DATA SHEET

GEN series GN1202B
Optical Fiber Isolated 100 MS/s Input Card

SPECIAL FEATURES

- 12 transmitters per receiver card
- Digital fiber optic connection, noise/error and drift free
- Cable length up to 1000 m
- Automatic cable length phase compensation
- Battery powered transmitter
- Continuous powered transmitter with 1.8 kV RMS isolation
- ± 20 mV to ± 100 V input ranges
- Analog/digital anti-alias filters
- Calibration values stored in transmitter
- 25 MS/s or 100 MS/s transmitter
- 15 or 14 bit resolution
- Real-time formula database calculators
- Triggering on real-time results
- Digital Event/Timer/Counter support

GN1202B FUNCTIONS AND BENEFITS

The optical fiber isolated system consists of up to 12 transmitter units connected to the GN1202B receiver card built into a GEN series mainframe using a fiber optic cable.
By converting the analog signal into a digital signal and transmitting the signal to the receiver card via fiber optic cable, the transmission does not add any drift or error to the measured signal. The automatic cable length compensation phase-matches all fiber optic isolated channels to any standard analog input channel.
The GN112 and GN113 transmitters offer continuous powered isolation at 1.8 kV RMS, while the GN110 and GN111 transmitters offer higher isolation options using battery power with a continuous operation time of 30 hours.
Superior, best in class anti-alias protection is achieved by a unique, multi stage approach. The first stage combination of a 6-pole analog anti-alias filter combined with the Analog-to-Digital converter creates an alias free digital data stream at constant rate of 100 MS/s.
The second stage feeds the 100 MS/s data stream into a user selectable digital filter, to reduce the signal to the desired maximum bandwidth. The digital filter supports 8 orders Bessel or Butterworth filter characteristics.
The third stage decimates the 100 MS/s filtered signal to the desired sample rate.
The digital filter before decimation guarantees a superior phase match, ultra-low noise and alias free result.
The real-time formula database calculators offer math routines to solve almost any real-time mathematical challenge. Dynamic digital cycle detection enables real-time storage as well as 1 µs latency digital output of calculation results like True-RMS on all analog, torque, angle, speed and Timer/Counter channels. Channel to channel math creates computed channels with 1 µs latency obtaining mechanical power and/or multiphase (not limited to three) electric power (P, Q, S) or even efficiency calculations. Real-time calculated results can be used to trigger the recording or signal alarms to the external world.

Capabilities Overview

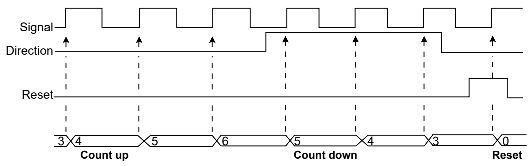
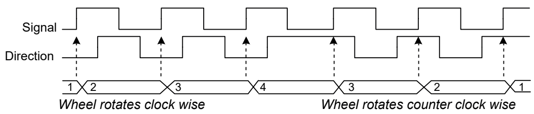
Receiver model	GN1202B
Transmitter models	GN110, GN111, GN112 and GN113
Maximum sample rate per channel	100 MS/s When either GN111 or GN113 is connected, the maximum sample rate for all channels will be limited to 25 MS/s
Memory per receiver	8 GB (4 GS)
Analog channels	1 input per transmitter (GN110, GN111, GN112 or GN113)
Anti-alias filters	Fixed bandwidth analog AA-filter combined with sample rate tracking digital AA-filter
ADC resolution	14 bit GN111 and GN113: 15 bit using four time over sampling
Isolation	Transmitter to receiver and transmitter to earth
Input type	Isolated, unbalanced differential inputs
Passive voltage/current probes	Passive, single-ended voltage probes
Sensors	Not supported
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. Due to technical implementation limits, some sample rates do not support Digital Event/Timer/Counters
Standard data streaming (CPCI up to 200 MB/s)	Not supported
Fast data streaming (PCIe up to 1 GB/s)	Supported
Slot width	1

Mainframe Support

<table>
<tr><th></th><th>GEN2tB</th><th>GEN4tB</th><th>GEN7tA / GEN7tB</th><th>GEN17tA / GEN17tB</th><th>GEN3iA</th><th>GEN7iA</th></tr>
<tr><td>GN1202B</td><td colspan="6">Yes</td></tr>
<tr><td>GEN DAQ API</td><td colspan="4">Yes</td><td colspan="2">Yes[1]</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>
<tr><td>XCP</td><td colspan="4">Yes</td><td colspan="2">No</td></tr>
</table>

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

Supported Analog Sensors and Probes		
Amplifier mode	**Supported analog sensors and probes**	**Features, Cabling and Accessories**
Basic voltage	• Electrical voltages single-ended and differential • Active single-ended voltage probes • Active differential voltage probes • Current probes	• ± 20 mV up to ± 100 V • Metal BNC

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

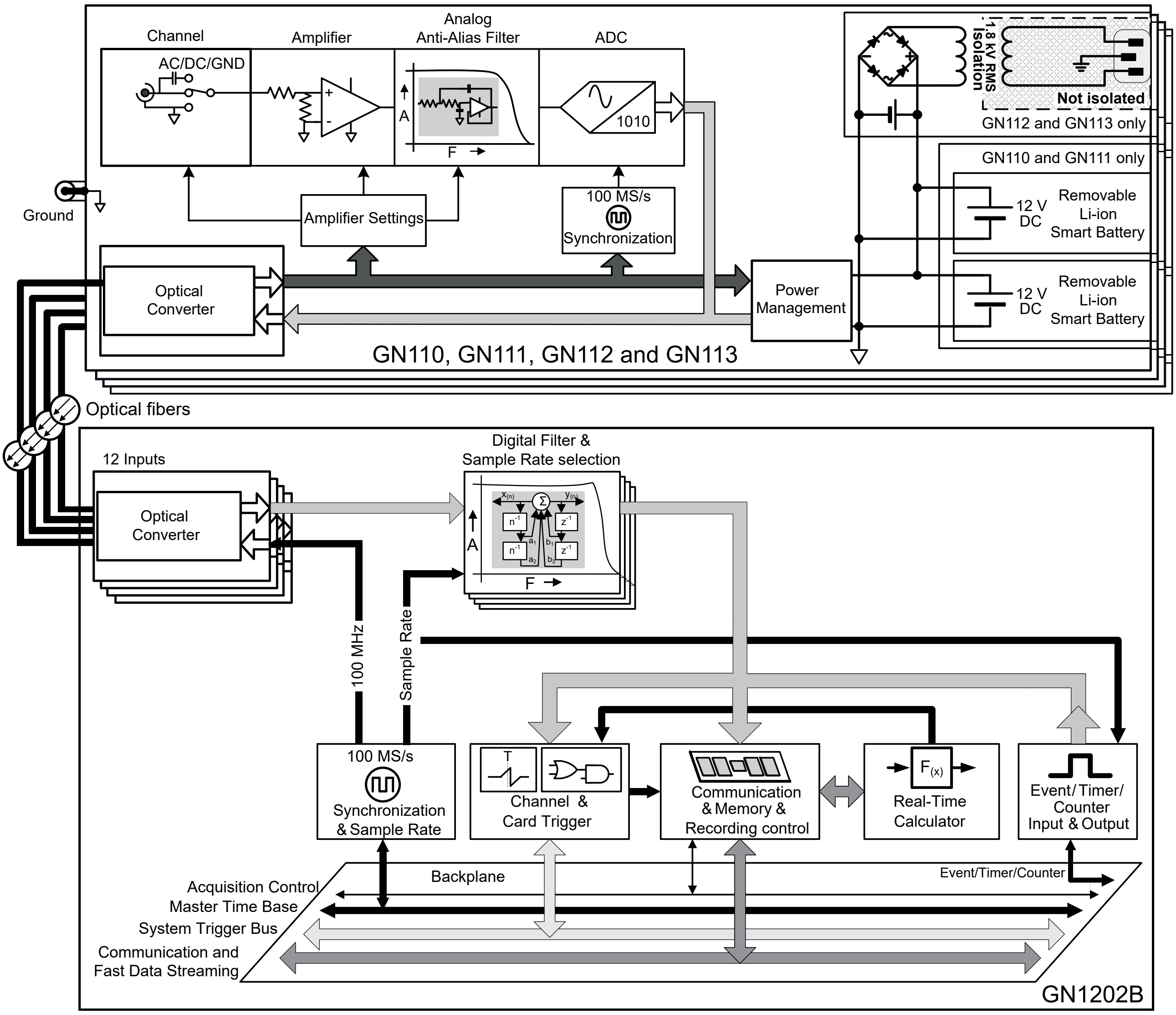


Figure 3: Block diagram

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 GN110, GN111, GN112 and GN113 (Transmitter)	
Channels	1
Connector	1; metal BNC
Input type	Isolated, unbalanced differential inputs (BNC connected to isolated common)
Input coupling	
Coupling modes	AC, DC, GND
AC coupling frequency	1.6 Hz (± 10%); - 3 dB

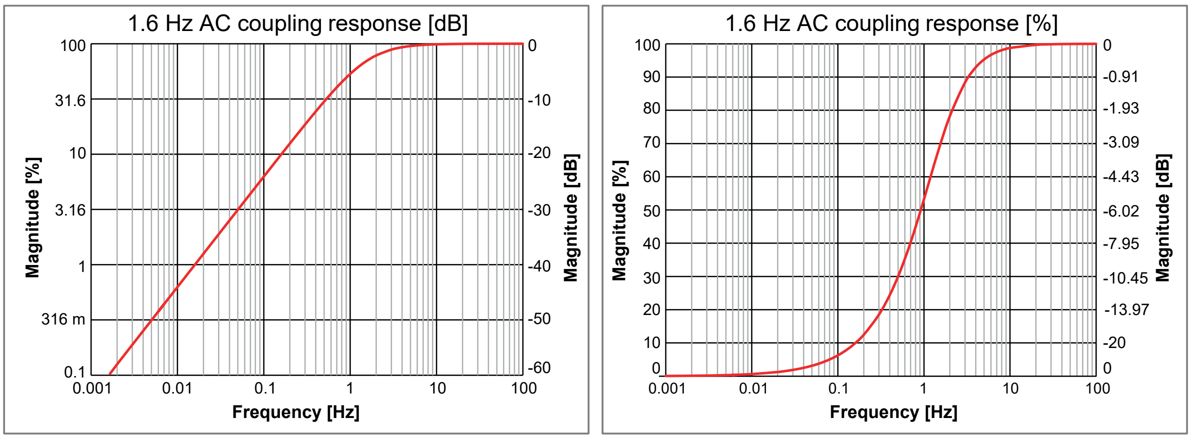


Figure 4: Representative AC coupling response

Impedance	1 MΩ (± 2%) // 38 pF (± 5%)
Ranges	± 20 mV, ± 50 mV, ± 100 mV, ± 200 mV, ± 500 mV, ± 1 V, ± 2 V, ± 5 V, ± 10 V, ± 20 V, ± 50V and ± 100 V
Offset	± 50% in 1000 steps (0.1%) ± 100 V range has fixed 0% offset
Input bias current	< 2 nA
Rise time	14 ns
DC Range error (*Pass/Fail limits*)	
Wideband	0.1% of range ± 50 µV
Bessel filter	0.1% of range ± 50 µV
DC range error drift	GN110 and GN111: ±(60 ppm + 10 µV)/°C (±(36 ppm + 6 µV)/°F) GN112 and GN113: ±(100 ppm + 10 µV)/°C (±(60 ppm + 6 µV)/°F)
DC Reading error (*Pass/Fail limits*)	
Wideband	0.1% of reading ± 50 µV
Analog Bessel anti-alias filter	0.1% of reading ± 50 µV
DC reading error drift	GN110 and GN111: ±100 ppm/°C (± 60ppm/°F) GN112 and GN113: ±(100 ppm + 10 µV)/°C (±(60 ppm + 6 µV)/°F)
RMS Noise (50 Ω terminated) (*Pass/Fail limits*)	
Wideband	0.05% of range ± 100 µV
Analog Bessel anti-alias filter	0.05% of range ± 100 µV
Common mode (referred to ground while protective ground is not connected) Requires a protected LAB environment and EN50191 compliant work procedures	
Rejection (CMR)	> 72 dB @ 80 Hz (GN110 and GN111: > 100 dB typical)
Maximum common mode voltage	1.8 KV RMS (GN112 and GN113) >1.8 kV RMS (GN110 and GN111); Limits set by fiber cable and transmitter air gap isolation
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 250 V, whichever value is the smallest.
Maximum nondestructive voltage	± 125 V DC; Ranges < ± 2 V ± 250 V DC; Ranges ≥ ± 2 V
Overload recovery time	Restored to 0.1% accuracy in less than 50 ns after 200% overload Restored to 10% accuracy in less than 10 ns after 200% overload

Analog to Digital Conversion

Sample rate per channel	1 S/s to 100 MS/s
ADC resolution; one ADC per channel	14 bit
ADC type	CMOS pipelined multi step flash converter, LTC2254
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/Bessel IIR/Butterworth IIR/etc.) or different filter bandwidths can result in phase mismatches between channels.

