AC Noise Rejection in NI-DCPower Measurements

2025-03-20

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How NI Power Supplies and SMUs Reject AC Noise from Measurements

You can manipulate the aperture time of measurements made with NI-DCPower instruments to reject specific AC noise frequencies in DC voltage and current measurements.

Each measurement that an NI-DCPower instrument returns is an average of one or more higher-speed samples. The exact rate of these samples varies by instrument, but for all instruments, it is a multiple of 50 Hz and 60 Hz to enable rejection of power line noise.

You can reject AC noise by adjusting the number of samples in a measurement so that the aperture time of the measurement is a multiple of the AC noise period. For most NI-DCPower instruments, you can set the aperture time directly; for a few older instruments, you can configure the number of samples to average to reject AC noise.

When you know the frequency of noise you want to reject, you can use the aperture time, which determines the number of samples in a measurement, to reject that frequency. Setting the aperture time to a multiple of an AC noise frequency averages out that frequency from your measurements.

Additionally, several NI-DCPower instruments support multiple noise rejection profiles. The choice of noise rejection profile offers a tradeoff between measurement speed and effectiveness of noise rejection.

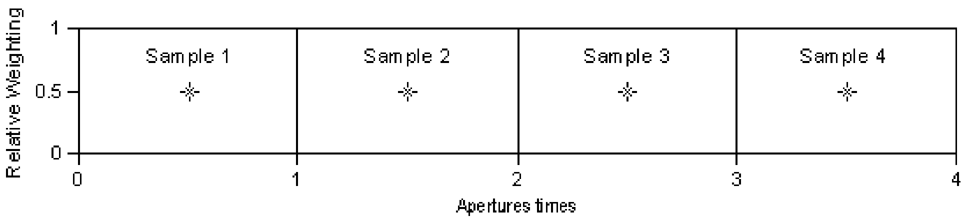
Normal DC Measurement Noise Rejection

With normal noise rejection, the instrument assigns equal weight to each sample. This setting mimics the behavior of most traditional power supplies and SMUs.

Normal noise rejection is the default behavior for all NI-DCPower instruments.

Figure 1 shows normal weighting, with aperture times on the x-axis and relative weighting on the y-axis.

