# High-Speed Digitizer Signal Processing Option: Block Average

- Signal Averaging in Hardware
- Maximum waveform length of 128 kSamples (one channel)
- Maximum average waveform throughput of more than 5,000,000 waveforms per second
- Average mode can run continuously in streaming (FIFO) mode
- Fully compatible with star-hub synchronization of multiple cards
- M4i.44xx/M4x.44xx/DN2.44x/DN6.44x dead time between waveforms:
  40 samples = 80 ns at 500 MS/s or 400 ns at 100 MS/s
- M4i.22xx/M4x.22xx/DN2.22x/DN6.22x dead time between waveforms: 80/160/320 samples = 64 ns at 5 GS/s, 64 ns at 2.5 GS/s or 64 ns at 1.25 GS/s
- Fully compatible with Spectrum API allowing usage with C/C++, .NET, Delphi, Basic, Python, LabVIEW, MATLAB and many more.
- Fully integrated into SBench 6 Professional software
- Available for all high-speed digitizers based on M4i and M4x technology (including digitizerNETBOX products)
- Fast data calculation in hardware reduces the needed transfer bandwidth extremely
- Calculation can run on all channels simultaneously
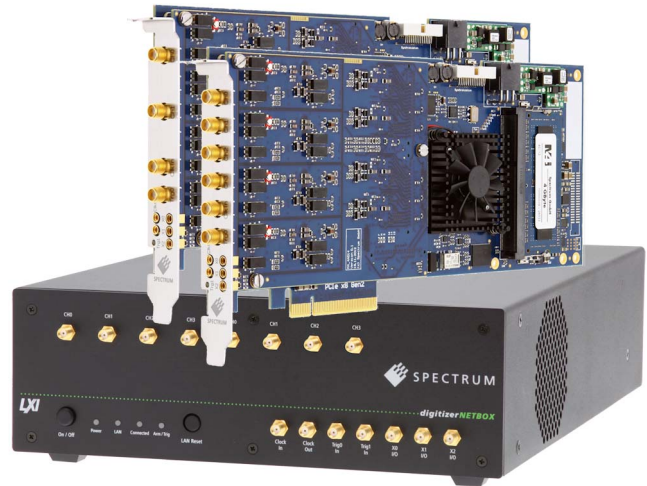
Application Examples

- Radar Test
- Ultrasonic Test
- Laser Ranging
- Medical Imaging
- Optical Fiber Test
- Mass Spectroscopy
- Component Testing
- Nanotechnology

