DATA SHEET

GEN series GN8101B/GN8102B/GN8103B
Basic 250, 100, 25 MS/s Input Card

SPECIAL FEATURES

- 8 analog channels
- Single-ended inputs
- 1 MΩ or 50 Ω termination
- ± 10 mV to ± 100 V input range
- Analog/digital anti-alias filters
- 14/16 bit resolution
- Real-time formula database
- Digital Event/Timer/Counter
- Multi sweep transient recorder
- Continuous/Dual sample rate
- Differential input using probes

GN8101B/GN8102B/GN8103B Functions and Benefits

Basic High Speed Input Card
The input card is a general purpose single-ended voltage input card. An external active differential probe supports measuring the differential signal directly at the source and creates the best high frequency common mode suppression possible.
For high frequency measurements, the inputs support a built-in 50 Ω termination option. The use of the 50 Ω termination supports voltage inputs from ± 10 mV to ± 5 V. The alternative 1 MΩ termination provides voltage inputs up to ± 100 V.
In multi sweep transient recorder mode triggers can be recorded without any re-arm time between sweeps, combined with sweep stretch to create variable post-trigger lengths.
Optimum anti-alias protection is achieved by the 6-pole analog anti-alias filter combined with a fixed high speed sampling Analog-to-Digital converter.
For sample rates 100 MS/s and lower, the digital anti-alias filter allows for a large range of high order filter characteristics with precise phase match and noise-free digital output.
The real-time formula database calculators option offers math routines to solve many real-time mathematical challenge like obtaining mechanical power and/or multi-phase (not limited to three) electric power (P, Q, S) or even efficiency calculations.
Every cycle based result from the real-time formula database can be transferred in real-time to the EtherCAT® output card.
Using voltage probes a single-ended 600 V RMS CAT III / 1000 V CAT II or a differential 1000 V RMS CAT III (1000 V RMS common mode) measurement range is created. The use of current clamps and external burdens allow for direct current measurements.

Capabilities Overview			
Model	**GN8101B**	**GN8102B**	**GN8103B**
Maximum sample rate per channel	250 MS/s	100 MS/s	25 MS/s
Memory per card	8 GB		
Analog channels	8		
Anti-alias filters	Fixed bandwidth analog AA-filter combined with sample rate tracking digital AA-filter		
ADC resolution	14 bit		
Isolation	Not supported		
Input type	Single-ended Differential using the differential probe		
Passive voltage/current probes	Passive, singled-ended voltage probes		
TEDS	Not supported		
Real-time formula database calculators (option)	Extensive set of user programmable math routines		
Digital Event/Timer/Counter	16 digital events and 2 Timer/Counter channels		
Standard data streaming (CPCI up to 200 MB/s)	Not supported [1]		
Fast data streaming (PCIe up to 1 GB/s)	Supported		
Slot width	1		

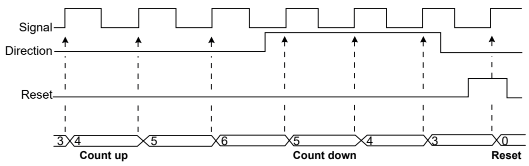
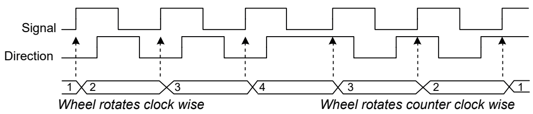
(1) GEN2i, GEN5i, GEN7t and GEN16t do not support GN8101B, GN8102B or GN8103B.

Real-time Calculated Results Output			
	Ethernet GEN DAQ API	**EtherCAT®**	**CAN/CAN FD**
Maximum results per block	240	240	240
Maximum result blocks per second	2000	1000	1000
Latency	Ethernet dependent	1 ms	CAN bus speed

<table>
<tr><th colspan="12">Mainframe Support</th></tr>
<tr><th></th><th>GEN2tB</th><th>GEN3t</th><th>GEN4tB</th><th>GEN7tA</th><th>GEN17tA</th><th>GEN3i / GEN3iA</th><th>GEN7i / GEN7iA</th><th>GEN2i [4]</th><th>GEN5i [4]</th><th>GEN7t [4]</th><th>GEN16t [4]</th></tr>
<tr><td>GN8101B/ GN8102B/GN8103B</td><td colspan="7">Yes</td><td colspan="4">No</td></tr>
<tr><td>GEN DAQ API</td><td colspan="5">Yes</td><td colspan="2">Yes[1]</td><td colspan="4">No</td></tr>
<tr><td>EtherCAT®</td><td>No</td><td colspan="4">Yes</td><td colspan="2">No</td><td colspan="4">No</td></tr>
<tr><td>CAN/CAN FD</td><td>Yes</td><td></td><td>Yes</td><td>Yes[2]</td><td>Yes[3]</td><td colspan="2">No</td><td colspan="4">No</td></tr>
</table>

(1) Close Perception to enable GEN DAQ API access.
(2) Early shipments have no access to an USB port. Contact Support-EPT@hbm.com for a user installed upgrade.
(3) Requires custom system modification.
(4) Mainframe replaced by newer version.

Supported Analog Sensors and Probes		
Perception input type	**Sensor/probe types**	**Remarks**
Basic voltage	• Single-ended voltage probe • Passive single-ended probe • Active differential probes • Current probes	• Non-isolated BNC input • Use coaxial cables

Supported Digital Sensors (TTL Level Input)		
Timer counter Input type	**Supported digital sensors**	**Features**
 **Figure 1:** Uni and Bi-directional clock	• HBM Torque sensors • Torque sensors • Speed sensors • Position sensors	• Angle measurement • Frequency / RPM measurement • Count/position measurement • Count frequency up to 5 MHz • Digital filter on input signals • Several reset options • RT-FDB can add a calculated Frequency/ RPM channel based on the angle measurement
 **Figure 2:** ABZ Incremental Encoder (Quadrature)	• HBM Torque sensors • Torque sensors • Speed sensors • Position sensors	• Angle measure • Frequency / RPM measurement • Count/position measurement • Count frequency up to 2 MHz • Digital filter on input signals • Single, dual and quad precision count • Transition tracking to avoid count drift • Several reset options • RT-FDB can add a calculated Frequency/ RPM channel based on the angle measurement

Block Diagram

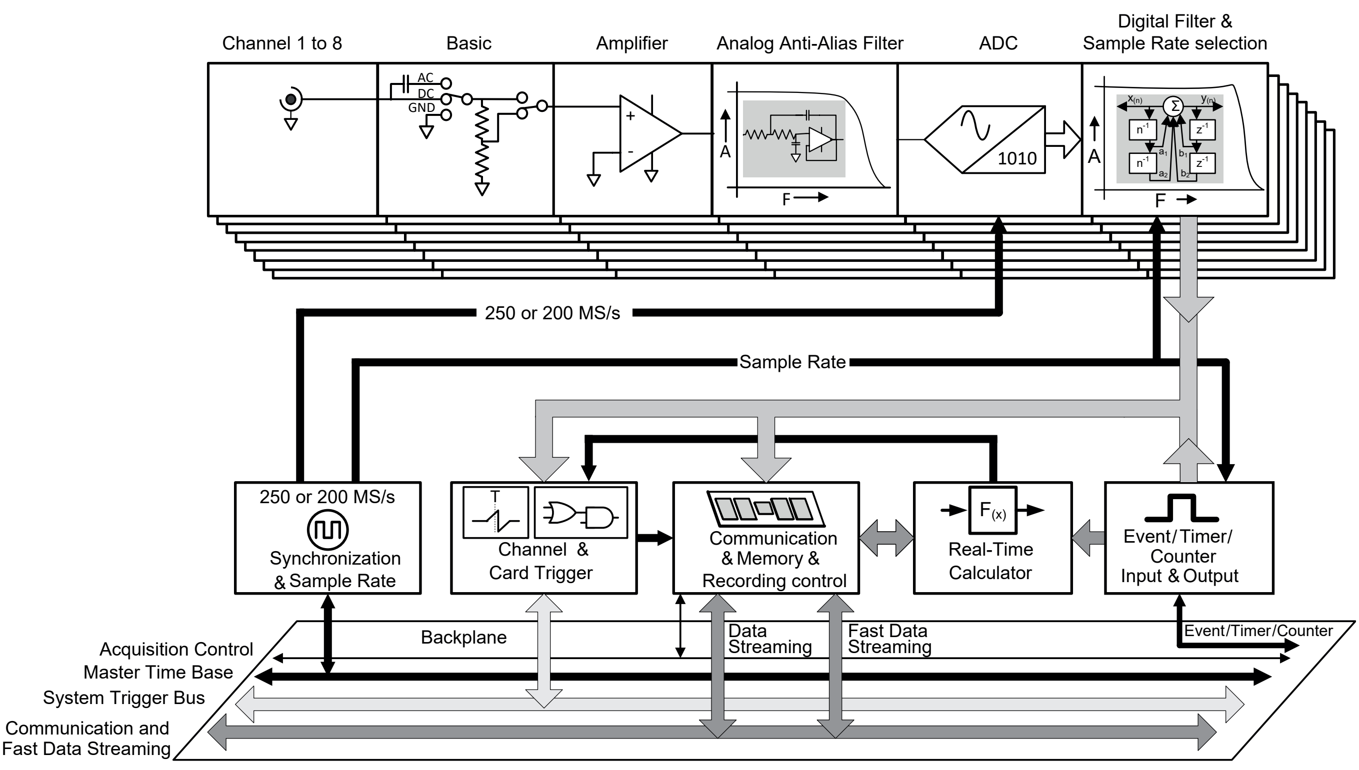


Figure 3: Block diagram

Specifications and measurement uncertainty

Specifications are established using 23 °C environmental temperature.
For measurement uncertainty improvements, the system could be readjusted at a specific environmental temperature to minimize the impact of temperature drift.

Any analog amplifier error source follows the = **ax** + **b** curve.

a % of reading error, represents the linear increasing error due to the increase of the input voltage: often referred to as gain error.
b % of range error, represents the error when measuring 0 V; often referred to as offset error.
For measurement uncertainty these errors can be considered independent error sources.

Noise is not a separate error source outside of the standard specification.
Noise specifications are added separately in case you need dynamic accuracy on sample by sample level.
Only for sample by sample measurement uncertainty add the RMS noise error.
For e.g. power accuracy, the RMS noise error is already included in the power specifications.

Pass/Fail limits are rectangular distributed specifications, therefore measurement uncertainty is 0.58 * specified value.

Adding/removing or swapping cards

The specifications listed are valid for cards that have been calibrated and are used in the same mainframe, mainframe configuration and slots as they were at the time of calibration.
If cards are added, removed or relocated the thermal conditions of the card will change, resulting in additional thermal drift errors. The maximum expected error can be up to two times the specified Reading and Range error as well as 10 dB reduced common mode rejection.
Recalibration after configuration changes is therefore highly recommended.

Analog Input Section	
Channels	8
Connectors	Metal BNC
Input type	Analog, single-ended
Input impedance	
1 MΩ impedance	≤ ± 1V ranges: 1 MΩ ± 1% // 27.5 pF ± 5% > ± 1V ranges: 1 MΩ ± 1% // 18.5 pF ± 5%
50 Ω impedance	50 Ω ± 2%
Input coupling	
Coupling modes	AC, DC, GND
AC coupling frequency (1 MΩ impedance)	1.6 Hz ± 10%; - 3 dB
AC coupling frequency (50 Ω impedance)	32 kHz ± 10%; - 3 dB

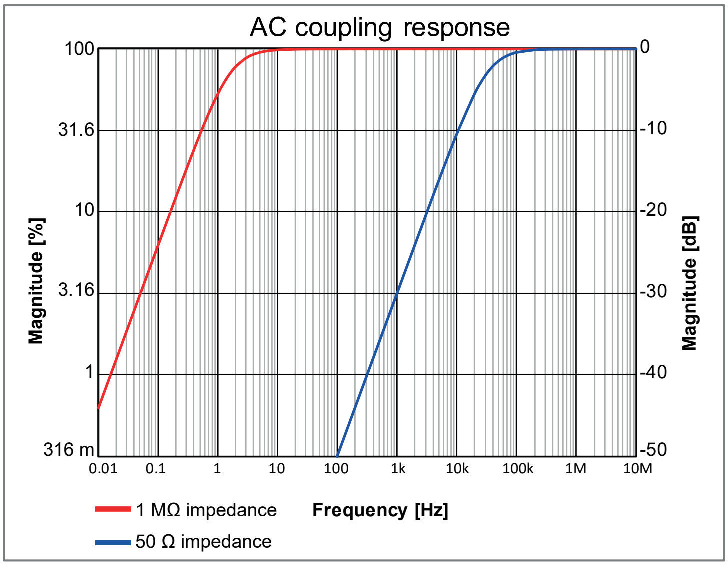


Figure 4: Representative AC coupling response

Ranges	
1 MΩ impedance	± 10 mV, ± 20 mV, ± 50 mV, ± 0.1 V, ± 0.2 V, ± 0.5 V, ± 1 V, ± 2 V, ± 5 V, ± 10 V, ± 20 V, ± 50 V, ± 100 V
50 Ω impedance	± 10 mV, ± 20 mV, ± 50 mV, ± 0.1 V, ± 0.2 V, ± 0.5 V, ± 1 V, ± 2 V, ± 5 V
Offset	± 50% in 1000 steps (0.1%); When 1 MΩ input is selected, the ± 100 V range has fixed 0% offset. When 50 Ω input is selected, the ± 5 V range has fixed 0% offset.
Overvoltage impedance change	The activation of the overvoltage protection system results in a reduced input impedance. The overvoltage protection is not active for as long as the input voltage remains less than 200% of the selected input range or 125 V, whichever value is the smallest.
Maximum nondestructive voltage	
1 MΩ impedance	± 125 V DC
50 Ω impedance	± 7 V DC
Overload recovery time	Restored to 0.1% accuracy in less than 40 ns after 200% overload

Voltage Specifications (Wideband)

	Pass/Fail limits
DC Reading error	0.125% of reading ± 75 µV
DC Range error	0.075% of range ± 175 µV
DC Reading error drift	250 ppm of reading / °C (139 ppm of reading / °F)
DC Range drift	± (175 ppm of range + 40 µV) / °C (± (98 ppm of range + 23 µV) / °F)
RMS Noise (50 Ω terminated)	0.075% of range ± 125 µV