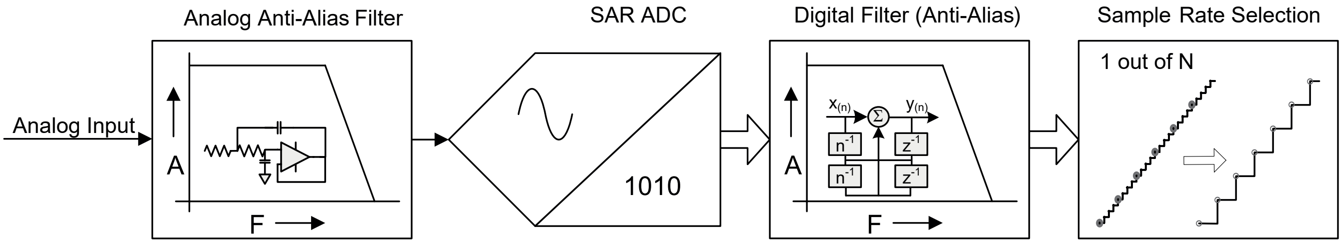


Figure 5: Combined analog and digital anti-alias filter block diagram

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	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. 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. 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 25 MS/s and lower, 16 bit resolution at 10 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 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. Enhanced resolution is supported by using oversampling combined with a digital filter at the following sample rates: 15 bit resolution at 25 MS/s and lower, 16 bit resolution at 10 MS/s and lower.

Bandwidth and Filter Characteristic Selection versus Sample Rate

The digital filter before decimation guarantees a superior phase match, ultra-low noise and alias free result.

	Wideband(1)	Analog(2)	Digital anti alias low pass filters (Second stage after analog AA)				
	No Anti-alias filter	Bessel Anti-alias filter	Butterworth IIR	Bessel IIR Butterworth IIR	Bessel IIR Butterworth IIR	Bessel IIR Butterworth IIR	Bessel IIR
Sample rate			1/4 Fs	1/10 Fs	1/20 Fs	1/40 Fs	1/100 Fs
100 MS/s	Wideband	10 MHz	--	--	5 MHz	2.5 MHz	1 MHz
50 MS/s	Wideband	10 MHz	--	5 MHz	2.5 MHz	1.25 MHz	500 kHz
25 MS/s	Wideband	10 MHz	--	2.5 MHz	1.25 MHz	625 kHz	250 kHz
20 MS/s	Wideband	10 MHz	5 MHz	2 MHz	1 MHz	500 kHz	200 kHz
12.5 MS/s	Wideband	10 MHz	3.125 MHz	1.25 MHz	625 kHz	312.5 kHz	125 kHz
10 MS/s	Wideband	10 MHz	2.5 MHz	1 MHz	500 kHz	250 kHz	100 kHz
5 MS/s	Wideband	10 MHz	1.25 MHz	500 kHz	250 kHz	125 kHz	50 kHz
4 MS/s	Wideband	10 MHz	1 MHz	400 kHz	200 kHz	100 kHz	40 kHz
2.5 MS/s	Wideband	10 MHz	12.5 kHz	250 kHz	125 kHz	62.5 kHz	25 kHz
2 MS/s	Wideband	10 MHz	500 kHz	200 kHz	100 kHz	50 kHz	20 kHz
1.25 MS/s	Wideband	10 MHz	312.5 kHz	125 kHz	62.5 kHz	31.25 kHz	12.5 kHz
1 MS/s	Wideband	10 MHz	250 kHz	100 kHz	50 kHz	25 kHz	10 kHz
500 kS/s	Wideband	10 MHz	125 kHz	50 kHz	25 kHz	12.5 kHz	5 kHz
400 kS/s	Wideband	10 MHz	100 kHz	40 kHz	20 kHz	10 kHz	4 kHz
250 kS/s	Wideband	10 MHz	62.5 kHz	25 kHz	12.5 kHz	6.25 kHz	2.5 kHz
200 kS/s	Wideband	10 MHz	50 kHz	20 kHz	10 kHz	5 kHz	2 kHz
125 kS/s	Wideband	10 MHz	31.25 kHz	12.5 kHz	6.25 kHz	3.125 kHz	1.25 kHz
100 kS/s	Wideband	10 MHz	25 kHz	10 kHz	5 kHz	2.5 kHz	1 kHz
50 kS/s	Wideband	10 MHz	12.5 kHz	5 kHz	2.5 kHz	1.25 kHz	500 Hz
40 kS/s	Wideband	10 MHz	10 kHz	4 kHz	2 kHz	1 kHz	400 Hz
25 kS/s	Wideband	10 MHz	6.25 kHz	2.5 kHz	1.25 kHz	625 Hz	250 Hz
20 kS/s	Wideband	10 MHz	5 kHz	2 kHz	1 kHz	500 Hz	200 Hz
12.5 kS/s	Wideband	10 MHz	3.125 kHz	1.25 kHz	625 Hz	312.5 Hz	125 Hz
10 kS/s	Wideband	10 MHz	2.5 kHz	1 kHz	500 Hz	250 Hz	100 Hz
5 kS/s	Wideband	10 MHz	1.25 kHz	500 Hz	250 Hz	125 Hz	50 Hz
4 kS/s	Wideband	10 MHz	1 kHz	400 Hz	200 Hz	100 Hz(3)	--
2.5 kS/s	Wideband	10 MHz	625 Hz	250 Hz	125 Hz	62.5 Hz(3)	--
2 kS/s	Wideband	10 MHz	500 Hz	200 Hz	100 Hz(3)	50 Hz(3)	--
1.25 kS/s	Wideband	10 MHz	312.5 Hz	125 Hz	62.5 Hz(3)	--	--
1 kS/s	Wideband	10 MHz	250 Hz	100 Hz(3)	50 Hz(3)	--	--
500 S/s	Wideband	10 MHz	125 Hz	50 Hz(3)	--	--	--

(1) Wideband does not prevents analog anti-aliasing for the ADC.

(2) Bessel analog anti-alias filter is selectable in all sample rates.

(3) Only supported for Bessel IIR filter selection.

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	Between 27 MHz and 36 MHz (-3 dB)
0.1 dB passband flatness[(1)]	DC to 3 MHz

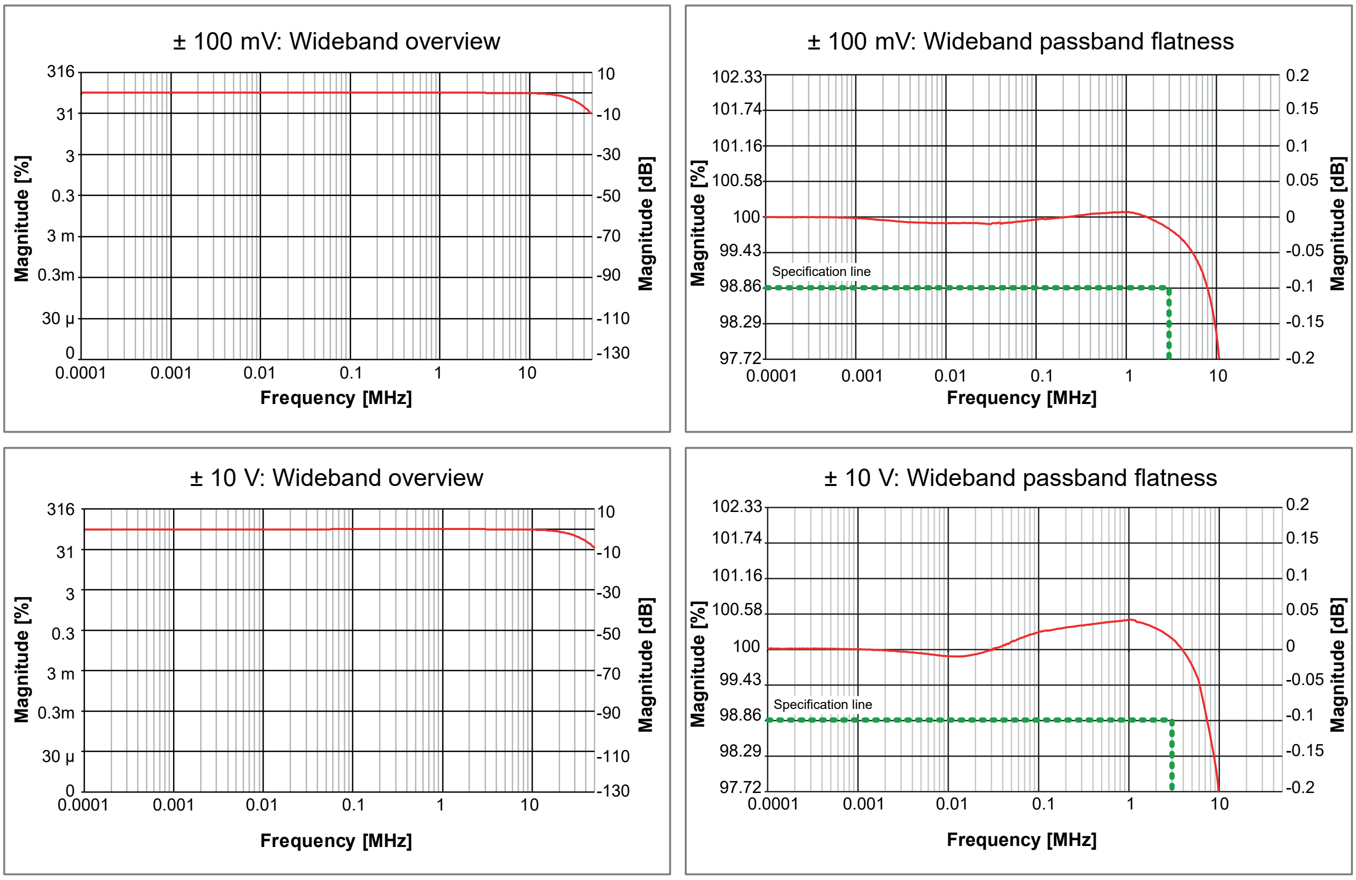
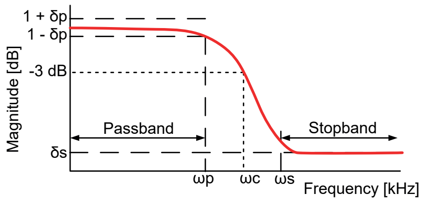


Figure 6: Representative Wideband examples

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

Bessel Filter (Analog Anti-Alias)



δp: Passband ripple
δs: Stopband attenuation

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

Figure 7: Bessel Filter

When Bessel filter is selected, this is only the analog Bessel anti-alias filter and not a digital filter.