Digitizer Models with Firmware Options

| Product	Interface	Resolution	Channels	Speed	Block Average	Block Statistics	Boxcar Average
M4i.2234/2233/2230-x8	PCI Express x8	8 Bit	1/2/4 channels	5 GS/s	available	available	not available
M4i.2223/2221/2220-x8	PCI Express x8	8 Bit	1/2 channels	2.5 GS/s	available	available	not available
M4i.2212/2211/2210-x8	PCI Express x8	8 Bit	1/2/4 channels	1.25 GS/s	available	available	not available
M4x.2234/2233/2230-x4	PXI Express x4	8 Bit	1/2/4 channels	5 GS/s	available	available	not available
M4x.2223/2221/2220-x4	PXI Express x4	8 Bit	1/2 channels	2.5 GS/s	available	available	not available
M4x.2212/2211/2210-x4	PXI Express x4	8 Bit	1/2/4 channels	1.25 GS/s	available	available	not available
DN2.225-04/08	Ethernet/LXI	8 Bit	2/4/8 channels	5 GS/s	available	available	not available
DN2.223-02	Ethernet/LXI	8 Bit	2 channels	5 GS/s	available	available	not available
DN2.222-02/04	Ethernet/LXI	8 Bit	2/4 channels	2.5 GS/s	available	available	not available
DN2.221-02/04/08	Ethernet/LXI	8 Bit	2/4/8 channels	1.25 GS/s	available	available	not available
DN6.221-12/16/20/24	Ethernet/LXI	8 Bit	12/16/20/24 channels	1.25 GS/s	available	available	not available
DN6.225-12/16/20/24	Ethernet/LXI	8 Bit	12/16/20/24 channels	5 GS/s	available	available	not available
M4i.4450/4451-x8	PCI Express x8	14 Bit	2/4 channels	500 MS/s	available	available	available
M4i.4420/4421-x8	PCI Express x8	16 Bit	2/4 channels	250 MS/s	available	available	available
M4i.4410/4411-x8	PCI Express x8	16 Bit	2/4 channels	130 MS/s	available	available	available
M4x.4450/4451-x4	PXI Express x4	14 Bit	2/4 channels	500 MS/s	available	available	available
M4x.4420/4421-x4	PXI Express x4	16 Bit	2/4 channels	250 MS/s	available	available	available
M4x.4410/4411-x4	PXI Express x4	16 Bit	2/4 channels	130 MS/s	available	available	available
DN2.445-02/04/08	Ethernet/LXI	14 Bit	2/4/8 channels	500 MS/s	available	available	available
DN2.442-02/04/08	Ethernet/LXI	16 Bit	2/4/8 channels	250 MS/s	available	available	available
DN2.441-02/04/08	Ethernet/LXI	16 Bit	2/4/8 channels	130 MS/s	available	available	available
DN6.445-12/16/20/24	Ethernet/LXI	14 Bit	12/16/20/24 channels	500 MS/s	available	available	available
DN6.442-12/16/20/24	Ethernet/LXI	16 Bit	12/16/20/24 channels	250 MS/s	available	available	available
DN6.441-12/16/20/24	Ethernet/LXI	16 Bit	12/16/20/24 channels	130 MS/s	available	available	available

General Information

The Block Average Module improves the fidelity of any repetitive signal by removing its random noise components. The Module allows multiple single acquisitions to be made, accumulated and averaged. The process reduces random noise improving the visibility of the repetitive signal. The averaged signal has an enhanced measurement resolution and increased signal-to-noise (SNR) ratio.

The complete averaging process is performed inside the FPGA of the digitizer and involves no CPU load at all. Averaging also reduces the amount of data that needs to be transferred to the host PC further reducing CPU demand and speeding up measurement times.

The Block Average mode is fully compatible with streaming (FIFO) mode so that the digitizer can accumulate and average signals for hours or days without losing a single event. The Module takes advantage of an advanced trigger circuit, with very fast re-arm time, so that signals can be averaged at ultra-fast rates going as high as 5 million events per second.


The signal processing firmware also includes the standard digitizer firmware so that normal digitizer operation can be performed with no limitations.
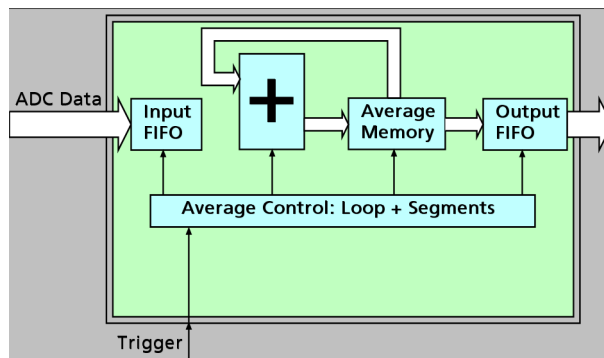
Principle of operation

In Block Average mode the acquisition works very similar to the Multiple Recording mode.

The memory is segmented and with each trigger condition a predefined number of samples, a segment, is acquired.
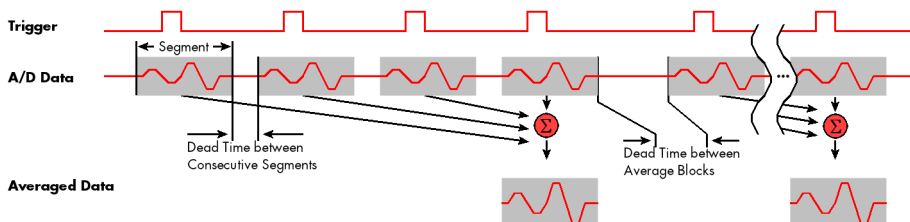

The Block Average option now takes a programmable number of these acquired consecutive data segments and averages them sample by sample over one another.