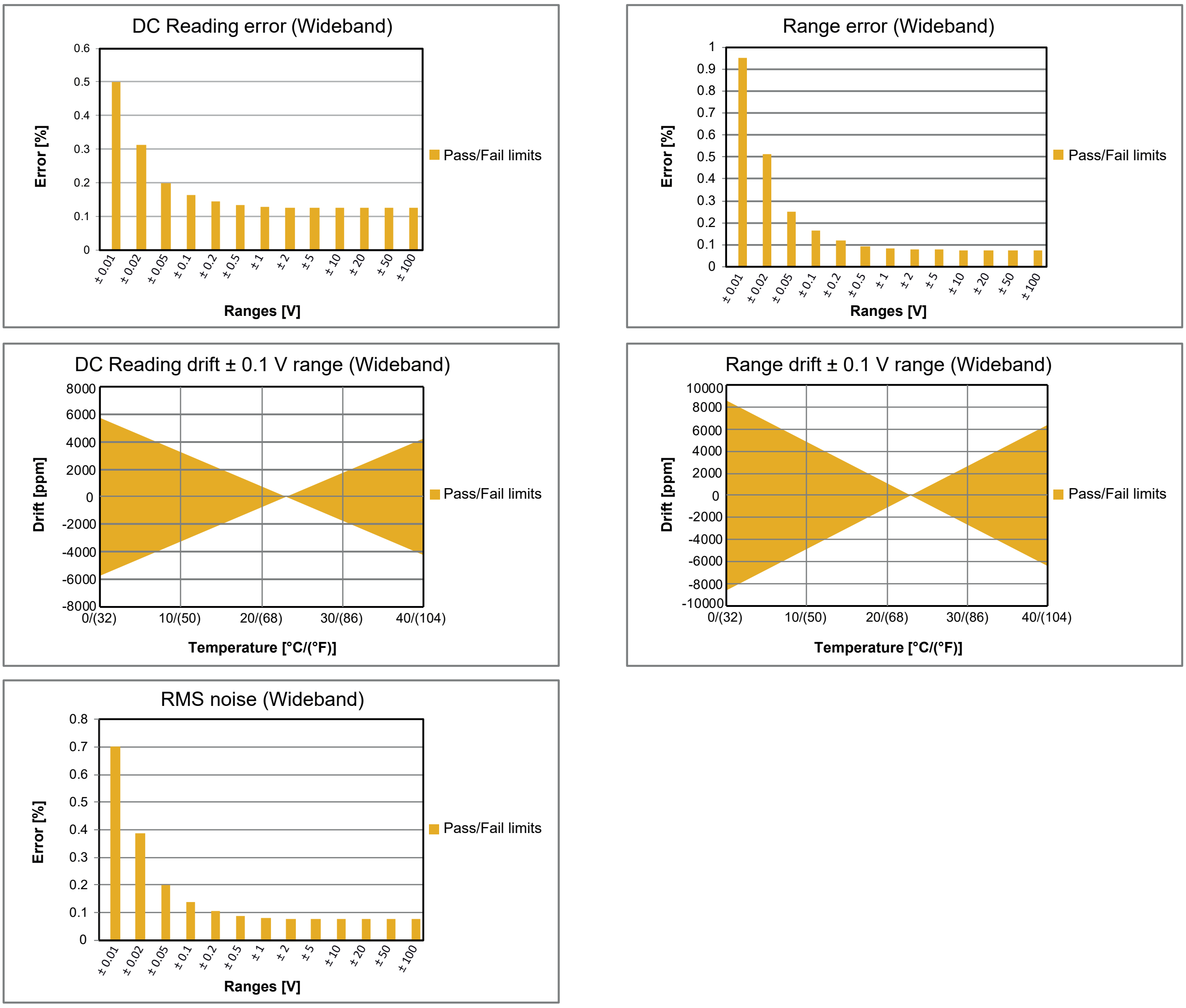


Figure 5: Wideband voltage specification

Voltage Specifications (Analog Filter Used)

	Pass/Fail limits
DC Reading error	0.125% of reading ± 75 µV
DC Range error	0.075% of range ± 175 µV
DC Reading error drift	250 ppm of reading / °C (139 ppm of reading / °F)
DC Range drift	± (225 ppm of range + 40 µV) / °C (± (125 ppm of range + 23 µV) / °F)
RMS Noise (50 Ω terminated)	0.075% of range ± 100 µV

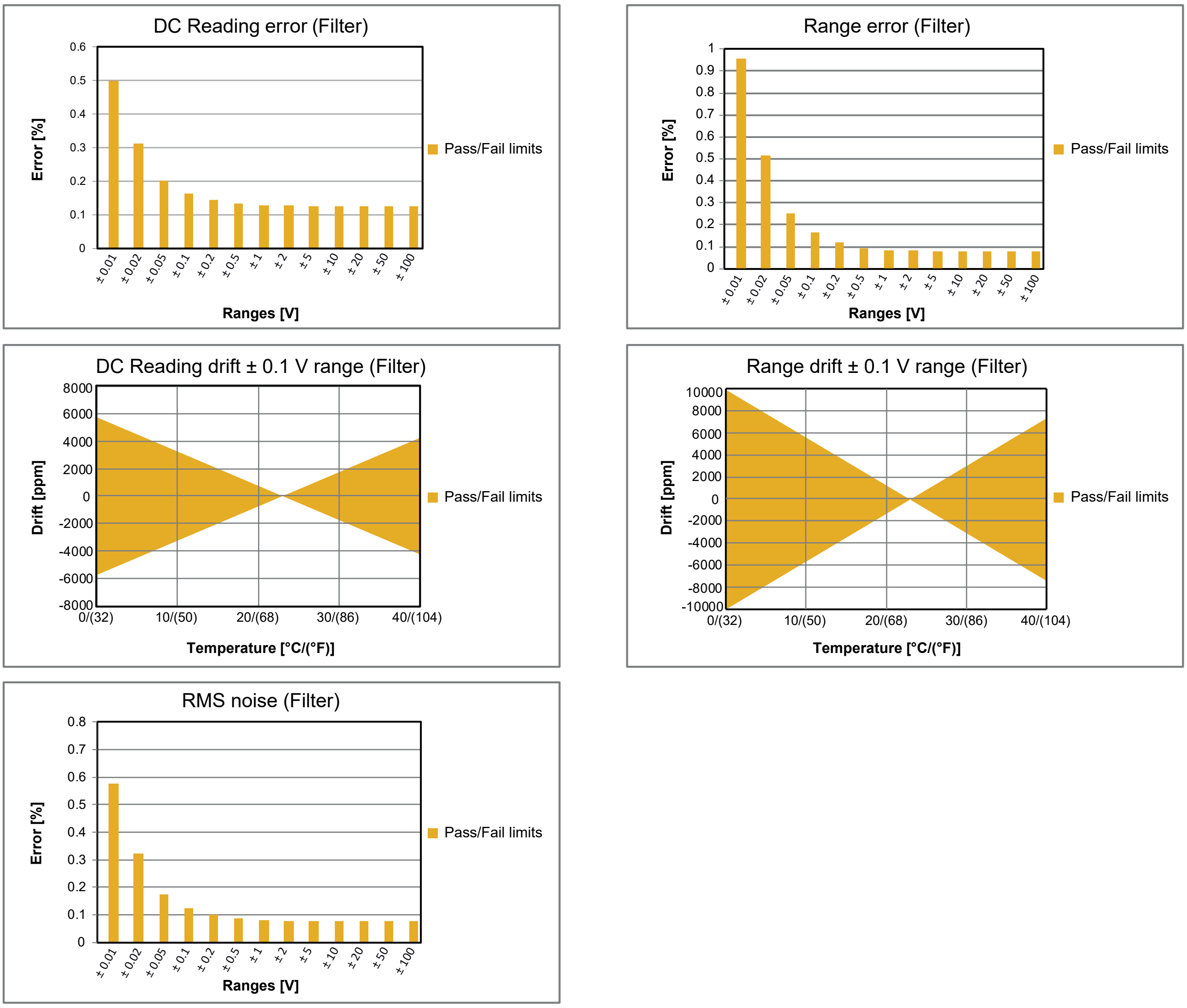


Figure 6: Filter used voltage specification

Channel Earthing

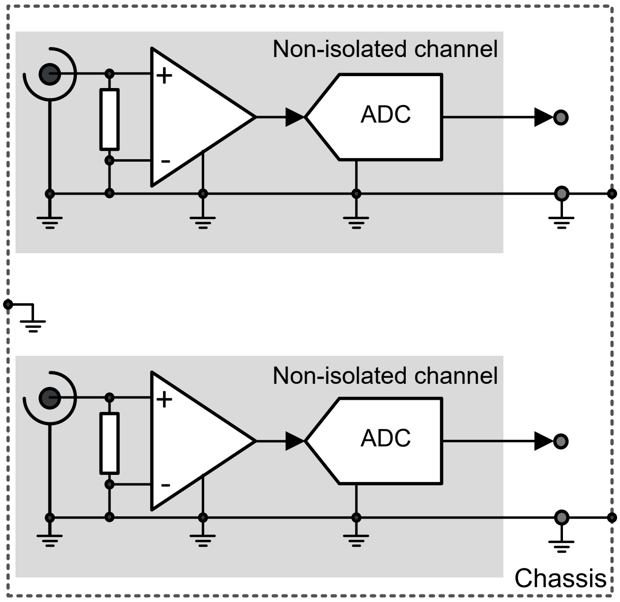


Figure 7: Earthing schematic

Analog to Digital Conversion	
Sample rate; per channel	10 S/s to 250 MS/s (GN8101B), 100 MS/s (GN8102B) or 25 MS/s (GN8103B)
ADC resolution; one ADC per channel	14 bit
ADC type	Pipelined multistep converter, Analog Devices AD9250
Time base accuracy	Defined by mainframe: ± 3.5 ppm; aging after 10 years ± 10 ppm
Binary sample rate	Supported; calculating FFTs results in rounded BIN values

Anti-Alias Filters

Using different filter selections (Wideband/Bessel/Bessel IIR) or different filter bandwidths can result in phase mismatches between channels.

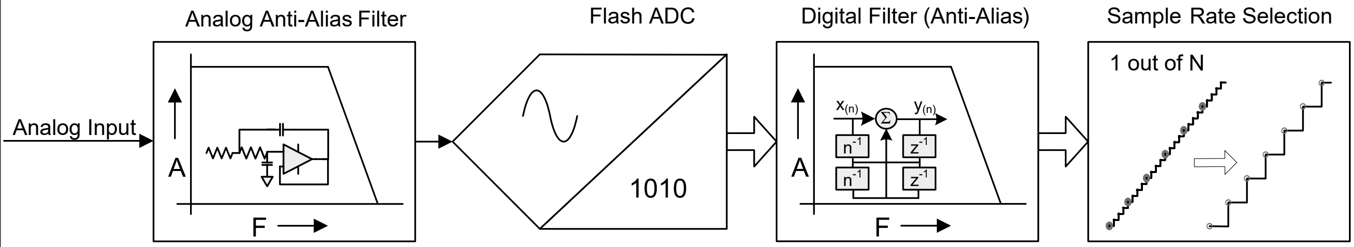


Figure 8: Combined analog and digital anti-alias filter block diagram

Anti-aliasing is prevented by a steep, fixed frequency analog anti-alias filter in front of the Analog to Digital Converter (ADC). The ADC always samples at a fixed sample rate. The fixed sample rate of the ADC avoids the need for different analog anti-alias filter frequencies.
Directly behind the ADC, the high precision digital filter is used as anti-alias protection before the digital downsampling to the desired user sample rate is performed. The digital filter supports a range of fixed bandwidth anti-alias filters. Compared to analog anti-alias filters, the programmable digital filter offers additional benefits like higher order filter with steep roll-off, a larger selection of filter characteristics, noise-free digital output and no additional phase shifts between channels that use the same filter settings.

Wideband	When wideband is selected, there is neither an analog anti-alias filter nor any digital filter in the signal path. Therefore, there is no anti-alias protection when wideband is selected. Wideband should not be used if working in a frequency domain with recorded data. Using wideband, enhanced resolution is not supported at lower sample rates.
Bessel (Fc @ -3 dB)	This analog Bessel filter can be used to reduce the higher bandwidth signals, but is also used to minimize aliasing at sample rates above 100 MS/s. For lower sample rates, the digital IIR filter must be used to prevent aliasing. Bessel filters are typically used when looking at signals in the time domain. They are best used for measuring transient signals or sharp edge signals like square waves or step responses. Using the Bessel filter, enhanced resolution is not supported at lower sample rates.
Bessel IIR (Fc @ -3 dB)	When Bessel IIR filter is selected, this is always a combination of an analog Bessel anti-alias filter and a digital Bessel IIR filter to prevent aliasing at lower sample rates. This can only be used for sample rates up to 100 MS/s. Bessel filters are typically used when looking at signals in the time domain. They are best used for measuring transient signals or sharp edge signals like square waves or step responses. Enhanced resolution is supported by using oversampling combined with a digital filter at the following sample rates: 15 bit resolution at 50 MS/s and lower, 16 bit resolution at 12.5 MS/s and lower.
Butterworth IIR (Fc @ -3 dB)	When Butterworth IIR filter is selected, this is always a combination of an analog Bessel anti-alias filter and a digital Butterworth IIR filter to prevent aliasing at lower sample rates. This can only be used for sample rates up to 100 MS/s. Butterworth filters are typically used when looking at signals in the frequency domain. They are best used for measuring continuous varying signals without sharp edge signals like square waves or step responses. Enhanced resolution is supported by using oversampling combined with a digital filter at the following sample rates: 15 bit resolution at 50 MS/s and lower, 16 bit resolution at 12.5 MS/s and lower.

Wideband (No Anti-Alias Protection)

When wideband is selected, there is neither an analog anti-alias filter nor any digital filter in the signal path. Therefore, there is no anti-alias protection when wideband is selected.

