DATA SHEET

GEN series GN815 (GN816)
Basic/IEPE ISO 2 MS/s (200 kS/s) Input Card

SPECIAL FEATURES

- IEPE transducer support
- TEDS Class 1 support for IEPE
- Isolated, unbalanced differential inputs
- ± 10 mV to ± 50 V input range
- Analog/digital anti-alias filters
- 18 bit at 2 MS/s (200 kS/s) sample rate
- 8 analog channels
- 2 GB (200 MB) memory
- Isolated metal BNC per channel
- Real-time cyclic calculators
- Triggering on real-time power results
- Digital Event/Timer/Counter support
- 1 kV RMS CAT II probe
- 1 kV RMS differential probe
- Current clamps and burdens

GN815/GN816 Functions and Benefits

The GEN DAQ Basic/IEPE ISO 2 MS/s (200 kS/S) Input Card is a general purpose signal conditioner for use with voltage inputs, externally conditioned signals or probes and current clamps.
This card also supports IEPE transducers and TEDS Class 1 for easy setup of the acquisition channels. Built-in diagnostics supports automatic sensor connected, open or shorted detection.
The amplifier provides voltage inputs from ± 10 mV to ± 50 V. Optimum anti-alias protection is achieved by the 7-pole analog anti-alias filter combined with a fixed 2 MS/s sampling Analog-to-Digital converter. The digital filters operating at the full ADC sample rate offer a large range of high order anti-alias filter characteristics with precise phase match and noise-free digital output.

For true real-time analysis, the card offers real-time cycle or timer based calculations. Automatic zero crossing detection allows for asynchronous true RMS, mean and other calculations that can be used to trigger the recording.
The GEN DAQ series input card offers 16 digital input events, two digital output events and two Timer/Counter channels.
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.

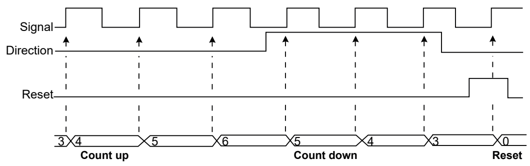
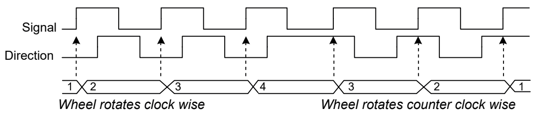
Capabilities Overview		
Model	**GN815**	**GN816**
Maximum sample rate per channel	2 MS/s	200 KS/s
Memory per card	2 GB	200 MB
Analog channels	8	
Anti-alias filters	Fixed bandwidth analog AA-filter combined with sample rate tracking digital AA-filter	
ADC resolution	18 bit	
Isolation	Channel to channel and channel to chassis	
Input type	Analog, isolated, unbalanced differential	
Passive voltage/current probes	Passive, singled-ended voltage probes	
Sensors	IEPE	
TEDS	Class 1, IEPE sensors	
Real-time cycle based calculators	32; Cycle and Timer based calculations with triggering on calculated results	
Real-time formula database calculators (option)	Not supported	
Real-time calculated results output	Not supported	
Digital Event/Timer/Counter	16 digital events and 2 Timer/Counter channels	
Standard data streaming (CPCI up to 200 MB/s)	Not supported	
Fast data streaming (PCIe up to 1 GB/s)	Supported	
Slot width	1	

<table>
<tr><th colspan="7">Mainframe Support</th></tr>
<tr><th></th><th>GEN2tB</th><th>GEN4tB</th><th>GEN7tA / GEN7tB</th><th>GEN17tA / GEN17tB</th><th>GEN3iA</th><th>GEN7iA / GEN7iB (1)</th></tr>
<tr><td>GN815/GN816</td><td colspan="6">Yes</td></tr>
<tr><td>GEN DAQ API</td><td colspan="4">Yes</td><td colspan="2">Yes(2)</td></tr>
<tr><td>EtherCAT®</td><td>No</td><td colspan="3">Yes</td><td colspan="2">No</td></tr>
<tr><td>CAN/CAN FD</td><td colspan="4">Yes</td><td colspan="2">No</td></tr>
</table>

(1) GEN7iA / GEN7iB with limited support (first three slots only)

(2) Close Perception to enable GEN DAQ API access.

Supported Analog Sensors and Probes		
Perception input type	**Sensor/probe types**	**Remarks**
Basic voltage	• Single ended voltage input • Passive single ended probes • Active differential probes • Current probes • External current burdens	• Isolated BNC input
IEPE	• IEPE vibration sensors • ICP® Accelerometers • 2, 4, 6 or 8 mA @ ≥ 23 V	• TEDS class I • Automatic sensor connected, open or shorted diagnostics • Isolated input

Supported Digital Sensors (TTL Level Input)		
Timer counter Input type	**Supported digital sensors**	**Features**
 **Figure 1:** Uni and Bi-directional clock	• HBK 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)	• HBK 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

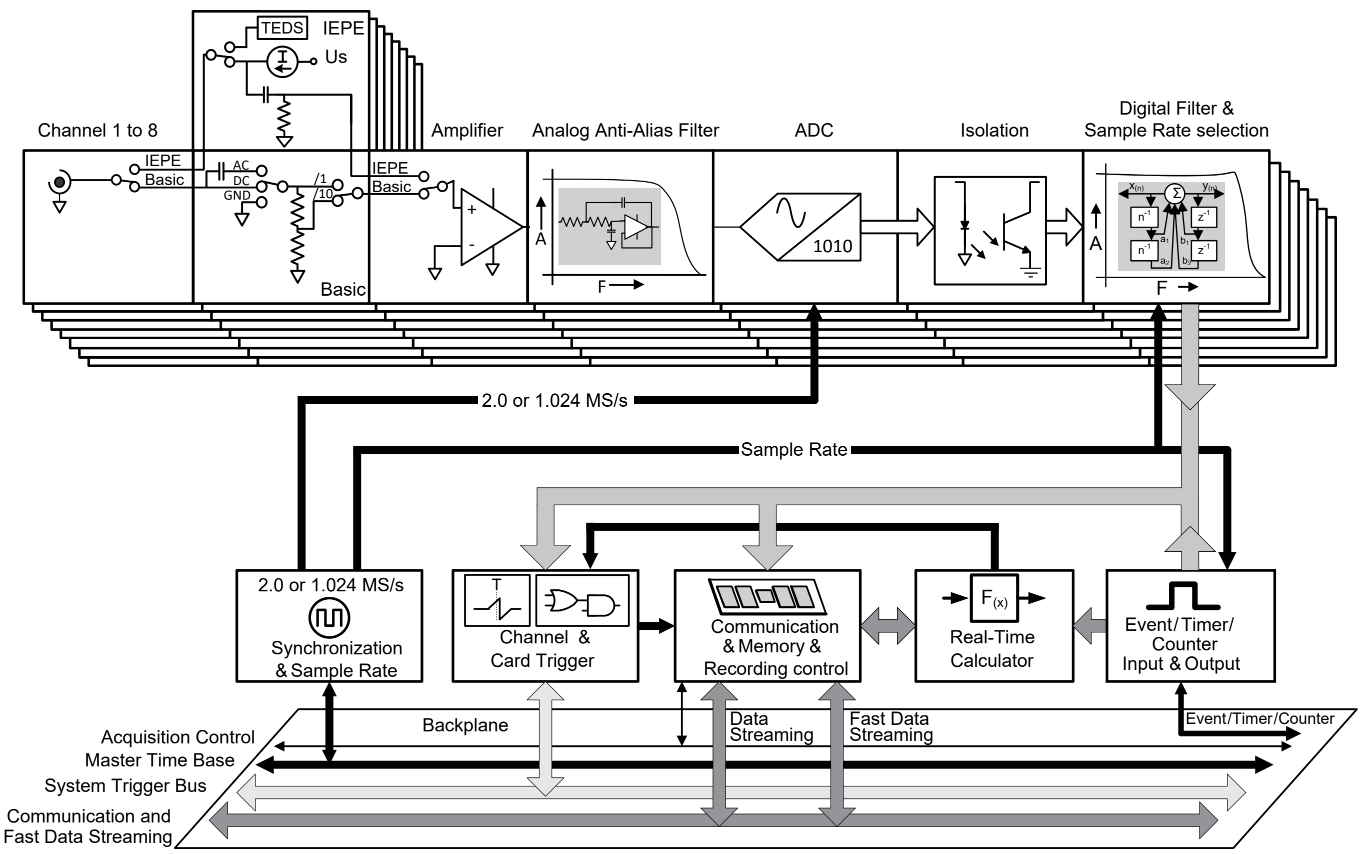


Figure 3: Block diagram

Specifications and measurement uncertainty

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

Any analog amplifier error source is a linear function (**y = ax + b**)

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	Isolated metal BNC	
Input type	Analog, isolated, unbalanced differential	
Input impedance		
1 MΩ impedance	≤ ± 1V ranges: ± 1% // 58 pF > ± 1V ranges: ± 10% All other ranges 66 pF ± 10%	
Input coupling		
Coupling modes	AC, DC, GND	
AC coupling frequency (1 MΩ impedance)	1.6 Hz ± 10%; - 3 dB	

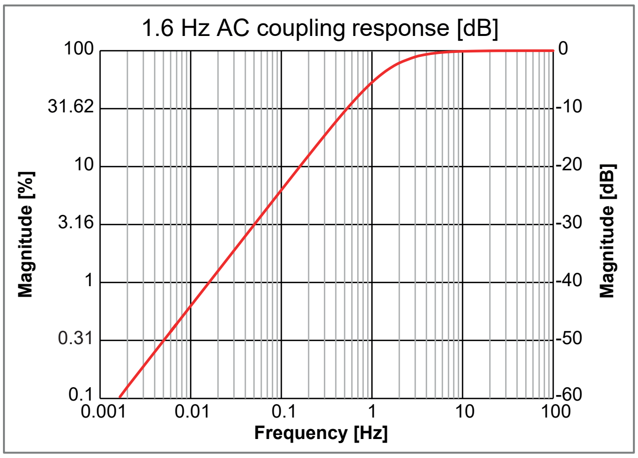


Figure 4: Representative AC coupling response

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	
Offset	± 50% in 1000 steps (0.1%); ± 50 V range has fixed 0% offset	
Common mode (referred to system ground)		
Ranges	Less than ± 2 V	Larger than or equal to ± 2 V
Rejection (CMR)	> 80 dB @ 80 Hz (100 dB typical)	> 60 dB @ 80 Hz (80 dB typical)
Maximum common mode voltage	33 V RMS	33 V RMS

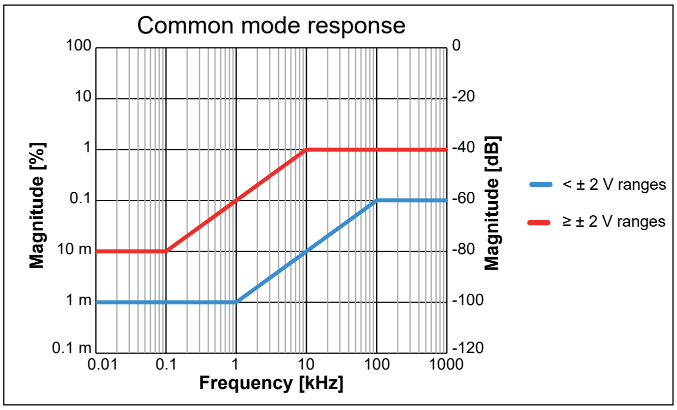


Figure 5: Representative common mode response

Input overload protection	
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	± 70 V DC
Overload recovery time	Restored to 0.1% accuracy in less than 5 µs after 200% overload

Voltage Specifications (Wideband) GN815[1]	
	Pass/Fail limits
DC gain error	0.035% of reading ± 35 µV
DC Offset error	0.01% of Full Scale ± 200 µV
Gain error drift	± 25 ppm/°C (± 14 ppm/°F)
Offset error drift	±(45 ppm + 5 µV)/°C (±(25 ppm + 3 µV)/°F)
RMS Noise (50 Ω terminated)	0.025% of Full Scale ± 50 µV

(1) Wideband filter is valid for GN815 only.

