Gantner Instruments

Condition Monitoring Solutions

Condition Monitoring Solutions

Here is what you can find in this presentation

Expand your engineering, test & measurement, monitoring, instrumentation, and control know-how with Gantner's high-quality and easy-to-use DAQ systems and solutions.

General Overview

Multiple Options – Your Choice

Ready to install into existing Enclosures/Cabinets

Q.series Xtended Edition

- Powerful signal conditioning with flexibility in Interface and form factor for DIN Rail, 19” Rack or portable
- Computer independent data logging,
- Event logger with adjustable pre- post trigger time
- Mix and Match types of I/O Cards as needed
- Vibration monitoring functions according to ISO 10816

Fully engineered solutions

Q.systems CMS

- Powerful and robust signal conditioning with several interface options
- IP54/68 Protection
- Computer independent data logging,
- Event logger with adjustable pre- post trigger time
- Pre-designed inputs and outputs
- Vibration monitoring functions according to ISO 10816

Q.series

Feature Comparison of Q.series X and .systems CMS

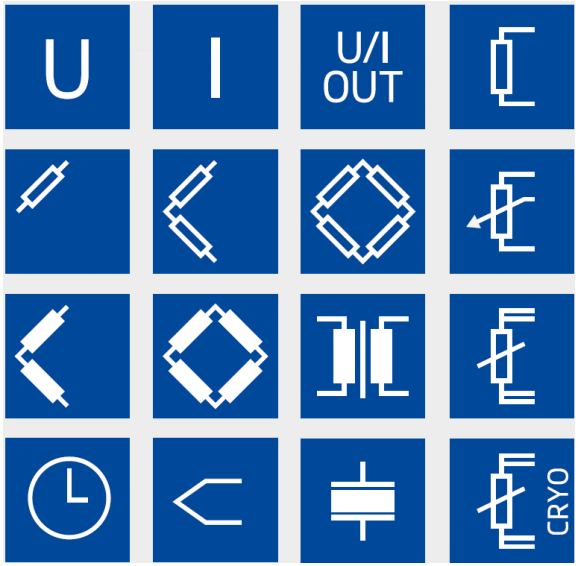
Feature	Q.series Xtended Edition	Q.Systems CMS
Sampling rate e.g. of Multi Purpose Module	20kHZ / 100kHz	20kHz / 100kHz
Amount of Input Channels at 20kHz	64	16
Decentralized I/O Modules	(√)	√
Connector on Module Front	Customization possible	BNC, Binder, LEMO
Enclosure	DIN rail, Portable, 19” Rack	Screw / pole mounting
Enclosure rating	IP20	IP54 / IP63
A141 Charge Amplifier	√	(√)
A108 with excitation for MEMS sensors	√	√
IEPE/ICP Inputs	√	√
Analog outputs (0/4-20mA, +/.10 VDC)	multiple	max. 4
Highest Order of Filter on Module	8th	6th
Time synchronization with Ethernet (PTP)	√	√
Frequency analysis: Spectral band and broad band analysis for - Vibration Velocity - Vibration Displacement - RMS - Max Amplitude @Frequency Time Domain Analysis: - 0-pk, pk-pk, rms, avg - Crest, Kurtosis	√	√

Q.series X

Measurement and I/O Modules for all Relevant Signals

Dedicated Modules

- 4 IEPE / ICP
- 4 Piezoelectric sensors
- 8 / 16 strain gage quarter, half and full bridge
- 8 thermocouples, 4 RTD
- 8 voltages or current



Multi Purpose Modules

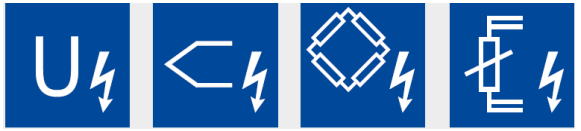
- 2 or 4 inputs for almost all sensors
- Strain gage module with DC and CF excitation

Digital Modules

- Frequency and PWM in and outputs
- Quadrature and up/down counter
- Specials like missing tooth detection and chronos method

High Isolation Modules

- Isolation 1200 VDC
- Inputs for voltage, current, thermocouples, Pt100, NTC, IEPE, strain gage full and half bridge



Q.systems CMS

Q.systems CMS

Q.sens

- 4 Ch Vibration Data Logger
- Inbuild powerfull Q.station with 4 Ch input card for IEPE/ICP or MEMS accelerometers
- Pre-configured for frequency and time domain analysis
- Internal 128 GB data logger
- Power Supply: 10-30 VDC input 110-240 VAC optional
- Digital output and LED for alarm indication
- Ethernet Interface for plant communication
- Multiple interface options like OPC UA, Modbus TCP

Product Highlights

Q.sens pre-configured Comes with optional sensor package

Easy to install

Easy to operate with GI.bench or data streaming to plant's SCADA system

Q.systems CMS

Q.cms

- 8, 12 or 16 Ch synchronous vibration channels
  - IEPE or +/-24 VDC sampling rate 100 kHz each channel, bandwidth 20 kHz with anti aliasing filter, 48 kHz optional
  - MEMS (optional)
  - Piezoelcetric / Charge (optional)
- 8 channel for process parameters as
  - 0/4-20mA or 0-10V or RTD (Pt100, Pt1000) individual per channel
  - Sampling rate 100 Hz
- 6 channels for tachometer / Speed sensor / Key Phasor
  - counter, frequency PWM or status
  - 0-30V, Threshold 3.0V as TTL Logic or 11.0V as 24V Logic
- 6 digital outputs for status, alarm, warning
  - 30VDC, 500mA max
  - Relay (optional)
- Analog output optional
- Pre-configured for frequency and time domain analysis according ISO 10816-3
  - Internal 128 GB data logger
  - FFT Line / bins 4096 or 8128
- Robust enclosure IP66 rating
  - Power Supply: 110-240 VAC
  - LED for Status and Power
- Ethernet Interface for plant communication
  - Multiple interface options like OPC UA, Modbus TCP
  - EtherCAT or Profinet optional

Product Highlights

Q.cms pre-configured For vibration monitoring according to ISO 10816-3

Direct asset mounting

Easy to operate with GI.bench or data streaming to plant‘s SCADA system

Q.systems CMS

Q.series portable

- 12Ch Vibration Data Logger
- Inbuild powerfull Q.station with 12 Ch input card for IEPE/ICP or MEMS accelerometers
- Input for tachometer / Speed sensor / Key Phasor
- Pre-configured for frequency and time domain analysis
- Internal 128 GB data logger
- Power Supply: 10-30 VDC input and 110-240 VAC selectable
- Extendable by additional Q.series I/O modules
- Roughed transport case
- IP54 / IP63 protection
- Ethernet Interface for plant communication
- Multiple interface options like OPC UA, Modbus TCP

Product Highlights

Weatherprooof logger / monitoring Systems

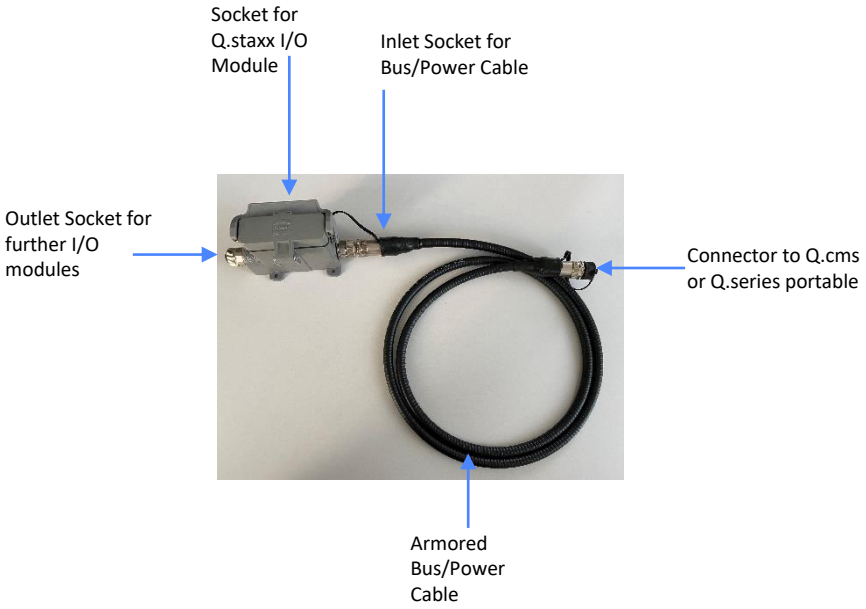
For short or long term monitoring

Battery (external) or grid powered

Q.systems CMS

Q.staxx

- I/O extension for Q.cms and Q.series portable
- IP68 protected I/O Module
- For a decentralized system layout



Product Highlights

Very roughed I/O extension

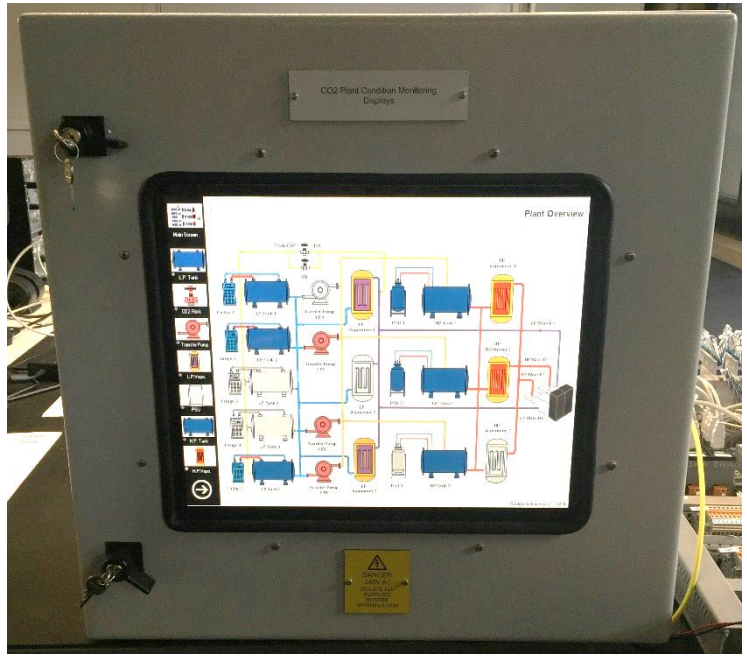
For short sensor cable and best signal quality

Installation directly on the asset (IP68)

Q.systems CMS

Q.series customized systems

- Individual designed systems
- With inbuild touch display for plant or process visualization
- Visualization of vibration parameters and warnings / alarms
- All available I/O modules can be used for multiple sensors
- Additional interface to SCADA systems e.g. with OPC UA or Modbus TCP
- Internal data logging with pre- and post trigger



Product Highlights

Designed to your needs and requirements

With inbuild Touch Display for visualization of asset parameters ans status

Q.systems CMS
Sensor Package

- Very roughed and industrialized IEPE/ICP accelerometers for stud or magnet mount
- Single axis
  - 80 g dynamic range
  - 100 mV/g
  - Frequency range 0.5 Hz to 14 kHz
  - Hermetically sealed
  - Top or side cable outlet
  - Temperature range -50°C to +120°C (150°C optional)

- Tri-axis
  - 80 g dynamic range
  - 100 mV/g
  - Frequency range 0.5 Hz to 10 kHz
  - Hermetically sealed
  - Side cable outlet
  - Temperature range -50°C to +120°C (150°C optional)

Product Highlights

Very rougehd IEPE/ICP Accelerometer

High Bandwidth

High Temperature Version

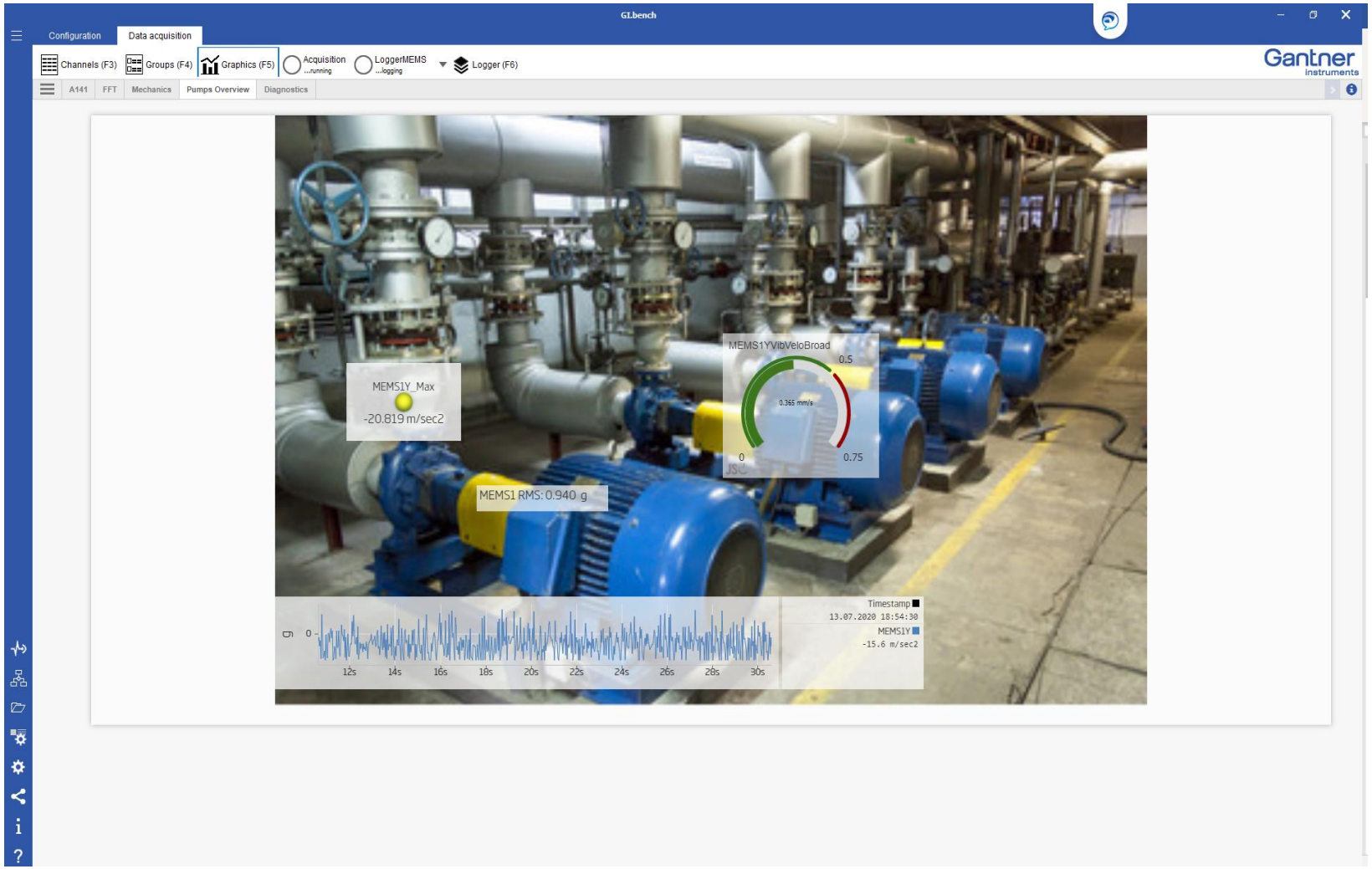
Q.systems CMS

GI.bench

- Software for Vibration Trend Monitoring on local Computer or within the network
- Combinend data logging for all connected controllers in addition to local storage
- Visualization with multiples graphic elements
- Multi Screen Applications with web browsers
- Status overview of all connected controllers
- Network security: websocket connection over port 8090 and 8004 only