Bessel filter bandwidth	10 MHz ± 1 MHz (-3 dB)
Bessel filter characteristic	6-pole Bessel, optimal step response
Bessel filter 0.1 dB passband flatness(1)	DC to 1 MHz
Stopband	50 dB at ωs = 60 MHz
Analog Bessel filter roll-off	-30 dB/Octave

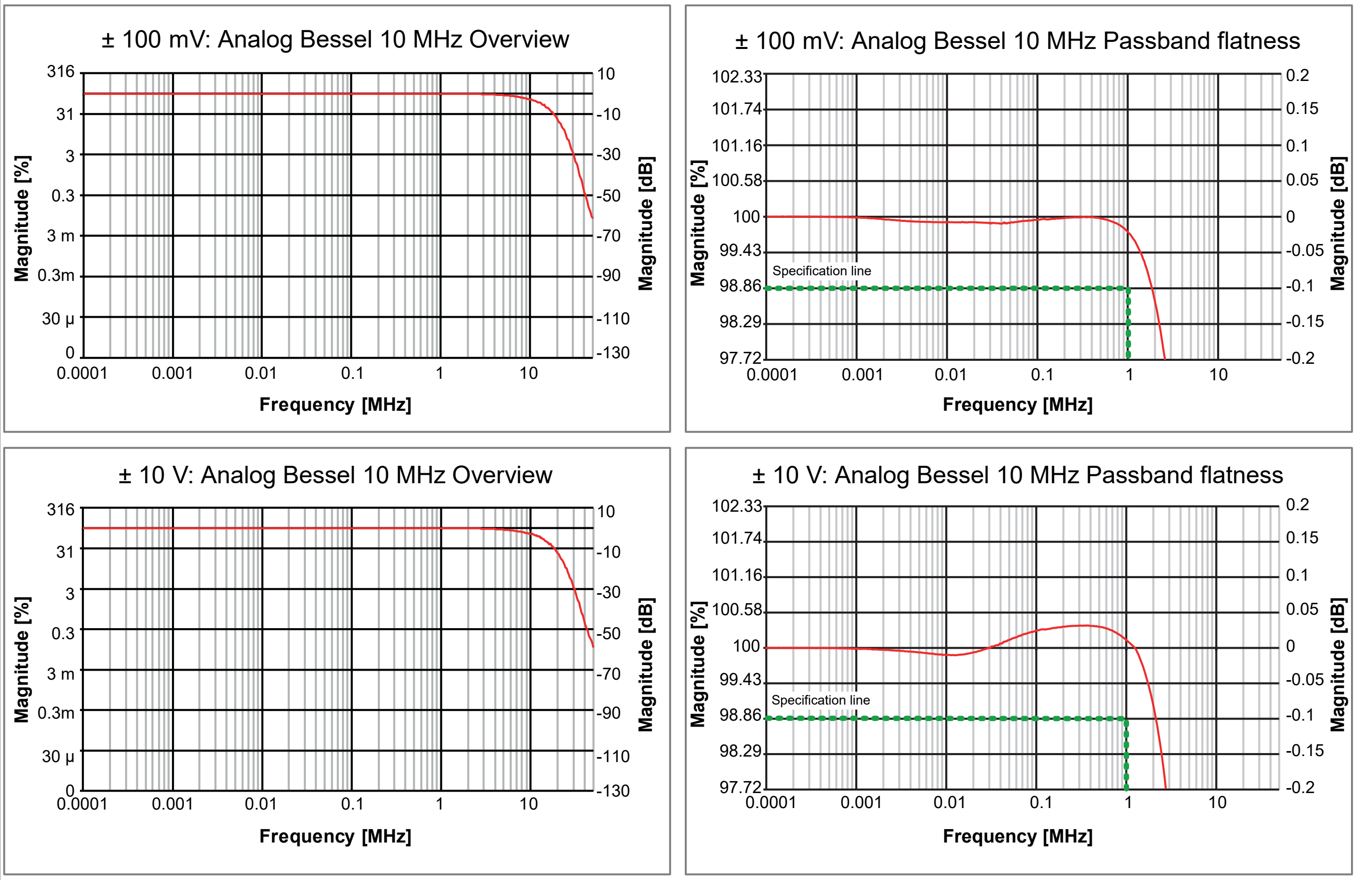
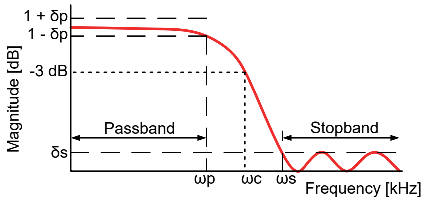


Figure 8: Representative Bessel examples

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

Bessel IIR Filter (Digital Anti-Alias)



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	Bessel
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 50 Hz to 5 MHz
Bessel IIR 0.1 dB passband (ωp)(1)	DC to 0.16 * ωc
Bessel IIR filter stopband attenuation (δs)	-60 dB
Bessel IIR filter roll-off 48	-48 dB/Octave

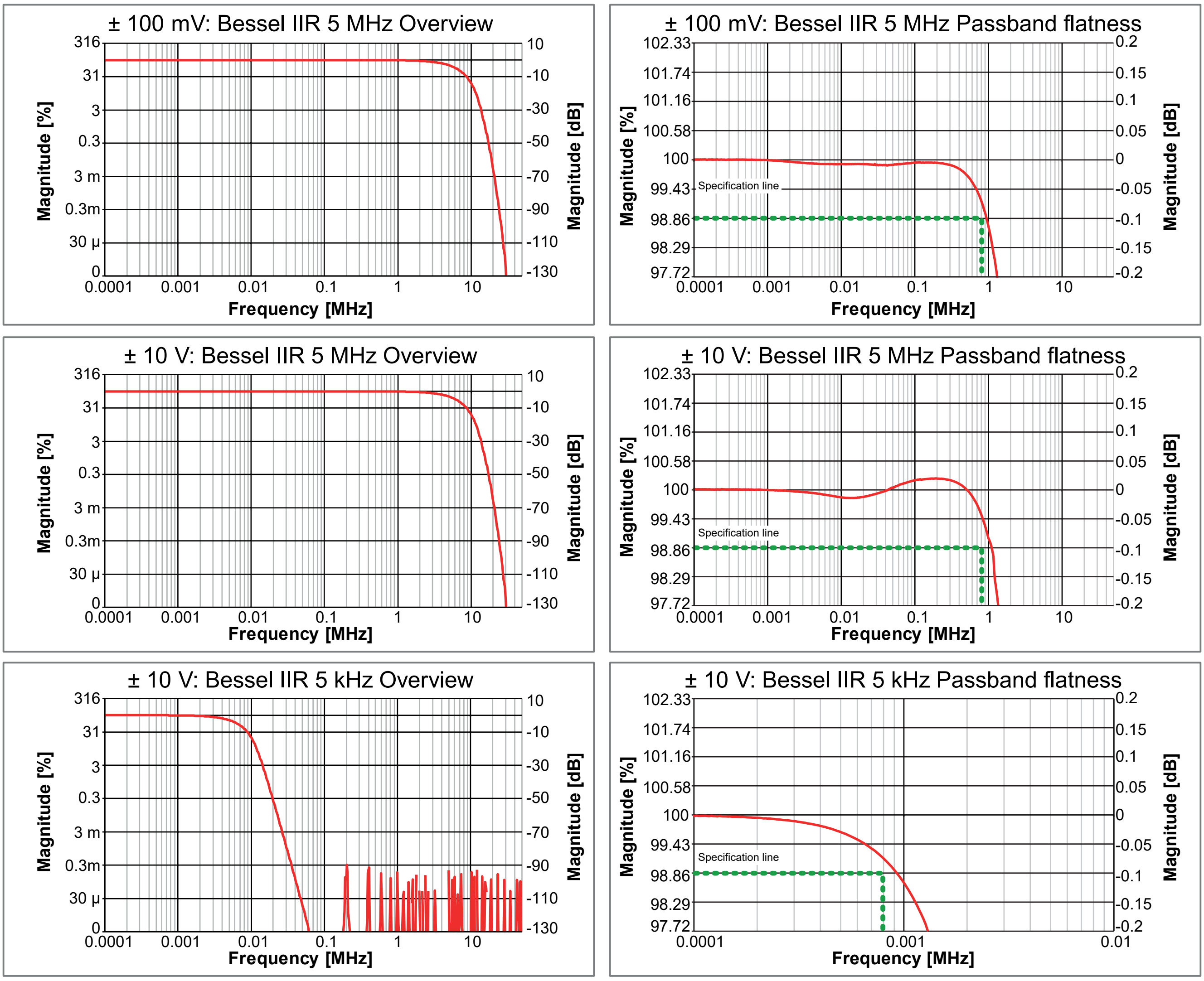


Figure 10: Representative Bessel IIR examples

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

Butterworth IIR Filter (Digital Anti-Alias)

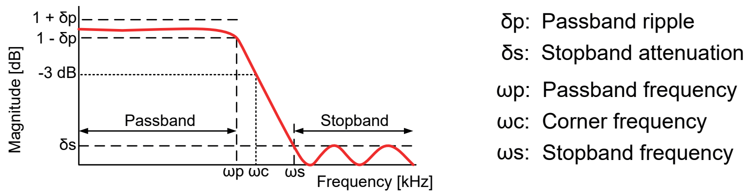


Figure 11: Digital Butterworth IIR Filter

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

Analog anti-alias filter	Bessel
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 125 Hz to 5 MHz
Butterworth IIR 0.1 dB passband (ωp)(1)	DC to 0.7 * ωc (for ωc > 1 MHz, DC to 0.3 * ωc, due to analog anti-alias filter bandwidth)
Butterworth IIR filter stopband attenuation (δs)	-60 dB
Butterworth IIR filter roll-off	-48 dB/octave

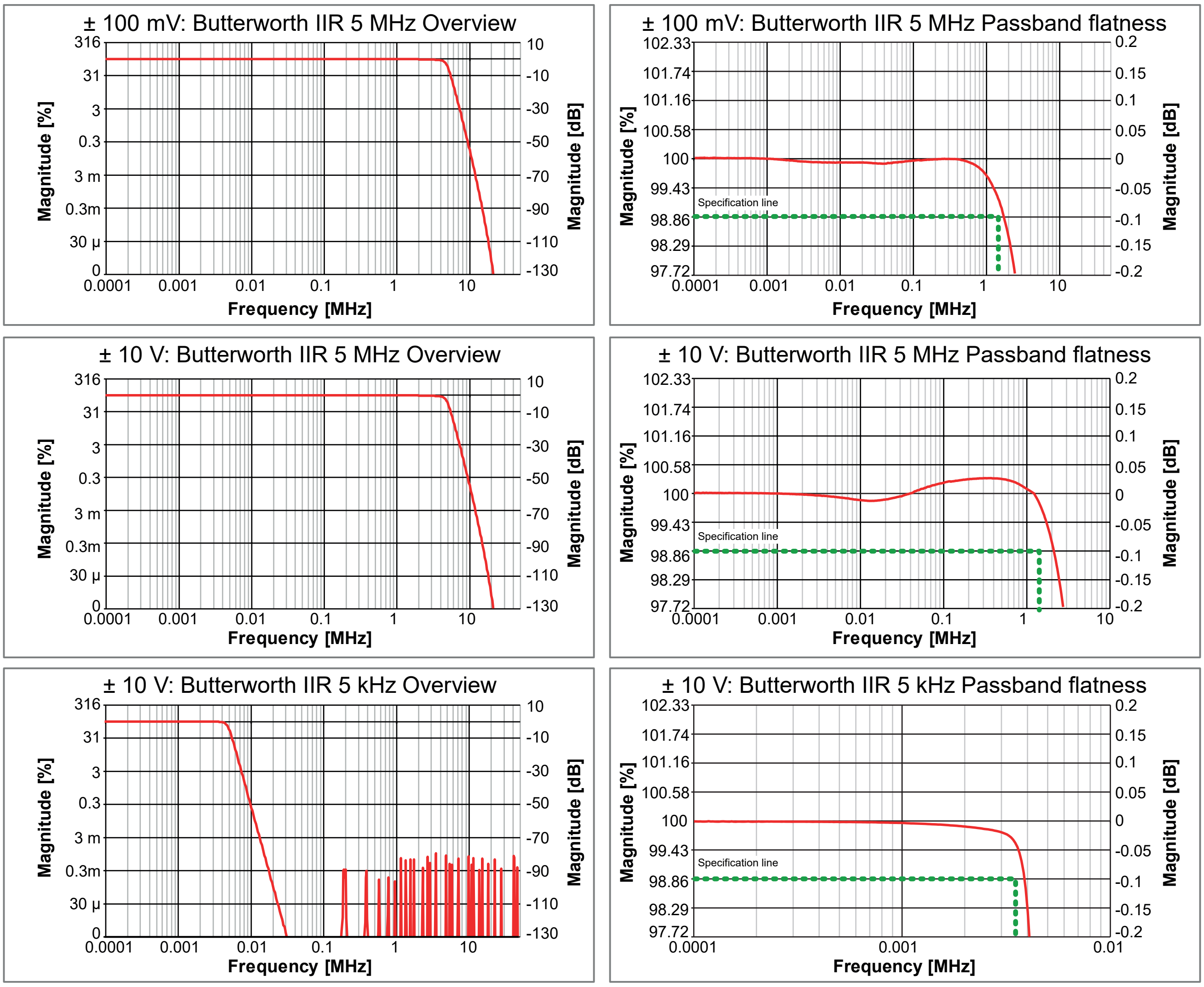


Figure 12: Representative Butterworth IIR examples (200 kHz for GN310B only; 20 kHz for GN310B and GN311B)

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

Channel to Channel Phase Match	
Using different filter selections (Wideband/Bessel/Bessel IIR/Butterworth IIR) or different filter bandwidths results in phase mismatches between channels.	
Channel to channel phase difference	Typical ± 10 ns with the same filter selections applied (≥ 100Hz)
Fiber cable length compensation	Yes, automatic when optical communication is established Optical cable delay is compensated to phase match standard GEN DAQ channels.
Typical fiber cable delay mismatch	± 20 ns
Fiber cable delay	5 ns/m; delay compensated by cable length compensation

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.