Voltage Specifications (All Filters Used)	
	Pass/Fail limits
DC gain error	0.035% of reading ± 35 µV
DC Offset error	0.01% of Full Scale ± 35 µV
Gain error drift	± 25 ppm/°C (± 14 ppm/°F)
Offset error drift	±(45 ppm + 5 µV)/°C (±(25 ppm + 3 µV)/°F)
RMS Noise (50 Ω terminated)	0.015% of Full Scale ± 20 µV

IEPE Sensor	
Input ranges	± 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
Overvoltage protection	- 1 V to 22 V
IEPE gain error	0.1% ± 250 µV
IEPE gain error drift	± 25 ppm/°C (± 14 ppm/°F)
IEPE compliance voltage	≥ 23 V
Excitation current	2, 4, 6, 8 mA, software selectable
Excitation current accuracy	± 5%
Coupling time constant	1.5 s
Lower bandwidth	-3 dB @ 0.11 Hz
Maximum cable length	100 m (RG-58)
TEDS support	Yes; class 1
Sensor diagnostics	Sensor connected, open or shorted
Supported sensors	IEPE vibration sensors ICP® Accelerometers

Isolation

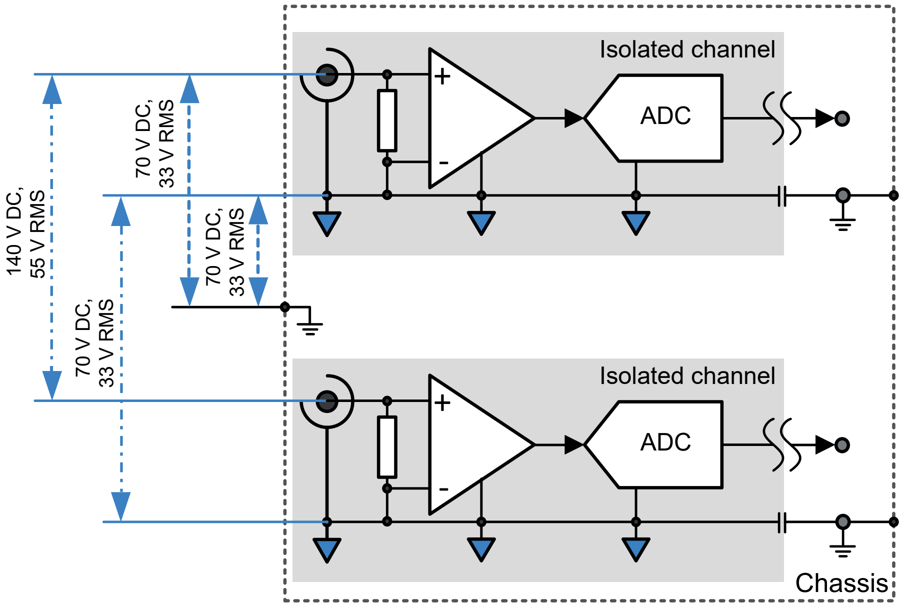


Figure 6: Isolation schematic

Channel to chassis (earth)	33 V RMS, ± 70 V DC
Channel to channel (Isolated GND to isolated GND)	33 V RMS, ± 70 V DC
Input signal-to-input signal	55 V RMS, ± 140 V DC

Analog to Digital Conversion

	GN815	GN816
Sample rate; per channel	0.1 S/s to 2 MS/s	0.1 S/s to 200 kS/s
ADC resolution; one ADC per channel	18 bit	
ADC type	Successive Approximation Register (SAR); Analog Devices AD4003BCPZ	
Time base accuracy	Defined by mainframe: ± 3.5 ppm; aging after 10 years ± 10 ppm	

Anti-Alias Filters

Note on phase matching channels. Every filter characteristic and/or filter bandwidth selection comes with it's own specific phase response. Using different filter selections (Wideband[1]/Bessel IIR/Butterworth IIR/etc.) or different filter bandwidths can result in phase mismatches between channels.

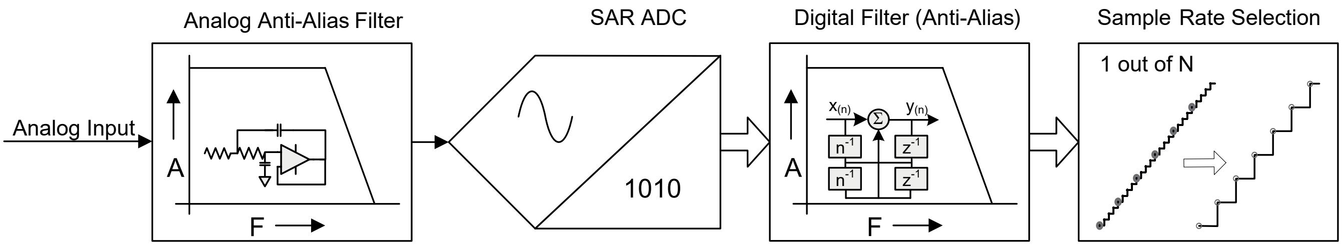


Figure 7: Combined analog and digital anti-alias filter block diagram

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 is programmed to a fraction of the user sample rate and automatically tracks any user sample rate selection. 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[1]	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.
Bessel IIR	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. 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.
Butterworth IIR	When Butterworth IIR filter is selected, this is always a combination of an analog Butterworth anti-alias filter and a digital Butterworth IIR filter to prevent aliasing at lower sample rates. This filter is best used when working in the frequency domain. When working in the time domain, this filter is best used for signals that are (close to) sine waves.
Elliptic IIR	When Elliptic IIR filter is selected, this is always a combination of an analog Butterworth anti-alias filter and a digital Elliptic IIR filter to prevent aliasing at lower sample rates. This filter is best used when working in the frequency domain. When working in the time domain, this filter is best used for signals that are (close to) sine waves.

(1) Wideband filter is valid for GN815 only.

Wideband (No Anti-Alias Protection) GN815[(1)]

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	Between 950 kHz and 1300 kHz (-3 dB)
0.1 dB passband flatness	DC to 200 kHz[(2)]

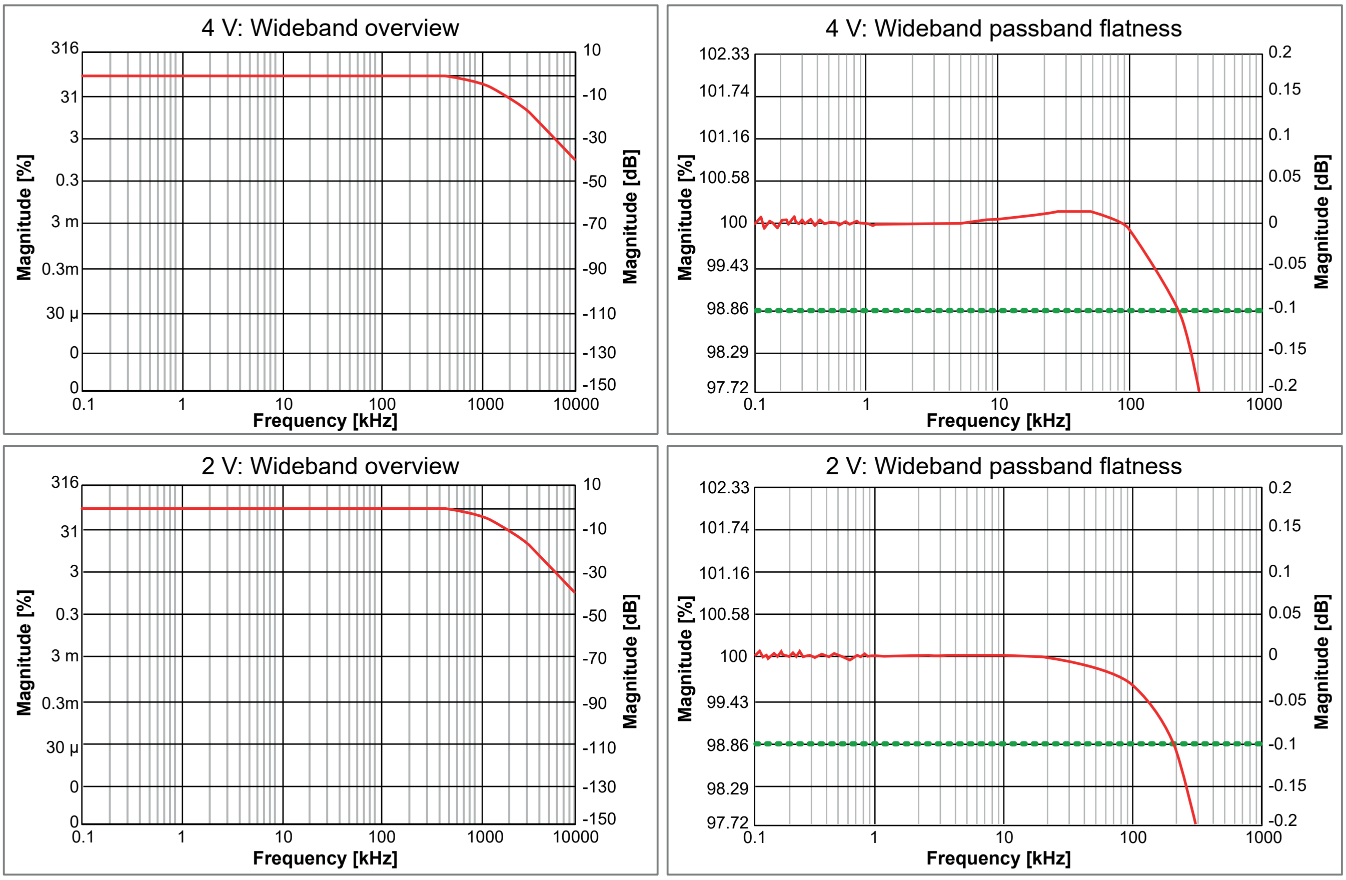
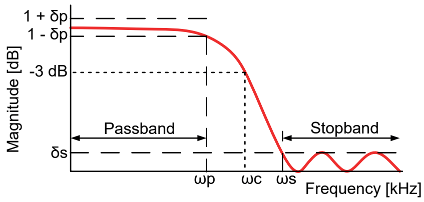


Figure 8: Representative Wideband examples

(1) Wideband filter is valid for GN815 only

(2) Measured using a Fluke 5700A calibrator, DC normalized.