The result of one averaging operation is a segment with summed values, that has the same length as each original „RAW" segment, but each sample now consists of the sum of all samples of the averaged segment at the same location in relation to the trigger signal.

In order to get any meaningful results out of the Block Average operation, a repetitive signal is required along with a stable trigger condition.

Simplified Block Diagram

The following block diagram shows the general structure and data flows of the M4i/M4x based digitizer hardware. When running in the standard digitizer configuration the signal processing block simply consists of a bypass handing the input data to the memory controller without further calculations.
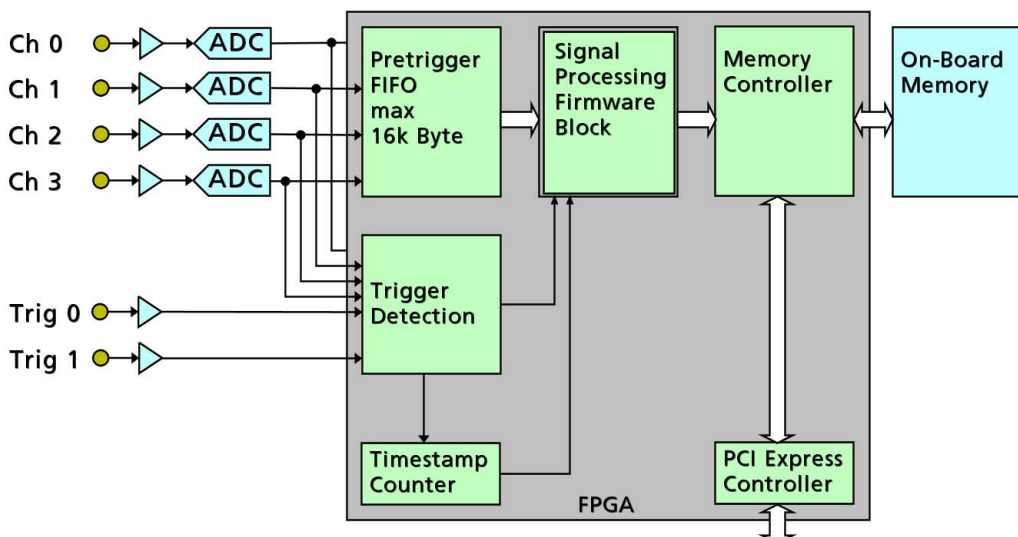
Acquisition and Average Examples

Improvement in Time Domain

The right side screenshot shows a low level signal (approximately 2 mV) that is completely overlaid by random noise and the improvement that can be achieved when using different averaging factors.

While the source signal is not even visible in the original single-shot acquisition averaging 10 times shows that there is actually a signal with 5 peaks. Doing a block average of 1000 times improves the signal quality even further revealing the real shape of the signal complete with secondary maximum and minimum peaks.

