages for NI 9244.

Figure 28. NI 9244 Voltage Scaling Equation

$$V_{corrected} = V_{raw}(bits) \times 118911\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)$$

$$V_{corrected} = V_{raw}(bits) \times 118911\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right)$$

where $V_{corrected}$ represents the calibrated voltage value and V_{raw} represents the data returned by the NI 9242/9244 in bits.

NI 9263

The following table lists the vendor configuration extensions for the NI 9263.

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	8		R	Ch3 Gain
	9		R	External Ch0 Offset
	...		—	—

Table 98. NI 9263 Vendor Configuration Extensions

NI 9263 Calibration Data

The NI 9263 has four channels with a nominal range of ±10.7 V. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	nV/LSB
Offset	Signed	nV

Table 99. NI 9263 Scan List Format

Use the calibration coefficients with the following equation to generate corrected data.

Figure 33. NI 9263 Corrected Data Equation

$$V_{desired}\left(Code\right) = Code \times LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right) + Offset\left(nV\right) \times {}_{10}{-9}\left(\frac{V}{nV}\right)$$

$$V_{desired}\left(Code\right) = Code \times LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right) + Offset\left(nV\right) \times {}_{10}{-9}\left(\frac{V}{nV}\right)$$

where Code represents the code returned by the NI 9263 and $V_{desired}$ represents the corrected voltage value.

NI 9264

The following table lists the vendor configuration extensions for the NI 9264.

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	—	Calibration = 64
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	32		R	Ch16

Index	Sub	Type	R/W	Description
	33		R	External Ch0 Offset
	...		—	—

Table 98. NI 9264 Vendor Configuration Extensions

NI 9264 Calibration Data

The NI 9264 has 16 channels with a nominal range of ±10.5 V. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

Note LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pV/LSB
Offset	Signed	nV

Table 99. NI 9264 Scan List Format

Use the calibration coefficients with the following equation to generate corrected data.

Figure 33. NI 9264 Corrected Data Equation

$$V_{desired}(Code) = Code \times LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right) + Offset(nV) \times 10^{-9}\left(\frac{V}{nV}\right)$$

$$V_{desired}(Code) = Code \times LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right) + Offset(nV) \times 10^{-9}\left(\frac{V}{nV}\right)$$

where Code represents the code returned by the NI 9264 and $V_{desired}$ represents the corrected voltage value.

NI 9265

The following table lists the vendor configuration extensions for the NI 9265.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R	Error Status, sent as 8-bit PDO

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—
	8		R	Ch3 Gain
	9		R	External Ch0 Offset
	...		—	—

Table 100. NI 9265 Vendor Configuration Extensions

NI 9265 Error Status

Each channel has open loop detection circuitry that reports an error whenever the load is disconnected and the current is set to a value higher than 0 mA. On the cycle after the error is reported, it is (internally) automatically acknowledged.

NI 9265 Calibration Data

The NI 9265 has four channels with a nominal range of 0 mA to 20.675 mA. Each channel has an associated LSB weight, which is the number of amps per bit, and an offset, which is the number of amps per bit measured when the inputs are grounded.

Note LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pA/LSB
Offset	Signed	pA

Table 101. NI 9265 Scan List Format

Use the calibration coefficients with the following equation to generate corrected data.

Figure 31. NI 9265 Corrected Data Equation

$$I_{desired}\left(Code\right) = Code \times LSB_{weight}\left(\frac{pA}{bits}\right) \times 10^{-12}\left(\frac{A}{pA}\right) + Offset\left(pA\right) \times 10^{-12}\left(\frac{A}{pA}\right)$$

$$I_{desired}\left(Code\right) = Code \times LSB_{weight}\left(\frac{pA}{bits}\right) \times 10^{-12}\left(\frac{A}{pA}\right) + Offset\left(pA\right) \times 10^{-12}\left(\frac{A}{pA}\right)$$

where Code represents the code returned by the NI 9265 and $I_{desired}$ represents the corrected current value.

NI 9266

The following table lists the vendor configuration extensions for the NI 9266.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R	Error Status, sent as 8-bit PDO
0x2100	0	ARR:U32	—	Calibration = 32
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	4		R	Ch1 Gain
	...		—	—
	15		R	Ch7 Offset
	16		R	Ch7 Gain
	17		R	External Ch0 Offset
	...		—	—

Table 102. NI 9266 Vendor Configuration Extensions

NI 9266 Error Status

Each channel has open loop detection circuitry that reports an error whenever the load is disconnected and the current is set to a value higher than 0 mA. On the cycle after the error is reported, it is (internally) automatically acknowledged.