Bessel IIR Filter (Digital Anti-Alias) GN815



δp: Passband ripple
δs: Stopband attenuation

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

Figure 9: 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	390 kHz ± 25 kHz (-3 dB)
Analog anti-alias filter characteristic	7-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.
Bessel IIR filter bandwidth (ωc)	User selectable from 0.4 Hz to 200 kHz
Bessel IIR 0.1 dB passband (ωp)(1)	DC to 35 kHz @ ωc = 200 kHz
Bessel IIR filter stopband attenuation (δs)	60 dB With the Bessel IIR filter bandwidth selection of ωc = 200 kHz, a peak of -55 dB occurs between 1.6 MHz and 1.8 MHz due to limited analog anti-alias filter amplitude reduction. At lower bandwidth selections, the digital filter reduces this peak to -60 dB.
Bessel IIR filter roll-off	48 dB/octave

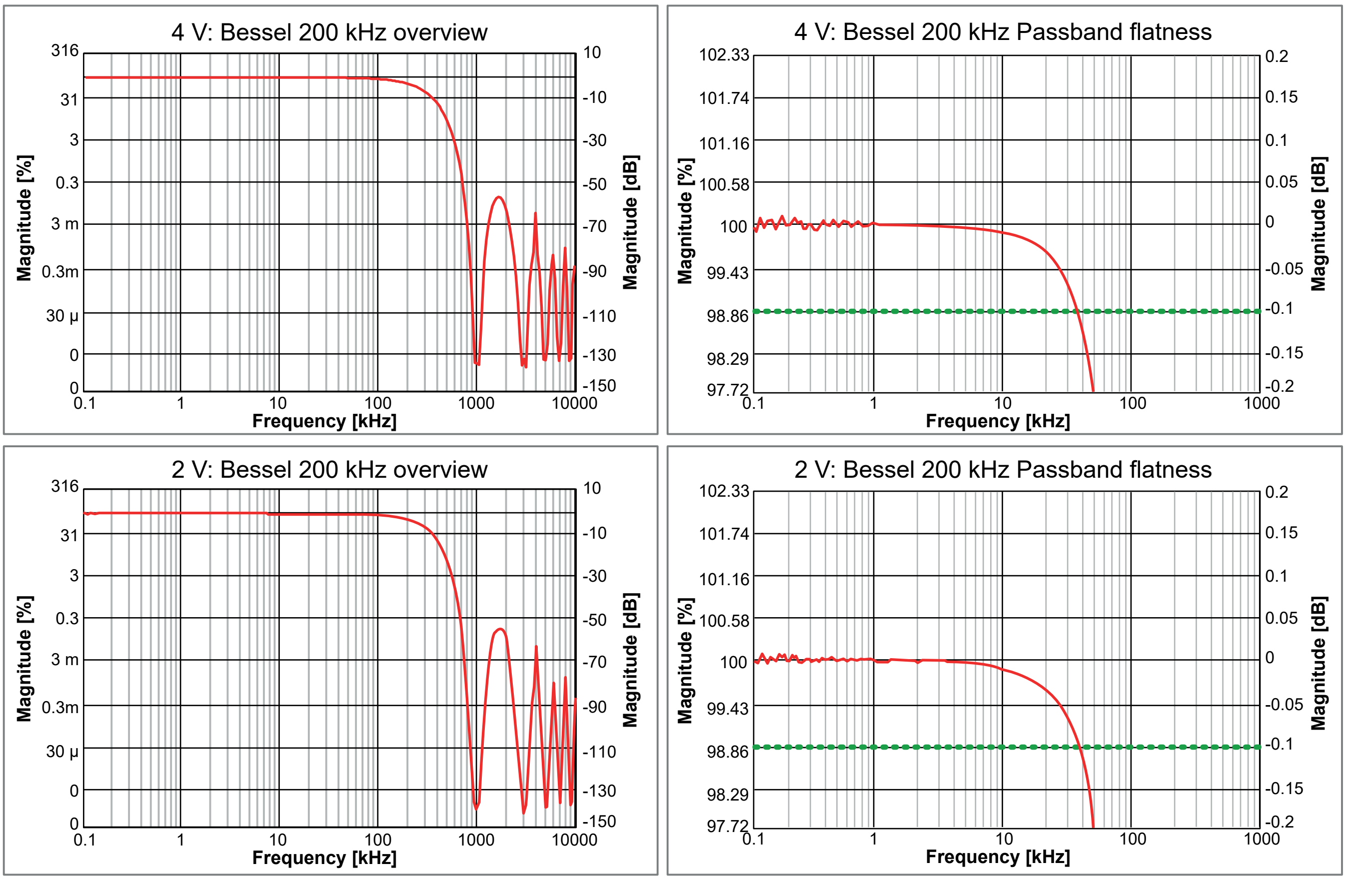
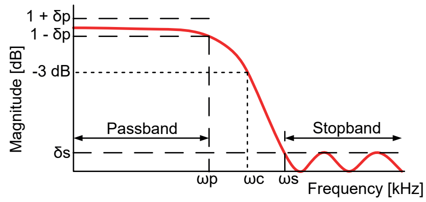


Figure 10: Representative Bessel IIR examples (GN815)

(1) Measured using a Fluke 5700A calibrator, DC normalized

Bessel IIR Filter (Digital Anti-Alias) GN816



δp: Passband ripple
δs: Stopband attenuation

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

Figure 11: 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	390 kHz ± 25 kHz (-3 dB)
Analog anti-alias filter characteristic	7-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.
Bessel IIR filter bandwidth (ωc)	User selectable from 0.4 Hz to 20 kHz
Bessel IIR 0.1 dB passband (ωp)(1)	DC to 3.5 kHz @ ωc = 20 kHz
Bessel IIR filter stopband attenuation (δs)	75 dB
Bessel IIR filter roll-off	48 dB/octave

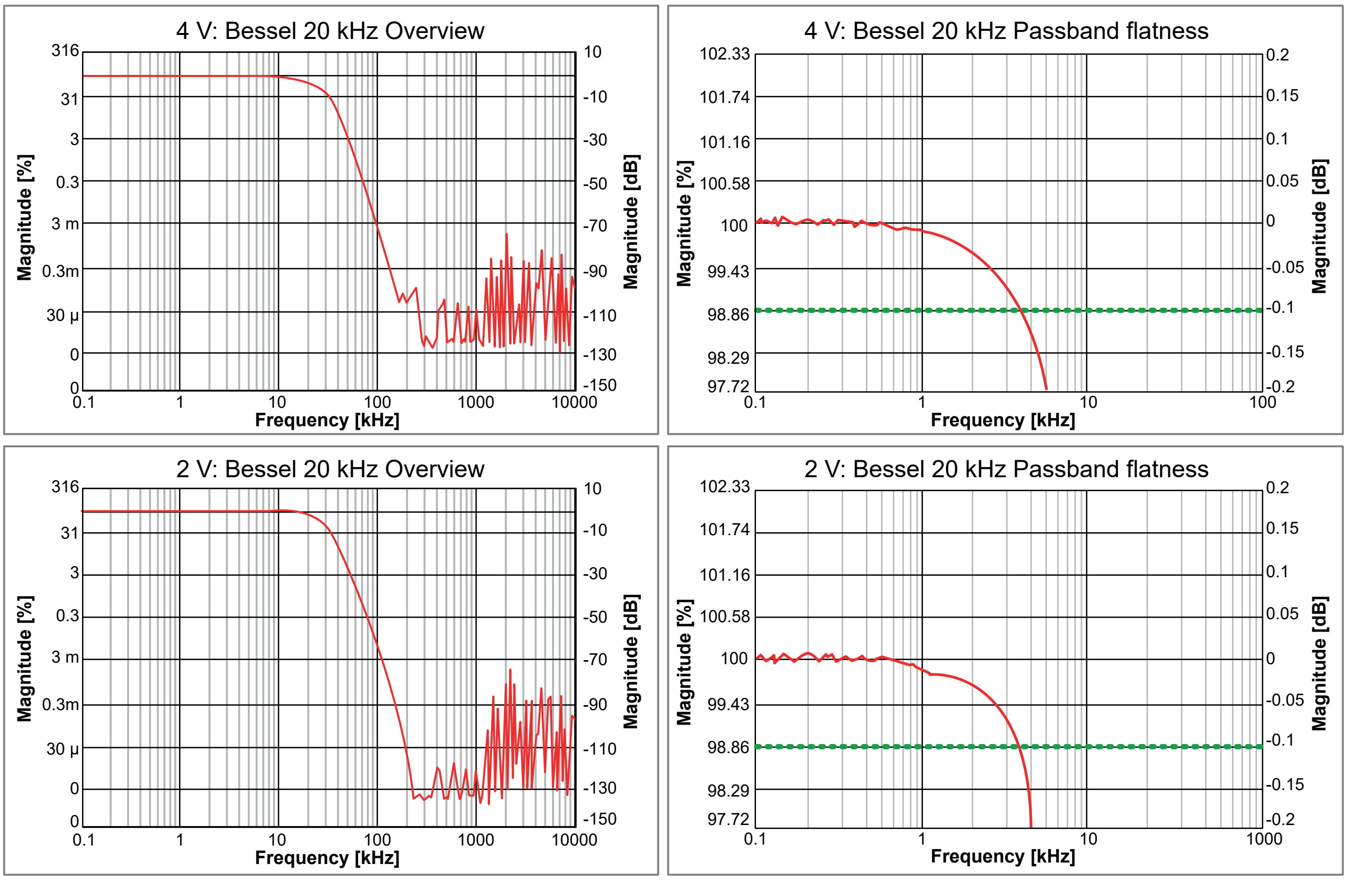
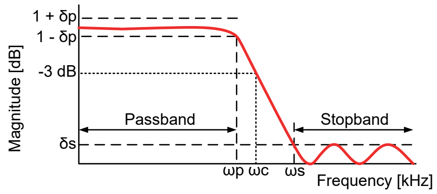


Figure 12: Representative Bessel IIR examples (GN816)

(1) Measured using a Fluke 5700A calibrator, DC normalized

Butterworth IIR Filter (Digital Anti-Alias) GN815



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

Figure 13: 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	460 kHz ± 25 kHz (-3 dB)
Analog anti-alias filter characteristic	7-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(1), 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
Butterworth IIR filter bandwidth (ωc)	User selectable from 1 Hz to 250 kHz
Butterworth IIR 0.1 dB passband (ωp)(2)	DC to 150 kHz @ ωc = 200 kHz
Butterworth IIR filter stopband attenuation (δs)	75 dB With the Butterworth IIR filter bandwidth selection of ωc = 250 kHz, a peak of -60 dB occurs between 1.8 MHz and 2.2 MHz due to limited analog anti-alias filter amplitude reduction. At lower bandwidth selections, the digital filter reduces this peak to -75 dB.
Butterworth IIR filter roll-off	48 dB/octave

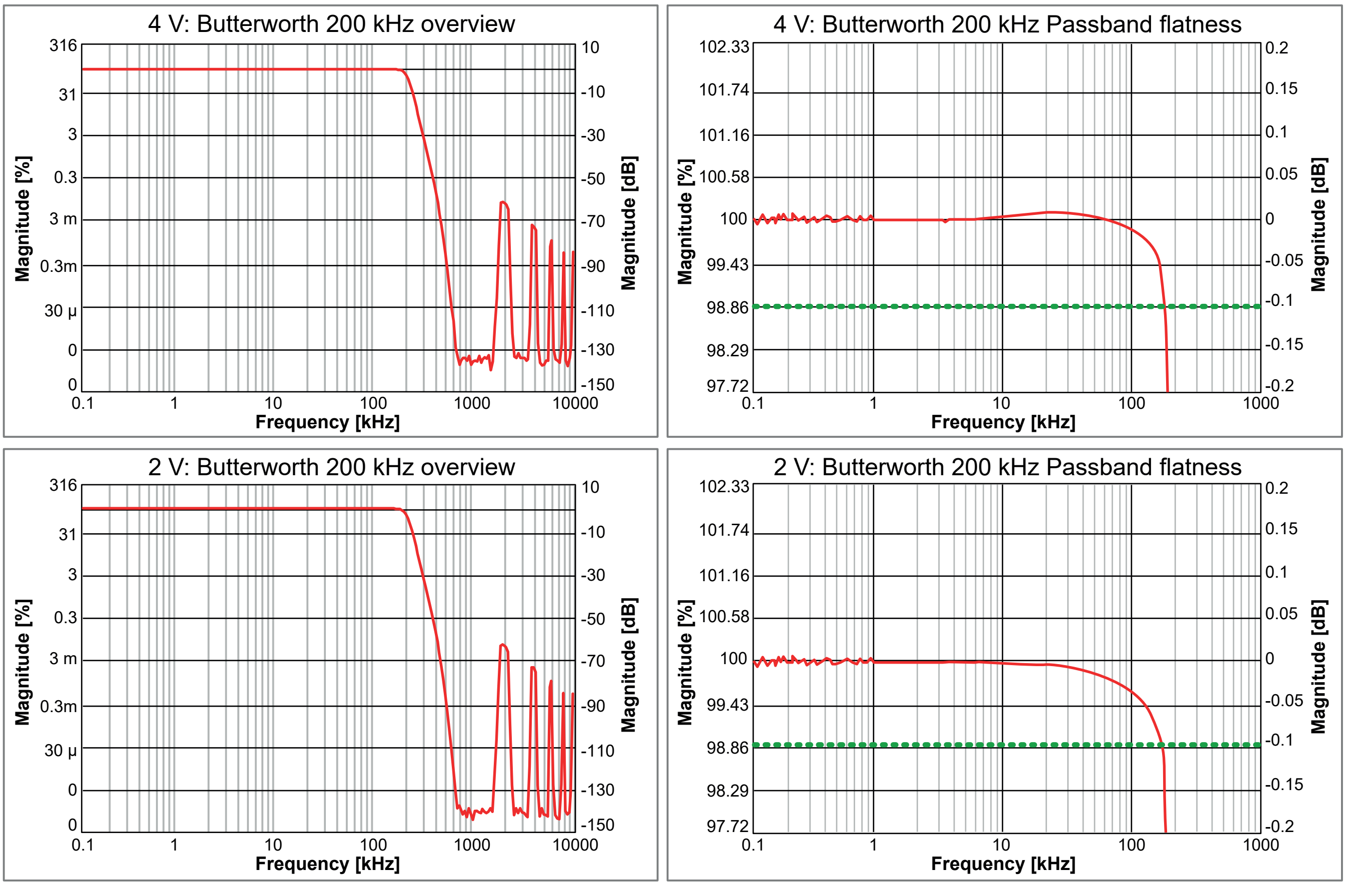
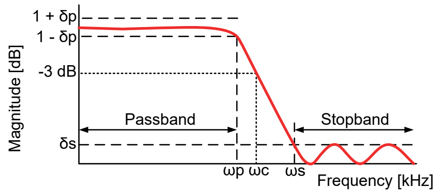