Q.systems CMS

GI.bench



- Software for Vibration Trend Monitoring on local Computer or within the network
- Combined data logging for all connected controllers in addition to local storage
- Visualization with multiples graphic elements
- Multi Screen Applications with web browsers
- Status overview of all connected controllers

Controller

DAQ Controller

Q.station X (B / T)

- For computer independent data logging
- Up to 64 I/O modules connectable
- Destibuted and Daisy Chainned I/O modules or connected directly to the controller
- Multiple sampling rates
- RT linux as operating system for reliable 24/7 operation
- CAN bus port (CAN-FD with external adapter)
- ModbusTCP, Modbus RTU with external adapter (e.g. RS485 to USB)
- 2 USB ports for e.g. GPS mouse
- Time syncronization with NTP, PTP, IRIG
- With test.con (T option),
- Multiple interface options like OPC UA

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Product Codes

As bloxx (DIN Rail)
Q.station-XB
Q.station-XT

As brixx (portable)
Q.brixx-X station B
Q.brixx-X station T

As raxx (19In Rack)
Q.raxx-X station B
Q.raxx-X station T

DAQ Controller

Q.station X (B / T) SSD-1TB

- Q.station standard or T version
  but with extension with 1TB SSD
- Footprint: Double-slot

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Product Codes

As bloxx (DIN Rail)
Q.station-XB SSD-1TB
Q.station-XT SSD-1TB

As brixx (portable)
Q.brixx-X station B
SSD-1TB
Q.brixx-X station T
SSD-1TB

As raxx (19In Rack)
Q.raxx-X station B
SSD-1TB
Q.raxx-X station T
SSD-1TB

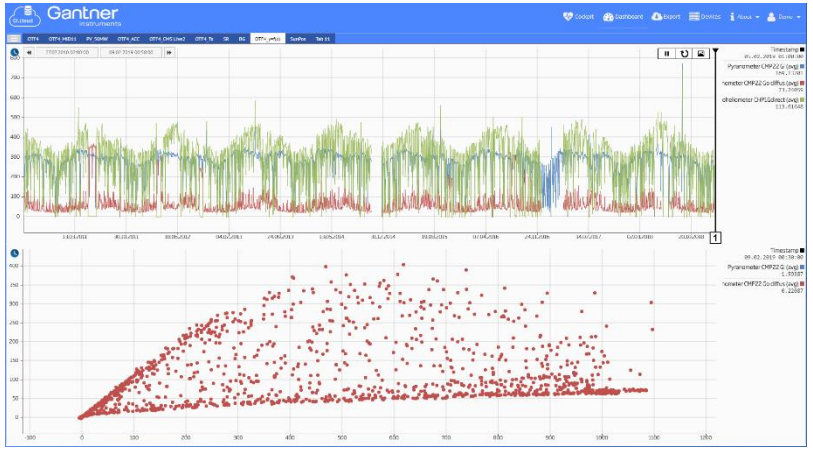
DAQ Controller

Q.core 101 / 102

- High performance edge controller with GI.bench, inbuild i7 CPU with Q.station Operating system and firmware
- Inbuild 1TB SSD for storage of large data streams from up to 6 Q.stations, extendable by NAS
- Central Data Logger configuration with pre- and post triggering
- Very high data rates up to 96 channel with 100 kHz each from Q.stations (Ethernet) or 10 channels with 4 Mhz from Q.boost (USB)
- Web Frontend for data visualization and export
  - Export as csv, UDBF, MDF, FAMOS,
- Arithmetik stack of GI.bench for evaluation of data sets
- All plugins e.g. OPC-UA available
- Configurable with GI.bench
- 19“ (1HU) Rack
- 10 - 30 VDC Power supply

Front


Rear



Web Frontend

Also Available:
- Without HDMI and USB ports on the front as Q.core 101

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Product Codes

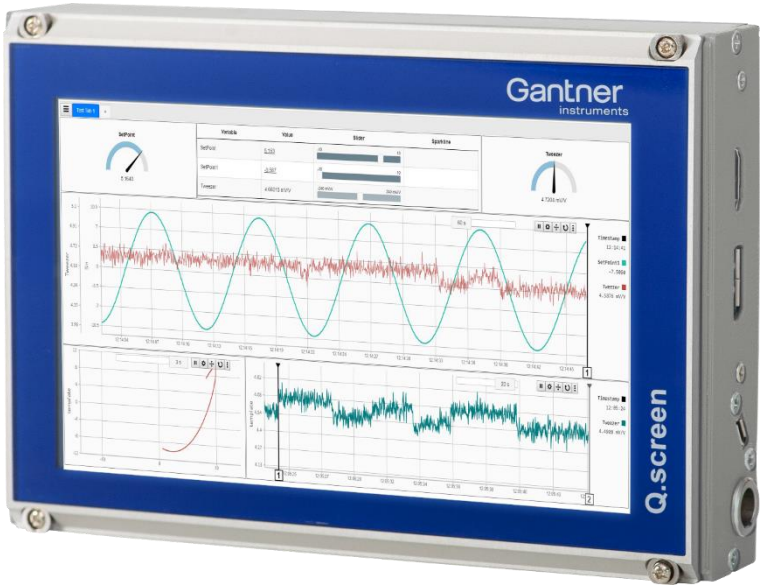
As raxx (slimline)
Q.Core 102 w/ USB & HDMI

Q.Core 101 w/h USB & HDMI

DAQ Controller

Q.station X Touch Screen

- 7 inch industrial touch screen
- 800x480 pixel TFT LCD
- Connectable to Display Port of Q.station
- Design HMI screens with test.con
- Requires 6 slots in a 19“ Q.raxx chassis



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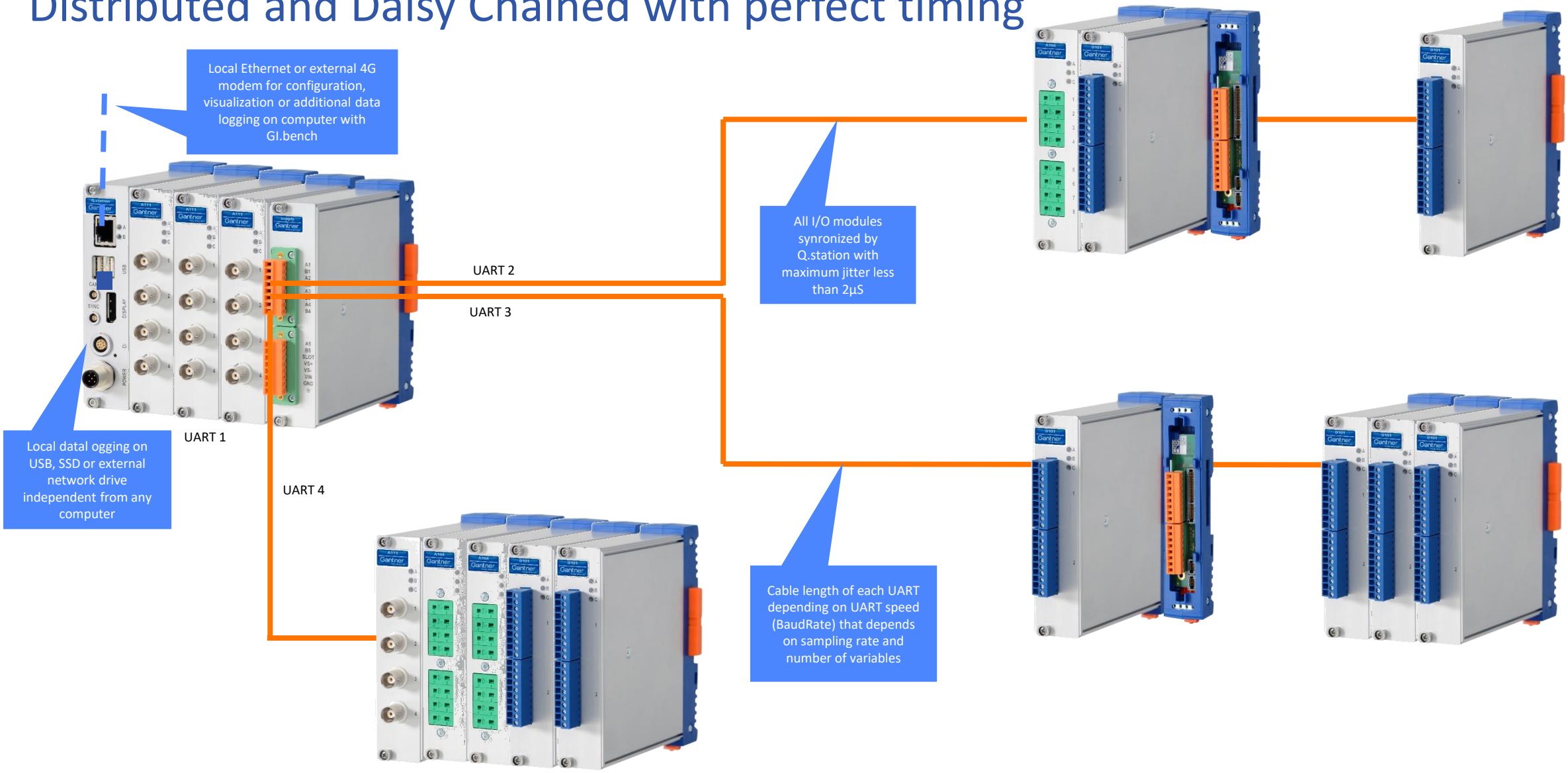
Product Codes

For rack (19Inch 3HU) or panel mount:
Q.screen

I/O Modules

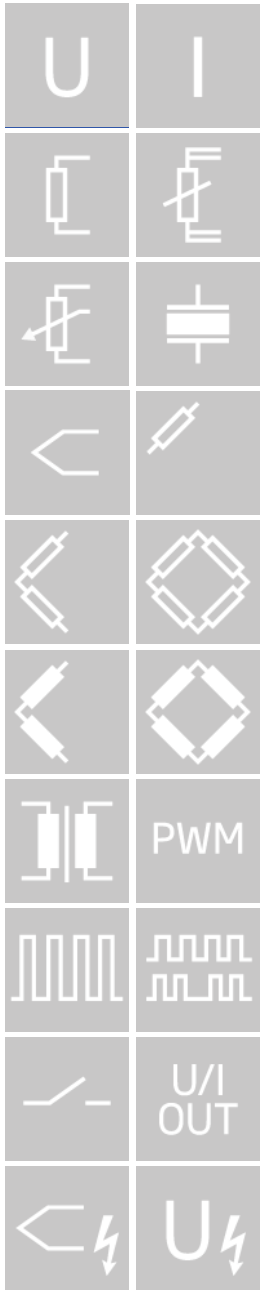
System Layout

Distributed and Daisy Chained with perfect timing



I/O Modules
Q.series X General Features

- All I/O Modules with 24-bit ADC (A102, A122 with 19-bit SAR)
- Isolation voltage of 500 VDC
  - channel-to-channel
  - channel to power supply
  - channel to bus
- High Voltage I/O modules with 1200 VDC isolation voltage permanent
- Software selectable:
  - Input type
  - Measurement range
  - Scaling and linearization with 300 points (1000+ for RTD)
  - Sensor excitation voltage
- Anti-aliasing filter and further digital filter selectable (High / Low pass, band-pass, Butterworth, Bessel up to 8th order
- Additional virtual variables for signal condition (module dependend):
  - Linearization, filter, average, calcing, min/max storage, rms, arithmetic, alarm

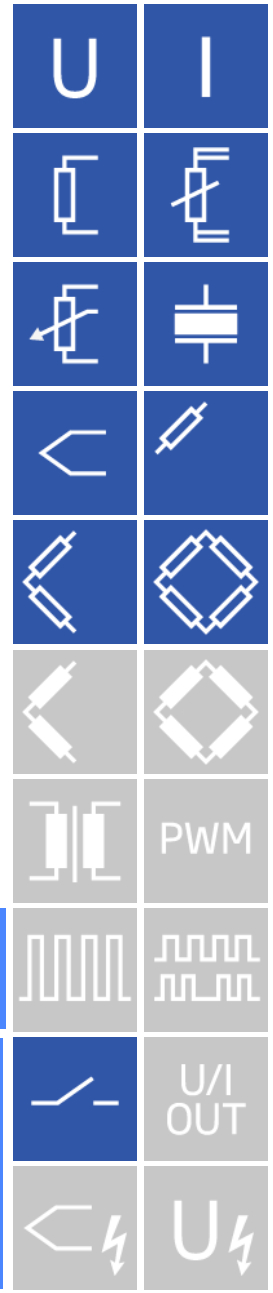


I/O Modules
Q.series X A101

- Multipurpose I/O module with 2 Ch at 100 kS/s each
  - 0-10V
  - 0-60V
  - 0/4-20mA
  - IEPE/ICP
  - Thermocouple
  - Pt100/Pt100
  - Resistance
  - Strain Gage (quarter, half, full)
- 2 Digital Inputs or Outputs
  - Status, trigger,
  - tare, alarm
- Standard 10-pole
- Or LEMO connectors with inbuild sensor excitation (2x 15 VDC, each)

Also Available:
- With Front Connectors 2x DSub9

Accessoires:
- Cold Junction Compensation Terminal: Qterm-CJC-A101
- Bridge Completion Resistor 120 Ohm: Qterm-B4/120-A101
- Bridge Completion Resistor 350 Ohm: Qterm-B4/350-A101



Q.bloxx XL/XE
A101-Lemo

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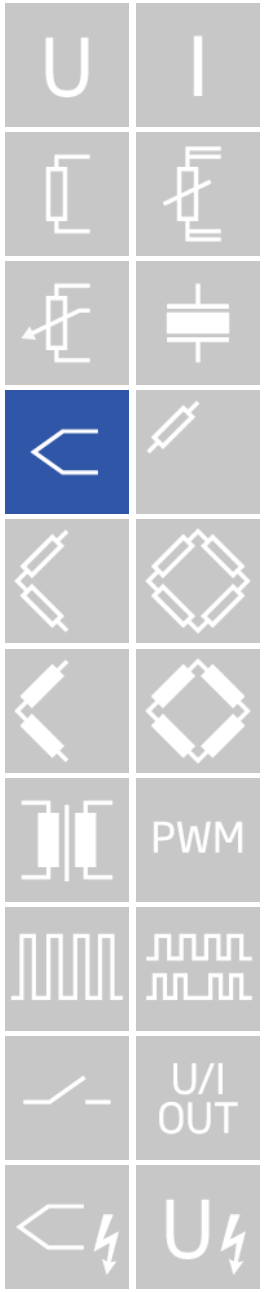
I/O Modules
Q.series X A104 TCK