NI 9266 Calibration Data

The NI 9266 has eight channels with a nominal range of 0 mA to 20.8896 mA. Each channel has an associated LSB weight, which is the number of amps per bit, and an offset, which is the number of amps per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	pA/LSB
Offset	Signed	pA

Table 103. NI 9266 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data.

Figure 32. NI 9266 Corrected Data Equation

$$I_{desired}\left(Code\right) = Code \times LSB_{weight}\left(\frac{pA}{bits}\right) \times 10^{-12}\left(\frac{A}{pA}\right) + Offset\left(pA\right) \times 10^{-12}\left(\frac{A}{pA}\right)$$

$$I_{desired}\left(Code\right) = Code \times LSB_{weight}\left(\frac{pA}{bits}\right) \times 10^{-12}\left(\frac{A}{pA}\right) + Offset\left(pA\right) \times 10^{-12}\left(\frac{A}{pA}\right)$$

where Code represents the code returned by the NI 9266 and $I_{desired}$ represents the corrected current value.

NI 9269

The following table lists the vendor configuration extensions for the NI 9269.

Index	Sub	Type	R/W	Description
0x2100	0	ARR:U32	—	Calibration = 16
	1		R	Ch0 Offset
	2		R	Ch0 Gain
	3		R	Ch1 Offset
	...		—	—

Index	Sub	Type	R/W	Description
	8		R	Ch3 Gain
	9		R	External Ch0 Offset
	...		—	—

Table 104. NI 9269 Vendor Configuration Extensions

NI 9269 Calibration Data

The NI 9269 has four channels with a nominal range of ±10.7 V. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

> **Note** LSB weight is referred to as gain in the object dictionary.

The calibration data is stored in a U32 array, though each offset field (subindex 1, 3, 5, and so on) should be interpreted as a signed value.

Coefficient	Representation	Units
LSB Weight	Unsigned	nV/LSB
Offset	Signed	nV

Table 105. NI 9269 Scan List Format

Use the calibration coefficients with the following equation to generate corrected data.

Figure 33. NI 9269 Corrected Data Equation

$$V_{desired}(Code) = Code \times LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right) + Offset(nV) \times 10^{-9}\left(\frac{V}{nV}\right)$$

$$V_{desired}(Code) = Code \times LSB_{weight}\left(\frac{nV}{bits}\right) \times 10^{-9}\left(\frac{V}{nV}\right) + Offset(nV) \times 10^{-9}\left(\frac{V}{nV}\right)$$

where Code represents the code returned by the NI 9269 and $V_{desired}$ represents the corrected current value.

NI 9381

The following table lists the vendor configuration extensions for the NI 9381.

Index	Sub	Type	R/W	Description
0x2100	0	U32	R/W	Digital Channel Direction Control, default = 0
	0	ARR:U16	—	Calibration = 64
	1		R	AI0 Offset
	2		R	AI0 Gain
	...		—	—
	15		R	AI7 Offset
	16		R	AI7 Gain
	17		R	AO0 Offset
	18		R	AO0 Gain
	...		—	—
	31		R	AO7 Offset
	32		R	AO7 Gain
	33		R	External AI0 Offset
	...		—	—

Table 106. NI 9381 Vendor Configuration Extensions

NI 9381 Calibration Data

The NI 9381 has either input channels or output channels with a nominal range of 0 V to 5 V. Each channel has an associated LSB weight, which is the number of volts per bit, and an offset, which is the number of volts per bit measured when the inputs are grounded.

Note LSB weight is referred to as gain in the object dictionary.

The NI 9381 EEPROM stores two constants for each channel. The host takes the constants and adjusts the raw data in calibrated data. The calibration data is stored in a U16 array.

Coefficient	Representation	Units
LSB Weight	Unsigned	100 nV/LSB
Offset	Signed	10 µV

Table 107. NI 9381 Calibration Coefficients

Use the calibration coefficients with the following equation to generate corrected data.

Figure 34. NI 9381 Corrected Data Equation

$$V_{corrected} = Raw \times \left(LSB_{weight} \times 10^{-7}\right) + Offset \times 10^{-5}$$

$$V_{corrected} = Raw \times \left(LSB_{weight} \times 10^{-7}\right) + Offset \times 10^{-5}$$

where Raw represents raw data returned by the NI 9381 and $V_{corrected}$ represents the corrected voltage value

NI 9381 Digital Channel Direction Control

Bits	Field
3	0: data bit as input
2	1: data bit as output
1	
0	

Table 108. NI 9381 Digital Channel Direction Control

NI 9401

The following table lists the vendor configuration extensions for the NI 9401.

