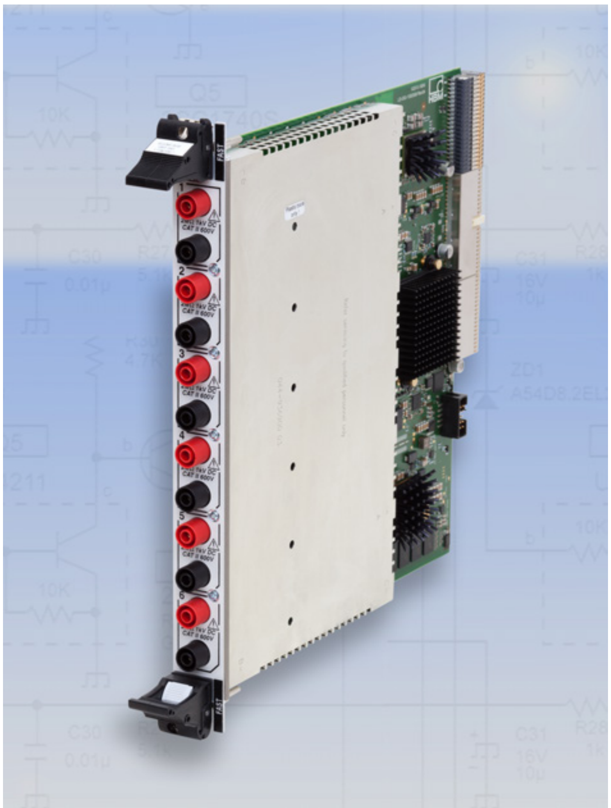


GEN series GN611B

Data sheet

Isolated 1 kV 200 kS/s Input Card

Special features

- **6 analog channels**
- **Isolated, balanced differential inputs**
- **± 10 mV to ± 1000 V input range**
- **Basic accuracy 0.02%**
- **Basic power accuracy 0.02%**
- **600 V RMS CAT II reinforced insulation, tested up to 6.4 kV**
- **Analog/digital anti-alias filters**
- **18 bit at 200 kS/s sample rate**
- **Real-time formula database calculators**
- **Triggering on real-time results**
- **Digital Event/Timer/Counter support**
- **5 kV RMS certified probe**

Isolated 1 kV 200 kS Input Card

The isolated balanced differential input offers voltage ranges from ± 10 mV to ± 1000 V. Tested up to 6.4 kV, the reinforced insulation allows for safe measurements up to 600 V RMS CAT II (without probes). 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.

The two Timer/Counters and the G070A torque/RPM adapter allow for direct interfacing to HBM torque transducers or other torque and speed sensors.

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.

HBM

Capabilities Overview

Model	GN611B
Maximum sample rate per channel	200 kS/s
Memory per card	200 MB
Analog channels	6
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 balanced differential
Passive voltage/current probes	Special designed matching probes only (e.g. Elas HVD50R)
Sensors	Not supported
TEDS	Not supported
Real-time formula database calculators (option)	Extensive set of user programmable math routines with triggering on calculated results
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

Real-time Calculated Results Output

	Ethernet GEN DAQ API	EtherCAT®	CAN/CAN FD
Maximum results per block	240	240	240
Maximum result blocks per second	2000	1000	1000
Latency	Ethernet dependent	1 ms	CAN bus speed

Mainframe Support

	GEN2tB	GEN3t	GEN4tB	GEN7tA	GEN17tA	GEN3i / GEN3iA	GEN7i / GEN7iA	GEN2i (4)	GEN5i (4)	GEN7t (4)	GEN16t (4)
GN610B/GN611B	Yes							No			
GEN DAQ API	Yes					Yes(1)		No			
EtherCAT®	No	Yes				No		No			
CAN/CAN FD	Yes	No	Yes	Yes(2)	Yes(3)	No		No			

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

(2) Early shipments have no access to an USB port. Contact Support-EPT@hbm.com for a user installed upgrade.

(3) Requires custom system modification.

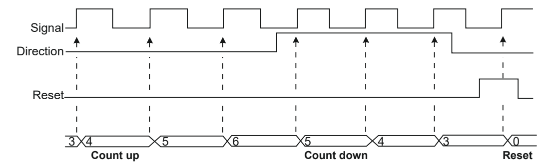
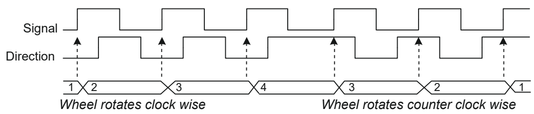
(4) Mainframe replaced by newer version.

Supported Analog Sensors and Probes

Amplifier mode	Supported analog sensors and probes	Features, Cabling and Accessories
Power measurement	• Current transducers • Current probes • Electrical voltages single-ended and differential[(1)] • Active single-ended voltage probes • Active differential voltage probes	• Voltage input: ± 10 mV up to ± 1000 V • Burden resistors • 5 kV RMS certified probe • Current probes

(1) 5 kV passive voltage probe

Supported Digital Sensors (TTL Level Input)

Timer counter Input type	Supported digital sensors	Features
 **Figure 1.1:** Uni and Bi-directional clock	• HBM Torque sensors • Torque sensors • Speed sensors • Position sensors	• Angle measurement • Frequency / RPM measurement • Count/position measurement • Count frequency up to 5 MHz • Digital filter on input signals • Several reset options • RT-FDB can add a calculated Frequency/RPM channel based on the angle measurement
 **Figure 1.2:** ABZ Incremental Encoder (Quadrature)	• HBM Torque sensors • Torque sensors • Speed sensors • Position sensors	• Angle measurement • 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

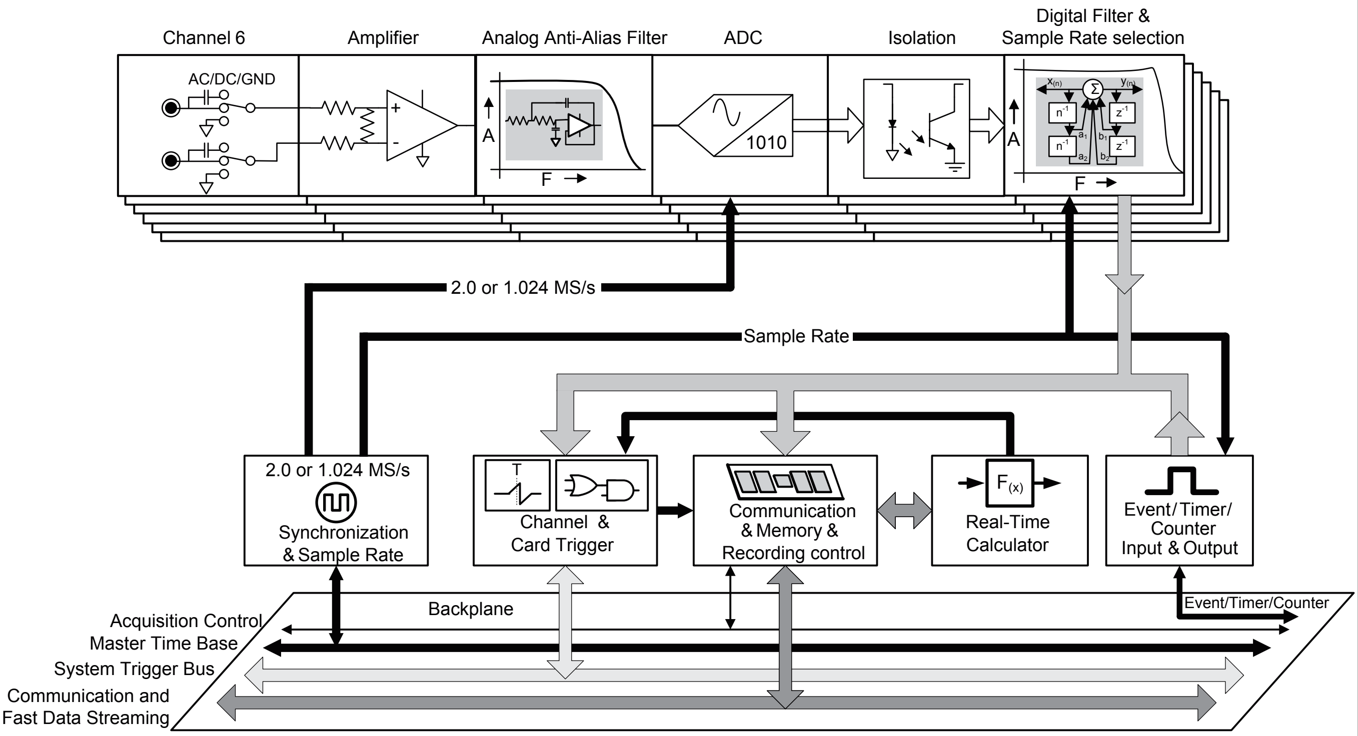


Figure 1.3: Block Diagram

Specifications and measurement uncertainty

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

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

a % of reading error, represents the linear increasing error due to the increase of the input voltage: often referred to as gain error.

b % of range error, represents the error when measuring 0 V; often referred to as offset error

For measurement uncertainty these errors can be considered independent error sources.

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

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

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

Analog Input Section

Channels	6	
Connectors	Fully isolated 4 mm banana plugs (plastic), 2 per channel (red and black)	
Input type	Analog, isolated balanced differential	
Input impedance	2 * 1 MΩ ± 1% // 33 pF ± 10% ranges larger than ± 5 V. All other ranges 57 pF ± 10%	
Input coupling		
Coupling modes	AC, DC, GND	
AC coupling frequency	48 Hz ± 5 Hz (-3 dB)	

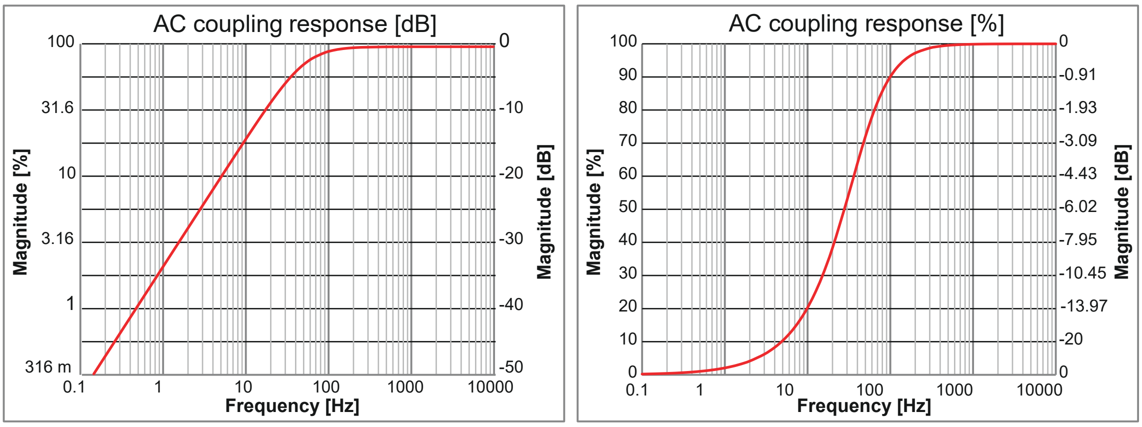
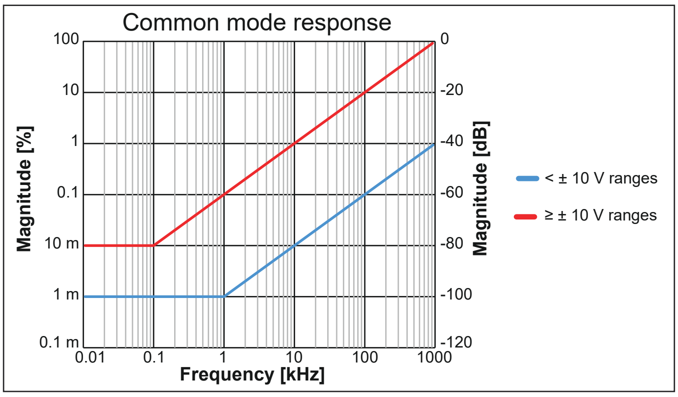


Figure 1.4: Representative AC coupling response

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, ± 50 V, ± 100 V, ± 200 V, ± 500 V, ± 1000 V	
Offset	± 50% in 1000 steps (0.1%); ± 1000 V range has fixed 0% offset	
Common mode (referred to system ground)		
Ranges	Less than ± 10 V	Larger than or equal to ± 10 V
Rejection (CMR)	> 80 dB @ 80 Hz (100 dB typical)	> 60 dB @ 80 Hz (80 dB typical)
Maximum common mode voltage	7 V RMS	1000 V RMS



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 1250 V, whichever value is the smallest.	
Maximum nondestructive voltage	± 2000 V DC	
Maximum overload without auto range	200% of selected range	
Automatic auto range	When overload causes the amplifier to overheat, the amplifier increases its range in steps of a factor of 10 until the overload ceases. When the overload exceeds 1000 V, the input signal is disconnected and the amplifier input is grounded. When the temperature returns to normal, the range that was originally selected is restored. The automatic auto range cannot be turned off.	
Overload recovery time	Restored to 0.1% accuracy in less than 5 μs after 200% overload	

Basic Power Accuracy

The GN610B/GN611B is calibrated and checked at 53 Hz voltage and current inputs using burden resistors. During calibration burden resistors are attached to three voltage channels to enable current measurements.
Specifications are given for the 2.5 Ω burden. Using the 1.0 Ω or 10.0 Ω burden will give different current ranges but identical results.