- Thermocouple type input connector Version of A104
  - 8 analog input channels:
    - Thermocouple
      - Type K (others on request)
      - Margin of error e.g. for type K ±0.5 K
    - Voltage
      - ±80 mV
      - Margin of error ±10µV
      - Resolution 10nV
    - 60/50Hz noise reduction filter (10/6 Hz sampling rate)
    - Open thermocouple detection
      - Detect broken wire, loose connection or thermocouple burnout
    - Isolation voltage channel-to-channel 100 VDC
- 8x TCK Miniature Connector with inbuild cold cunction compensation by Pt100



Also Available:
- With Front Connectors in Yellow for TCK (ANSI)

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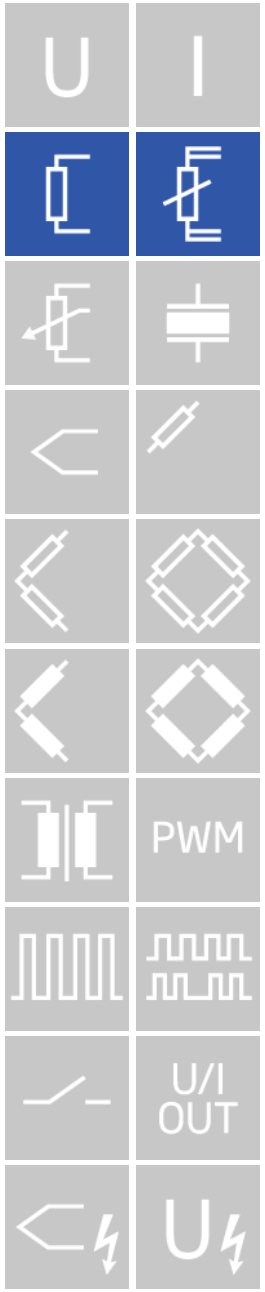
I/O Modules
Q.series X A105

- Measurement Module for Temperature (RTD) and Resistance with 4 Ch at 10 kS/s reduced by averaging to available 10 S/s each
  - 4 analog input channels:
    - Pt100
      - Margin of error 0.05 °C
      - Resolution 0.0001 °C
    - Pt1000
    - Resistance 400 Ω / 4000 Ω
      - 3- or 4- wire connection
- Standard 10-pole screw terminals



Also Available:
- With Front Connectors 2x DSub15 and 2x BNC
- With Front Connectors 4x Dsub15

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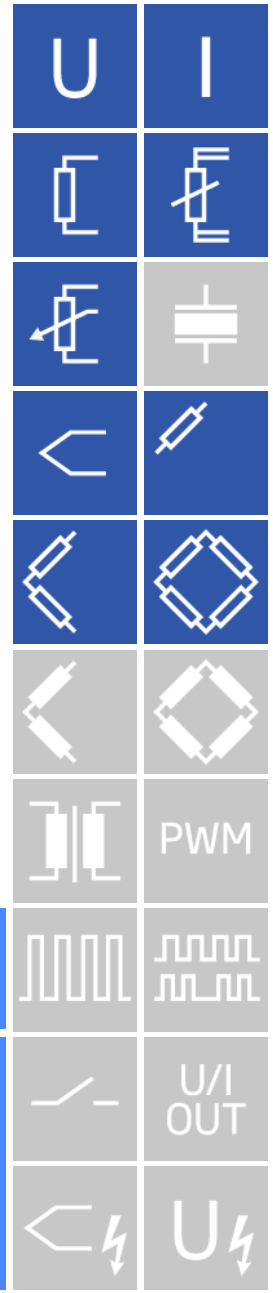
I/O Modules
Q.series X A107

- Universal Measurement Module with 4 Ch at 20 kS/s each
  - 4 Universal analog input channels:
    - Voltage with input range ±10 V, ±1 V and ±100 mV
    - Current with input range ±25 mA
    - Potentiometer with input range 1 kOhm to 10 kOhm
    - Resistance with input range 400 Ohm and 4 kOhm
    - RDT (Pt100 / Pt1000)
    - Thermocouple
    - Strain Gage with input range ±2.5 mV/V, ±50 mV/V and ±500 mV/V
- Standard 10-pole screw terminals
- Or LEMO connectors with inbuild sensor excitation (4x 15 VDC, 20 mA each)



Q.bloxx XL/XE
A107-Lemo

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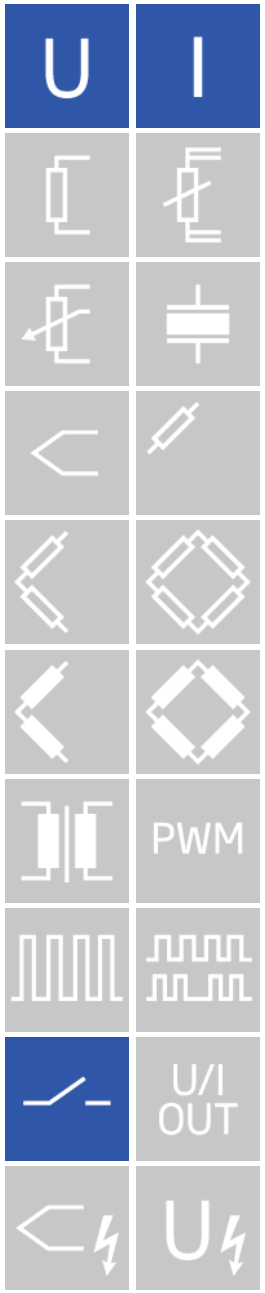
Also Available:
- With Front Connectors 4x DSub9

Accessoires:
- Cold Junction Compensation Terminal: Qterm-CJC-A107
- Bridge Completion Resistor 120 Ohm: Qterm-B4/120-A107
- Bridge Completion Resistor 350 Ohm: Qterm-B4/350-A107

I/O Modules
Q.series X A108

- Voltage and Current Measurement Module with 8 Ch at 20 kS/s each
  - 8 analog input channels:
    - Voltage differential
      - Input range ±10 VDC
      - Margin of error ±2 mV
      - Resolution 1.5 µV
      - Overvoltage protection ±200 V
    - Current (with shunt resistor)
  - 2 Digital inputs and outputs
    - Status, Trigger, Tare, Alarm
- Standard 10-pole screw terminals



Also Available:
- With Front Connectors 8x BNC as double slot module

Accessoires:
- Shunt Terminal for Current Measurement (0/4-20mA): Qterm-SR

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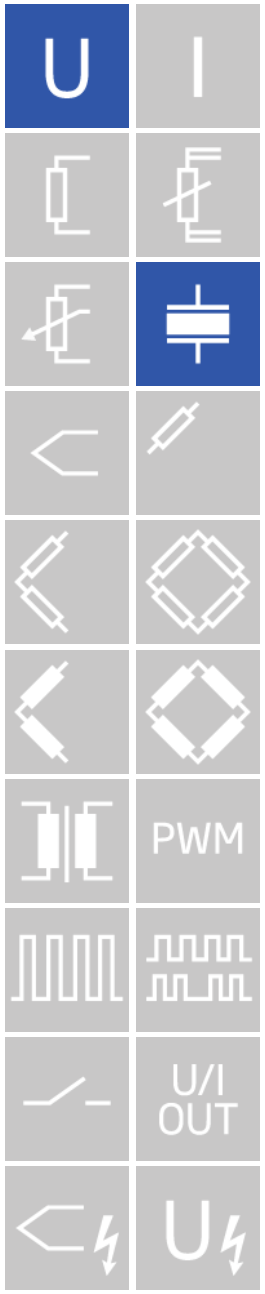
I/O Modules
Q.series X A108 4M1 / 2M3

- 2M3: I/O Module for 2 tri-axis MEMS sensors
  - 6+2 Analog Input channels with 20 kS/s each
    - AI1, AI2, AI3 differential/ single-ended switchable in groups
    - AI5, AI6, AI7 differential/ single-ended switchable in groups
    - AI4, AI8 single-ended (e.g. for temperature compensation)
- 4M1: I/O Module for 4 single-axis MEMS sensors
  - 4+4 Analog Input channels with 20 kS/s each
    - AI1, AI2, AI3, AI4 differential/ single-ended switchable in groups
    - AI5, AI6, AI7, AI8 single-ended (e.g. for temperature compensation)
- All analog inputs:
  - Input range ±10 VDC
  - Margin of error ± 2 mV
  - Resolution 1.5 µV
- Sensor excitation for each sensor
  - 15 V max. 40 mA (short circuit proof)
- Available in 2M3 (DB9) and 4M1 (MicroCom CMR)



Q.bloxx XL/XE A108-2M3

Q.bloxx XL/XE A108-4M1

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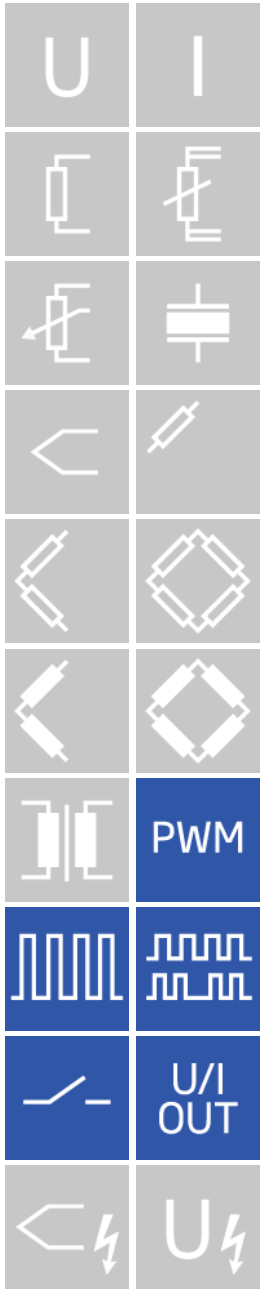
I/O Modules
Q.series X A109

- Analog Output Module with Digital I/Os
  - 4 analog output channels:
    - Voltage ±10 VDC
    - Current 0-20 mA
  - 4 Digital inputs and outputs
    - 2 counter / 2 frequency
    - 2 PWM Inputs / 4 frequency out
    - 4 PWM output
    - 4 state outputs
- Standard 10-pole screw terminals



Also Available:
- With Front Connectors 4x BNC (analog output only)

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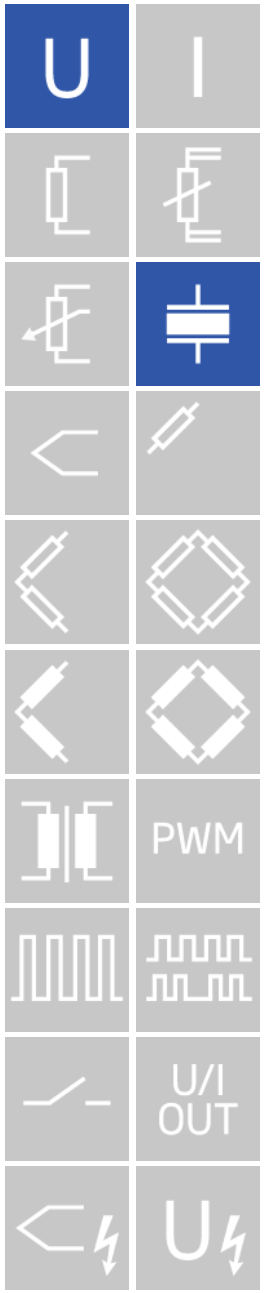
I/O Modules
Q.series X A111 / A111 BNC

- Module for IEPE/ICP Sensors and Voltages with 4 Ch at 100 kS/s each
  - 4 galvanic isolated analog input channels:
    - IEPE
      - Input range ±1 V or ± 10 V
      - margin of error ±1 mV / ±10 mV
      - Sensor excitation with 4mA constant current
      - Compliance voltage 24 VDC ±10 %
      - Input frequency range 0.5 Hz to 20 kHz
    - Voltage
      - Input range ±100 mV, ±1 V or ± 10 V
      - margin of error ±20 µV / ±200 µV / ±2 mV
- Standard 10-pole screw terminals or BNC-Connectors



Q.bloxx XL/XE A111-BNC

Q.bloxx XL/XE A111

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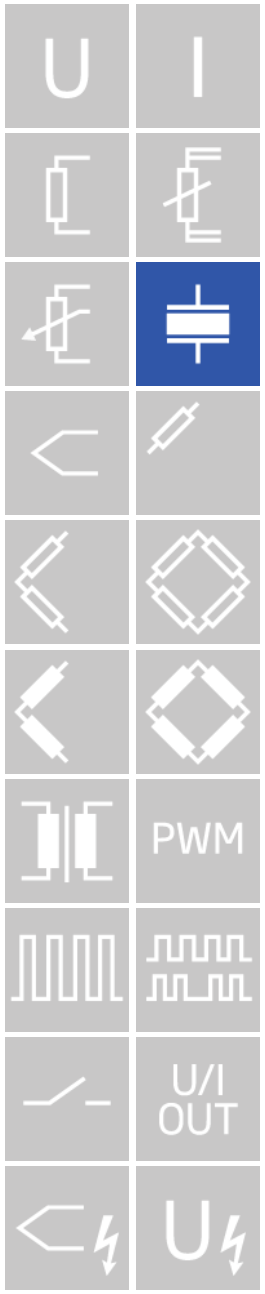
I/O Modules
Q.series X A141

- Charge Amplifier Module for Piezoelectrical Sensors
- Engineerd with Kistler
- 4 channels Charge Amplifier:
  - For Piezoelectric Sensor
    - Input Range: 1000 to 1000000 pC
    - Margin of error < ±1 % FSO
    - Drift 0.5 pCpp
    - Frequency range 0 Hz to 20 kHz
- 4x BCN Connector



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Vibration Monitoring Essentials

Selection of Data Evaluation Functions

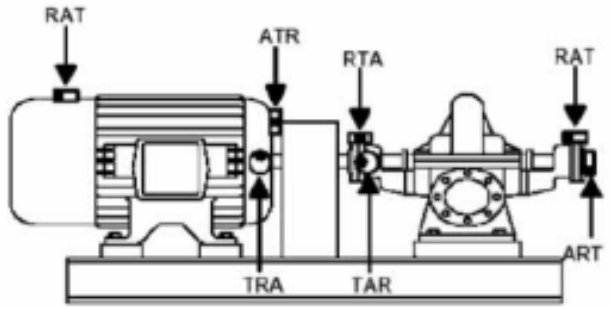
Gantner Instruments
Austria | Germany | France | Sweden
India | USA | China | Singapore

Gantner instruments

Test and Measurement Technology.
Designed for You.