This example was made using a sampling rate of 500 MS/s (2 ns per point) and 14 bit ADC resolution.
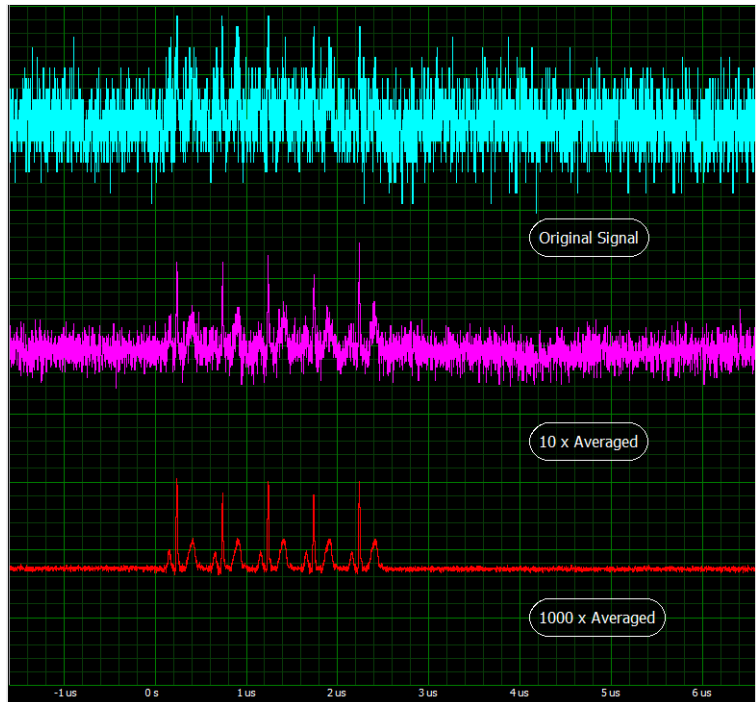

Improvement in Frequency Domain

The frequency domain plots show the acquisition of a low level sine signal with different averaging factors.

In the first plot the frequency domain signal of a single-shot acquisition can be seen having a SFDR (spurious free dynamic range) of about 30 dB. By using the Block Averaging Module the SFDR is significantly improved, to more than 65 dB after 10000 averages.

In this case the original sine signal contains high distortion parts which are barely visible in the single-shot acquisition. The distortion is produced by the signal generator which is far away from its optimum operating conditions when making low level 10 mVpp sine signals. After averaging it is easy to see this distortion and to measure its major components.
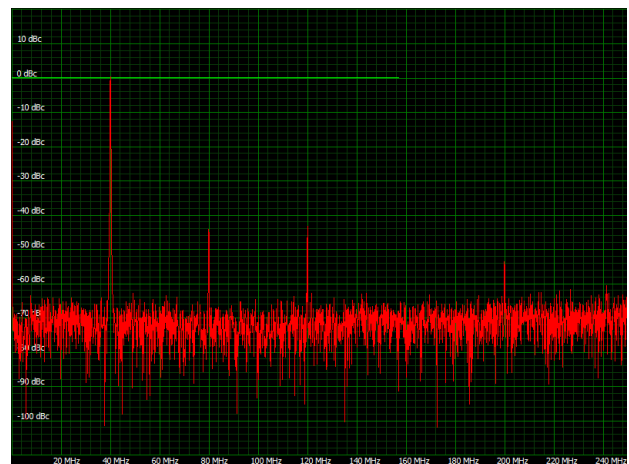
Single-Shot
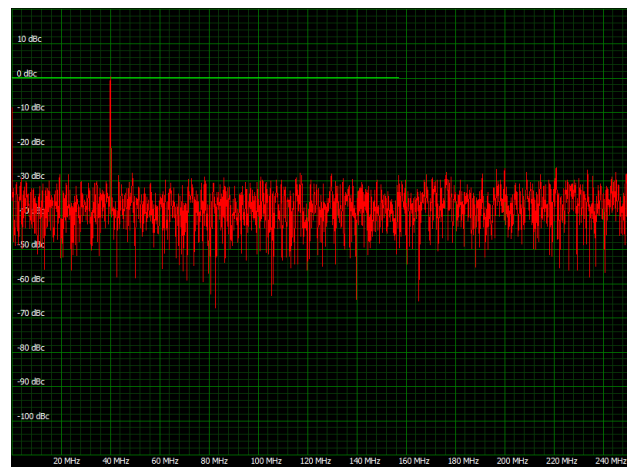
100 times averaged
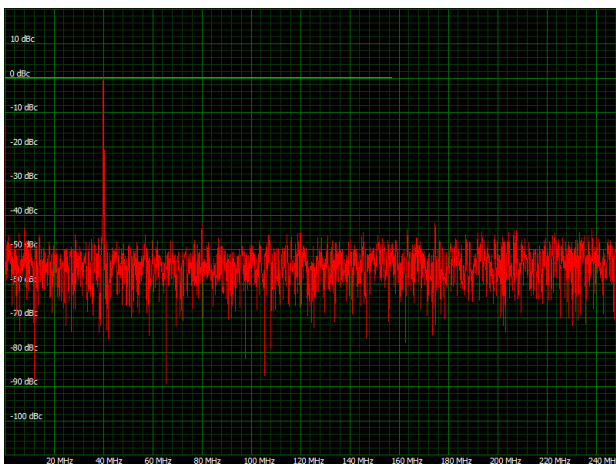
10000 times averaged