Figure 14: Representative Butterworth IIR examples (GN815)

(1) Division by 4 not possible for the 2 MS/s sample rate

(2) Measured using a Fluke 5700A calibrator, DC normalized

Butterworth IIR Filter (Digital Anti-Alias) GN816



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

Figure 15: 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	460 kHz ± 25 kHz (-3 dB)
Analog anti-alias filter characteristic	7-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
Butterworth IIR filter bandwidth (ωc)	User selectable from 1 Hz to 50 kHz
Butterworth IIR 0.1 dB passband (ωp)(1)	DC to 35 kHz @ ωc = 50 kHz
Butterworth IIR filter stopband attenuation (δs)	75 dB
Butterworth IIR filter roll-off	48 dB/octave

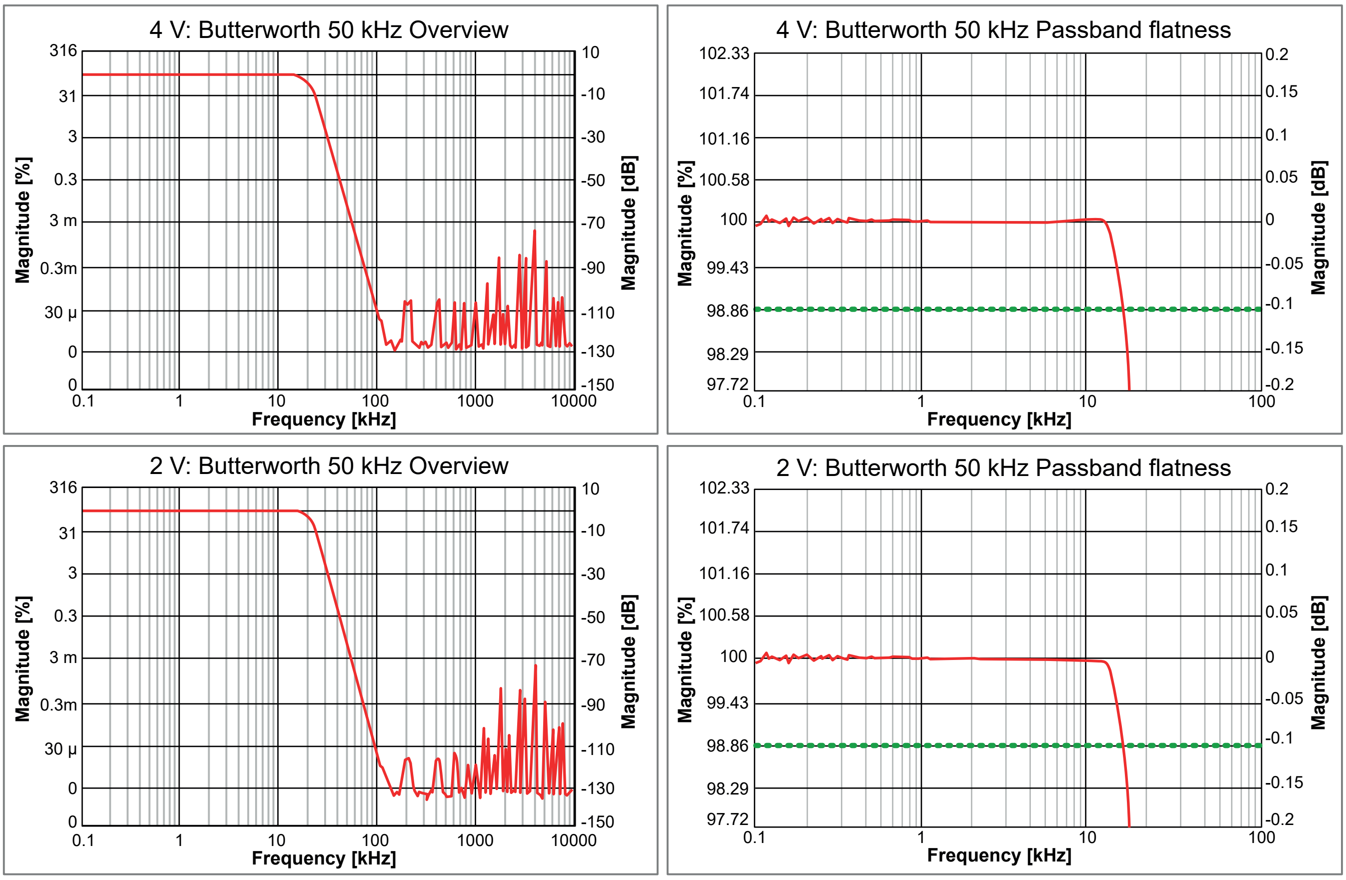
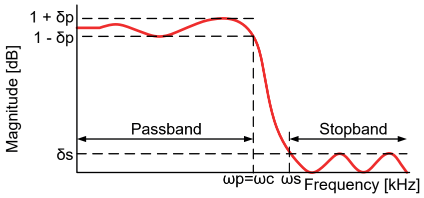


Figure 16: Representative Butterworth IIR examples (GN816)

(1) Measured using a Fluke 5700A calibrator, DC normalized

Elliptic IIR Filter (Digital Anti-Alias) GN815



δp: Passband ripple
δs: Stopband attenuation

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

Figure 17: Digital Elliptic IIR Filter

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

Analog anti-alias filter bandwidth	460 kHz ± 25 kHz (-3 dB)
Analog anti-alias filter characteristic	7-pole Elliptic, extended passband response
Elliptic IIR filter characteristic	7-pole Elliptic style IIR
Elliptic IIR filter user selection	Auto tracking for sample rate divided by: 4(1), 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
Elliptic IIR filter bandwidth (ωc)	User selectable from 1 Hz to 250 kHz
Elliptic IIR 0.1 dB passband (ωp)(2)	DC to ωc
Elliptic IIR filter stopband attenuation (δs)	75 dB With the Elliptic IIR filter bandwidth selection of ωc = 250 kHz, a peak of -60 dB occurs between 1.8 MHz and 2.2 MHz due to limited analog anti-alias filter amplitude reduction. At lower bandwidth selections, the digital filter reduces this peak to -75 dB.
Elliptic IIR filter roll-off	72 dB/octave

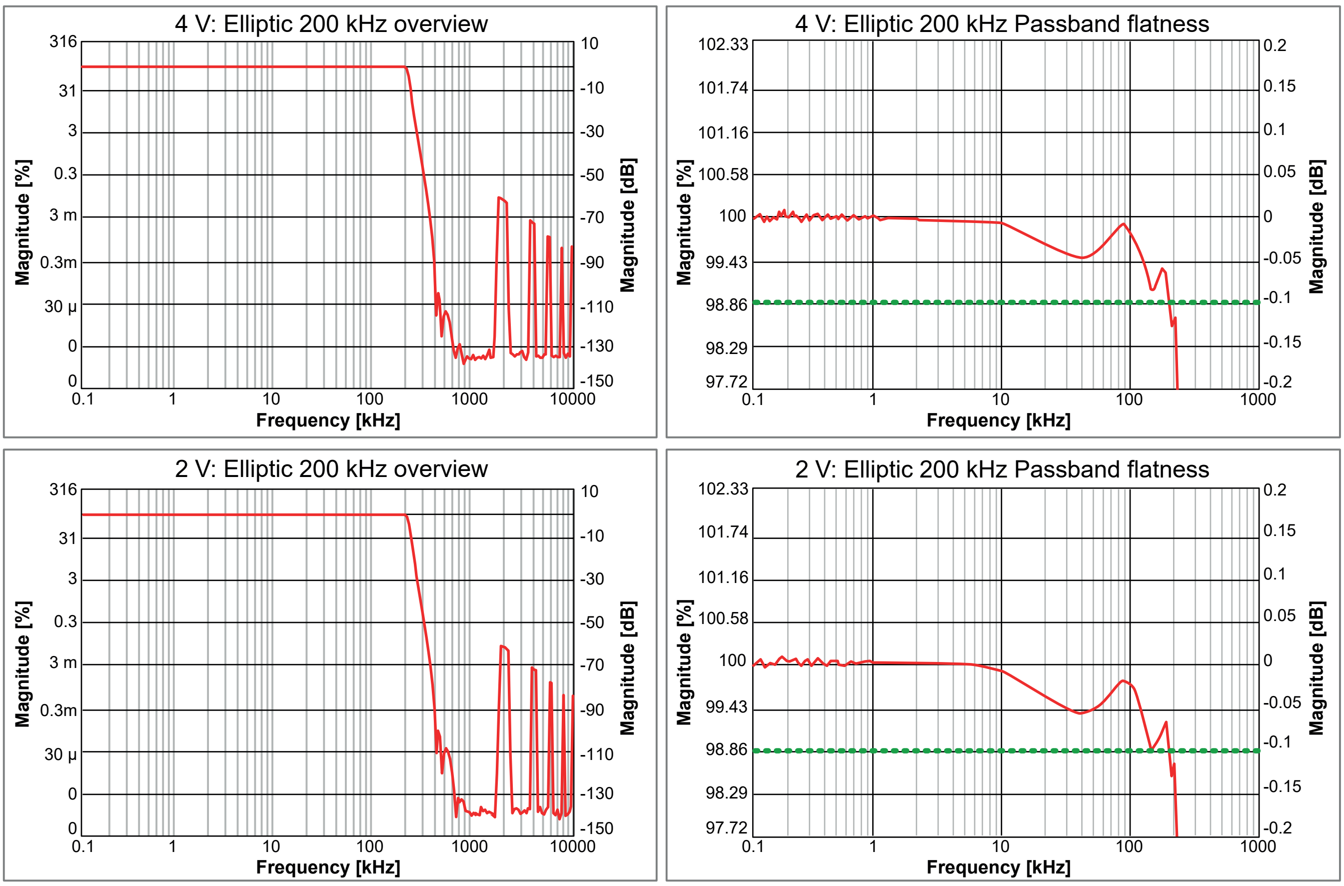
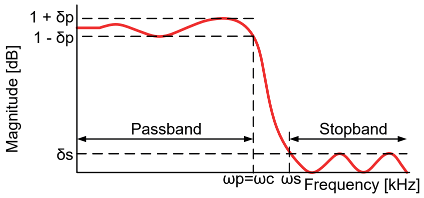