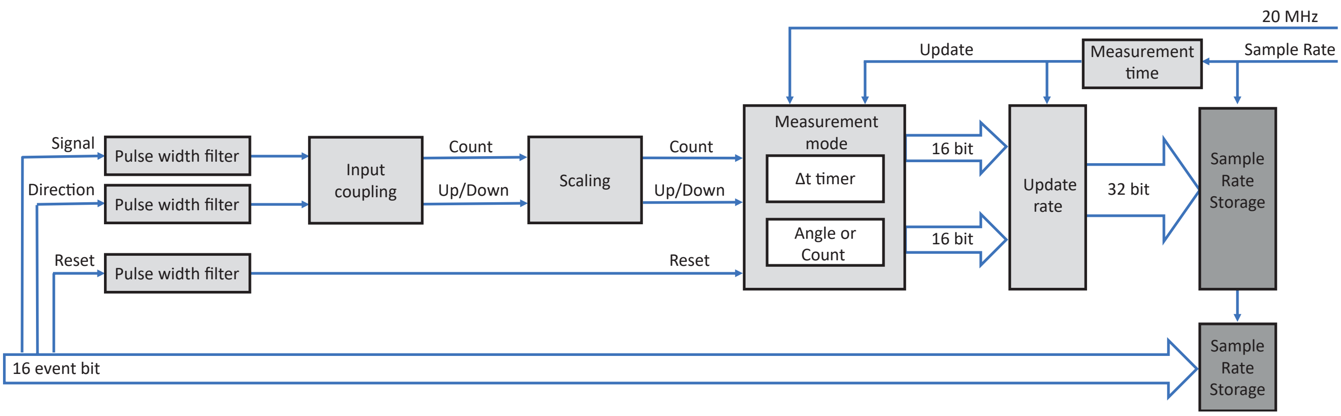


Figure 13: Timer/Counter block diagram

Card sample rate	Digital Event/Timer/Counter sample rate
≤10 MS/s and 20 MS/s	Sample rate
40 MS/s and 100 MS/s	20 MS/s limited by the 20 MS/s digital event sample rate on mainframe
12.5 MS/s, 25 MS/s and 50 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	± 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.

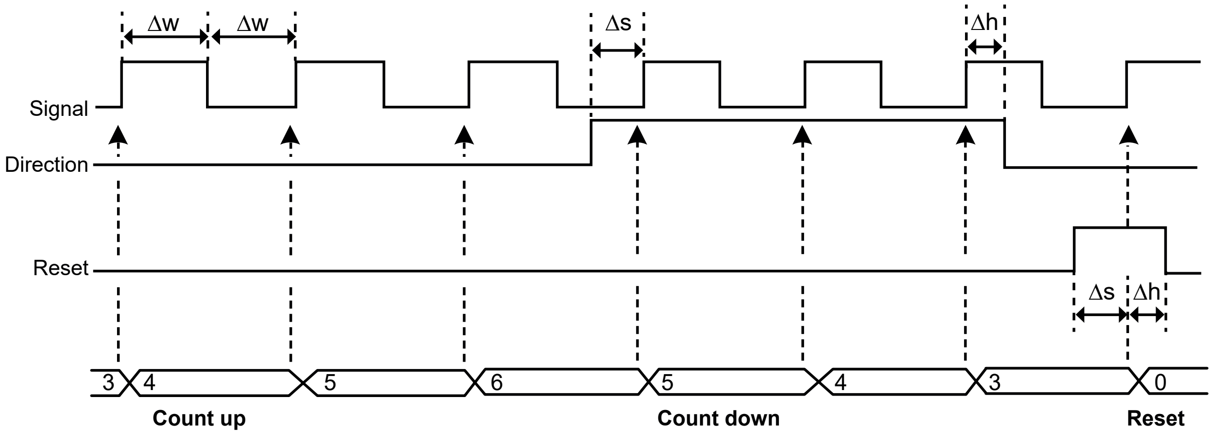


Figure 14: Uni- and Bi-directional timing

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.	

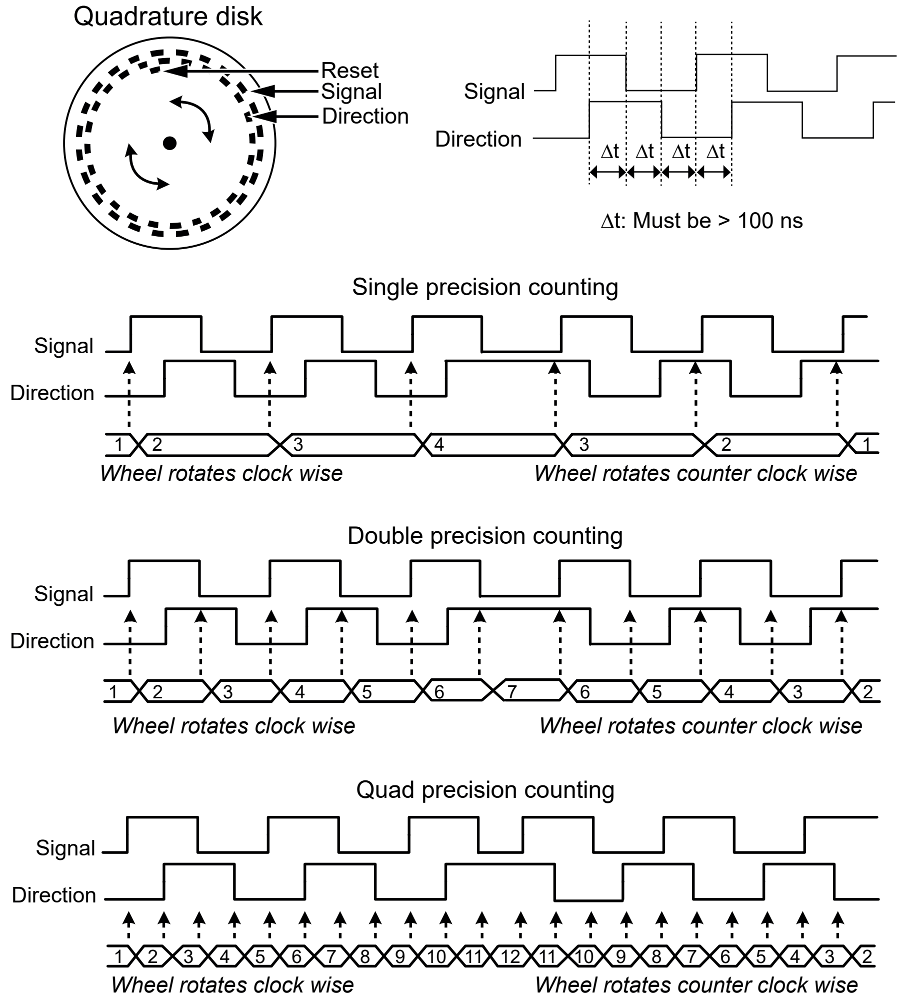


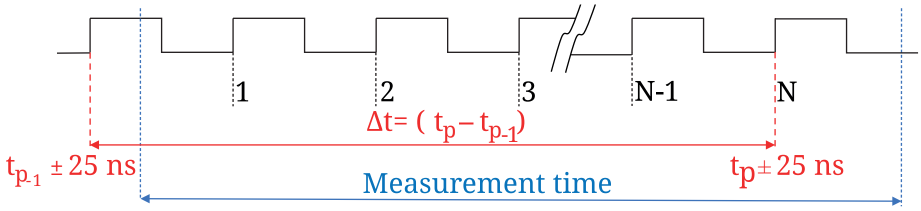
Figure 15: Bi-directional quadrature count modes

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.



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

Figure 16: 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)

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

Measurement time	Higher signal frequencies: Signal frequency 2 MHz down to 10 kHz										
	Worst case (in %)	**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 MHz(2)	±5.000%									
2 µs	±5.000 @ ~1 MHz(2)	±2.500%									
5 µs	±2.000 @ ~400 kHz(2)	±1.000%		±1.250%	±1.000%						
10 µs	±1.000 @ ~200 kHz(2)	±0.500%									
20 µs	±0.500 @ ~100 kHz(2)	±0.250%									
50 µs	±0.200 @ ~40 kHz(2)	±0.100%						±0.125%	±0.100%		
100 us	±0.100 @ ~20 kHz(2)	±0.050%									
200 us	±0.050 @ ~10 kHz(2)	±0.0250%									
500 us	±0.020 @ ~4 kHz(2)	±0.0100%									
1 ms	±0.0100 @ ~2 kHz(2)	±0.0050%									
2 ms	±0.0100 @ ~1 kHz(2)	±0.0050%									
5 ms	±0.0080 @ ~400 Hz(2)	±0.0040%									
10 ms	±0.0070 @ ~200 Hz(2)	±0.0035%									
20 ms	±0.0070 @ ~100 Hz(2)	±0.0035%									
50 ms	±0.0068 @ ~40 Hz(2)	±0.0034%									
100 ms	±0.0067 @ ~20 Hz(2)	±0.00335%									

Measurement time	Lower signal frequencies: Signal frequency 5 kHz down to 40 Hz										
	Worst case (in %)	**5 kHz**	**4 kHz**	**2 kHz**	**1 kHz**	**500 Hz**	**400 Hz**	**200 Hz**	**100 Hz**	**50 Hz**	**40 Hz**
500 us	±0.0200 @ ~4 kHz(2)	±0.0125%	±0.0100%								
1 ms	±0.0100 @ ~2 kHz(2)	±0.0050%									
2 ms	±0.0100 @ ~1 kHz(2)	±0.0050%									
5 ms	±0.0080 @ ~400 Hz(2)	±0.0040%				±0.00500%	±0.0040%				
10 ms	±0.0070 @ ~200 Hz(2)	±0.0035%									
20 ms	±0.0070 @ ~100 Hz(2)	±0.0035%									
50 ms	±0.0068 @ ~40 Hz(2)	±0.0034%								±0.0043%	±0.0034%
100 ms	±0.0067 @ ~20 Hz(2)	±0.00335%									

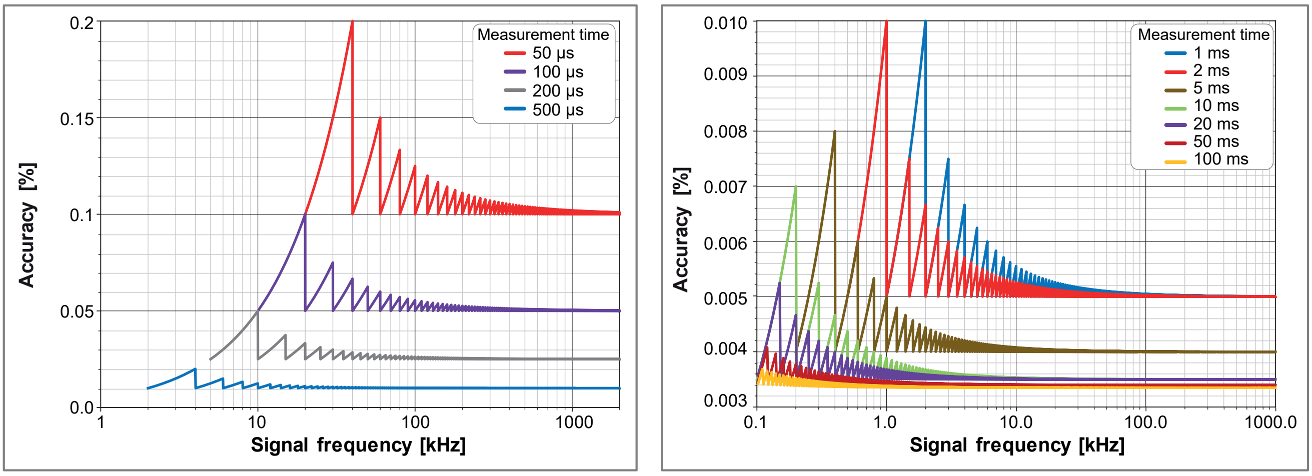


Figure 17: Maximum frequency inaccuracy

(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 frequency is slightly below the displayed value, consistent with the sawtooth pattern observed in Figure 17.