2.5 Ω	**Burden spans**	**1.264 A DC**	**800 mA DC**	**400 mA DC**	**160 mA DC**	**80 mA DC**	**40 mA DC**
0 - 100 Hz Sine wave CF: 1.41 Cos Phi : 1	**Burden ranges**	**440 mA RMS**	**280 mA RMS**	**140 mA RMS**	**56 mA RMS**	**28 mA RMS**	**14 mA RMS**
Voltage spans	**Voltage ranges**	Typical	Typical	Typical	Typical	Typical	Typical
40 V DC	**14.1 V RMS**	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.1% range	0.02% reading + 0.1% range	0.02% reading + 0.15% range
100 V DC	**35.3 V RMS**	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.1% range	0.02% reading + 0.1% range	0.02% reading + 0.15% range
200 V DC	**70.7 V RMS**	0.02% reading +0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.1% range	0.02% reading + 0.1% range	0.02% reading + 0.15% range
400 V DC	**141 V RMS**	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.1% range	0.02% reading + 0.1% range	0.02% reading + 0.15% range
1 kV DC	**353 V RMS**	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.1% range	0.02% reading + 0.1% range	0.02% reading + 0.15% range
2 kV DC	**707 V RMS**	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.05% range	0.02% reading + 0.1% range	0.02% reading + 0.1% range	0.02% reading + 0.15% range

Voltage Specifications (All Filters Used)

	Pass/Fail limits
DC Reading error	0.1% of reading
DC Range error	0.01% of range ± 10 µV
DC Reading error drift	±35 ppm/°C (±20 ppm/°F)
DC Range error drift	±(80 ppm + 10 µV)/°C (±(45 ppm + 6 µV)/°F)
RMS Noise (50 Ω terminated)	0.02% of range ± 20 µV

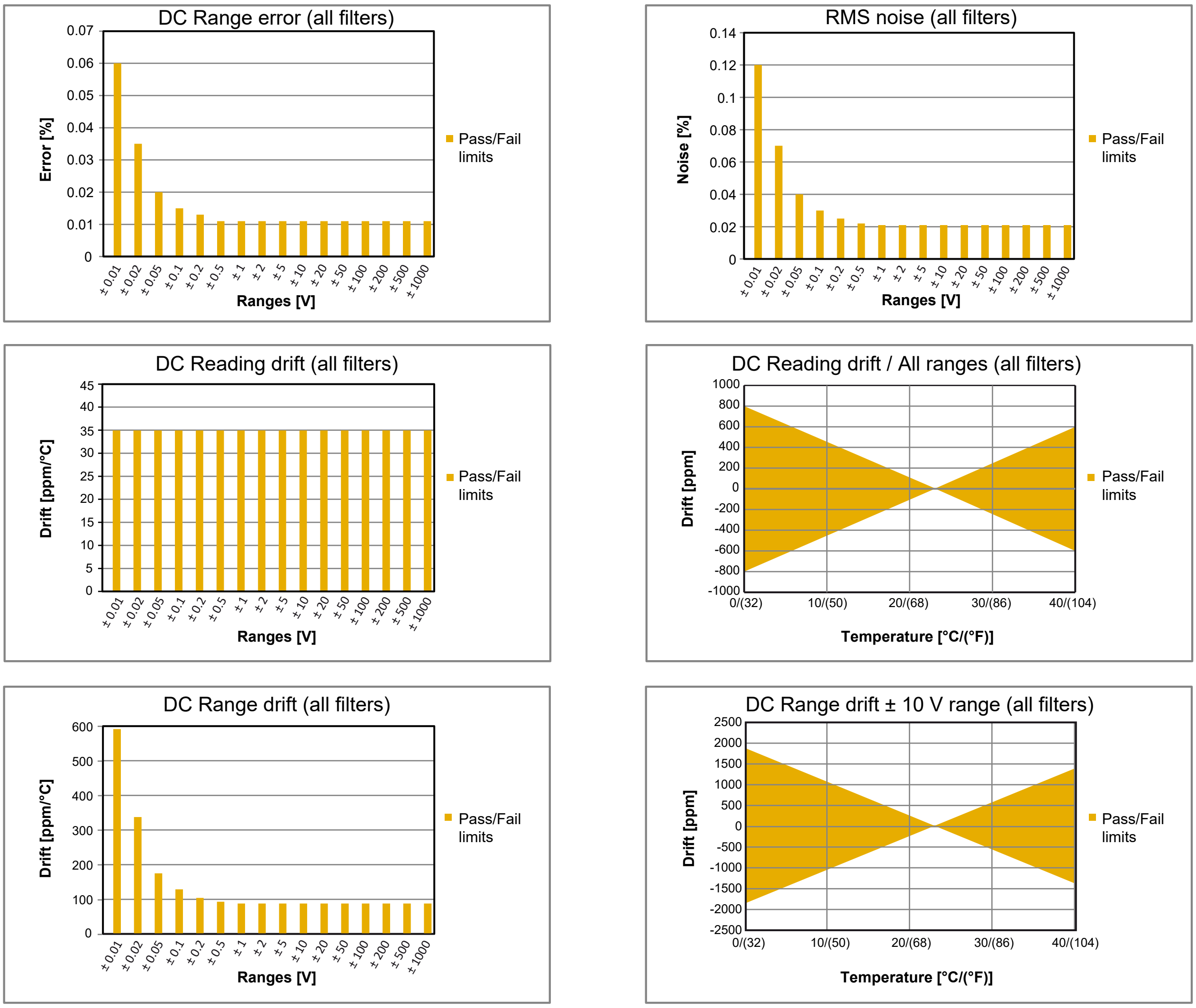


Figure 1.5: All filters used voltage specification

Isolation

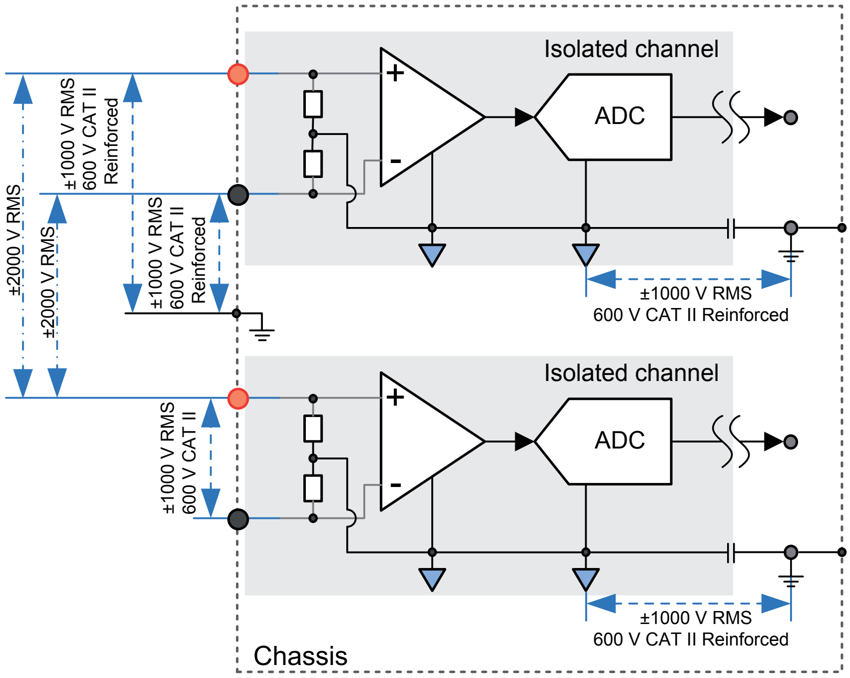


Figure 1.6: Isolation 1kV card overview

		CAT II	CAT III
Channel to chassis (earth)	1000 V RMS	600 V RMS (1)	300 V RMS(1)
Channel to channel	2000 V RMS	(2)	(2)

(1) IEC61010-1 category voltage ratings are RMS voltages.

(2) Channel to channel CAT II and CAT III ratings are not a valid method to specify.

Isolation and Input Type Testing

IEC61010-1:2010 and IEC61010-2-030:2010 isolation tests	
Channel to channel	3510 V RMS and 4935 V DC for 5 s 3260 V RMS and 4596 V DC for 1 minute
Channel to chassis	3510 V RMS and 4935 V DC for 5 s 3260 V RMS and 4596 V DC for 1 minute
Channel to channel impulse	6400 V peak using a 2 Ω series resistor Rise time 1.2 μs, 50% amplitude reduction in 50 μs
Channel to chassis impulse	6400 V peak using a 2 Ω series resistor Rise time 1.2 μs, 50% amplitude reduction in 50 μs

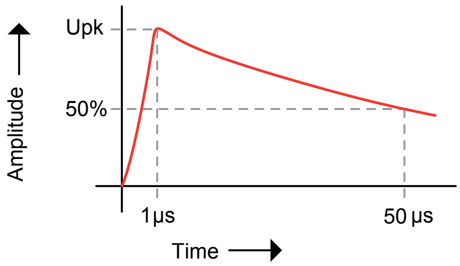


Figure 1.7: Example of 1.2/50 μs impulse

Input impulse test	
Channel positive to negative input	4000 V peak using a 12 Ω series resistor, rise time 1.2 μs, 50% amplitude reduction in 50 μs

Analog to Digital Conversion

Sample rate per channel	0.1 S/s to 200 kS/s
ADC resolution; one ADC per channel	18 bit
ADC type	Successive Approximation Register (SAR); Analog Devices AD7986BCPZ
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 (Bessel IIR/Butterworth IIR/etc.) or different filter bandwidths can result in phase mismatches between channels.

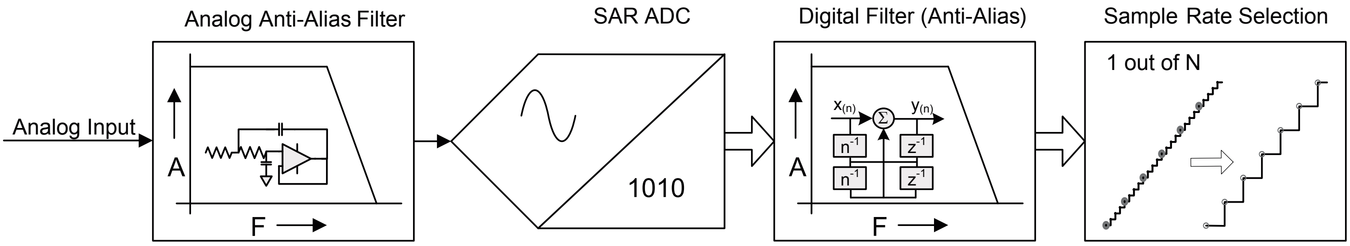


Figure 1.8: Combined analog and digital anti-alias filter block diagram

Anti-aliasing is prevented by a steep, fixed frequency analog anti-alias filter in front of the Analog to Digital Converter (ADC). The ADC always samples at a fixed sample rate. The fixed sample rate of the ADC avoids the need for different analog anti-alias filter frequencies.
Directly behind the ADC, the high precision digital filter is used as anti-alias protection before the digital downsampling to the desired user sample rate is performed. The digital filter 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.

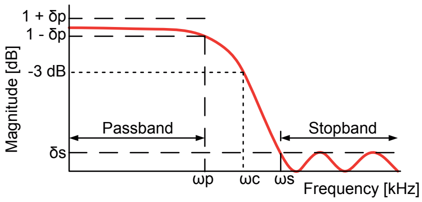
Bessel IIR	When Bessel IIR filter is selected, this is always a combination of an analog Bessel anti-alias filter and a digital Bessel IIR filter to prevent aliasing at lower sample rates. Bessel filters are typically used when looking at signals in the time domain. They are best used for measuring transient 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.

