NI-9253 Getting Started

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NI-9253 Pinout

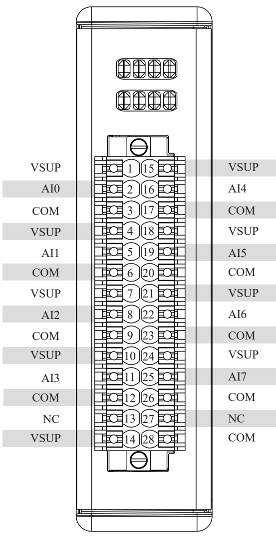


Table 1. Signal Descriptions

Signal	Description
AI	Analog input signal connection
V_{sup}	Voltage supply connection
COM	Common reference connection to isolated ground
NC	No connection

NI-9253 LEDs

Status	Color	Indication
ON	Green	• Channel is operational with input limits detection

Status	Color	Indication
		enabled • V_{sup} is in range if field side power fault detection is enabled
	Red	• Channel is in fault condition[1]1 • V_{sup} is in range if field side power fault detection is enabled
OFF	None	• Channel is operational without input limits detection enabled • V_{sup} is in range if field side power detection is enabled
		• Master timebase is absent
Flashing	Green	• Channel is operational • V_{sup} is out of range if field side power detection is enabled
	Red	• Channel is in fault condition[1] • V_{sup} is out of range if field side power detection is enabled

1. The channel is in the over-current state and/or the data has exceeded user-defined input limits.

Status	Color	Indication
Alternating flashing rows	Green	• Module is powered on • First acquisition is not initiated

Connecting an External Power Supply

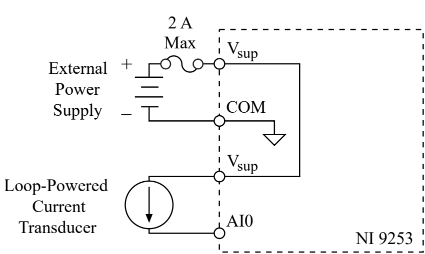
You can connect an external power supply to the NI-9253. This power supply provides the current for the devices you connect to the module. Connect the positive lead of the power supply to a V_{sup} pin and the negative lead of the power supply to COM. Install a 2 A maximum, fast-acting fuse between the external power supply and the V_{sup} pin.

Note The V_{sup} pins are internally connected to each other. You can connect only one external voltage supply to the device.

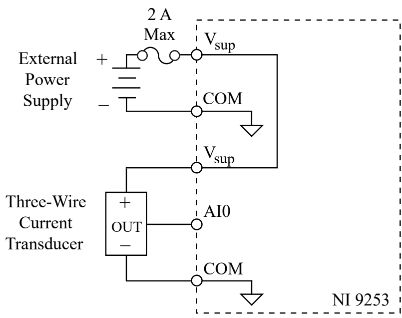
Caution Do not remove or insert modules if the external power supply connected to the V_{sup} and COM pins is powered on.

Attention Ne retirez ou n'insérez pas de modules si l'alimentation externe connectée aux broches V_{sup} et COM est sous tension.

Connecting a Loop-Powered Current Transducer



Connecting a Three-Wire Current Transducer



NI-9253 Connection Guidelines

- Make sure that devices you connect to the NI-9253 are compatible with the module specifications.
- You must use 2-wire ferrules to create a secure connection when connecting more than one wire to a single terminal on the NI-9253 with spring terminal.
- Push the wire into the terminal when using a solid wire or a stranded wire with a ferrule.
- Open the terminal by pressing the push button when using stranded wire without a ferrule.

High-Vibration Application Connections

If your application is subject to high vibration, NI recommends that you use the NI 9963 backshell kit to protect connections to the NI-9253 with spring terminal.

You must follow these guidelines to meet the shock and vibration performance specifications stated in the device datasheet on ni.com/manuals.

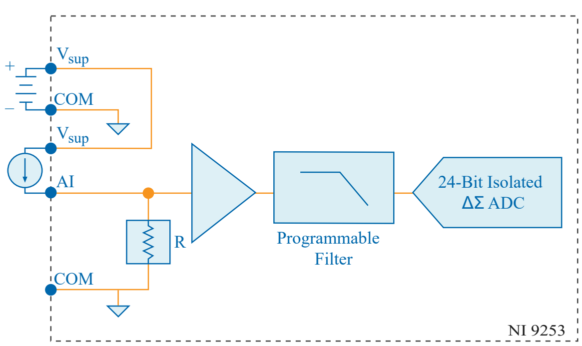
- Panel mount the system.
- Provide strain relief for the module by securing the cabling to a supporting fixture no more than 8 cm (3 in.) away from the opening of the connector backshell.
- Ensure that the supporting fixture for strain relief is stiff and rigidly coupled to the chassis mounting surface.
- Ensure that you do not directionally bias the module when applying strain relief.