Wideband bandwidth	≥ ± 50 mV ranges: between 100 MHz and 160 MHz (-3 dB); ≤ ± 20 mV ranges: between 75 MHz and 100 MHz (-3 dB)
0.1 dB passband flatness	DC to 5 MHz[1]

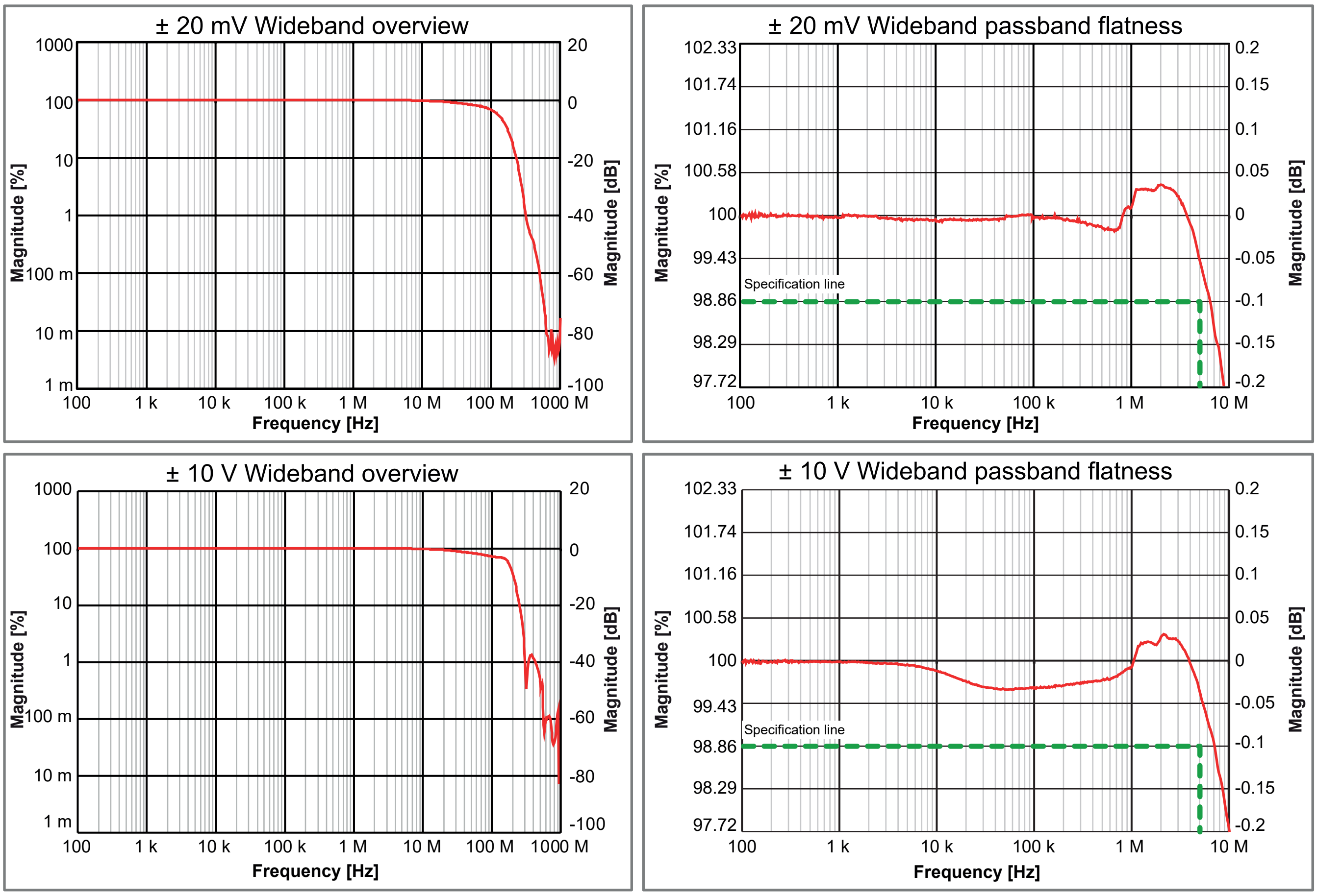
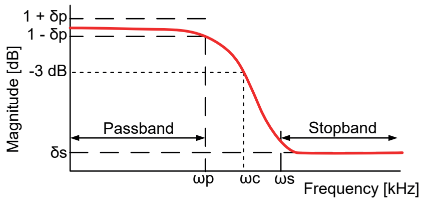


Figure 9: Representative Wideband examples

(1) Measured using Fluke 5730A calibrator, DC normalized and a Fluke 9500B calibrator for the card, when 1 MΩ input is selected.

Bessel Filter (Analog Anti-Alias)



δp: Passband ripple
δs: Stopband attenuation

ωp: Passband frequency
ωc: Corner frequency
ωs : Stopband frequency

Figure 10: Bessel Filter

When Bessel filter is selected, this is only the analog Bessel anti-alias filter and not a digital filter.	
Bessel filter bandwidth	32 MHz ± 3 MHz (-3 dB)
Bessel filter characteristic	6-pole Bessel, optimal step response
Bessel filter 0.1 dB passband flatness[1]	DC to 4 MHz
Stopband magnitude (δs) at frequency (ωs)	≥ ± 50 mV ranges: -50 dB at ωs = 700 MHz; ≤ ± 20 mV ranges: -70 dB at ωs = 700 MHz
Bessel filter roll-off	36 dB/Octave

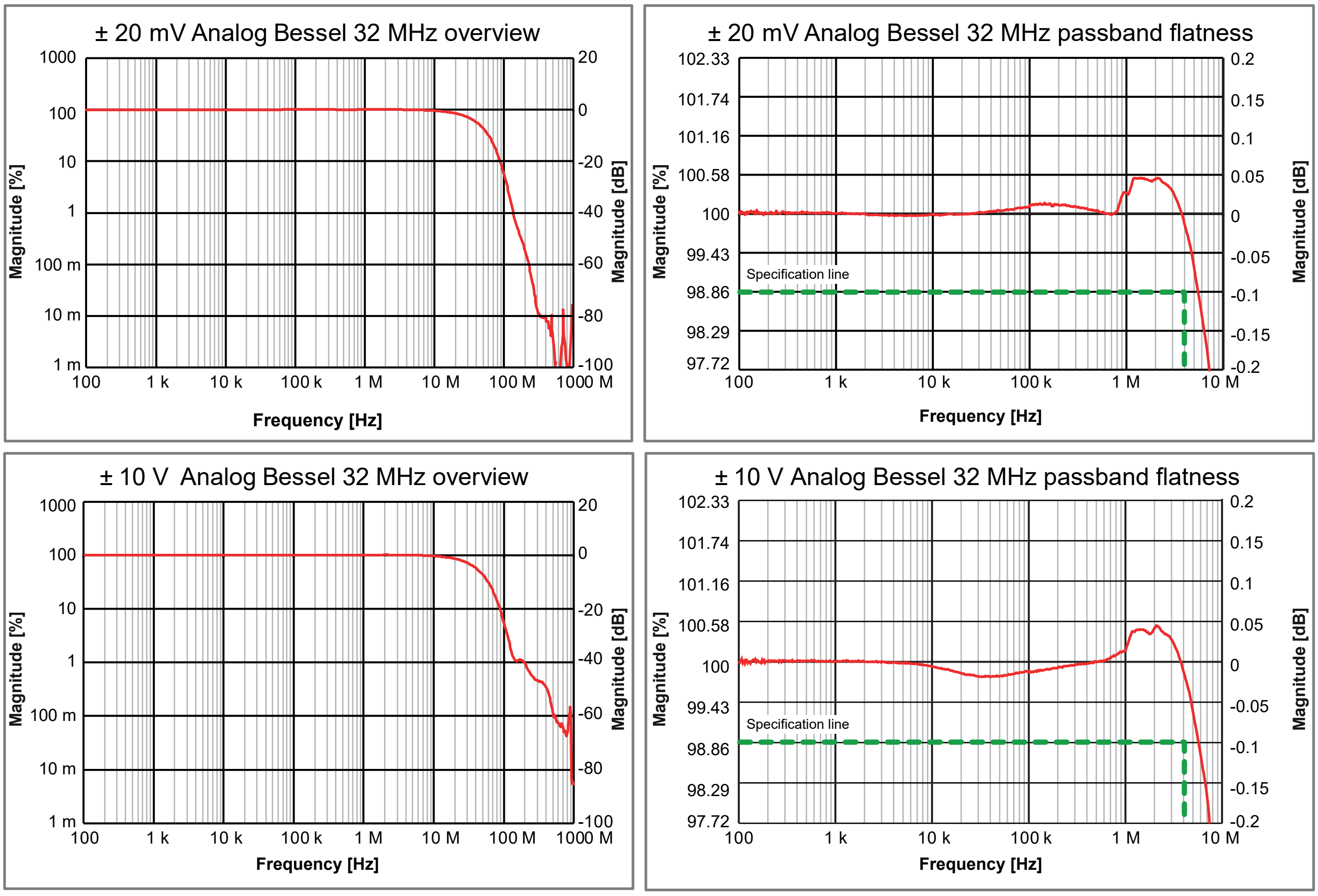
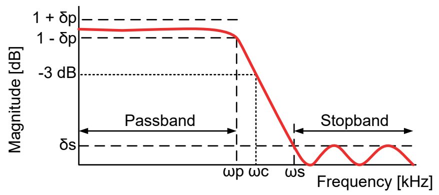


Figure 11: Representative Bessel examples

(1) Measured using Fluke 5730A calibrator, DC normalized and a Fluke 9500B calibrator for the card, when 1 MΩ input is selected.

Bessel IIR Filter (Digital Anti-Alias)



δp: Passband ripple
δs: Stopband attenuation
ωp: Passband frequency
ωc: Corner frequency
ωs: Stopband frequency

Figure 12: Digital Bessel IIR Filter

When Bessel IIR filter is selected, this is always a combination of an analog Bessel anti-alias filter and a digital Bessel IIR filter.

Analog anti-alias filter bandwidth	32 MHz ± 3 MHz (-3 dB)
Analog anti-alias filter characteristic	6-pole Bessel, optimal step response
Bessel IIR filter characteristic	8-pole Bessel style IIR
Bessel IIR filter user selection	Auto tracking for sample rate divided by: 10, 20, 40, 100 The user selects a division factor from the current sample rate; software then adjusts the filter when the sample rate is changed. Maximum sample rate: 100 MS/s (GN8101B/ GN8102B), 25 MS/s (GN8103B), minimum filter selection: 40 Hz.
Bessel IIR filter bandwidth (ωc)	User selectable from 40 Hz to 10 MHz
Bessel IIR 0.1 dB passband (ωp)(1)	DC to 0.1 * ωc or 2 MHz, whichever is lower
Stopband magnitude (δs) at frequency (ωs)	-80 dB at 8 * ωc With the Bessel IIR filter bandwidth selection at high corner frequencies, the magnitude can be more due to the analog anti-alias filter characteristic. At high bandwidth selections, the analog filter can increase this peak to -30 dB, see Figure 13.
Bessel IIR filter roll-off	48 dB/octave

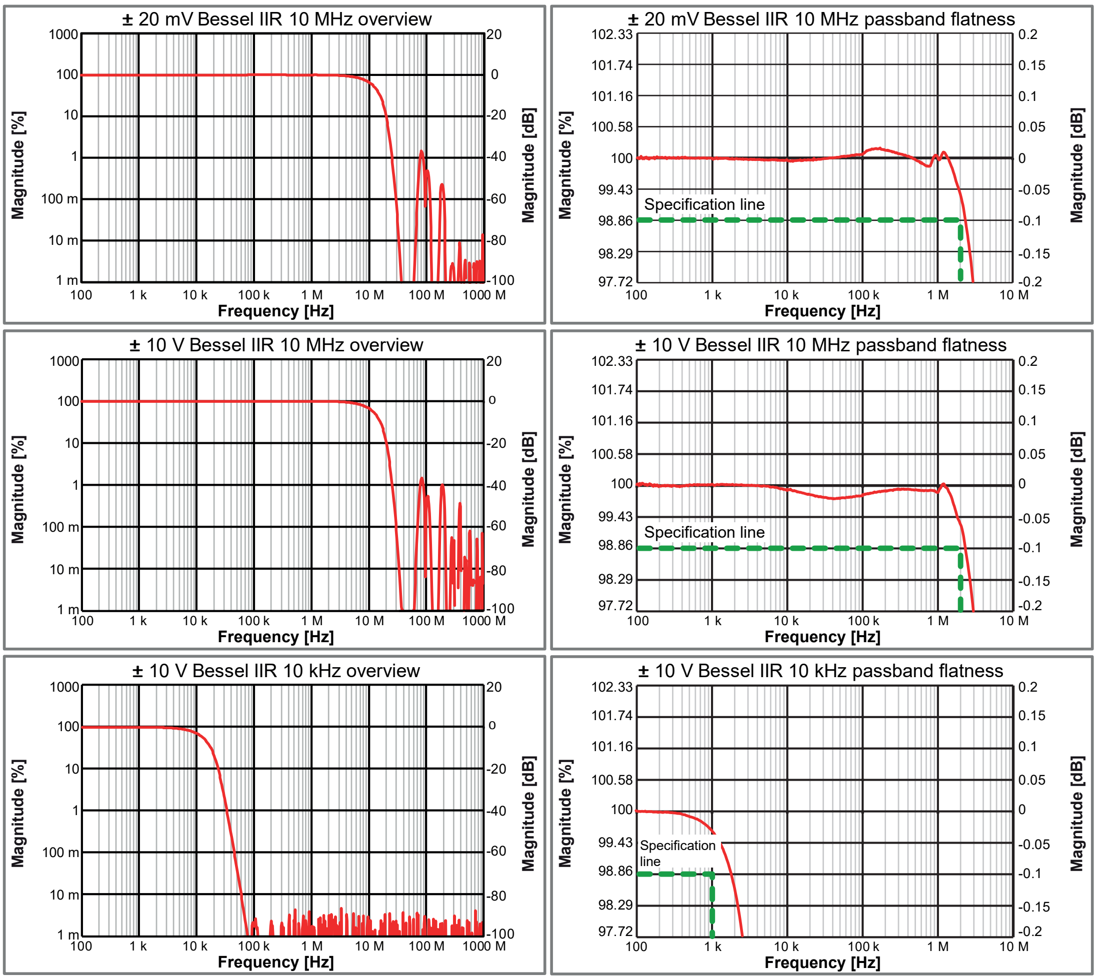
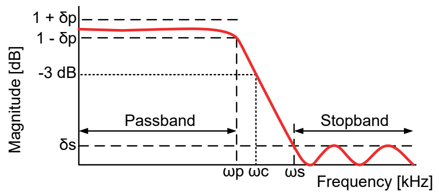


Figure 13: Representative Bessel IIR examples

(1) Measured using Fluke 5730A calibrator, DC normalized and a Fluke 9500B calibrator for the card, when 1 MΩ input is selected.

Butterworth IIR Filter (Digital Anti-Alias)



δp: Passband ripple
δs: Stopband attenuation
ωp: Passband frequency
ωc: Corner frequency
ωs: Stopband frequency

Figure 14: Digital Butterworth IIR Filter

When Butterworth IIR filter is selected, this is always a combination of an analog Bessel anti-alias filter and a digital Butterworth IIR filter.