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 17 will result in Figure 18 (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%

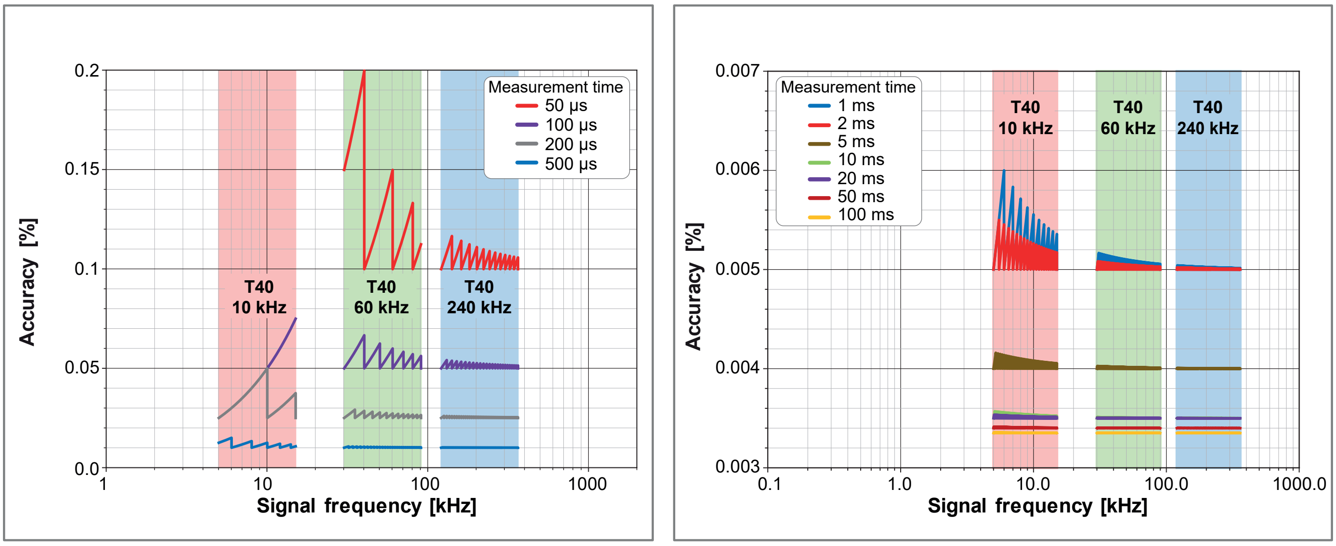


Figure 18: Torque operating range versus inaccuracy and measurement time

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 17 will result in Figure 19 (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%

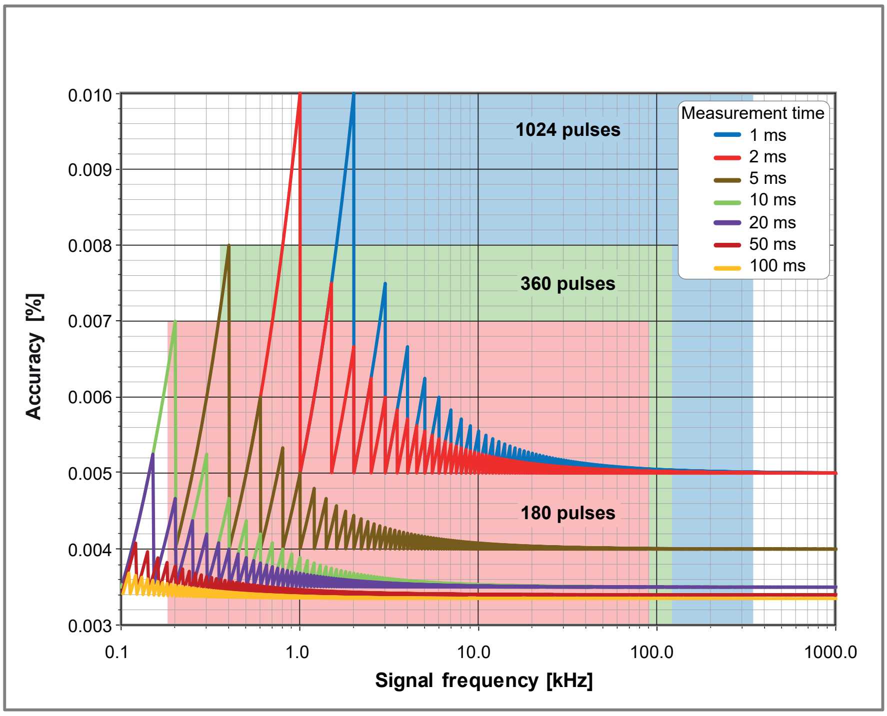


Figure 19: RPM sensor operating range versus inaccuracy and measurement time

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.			

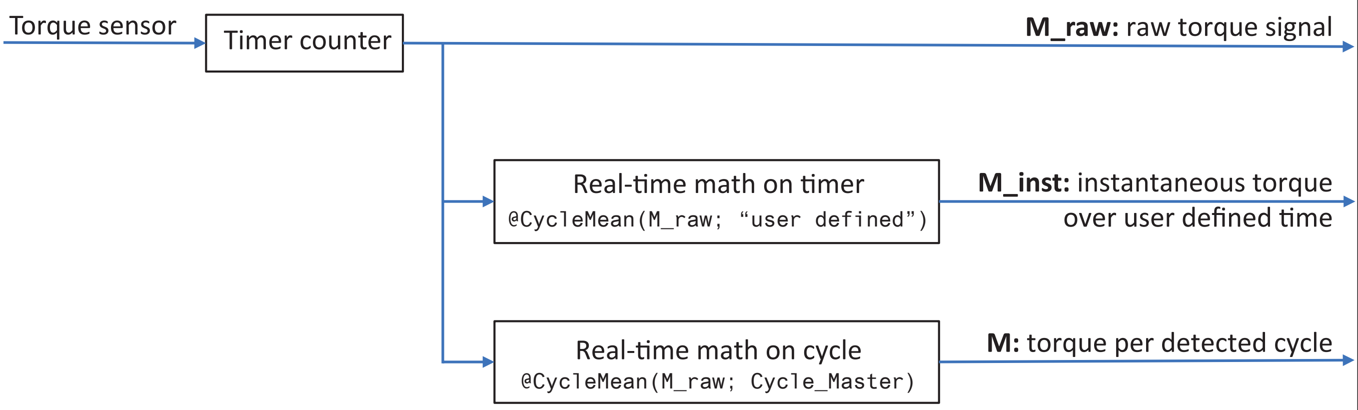


Figure 20: Simultaneous dynamic and accurate torque calculations

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	8 GB (4 GS)
Organization	Automatic distribution amongst enabled channels
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.

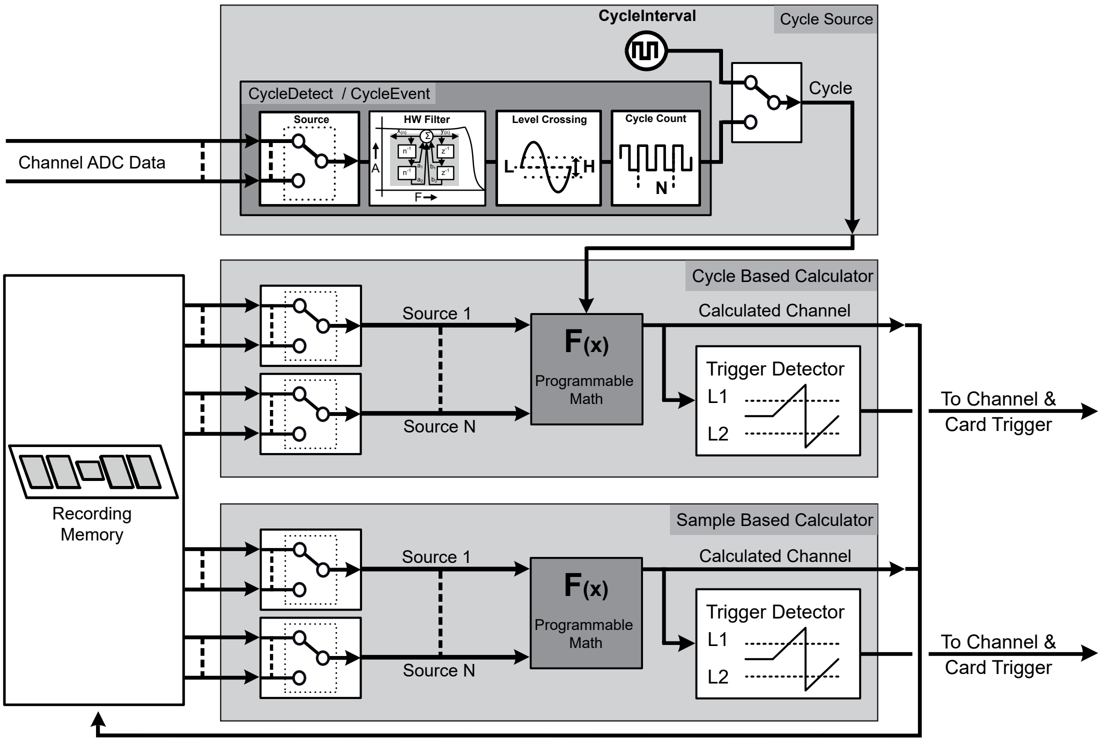


Figure 21: Real-time formula database (RT-FDB) calculators

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

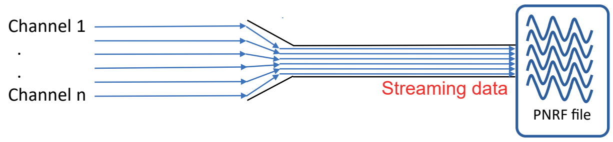
Group	Available RT-FDB functions		
Basic			
	+ (add) - (subtract)	* (multiply) / (divide)	
Boolean			
	AlarmOnLevel And Equal GreaterEqualThan GreaterThan InsideBand	Not NotEqual OneShotTimer Or OutsideBand SetAlarm StartStopTriggerOnBooleanChange StopTriggerOnBooleanChange	ToAsyncBoolean TriggerArmOnBooleanChange TriggerOnBooleanChange TriggerOnLevel Xor

Real-time Formula Database Calculators (Option to be ordered separately)			
Group	**Available RT-FDB functions**		
Cycle			
	CycleArea CycleBusDelay CycleCount CycleCrestFactor CycleDetect CycleEnergy CycleEvent CycleFrequency	CycleFundamentalPhase CycleFundamentalRMS CycleHarmonicPhase CycleHarmonicRMS CycleInterval CycleMax CycleMean CycleMin	CycleNOP CyclePeak2Peak CyclePhase CycleRMS CycleRPM CycleSampleCount CycleStdDev CycleTHD ExternalCycleEvent
eDrive			
	AronConversion DQ0Transformation EfficiencyMode	EfficiencyValue HarmonicsIEC61000 PowerLoss	SpaceVector SpaceVectorInv
Enhanced			
	Abs Atan Atan2 Cos DegreesToRadians Integrate IntegrateGated	LessEqualThan LessThan Max Min Minus Modulo PureDFT	RadiansToDegrees SampleCount Sin Sqrt Tan
Fieldbus			
	SetScalarFromFieldbus		
Filter			
	FilterBesselBP FilterBesselHP FilterBesselLP HWFilter	FilterButterworthBP FilterButterworthHP FilterButterworthLP	FilterChebyshevBP FilterChebyshevHP FilterChebyshevLP
Math			
	NumSamplesMean NumSamplesStdDev	TimedMean TimedStdDev	
Signal generation			
	Ramp Sinewave		