Figure 18: Representative Elliptic IIR examples (GN815)

(1) Division by 4 not possible for the 2 MS/s sample rate

(2) Measured using a Fluke 5700A calibrator, DC normalized

Elliptic IIR Filter (Digital Anti-Alias) GN816



δp: Passband ripple
δs: Stopband attenuation

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

Figure 19: Digital Elliptic IIR Filter

When Elliptic IIR filter is selected, this is always a combination of an analog Butterworth anti-alias filter and a digital Elliptic IIR filter.	
Analog anti-alias filter bandwidth	460 kHz ± 25 kHz (-3 dB)
Analog anti-alias filter characteristic	7-pole Elliptic, extended passband response
Elliptic IIR filter characteristic	7-pole Elliptic style IIR
Elliptic 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
Elliptic IIR filter bandwidth (ωc)	User selectable from 1 Hz to 50 kHz
Elliptic IIR 0.1 dB passband (ωp)(1)	DC to ωc
Elliptic IIR filter stopband attenuation (δs)	75 dB
Elliptic IIR filter roll-off	72 dB/octave

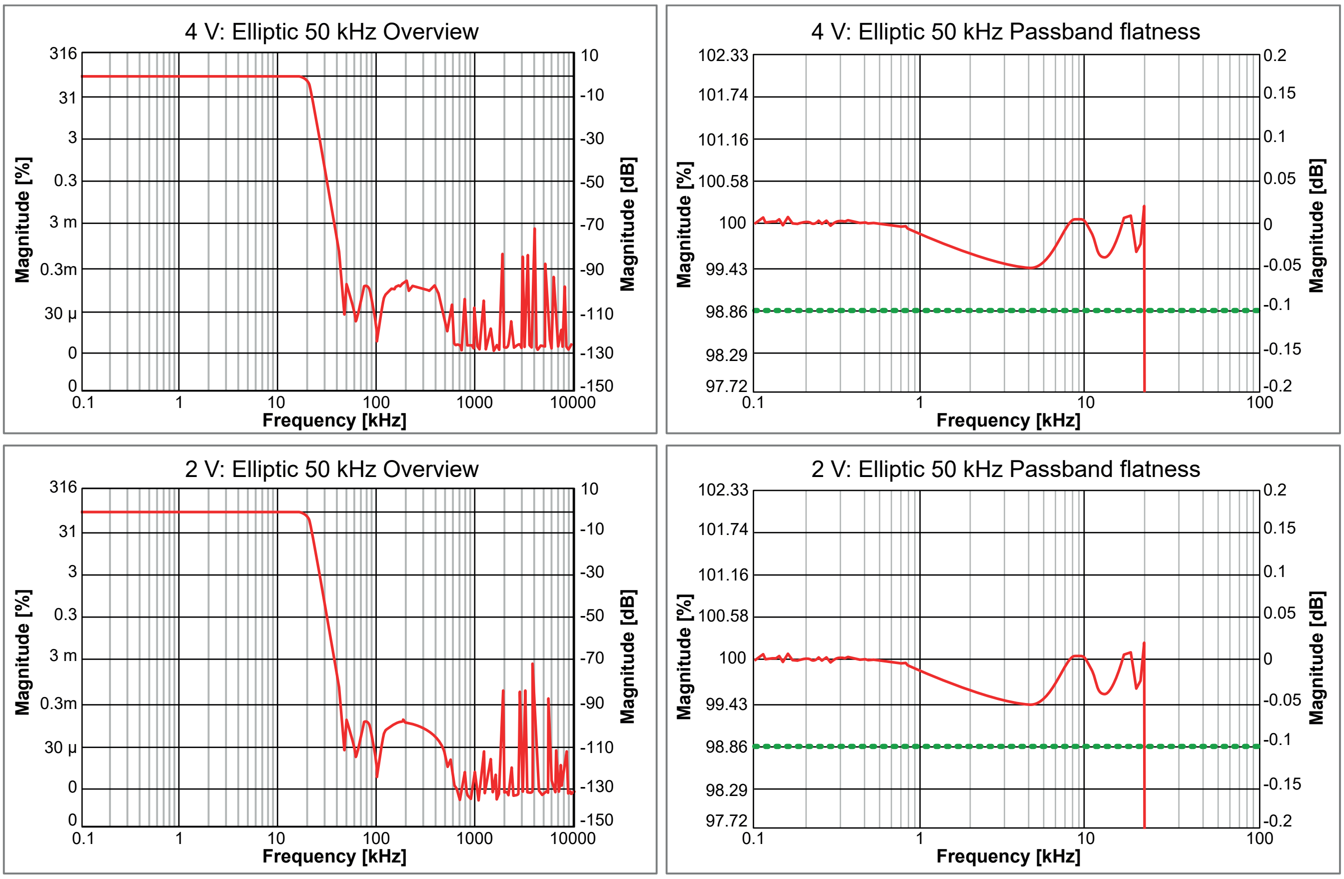


Figure 20: Representative Elliptic IIR examples (GN816)

(1) Measured using a Fluke 5700A calibrator, DC normalized

Channel to Channel Phase Match			
Using different filter selections (Wideband(1)/Bessel IIR/Butterworth IIR/etc.) or different filter bandwidths results in phase mismatches between channels.			
	100 kHz Sine wave (GN815)	**800 kHz Sine wave (GN815)**	**10 kHz Sine wave (GN816)**
Wideband(1)			
Channels on card	0.5 deg (14 ns)	2.0 deg (7 ns)	
GN815 Channels within mainframe	0.5 deg (14 ns)	2.0 deg (7 ns)	
Bessel IIR, Filter frequency 200 kHz @ 2 MS/s (GN815)			
Channels on card	0.5 deg (14 ns)		
GN815 Channels within mainframe	0.5 deg (14 ns)		
Butterworth IIR, Filter frequency 200 kHz @ 2 MS/s (GN815)			
Channels on card	0.5 deg (14 ns)		
GN815 Channels within mainframe	0.5 deg (14 ns)		
Elliptic IIR, Filter frequency 200 kHz @ 2 MS/s (GN815)			
Channels on card	0.5 deg (14 ns)		
GN815 Channels within mainframe	0.5 deg (14 ns)		
Bessel IIR, Filter frequency 20 kHz @ 200 kS/s (GN816)			
Channels on card			0.5 deg (0.14 µs)
GN816 Channels within mainframe			0.5 deg (0.14 µs)
Butterworth IIR, Filter frequency 20 kHz @ 200 kS/s; 10 kHz Sine wave (GN816)			
Channels on card			0.5 deg (0.14 µs)
GN816 Channels within mainframe			0.5 deg (0.14 µs)
Elliptic IIR, Filter frequency 20 kHz @ 200 kS/s (GN816)			
Channels on card			0.5 deg (0.14 µs)
GN816 Channels within mainframe			0.5 deg (0.14 µs)
GN815/GN816 channels across mainframes	Defined by synchronization method used (None, IRIG, GPS, Master/Sync, PTP)		

(1) Wideband filter is valid for GN815 only.

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.

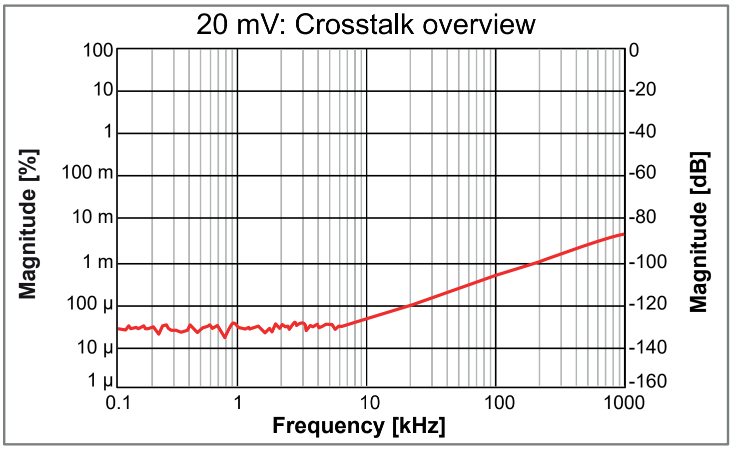


Figure 21: Representative Channel to Channel crosstalk

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.

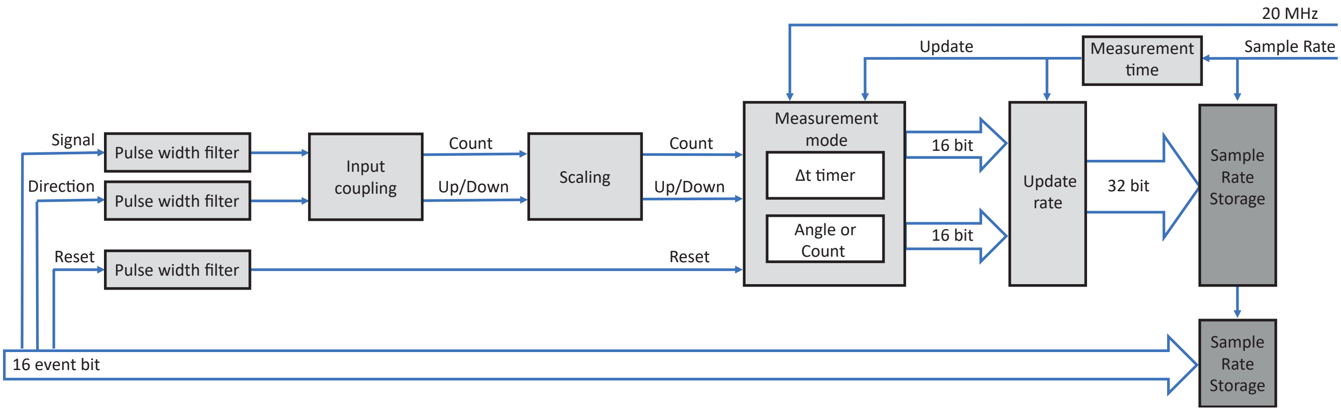


Figure 22: Timer/Counter block diagram

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	± 30 V DC continuously
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.

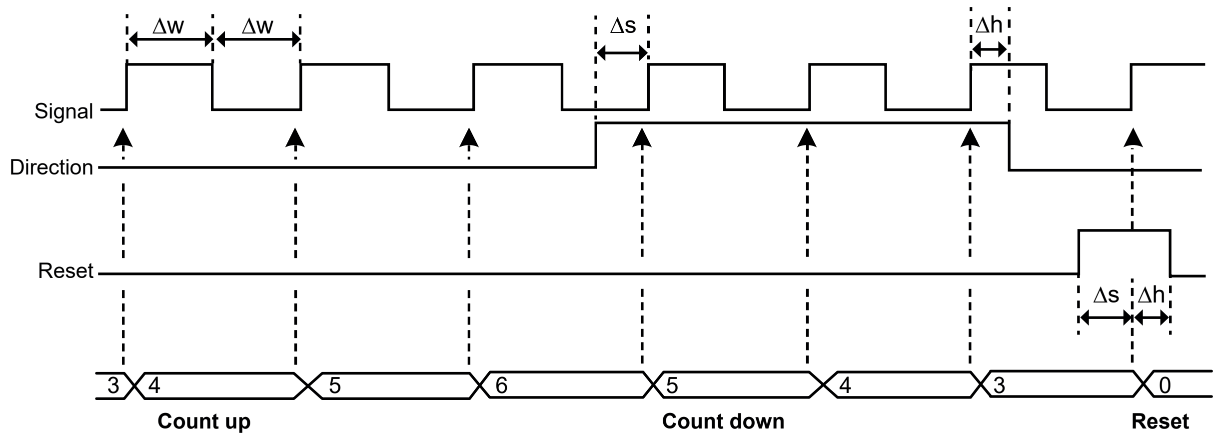


Figure 23: Uni- and Bi-directional timing

Inputs	3 pins: signal, reset and direction (only used in bi-directional count)
Minimum pulse width (Δw)	100 ns
Maximum input signal frequency	5 MHz
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 HBK torque and speed transducers.