Diagnostics

The NI-9253 supports the following diagnostics features:

- **Overcurrent Detection**—NI-9253 has built-in circuitry to detect overcurrent faults on its inputs. If an overcurrent event occurs on any channel, the channel overcurrent status in software returns TRUE and the LED lights up RED. The module uses fold back protection architecture so even under fault conditions the module may still read values between 0 mA to 20 mA. It is recommended to constantly poll the overcurrent status to ensure that the module readings are valid readings instead of fault induced readings.
- **Input Limits Detection**—NI-9253 supports user programmable input limits. These limits can be set to values between 0 mA to 21.9 mA. These values are symmetrical around 0 mA. For example, if the lower limit is set to 4 mA and the upper limit to 20 mA, the channel input limits fault status in software returns FALSE and the LED lights up GREEN when the module readings are between 4 mA to 20 mA or -4 mA to -20 mA. It returns TRUE otherwise. Input Limits Detection can be enabled or disabled via software.
- **Field Side Power Detection**—NI-9253 supports field side power detection. When enabled, this allows the user to detect if any power supply is connected to the V_{sup} pin of the module. If the power supply is below a certain threshold[2], the field side power fault status in the software returns TRUE and all eight LEDs blink. Field Side Power Detection can be enabled or disabled via software. It is recommended that this feature be disabled when the V_{sup} pin is not used.

NI-9253 Block Diagram



- Input signals on each channel are buffered, conditioned, and then sampled by an ADC.
- Each AI channel provides an independent signal path and ADC, enabling you to sample all channels simultaneously.

2. Refer to the ***Field side power detection threshold*** for the threshold values.

- The module protects each channel from overvoltages.

Data Rates

The frequency of a master timebase (f_M) controls the data rate (f_S) of the NI-9253. The NI-9253 includes an internal master timebase with a frequency of 12.8 MHz. Using the internal master timebase of 12.8 MHz results in data rates of 50 kS/s, 33.3333 kS/s, 25 kS/s, 20 kS/s, and so on down to 10 S/s, depending on the decimation rate. However, the data rate must remain within the appropriate data rate range.

The following equation provides the available data rates of the NI-9253:

$$f_s = \frac{f_M}{128 \times a}$$

where a is the decimation rate.

Table 2. Available Data Rates with the Internal Master Timebase

f_S (S/s)	Decimation Rate	f_S (S/s)	Decimation Rate	f_S (S/s)	Decimation Rate
50000.0	2	2272. 7	44	347.2	288
33333.3	3	2083.3	48	312.5	320
25000.0	4	2000.0	50	284.1	352
20000.0	5	1785.7	56	260.4	384
16666.7	6	1562.5	64	250.0	400
14285.7	7	1388.9	72	223.2	448
12500.0	8	1250.0	80	200.0	500
11111.1	9	1136.4	88	195.3	512
10000.0	10	1041.7	96	142.1	704
8333.3	12	1000.0	100	125.0	800
7142.9	14	892.9	112	100.0	1000
6250.0	16	781.3	128	97.7	1024
5555.6	18	694.4	144	60.0[3]3	1666 or 1706[4]4

f_s (S/s)	Decimation Rate	f_s (S/s)	Decimation Rate	f_s (S/s)	Decimation Rate
5000.0	20	625.0	160	50.0[3]	2000 or 2048[4]
4545.5	22	568.2	176	10.0[3]	10000 or 10240[4]
4166.7	24	520.8	192		
3571.4	28	500.0	200		
3125.0	32	446.4	224		
2777.8	36	400.0	250		
2500.0	40	390.6	256		

The NI-9253 can also accept an external master timebase or export its own master timebase. To synchronize the data rate of an NI-9253 with other modules that use master timebases to control sampling, all of the modules must share a single master timebase source. When using an external timebase with a frequency other than 12.8 MHz, the available data rates of the NI-9253 shift by the ratio of the external timebase frequency to the internal timebase frequency. The programmable filter specifications, expressed in Hz, will also scale with the external timebase. Refer to the software help for information about configuring the master timebase source for the NI-9253.

Note The cRIO-9151R Series Expansion chassis does not support sharing timebases between modules.