Typical Application
Electric Pump

- Standard pumping System with electric motor
- Two Motor bearings and two pump bearings (all roller bearings)
- Minimum Setup:
  - 8 Accelerometers x/y on motor shaft and pump bearings, x on motor Fan, z on end of pump shaft
- Advanced Setup
  - Rotor speed
  - Electrical parameters of motor (U, I, Power, …)
  - Process parameters (Temp, pressure, flow, …)
  - two proximity probes if plain bearings (large pumps)



Typical Application Electric Pump

- What is measured and analyzed

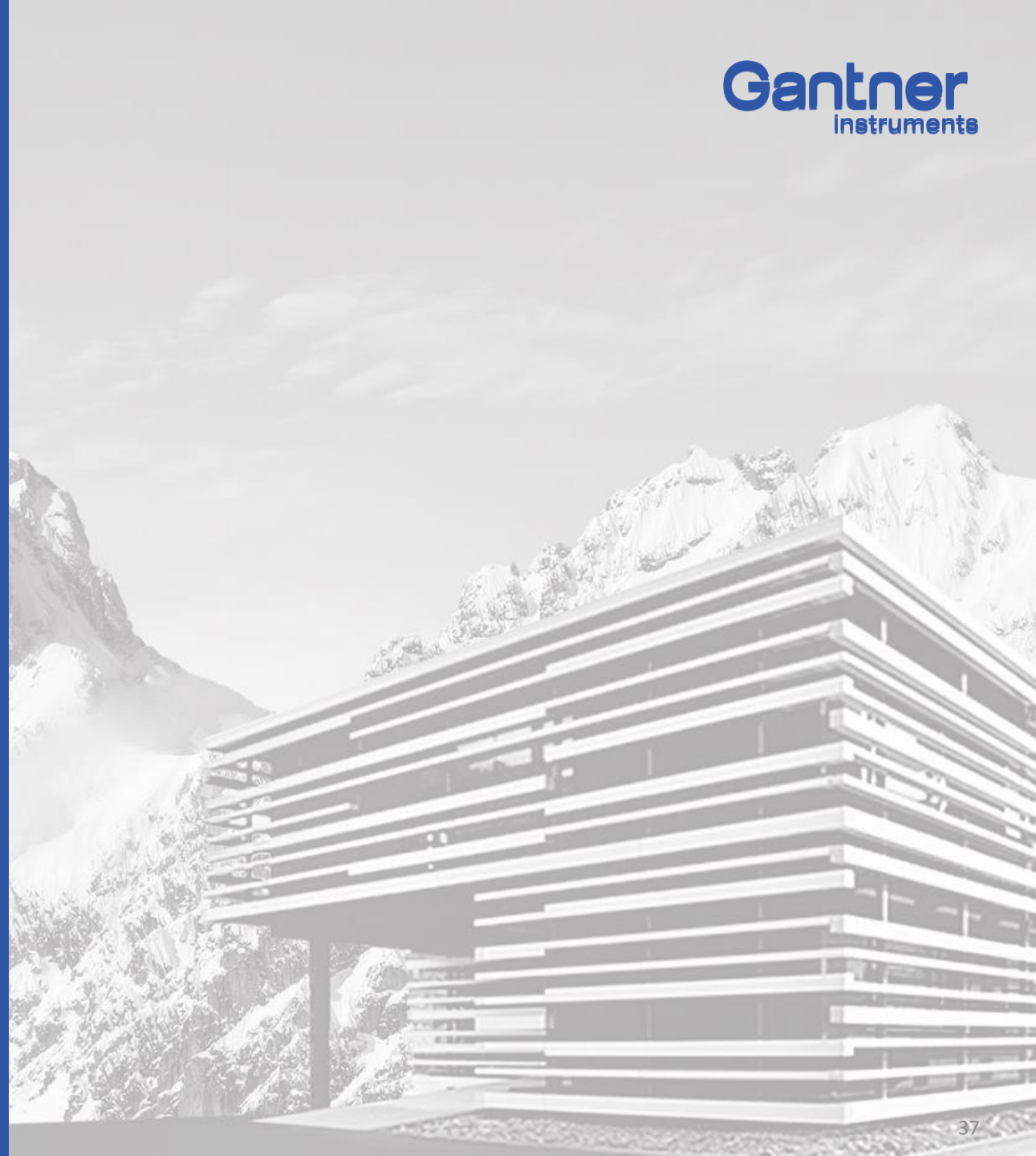
	Process signals	Vibration signals	Voltage and current signals
Monitoring parameters (online extracted and monitored partly within the Q.Station)	• Speed, • Power, • Mass flow, • Pressure, • Temperature,	• RMS: Overall, LF, ISO, HF (energy) • Peak: Peak-to-peak, Max-Min (amplitude) • Crest: Peak/RMS (impacting) • Kurtosis (peakiness) • Smax (max displacement) • Harmonics (1X, 2X, NX) • Speed / Keyphasor (Position, angle)	• Effective voltage Ueff • Effective current Ieff • Impedance Z • Effective power Peff • Reactive power Seff • Power factor Cosphi • Total effective power • Mechanical power • Torque • Motor load • Voltage deviation • Voltage asymmetry
Diagnostic parameters (offline extracted as diagnostic features within GI.bench / GI.cloud)	• Operating mode or load condition	• Order Tracking • Torsional Vibration • Stiffness analysis	• Supply frequency • Synchronous frequency • Slip frequency • Pole pass frequency • Slot pass frequency • Static eccentricity • Dynamic eccentricity • Stator mechanical damage • Rotor defect

Vibration Monitoring Essentials
Selection of Data Evaluation Functions

Gantner Instruments point of view on Vibration Monitoring

- Objective is a robust and industrialized DAQ (data Acquisition) hardware and a sufficient package on data evaluation capabilities for trend monitoring, alarm indication and raw data storage for detailed data analysis.
- We do not provide a software suite with hundreds of analytic functions; we focus on the most essential ones taking into account the above-mentioned objectives.
- We provide an online operating data evaluation package working on the DAQ controller and features for offline and online data evaluation in addition.
- We can customize I/O-Module Firmware and Software for Desktop and Cloud in case special evaluation functions are missing
- We do not charge high prices for software license and annual fees; we provide a working platform paid once only.
- It is still an engineering system with sometimes less comfort in configuration but provides the full flexibility for the experienced user. As a service we provide system setup as well as turnkey design of monitoring systems.

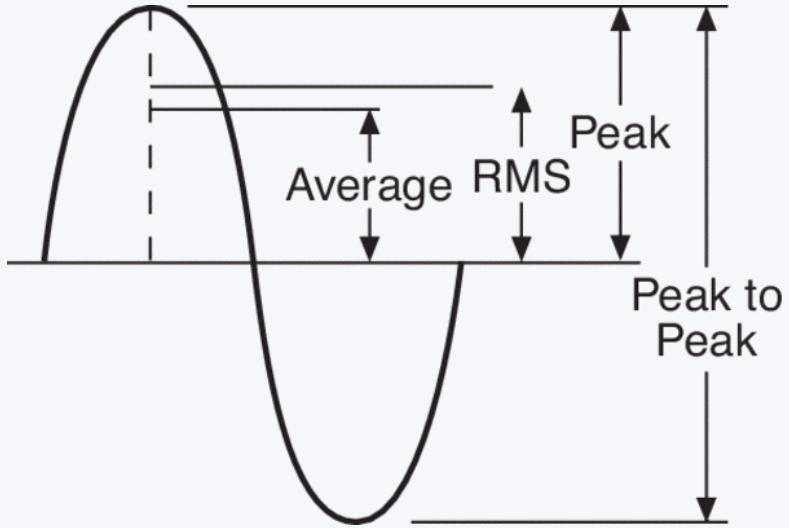
Vibration Parameter

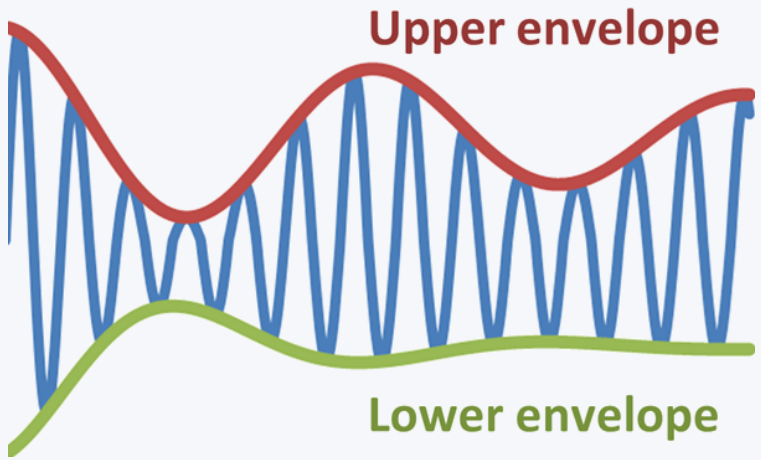


Vibration Parameters

- Statistics in Time Domain
  - RMS (arithmetic function *TrueRMS*),
  - [Peak or Envelope upper/lower (aritmethic function *Min*, *Max*)],
  - Peak-to-Peak (p-p) or Envelope (arithmetic function *Max-Min*),
  - Envelope (test.con function envelope)
  - Average (Avg) (arithmetic function *Averaging*)
  - Crest as and indicator for impacting (crest= peak/rms)
  - Kurtosis as an indicator for peakiness (arithmetic function *Statistics, Type 4*)

- These parameters can be calculated based on
  - the acceleration signal in g or m/s^2
  - the vibration velocity signal in mm/s (derived on integration of the raw acceleration signal)





Vibration Parameters

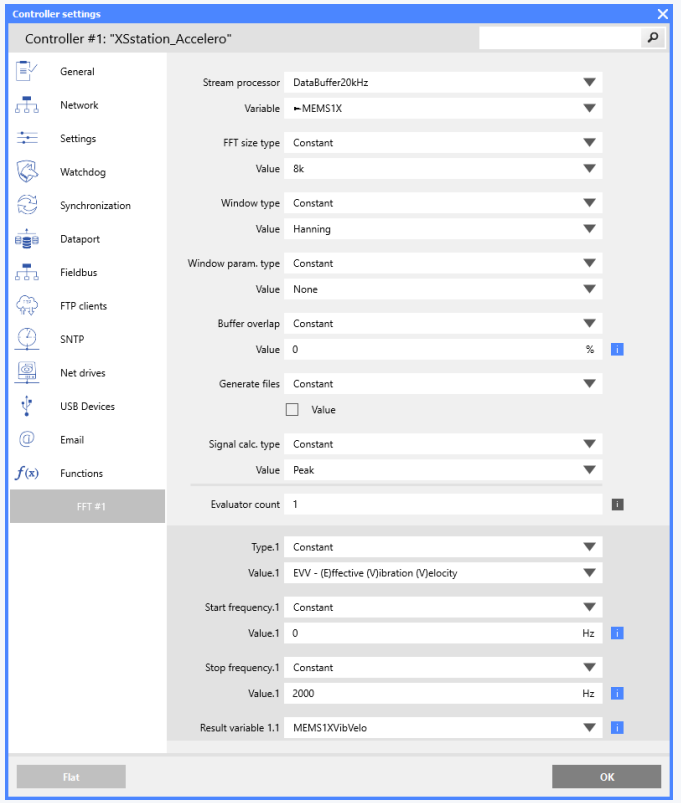
- In Frequency Domain

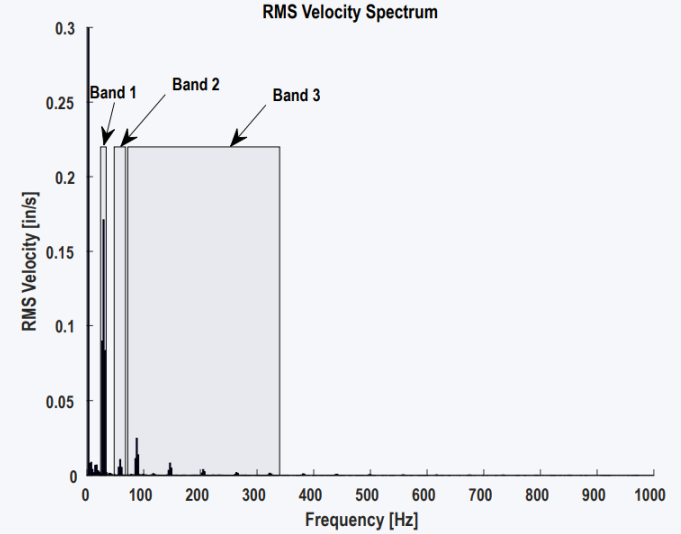
- On Q.station with *FFTProcessor* and *FFTEvaluator*

  Note: we calculate the spectrum based on peak or peak-to-peak, rms not yet available)

  - RMS (overall single value for the selected spectrum)
  - Max Amplitude@Frequency
  - Vibration velocity (overall)
  - Vibration displacement (overall)

- In Wide band FFT or Spectral Bands
  - For each spectral band analysis the FFT Evaluator must be configured





Vibration Parameters

- In Frequency Domain

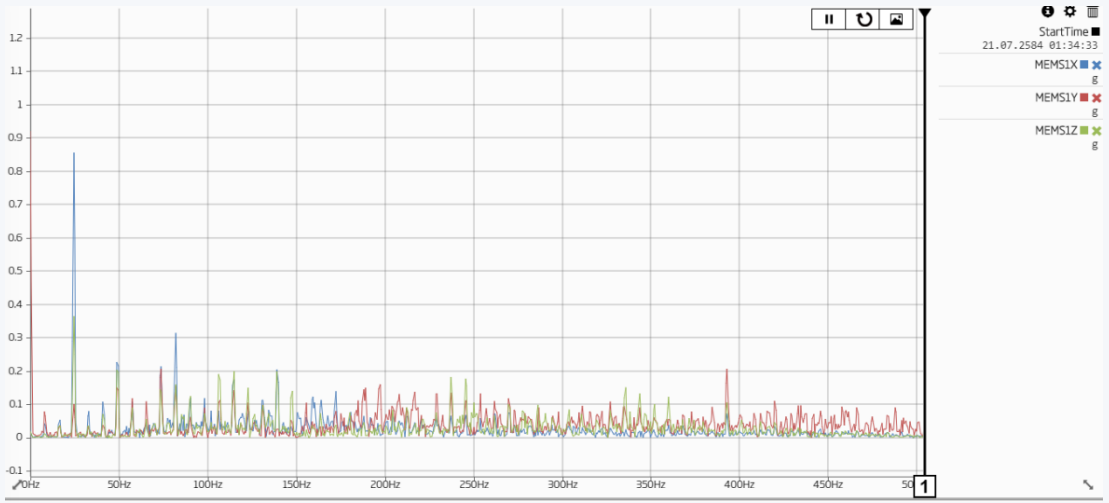
- On GI.bench for visualization by *FFTChart*
  - Raw acceleration [g]
  - Vibration Velocity (raw accelerations signal in [m/s²] integrated and filtered in enhanced stream)
  - Vibration Displacement (raw accelerations signal in [m/s²] double integrated and filtered in enhanced stream)

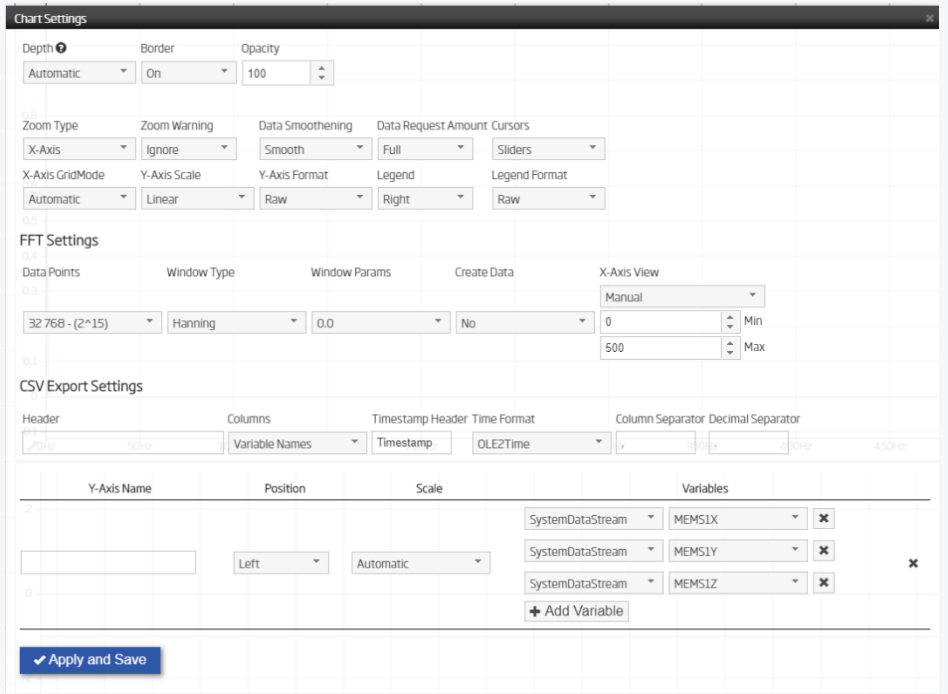
  NOTE:

  - it is an autopower spectral plot and NOT a spectrum as we do not have any phase information.