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	**Digital lowpass filters (alias freeby using an analog anti alias filter in front of ADC)**				
	No Anti-alias filter	**Butterworth IIR Elliptic IIR**	**Bessel IIR Butterworth IIR Elliptic IIR**	**Bessel IIR Butterworth IIR Elliptic IIR**	**Bessel IIR Butterworth IIR Elliptic IIR**	**Bessel IIR**
User selectable sample rates		**1/4 Fs**	**1/10 Fs**	**1/20 Fs**	**1/40 Fs**	**1/100 Fs**
2 MS/s	Wideband	--	200 kHz	100 kHz	50 kHz	20 kHz
1 MS/s	Wideband	250 kHz	100 kHz	50 kHz	25 kHz	10 kHz
500 kS/s	Wideband	125 kHz	50 kHz	25 kHz	12.5 kHz	5 kHz
400 kS/s	Wideband	100 kHz	40 kHz	20 kHz	10 kHz	4 kHz
250 kS/s	Wideband	62.5 kHz	25 kHz	12.5 kHz	6.25 kHz	2.5 kHz
200 kS/s	Wideband	50 kHz	20 kHz	10 kHz	5 kHz	2 kHz
125 kS/s	Wideband	25 kHz	12.5 kHz	6.25 kHz	2.5 kHz	1.25 kHz
100 kS/s	Wideband	20 kHz	10 kHz	5 kHz	2 kHz	1 kHz
50 kS/s	Wideband	12.5 kHz	5 kHz	2.5 kHz	1.25 kHz	500 Hz
40 kS/s	Wideband	10 kHz	4 kHz	2 kHz	1 kHz	400 Hz
25 kS/s	Wideband	6.25 kHz	2.5 kHz	1.25 kHz	625 Hz	250 Hz
20 kS/s	Wideband	5 kHz	2 kHz	1 kHz	500 Hz	200 Hz
12.5 kS/s	Wideband	2.5 kHz	1.25 kHz	625 Hz	312.5 Hz	125 Hz
10 kS/s	Wideband	2 kHz	1 kHz	500 Hz	250 Hz	100 Hz
5 kS/s	Wideband	1.25 kHz	500 Hz	250 Hz	125 Hz	50 Hz
4 kS/s	Wideband	1 kHz	400 Hz	200 Hz	100 Hz	40 Hz
2.5 kS/s	Wideband	625 Hz	250 Hz	125 Hz	62.5 Hz	25 Hz
2 kS/s	Wideband	500 Hz	200 Hz	100 Hz	50 Hz	20 Hz
1.25 kS/s	Wideband	312.5 Hz	125 Hz	62.5 Hz	31.25 Hz	12.5 Hz
1 kS/s	Wideband	250 Hz	100 Hz	50 Hz	25 Hz	10 Hz
500 S/s	Wideband	125 Hz	50 Hz	25 Hz	12.5 Hz	5 Hz
400 S/s	Wideband	100 Hz	40 Hz	20 Hz	10 Hz	4 Hz
250 S/s	Wideband	62.5 Hz	25 Hz	12.5 Hz	6.25 Hz	2.5 Hz
200 S/s	Wideband	50 Hz	20 Hz	10 Hz	5 Hz	2 Hz
125 S/s	Wideband	31.25 Hz	12.5 Hz	6.25 Hz	3.125 Hz	1.25 Hz
100 S/s	Wideband	25 Hz	10 Hz	5 Hz	2.5 Hz	1 Hz
50 S/s	Wideband	12.5 Hz	5 Hz	2.5 Hz	1.25 Hz	0.5 Hz
40 S/s	Wideband	10 Hz	4 Hz	2 Hz	1 Hz	0.4 Hz

Bessel IIR Filter (Digital Anti-Alias)



δp: Passband ripple
δs: Stopband attenuation

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

Figure 1.9: 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	400 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 0.14 * ωc
Bessel IIR filter stopband attenuation (δs)	60 dB
Bessel IIR filter roll-off	48 dB/octave

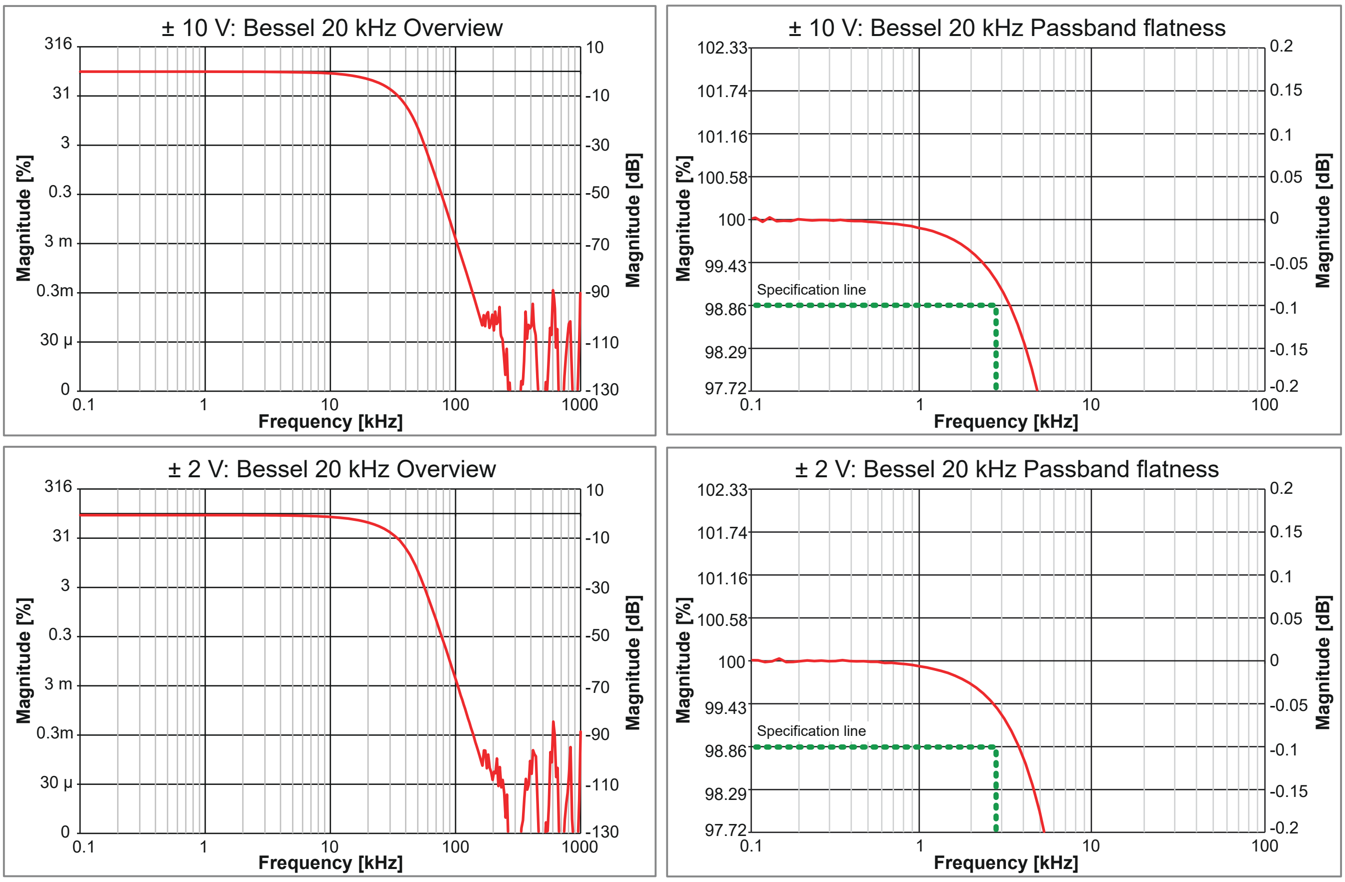
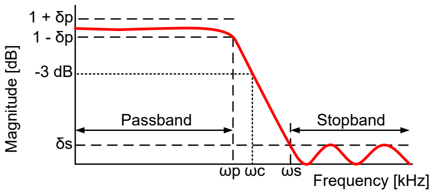


Figure 1.10: Representative Bessel IIR examples

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

Butterworth IIR Filter (Digital Anti-Alias)



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

Figure 1.11: Digital Butterworth IIR Filter

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

Analog anti-alias filter bandwidth	465 kHz ± 25 kHz (-3 dB)
Analog anti-alias filter characteristic	7-pole Butterworth, 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 0.7 * ωc
Butterworth IIR filter stopband attenuation (δs)	75 dB
Butterworth IIR filter roll-off	48 dB/octave

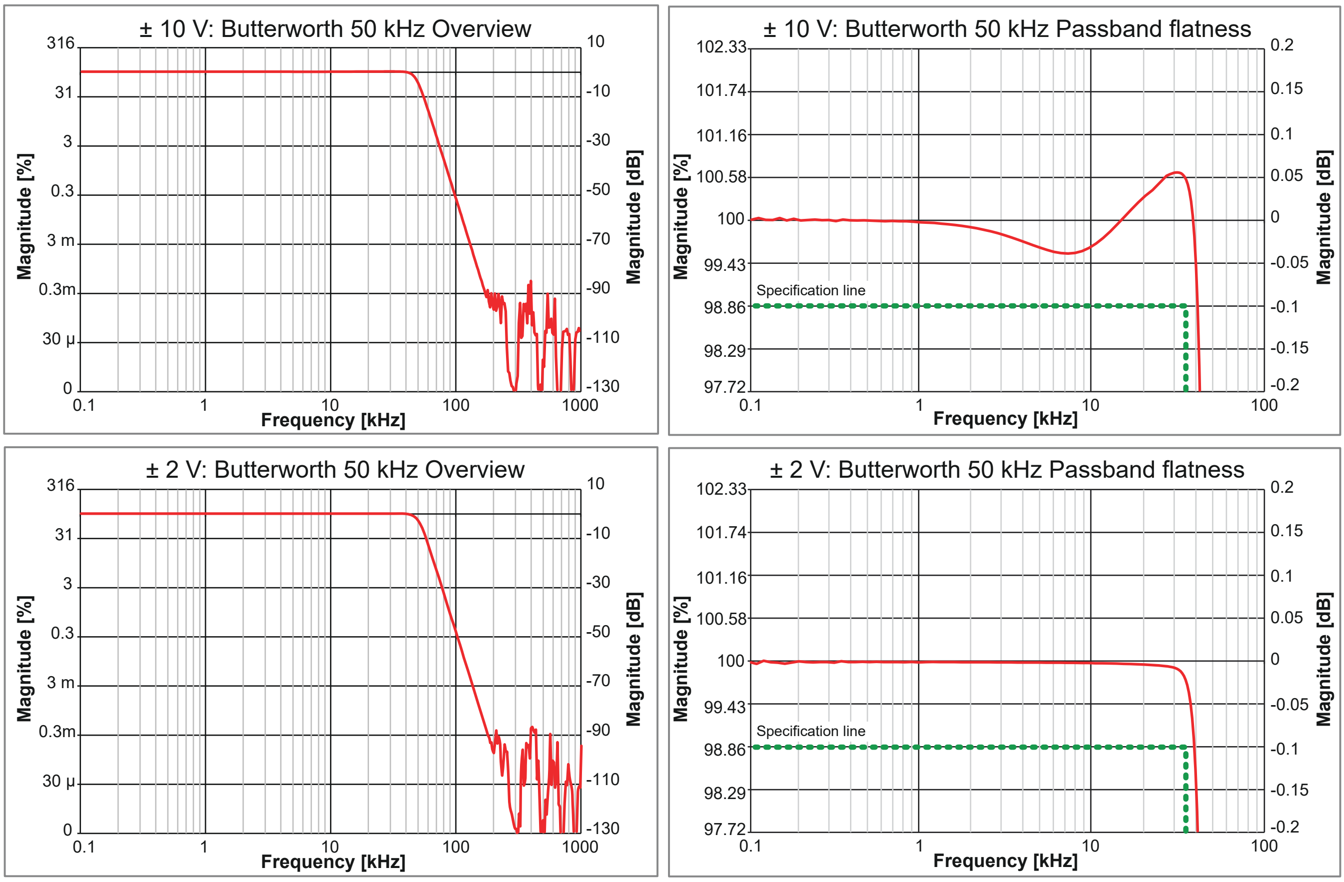
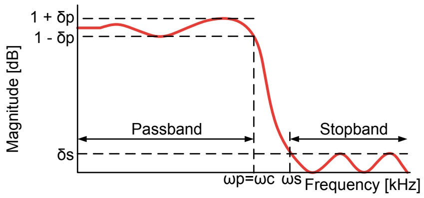


Figure 1.12: Representative Butterworth IIR examples

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

Elliptic IIR Filter (Digital Anti-Alias)



δp: Passband ripple
δs: Stopband attenuation

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

Figure 1.13: 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	465 kHz ± 25 kHz (-3 dB)
Analog anti-alias filter characteristic	7-pole Butterworth, 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