Analog anti-alias filter bandwidth	32 MHz ± 3 MHz (-3 dB)
Analog anti-alias filter characteristic	6-pole Bessel, extended passband response
Butterworth IIR filter characteristic	8-pole Butterworth style IIR
Butterworth IIR filter user selection	Auto tracking for sample rate divided by: 4, 10, 20, 40 The user selects a division factor from the current sample rate; software then adjusts the filter when the sample rate is changed. Maximum sample rate: 100 MS/s (GN8101B/GN8102B), 25 MS/s (GN8103B), minimum filter selection: 50 Hz.
Butterworth IIR filter bandwidth (ωc)	User selectable from 50 Hz to 25 MHz
Butterworth IIR 0.1 dB passband (ωp)(1)	DC to 0.7 * ωc or 4 MHz, whichever is lower
Stopband magnitude (δs) at frequency (ωs)	-80 dB at 4 * ωc With the Butterworth IIR filter bandwidth selection at high corner frequencies, the magnitude can be more due to the analog anti-alias filter characteristic. At high bandwidth selections, the analog filter can increase this peak to -20 dB, see Figure 15.
Butterworth IIR filter roll-off	48 dB/octave

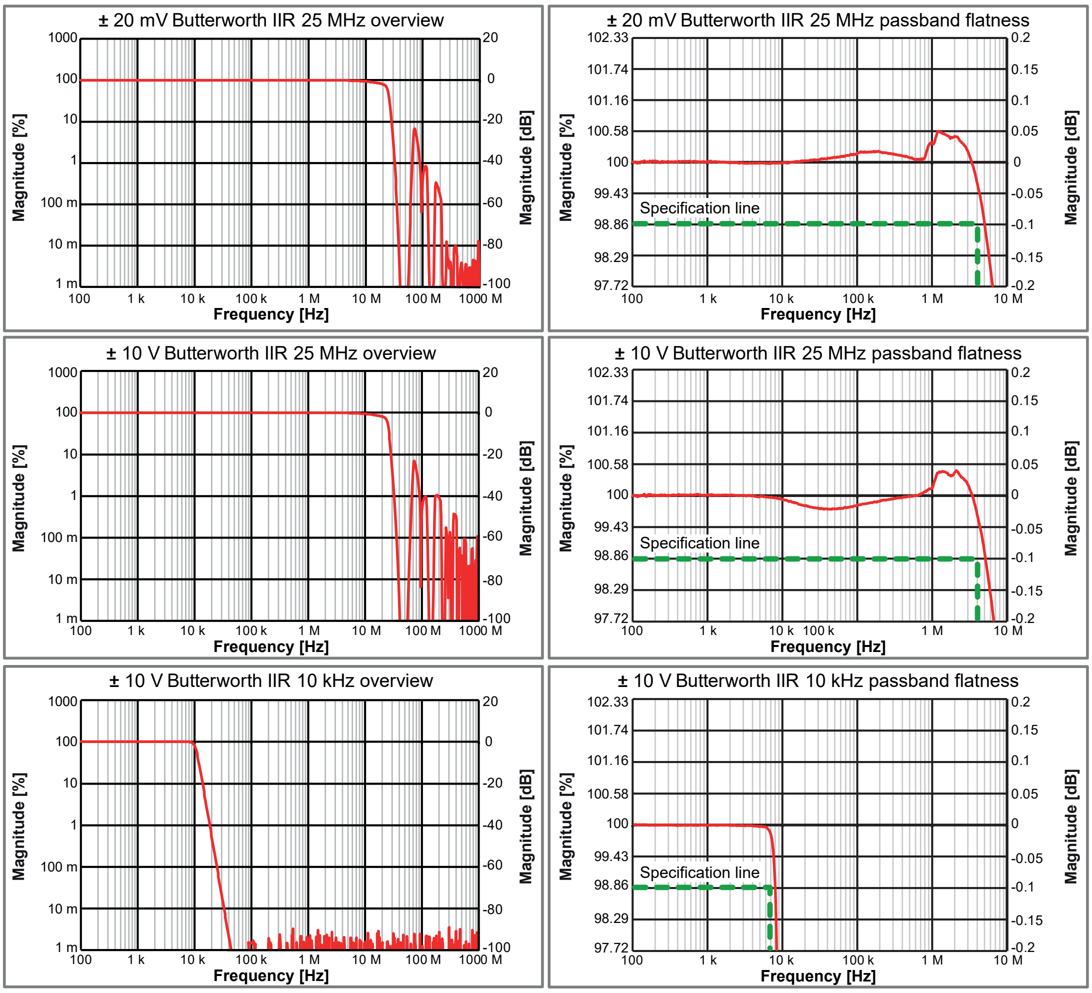


Figure 15: Representative Butterworth IIR examples

(1) Measured using Fluke 5730A calibrator, DC normalized and a Fluke 9500B calibrator for the card, when 1 MΩ input is selected.

Channel to Channel Phase Match

Using different filter selections (Wideband/analog Bessel/Bessel IIR/Butterworth IIR) or different filter bandwidths will lead to phase mismatches between channels. Under a condition of a sample rate of 250 MS/s and a frequency from 100 kHz to 50 MHz or filter frequency, whichever has a smaller bandwidth.

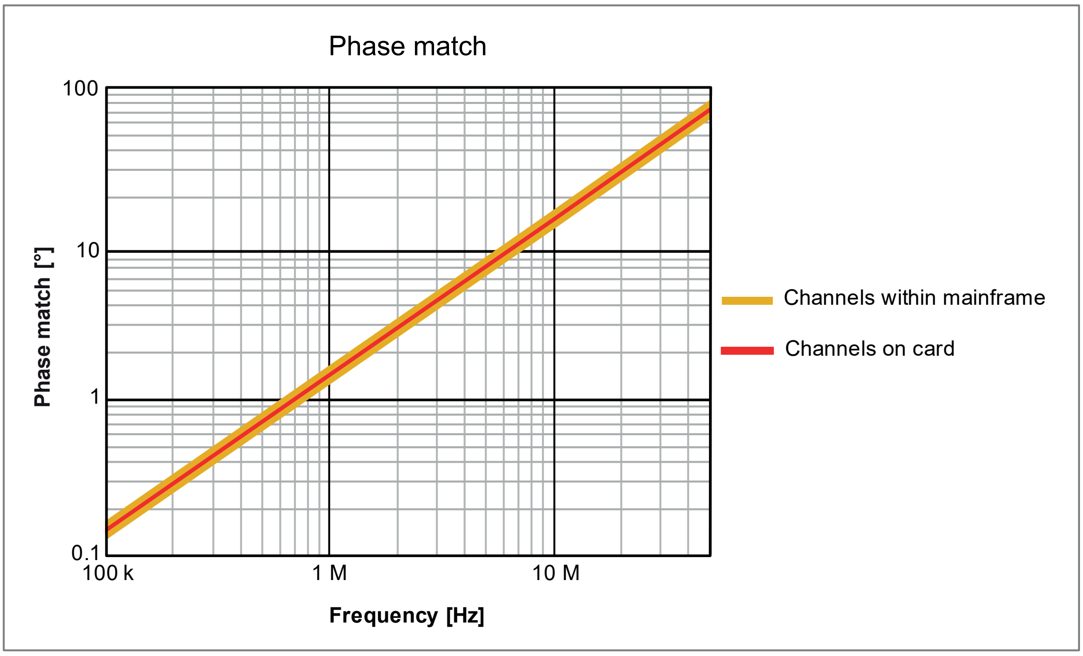


Figure 16: Representative channel to channel phase match

	All ranges
Wideband	
Channels on card	4 ns
Channels within mainframe	4 ns
Analog Bessel	
Channels on card	4 ns
Channels within mainframe	4 ns
Bessel IIR	
Channels on card	4 ns
Channels within mainframe	4 ns
Butterworth IIR	
Channels on card	4 ns
Channels within mainframe	4 ns
GN8101B/GN8102B/GN8103B channels across mainframes	Defined by synchronization method used (None, IRIG, GPS, Master/Sync)

Channel to Channel Crosstalk

Channel to channel crosstalk is measured with a 50 Ω termination resistor on the input and uses sine wave signals on the channel above and below the channel being tested. To test Channel 2, Channel 2 is terminated with 50 Ω, while Channels 1 and 3 are connected to the sine wave generator.

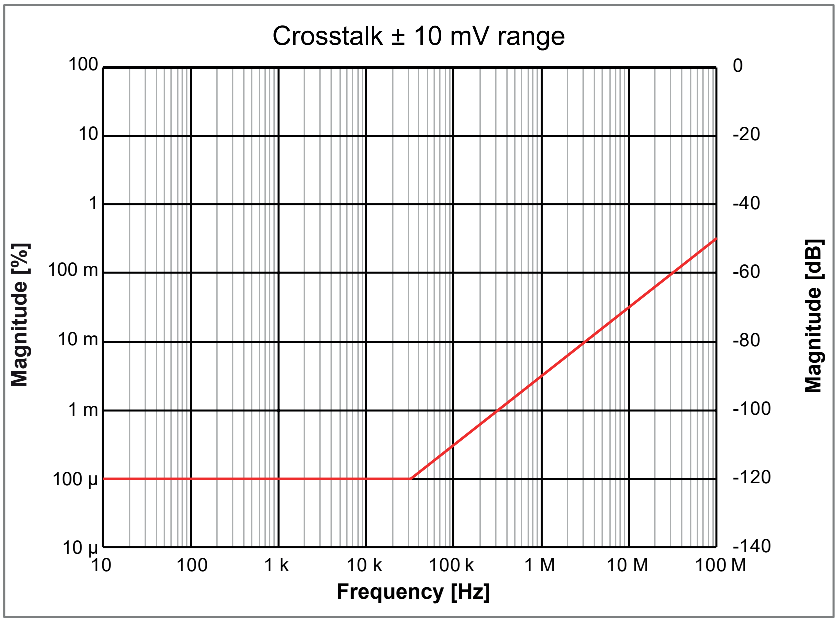


Figure 17: Representative crosstalk overview

Digital Event/Timer/Counter

The Digital Event/Timer/Counter input connector is located on the mainframe. For exact layout and pinning see mainframe data sheet.

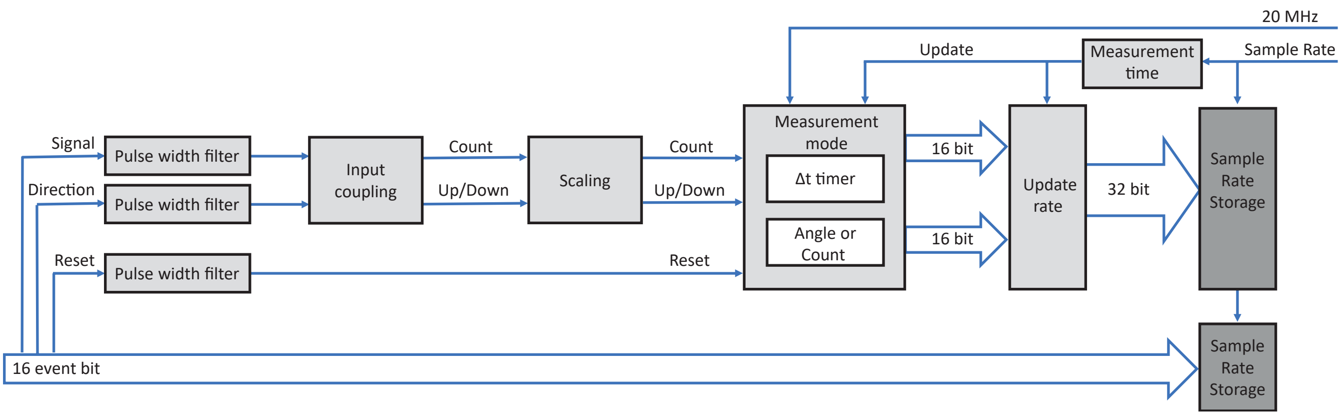


Figure 18: Timer/Counter block diagram

Card sample rate	Digital Event/Timer/Counter sample rate
≤10 MS/s and 20 MS/s	Sample rate
40 MS/s, 100 MS/s and 200 MS/s	20 MS/s limited by the 20 MS/s digital event sample rate on mainframe
12.5 MS/s, 25 MS/s, 50 MS/s, 125 MS/s and 250 MS/s	Not supported, mismatch with the 20 MS/s digital event sample rate on mainframe
Digital input events	16 per card
Levels	TTL input level, user programmable invert level
Inputs	1 pin per input, some pins are shared with Timer/Counter inputs
Overvoltage protection	User selectable: Recording active, set High or Low
Minimum pulse width	100 ns
Maximum frequency	5 MHz
Digital output events	2 per card
Levels	TTL output levels, short circuit protected
Output event 1	User selectable: Trigger, Alarm, set High or Low
Output event 2	User selectable: Recording active, set High or Low
Digital output event user selections	
Trigger	1 high pulse per trigger (on every channel trigger of this card only) 12.8 µs minimum pulse width 200 µs ± 1 µs ± 1 sample period pulse delay
Alarm	High when alarm condition of card is activated, low when not activated 200 µs ± 1 µs ± 1 sample period alarm event delay
Recording active	High when recording, low when in idle or pause mode Recording active output delay of 450 ns
Set High or Low	Output set High or Low; can be controlled by Custom Software Interface (CSI) extensions; delay depends on specific software implementation
Timer/Counter	2 per card
Levels	TTL input levels
Inputs	3 pins: signal, reset and direction All pins are shared with digital event inputs
Input coupling	Uni-directional, Bi-directional and ABZ incremental encoder (Quadrature)
Measurement modes	Count (C) Angle (0 to 360 degrees) Frequency (Δcount / Δt) RPM (Δcount / Δt / 60 s)
Timer accuracy	± 25 ns (20 MHz)
Measurement time	1 to n samples (User selectable maximum Δt)
Measurement time and reading update rate	Measurement time sets the maximum update rate of the Measurement values
Measurement time and minimum frequency	Minimum measured frequency or RPM = 1 / Measurement time

Input Coupling Uni- and Bi-directional Signal

Uni- and bi-directional input coupling is used when the direction signal is a stable signal.