  - We do not have a Power Spectral Density (PSD) plot.

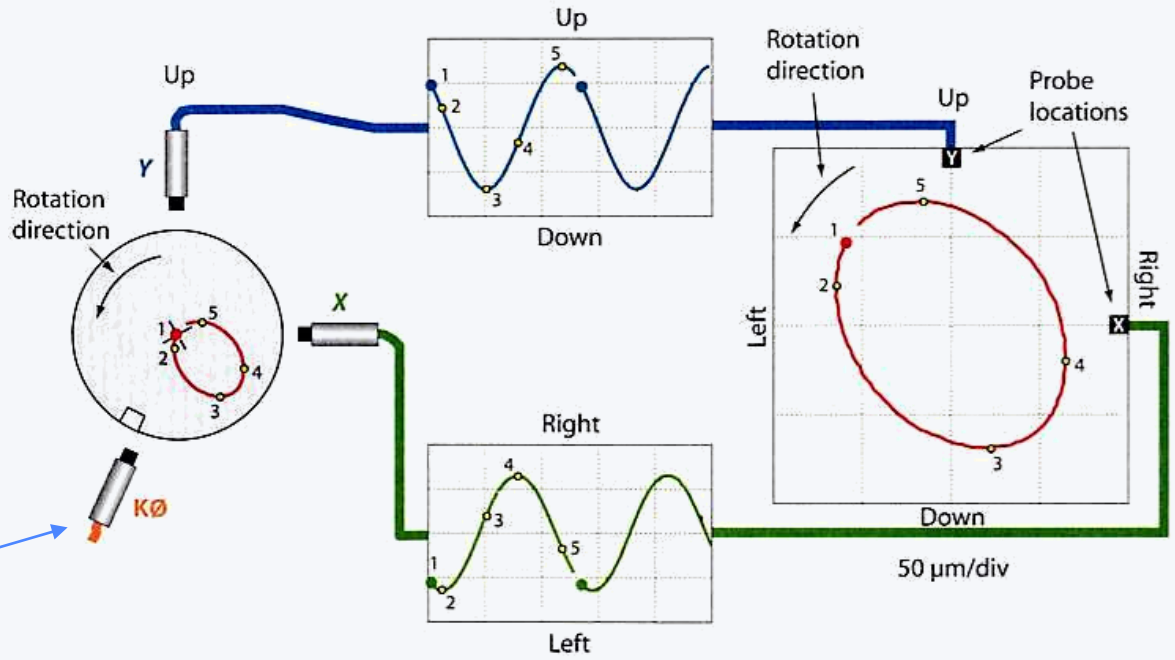
- In Wide band FFT or Spectral Bands
  - For each spectral band analysis a new FFT Chart can be used with a x-axis scaling according to the band spectra

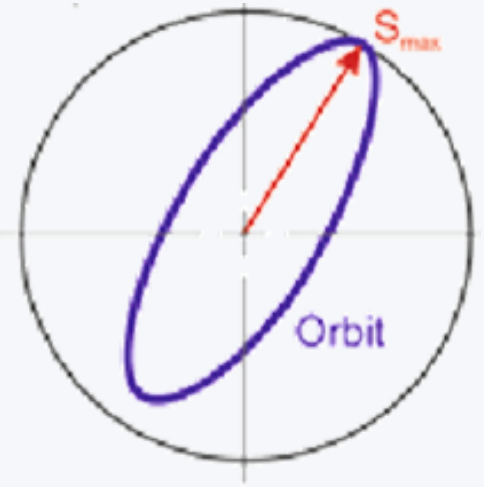




Vibration Paramters

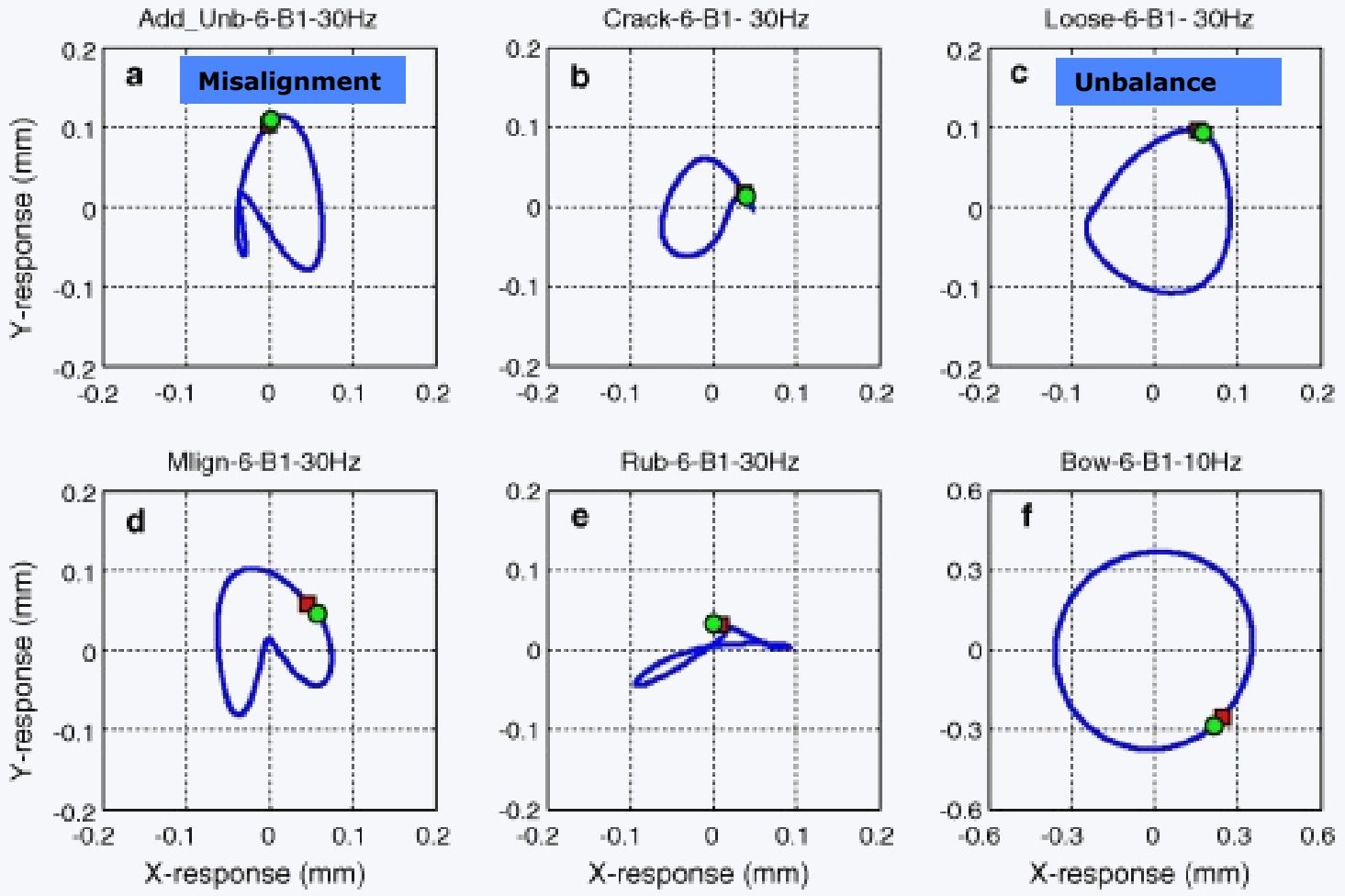
- Smax for plain bearings
- Measured by two (or more) proximity probes at a 90 degree angle to each other
- Plotted on a XY-chart it shows the orbit
- The Smax value is the maximum displacement (peak) of the shaft in the bearing and is calculate by vector multiplication of two or more sensor signals
- Information: The Keyphasor (brand name of GE Bentley Nevada) signal is a once-per-turn voltage pulse provided by a transducer (normally an eddy current proximity measurement system).