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

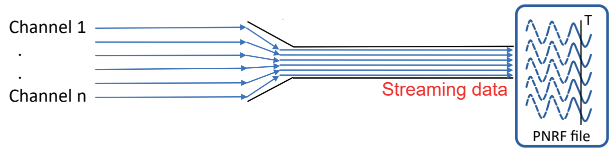
Data Recording Modes

On start of acquisition



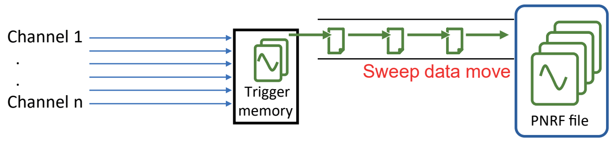
Recorded data is continuously streamed into the recording file on a mainframe or PC drive
Data recording to a drive is limited by an **aggregate sample rate**, the recording time is limited by the **size of drive**.
Note: As the aggregate sample rate limit depends on Ethernet speed and storage drive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



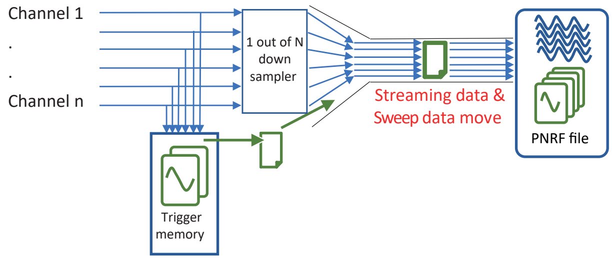
Recorded data is continuously streamed into the recording file on a mainframe or PC drive, but only the data before and after a single trigger event, the so-called 'pre-trigger' and 'post-trigger' data, is retained in the recording file.
Trigger data recording to a drive is limited by an **aggregate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

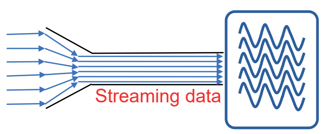


Data recording to PC or mainframe drive and simultaneous triggered data recording to trigger memory on the acquisition card.
The **Low** rate data recording to a drive is limited by an **aggregate sample rate** and the recording time is limited by the **size of drive**. The triggered data recording to 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.

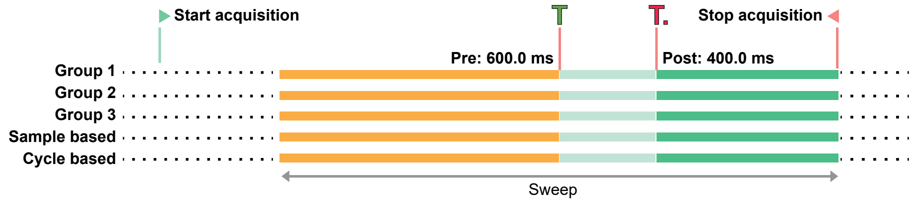
Data Recording Compared

	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

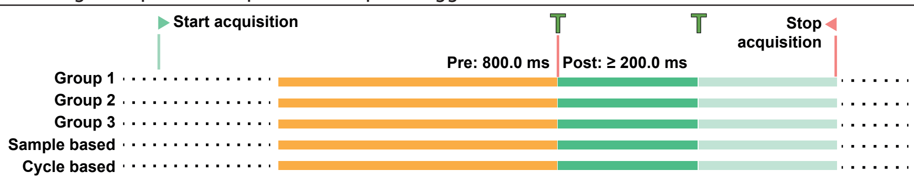
Aggregate sample rate limits when using streaming data

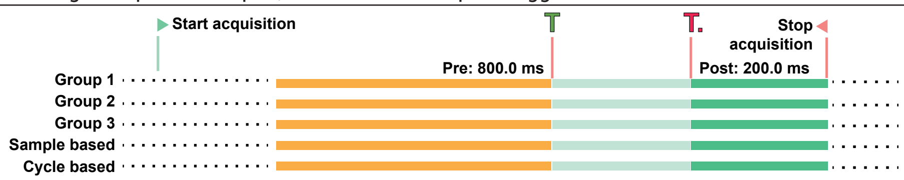


The maximum aggregate streaming rate per mainframe is defined by mainframe type and solid state drive, Ethernet speed, PC drive and other PC parameters.
When an aggregate sample rate is higher than the aggregate streaming rate of the system is selected, the memory on each acquisition card acts as a FIFO. 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.

<table>
<tr><th colspan="2">Triggered Recording Definitions</th></tr>
<tr><td colspan="2">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</td></tr>
<tr><td>Sweep
</td><td>

Defined by a trigger signal, pre- and post-trigger data and optionally between-trigger data and/or stop-trigger signal.</td></tr>
<tr><td colspan="2">Triggered data segments</td></tr>
<tr><td>Pre-trigger data</td><td>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.</td></tr>
<tr><td>Post-trigger data</td><td>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.</td></tr>
<tr><td>Between-trigger data</td><td>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.</td></tr>
<tr><td colspan="2">Trigger signals</td></tr>
<tr><td>Trigger signal</td><td>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.</td></tr>
<tr><td>Stop-trigger signal</td><td>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.</td></tr>
<tr><td colspan="2">Post-trigger begins on</td></tr>
<tr><td>First trigger</td><td>

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.</td></tr>
<tr><td>Every trigger</td><td>

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.</td></tr>
<tr><td>Stop trigger</td><td>

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.</td></tr>
</table>

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 [1]

On start of acquisition & On trigger															
Enabled channels	1 channel	2 channels	3 channels	4 channels	5 channels	6 channels	7 channels	8 channels	9 channels	10 channels	11 channels	12 channels	12 channels 1 Timer/Counter	12 channels 2 Timer/Counters	12 channels 2 Timer/Counters Digital events
Max. FIFO	3800 MS	1800 MS	1200 MS	900 MS	720 MS	600 MS	510 MS	450 MS	400 MS	360 MS	320 MS	280 MS	230 MS	210 MS	190 MS
Max. sample rate [2]	25 MS/s												20 MS/s (Timer/Counter limitation)		
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	225 MS/s	250 MS/s	275 MS/s	300 MS/s	280 MS/s	320 MS/s	340 MS/s
On trigger - buffered with Low rate Storage disabled															
Enabled channels	1 channel	2 channels	3 channels	4 channels	5 channels	6 channels	7 channels	8 channels	9 channels	10 channels	11 channels	12 channels	12 channels 1 Timer/Counter	12 channels 2 Timer/Counters	12 channels 2 Timer/Counters Digital events
Max. trigger memory	1000 MS	1000 MS	1000 MS	760 MS	595 MS	490 MS	410 MS	355 MS	310 MS	275 MS	245 MS	220 MS	185 MS	160 MS	148 MS
Max. sample rate	100 MS/s (GN110 / GN112) 25 MS/s (GN111 / GN113)														
On trigger - buffered with Low rate Storage enabled															
Enabled channels	1 channel	2 channels	3 channels	4 channels	5 channels	6 channels	7 channels	8 channels	9 channels	10 channels	11 channels	12 channels	12 channels 1 Timer/Counter	12 channels 2 Timer/Counters	12 channels 2 Timer/Counters Digital events
Max. trigger memory	1000 MS	1000 MS	1000 MS	760 MS	595 MS	490 MS	410 MS	355 MS	310 MS	275 MS	245 MS	220 MS	185 MS	160 MS	148 MS
Max. high rate sample rate [2]	100 MS/s (GN110 / GN112) 25 MS/s (GN111 / GN113)														
Max. Low rate FIFO	800 MS	400 MS	260 MS	180 MS	144 MS	120 MS	103 MS	89 MS	75 MS	68 MS	61 MS	55 MS	46 MS	40 MS	37 MS
Max. Low rate sample rate	25 MS/s												20 MS/s (Timer/Counter limitation)		
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	225 MS/s	250 MS/s	275 MS/s	300 MS/s	280 MS/s	320 MS/s	340 MS/s

(1) Terminology used in alignment with Perception software.

(2) Maximum sample rate is determined by the connected and enabled transmitter with the lowest sample rate.

G091: 2 Gbit Optical SFP Module Multi Mode 850 nm (Option, to be ordered separately)	
Small Form-factor Pluggable (SFP) Optical transceiver used for: ● Multi Mode 850 nm 1 Gbit optical network support ● GN1202B optical front end connection ● GEN DAQ optical Master/Sync connections	
⚠	**WARNING** **Use HBM approved transceivers only.**
Data rate	2.125 Gbps
Wavelength	850 nm
Input connector	LC
Form factor	SFP
Laser class	1
Original manufacturer's part number	Finisar FTLF8519P3BNL
Temperature Range	
Operational	-20 °C to +60 °C (-4 °F to +140 °F)
Non-operational (Storage)	-40 °C to +85 °C (-40 °F to +158 °F)

Fiber Optic Link	
Light source	Class 1 laser product
Transfer rate	2.125 Gbit/s
Wavelength	850 nm
Connector	LC duplex on GN1202B SCRJ/IP67 duplex on GN110, GN111, GN112 and GN113
Cable	
Isolation	10^{15} Ω/m
Type	Duplex Multi Mode, 50/125 µm, ISO/IEC 11801 type OM2, OM3 or OM4
Coupler	LC duplex or SCRJ/IP67 duplex
Maximum cable length For every extra coupler used subtract 200 m (656 ft). Refer to the GEN series Isolated Digitizer manual for details on maximum length calculations.	
ISO/IEC 11801 type OM2	500 m (1640 ft) no extra cable couplers used 300 m (984 ft) 1 additional cable coupler used
ISO/IEC 11801 type OM3	1000 m (3280 ft) no extra cable couplers used 800 m (2624 ft) 1 additional cable coupler used

Power Requirement GN110 and GN111 (Transmitter)	
Battery powered	Maximum 2 removable batteries possible **Note** *Use HBM approved batteries only. See option G034 for approved battery details.*
Power consumption	6 VA typical, 8 VA maximum
Operation Time (using G034 batteries)	30 hours; 2 batteries installed (15 hours; 1 battery installed) Perception software can activate a low power sleep mode to extend the operation time

Power Requirement GN112 and GN113 (Transmitter)	
Power supply input (manual voltage selector)	47-63 Hz, 115/230 V AC (± 10% of selected power input voltage)
Overvoltage category mains	OVC II
Power consumption	12 VA maximum
Fuse(s)	2 x 250 mA; Slow blow
Battery	12 V @ 300 mAh; Internal, rechargeable, NiMH
Battery back-up time	5 minutes (with new and fully charged battery)
Power supply isolation	
Ground terminal connected to protective ground	0 V, both sides grounded
Ground terminal floating	1.8 kV RMS (IEC 61010-1) Requires a protected LAB environment and EN50191 compliant work procedures

Physical, Weight and Dimensions GN110 and GN111	
Weight	4.6 kg (10 lb) including two batteries
Dimensions including handles	175 mm (6.89") x 277 mm (10.91") x 119 mm (4.69") (W x D x H)
Battery carrier	2 (batteries need to be ordered separately)
Shielding and casing	Single metal shielding in plastic housing. Correct operation has been verified by placing the transmitter cabinet within 1 meter of an EMC field created by a 80 kA current
Cooling fans	0
Handle	One carrying handle
Ground terminal	M6 screw