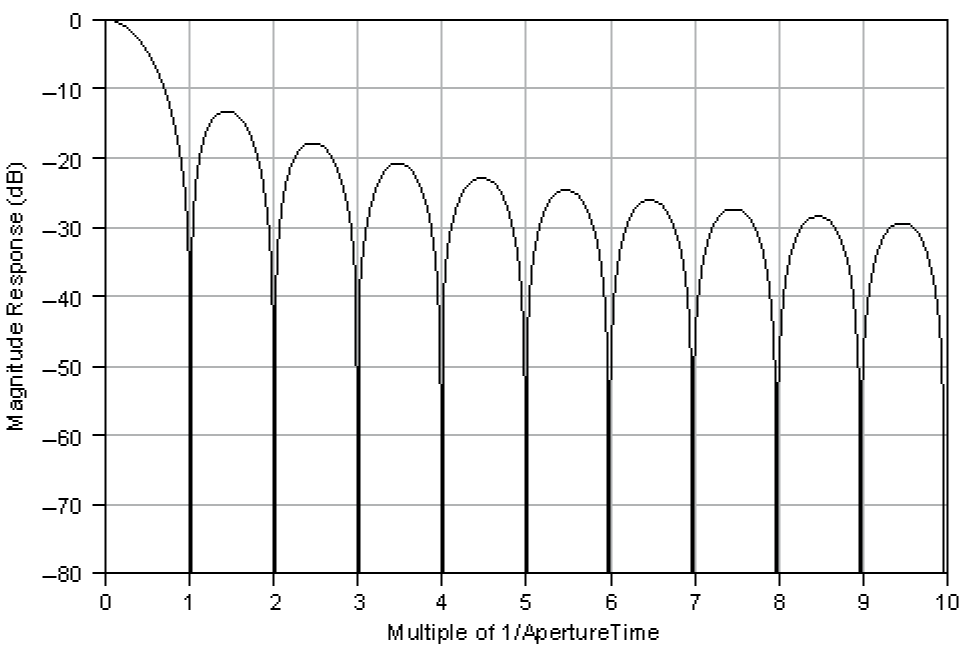
Figure 1. Normal Noise Rejection



1. Sample 1
2. Sample 2
3. Sample 3
4. Sample 4

Figure 2 shows the resulting noise rejection as a function of frequency, with multiples of 1 / ***Aperture Time*** on the x-axis and magnitude response, in dB, on the y-axis.

Figure 2. Normal Noise Rejection by Frequency



The best frequency rejection is available only near integer multiples of 1 / ***Aperture Time***. You can achieve the fastest possible readings along with good power-line noise rejection by setting the aperture to one power-line cycle (PLC) and noise rejection to Normal.

Support for Normal AC Noise Rejection

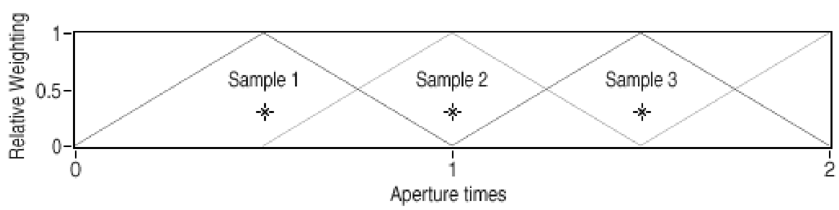
All NI-DCPower support normal AC noise rejection, the default noise rejection behavior of NI-DCPower instruments.

Second-Order DC Measurement Noise Rejection

With second-order noise rejection, the instrument assigns a triangular weighting to measurement samples. Samples taken in the middle of the aperture time have more weight than samples taken at the beginning and end of that measurement.

Figure 1 shows second-order weighting, with aperture times on the x-axis and relative weighting on the y-axis.

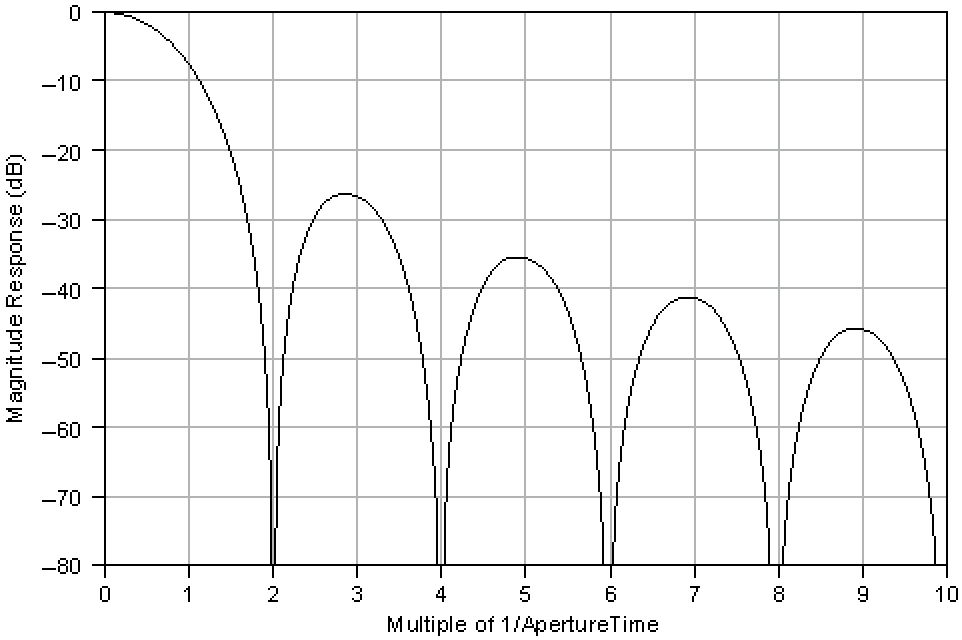
Figure 3. Second-Order Noise Rejection



1. Sample 1
2. Sample 2
3. Sample 3

Figure 2 shows the resulting noise rejection as a function of frequency, with multiples of 1 / ***Aperture Time*** on the x-axis and magnitude response, in dB, on the y-axis.