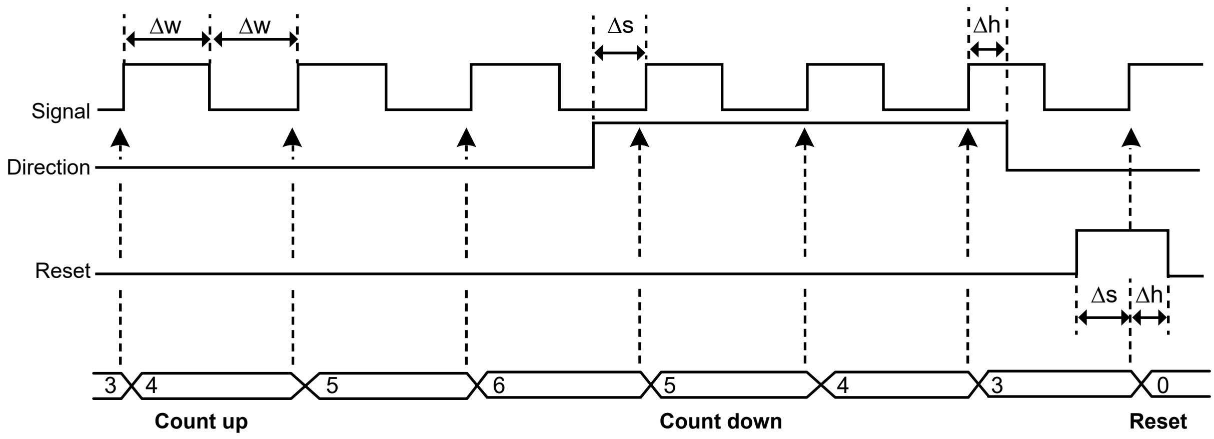


Figure 19: Uni- and Bi-directional timing

Inputs	3 pins: signal, reset and direction (only used in bi-directional count)
Minimum pulse width filter	100 ns, 200 ns, 500 ns, 1 µs, 2 µs, 5 µs
Maximum input signal frequency	4 MHz
Minimum pulse width (Δw)	100 ns
Reset input	
Level sensitivity	User selectable invert level
Minimum setup time prior to signal edge (Δs)	100 ns
Minimum hold time after signal edge (Δh)	100 ns
Reset options	
Manual	Upon user request by software command
Start recording	Count value set to 0 at Start of recording
First reset pulse	After the recording is started, the first reset pulse sets the counter value to 0. The next reset pulses are ignored.
Each reset pulse	On each external reset pulse, the counter value is reset to 0.
Direction input	
Input Level sensitivity	Only used when in bi-directional mode Low: increment counter/positive frequency High: decrement counter/negative frequency
Minimum setup time prior to signal edge (Δs)	100 ns
Minimum hold time after signal edge (Δh)	100 ns

Input Coupling ABZ Incremental Encoder (Quadrature)

Typically used for tracking rotating/moving devices using a decoder with two signals that are always 90 degree phase shifted. E.g. allow for direct interfacing to HBM torque and speed transducers.

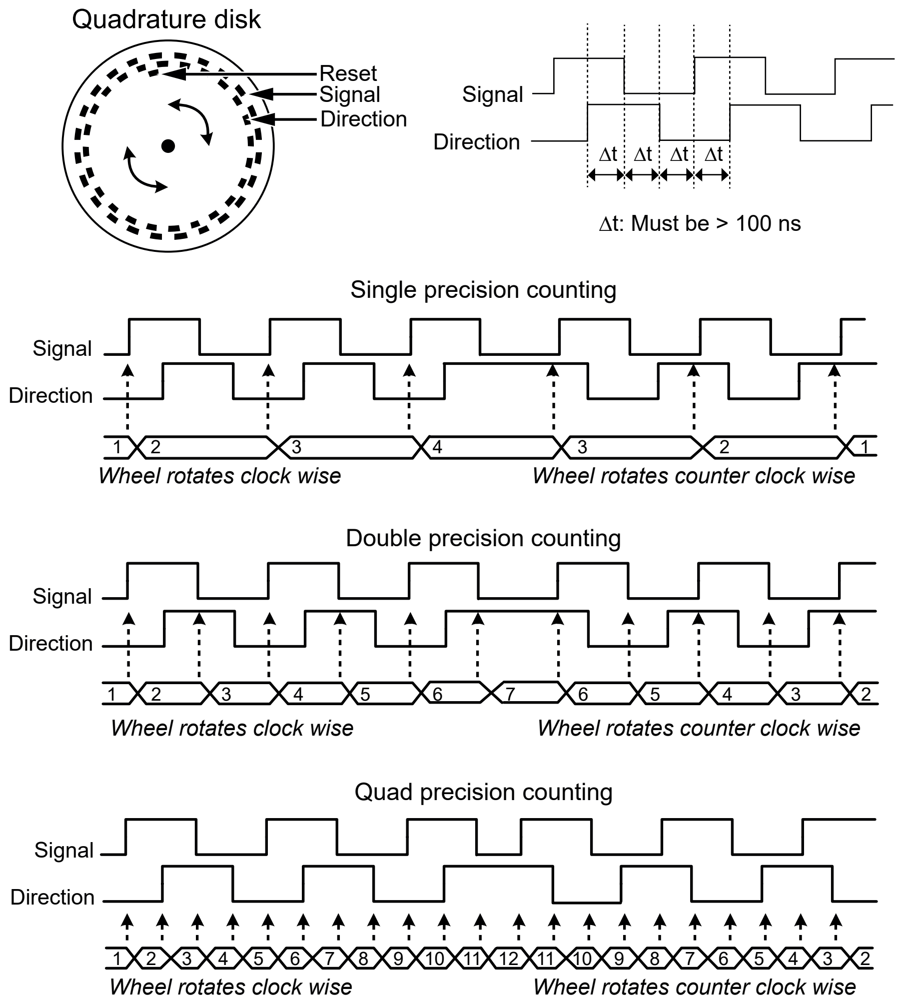
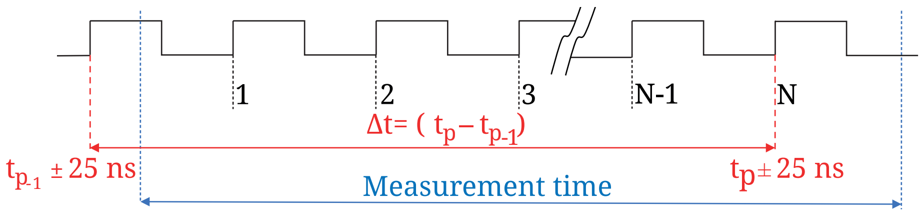


Figure 20: Bi-directional quadrature count modes

Inputs	3 pins: signal, direction and reset
Minimum pulse width filter	100 ns, 200 ns, 500 ns, 1 µs, 2 µs, 5 µs
Maximum input signal frequency	2 MHz
Minimum pulse width	200 ns (2 * Δt)
Minimum setup time	100 ns (Δt)
Minimum hold time	100 ns (Δt)
Accuracy	Single (X1), dual (X2) or quad (X4) precision
Input coupling	ABZ incremental encoder (Quadrature)
Reset input	
Level sensitivity	User selectable invert level
Minimum setup time prior to signal edge (Δt)	100 ns
Minimum hold time after signal edge (Δt)	100 ns
Reset options	
Manual	Upon user request by software command
Start recording	Count value set to 0 at Start of recording
First reset pulse	After the recording is started, the first reset pulse sets the counter value to 0. The next reset pulses are ignored.
Each reset pulse	On each external reset pulse, the counter value is reset to 0.

Measurement Mode Angle	
In angle measurement mode the counter will use a user defined maximum angle and revert back to zero when this count value is reached. Using the reset input the measured angle can be synchronized to the mechanical angle. The real-time calculators can extract the RPM from the measured angle independent from the mechanical synchronization.	
Angle options	
Reference	User selectable. Enables the use of the reset pin to reference the mechanical angle to the measured angle
Angle at reference point	User defined to specify mechanical reference point
Reset pulse	Angle value is reset to user defined “angle at reference point” value
Pulses per rotation	User defined to specify the encoder/count resolution
Maximum pulses per rotation	32767
Maximum RPM	30 * sample rate (Example: Sample rate 10 kS/s means maximum 300 k RPM)

Measurement Mode Frequency/RPM	
Used to measure any kind of frequency like engine RPM, or active sensors with proportional frequency output signal.	



$$Frequency = \frac{N}{(t_p - t_{p\text{-}1}) \pm 50\ \text{ns}}$$

Figure 21: Frequency measurement

Accuracy	0.1%, when using a measurement time of 40 µs or more. With lower measurement times, the real-time calculators or Perception formula database can be used to enlarge the measurement time and improve the accuracy more dynamically e.g. based on measured cycles.
Measurement time	Sample period (1 / sample rate) to 50 s. Minimum measurement time is 50 ns. Can be selected by user to control update rate independent of sample rate

Measurement Mode Count/Position	
Count/position mode is typically used for tracking movement of device under test. To reduce the sensitivity for count/position errors due to clock glitches use the minimum pulse width filter or enable the ABZ in stead of uni-/bipolar input coupling.	
Counter range	0 to 2^{31}; uni-directional count -2^{31} to $+2^{31}$ - 1; bi-directional count

Maximum Timer Inaccuracy

Timer accuracy is a tradeoff between update rate and minimum required accuracy. This table shows the relationships between measured signal frequency, selected measurement time (update rate) and timer accuracy. The inaccuracy distribution is to be considered rectangular.

Calculate the inaccuracy by using:

$$\text{Inaccuracy} = \pm\left(\frac{(signal\ \ frequency\ \ * 50\ ns)}{INTEGER\ (\ (signal\ \ frequency\ \ \text{-}1) * \text{measurement time})}\right) * 100\%$$

Measurement	Higher signal frequencies: Signal frequency (2 MHz down to 10 kHz)									
	2 MHz	1 MHz	500 kHz	400 kHz	200 kHz	100 kHz	50 kHz	40 kHz	20 kHz	10 kHz
1 µs	±10.000%									
2 µs	±3.333%	±5.000%								
5 µs	±1.111%	±1.250%	±1.333%	±2.000%						
10 µs	±0.526%	±0.556%	±0.625%	±0.667%	±1.000%					
20 µs	±0.256%	±0.263%	±0.278%	±0.286%	±0.333%	±0.500%				
50 µs	±0.101%	±0.102%	±0.103%	±0.105%	±0.111%	±0.125%	±0.133%	±2.000%		
0.1 ms	±0.050%	±0.051%	±0.051%	±0.051%	±0.053%	±0.056%	±0.063%	±0.067%	±0.100%	
0.2 ms	±0.025%				±0.026%	±0.026%	±0.028%	±0.029%	±0.033%	±0.050%
0.5 ms	±0.010%					±0.010%	±0.010%	±0.0011%	±0.0011%	±0.0013%
1 ms	±0.0050%					±0.0051%	±0.0051%	±0.0051%	±0.0053%	±0.0056%
2 ms	±0.0025%								±0.0026%	±0.0026%
5 ms	±0.0010%									
10 ms	±0.0005%									
20 ms	±0.00025%									
50 ms	±0.00010%									
100 ms	±0.00005%									

Measurement	Lower signal frequencies: Signal frequency (40 Hz to 5 kHz)									
	5 kHz	4 kHz	2 kHz	1 kHz	500 Hz	400 Hz	200 Hz	100 Hz	50 Hz	40 Hz
0.5 ms	±0.0133%	±0.0200%								
1 ms	±0.0063%	±0.0067%	±0.0100%							
2 ms	±0.0028%	±0.0029%	±0.0033%	±0.0050%						
5 ms	±0.0010%	±0.0011%	±0.0011%	±0.0013%	±0.0013%	±0.0020%				
10 ms	±0.00051%	±0.00051%	±0.00053%	±0.00056%	±0.00063%	±0.00067%	±0.00100%			
20 ms	±0.00025%	±0.00025%	±0.00026%	±0.00026%	±0.00028%	±0.00029%	±0.00033%	±0.00050%		
50 ms	±0.00010%	±0.00010%	±0.00010%	±0.00010%	±0.00010%	±0.00011%	±0.00011%	±0.00130%	±0.00013%	±0.00020%
100 ms	±0.000050%	±0.000050%	±0.000050%	±0.000051%	±0.000051%	±0.000051%	±0.000053%	±0.000056%	±0.000063%	±0.000067%

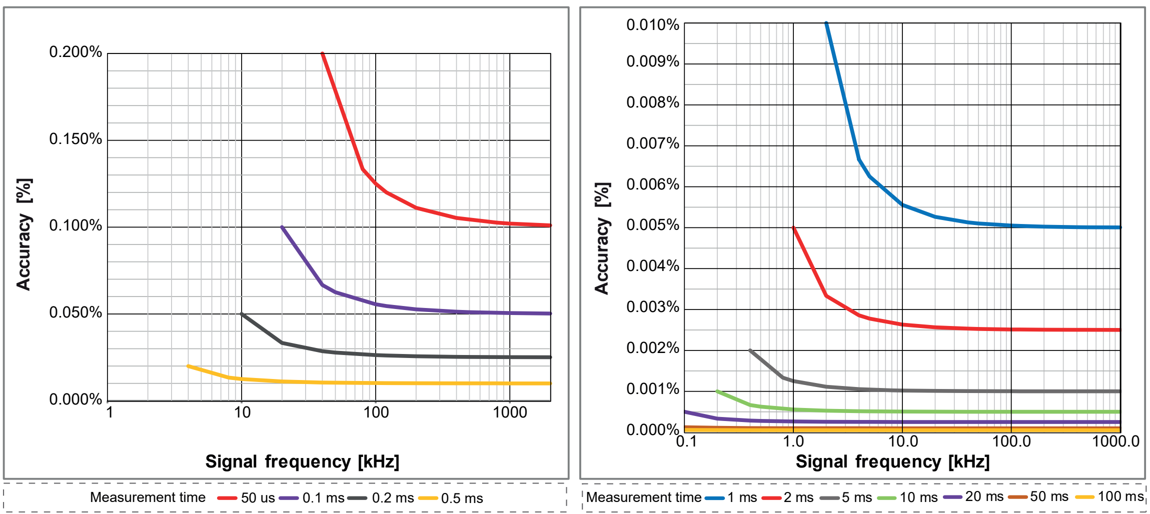


Figure 22: Maximum Timer Inaccuracy

Torque Measurement Uncertainty using Frequency Measurements

When using the Timer/Counter channels to measure torque, the measurement uncertainty introduced by the timer inaccuracies can be calculated using the following examples based on HBK T40 torque transducers.
The T40 torque transducer comes with 3 variants for frequency output: 10 kHz, 60 kHz or 240 kHz center frequency.
From the datasheets you can extract the minimum and maximum frequency output like table below.