Technical Data

Block Average Signal Processing Option M4i.44xx/M4x.44xx/DN2.44x/DN6.44x Series

		Firmware ≥ V1.14 (August 2015)	Firmware < V1.14
Minimum Waveform Length		32 samples	32 samples
Minimum Waveform Stepsize		16 samples	16 samples
Maximum Waveform Length	1 channel active	128 kSamples	32 kSamples
Maximum Waveform Length	2 channels active	64 kSamples	16 kSamples
Maximum Waveform Length	4 or more channels active	32 kSamples	8 kSamples
Minimum Number of Averages		2	2
Maximum Number of Averages		65536 (64k)	65536 (64k)
Data Output Format	fixed	32 bit signed integer	32 bit signed integer
Re-Arming Time between waveforms		40 samples (+ programmed pretrigger)	40 samples (+ programmed pretrigger)
Re-Arming Time between end of average to start of next average		Depending on programmed segment length, max 100 µs	40 samples (+ programmed pretrigger)

Block Average Signal Processing Option M4i.22xx/DN2.22x/DN6.22x Series

		Firmware ≥ V1.14 (August 2015)		Firmware < V1.14
Data Mode	software programmable	32 bit mode	16 bit mode	32 bit mode only
Minimum Waveform Length		64 samples	128 samples	64 samples
Minimum Waveform Stepsize		32 samples	64 samples	32 samples
Maximum Waveform Length	1 channel active	64 kSamples	128 kSamples	32 kSamples
Maximum Waveform Length	2 channels active	32 kSamples	64 kSamples	16 kSamples
Maximum Waveform Length	4 or more channels active	16 kSamples	32 kSamples	8 kSamples
Minimum Number of Averages		2	2	4
Maximum Number of Averages		16777216 (16M)	256	16777216 (16M)
Data Output Format	fixed	32 bit signed integer	16 bit signed integer	32 bit signed integer
Re-Arming Time between waveforms	1.25 GS/s or below	80 samples (+ programmed pretrigger)		80 samples (+ programmed pretrigger)
Re-Arming Time between waveforms	2.5 GS/s	160 samples (+ programmed pretrigger)		160 samples (+ programmed pretrigger)
Re-Arming Time between waveforms	5 GS/s	320 samples (+ programmed pretrigger)		320 samples (+ programmed pretrigger)
Re-Arming Time between end of average to start of next average		Depending on programmed segment length, max 50 µs		80/160&320 samples as above listed

Order Information digitizerNETBOX Models

Firmware Options

Order no.	Option
DN2.xxx–spavg	Signal Processing Firmware Option: Block Average (later installation by firmware - upgrade available)
DN2.xxx-spstat	Signal Processing Firmware Option: Block Statistics/Peak Detect (later installation by firmware - upgrade available)
DN6.xxx-spavg	Signal Processing Firmware Option: Block Average (later installation by firmware - upgrade available)
DN6.xxx-spstat	Signal Processing Firmware Option: Block Statistics/Peak Detect (later installation by firmware - upgrade available)

Order Information M4i and M4x Card Models

Firmware Options

Order no.	Option
M4i.xxxx–spavg	Signal Processing Firmware Option: Block Average (later firmware - upgrade available)
M4i.xxxx-spstat	Signal Processing Firmware Option: Block Statistics/Peak Detect (later firmware - upgrade available)