Index	Sub	Type	R/W	Description
0x2001	0	U32	R/W	Nibble direction control, default = 0

Table 114. NI 9401 Vendor Configuration Extensions

NI 9401 Direction Control

Bits	Field
1	0: data bits <3..0> as input
0	1: data bits <7..4> as output

Table 110. NI 9401 Scan List Format

Note Both the input and output bytes are transmitted in the PDO regardless of the direction control; only the relevant bits are connected to the I/O pins.

NI 9402

The following table lists the vendor configuration extensions for the NI 9402.

Index	Sub	Type	R/W	Description
0x2001	0	U32	R/W	Line direction control, default = 0

Table 114. NI 9402 Vendor Configuration Extensions

NI 9402 Direction Control

Bits	Field
3	0: data bit as input 1: data bit as output
2	
1	
0	

Table 112. NI 9402 Scan List Format

Note Both the input and output bytes are transmitted in the PDO regardless of the direction control; only the relevant bits are connected to the I/O pins.

NI 9403

The following table lists the vendor configuration extensions for the NI 9403.

Index	Sub	Type	R/W	Description
0x2001	0	U32	R/W	I/O direction control, default = 0

Table 114. NI 9403 Vendor Configuration Extensions

NI 9403 Direction Control

The direction control field has one bit for each I/O pin, with bit 0 matching channel 0, and so forth. 0 in the direction control indicates that I/O is an input; 1 indicates an output.

> **Note** Both the input and output data is transmitted in the PDO regardless of the direction control; only the relevant bits are connected to the I/O pins.

NI 9476

The following table lists the vendor configuration extensions for the NI 9476.

Index	Sub	Type	R/W	Description
0x2002	0	U32	R	Error Status, sent as 8-bit PDO

Table 114. NI 9476 Vendor Configuration Extensions

NI 9476 Error Status

If a channel over-current occurs on any of the 32 channels, the corresponding bit in error status field is set to inform the user.

Errors are automatically internally acknowledged on the cycle after the error is reported.

NI 9478

The following table lists the vendor configuration extensions for the NI 9478.

Index	Sub	Type	R/W	Description
0x2001	0	U32	R/W	Current Limit Select
0x2002	1	U32	R	Error Status A, sent as 16-bit PDO
	2	U32	R	Error Status B, sent as 16-bit PDO
0x2003	1	U32	R	Error Overtemp, sent as 8-bit PDO
0x2004	1	U8	R/W	Limit A

Index	Sub	Type	R/W	Description
	2	U8	R/W	Limit B
0x2005	0	U8	R/W	Refresh Period

Table 115. NI 9478 Vendor Configuration Extensions

Current Limits and Selection

Each of the 15 channels has 2 bits represented in index 0x2001 Current Limit Select, with channel 0 controlled by bits 0 and 1.

NI 9478 Direction Control

Bits	Field
31..30	0: Limit A
29..28	1: Limit B
...	2: No Limit
1..0	3: (no charge)

Table 116. NI 9478 Scan List Format

The current limits are set in index 0x2002 sub-indices1 (Limit A) and 2 (Limit B). The current limits are 8-bit unsigned integers in increments of 20 mA (1 = 20 mA, 2 = 40 mA, and so on).

Error Status and Overtemp

The two error status fields each hold 16 bits of data (one bit per channel, with bit 0 for channel 0). The error status bits in 0x2002.1 are for Limit A reporting. Bits 0x2002.2 are for Limit B reporting.

Errors are reported for at least one cycle and are automatically cleared by the module when appropriate.

The Error Overtemperature field has seven bits to ignore and one bit (bit 0) that when set indicates that the module in an over-temperature condition.

Bits	Field
7..1	Reserved

Bits	Field
0	Overtemp

Refresh Period

During the Refresh Period, output values that may have experienced an over-current condition are re-enabled. An eight byte value in 10 µs is listed in the following table.

Value	Description
0	Infinity (no refresh)
1	Invalid value
2..255	20 µs to 2,550 µs refresh period

NI 951x

Refer to the **NI 951x C Series Modules Object Dictionary**, available at ni.com/manuals, for NI 951xC Series drive interface module object dictionary entries.

C Series Modules with No Configurable Options

The following C Series modules are supported with no configurable options.

- NI 9344
- NI 9375
- NI 9411
- NI 9421
- NI 9422
- NI 9423
- NI 9425
- NI 9426
- NI 9435
- NI 9436
- NI 9437

- NI 9472
- NI 9474
- NI 9475
- NI 9477
- NI 9481
- NI 9482
- NI 9485

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