T40 Variant	-Full Scale frequency output	+Full Scale frequency output
T40 - 10 kHz	5 kHz	15 kHz
T40 - 60 kHz	30 kHz	90 kHz
T40 - 240 kHz	120 kHz	360 kHz

Overlay these operating ranges on top of the timer inaccuracy plots of Figure 22 will result in Figure 23 (see below).

- Remains the step to balance the update rate (torque bandwidth) versus the torque accuracy required.
- Calculate the inaccuracy using the -Full Scale frequency output and desired measurement time.
- Using a minimum of 60 RPM the following inaccuracies are calculated.

Selected measurement time	Maximum inaccuracy: T40 - 240 kHZ	Maximum inaccuracy: T40 - 60 kHZ	Maximum inaccuracy: T40 - 10 kHZ
50 µs (left red curve)	0.1200%	0.1500%	Not possible
100 µs (left purple curve)	0.0546%	0.0750%	Not possible
500 µs (left orange curve)	0.0101%	0.0107%	0.0125%
1 ms (right blue curve)	0.0050%	0.0052%	0.0063%
2 ms (right red curve)	0.0025%	0.0025%	0.0028%
5 ms (right grey curve)	0.0010%	0.0010%	0.0010%

For K=1 (70% probability) use the specified rectangular distribution and the maximum inaccuracy numbers and calculate:

```
Measurement uncertainty = Maximum inaccuracy * 0.58 (Conversion for rectangular distribution)
```

Measurement uncertainty K=1 (About 70% probability)	Maximum inaccuracy: T40 - 240 kHZ	Maximum inaccuracy: T40 - 60 kHZ	Maximum inaccuracy: T40 - 10 kHZ
50 µs (left red curve)	0.0696%	0.0870%	Not possible
100 µs (left purple curve)	0.0316%	0.0435%	Not possible
500 µs (left orange curve)	0.0059%	0.0062%	0.00725%
1 ms (right blue curve)	0.0029%	0.0029%	0.00365%
2 ms (right red curve)	0.00145%	0.0015%	0.00162%
5 ms (right grey curve)	0.00058%	0.0006%	0.00058%

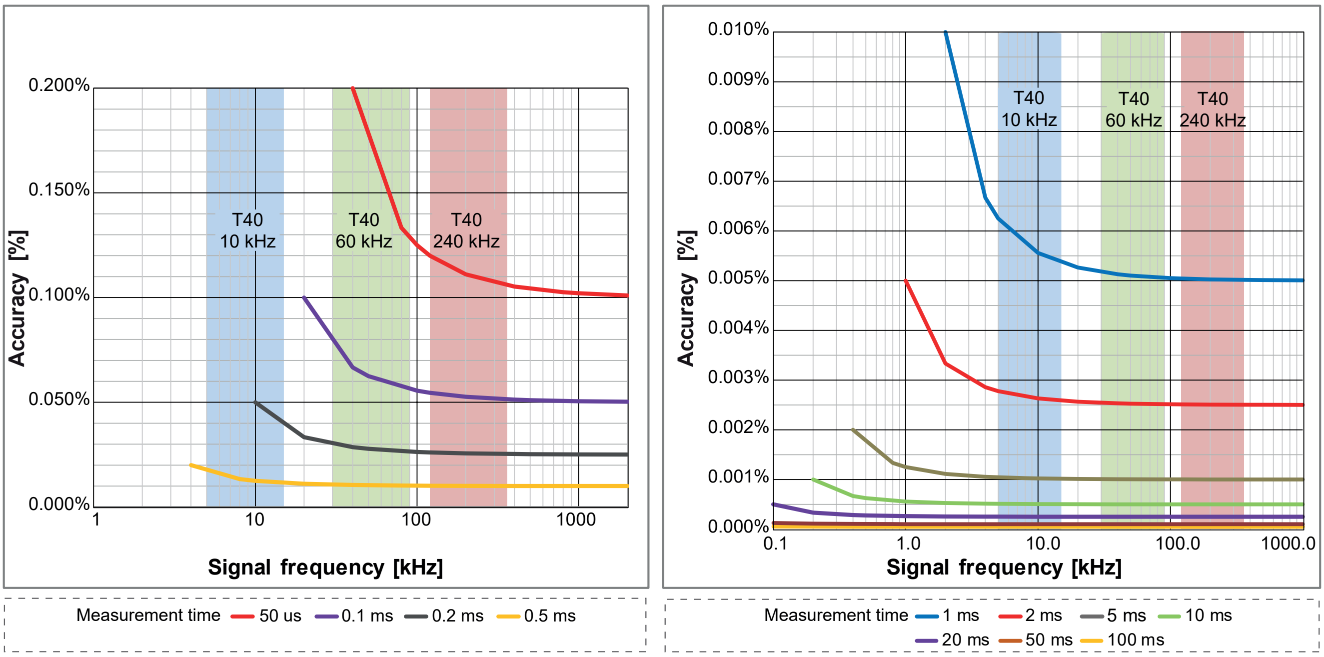


Figure 23: Torque operating range versus inaccuracy and measurement time

Speed (RPM) Measurement Uncertainty using Frequency Measurements

When using the Timer/Counter channels to measure speed (RPM), the measurement uncertainty introduced by the timer inaccuracies can be calculated using the following example.
In the datasheet of the speed sensor locate the specified number of pulse per rotation to calculate the frequency range of the sensor output:

```
Minimum frequency = minimum RPM used during testing * number of pulse per rotation / 60 sec
Maximum frequency = maximum RPM used during testing * number of pulse per rotation / 60 sec
```

Speed Sensor pulse per rotation	Frequency at 60 RPM	Frequency at 10 000 RPM	Frequency at 20 000 RPM
180	180 Hz	30 kHz	60 kHz
360	360 Hz	60 kHz	120 kHz
1024	1024 Hz	170.7 kHz	341.3 kHz

Overlay these operating ranges on top of the timer inaccuracy plots of Figure 22 will result in Figure 24 (see below).

- Remains the step to balance the update rate (torque bandwidth) versus the torque accuracy required.
- Using the graphs find the crossings of the overlayed operating frequencies with the measurement time curves.
- As examples the following crossings can be found in the graphs (at 60 RPM)..

Selected measurement time	180 pulse sensor	360 pulse sensor	1024 pulse sensor
2 ms (red curve)	Can't record at 60 RPM	Can't record at 60 RPM	0.00256%
5 ms (grey curve)	Can't record at 60 RPM	0.0018%	0.0010%
10 ms (Green curve)	0.0009%	0.0006%	0.00051%

For K=1 (70% probability) use the specified rectangular distribution and the maximum inaccuracy numbers and calculate:

```
Measurement uncertainty = Maximum inaccuracy * 0.58 (Conversion for rectangular distribution)
```

Measurement uncertainty K=1 (About 70% probability)	180 pulse sensor	360 pulse sensor	1024 pulse sensor
2 ms (red curve)	Can't record at 60 RPM	Can't record at 60 RPM	0.00148%
5 ms (grey curve)	Can't record at 60 RPM	0.00104%	0.00059%
10 ms (Green curve)	0.00052%	0.00035%	0.00030%

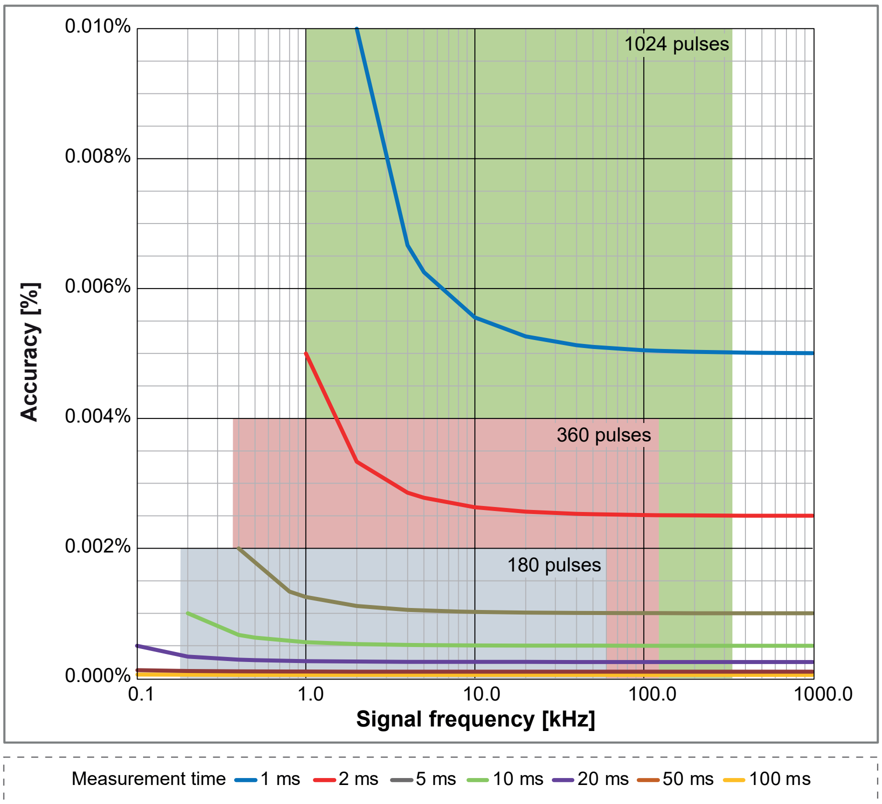


Figure 24: RPM sensor operating range versus inaccuracy and measurement time

Simultaneous Dynamic Torque Ripple and Accurate Torque Efficiency Measurement

If a high update rate is required to measure e.g. dynamic torque ripple yet for efficiency a high accuracy is required use both a measurement time of 50 µs as well as a RT-FDB function to calculate the mean value for each electric cycle.
The measured torque signal coming from the timer counter will be 0.15 to 0.17% accurate, while the torque calculate for the electric cycle (typically being 1 ms or less) results in 0.0075% accuracy.
As both signals are simultaneously available, the dynamic signal allows you to analyse the torque ripple behaviour, the electric cycle signal will be extremely accurate for efficiency calculations.

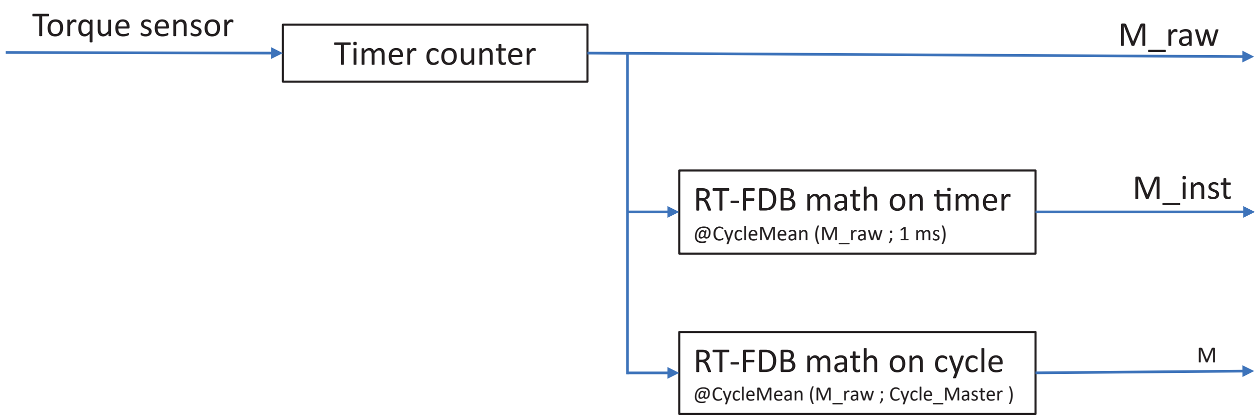


Figure 25: Simultaneous dynamic and accurate torque calculations

ePower signals	Application use	Dynamic response	10 kHz < f ≤ 100 kHz
M_raw	Torque ripple	Highest	Lowest
M_inst	Torque mean	Average	Average
M	Efficiency calculation	Lowest	Highest

Alarm Output

Selection per card	User selectable On/Off
Analog channel alarm modes	
Basic	Above or below level check
Dual	Outside or within bounds check
Analog channel alarm levels	
Levels	Maximum 2 level detectors
Resolution	16 bit (0.0015%) for each level
Event channel alarm modes	High or low level check
Cross channel alarms	Logical OR of alarms from all measured channels
Alarm output	Active during valid alarm condition, output supported through mainframe
Alarm output level	High or low user selectable
Alarm output delay	515 µs ± 1 µs + maximum 1 sample period. Default 516 µs, compatible with standard behavior. Minimum selectable delay is the smallest delay available for all acquisition cards used within the mainframe. Delay equal to Trigger Out delay.

Triggering	
Channel trigger/qualifier	1 per channel; fully independent per channel, software selectable either trigger or qualifier
Pre- and post-trigger length	0 to full memory
Maximum trigger rate	400 triggers per second
Maximum delayed trigger	1000 seconds after a trigger occurred
Manual trigger (Software)	Supported
External Trigger In	
Selection per card	User selectable On/Off
Trigger In edge	Rising/Falling mainframe selectable, identical for all cards
Minimum pulse width	500 ns
Trigger In delay	± 1 µs + maximum 1 sample period
Send to External Trigger Out	User can select to forward External Trigger In to the External Trigger Out BNC
External Trigger Out	
Selection per card	User selectable On/Off
Trigger Out level	High/Low/Hold High; mainframe selectable, identical for all cards
Trigger Out pulse width	High/Low: 12.8 µs Hold High: Active from first mainframe trigger to end of recording Pulse width created by mainframe; For details, please refer to the mainframe datasheet
Trigger Out delay	Selectable (10 µs to 516 µs) ± 1 µs + maximum 1 sample period Default 516 µs, compatible with standard behavior. Minimum selectable delay is the smallest delay available for all acquisition cards used within the mainframe
Cross channel triggering	
Measurement channels	Logical OR of triggers from all measured signals Logical AND of qualifiers from all measured signals
Calculated channels	Logical OR of triggers from all calculated signals (RT-FDB) Logical AND of qualifiers from all calculated signals (RT-FDB)
Analog channel trigger levels	
Levels	Maximum 2 level detectors
Resolution	16 bit (0.0015%) for each level
Direction	Rising/Falling; single direction control for both levels based on selected mode
Hysteresis	0.1 to 100% of Full Scale; defines the trigger sensitivity
Pulse detect/reject	Disable/Detect/Reject selectable. Maximum pulse width 65 535 samples
Analog channel trigger modes	
Basic	POS or NEG crossing; single level
Dual Level	One POS and one NEG crossing; two individual levels, logical OR
Analog channel qualifier modes	
Basic	Above or below level check. Enable/Disable trigger with single level
Dual	Outside or within bounds check. Enable/Disable trigger with dual level
Event channel trigger	
Event channels	Individual event trigger per event channel
Levels	Trigger on rising edge, falling edge or both edges
Qualifiers	Active High or Active Low for every event channel

On-board Memory	
Per card	8 GB (4 GS)
Organization	Automatically distributed amongst channels enabled for storage or real-time calculations
Memory diagnostics	Automatic memory test when system is powered on but not recording
Storage sample size analog and digital event channels	16 bits, 2 bytes/sample
Storage sample size Timer/Counter channels	32 bits, 4 bytes/sample

Real-time Formula Database Calculators (Option to be ordered separately)

The real-time formula database (RT-FDB) option offers an extensive set of math routines to enable almost any real-time mathematical challenge. The database structure enables the user to define a list of mathematical equations similar to the Perception review formula database.
The maximum supported sample rate is 2 MS/s.
Different versions of Perception can enable more or less features as described in GEN DAQ the mainframes manuals.