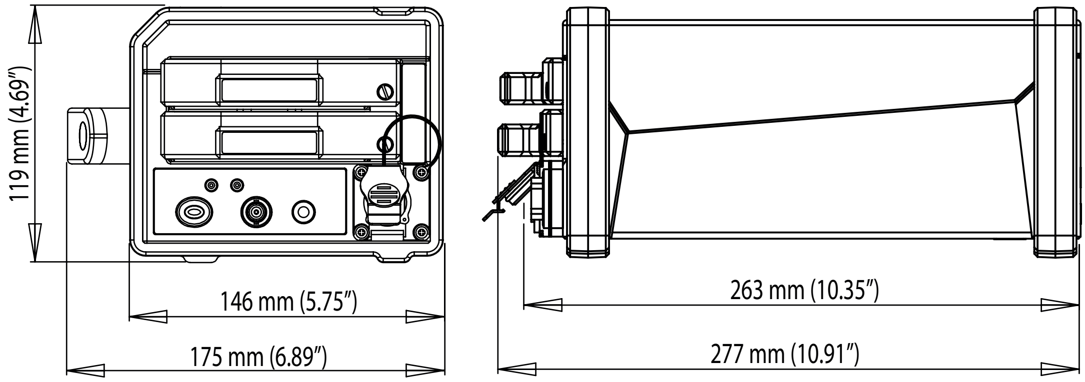


Figure 22: Dimensions GN110 and GN111 transmitter

Physical, Weight and Dimensions GN112 and GN113	
Weight	3 kg (6.6 lb)
Dimensions including handles	175 mm (6.89") x 267 mm (10.51") x 119 mm (4.69") (W x D x H)
Shielding and casing	Single metal shielding in plastic housing. Correct operation has been verified by placing the transmitter cabinet within 1 meter of an EMC field created by a 80 kA current
Cooling fans	1
Handle	One carrying handle
Ground terminal	M6 screw

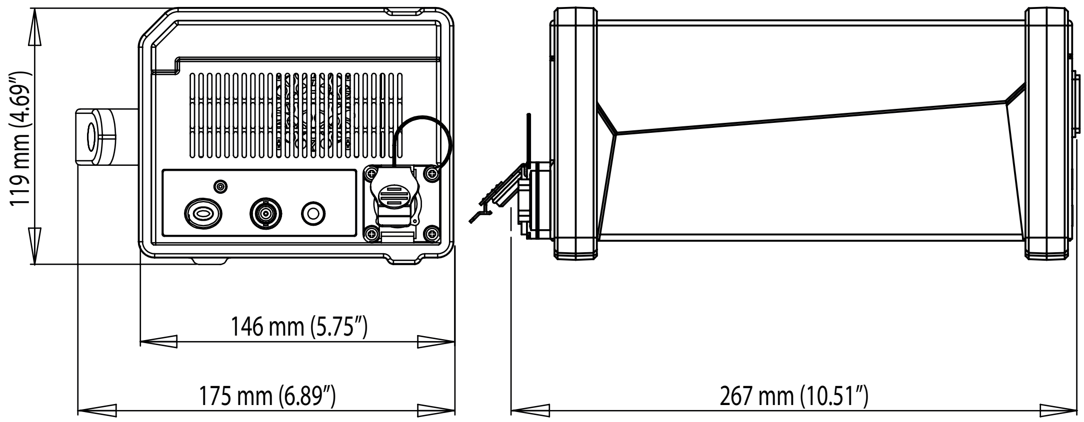


Figure 23: Dimensions GN112 and GN113 transmitter

Environmental Specifications	
Temperature Range	
Operational	GN110 and GN111: -15 °C to +50 °C (+5 °F to +122 °F) GN112 and GN113: 0 °C to +40 °C (+32 °F to +104 °F) GN1202B: 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
Ingress protection class	IP20
Altitude	Maximum 2000 m (6562 ft) above sea level; operational
Operating environment	Indoor, pollution degree 2
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	Safety requirements for electrical equipment for measurement, control, and laboratory use - General requirements
EN 61010-2-030	Particular requirements for testing and measuring circuits
Electromagnetic Compatibility	
EN 61326-1	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
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.

Manufacturer:

Hottinger Brüel & Kjaer GmbH
Im Tiefen See 45
64293 Darmstadt
Germany

Importer:

Hottinger Bruel & Kjaer UK Ltd.
Technology Centre Advanced Manufacturing Park
Brunel Way Catcliffe
Rotherham
South Yorkshire
S60 5WG
United Kingdom

G034: Rechargeable Li-ion SM202 Battery (Option, to be ordered separately)

Note *Local regulations don't allow HBM to import batteries to several countries. These regulations change regularly and are increasingly becoming more strict. Check with the local HBM office before ordering the battery from HBM.*
Use only HBM approved batteries to avoid unexpected failures and/or specification deviations. G034 batteries have almost all world-wide approvals and are available for purchase locally in many countries. For more information, please refer to the following website: www.rrc-ps.com

Original manufacturers part number	RRC2020
Chemical system	Lithium Ion (Li-Ion)
Nominal voltage	11.25 V
Typical weight	490 g (1.1 lb)
Nominal capacity	8850 mAh
Capacity life expectancy @ 25 °C 4.40 A Charge/4.40 A Discharge	>300 cycles with minimum 80% of initial capacity
Mechanical form factor	SM202
Dimensions	149 mm (5.86") x 89 mm (3.50") x 19.7 mm (0.77") (D x W x H)
Smart battery	SMbus & SBDS revision 1.1 Compliant
Maximum charge voltage	13.0 V
Recommended maximum charge current	4.0 A
Typical charging time	3 hours @ charging current of 4 A
Discharge temperature	-20 °C to +55 °C (-4 °F to +131 °F)
Charge temperature	+0 °C to +40 °C (+32 °F to +104 °F)
Storage temperature	-20 °C to +60 °C (-4 °F to +140 °F). Recommended -20 °C to +20 °C (-4 °F to +68 °F)
Original manufacturer's part number	RRC power solutions RRC2020
Compliance information	CE / UL2054 / FCC / PSE / KC / Gost / EAC / CQC / RCM / IEC62133 / UN38.3 / RoHS / REACH / BIS
Availability	Available in most countries worldwide
Recycling	Registered with many recycling systems worldwide

Figure 24: G034 Battery

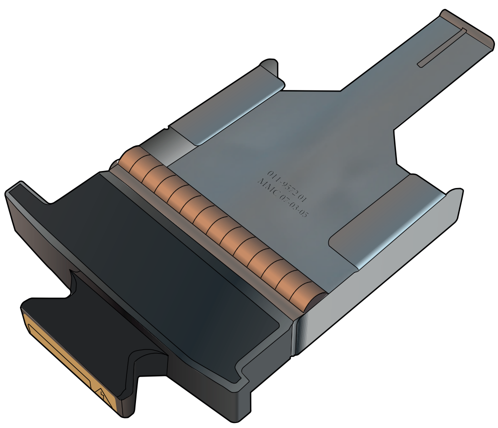


Figure 25: G301 Battery carrier

G109: Li-ion Battery Charger (Option, to be ordered separately)	
Li-ion two-bay battery charger	
Smart battery support	SmBus Level 3
Maximum charge current	3 A, or limited by smart battery
Battery recalibration	SmBus 1.2 A @ 12 V
Charge strategy	Simultaneous for two batteries

Figure 26: Two-bay Li-ion battery charger

KAB277: Fiber Cables (Option, to be ordered separately)	
Standard fiber optic duplex cable (1-KAB277-xxx)	

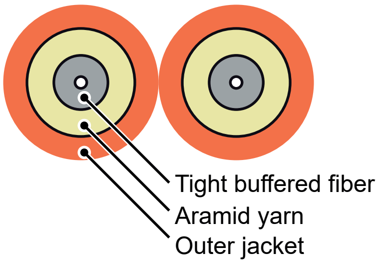


Figure 27: Block diagram and image

Connector type	LC - SCRJ
Glass rating	OM2; Multi Mode
Core/Cladding diameter	50/125 µm
Jacket size	2 mm (0.08”)
Jacket rating	Low-smoke zero-halogen
Attenuation	≤ 2.7 dB/km @ 850 nm
Available lengths	10, 20, 50 and 100 m (33, 66, 164 and 328 ft)
Operating temperature	-40 °C to +80 °C (-40°F to +176°F)

KAB278: Fiber Cables (Option, to be ordered separately)

Heavy duty fiber optic duplex cable (1-KAB278-xxx)

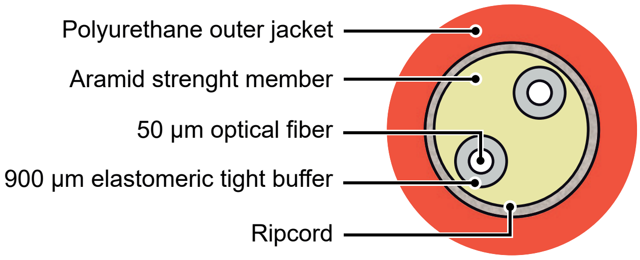


Figure 28: Block diagram and image

Connector type	LC - SCRJ/IP67
Glass rating	OM2; Multi Mode
Core/Cladding diameter	50/125 µm
Jacket size	6 mm (0.24")
Jacket rating	Polyurethane, halogen free, non-corrosive
Jacket coating	High chemical resistance against acids/alkalis
Attenuation	≤ 2.7 dB/km @ 850 nm
Available lengths	10, 20, 50, 100, 150 and 300 m (33, 66, 164, 328, 492 and 984 ft)
Operating temperature	-40 °C to +80 °C (-40°F to +176°F)

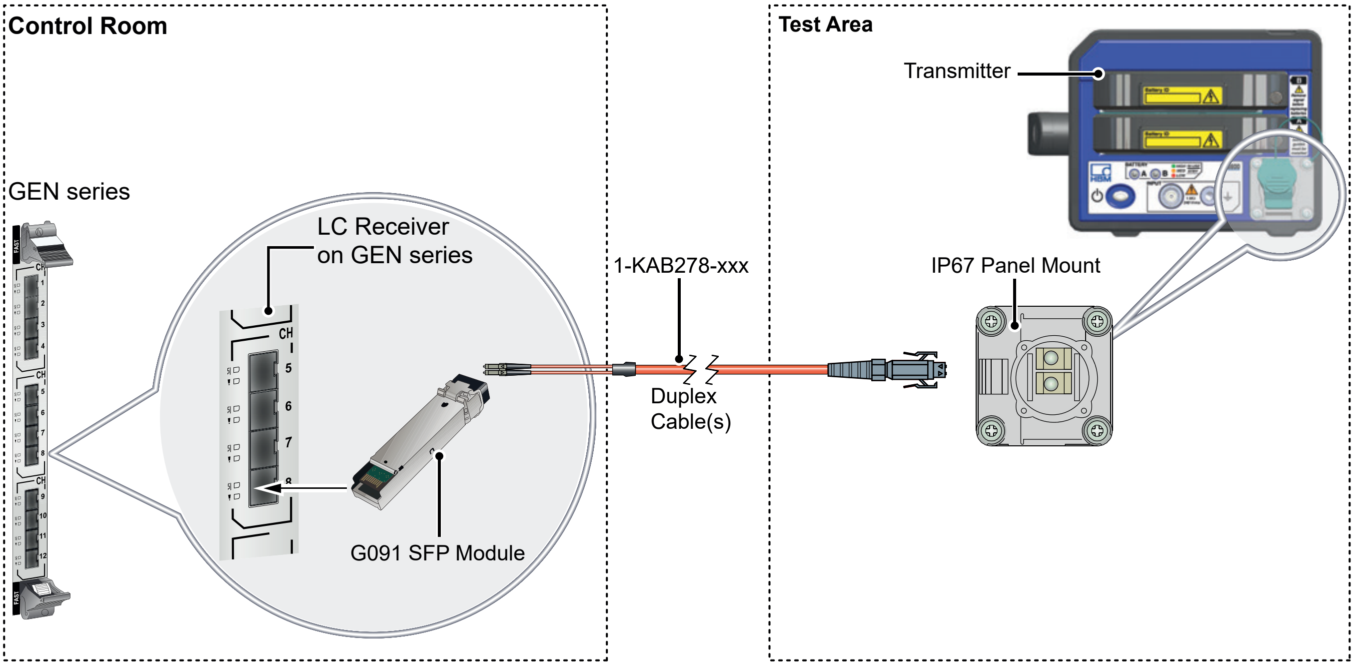


Figure 29: Application area of a fiber optic duplex cable (Example 1)

KAB279: Fiber Cables (Option, to be ordered separately)	
Standard fiber optic duplex cable (1-KAB279-xxx)	