Note The cRIO-9151R Series Expansion chassis has different maximum data rates from the CompactRIO and CompactDAQ chassis. Refer to the ***Input Characteristics*** section for detailed information.

3. When using an external timebase of 13.1072 MHz, this data rate does not change with the ratio of the external to internal clocks.
4. When using an external timebase of 13.1072 MHz.

Filtering

The NI-9253 uses programmable hardware filtering to provide an accurate representation of in-band signals and reject out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal.

The NI-9253 programmable hardware filter supports both Butterworth and comb filter responses.

Butterworth Filter

The NI-9253 has a programmable hardware Butterworth low-pass filter. The Butterworth filter provides two selectable filter orders, each with six selectable cut-off frequencies that are configurable per module. The cut-off frequency (f_C) of the filter is independent of the data rate (f_S). However, using an external master timebase (f_M) will influence both the cut-off frequency (f_C) and data rate (f_S). The following figures show the overall filter response with different filter settings.

Figure 1. 4th Order Butterworth Filter Response

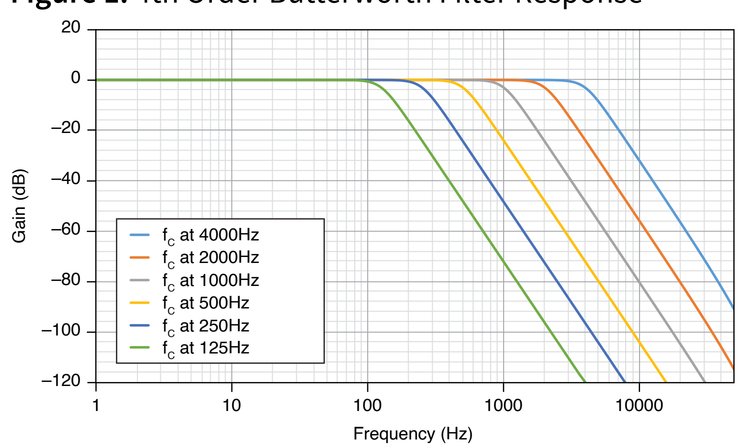
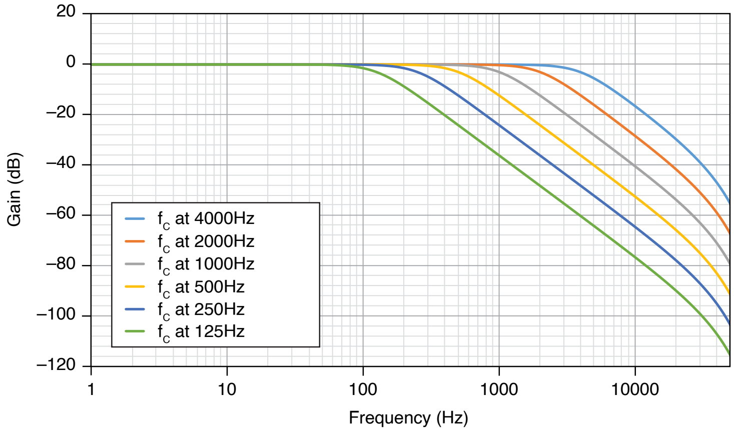


Figure 2. 2nd Order Butterworth Filter Response



Comb Filter

The NI-9253 comb filter frequency response is characterized by deep, evenly spaced notches and an overall roll-off towards higher frequencies. The NI-9253 provides five per module-configurable comb filter settings. The different options provide a trade-off of noise rejection (refer to Idle Channel Noise table) for filter settling time (refer to Settling Time equation) and latency (refer to Input Delay equation). To control the response of the programmable comb filter, you can select to have the first notch at 1, 1/2, 1/4, 1/8 or 1/16 of the data rate. The following figure shows the overall filter response with different filter settings.