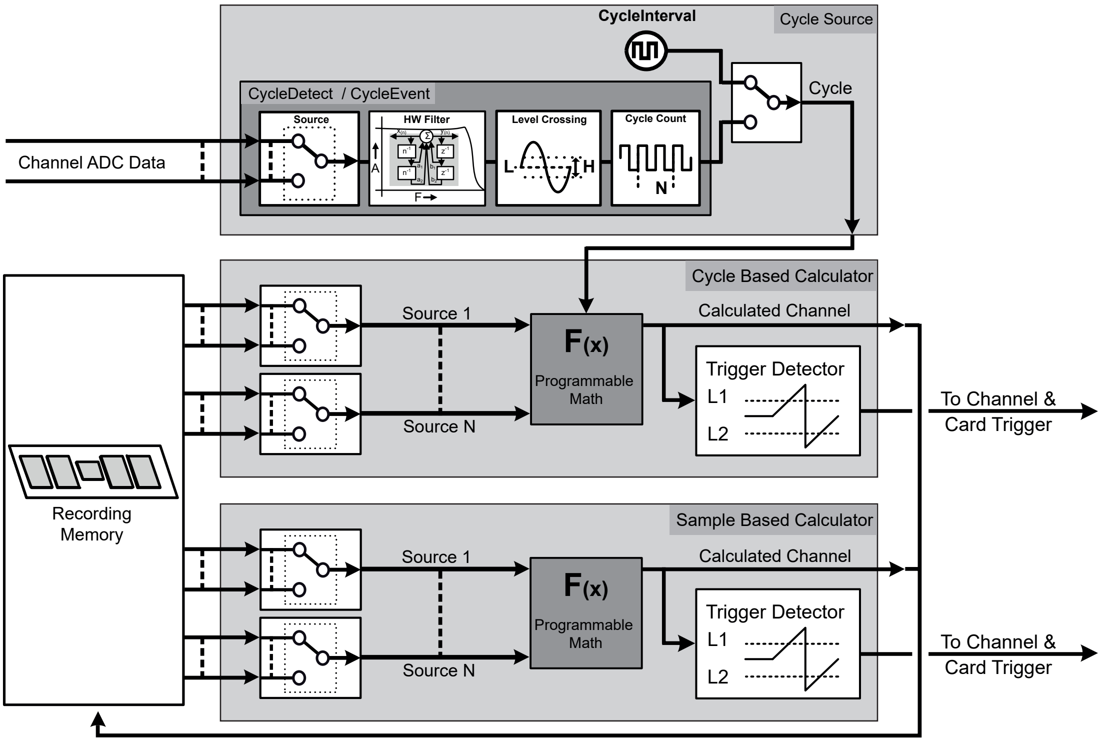


Figure 26: Real-time formula database (RT-FDB) calculators

The real-time formula database supports the following list of calculations (Details of each calculation are described in the manual).

Operation	Sample based results synchronous	Cycle based results asynchronous	Storage in PNRF recording	Real-time output
Basic calculations				
`+ (add)`	✓	✓	✓	✓ (1)
`- (subtract)`	✓	✓	✓	✓ (1)
`* (multiply)`	✓	✓	✓	✓ (1)
`/ (divide)`	✓	✓	✓	✓ (1)
Enhanced calculations				
`Abs`	✓	✓	✓	✓ (1)
`Atan`	✓	✓	✓	✓ (1)
`Atan2`	✓	✓	✓	✓ (1)
`Cosine`	✓	✓	✓	✓ (1)
`DegreesToRadians`	✓	✓	✓	✓ (1)
`Min`	✓	✓	✓	✓ (1)
`Max`	✓	✓	✓	✓ (1)
`Modulo`	✓	✓	✓	✓ (1)
`RadiansToDegrees`	✓	✓	✓	✓ (1)
`Sine`	✓	✓	✓	✓ (1)
`Sqrt`	✓	✓	✓	✓ (1)
`Tan`	✓	✓	✓	✓ (1)

Real-time Formula Database Calculators (Option to be ordered separately)				
Operation	**Sample based results synchronous**	**Cycle based results asynchronous**	**Storage in PNRF recording**	**Real-time output**
Boolean calculations				
`Equal`	✓	✓	✓	✓
`GreaterEqualThan`	✓	✓	✓	✓
`GreaterThan`	✓	✓	✓	✓
`LessEqualThan`	✓	✓	✓	✓
`LessThan`	✓	✓	✓	✓
`NotEqual`	✓	✓	✓	✓
`InsideBand`	✓	✓	✓	✓
`OutsideBand`	✓	✓	✓	✓
`And`	✓	✓	✓	✓
`Or`	✓	✓	✓	✓
`Xor`	✓	✓	✓	✓
`Not`	✓	✓	✓	✓
Cycle based calculations				
`CycleArea`		✓	✓	✓
`CycleBusDelay`		✓	✓	✓
`CycleCount`		✓	✓	✓
`CycleCrestFactor`		✓	✓	✓
`CycleEnergy`		✓	✓	✓
`CycleFundamentalPhase`		✓	✓	✓(2)
`CycleFundamentalRMS`		✓	✓	✓
`CycleFrequency`		✓	✓	✓
`CycleMax`		✓	✓	✓
`CycleMean`		✓	✓	✓
`CycleMin`		✓	✓	✓
`CyclePeak2Peak`		✓	✓	✓
`CyclePhase`		✓	✓	✓
`CycleRMS`		✓	✓	✓
`CycleRPM`		✓	✓	✓
`CycleSampleCount`		✓	✓	✓
`CycleTHD`(2)		✓	✓	✓
Cycle source				
`CycleDetect`(4)		✓	✓	
`CycleEvent`		✓	✓	
`CycleInterval`		✓	✓	

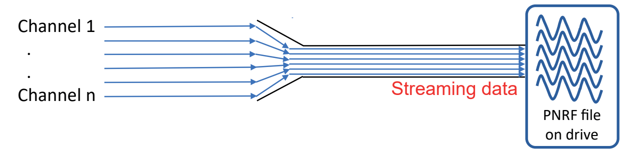
Real-time Formula Database Calculators (Option to be ordered separately)				
Operation	Sample based results synchronous	Cycle based results asynchronous	Storage in PNRF recording	Real-time output
Hardware based signal filtering				
`HWFilter`(4)	✓		✓	
Software based signal filtering				
`FilterBesselBP`	✓		✓	
`FilterBesselHP`	✓		✓	
`FilterBesselLP`	✓		✓	
`FilterButterworthBP`	✓		✓	
`FilterButterworthHP`	✓		✓	
`FilterButterworthLP`	✓		✓	
`FilterChebyshevBP`	✓		✓	
`FilterChebyshevHP`	✓		✓	
`FilterChebyshevLP`	✓		✓	
Special category calculation				
`HarmonicsIEC61000`	✓		✓	
`Integrate`	✓	✓	✓	✓
Signal transformation				
`DQZeroTransformation (Park)`(3)	✓		✓	✓ (1)
`SpaceVectorTransformation`(3)	✓		✓	
`SpaceVectorInverse Transformation`(3)	✓		✓	
Signal generation				
`SineWave`	✓		✓	
`Ramp`	✓		✓	
Trigger functions				
`TriggerOnBooleanChange`			Trigger mark	
`TriggerOnLevel`			Trigger mark	

(1) Only cycle based results can be used for real-time output. Use the CycleMean calculation on recorded channel data or sample based results to enable the real-time output of this data.
(2) The time required to calculate the output depends on maximum cycle length and sample rate. Depending on the selected settings the output latency will increase. HBM refers to these calculations as not deterministic. All real-time output published values (deterministic and/or not deterministic) will always have the same latency.
(3) This formula is only available if the eDrive license is added to Perception.
(4) The output of HWFilter is used for CycleDetect.

Real-time Statstream®	
Patent Number : 7,868,886 Real-time extraction of basic signal parameters. Supports real-time live scrolling and scoping waveform displays as well as real-time meters while recording. During recording reviews, it enhances speed for displaying and zooming extremely large recordings and it reduces the calculation time for statistical values on large data sets.	
Analog channels	Maximum, Minimum, Mean, Peak to Peak, Standard Deviation and RMS values
Event/Timer/Counter channels	Maximum, Minimum and Peak to Peak values

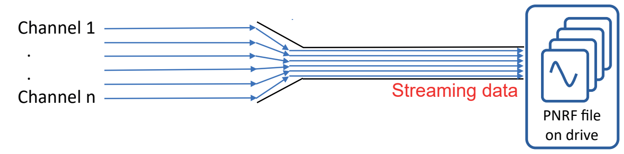
Data Recording Modes

On start of acquisition



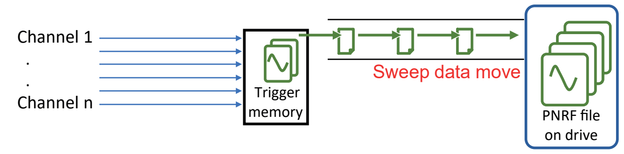
Data recording to PC or mainframe drive.
Data recording to a drive is limited by an **aggregate sample rate**, the recording time is limited by the **size of drive**.
Note: As the aggregate sample rate limit depends on Ethernet speed and storage drive used, as well as the PC and drive not being used for other purposes as data recording, it is strongly recommended for higher aggregate sample rates to test the chosen setup prior to performing your test.

Wait for trigger



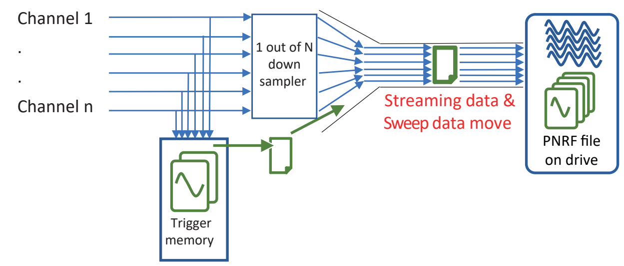
Triggered data recording to PC or mainframe drive.
Trigger data recording to a drive is limited by an **aggregate sample rate**, the recording time is limited by the size of drive.
Note: As the aggregate sample rate limit depends on Ethernet speed and storage drive used, as well as the PC and drive not being used for other purposes as data recording, it is strongly recommended for higher aggregate sample rates to test the chosen setup prior to performing your test.
Not recommended for transient/one time only/destructive tests.

Wait for trigger to trigger memory first



Triggered data recording to trigger memory on the acquisition card.
Triggered data recording to trigger memory has **no sample rate limits**, the recording time is limited by the **size of trigger memory**. Triggered data recorded in trigger memory is moved to a drive as quickly as possible.
Note: This data recording mode guarantees the data will always be recorded according to the user defined settings.
Recommended for transient/one time only/destructive tests.

On start of acquisition reduced rate and wait for trigger to trigger memory first

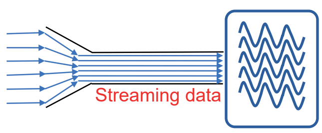


Data recording to PC or mainframe drive and simultaneous triggered data recording to trigger memory on the acquisition card.
The reduced rate data recording to a drive is limited by an **aggregate sample rate** and the recording time is limited by the **size of drive**.
The triggered data recording to trigger memory has **no sample rate limits,** the triggered data recording time is limited by the **size of trigger memory.** The triggered data recorded in trigger memory is moved to a drive as quickly as possible. As this data move happens simultaneously with the reduce rate data recording, it uses bandwidth of the aggregate sample rate.
Note: As the aggregate sample rate limit depends on Ethernet speed and storage drive used, as well as the PC and drive not being used for other purposes as data recording, it is strongly recommended for higher aggregate sample rates as well as higher number of triggers per second to test the chosen setup prior to performing your test.

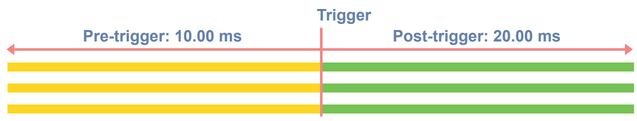
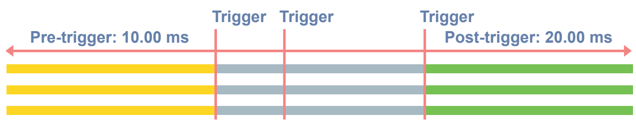
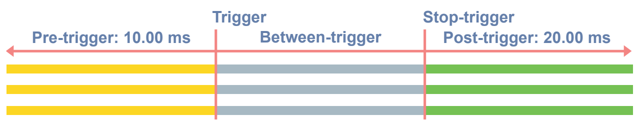
Data Recording Compared

	Aggregate sample rate limit	Maximum recorded data	Direct recording to drive	Trigger memory first	Trigger required to start recording
On start of acquisition	Yes	Free drive space	Yes	No	No
Wait for trigger	Yes	Free drive space	Yes	No	Yes
Wait for trigger to trigger memory first	No	Trigger memory	No	Yes	Yes
On start of acquisition reduced rate and wait for trigger to trigger memory first	Reduced rate: Yes	Free drive space	Yes	No	No
	Sample rate: No	Trigger memory	No	Yes	Yes

Aggregate sample rate limits when using streaming data



The maximum aggregate streaming rate per mainframe is defined by mainframe type and solid state drive, Ethernet speed, PC drive and other PC parameters.
When an aggregate sample rate is higher than the aggregate streaming rate of the system is selected, the memory on each acquisition card acts as a FIFO. As soon as this FIFO fills up, the recording is suspended (no data is recorded temporarily). During this period, the FIFO memory is transferred to a drive. When all FIFO's are empty, the recording is automatically resumed.
User notifications are added to the recording file for post recording identification of suspended recording.