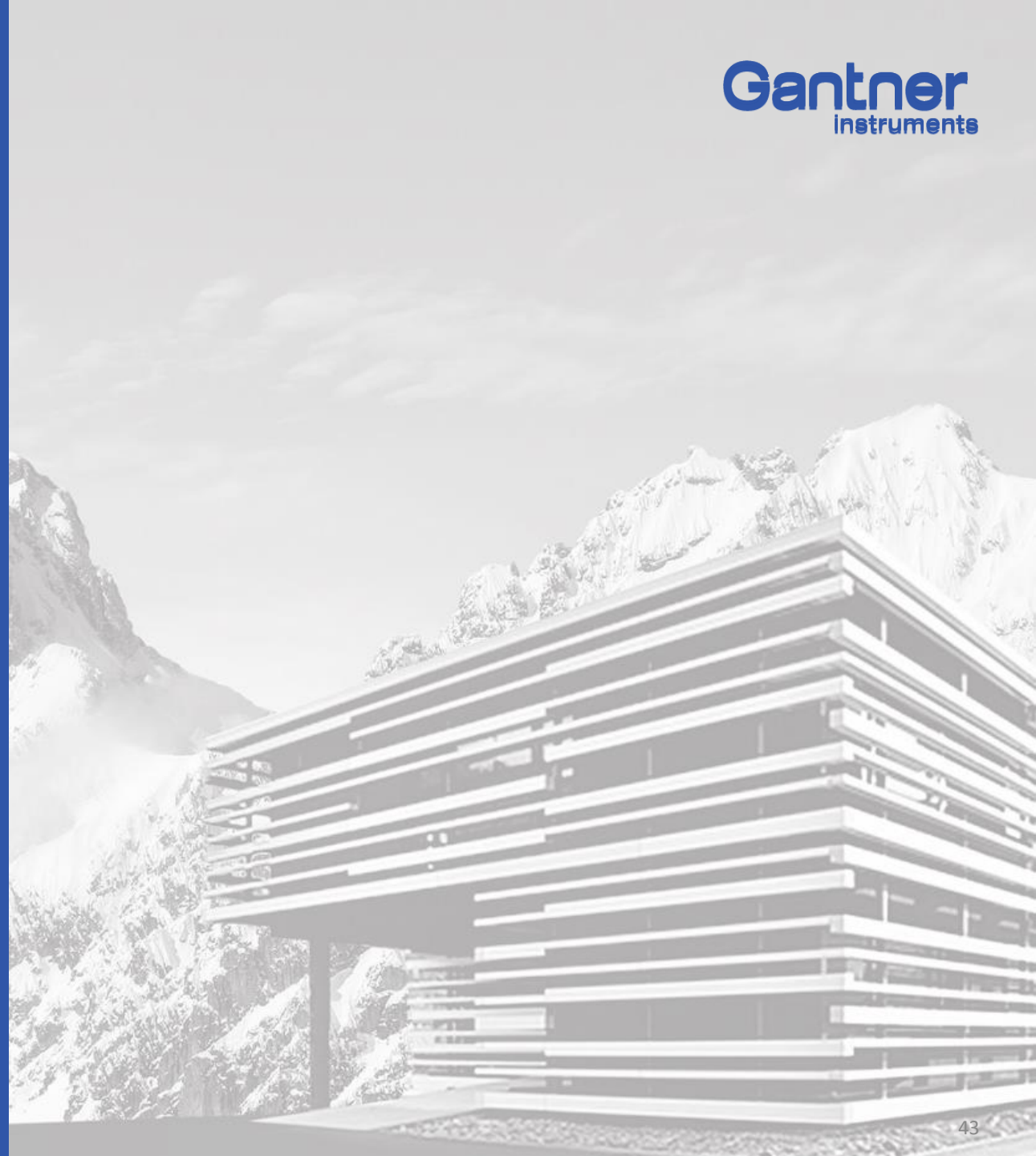
Vibration Paramters

- Smax for plain bearings
- Examples of different orbits



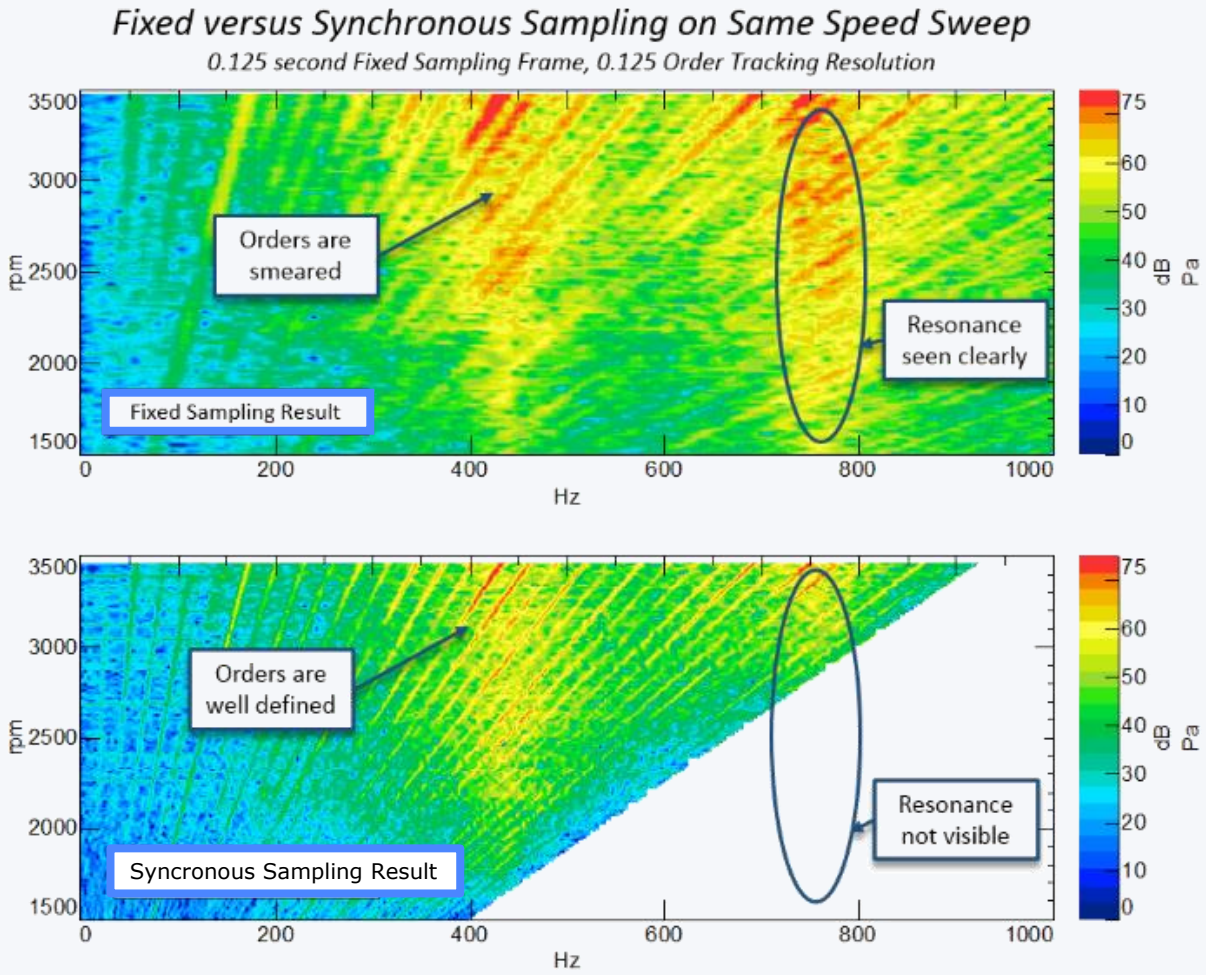
Order Tracking

Coming Soon



Order Tracking

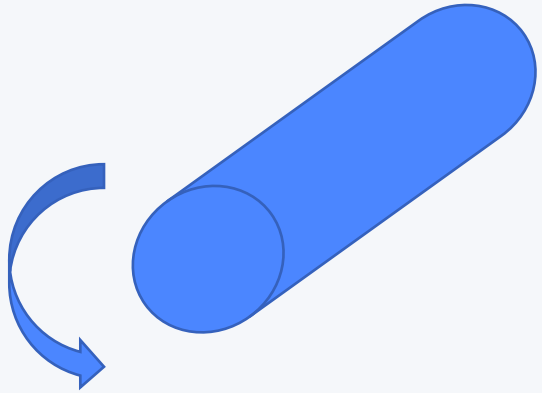
- Order Tracking / Order Analysis / Tracking Filter: technique for analyzing vibration signals in rotating machinery (pumps, turbines, compressors). These machines have several parts parts each of which contributes unique vibration patterns to those of the whole machine. With order analysis these patterns can be visualized to identify individual parts.
- In general possible with two methods:
  - Fixed sampling (fixed data rate e.g. 10kHz)
  - Syncronous sampling (data rate proportional to speed)
- With the X-series we use fixed sampling with the advantage that resonances can be seen clearly e.g. in a heatmap.
- Important:
  - the Fourier Transform requires a fixed time frame of data. During the fixed time frame, the speed of the rotating system changes. As the speed changes, the frequency of the order content also changes. This is referred as “smearing” effect or “leakage”.
  - That can be avoided when sampling rate is high enough and number of bins small in relation to the required resolution



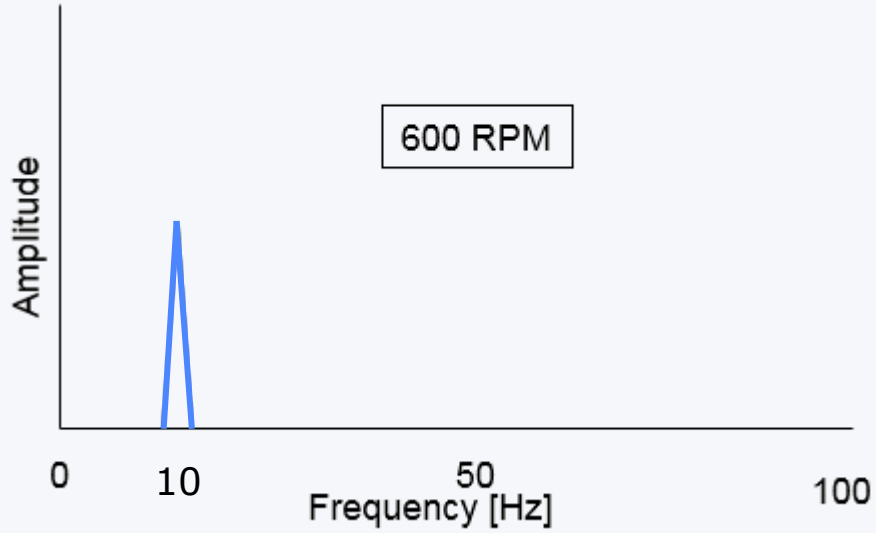
Order Tracking

What is an order?

- This shaft spins with 600 rpm



- 600 rpm = 10 rotation per second = 10Hz
- The frequency of the rotation is 10 Hz



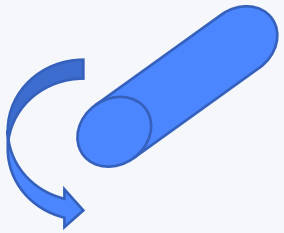
Order Tracking

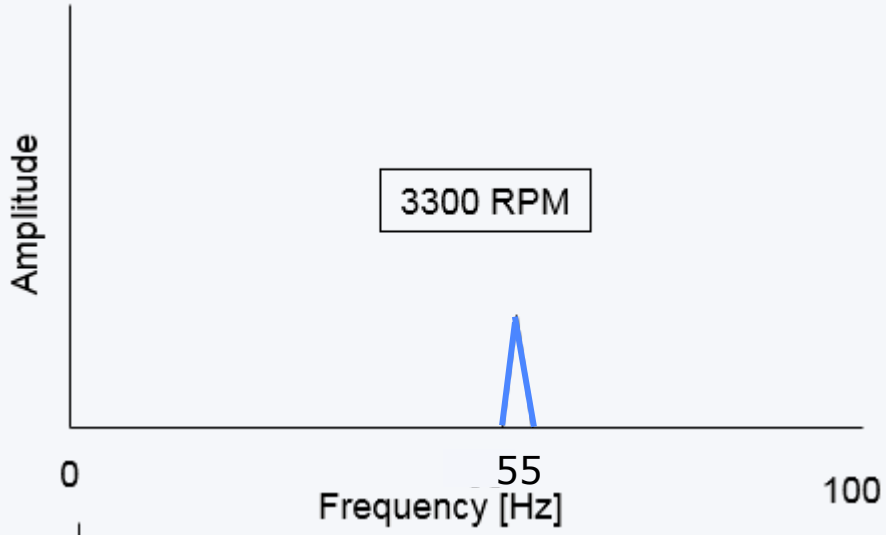
What is an order?

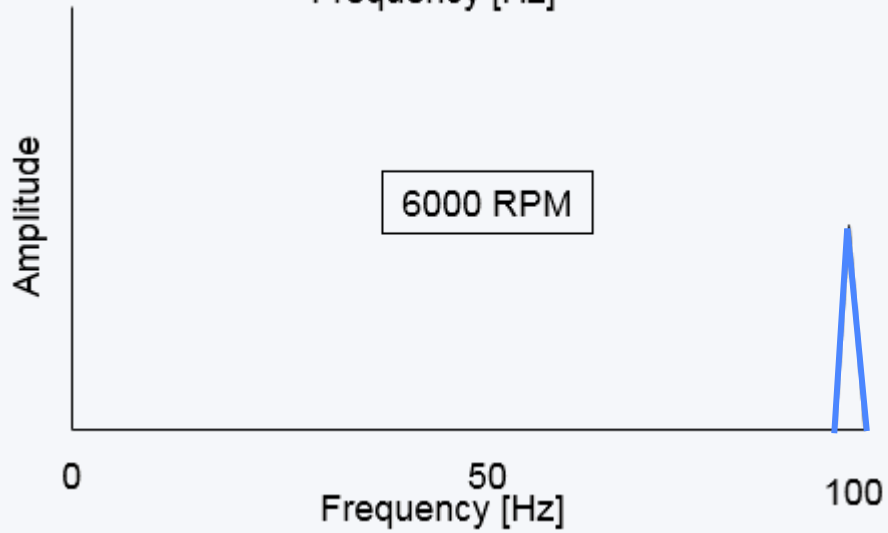
- This shaft is now inthe run-up

  - 3300 rpm = 55 rotation per second = 55Hz
  - The frequency of the rotation is 55 Hz

  - 6000 rpm = 100 rotation per second = 100Hz
  - The frequency of the rotation is 100 Hz





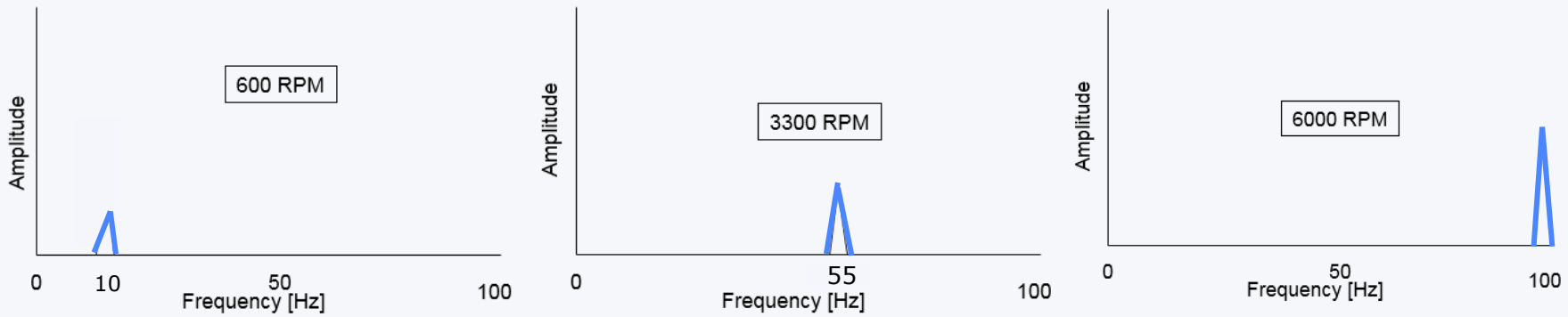


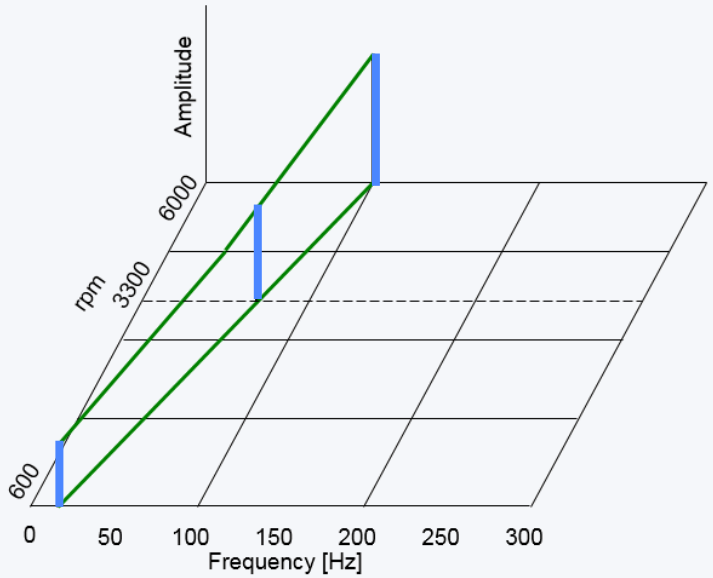
Order Tracking

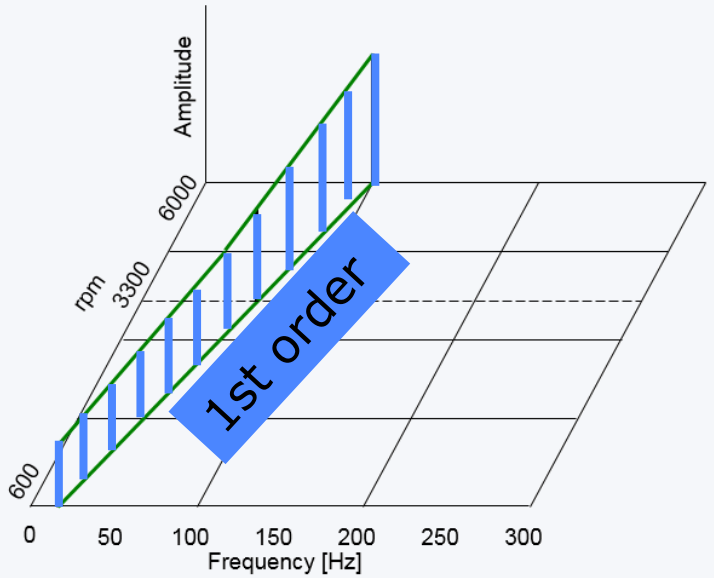
What is an order?