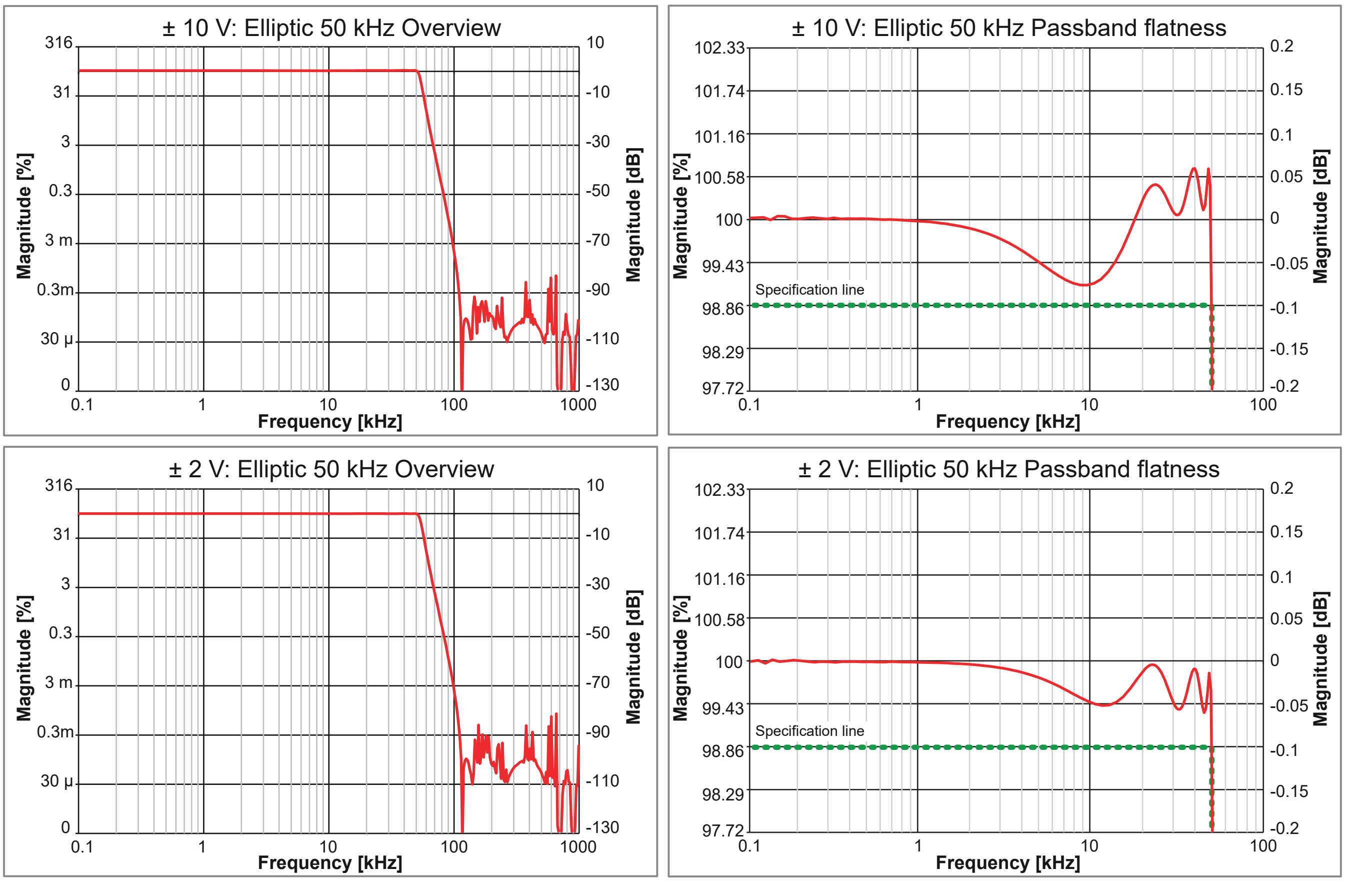


Figure 1.14: Representative Elliptic IIR examples

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

Channel to Channel Phase Match

Using different filter selections (Bessel IIR/Butterworth IIR/etc.) or different filter bandwidths results in phase mismatches between channels. All specifications are typical static values and measured using a 10 kHz sine wave and 200 kS/s sample rate.

	< ±10V spans	**≥ ±10V spans**	**Combined spans**
Bessel IIR, Filter frequency 20 kHz			
Channels on card	0.01° (3 ns)	0.04° (13 ns)	0.27° (76 ns)
GN611B Channels within mainframe	0.01° (3 ns)	0.06° (17 ns)	0.27° (76 ns)
Butterworth IIR, Filter frequency 50 kHz			
Channels on card	0.02° (6 ns)	0.04° (13 ns)	0.27° (76 ns)
GN611B Channels within mainframe	0.02° (6 ns)	0.06° (17 ns)	0.27° (76 ns)
Elliptic IIR, Filter frequency 50 kHz			
Channels on card	0.02° (6 ns)	0.04° (13 ns)	0.27° (76 ns)
GN611B Channels within mainframe	0.02° (6 ns)	0.06° (17 ns)	0.27° (76 ns)
GN611B channels across mainframes	Defined by synchronization method used (None, IRIG, GPS, Master/Sync, PTP)		

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 and Channels 1 and 3 are connected to the sine wave generator.

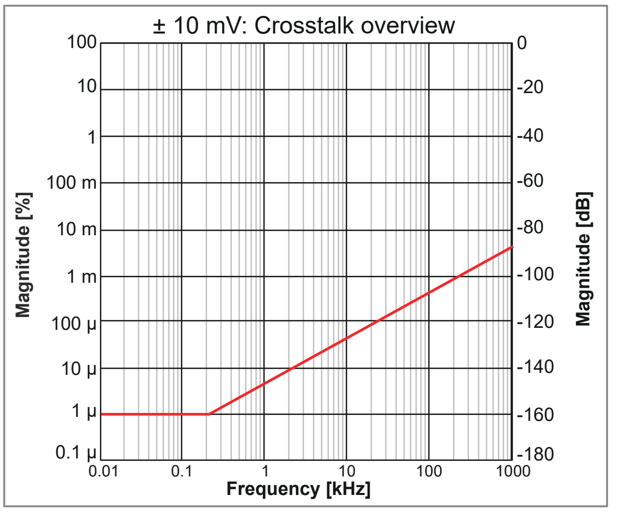


Figure 1.15: Representative Channel to Channel crosstalk

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.

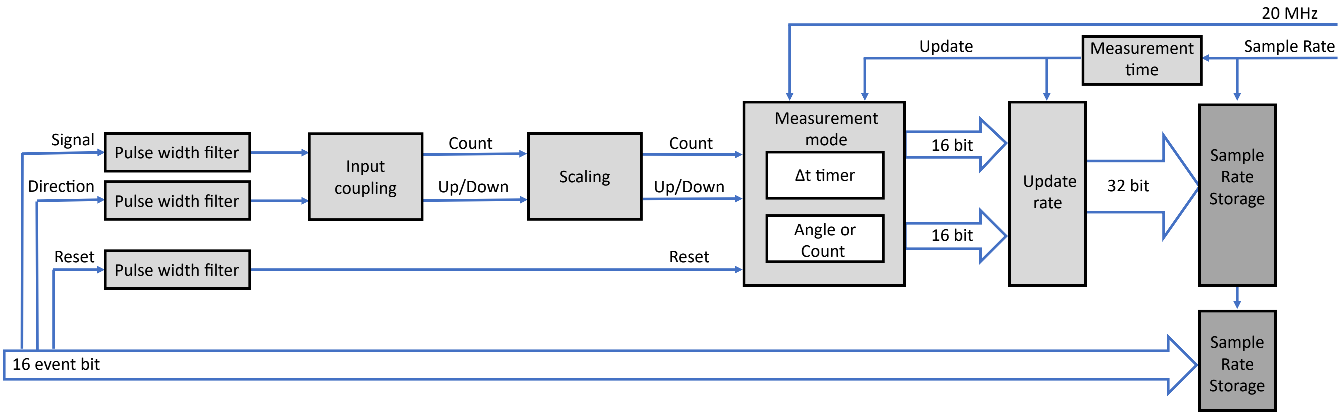


Figure 1.16: Timer/Counter block diagram

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.

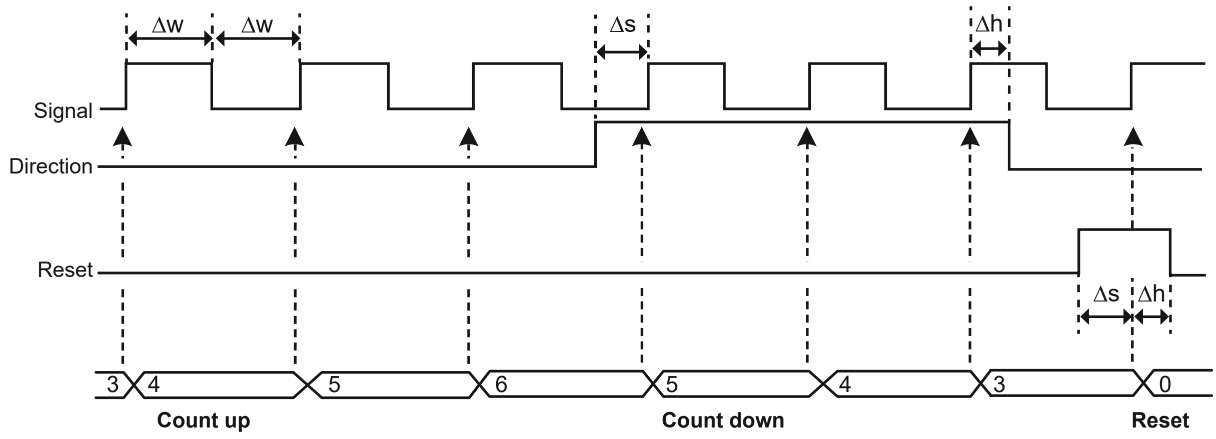


Figure 1.17: Uni- and Bi-directional timing

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.

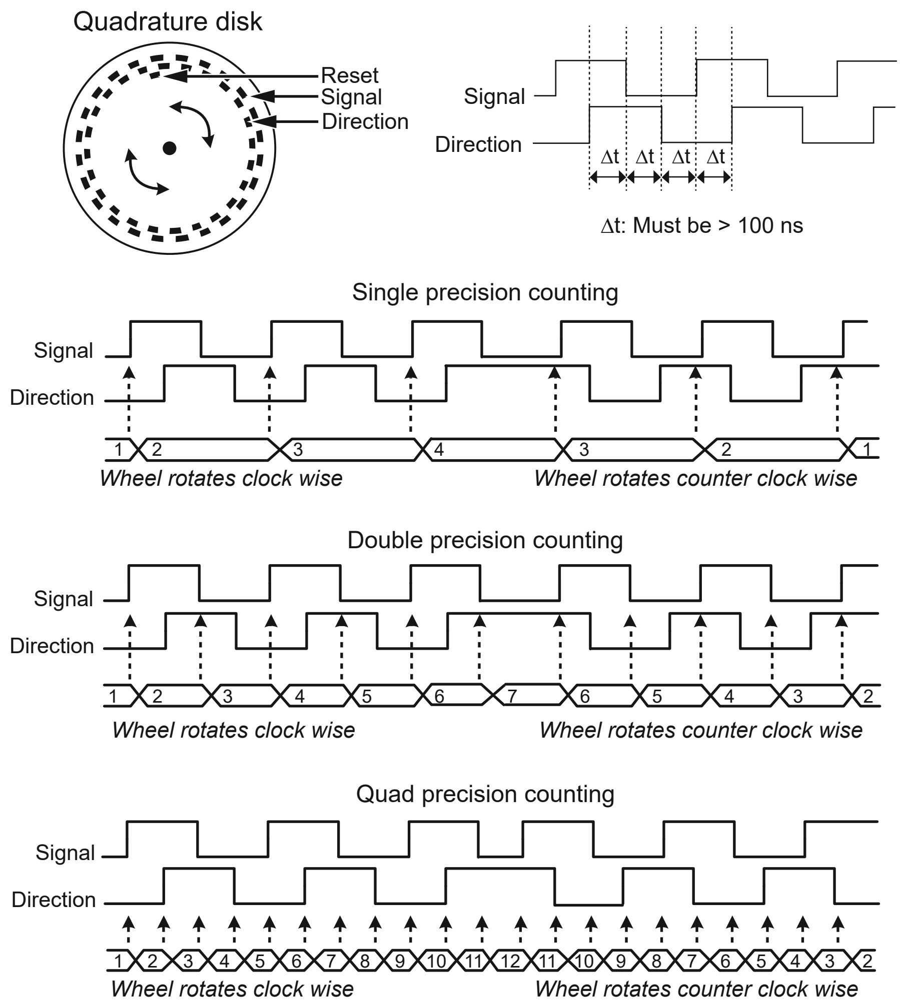


Figure 1.18: Bi-directional quadrature count modes

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

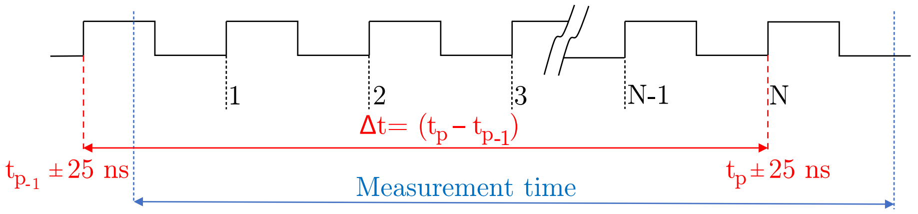
In angle measurement mode the counter will use a user defined maximum angle and revert back to zero when this count value is reached. Using the reset input the measured angle can be synchronized to the mechanical angle. The real-time calculators can extract the RPM from the measured angle independent 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 1.19: 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-/bi-polar input coupling.