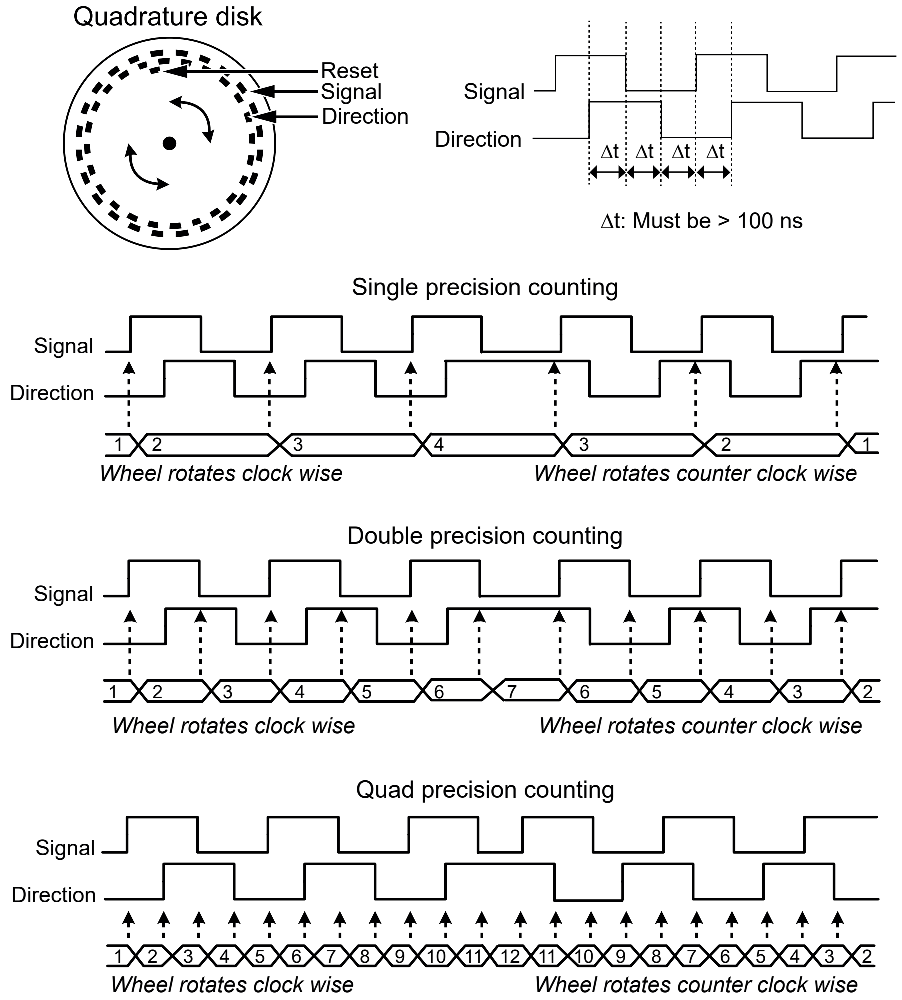


Figure 24: Bi-directional quadrature count modes

Inputs	3 pins: signal, direction and reset
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.

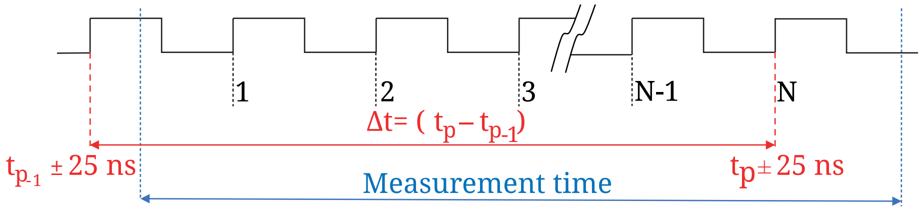
Measurement Mode Angle

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 25: 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

Frequency Measurement Inaccuracy

Frequency measurement 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 frequency accuracy. The inaccuracy distribution is to be considered rectangular.

Calculate the inaccuracy by using:(1)

$$Inaccuracy = \pm \frac{Signal\ frequency * \left(CEILING\left(\frac{Measuring\ time}{30000 * 50\ ns}\right)\right) * 50\ ns}{Frequency\ prescaler * FLOOR\left(\frac{Signal\ frequency * Measuring\ time}{Frequency\ prescaler}\right)} * 100\%$$

<table>
<tr><th rowspan="2">Measurement time</th><th colspan="11">Higher signal frequencies: Signal frequency 2 MHz down to 10 kHz</th></tr>
<tr><th>Worst case (in %)</th><th>2 MHz</th><th>1 MHz</th><th>500 kHz</th><th>400 kHz</th><th>200 kHz</th><th>100 kHz</th><th>50 kHz</th><th>40 kHz</th><th>20 kHz</th><th>10 kHz</th></tr>
<tr><td>1 µs</td><td>±10.000 @ ~2 MHz(2)</td><td>±5.000%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2 µs</td><td>±5.000 @ ~1 MHz(2)</td><td colspan="2">±2.500%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5 µs</td><td>±2.000 @ ~400 kHz(2)</td><td colspan="2">±1.000%</td><td>±1.250%</td><td>±1.000%</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10 µs</td><td>±1.000 @ ~200 kHz(2)</td><td colspan="5">±0.500%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>20 µs</td><td>±0.500 @ ~100 kHz(2)</td><td colspan="6">±0.250%</td><td></td><td></td><td></td><td></td></tr>
<tr><td>50 µs</td><td>±0.200 @ ~40 kHz(2)</td><td colspan="6">±0.100%</td><td>±0.125%</td><td>±0.100%</td><td></td><td></td></tr>
<tr><td>100 us</td><td>±0.100 @ ~20 kHz(2)</td><td colspan="9">±0.050%</td><td></td></tr>
<tr><td>200 us</td><td>±0.050 @ ~10 kHz(2)</td><td colspan="10">±0.0250%</td></tr>
<tr><td>500 us</td><td>±0.020 @ ~4 kHz(2)</td><td colspan="10">±0.0100%</td></tr>
<tr><td>1 ms</td><td>±0.0100 @ ~2 kHz(2)</td><td colspan="10">±0.0050%</td></tr>
<tr><td>2 ms</td><td>±0.0100 @ ~1 kHz(2)</td><td colspan="10">±0.0050%</td></tr>
<tr><td>5 ms</td><td>±0.0080 @ ~400 Hz(2)</td><td colspan="10">±0.0040%</td></tr>
<tr><td>10 ms</td><td>±0.0070 @ ~200 Hz(2)</td><td colspan="10">±0.0035%</td></tr>
<tr><td>20 ms</td><td>±0.0070 @ ~100 Hz(2)</td><td colspan="10">±0.0035%</td></tr>
<tr><td>50 ms</td><td>±0.0068 @ ~40 Hz(2)</td><td colspan="10">±0.0034%</td></tr>
<tr><td>100 ms</td><td>±0.0067 @ ~20 Hz(2)</td><td colspan="10">±0.00335%</td></tr>
<tr><th rowspan="2">Measurement time</th><th colspan="11">Lower signal frequencies: Signal frequency 5 kHz down to 40 Hz</th></tr>
<tr><th>Worst case (in %)</th><th>5 kHz</th><th>4 kHz</th><th>2 kHz</th><th>1 kHz</th><th>500 Hz</th><th>400 Hz</th><th>200 Hz</th><th>100 Hz</th><th>50 Hz</th><th>40 Hz</th></tr>
<tr><td>500 us</td><td>±0.0200 @ ~4 kHz(2)</td><td>±0.0125%</td><td>±0.0100%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1 ms</td><td>±0.0100 @ ~2 kHz(2)</td><td colspan="3">±0.0050%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2 ms</td><td>±0.0100 @ ~1 kHz(2)</td><td colspan="4">±0.0050%</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5 ms</td><td>±0.0080 @ ~400 Hz(2)</td><td colspan="4">±0.0040%</td><td>±0.00500%</td><td>±0.0040%</td><td></td><td></td><td></td><td></td></tr>
<tr><td>10 ms</td><td>±0.0070 @ ~200 Hz(2)</td><td colspan="7">±0.0035%</td><td></td><td></td><td></td></tr>
<tr><td>20 ms</td><td>±0.0070 @ ~100 Hz(2)</td><td colspan="8">±0.0035%</td><td></td><td></td></tr>
<tr><td>50 ms</td><td>±0.0068 @ ~40 Hz(2)</td><td colspan="8">±0.0034%</td><td>±0.0043%</td><td>±0.0034%</td></tr>
<tr><td>100 ms</td><td>±0.0067 @ ~20 Hz(2)</td><td colspan="10">±0.00335%</td></tr>
</table>

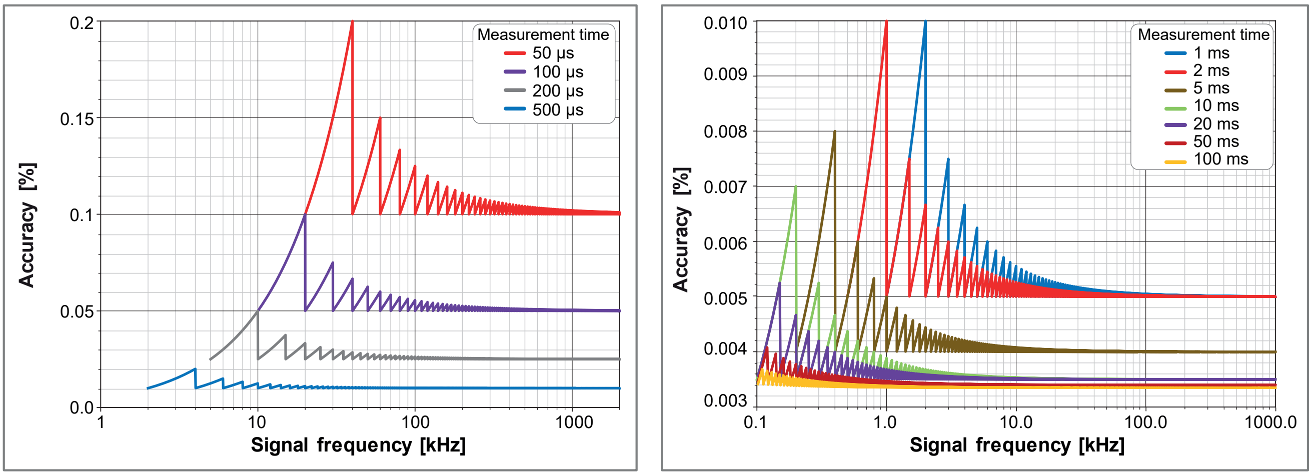


Figure 26: Maximum frequency inaccuracy

(1) Note: Keep the Frequency PreScaler as small as possible for the selected frequency range to get the best accuracy.

(2) The worst case scenario signal frequency is slightly below the displayed value, consistent with the sawtooth pattern observed in Figure 26.

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 26 will result in Figure 27 (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.