- Plot the three measurements in a 3D chart Amplitude vs. Frequency vs. RPM
- This is the order data over three points for the shaft

- If amplitudes are tracked at small rpm increments along the sweep we call it 1st order

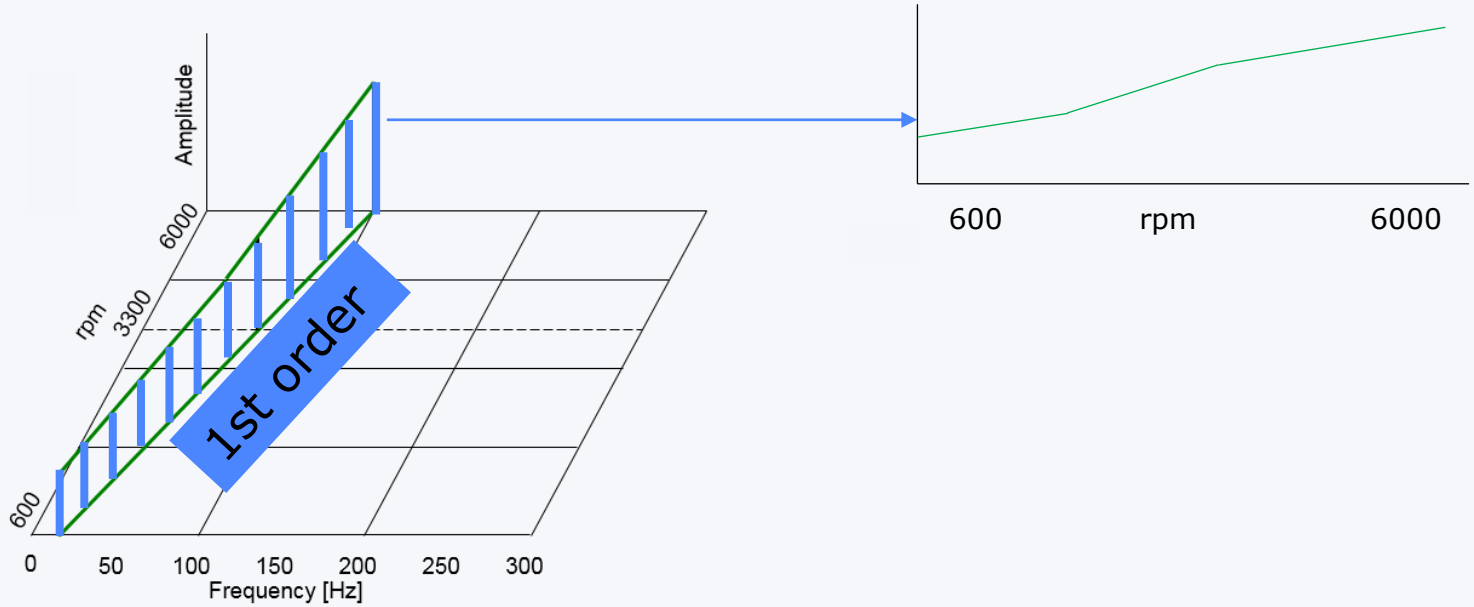






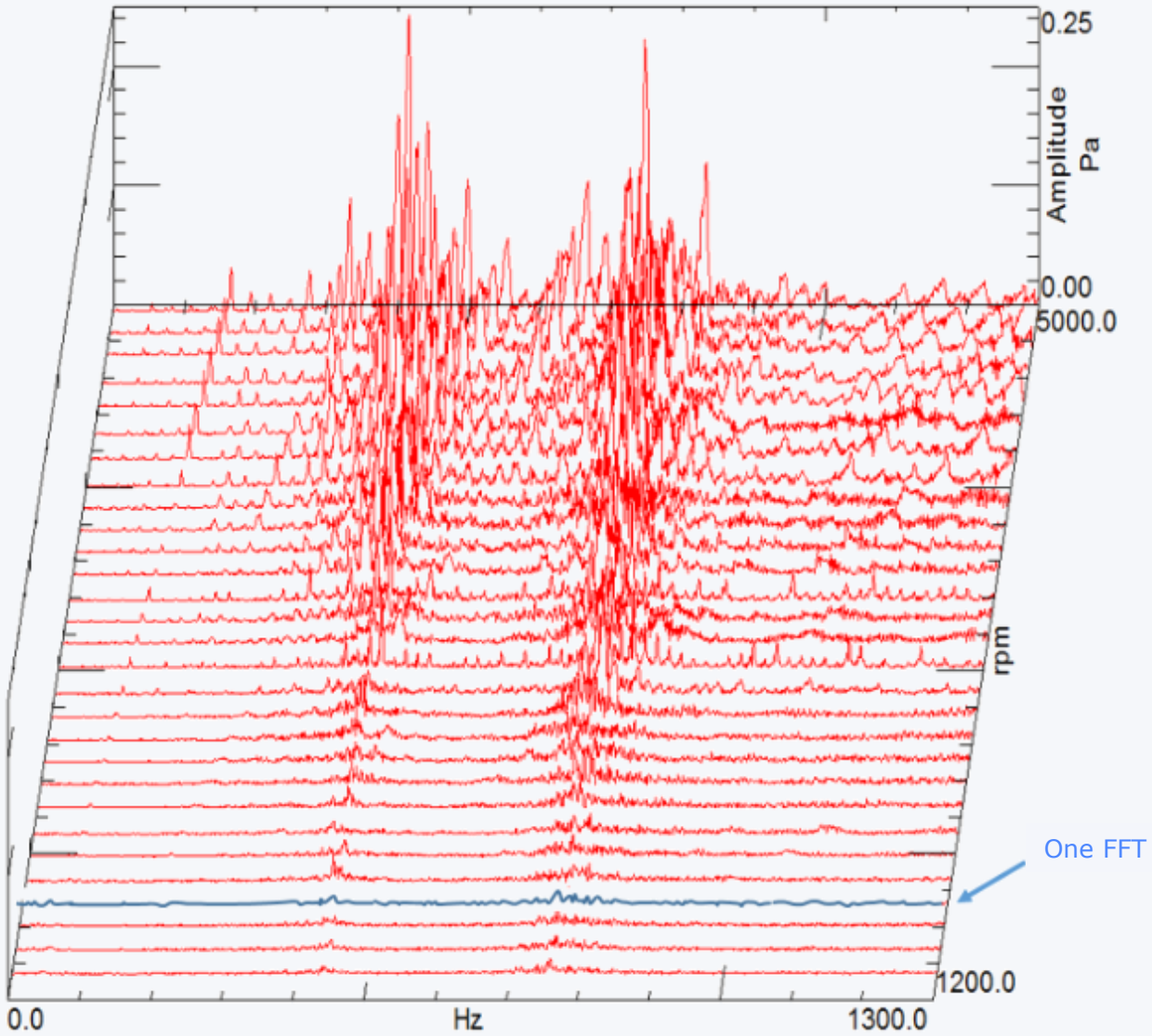
Order Tracking

- Order Cut
  - Visualization of the amplitudes from one order in a 2D Chart



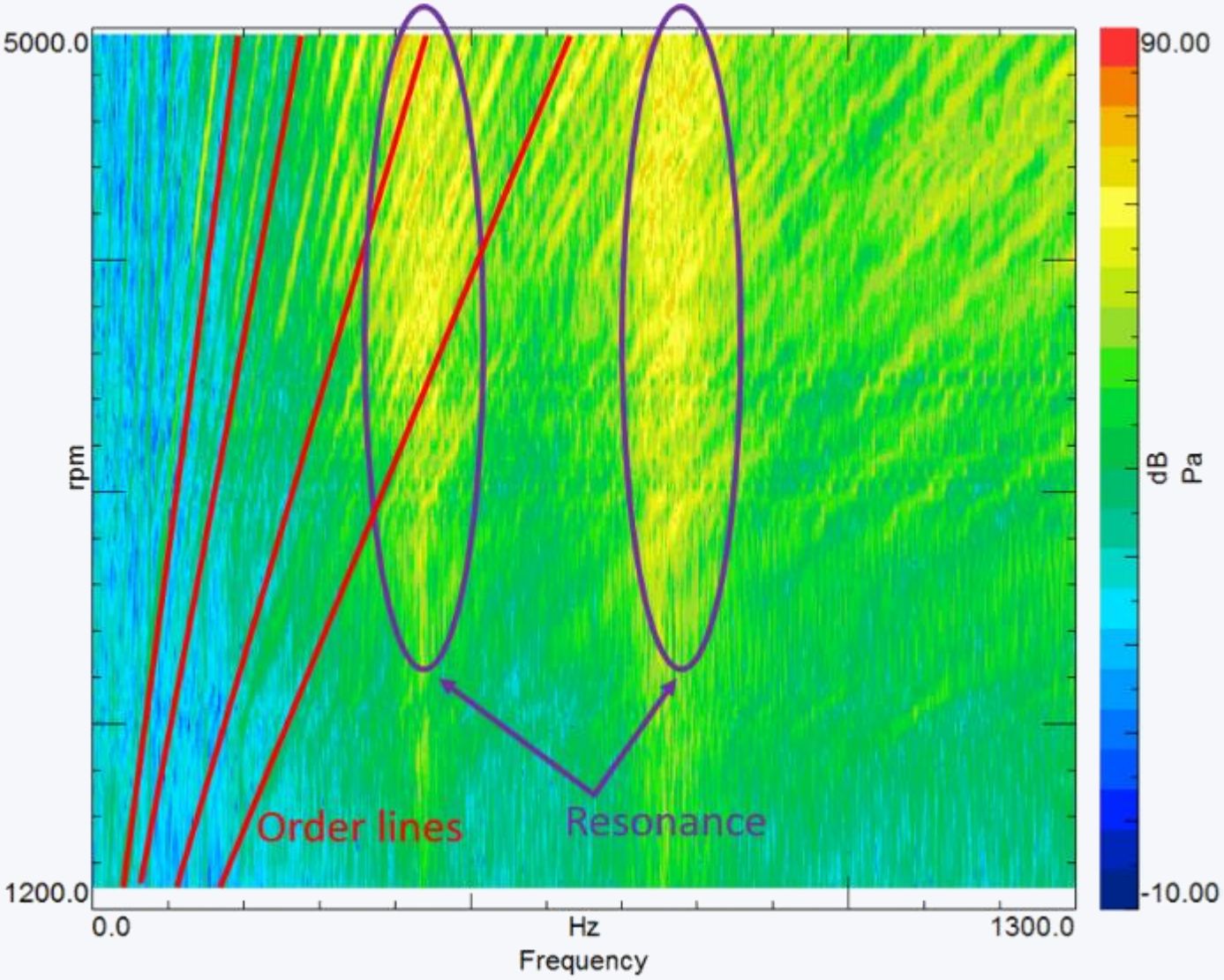
Order Tracking

- Commonly used display for order analysis
  - 3D Chart / Waterfall Plot
  - Each one of the lines along the frequency axis is an individual FFT that was taken at a specific RPM increment. Stacked together they create the waterfall graph



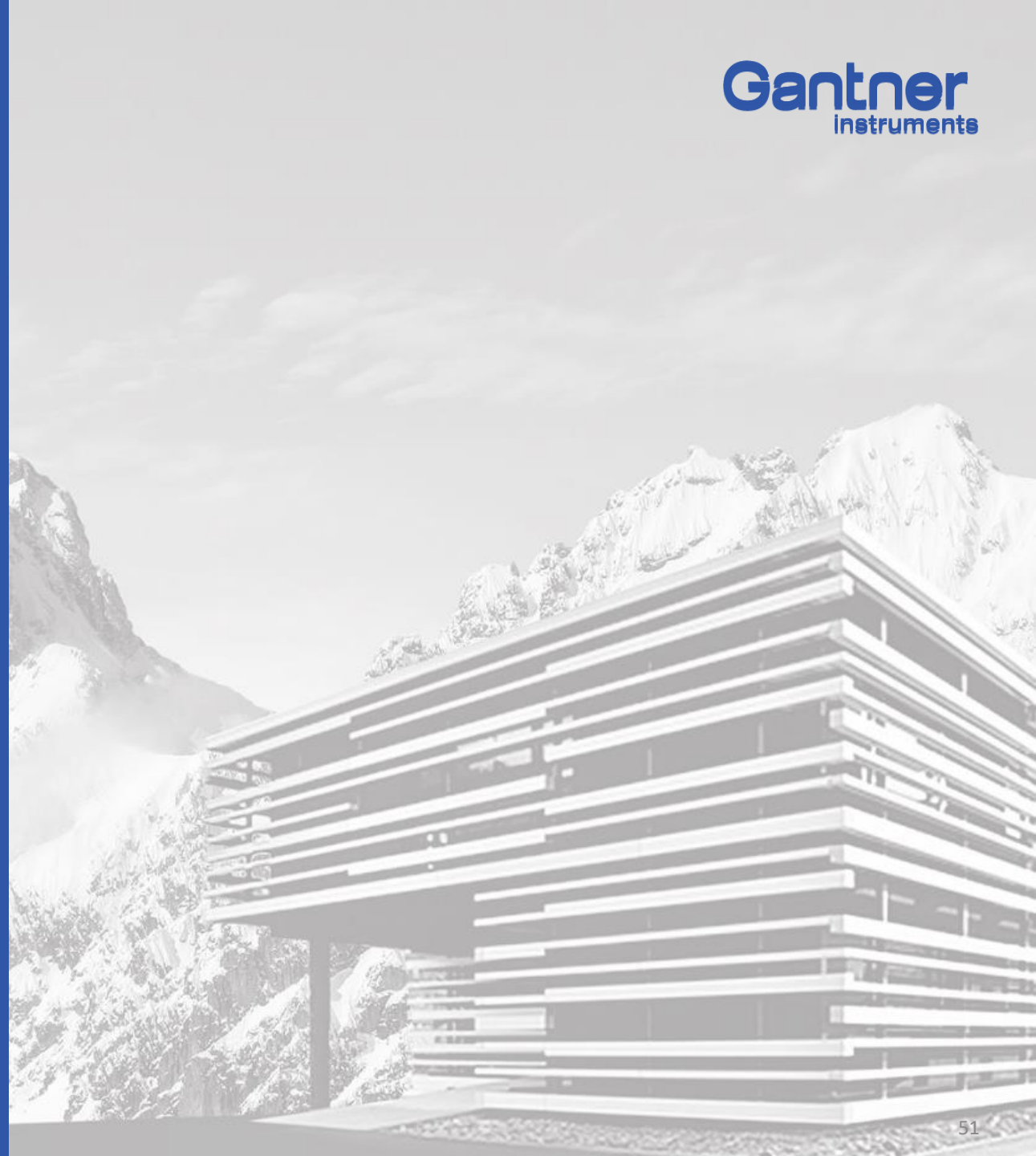
Order Tracking

- Commonly used display for order analysis
  - Heatmap/ Color Map
  - The amplitude is represented by the color intensity. The darker/cooler colors are lower amplitude while the warmer/brighter colors are higher amplitude.
  - Key things to identify on the colormap/waterfall include resonant frequencies and order lines. The order lines are the diagonal lines coming from the origin on the map. The resonant frequencies are the high amplitude lines that extend vertically from the frequency axis.



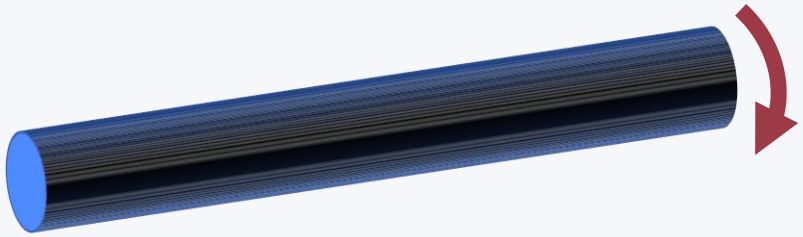
Torsional Vibration

Coming Soon

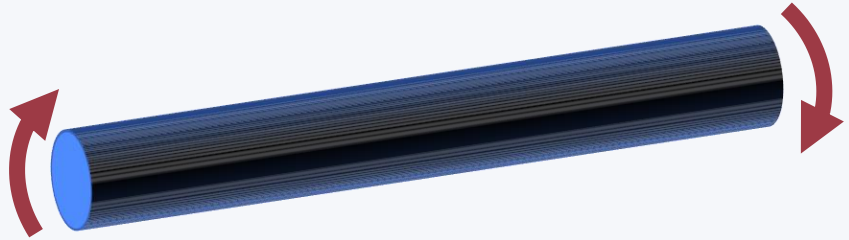


Torsional Vibration

- We distinguish between two types:
- Rotational Vibration
  - Fluctuation in rotational velocity (Difference in angular velocity) during one turn or during run-up and coast down measured with **one** tacho sensor or encoder on a toothed wheel.