Counter range	0 to 2^{31}; uni-directional count -2^{31} to $+2^{31}$ - 1; bi-directional count

Maximum Timer Inaccuracy

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

Calculate the inaccuracy by using:

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

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

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

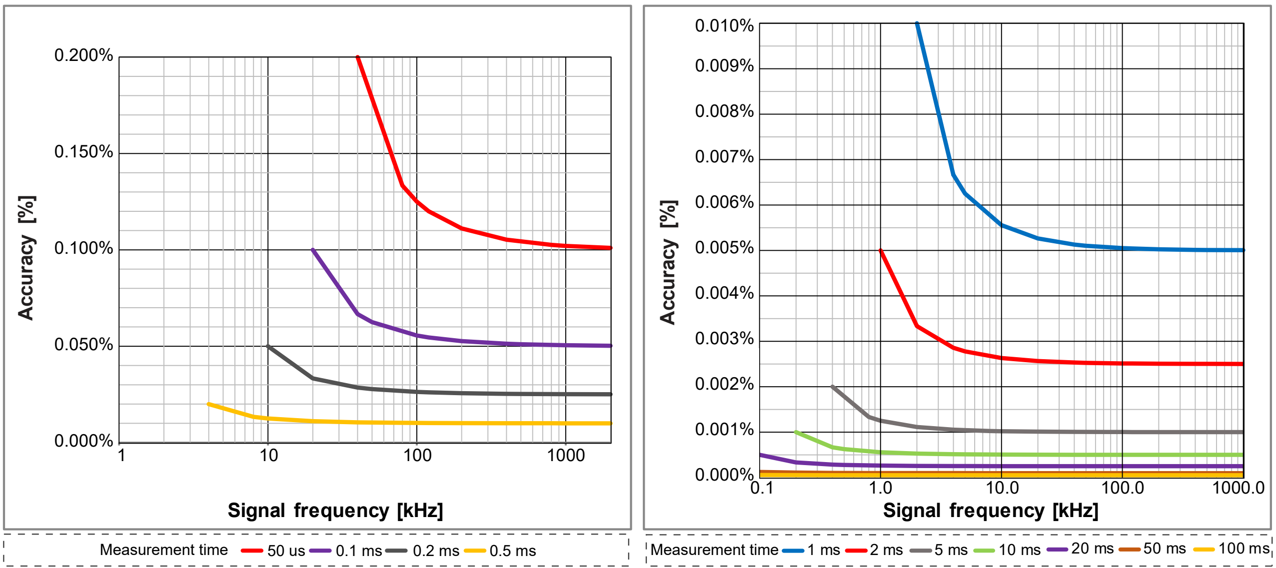


Figure 1.20: Maximum Timer Inaccuracy

Torque Measurement Uncertainty using Frequency Measurements

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

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

Overlay these operating ranges on top of the timer inaccuracy plots of Figure 1.20 will result in Figure 1.21 (see below)

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

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

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

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

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

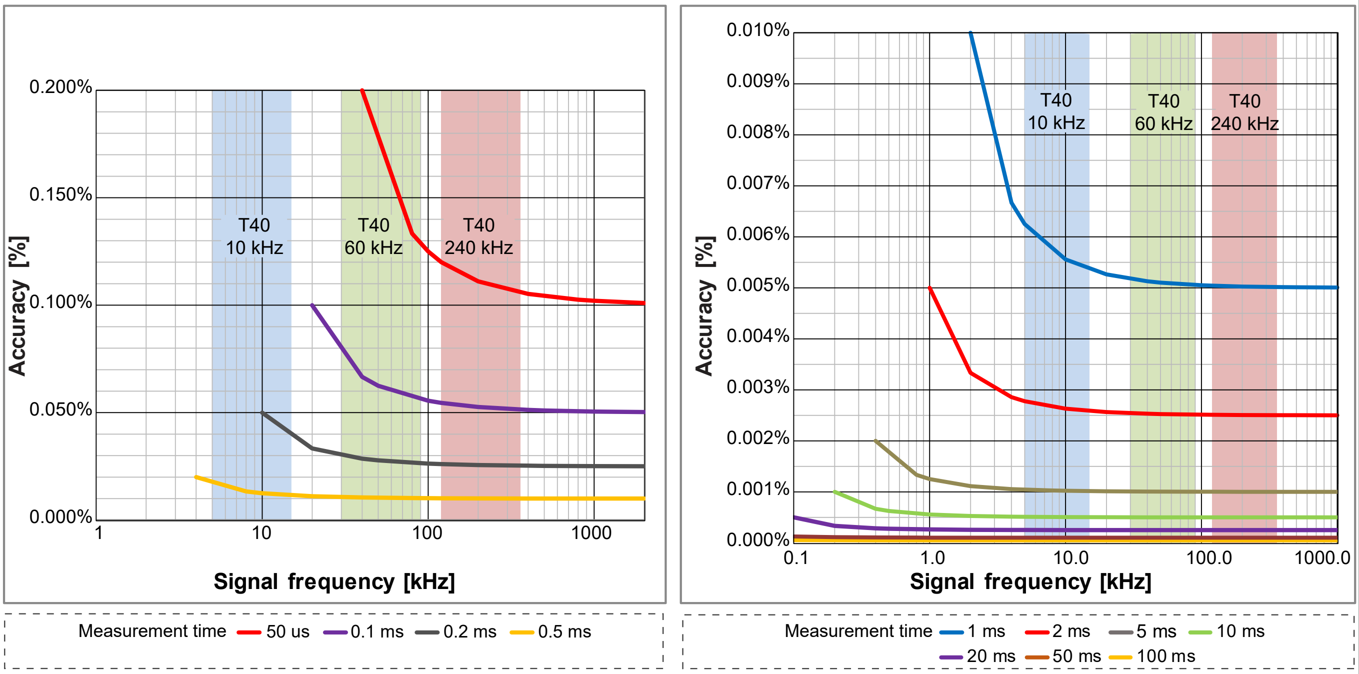


Figure 1.21: Torque operating range versus inaccuracy and measurement time

Speed (RPM) Measurement Uncertainty using Frequency Measurements

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

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

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

Overlay these operating ranges on top of the timer inaccuracy plots of Figure 1.20 will result in Figure 1.22 (see below)

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

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

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

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

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

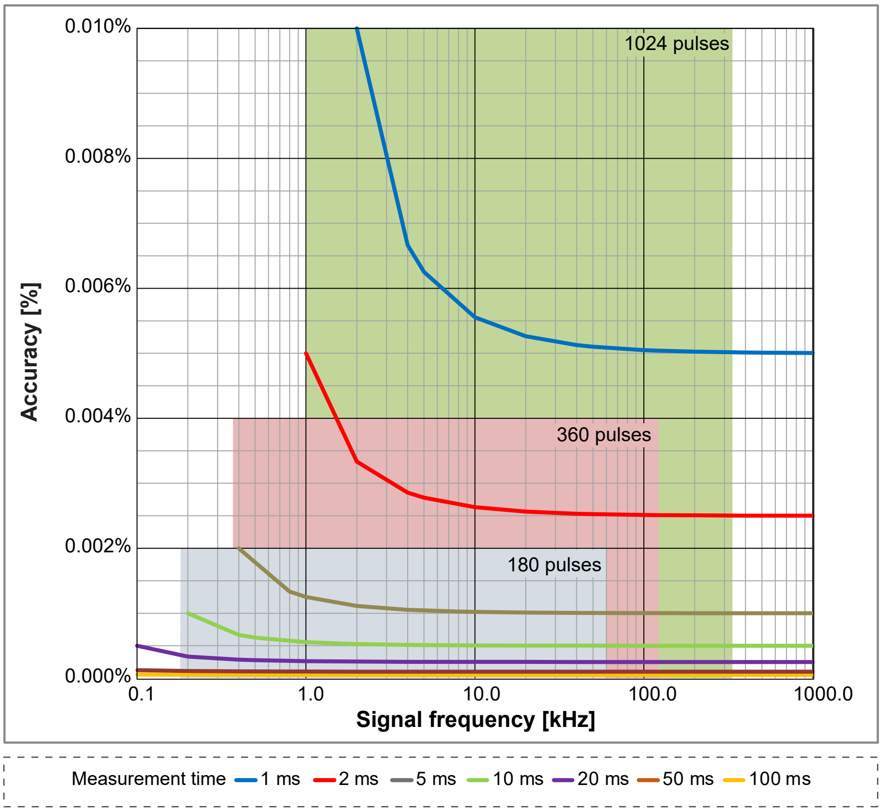


Figure 1.22: RPM sensor operating range versus inaccuracy and measurement time

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 calcuate 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.

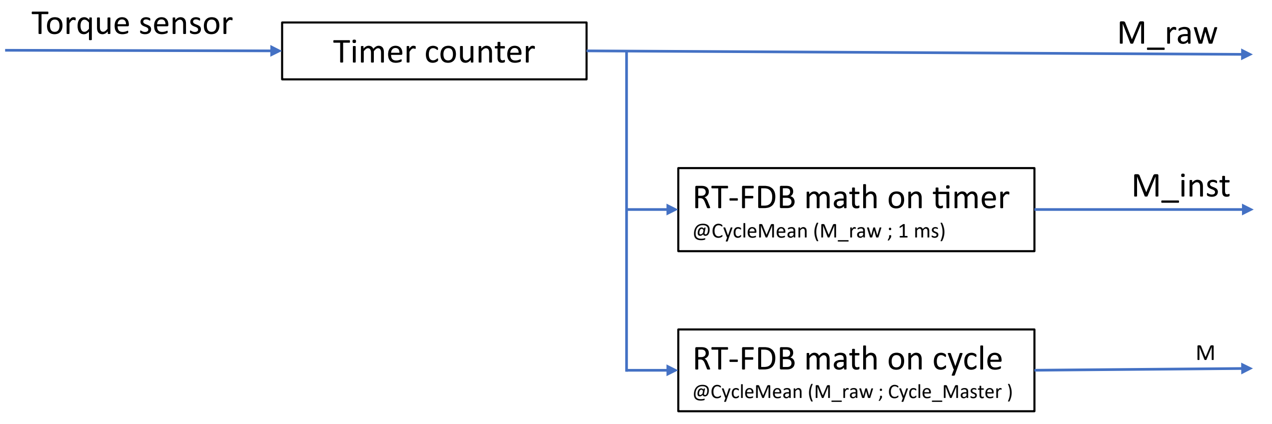


Figure 1.23: Simultaneous dynamic and accurate torque calculations

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

Alarm Output

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

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

On-board Memory	
Per card	200 MB (100 MS @ 16 bits, 50 MS @ 18 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 Cycle Based Calculators

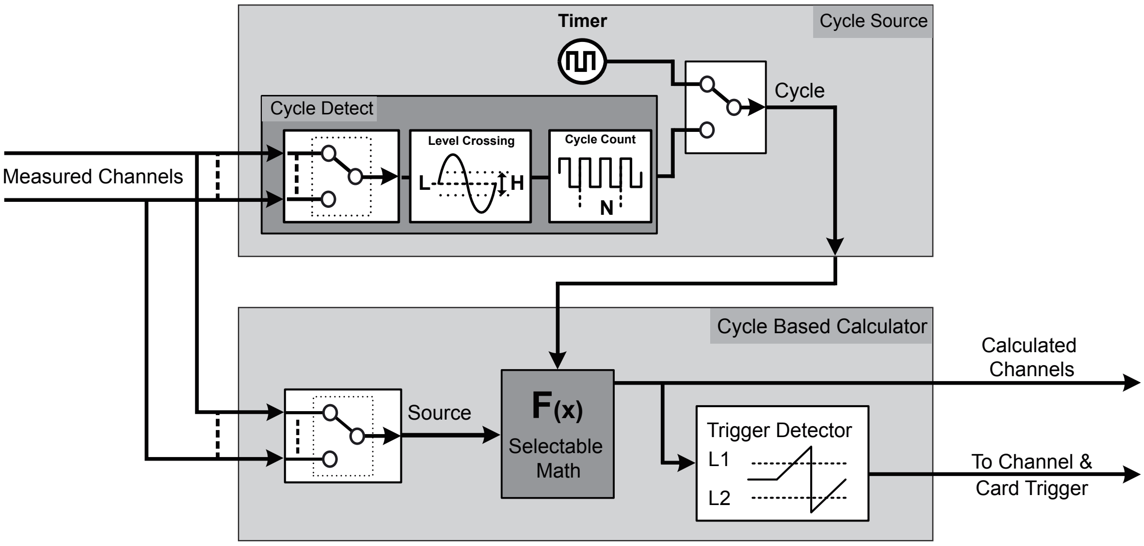


Figure 1.24: Real-time cycle based calculators

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	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	RMS, Minimum, Maximum, Mean, Peak-to-Peak, Area, Energy and Crest Factor
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 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 this table.