Figure 3. Typical Comb Filter Response

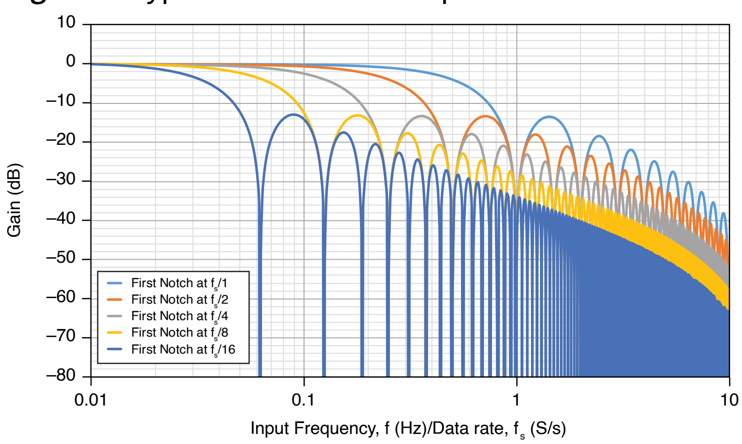
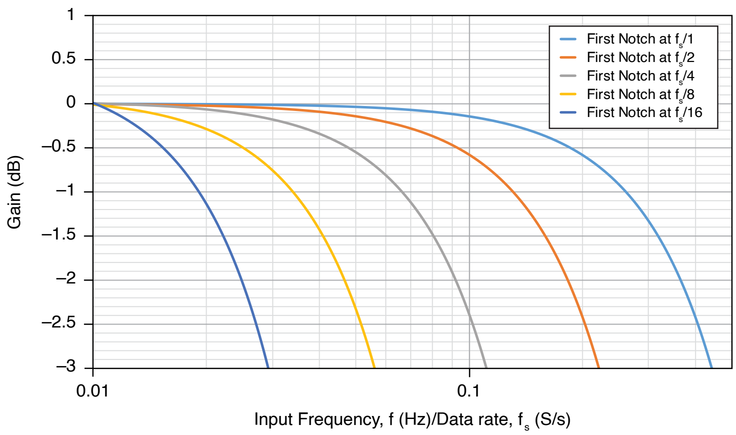


Figure 4. Typical Comb Filter Flatness



Passband

The signals within the passband have frequency-dependent gain or attenuation. The small amount of variation in gain with respect to frequency is called the passband flatness. The hardware filter of the NI-9253 adjust the frequency range of the passband to match the data rate. Therefore, the amount of gain or attenuation at a given frequency depends on the data rate.

Choosing the Right Filter for your Application

The NI-9253 Butterworth filter response is a low pass filter that allows signals with frequencies below the filter cutoff frequency to pass through while attenuating signals with frequencies higher than the filter cutoff frequency. This is useful to filter out unwanted high frequency noise in a signal. The Butterworth filter has a better flatness in the passband compared to the comb filter.

The NI-9253 Butterworth filter is a programmable-order filter. The different filter orders are characterized by the steepness of the filter response roll-off. The higher the filter order, the steeper the roll-off is. However, the trade-off of using higher order response is the higher input delay. The NI-9253 Butterworth filter allows user to trade-off between filter roll-off and input delay.

The NI-9253 comb filter frequency response is characterized by deep, evenly spaced notches and an overall roll-off towards higher frequencies. This is useful in rejecting specific frequencies and all its harmonics at a specific data rate. For example, the NI-9253 comb filter rejects powerline frequency of 50 Hz and all its harmonics when running at 50 S/s. The comb filter has lower settling time compared to the Butterworth filter.

For more information about filters, refer to the ***NI-9253 Getting Started Guide***.

Appendix

NI-9253 Filtering

The NI-9253 supports two types of lowpass filtering:

- Butterworth
- Comb

Table 3. Comparing NI-9253 Filters

Attribute	Butterworth	Comb
Passband	Configurable independent of sample rate	Tracks sample rate
Latency	Medium to high (configuration-dependent)	Low
Phase Delay Variation versus Frequency	Variable input delay	Constant input delay
Flatness	Best	Good
Step Response (Time Domain)	Mid-level delay, overshoot	Short delay, no overshoot/ undershoot
Typical Applications	Filtering out high frequency noise sources Reducing measurement noise	Filtering out specific noise sources Control applications

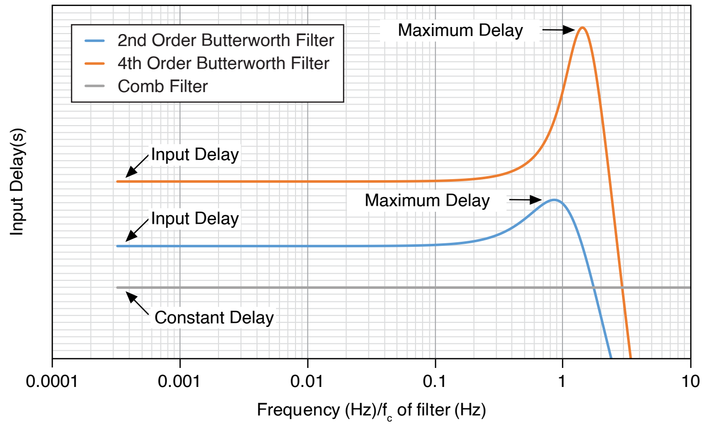
Refer to the specifications for details on the amount of variation in the response you can expect for different input frequency ranges.