Figure 4. Second-Order Noise Rejection by Frequency



With second-order noise rejection, the instrument provides superior noise rejection even near multiples of 1 / ***Aperture Time***, and noise rejection increases more rapidly with frequency compared to normal noise rejection. Notches are also wider than they would be with normal weighting, which results in less sensitivity to slight variations in noise frequency.

Use second-order noise rejection if you need better power-line noise rejection or better high-frequency noise rejection than you can obtain with normal noise rejection.

You can achieve the fastest possible readings with second-order noise rejection, along with excellent power-line noise rejection, by setting the aperture to two power-line cycles (PLC) and noise rejection to Second-Order.

In this configuration, one measurement is produced in the first full aperture, followed by two measurements for each subsequent aperture time. This results in approximately the same measurement rate as normal filtering for large measure records.

Support for Second-Order AC Noise Rejection

The following NI-DCPower instruments support second-order AC noise rejection:

- PXIe-4135
- PXIe-4137
- PXIe-4139
- PXIe-4141
- PXIe-4143
- PXIe-4145
- PXIe-4147
- PXIe-4162
- PXIe-4163

Choosing an AC Noise Rejection Profile for NI-DCPower Instruments

For some NI-DCPower instruments, you have a choice of AC noise rejection profiles: ***normal*** and ***second-order***. Normal noise rejection is the default noise rejection behavior for all NI-DCPower instruments, while second-order noise rejection can provide better frequency rejection in some situations.

The length of the measurement aperture time affects which noise frequencies are rejected. The noise rejection profile changes how frequencies are rejected with respect to the measurement aperture time and affects the minimum time required for the instrument to make a single measurement.

Support for AC Noise Rejection Profiles

All NI-DCPower support normal AC noise rejection, the default noise rejection behavior of NI-DCPower instruments.

The following NI-DCPower instruments support second-order AC noise rejection:

- PXIe-4135
- PXIe-4137
- PXIe-4139
- PXIe-4141
- PXIe-4143
- PXIe-4145
- PXIe-4147

- PXIe-4162
- PXIe-4163

Choose the AC noise rejection profile that suits your application based on the following criteria.

Lowest Frequency Rejection Notch	High-Frequency Noise Rejection	Minimum Measurement Time Required	Recommended Noise Rejection Profile
1 / ***Aperture Time***	Good	Shorter: ***Aperture Time***	Normal
2 / ***Aperture Time***	Better	Longer: 2 × ***Aperture Time***	Second-Order

Rejecting AC Noise in DC Measurements with NI-DCPower

Many environments and systems include unwanted periodic signals that can degrade measurement quality. By manipulating measurement aperture time, you can use the NI-DCPower API to reject specific AC noise frequencies from measurements you make with NI-DCPower instruments.

With a short aperture time, measurements are completed faster, but noise from the environment, such as the 50 Hz or 60 Hz power line noise introduced by cabling, increases measurement uncertainty. Longer aperture times improve measurement resolution, and internal noise also decreases; your instrument specifications may describe this relationship. Specific aperture times can reject specific noise frequencies in DC measurements.

Different NI-DCPower instruments require different ways of using aperture time to reject noise. Additionally, some instruments support multiple noise rejection profiles that offer a trade-off between measurement speed and improved noise rejection.

Choose the noise rejection method supported by your instrument.

- Rejecting AC Noise in DC Measurements with Aperture Time
- Rejecting AC Noise in DC Measurements with Measurement Averaging

Rejecting AC Noise in DC Measurements with Aperture Time

Directly adjusting the aperture time of your measurements allows you to reject specific AC noise frequencies in your DC measurements with NI-DCPower.

Complete the following steps to reject AC noise frequencies by adjusting the aperture time of your measurements.