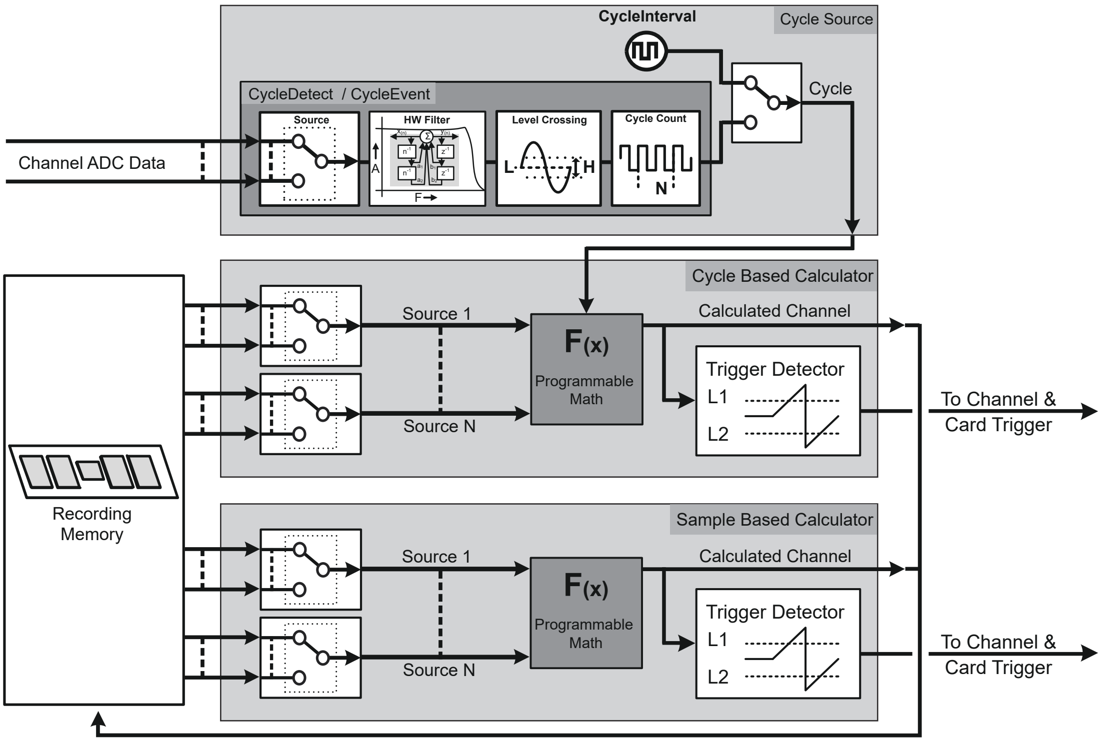


Figure 1.25: Real-time formula database (RT-FDB) calculators

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

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

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

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

(1) Only cycle based results can be used for real-time output. Use the CycleMean calculation on recorded channel data or sample based results to enable the real-time output of this data.

(2) The time required to calculate the output depends on maximum cycle length and sample rate. Depending on the selected settings the output latency will increase. HBM refers to these calculations as not deterministic. All real-time output published values (deterministic and/or not deterministic) will always have the same latency.

(3) This formula is only available if the eDrive license is added to Perception.

(4) The output of HWFilter is used for CycleDetect.

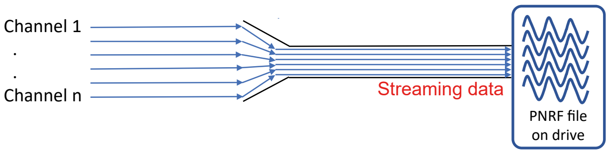
Real-time Statstream®

Patent Number : 7,868,886
Real-time extraction of basic signal parameters.
Supports real-time live scrolling and scoping waveform displays as well as real-time meters while recording.
During recording reviews, it enhances speed for displaying and zooming extremely large recordings and it reduces the calculation time for statistical values on large data sets.

Analog channels	Maximum, Minimum, Mean, Peak to Peak, Standard Deviation and RMS values
Event/Timer/Counter channels	Maximum, Minimum and Peak to Peak values

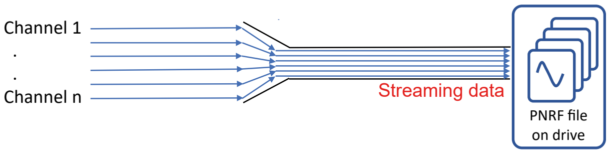
Data Recording Modes

On start of acquisition



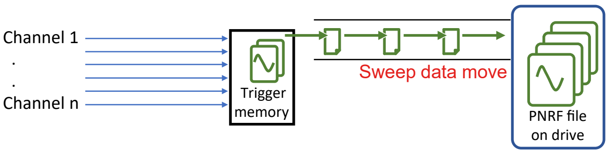
Data recording to PC or mainframe drive.
Data recording to a drive is limited by an **aggregate sample rate**, the recording time is limited by the **size of drive**.
Note: As the aggregate sample rate limit depends on Ethernet speed and storage drive used, as well as the PC and drive not being used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

Wait for trigger



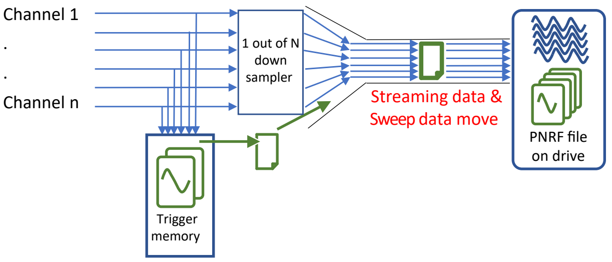
Triggered data recording to PC or mainframe drive.
Trigger data recording to a drive is limited by an **aggregate sample rate**, the recording time is limited by the **size of drive**.
Note: As the aggregate sample rate limit depends on Ethernet speed and storage drive used, as well as the PC and drive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

Wait for trigger to trigger memory first



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

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

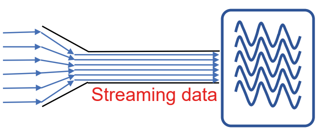


Data recording to PC or mainframe drive and simultaneous triggered data recording to trigger memory on the acquisition card.
The reduced rate data recording to a drive is limited by an **aggregate sample rate** and the recording time is limited by the **size of drive**. The triggered data recording to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

Data Recording Compared

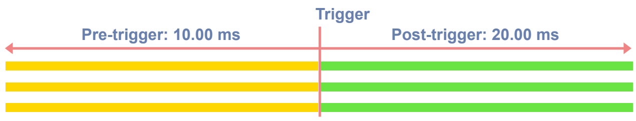
	Aggregate sample rate limit	Maximum recorded data	Direct recording to drive	Trigger memory first	Trigger required to start recording
On start of acquisition	Yes	Free drive space	Yes	No	No
Wait for trigger	Yes	Free drive space	Yes	No	Yes
Wait for trigger to trigger memory first	No	Trigger memory	No	Yes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

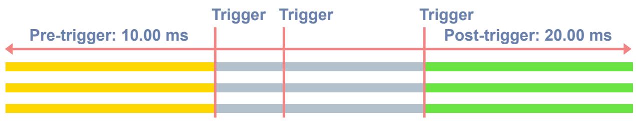
Aggregate sample rate limits when using streaming data

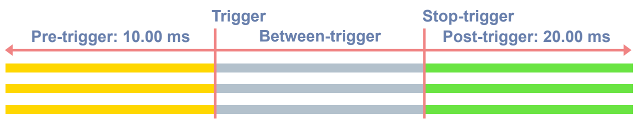


The maximum aggregate streaming rate per mainframe is defined by mainframe type and solid state drive, Ethernet speed, PC drive and other PC parameters.
When an aggregate sample rate is higher than the aggregate streaming rate of the system is selected, the memory on each acquisition card acts as a FIFO.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

<table>
<tr><th colspan="2">Triggered Recording Definitions</th></tr>
<tr><td colspan="2">The details in this table apply to:
• Wait for trigger
• Wait for trigger to trigger memory first
• On start of acquisition reduced rate and wait for trigger to trigger memory first</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 sample rates combined with high trigger rates . This section explains how triggers are handled when the trigger memory is completely filled.

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

Triggered Recording Limits

The details in this table apply to:

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

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

Data Recording Details

16 Bit Resolution

Data Recording Mode	**Wait for trigger to trigger memory first**			**On start of acquisition & wait for trigger**			**On start of acquisition reduced rate and wait for trigger to trigger memory first**		
	Enabled channels			Enabled channels			Enabled channels		
	1 Ch	6 Ch	6 Ch & events	1 Ch	6 Ch	6 Ch & events	1 Ch	6 Ch	6 Ch & events
Max. trigger memory	100 MS	16 MS	14 MS	not used			80 MS	13 MS	11 MS
Max. trigger sample rate	200 kS/s			not used			200 kS/s		
Max. reduced FIFO	not used			100 MS	16 MS	14 MS	18 MS	3 MS	2.5 MS
Max. reduced rate	not used			200 kS/s			Sweep sample rate / 2		
Max. aggregate reduced streaming rate	not used			0.2 MS/s 0.4 MB/s	1.2 MS/s 2.4 MB/s	1.4 MS/s 2.8 MB/s	0.2 MS/s 0.4 MB/s	1.2 MS/s 2.4 MB/s	1.4 MS/s 2.8 MB/s

18 Bit Resolution

Data Recording Mode	**Wait for trigger to trigger memory first**			**On start of acquisition & wait for trigger**			**On start of acquisition reduced rate and wait for trigger to trigger memory first**		
	Enabled channels			Enabled channels			Enabled channels		
	1 Ch	6 Ch	6 Ch & events & Timer/ Counter	1 Ch	6 Ch	6 Ch & events & Timer/ Counter	1 Ch	6 Ch	6 Ch & events & Timer/ Counter
Max. trigger memory	50 MS	8 MS	5 MS	not used			40 MS	6.5 MS	4 MS
Max. trigger sample rate	200 kS/s			not used			200 kS/s		
Max. reduced FIFO	not used			50 MS	8 MS	5 MS	9 MS	1.5 MS	1 MS
Max. reduced rate	not used			200 kS/s			Sweep sample rate / 2		
Max. aggregate reduced streaming rate	not used			0.2 MS/s 0.8 MB/s	1.2 MS/s 4.8 MB/s	1.8 MS/s 7.2 MB/s	0.2 MS/s 0.8 MB/s	1.2 MS/s 4.8 MB/s	1.8 MS/s 7.2 MB/s

Environmental Specifications

Temperature Range	
Operational	0 °C to +40 °C (+32 °F to +104 °F)
Non-operational (Storage)	-25 °C to +70 °C (-13 °F to +158 °F)
Thermal protection	Automatic thermal shutdown at 85 °C (+185 °F) internal temperature User warning notifications at 75 °C (+167 °F)
Relative humidity	0% to 80%; non-condensing; operational
Protection class	IP20
Altitude	Maximum 2000 m (6562 ft) above sea level; operational
Shock: IEC 60068-2-27	
Operational	Half-sine 10 g/11 ms; 3-axis, 1000 shocks in positive and negative direction
Non-operational	Half-sine 25 g/6 ms; 3-axis, 3 shocks in positive and negative direction
Vibration: IEC 60068-2-64	
Operational	1 g RMS, ½ h; 3-axis, random 5 to 500 Hz
Non-operational	2 g RMS, 1 h; 3-axis, random 5 to 500 Hz
Operational Environmental Tests	
Cold test IEC 60068-2-1 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 IEC 60068-2-14 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 IEC 60068-2-30 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 Compliance, According to the Following Directives

Low Voltage Directive (LVD): 2014/35/EU
Electromagnetic Compatibility Directive (EMC): 2014/30/EU

Electrical Safety	
EN 61010-1 (2010)	Safety requirements for electrical equipment for measurement, control, and laboratory use - General requirements
EN 61010-2-030 (2010)	Particular requirements for testing and measuring circuits
Electromagnetic Compatibility	
EN 61326-1 (2013)	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements
Emission	
EN 55011	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics Conducted disturbance: class B; Radiated disturbance: class A
EN 61000-3-2	Limits for harmonic current emissions: class D
EN 61000-3-3	Limitation of voltage changes, voltage fluctuations and flicker in public low voltage supply systems
Immunity	
EN 61000-4-2	Electrostatic discharge immunity test (ESD); contact discharge ± 4 kV/air discharge ± 8 kV: performance criteria B
EN 61000-4-3	Radiated, radio-frequency, electromagnetic field immunity test; 80 MHz to 2.7 GHz using 10 V/m, 1000 Hz AM: performance criteria A
EN 61000-4-4	Electrical fast transient/burst immunity test Mains ± 2 kV using coupling network. Channel ± 2 kV using capacitive clamp: performance criteria B
EN 61000-4-5	Surge immunity test Mains ± 0.5 kV/± 1 kV Line-Line and ± 0.5 kV/± 1 kV/± 2 kV Line-earth Channel ± 0.5 kV/± 1 kV using coupling network: performance criteria B
EN 61000-4-6	Immunity to conducted disturbances, induced by radio-frequency fields 150 kHz to 80 MHz, 1000 Hz AM; 10 V RMS @ mains, 3 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

KAB2128: Shielded 3 Wire 600 V RMS CAT II Cable (Option, to be ordered separately)

This cable is specially designed to be used with the GN310B/GN311B/GN610B and GN611B cards. Significantly reduces signal disturbance pickup by using three identical signal wires with earthed shield.