Selected measurement time	Maximum inaccuracy: T40 - 240 kHZ	Maximum inaccuracy: T40 - 60 kHZ	Maximum inaccuracy: T40 - 10 kHZ
50 µs	0.1167%	0.2000%	Not possible
100 µs	0.0542%	0.0667%	Not possible
500 µs	0.0102%	0.0107%	0.0150%
1 ms	0.0050%	0.0052%	0.0060%
2 ms	0.0050%	0.0051%	0.0055%
5 ms	0.0040%	0.0040%	0.0042%

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	0.0677%	0.1160%	Not possible
100 µs	0.0314%	0.0387%	Not possible
500 µs	0.0059%	0.0062%	0.0087%
1 ms	0.0029%	0.0030%	0.0035%
2 ms	0.0029%	0.0029%	0.0032%
5 ms	0.0023%	0.0023%	0.0024%

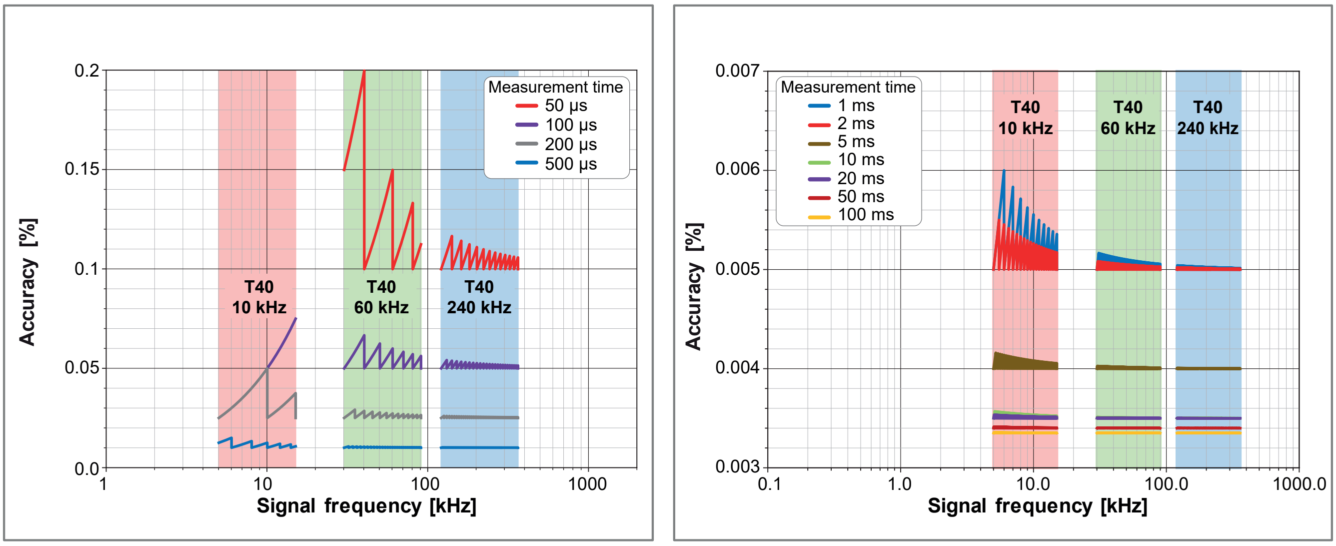


Figure 27: Torque operating range versus inaccuracy and measurement time

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 10000 RPM	Frequency at 30000 RPM
180	180 Hz	30 kHz	90 kHz
360	360 Hz	60 kHz	180 kHz
1024	1024 Hz	170.7 kHz	512 kHz

Overlay these operating ranges on top of the timer inaccuracy plots of Figure 26 will result in Figure 28 (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	Can't record at 60 RPM	Can't record at 60 RPM	0.0051%
5 ms	Can't record at 60 RPM	0.0072%	0.0041%
10 ms	0.0063%	0.0042%	0.0036%

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	Can't record at 60 RPM	Can't record at 60 RPM	0.0030%
5 ms	Can't record at 60 RPM	0.0042%	0.0024%
10 ms	0.0037%	0.0024%	0.0021%

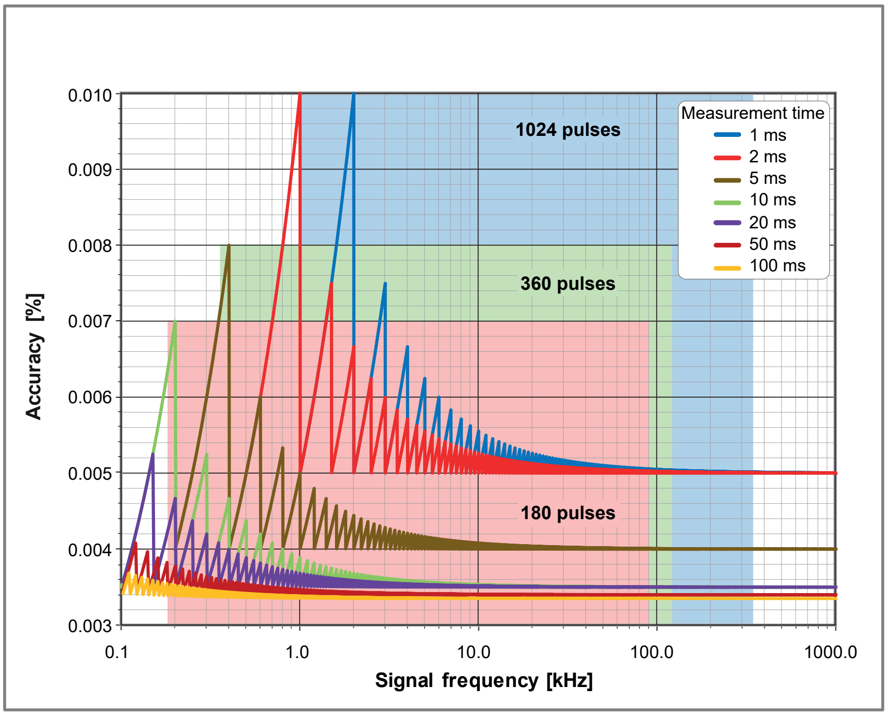


Figure 28: RPM sensor operating range versus inaccuracy and measurement time

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.

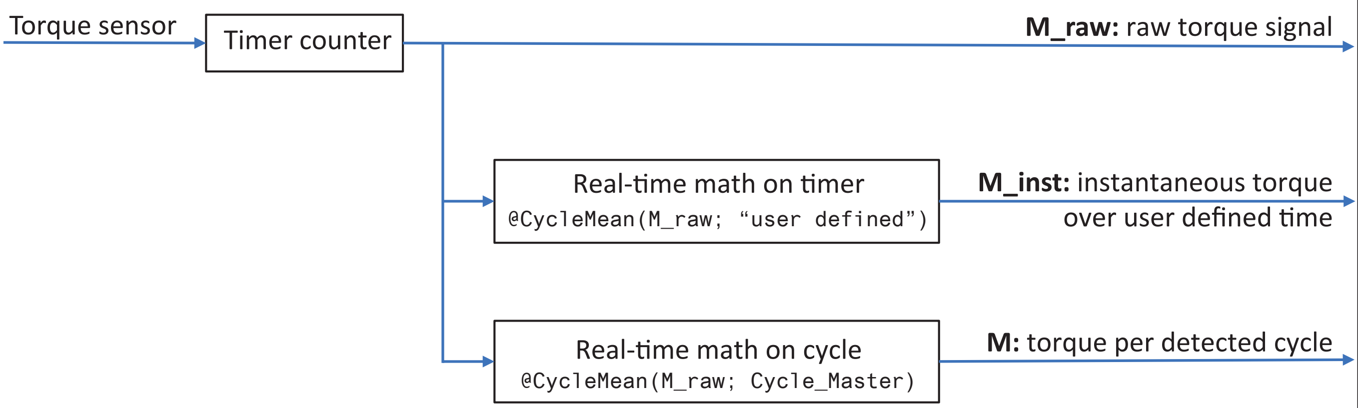


Figure 29: Simultaneous dynamic and accurate torque calculations

ePower signals	Application use	Dynamic response	Accuracy
M_raw	Torque ripple	Highest	Lowest
M_inst	Torque mean	Average	Average
M	Efficiency calculation	Lowest	Highest

Alarm Output

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.
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

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	GN815: 2 GB (1 GS @ 16 bits, 500 MS @ 18 bits storage) GN816: 200 MB (100 MS @ 16 bits storage)
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	User selectable 16 or 18 bits 16 bits, 2 bytes/sample 18 bits, 4 bytes/sample

Real-time Formula Database Calculators

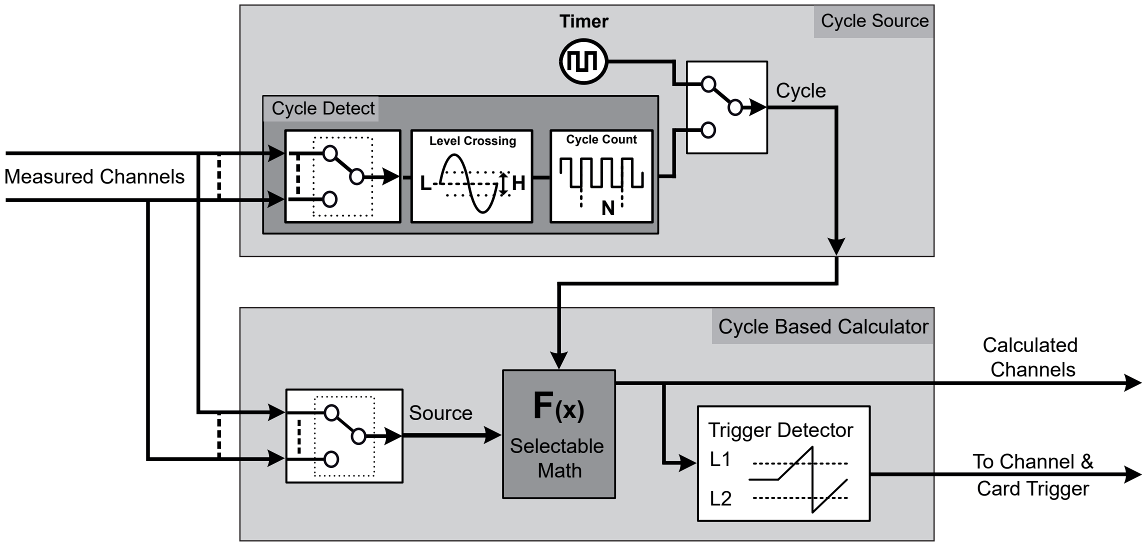


Figure 30: Real-time cycle based calculators

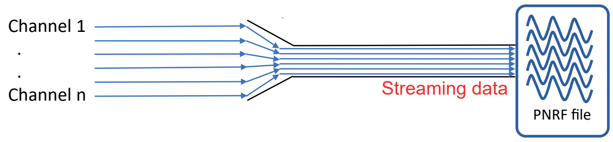
Cycle Source	Determines the periodic real-time calculation speed by either setting a timer or using a real-time cycle detect
Cycle Source: Timer	
Timer duration	1.0 ms (1 kHz) to 60 s (0.0167 Hz)
Cycle Source: Cycle detect	
Level crossing	Real-time monitors one input channel using a signal level, hysteresis and direction to determine the cyclic nature of the signal
Cycle count	Sets the counted number of cycles used for periodic calculation output
Cycle period(1)	Maximum Cycle period that can be detected: 0.25 s (4 Hz) Minimum Cycle period that can be detected: 0.91 ms (1.1 kHz) Calculations are stopped when the Cycle period exceeds its maximum Cycle period (0.25 s) Cycle count is temporarily increased when Cycle period becomes shorter than minimum Cycle period (0.91 ms). Time event notifications in the channel data indicate when the Cycle period has been exceeded or when the automatic Cycle count is increased
Cycle based calculator	
Number of calculators	GN815: 32; at sample rates 200 kS/s or lower. At higher sample rates, the number of calculators is reduced to match the available DSP power GN816: 32
DSP load	Each calculator can perform 1 calculation. Not every calculation uses the same DSP power. Selecting a calculation with the highest computation power could result in a reduction in the total number of calculators. Different combinations require different computation power. The effects of selected combinations is reflected in Perception software.
Cycle Source calculations	Cycle and Frequency
Analog channel calculations	GN815: RMS, Minimum, Maximum, Mean, Peak-to-Peak, Area, Energy and Crest Factor GN816: RMS, Minimum, Maximum, Mean, Peak-to-Peak, Area, Energy and MeanOfMultiplication
Timer/Counter channel calculations	Frequency (to enable triggering), RPM of Angle
Cycle	Square wave signal, 50% duty cycle Represent Cycle Source; rising edge indicates start of new calculation period
Frequency	Detected cycle interval is converted to a frequency (1/cycle time of input signal)
Trigger detector	
Number of detectors	32; One per real-time calculator
Trigger level	Defined by the user for each detector. Generates trigger when the calculated signal crosses the level
Trigger output delay	Triggers are delayed by 100 ms on calculated signals. The trigger time is corrected internally so that the sweep triggering is correct. An additional pre-trigger length of 100 ms is added to enable the trigger time correction. This reduces the maximum sweep length by 100 ms

(1) Cycle period range depends on signal wave shape and hysteresis setting. Specified for Sine wave with 25% Full Scale hysteresis.