Support for Measurement Aperture Time

The following NI-DCPower instruments support direct control over measurement aperture time:

- PXIe-4112
- PXIe-4113
- PXI-4132
- PXIe-4135
- PXIe-4136
- PXIe-4137
- PXIe-4138
- PXIe-4139
- PXIe-4140
- PXIe-4141
- PXIe-4142
- PXIe-4143
- PXIe-4144
- PXIe-4145
- PXIe-4147
- PXIe-4162
- PXIe-4163

1. If your instrument supports multiple options, choose the noise rejection profile that suits your application.
    - Normal
        - Default behavior. Good noise rejection, shorter time per measurement required.
        - Best frequency rejection at nonzero integer multiples of 1 / ***Aperture***

Time

- Second-Order
  - Available on some instruments. Best noise rejection, longer time per measurement required.
  - Best frequency rejection at nonzero integer multiples of 2 / ***Aperture Time***

2. Based on the aperture time units and the noise rejection profile you intend to use, calculate the aperture time required to reject the frequency f (Hz) you need to reject.
   - Aperture time units: seconds

Noise Rejection Profile	Target Aperture Time (s)
Normal	***Aperture Time*** = 1 / f
Second-Order	***Aperture Time*** = 2 / f

   - Aperture time units: power line cycles (PLC)

Noise Rejection Profile	Power Line Frequency	Target Aperture Time (PLC)
Normal	60 Hz	***Aperture Time*** = 60 Hz / f
	50 Hz	***Aperture Time*** = 50 Hz / f
Second-Order	60 Hz	***Aperture Time*** = 2 × (60 Hz / f)
	50 Hz	***Aperture Time*** = 2 × (50 Hz / f)

> **Note** Each NI-DCPower instrument supports discrete aperture times: an instrument-specific minimum value and integer multiples of that value. When you set an unsupported aperture time, NI-DCPower coerces the value to the nearest longer supported value for your instrument.

3. Configure the aperture time you calculated.
   a. Set the aperture time and the appropriate units with Configure Aperture Time.
   b. If using power line cycle units, provide the frequency of the AC power line for your system to Configure Power Line Frequency.

4. Use DC Noise Rejection to set the noise rejection profile you chose.

Rejecting AC Noise in DC Measurements with Measurement Averaging

For NI-DCPower instruments that do not support directly changing the aperture time, you can adjust the number of samples averaged in each measurement to influence the aperture time of your measurements, which allows you to reject specific AC noise frequencies.

The number of samples you choose to average in a measurement implicitly controls the aperture time based on the following relationship:

Aperture Time = ***Samples To Average*** / ***Maximum Sample Rate***

where

- ***Samples To Average*** is the number of samples, as determined by Samples To Average, that compose each measurement; the default value and valid range of samples to average depend on your instrument
- ***Maximum Sample Rate*** is the maximum sample rate of the instrument as documented in the specifications for your instrument

The overall hardware measurement rate of the instrument is the reciprocal of the aperture time.

Complete the following steps to reject AC noise frequencies by manipulating the aperture time of your measurements with measurement averaging.

Support for Measurement Averaging

The following NI-DCPower instruments support measurement averaging:

- PXI-4110
- PXI-4130
- PXIe-4154

1. Based on the frequency f (Hz) you need to reject and the maximum sample rate of your instrument as indicated in the specifications, calculate the number of samples you need to average to reject the frequency.

   Samples To Average = ***Maximum Sample Rate*** / f

2. Set Samples To Average to the value you calculated.

> **Tip** To improve noise reduction while keeping frequency rejection, you can use integer multiples of ***Samples To Average***, as long as that multiple is a supported value of Samples To Average for your instrument and the longer aperture time that results is appropriate for your application.

> **Note** If you set the Samples To Average property in the Running state, the output channel measurements may move out of synchronization.
>
> If this occurs, set Reset Average Before Measurement to `True` before calling Measure Multiple in your program. You can set Reset Average Before Measurement to `False` after Measure Multiple runs.