Cable setup	3 wires with shield and isolation. Signal wires terminated on both sides using (brown, grey, black) shrouded banana plugs. Shield connected on one side using (yellow) shrouded banana plug.

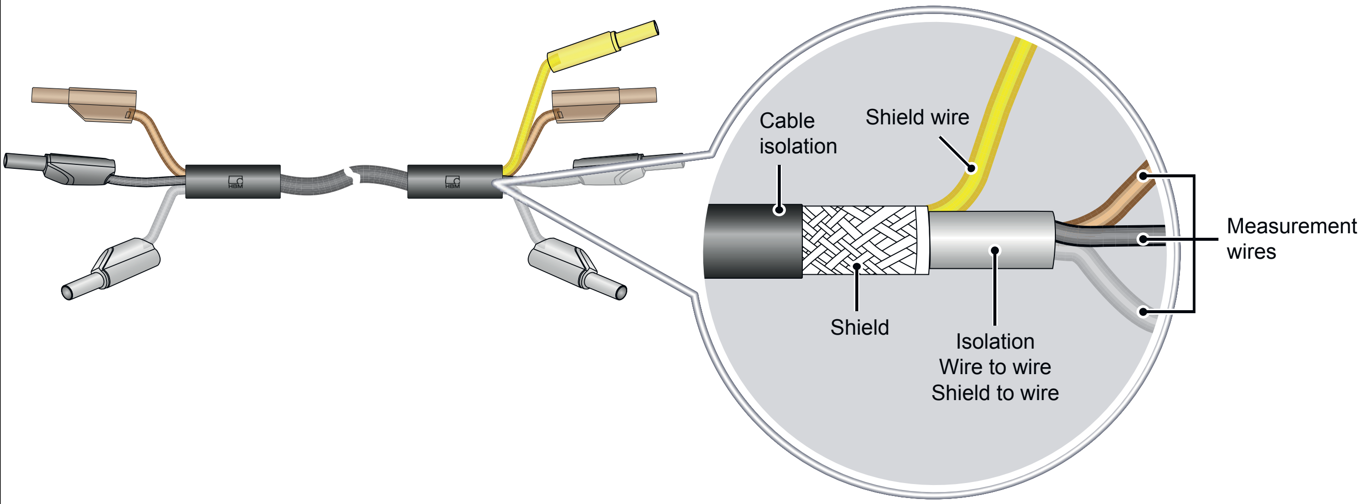


Figure 1.26: Three wire shielded cable setup

Maximum current	1 A RMS
Wire thickness	AWG19 0.65 mm^2 (0.001 in^2)
Maximum wire resistance	25.4 mΩ / m (8.0 mΩ / ft) ± 5%
Weight	Approximately 155 g/m (1.67 oz/foot)
Outside cable diameter	Approximately 9.1 mm (0.36 inch)
Minimum bend radius	10 times that of the cable diameter
Isolation	
Resistance	20 MΩ / km (32.19 MΩ/ mile)
Voltage	600 V RMS CAT II; wire to wire; wire to shield; shield to outside
Capacitance	
Wire to wire	110 pF/m (39.6 pF/ft) ± 10%
Wire to shield	140 pF/m (61 pF/ft) ± 10%
Temperature range	
Operational	-15 °C (+5 °F) to +80 °C (+176 °F)
Non-operational (storage)	-40 °C (-40 °F) to +80 °C (+176 °F)
Available lengths	1.5 m (4.92 ft), 3.0 m (9.84 ft), 6.0 m (19.7 ft),12 m (39.37 ft), 20 m (65.62 ft)

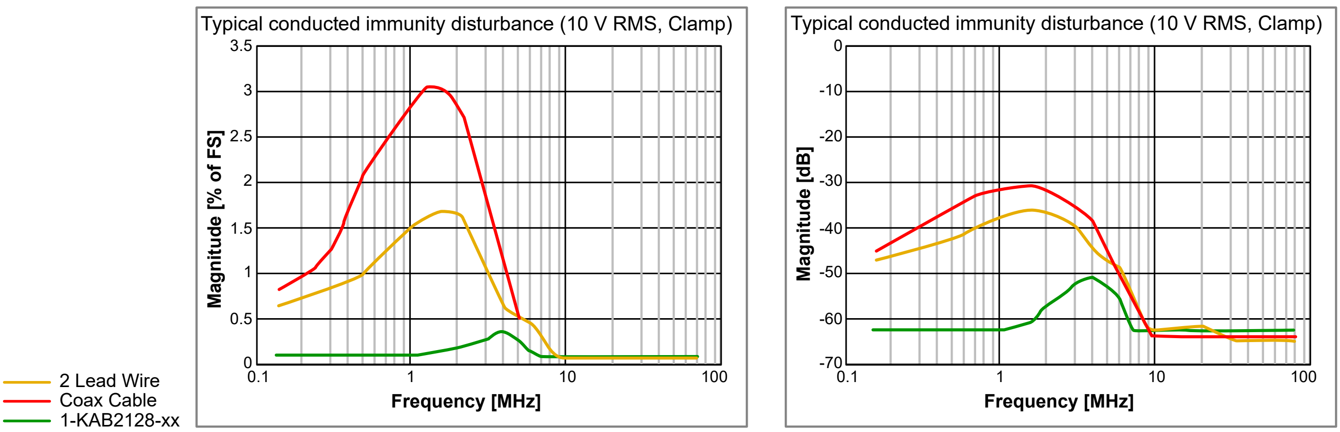


Figure 1.27: Typical conducted immunity, tested using ± 10 V range

G068: Artificial Star Adapter (Option, to be ordered separately)

The artificial star adapter creates an artificial star point to measure 3-phase signals

Maximum input voltage	1000 V DC (707 V RMS) between each of the phases
Inputs	3; 4 mm safety banana plugs
Outputs	6; 4 mm safety banana pins; plugs straight into GN610B/GN611B cards
Artificial star N	Reference plug only. Not to be used as input
Safety	Compliant with IEC61010-1 600 V CAT II
Application use	The 3-phase signals L1, L2 and L3 can be connected with inputs L1, L2, L3 of the artificial star adapter. The connection N* is the voltage present on the artificial “star point”.

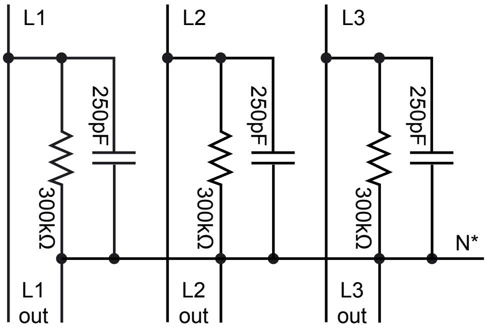


Figure 1.28: Electrical schematic

Weight	170 g (6 oz)
Material housing	Polyurethane, vacuum resin casting
Setup	Two boxes can be plugged into a single GN610B/GN611B card Two or more GN610B/GN611B cards with Artificial star adapters fit next to each other
Temperature range	
Operational temperature	0 °C to +40 °C (+32 °F to +104 °F)
Non-operational (storage)	-25 °C to +70 °C (-13 °F to +158 °F)