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

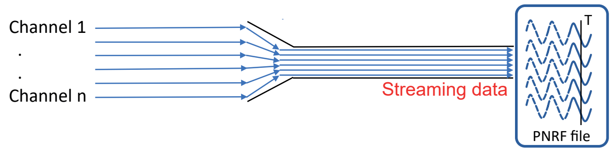
Data Recording Modes

On start of acquisition



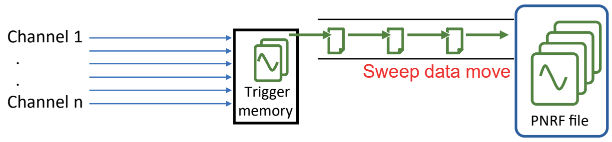
Recorded data is continuously streamed into the recording file on a mainframe or PC drive
Data recording to a drive is limited by an **aggregate sample rate**, the recording time is limited by the **size of drive**.
Note: As the aggregate sample rate limit depends on Ethernet speed and storage drive 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.

On trigger



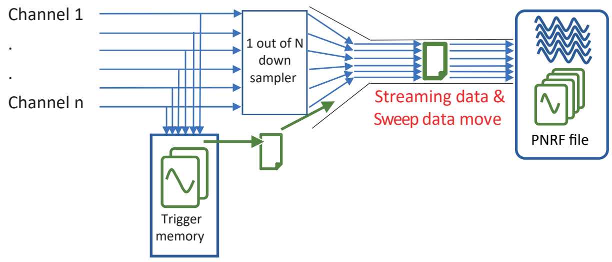
Recorded data is continuously streamed into the recording file on a mainframe or PC drive, but only the data before and after a single trigger event, the so-called 'pre-trigger' and 'post-trigger' data, is retained in the recording file.
Trigger data recording to a drive is limited by an **aggregate 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.

On trigger - buffered with Low rate Storage disabled



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 trigger - buffered with Low rate Storage enabled

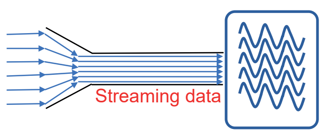


Data recording to PC or mainframe drive and simultaneous triggered data recording to trigger memory on the acquisition card.
The **Low** rate data recording to a drive is limited by an **aggregate sample rate** and the recording time is limited by the **size of drive**. The triggered data recording to 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 **Low** 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
On trigger	Yes	Free drive space	Yes	No	Yes
On trigger - buffered with Low rate Storage disabled	No	Trigger memory	No	Yes	Yes
On trigger - buffered with Low rate Storage enabled	Low rate: Yes	Free drive space	Yes	No	No
	High rate: No	Trigger memory	No	Yes	Yes

Aggregate sample rate limits when using streaming data

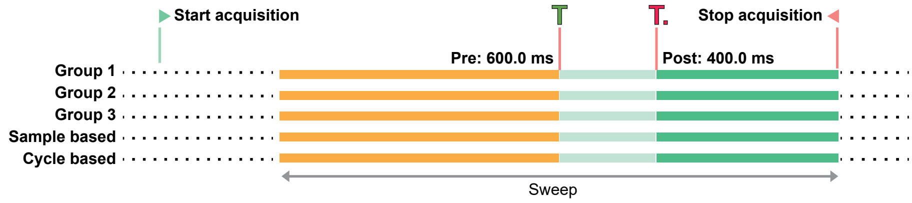


The maximum aggregate streaming rate per mainframe is defined by mainframe type and solid state drive, Ethernet speed, PC drive and other PC parameters.
When an aggregate sample rate is higher than the aggregate streaming rate of the system is selected, the memory on each acquisition card acts as a FIFO. 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 the next recording modes:
- On trigger
- On trigger - buffered with Low rate Storage disabled
- On trigger - buffered with Low rate Storage enabled

Sweep



Defined by a trigger signal, pre- and post-trigger data and optionally between-trigger data and/or stop-trigger 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

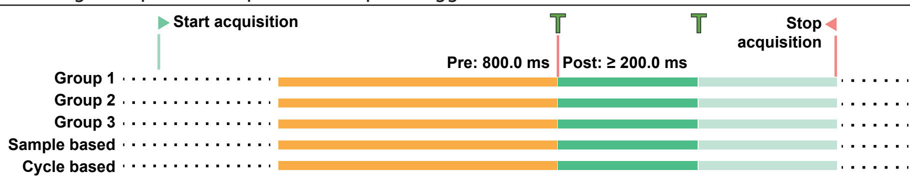
Trigger signal	This signal ends the pre-trigger and starts the post-trigger data recording. See table section "Post-trigger begins on" for more details. A trigger signal can be set up on external input trigger, analog and digital channels as well as using simple to complex RT-FDB formulas.
Stop-trigger 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

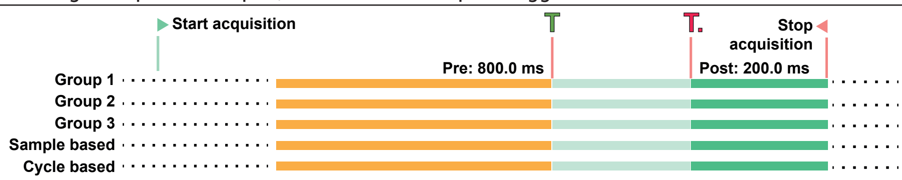
The first trigger signal ends the pre-trigger data recording and starts the recording of the post-trigger data.
Any **trigger** received during the post-trigger data recording is ignored.
Between-trigger data does not exist in this mode.
The resulting sweep contains pre- and the post-trigger data.

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 rate samples 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	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 the next recording modes: • On trigger • On trigger - buffered with Low rate Storage disabled • On trigger - buffered with Low rate Storage enabled				
	On trigger - buffered, independent of Low rate Storage		**On 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 second	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 (GN815) [1]

Data Recording Mode	On start of acquisition & Wait for trigger			Wait for trigger to trigger memory first			On start of acquisition reduced rate and wait for trigger to trigger memory first		
16 Bit Resolution									
	Enabled channels			Enabled channels			Enabled channels		
	1 Ch	8 Ch	8 Ch & events	1 Ch	8 Ch	8 Ch & events	1 Ch	8 Ch	8 Ch & events
Max. trigger memory	not used			954 MS	119 MS	106 MS	762 MS	95 MS	84 MS
Max. trigger sample rate	not used			2 MS/s			2 MS/s		
Max. reduced FIFO	954 MS	119 MS	106 MS	not used			190 MS	23 MS	21 MS
Max. (reduced) sample rate	2 MS/s			not used			Trigger sample rate / 2		
Max. aggregate reduced streaming rate	2 MS/s 4 MB/s	16 MS/s 32 MB/s	18 MS/s 36 MB/s	not used			1 MS/s 2 MB/s	8 MS/s 16 MB/s	9 MS/s 18 MB/s
18 Bit Resolution									
Data Recording Mode	**On start of acquisition & Wait for trigger**			**Wait for trigger to trigger memory first**			**On start of acquisition reduced rate and wait for trigger to trigger memory first**		
	Enabled channels			Enabled channels			Enabled channels		
	1 Ch	8 Ch	8 Ch & events Timer/ Counter	1 Ch	8 Ch	8 Ch & events Timer/ Counter	1 Ch	8 Ch	8 Ch & events Timer/ Counter
Max. trigger memory	not used			477 MS	59 MS	43 MS	381 MS	47 MS	34 MS
Max. trigger sample rate	not used			2 MS/s			2 MS/s		
Max. reduced FIFO	477 MS	59 MS	43 MS	not used			95 MS	11 MS	8 MS
Max. (reduced) sample rate	2 MS/s			not used			Trigger sample rate / 2		
Max. aggregate reduced streaming rate	2 MS/s 8 MB/s	16 MS/s 64 MB/s	22 MS/s 88 MB/s	not used			1 MS/s 4 MB/s	8 MS/s 32 MB/s	11 MS/s 44 MB/s

(1) Terminology used in alignment with Perception software.

Data Recording Details (GN816) [1]

16 Bit Resolution

Data Recording Mode	On start of acquisition & Wait for trigger			Wait for trigger to trigger memory first			On start of acquisition reduced rate and wait for trigger to trigger memory first		
	Enabled channels			Enabled channels			Enabled channels		
	1 Ch	8 Ch	8 Ch & events	1 Ch	8 Ch	8 Ch & events	1 Ch	8 Ch	8 Ch & events
Max. trigger memory	not used			100 MS	12 MS	10.5 MS	80 MS	9.5 MS	8 MS
Max. trigger sample rate	not used			200 kS/s			200 kS/s		
Max. (reduced) sample rate	200 kS/s			not used			Trigger sample rate / 2		
Max. aggregate reduced streaming rate	0.2 MS/s 0.4 MB/s	1.6 MS/s 3.2 MB/s	1.8 MS/s 3.6 MB/s	not used			0.1 MS/s 0.2 MB/s	0.8 MS/s 1.6 MB/s	0.9 MS/s 1.8 MB/s

18 Bit Resolution

Data Recording Mode	On start of acquisition & Wait for trigger			Wait for trigger to trigger memory first			On start of acquisition reduced rate and wait for trigger to trigger memory first		
	Enabled channels			Enabled channels			Enabled channels		
	1 Ch	8 Ch	8 Ch & events Timer/ Counter	1 Ch	8 Ch	8 Ch & events Timer/ Counter	1 Ch	8 Ch	8 Ch & events Timer/ Counter
Max. trigger memory	not used			50 MS	6 MS	4 MS	40 MS	4.5 MS	3 MS
Max. trigger sample rate	not used			200 kS/s			200 kS/s		
Max. reduced FIFO	50 MS	6 MS	4 MS	not used			10 MS	1 MS	0.7 MS
Max. (reduced) sample rate	200 kS/s			not used			Trigger sample rate / 2		
Max. aggregate reduced streaming rate	0.2 MS/s 0.8 MB/s	1.6 MS/s 6.4 MB/s	2.2 MS/s 8.8 MB/s	not used			0.1 MS/s 0.4 MB/s	0.8 MS/s 3.2 MB/s	1.1 MS/s 4.4 MB/s

(1) Terminology used in alignment with Perception software.

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 (2017)	Safety requirements for electrical equipment for measurement, control, and laboratory use - General requirements
EN 61010-2-030 (2017)	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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Importer:

Hottinger Bruel & Kjaer UK Ltd.
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South Yorkshire
S60 5WG
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Ordering Information

Article		Description	Order No.
Basic/IEPE 2M ISO		8 channels, 18 bit, 2 MS/s, ± 10 mV to ± 50 V input range, 2 GB RAM, 33 V RMS isolated, unbalanced differential input, single metal isolated BNC per channel. Basic voltage and IEPE sensor with TEDS class 1 support. Real-time cycle and timer based calculations with triggering on calculated results. Supported by Perception V6.50 and higher.	1-GN815
Basic/IEPE 200k ISO		8 channels, 18 bit, 200 kS/s, ± 10 mV to ± 50 V input range, 200 MB RAM, 33 V RMS isolated unbalanced differential input, single metal isolated BNC per channel. Basic voltage and IEPE sensor with TEDS class 1 support. Real-time cycle and timer based calculations with triggering on calculated results. Supported by Perception V6.50 and higher.	1-GN816

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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