Triggered Recording Definitions	
The details in this table apply to: • Wait for trigger • Wait for trigger to trigger memory first • On start of acquisition reduced rate and wait for trigger to trigger memory first	
Sweep 	 Defined by a trigger signal, pre- and post-trigger data and optionally between-trigger data and/or stoptrigger signal.
Triggered data segments	
Pre-trigger data	Data recorded prior to a trigger signal. **Note:** If a trigger signal is received before the full length of pre-trigger data is recorded, the trigger is accepted and the pre-trigger data recorded is automatically reduced to the available pre-trigger data at the time of the trigger.
Post-trigger data	Data recorded after a trigger or stop-trigger signal. **Note:** The recording of the post-trigger data can be re-started or delayed depending on the "*post-trigger begins on*" selection.
Between-trigger data	Data recorded due to re-trigger(s) or while waiting for the Stop-trigger. The length of between-trigger data is not specified and added based on the timing of the trigger or stop-trigger signals.
Trigger signals	
Trigger signal	This signal ends the pre-trigger and starts the post-trigger data recording. See table section "Post-trigger begins on" for more details. A trigger signal can be set up on external input trigger, analog and digital channels as well as using simple to complex RT-FDB formulas.
Stop-trigger signal	This signal starts the post-trigger data recording when in "post-trigger begins on stop-trigger" mode. See table section "Post-trigger begins on" for more details. A stop-trigger signals can be set up on external input trigger and simple to complex RT-FDB formulas.
Post-trigger begins on	
First trigger	 The first trigger signal ends the pre-trigger data recording and starts the recording of the post-trigger data. Any **trigger** received during the post-trigger data recording is ignored. Between-trigger data does not exist in this mode. The resulting sweep contains pre- and the post-trigger data.
Every trigger	 The first trigger ends the pre-trigger data recording and starts the recording of the post-trigger data. Any **trigger** received during the post-trigger data recording restarts the recording of post-trigger data. All recorded post-trigger data recorded at the time of the trigger is added to the between-trigger data. The resulting sweep contains pre-, between- and the post-trigger data.
Stop-trigger	 The trigger signal ends the pre-trigger data recording and starts the between-trigger data recording. The stop-trigger then ends the between-trigger data recording and starts the post-trigger data recording. Any **trigger** received during the between-trigger and post-trigger data recording is ignored. Any **stop-trigger** received during the pre-trigger and post-trigger data recording is ignored. The resulting sweep contains pre-, between- and the post-trigger data.

Trigger Memory Filled While Recording

The trigger memory is limited in size and can easily get filled when using high sample rates combined with high trigger rates. This section explains how triggers are handled when the trigger memory is completely filled.

Post-trigger begins on	Sweep recording selection
First trigger	A new sweep is only recorded if both pre- and post-trigger data fits in the free trigger memory at the time a trigger signal is received. When not enough free trigger memory is available, only the trigger time and trigger source get recorded (No pre- or post data is recorded).
Every trigger	A new sweep is started using the same rules as for the first trigger mode. If during the post-trigger recording a new trigger is received, the sweep is only extended with new post-trigger data if the additional post-trigger data fits the available free trigger memory. When not enough trigger memory is available, the already recorded pre-, between and post-trigger data for the previously received trigger(s) will be recorded.
Stop-trigger signal	A new sweep is only recorded if both pre-, 2.5 ms between and post-trigger data fits in the free trigger memory at the time a trigger signal is received. If no stop-trigger signal is received before the trigger memory fills up, the sweep recording is automatically stopped at the time the trigger memory is completely filled.

Triggered Recording Limits

The details in this table apply to:

- Wait for trigger
- Wait for trigger to trigger memory first
- On start of acquisition reduced rate and wait for trigger to trigger memory first

	Wait for trigger to trigger memory first **On start of acquisition reduced rate and wait for trigger to trigger memory first**		**Wait for trigger**	
Triggered data recording	Limited recording time		Use available size of drive	
Sample rate	Unlimited sample rates		Low to medium sample rates (Depending on system used)	
Channel count	Unlimited channel count		Low to medium channel counts (Depending on system used)	
Maximum number of sweeps				
In trigger memory	2000		Not applicable	
In PNRF recording file	200 000		1	
Sweep parameters	Minimum	Maximum	Minimum	Maximum
Pre-trigger length	0	Trigger memory of acquisition card	0	Available free drive space
Post-trigger length	0	Trigger memory of acquisition card	0	0
Sweep length	10 samples	Trigger memory of acquisition card	1 minute	Available free drive space
Maximum sweeps rate	400/s		Not applicable	
Minimum time between-triggers	2.5 ms		Not applicable	
Dead time between sweeps	0 ms		Not applicable	

Data Recording Details

Wait for trigger to trigger memory first

Single sweep Wait for Trigger High Sample Rate to Trigger Memory	1 channel	2 channels	3 channels	4 channels	5 channels	6 channels	7 channels	8 channels	8 channels 1 Timer/Counter	8 channels 2 Timer/Counters	8 channels 2 Timer/Counters Digital events
Maximum sweep memory	1000 MS	1000 MS	1000 MS	940 MS	740 MS	605 MS	510 MS	435 MS	340 MS	280 MS	250 MS
Maximum sweep sample rate	250 MS/s (GN8101B) 100 MS/s (GN8102B) 25 MS/s (GN8103B)								200 MS/s (GN8101B) 100 MS/s (GN8102B) 20 MS/s (GN8103B)		

On start of acquisition & wait for trigger

On start of acquisition reduced rate and high sample rate to trigger memory	1 channel	2 channels	3 channels	4 channels	5 channels	6 channels	7 channels	8 channels	8 channels 1 Timer/Counter	8 channels 2 Timer/Counters	8 channels 2 Timer/Counters Digital events
Maximum FIFO	3800 MS	1800 MS	1200 MS	900 MS	720 MS	600 MS	510 MS	450 MS	360 MS	280 MS	250 MS
Maximum sample rate	50 MS/s (GN8101B) 50 MS/s (GN8102B) 25 MS/s (GN8103B)								40 MS/s (GN8101B) 40 MS/s (GN8102B) 20 MS/s (GN8103B)		
Maximum aggregate streaming rate	25 MS/s	50 MS/s	75 MS/s	100 MS/s	125 MS/s	150 MS/s	175 MS/s	200 MS/s	200 MS/s	240 MS/s	260 MS/s

On start of acquisition reduced rate and wait for trigger to trigger memory first

Dual	1 channel	2 channels	3 channels	4 channels	5 channels	6 channels	7 channels	8 channels	8 channels 1 Timer/Counter	8 channels 2 Timer/Counters	8 channels 2 Timer/Counters Digital events
Max. sweep memory	1000 MS	1000 MS	1000 MS	745 MS	585 MS	477 MS	399 MS	342 MS	267 MS	217 MS	195 MS
Max. sweep sample rate	250 MS/s (GN8101B) 100 MS/s (GN8102B) 25 MS/s (GN8103B)								200 MS/s (GN8101B) 100 MS/s (GN8102B) 20 MS/s (GN8103B)		
Max. FIFO	800 MS	400 MS	260 MS	180 MS	144 MS	120 MS	103 MS	89 MS	68 MS	55 MS	50 MS
Max. continuous	The minimum of the Sweep Sample Rate / 2 and 50 MS/s								The minimum of the Sweep Sample Rate / 2 and 40 MS/s		
Max. aggregate streaming rate	25 MS/s	50 MS/s	75 MS/s	100 MS/s	125 MS/s	150 MS/s	175 MS/s	200 MS/s	200 MS/s	240 MS/s	260 MS/s

Environmental Specifications	
Temperature Range	
Operational	0 °C to +40 °C (+32 °F to +104 °F)
Non-operational (Storage)	-25 °C to +70 °C (-13 °F to +158 °F)
Thermal protection	Automatic thermal shutdown at 85 °C (+185 °F) internal temperature User warning notifications at 75 °C (+167 °F)
Relative humidity	0% to 80%; non-condensing; operational
Protection class	IP20
Altitude	Maximum 2000 m (6562 ft) above sea level; operational
Shock: IEC 60068-2-27	
Operational	Half-sine 10 g/11 ms; 3-axis, 1000 shocks in positive and negative direction
Non-operational	Half-sine 25 g/6 ms; 3-axis, 3 shocks in positive and negative direction
Vibration: IEC 60068-2-64	
Operational	1 g RMS, ½ h; 3-axis, random 5 to 500 Hz
Non-operational	2 g RMS, 1 h; 3-axis, random 5 to 500 Hz
Operational Environmental Tests	
Cold test IEC60068-2-1 Test Ad	-5 °C (+23 °F) for 2 hours
Dry heat test IEC 60068-2-2 Test Bd	+40 °C (+104 °F) for 2 hours
Damp heat test IEC 60068-2-3 Test Ca	+40 °C (+104 °F), humidity > 93% RH for 4 days
Non-Operational (Storage) Environmental Tests	
Cold test IEC-60068-2-1 Test Ab	-25 °C (-13 °F) for 72 hours
Dry heat test IEC-60068-2-2 Test Bb	+70 °C (+158 °F) humidity < 50% RH for 96 hours
Change of temperature test IEC60068-2-14 Test Na	-25 °C to +70 °C (-13 °F to +158 °F) 5 cycles, rate 2 to 3 minutes, dwell time 3 hours
Damp heat cyclic test IEC60068-2-30 Test Db variant 1	+25 °C/+40 °C (+77 °F/+104 °F), humidity > 95/90% RH 6 cycles, cycle duration 24 hours

Harmonized Standards for CE and UKCA Compliance, According to the Following Directives[1]	
Low Voltage Directive (LVD): 2014/35/EU **Electromagnetic Compatibility Directive (EMC): 2014/30/EU**	
Electrical Safety	
EN 61010-1 (2010)	Safety requirements for electrical equipment for measurement, control, and laboratory use - General requirements
EN 61010-2-030 (2010)	Particular requirements for testing and measuring circuits
Electromagnetic Compatibility	
EN 61326-1 (2013)	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements
Emission	
EN 55011	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics Conducted disturbance: class B; Radiated disturbance: class A
EN 61000-3-2	Limits for harmonic current emissions: class D
EN 61000-3-3	Limitation of voltage changes, voltage fluctuations and flicker in public low voltage supply systems
Immunity	
EN 61000-4-2	Electrostatic discharge immunity test (ESD); contact discharge ± 4 kV/air discharge ± 8 kV: performance criteria B
EN 61000-4-3	Radiated, radio-frequency, electromagnetic field immunity test; 80 MHz to 2.7 GHz using 10 V/m, 1000 Hz AM: performance criteria A
EN 61000-4-4	Electrical fast transient/burst immunity test Mains ± 2 kV using coupling network. Channel ± 2 kV using capacitive clamp: performance criteria B
EN 61000-4-5	Surge immunity test Mains ± 0.5 kV/± 1 kV Line-Line and ± 0.5 kV/± 1 kV/± 2 kV Line-earth Channel ± 0.5 kV/± 1 kV using coupling network: performance criteria B
EN 61000-4-6	Immunity to conducted disturbances, induced by radio-frequency fields 150 kHz to 80 MHz, 1000 Hz AM; 10 V RMS @ mains, 10 V RMS @ channel, both using clamp: performance criteria A
EN 61000-4-11	Voltage dips, short interruptions and voltage variations immunity tests Dips: performance criteria A; Interruptions: performance criteria C

(1) UKCA The manufacturer declares on its sole responsibility that the product is in conformity with the essential requirements of the applicable UK legislation and that the relevant conformity assessment procedures have been fulfilled.

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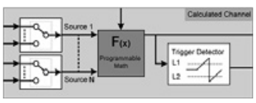
Ordering Information

Article		Description	Order No.
Basic 250 MS/s		250 MS/s per channel, 75 MHz bandwidth, 14 bit. 8 channels per card with 8 GB RAM/card. Single-ended metal BNC inputs; 1 MΩ or 50 Ω impedance; ± 10 mV to ± 100 V input range @ 1 MΩ; ± 10 mV to ± 5 V input range @ 50 Ω. Bessel analog anti-alias filter, with digital Bessel and Butterworth down sampling filters. 16 digital event and two Timer/Counter inputs. Supported by Perception V7.20 and higher	1-GN8101B
Basic 100 MS/s		100 MS/s per channel, 75 MHz bandwidth, 14 bit. 8 channels per card with 8 GB RAM/card. Single-ended metal BNC inputs; 1 MΩ or 50 Ω impedance; ± 10 mV to ± 100 V input range @ 1 MΩ; ± 10 mV to ± 5 V input range @ 50 Ω. Bessel analog anti-alias filter, with digital Bessel and Butterworth down sampling filters. 16 digital event and two Timer/Counter inputs. Supported by Perception V7.20 and higher	1-GN8102B
Basic 25 MS/s		25 MS/s per channel, 75 MHz bandwidth, 14 bit. 8 channels per card with 8 GB RAM/card. Single-ended metal BNC inputs; 1 MΩ or 50 Ω impedance; ± 10 mV to ± 100 V input range @ 1 MΩ; ± 10 mV to ± 5 V input range @ 50 Ω. Bessel analog anti-alias filter, with digital Bessel and Butterworth down sampling filters. 16 digital event and two Timer/Counter inputs. Supported by Perception V7.20 and higher	1-GN8103B

Option, to be ordered separately

Article		Description	Order No.
GEN DAQ real-time formula database calculators		Option to enable enhanced real-time calculators. Setup uses a user configurable formula database similar to the Perception formula database. All calculations are performed by the DSP of the acquisition card. Calculated results can be transferred to the GEN DAQ EtherCAT® option with a 1 ms latency.	1-GEN-OP-RTFDB

Current Probes (Options, to be ordered separately)			
Article		**Description**	**Order No.**
AC/DC current clamp i30s		AC/DC Hall effect current probe; 30 mA to 30 A DC; 30 mA to 20 A AC RMS; DC-100 kHz; BNC output cable 2 m (6.5 ft), incl. adapter for 4 mm safety banana, requires 9 V battery.	1-G912
AC current clamp SR661		AC current probe; 100 mA to 1200 A AC RMS; 1 Hz - 100 kHz; safety BNC output cable 2 m (6.5 ft).	1-G913
AC current clamp M1V20-2		Highly accurate AC current probe; 50 mA to 20 A; 30 Hz - 40 kHz; metal BNC output cable 2 m (6.5 ft).	1-G914

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