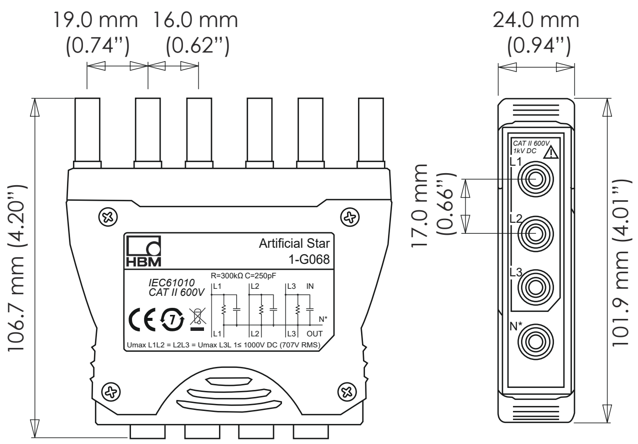


Figure 1.29: Artificial star adapter

Artifical Star Adapter Wiring Diagram

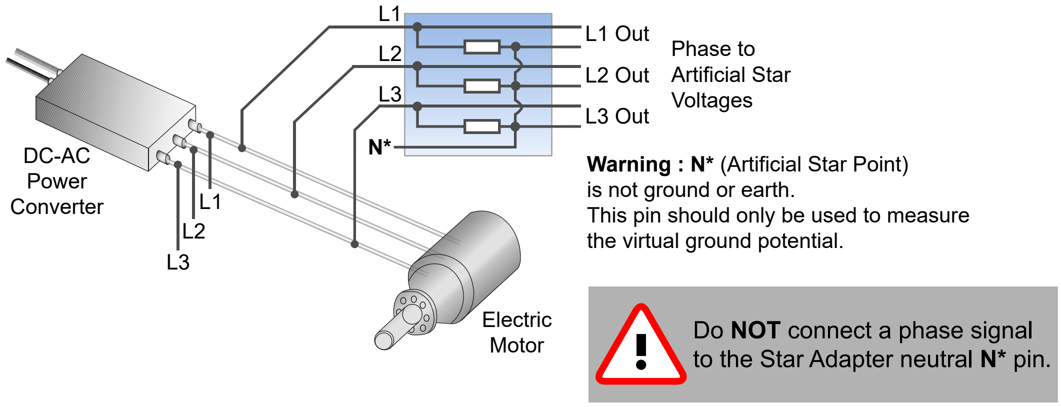


Figure 1.30: Three phase representative use of artificial star adapter

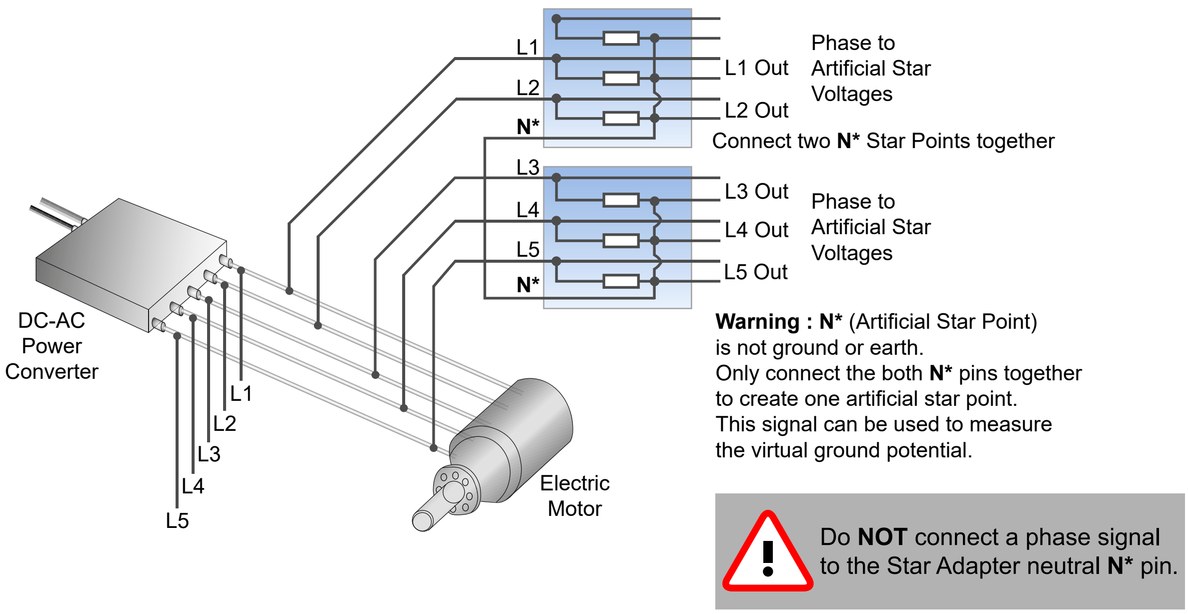


Figure 1.31: Five or more phase representative use of dual star adapter

GN610B/GN611B Current Transducer (CT) Wire Diagram

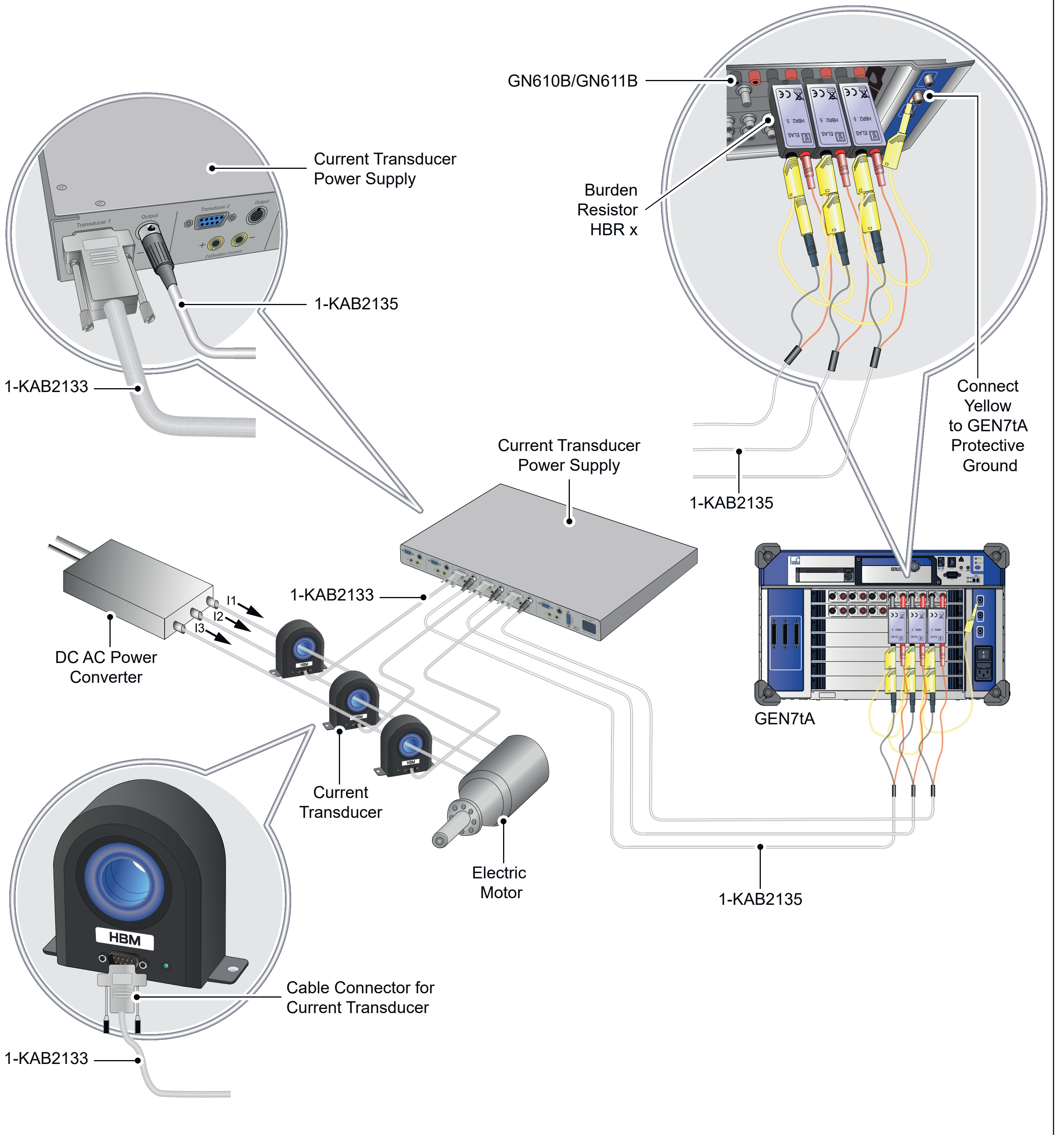
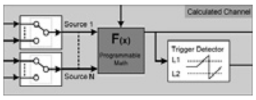
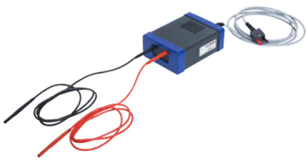


Figure 1.32: Current transducer connection diagram

Ordering Information			
Article		**Description**	**Order No.**
Basic 1 kV ISO 200 kS/s		6 channels, 18 bit, 200 kS/s, ± 10 mV to ± 1000 V input range, 200 MB RAM, 1 kV isolated balanced differential input. (600 V RMS CAT II isolation), 4 mm fully isolated banana plugs. Real-time cycle based calculations with triggering on calculated results Supported by Perception V6.72 and higher. This card is not supported by GEN2i, GEN5i, GEN7t and GEN16t mainframes.	1-GN611B

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

Special Voltage Probes, to be ordered separately			
Article		**Description**	**Order No.**
5 kV RMS, 20 MΩ, 50:1 differential probe		5 kV RMS, 20 MΩ, 50:1, 0.2% high precision, differential probe to be used in combination with GN610B, GN611B (HVD50R-61x), GN310B and GN311B (HVD50R-31x) acquisition cards. The built-in earthing monitor system increases safety of the user and protects the GEN series inputs for isolation overloads.	HVD50R-61x HVD50R-31x Ordered from custom systems(1)
5 kV RMS High Voltage Cable		The High Voltage Cable (HVC) is an extension for measurement cables with voltages up to 5 kV RMS. This device is designed to be connected with a cable on the input terminal of the high precision differential probe HVD10, HVD50R-61x and HVD50R-31x. The HVC is designed according IEC 61010-031:2015 compliant to 1000 V RMS CAT IV and 1500 V DC CAT IV.	HVC Ordered from custom systems(1)

(1) Contact custom systems at: customsystems@hbm.com
Request quote/information for special products for GEN series.

Accessories, to be ordered separately			
Article		**Description**	**Order No.**
Artificial star adapter		The artificial star adapter is a plug-on interface card to measure 3-phase signals with the GN610/GN611/GN610B/GN611B cards. This adapter is intended for measuring 3-phase signals while creating a virtual/artificial star point.	1-G068
1000 V CAT IV / 1500 V DC CAT III 3-wire Isolated shielded test leads		Brown/Grey/Black lead set combined within shielded housing (Yellow). 1000 V RMS CAT IV / 1500 V DC CAT III, 5 A RMS safety-shrouded banana plugs. Typically used for three-phase voltage measurements using the GN310B/GN311B/GN610B/ GN611B cards. The earthed shield reduces high frequency emissions. Available lengths: 1.5 m (4.92 ft), 3.0 m (9.84 ft), 6.0 m (19.7 ft),12 m (39.4 ft)	1-KAB2139-1.5 1-KAB2139-3.0 1-KAB2139-6.0 1-KAB2139-12.0
XLR to Banana cable for GN61XB		CT interface unit to GN61xB DAQ 1kV card connection cable. Uses XLR and banana connectors for a current output connection to the GEN DAQ card. Requires an additional burden resistor in front of the GN61xB card to convert current to voltage. Length 2 m (6 ft)	1-KAB2135-2

Current Transducers Interface and Cables, to be ordered separately			
Article		**Description**	**Order No.**
CT Interface unit		100 - 240 V AC 50/60 Hz AC input voltage. 120 - 370 V DC input voltage. 1U height 19" rack mountable.	1-CTPSIU-6-1U
CT cables		Industry standard current transducer connection cable. Shielded, low ohmic 9 wire cable with D-SUB 9 connectors on both ends. Supports power, status, current output and calibration current input. Lengths: 2, 5, 10 and 20 meters (6, 16, 32 and 65 ft)	1-KAB2133-2 1-KAB2133-5 1-KAB2133-10 1-KAB2133-15 1-KAB2133-20

Current Transducers, to be ordered separately

Figure 1.33: HBM current transducers, power supply and cables

Current Transducer Family Overview

Type	Maximum current	Bandwidth (-3 dB)	Ratio Primary : Secundary	Aperture size
CTS50ID	75 A DC / 50 A RMS	1000 kHz	1 : 500	27.6 mm
CTS200ID	300 A DC / 200 A RMS	500 kHz	1 : 500	27.6 mm
CTS400ID	600 A DC / 400 A RMS	300 kHz	1 : 2000	27.6 mm
CTS600ID	900 A DC / 600 A RMS	500 kHz	1 : 1500	27.6 mm
CTM1200ID	1500 A DC / 1200 A RMS	400 kHz	1 : 1500	45.0 mm
CTM1200ID-CD3000	1500 A DC / 1200 A RMS	15 kHz	1 : 1500	45.0 mm

Article		Description	Order No.
75 A DC or 50 A RMS current transducer		Ultra-stable, high-precision fluxgate technology current transducer. Non-intrusive isolated 75 A DC or 50 A RMS up to 1 MHz AC current measurements.	1-CTS50ID
300 A DC or 200 A RMS current transducer		Ultra-stable, high-precision fluxgate technology current transducer. Non-intrusive isolated 300 A DC or 200 A RMS up to 500 kHz AC current measurements.	1-CTS200ID
600 A DC or 400 A RMS current transducer		Ultra-stable, high-precision fluxgate technology current transducer. Non-intrusive isolated 600 A DC or 400 A RMS up to 300 kHz AC current measurements.	1-CTS400ID
900 A DC or 600 A RMS current transducer		Ultra-stable, high-precision fluxgate technology current transducer. Non-intrusive isolated 900 A DC or 600 A RMS up to 500 kHz AC current measurements.	1-CTS600ID
1500 A DC or 1200 A RMS, 400 kHz current transducer		Ultra-stable, high-precision fluxgate technology current transducer. Non-intrusive isolated 1500 A DC or 1200 A RMS up to 400 kHz AC current measurements.	1-CTM1200ID
1500 A DC or 1200 A RMS, 15 kHz current transducer		Ultra-stable, high-precision fluxgate technology current transducer with calibration winding. Non-intrusive isolated 1500 A DC or 1200 A RMS up to 15 kHz AC current measurement	1-CTM1200ID-CD3000

(1) Contact custom systems at: customsystems@hbm.com
Request quote/information for special products for GEN series.

GN610B/GN611B Burden Resistors, to be ordered separately

Burden selection for GN610B/GN611B

Note: When using the CTS/CTM series together with GN610B/GN611B cards a burden resistor is required to convert the CT output current to a voltage. When selecting the burden several specifications need to be taken into account: maximum power of the burden, maximum voltage the CT can drive with constant current, the wire impedance of the cables used etc. See the CT operating manual for more details.

Model	Recommended burden	mV/A sensitivity	A/V scaling
CTS50ID	HBR 2.5 Ω	5.0	200
CTS200ID	HBR 1.0 Ω	2.0	500
CTS400ID	HBR 1.0 Ω	0.5	2000
CTS600ID	HBR 1.0 Ω	0.6667	1500
CTS1200ID	HBR 1.0 Ω	0.6667	1500
CTS1200ID-CD3000	HBR 1.0 Ω	0.6667	1500

Article		**Description**	**Order No.**
HBR 0.25 Ω, 1 W precision burden resistor		0.25 Ω1 W, 0.02% high precision, low thermal drift burden resistor. Internally uses 4 wire connection to reduce inaccuracy caused by the currents running to the burden resistor. Using banana input connectors and banana output pins. Directly compatible with GN610B/GN611B acquisition cards.	Ordered from custom systems(1)
HBR 0.5 Ω, 1 W precision burden resistor		0.5 Ω1 W, 0.02% high precision, low thermal drift burden resistor. Internally uses 4 wire connection to reduce inaccuracy caused by the currents running to the burden resistor. Using banana input connectors and banana output pins. Directly compatible with GN610B/GN611B acquisition cards.	Ordered from custom systems(1)
HBR 1 Ω, 1 W precision burden resistor		1 Ω, 1 W, 0.02% high precision, low thermal drift burden resistor. Internally uses 4 wire connection to reduce inaccuracy caused by the currents running to the burden resistor. Using banana input connectors and banana output pins. Directly compatible with GN610B/GN611B acquisition cards.	Ordered from custom systems(1)
HBR 2.5 Ω, 1 W precision burden resistor		2.5 Ω, 1 W, 0.02% high precision, low thermal drift burden resistor. Internally uses 4 wire connection to reduce inaccuracy caused by the currents running to the burden resistor. Using banana input connectors and banana output pins. Directly compatible with GN610B/GN611B acquisition cards.	Ordered from custom systems(1)
HBR 10 Ω, 1 W precision burden resistor		10 Ω, 1 W, 0.02% high precision, low thermal drift burden resistor. Internally uses 4 wire connection to reduce inaccuracy caused by the currents running to the burden resistor. Using banana input connectors and banana output pins. Directly compatible with GN610B/GN611B acquisition cards.	Ordered from custom systems(1)

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