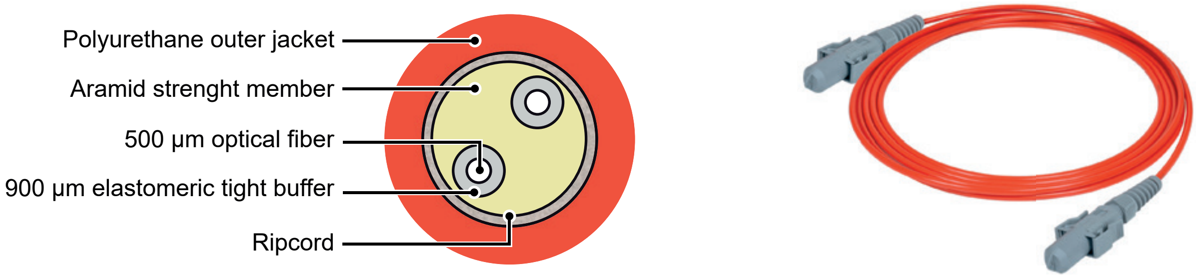


Figure 30: Block diagram and image

Connector type	SCRJ/IP67 - SCRJ/IP67
Glass rating	OM2; Multi Mode
Core/Cladding diameter	50/125 µm
Jacket size	6 mm (0.24")
Jacket rating	Polyurethane, halogen free, non-corrosive
Jacket coating	High chemical resistance against acids/alkalis
Attenuation	≤ 2.7 dB/km @ 850 nm
Available lengths	20 and 50 m (66 and 164 ft)
Operating temperature	-40 °C to +80 °C (-40°F to +176°F)

KAB280: Fiber Optic Cable MM 50/125 µm LC-LC (Option, to be ordered separately)

Standard zipcord fiber optic duplex Multi Mode patch cable
Used with 850 nm optical 1 Gbit or 10 Gbit Ethernet (1-G091 and 1-G065), Master/Sync, GN1202B and GN800B cards.
Typically used for fixed cable routing or LAB environments.

Figure 31: Block diagram and image

Connector type	LC - LC
Cable rating	OM3; Multi Mode, 850 nm
Core/Cladding diameter	50/125 µm
Jacket size/diameter	Typically 2 mm (0.08”) single core
Jacket rating	Low-smoke zero-halogen
Attenuation	≤ 2.7 dB/km @ 850 nm
Available lengths	3, 10, 20 and 50 m (10, 33, 66 and 164 ft). For other lengths contact custom systems(1).
Bend radius	30 mm (1.2”)
Weight	Typically 14 kg/km (9 lb/1000 ft)
Operating temperature	-40 °C to +80 °C (-40 °F to 176 °F)

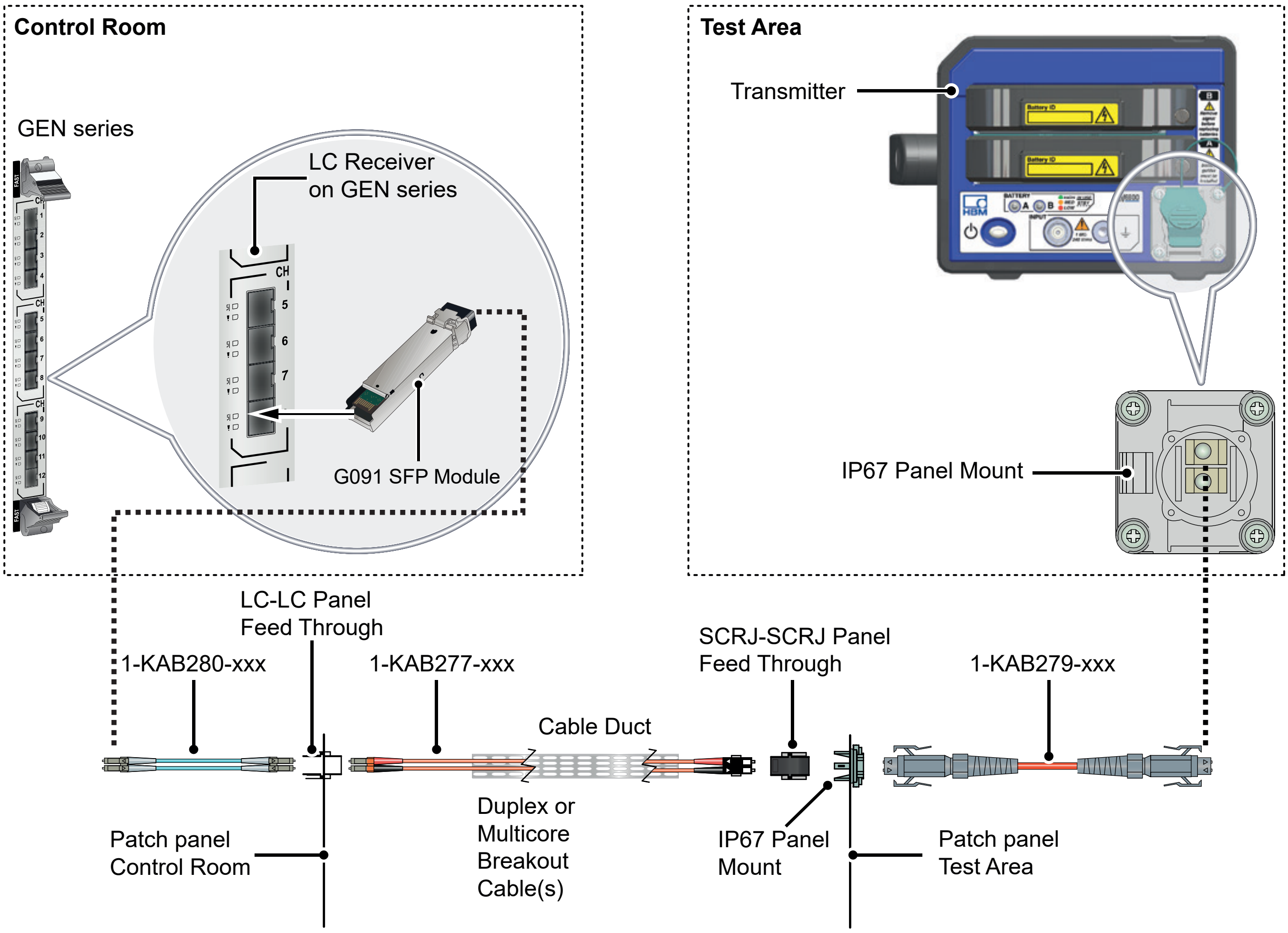
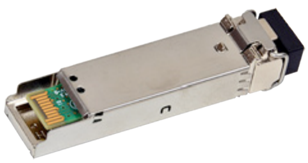


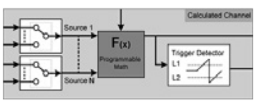
Figure 32: Application area of a fiber optic duplex cable (Example 2)

(1) Contact custom systems at: customsystems@hbkworld.com

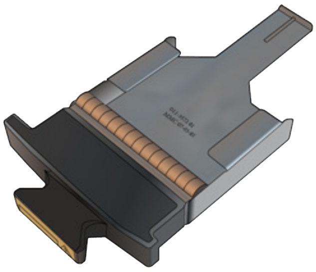
Ordering Information

Article		Description	Order No.
Battery powered 1 ch Transmitter		GN110 optical isolated transmitter HV, 100 MS/s, 14 bit, 25 MHz bandwidth, two Li-ion battery holders, SCRJ/IP67 connector. **Note** *Batteries need to be ordered separately. Check the import restrictions before ordering batteries from HBM. Use only HBM approved batteries to avoid unexpected failures and/or specification deviations.*	1-GN110
		GN111 optical isolated transmitter HV, 25 MS/s, 15 bit, 10 MHz bandwidth, two Li-ion battery holders, SCRJ/IP67 connector. **Note** *Batteries need to be ordered separately. Check the import restrictions before ordering batteries from HBM. Use only HBM approved batteries to avoid unexpected failures and/or specification deviations.*	1-GN111
Continuous powered 1 ch Transmitter		GN112 optical isolated transmitter MV, 100 MS/s, 14 bit, 25 MHz, built-in power supply with 1.8 kV RMS isolation, SCRJ/IP67 connector.	1-GN112
		GN113 optical isolated transmitter MV, 25 MS/s, 15 bit, 10 MHz, built-in power supply with 1.8 kV RMS isolation, SCRJ/IP67 connector.	1-GN113
GN1202B 12 ch Receiver		GN1202B optical isolated receiver, 12 channels, 12 x LC in, 2 GB memory. **Note** *When mixing 100 MS/s and 25 MS/s transmitters, the maximum receiver sample rate is limited to 25 MS/s for all 12 channels.*	1-GN1202B
2 Gbit Optical SFP module MM 850 nm		GEN DAQ 2 Gbit Ethernet SFP, 850 nm Multi Mode, up to 600 m optical cable length supported, LC connector support. Not compatible with the 10 Gbit SFP+ modules. Operating temperature: -20 °C to +60 °C	1-G091

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. Triggering possible on many of the results of the calculations. Calculated cycle based results can be real-time transferred to the GEN DAQ API, USB-to-CAN-FD or EtherCAT® option. EtherCAT® output supports true real-time 1 ms latency.	1-GEN-OP-RT-FDB

Accessories, to be ordered separately

Article		Description	Order No.
Li-ion SM202 Battery		Rechargeable Li-ion battery unit for GN110/ GN111 and ISOBE5600t The battery is compliant with CE / UL 2054 / UL1642 / FCC / IEC 62133 / EN 60950 / RoHS / UN 38.3 / PSE / RCM / CQC / BIS IS 160346 **Note** *Check the import restrictions before ordering batteries from HBM.*	1-G034
Battery carrier		Li-ion battery carrier for GN110/GN111 and ISOBE5600t. Battery (1-G034) not included.	1-G301
2 bay Li-ion battery charger		Li-ion two bay battery charger for GN110/ GN111 and ISOBE5600t batteries. Accepts two batteries without removing the carrier.	1-G109
Fiber cable standard MM LC-SCRJ		GEN DAQ standard fiber optic duplex Multi Mode 50/125 µm cable, 2.7 dB/km loss (or 3.5 dB/km for general specification ISO/IEC 11801), LC-SCRJ connectors, orange, ISO/IEC 11801 type OM2. Typically used for fixed cable routing or LAB environments. Lengths: 10, 20, 50 and 100 meter (33, 66, 164 and 328 ft)	1-KAB277-10 1-KAB277-20 1-KAB277-50 1-KAB277-100
Fiber cable heavy duty MM LC-SCRJ		GEN DAQ heavy duty fiber optic duplex Multi Mode 50/125 µm cable, 2.7 dB/km loss (or 3.5 dB/ km for general specification ISO/IEC 11801), LC-SCRJ/ IP67 connectors, orange, ISO/IEC 11801 type OM2. Typically used for test cell environments. Lengths: 10, 20, 50, 100, 150 and 300 meters (33, 66, 164, 328, 492 and 984 ft)	1-KAB278-10 1-KAB278-20 1-KAB278-50 1-KAB278-100 1-KAB278-150 1-KAB278-300
Fiber cable heavy duty MM SCRJ-SCRJ		GEN DAQ heavy duty fiber optic duplex Multi Mode 50/125 µm cable, 2.7 dB/km loss (or 3.5 dB/ km for general specification ISO/IEC 11801), SCRJSCRJ/ IP67 connectors, orange, ISO/IEC 11801 type OM2. Typically used for test cell environments as patch panel to transmitter connections. Lengths: 20 and 50 meter (66, 164 ft)	1-KAB279-20 1-KAB279-50
Fiber cable MM LC-LC		GEN DAQ standard zipcord fiber optic duplex Multi Mode 50/125 µm cable, 3.0 dB/km loss, LC-LC connectors, aqua, ISO/IEC 11801 type OM3. Typically used for fixed cable routing or LAB environments. Lengths: 3, 10, 20 and 50 meters (10, 33, 66 and 164 ft) Used with 850 nm optical 1 Gbit Ethernet (1-G091), 10 Gbit Ethernet (1-G065), Master/ Sync, GN1202B- and GN800B cards.	1-KAB280-3 1-KAB280-10 1-KAB280-20 1-KAB280-50

Note *Other fiber cable lengths can be ordered from custom systems at:* customsystems@hbkworld.com

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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