Frequency Response of NI-9253 Filters

The NI-9253 uses programmable hardware filtering to provide an accurate representation of in-band signals and reject out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal. How the filter discriminates signals based on their frequency is known as frequency response. In general, the frequency response of a filter is described by a signal attenuation (magnitude response) and a input delay (phase response) for every input frequency.

- **Magnitude Response**—The three important frequency ranges, or bandwidths, to consider for magnitude response are passband, transition band, and stopband:
  - Passband—The range of frequencies at which the filter attempts to pass a signal without modifying it. The small amount of variation in magnitude at these frequencies is called passband flatness. This is the frequency range of signals that you want to measure.
  - Transition band—The range of frequencies in which the filter magnitude response has started to roll-off such that it attenuates signals by some amount, but has not reached the full attenuation amount. The shape of the transition band has an impact on the alias rejection and how signals are represented in the time domain (for example, step response).
  - Stopband—The range of frequencies at which the filter attenuates input signals to its maximum attenuation level. Ideally, you want to choose a filter with a stopband that covers frequencies of noise sources that you do not want in your measurements.
- **Input Delay**—Filters delay the input signal by some amount when processing data. In some cases, the delay is a function of the input signal frequency; when this is the case, the input delay plot is useful for knowing the exact delay at different input frequencies and the maximum variation between signals of different frequencies within the passband.

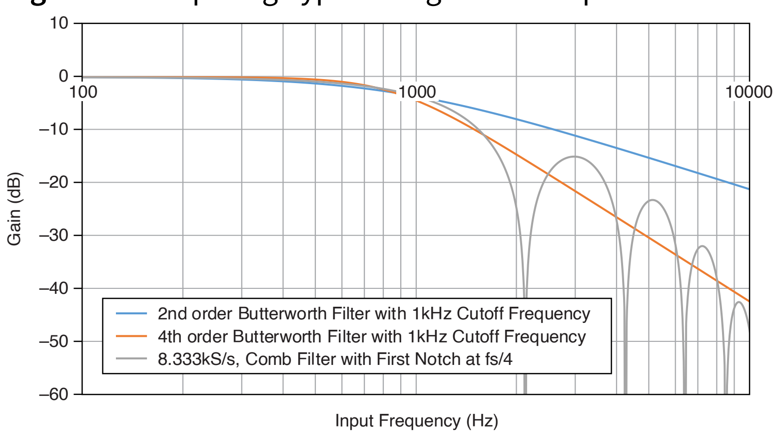
Figure 5. Comparing Typical Input Delay for NI-9253 Filters



Each NI-9253 filter has a different frequency response to serve different applications:

- **Butterworth**—Has a passband independent of the sampling rate (as opposed to the comb filter), which offers more flexibility when filtering out noise that is below one-half of the sample rate. However, depending on your settings, you may see alias components of higher frequency signals in your measurement that extend beyond one-half of the sample rate due to the larger transition band.
- **Comb**—Has a smaller passband because its transition band starts early in the frequency range. The comb filter has shorter group delay than other filters and better representation of signals in the time domain (step response). The comb filter's transition band features equally-spaced notches at different frequencies. It is common to use the comb filter with a specific sample rate to align the notches of the transition band thereby removing a specific noise-source frequency from measurements.

Figure 6. Comparing Typical Magnitude Response of NI-9253 Filters



The NI-9253 filter delay across signals in the passband varies between filters:

- **Butterworth**—Delays signals by a variable amount depending on their frequency.
- **Comb**—All input frequencies have the same amount of delay when going through the filter. Choose this filter for applications where linear phase, short delay, or data correlation of different devices and configurations is required.

Refer to the specifications for details on the amount of variation in the passband gain and input delay you can expect for different input frequency ranges.

Step Response of NI-9253 Filters

The shape of the magnitude and phase responses of a filter impacts how signals look in the time domain. The step response of a filter is typically used to identify the behavior of a filter in the time domain.

Three important factors of the filter step response are group delay, rise time, and overshoot/undershoot. The three filters differ in step response across signals in the transition band:

- **Butterworth**—Has a short group delay and the longest rise time. The output signal shows overshoot.
- **Comb**—Has the shortest group delay and the shortest rise time. The output signal does not show overshoot or undershoot.

Figure 7. Comparing Typical Step Response of NI-9253 Filters