- Torsional Vibration also known as torsional twist or twist angle, twist rpm
  - Oscillation of angular motions. The rotating shaft rotates on different phase or angular position on both ends. The result is a mechanical torsion of the shaft. With **two** encoders the angular difference on both sides of the shaft is measured.



Torsional Vibration

- We distinguish between two types:
- Rotational Vibration
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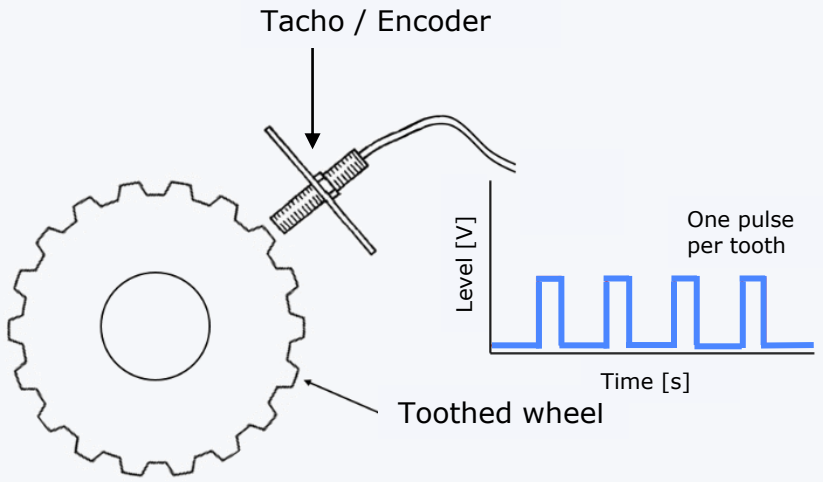
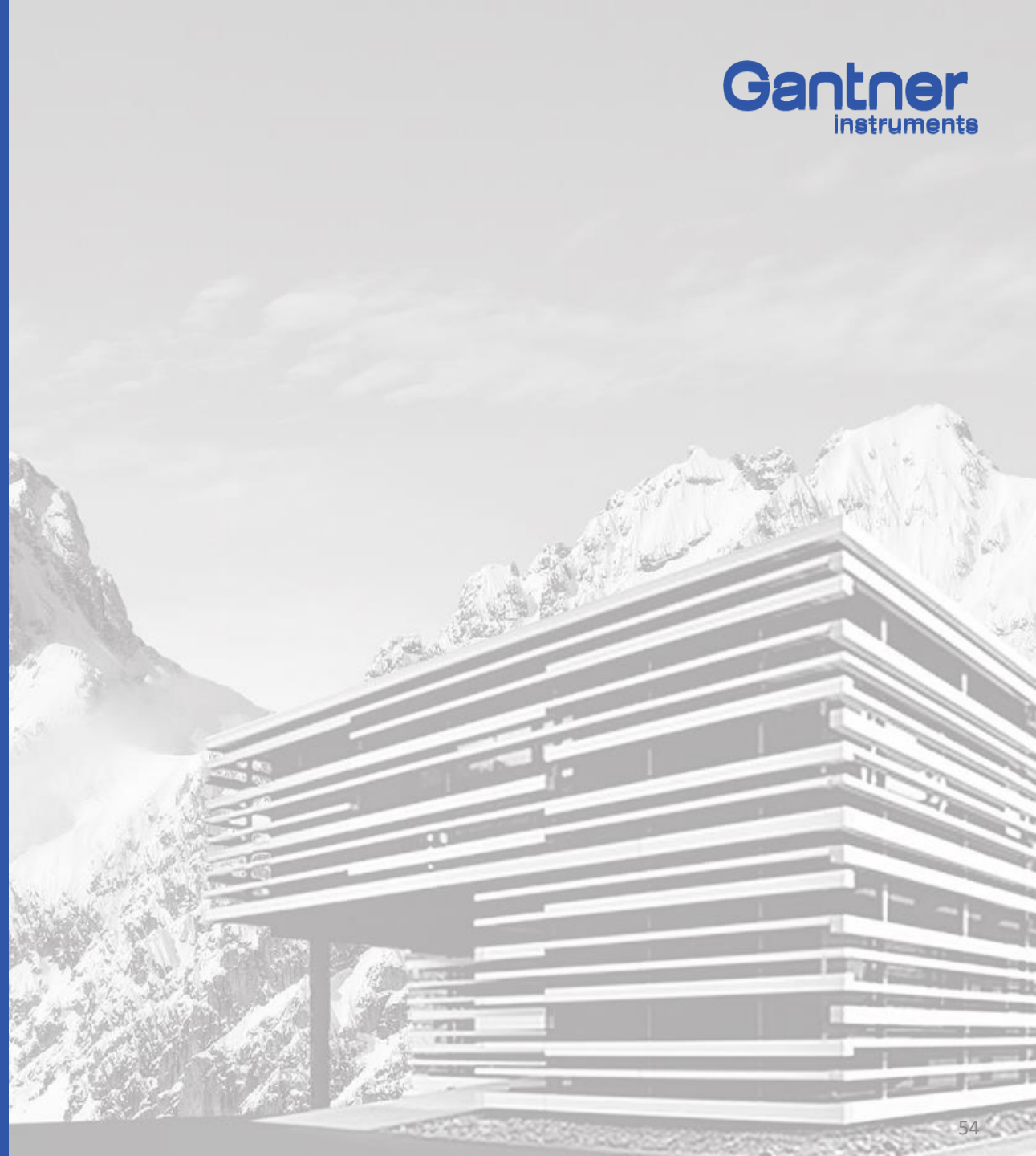


- The tacho / encoder generates a signal for each passed teeth. The time difference between the pulses is the angular velocity

Configuration Guide for GI.bench

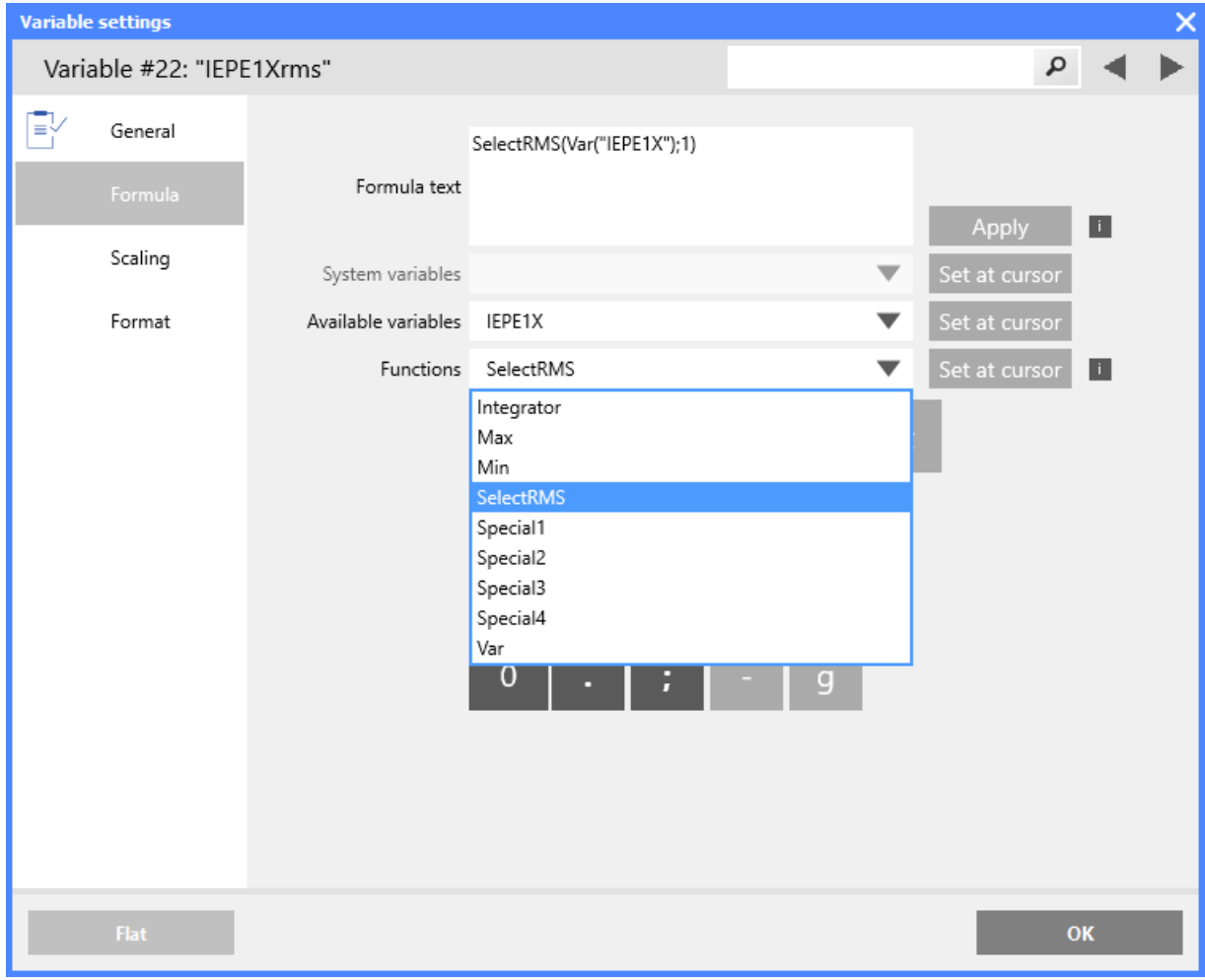


Configuration with GI.bench

Statistics in time domain – **rms**

- **On I/O Module as arithmetic variable**
  - Formula ? Select RMS value (Value; Timebase [s])
  - Value = Input channel on module
  - Timebase = calculation rate of rms

    Example: A111 with 100kHz per channel sampling rate use 100,000 samples for rms calculation if timebase 1 second is used. The calculated rms value is actualized every second in this example.
  - NOTE: This arithmetic variable needs to be transferred over the UART to the Q.station. In case there is no cycle time on the UART available to transfer the additional arithmetic variable. Use rms arithmetic on virtual variable on Q.station.



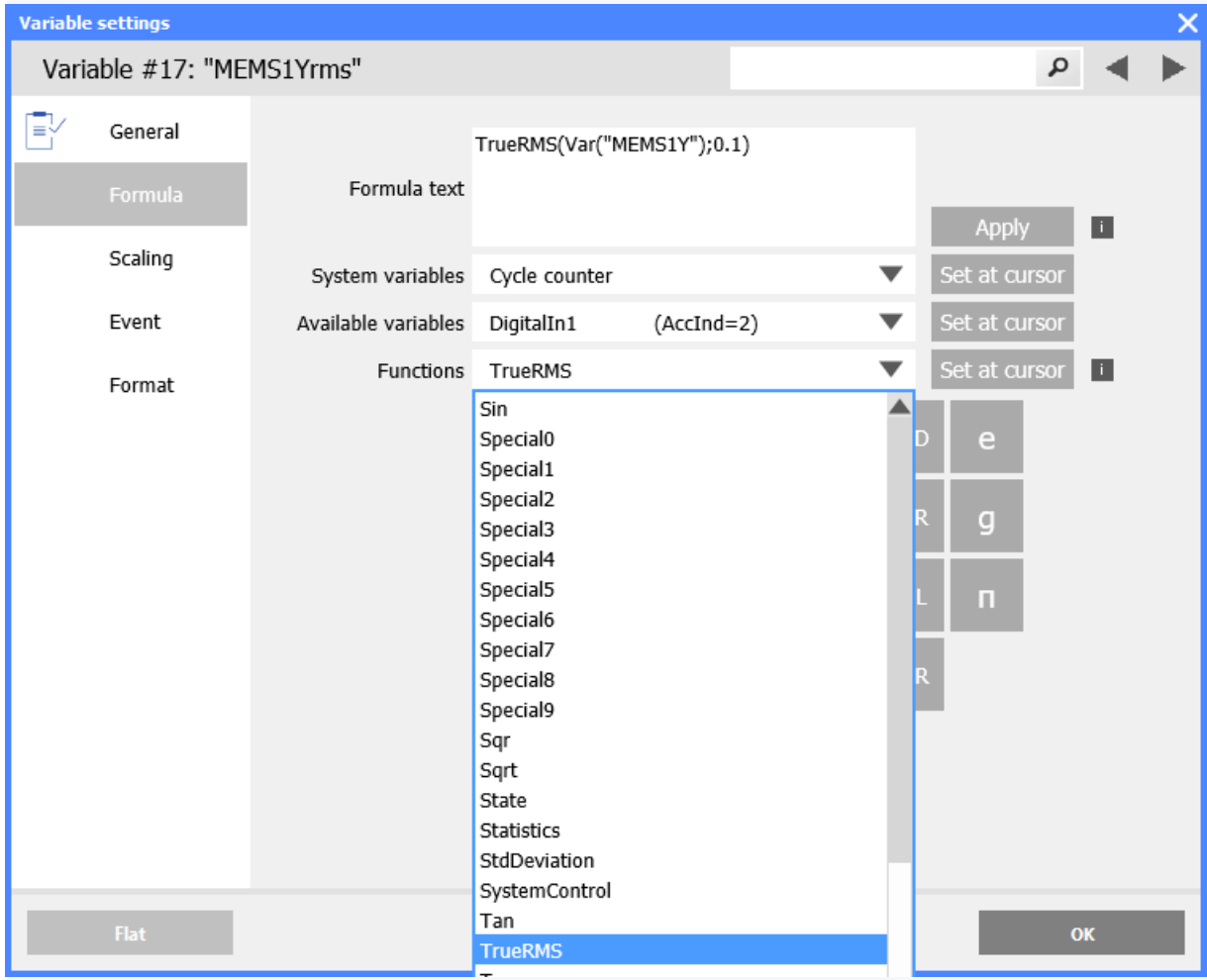
Configuration with GI.bench

Statistics in time domain – **rms**

- **On Q.station as arithmetic variable**
  - Formula

```
True RMS value (Value[; Type;] AddParam)
        Value
        Type:
                [if not present]
                        AddParam = TimeConstTau [s]
                0 ... Lowpass
                        AddParam = TimeConstTau [s]
                1 ... Sliding
                        AddParam = Count (1...9999)
                2 ... Arithmetic mean
                        AddParam = Count (1...9999)
```

  - Value = Input channel on module
  - Type = select type of rms calculation 0 and [if not present] is equal
  - TimeConstTau = time constant for lowpass filter
    - Calculation of rms
      - Factor=TimeConstTau / CPU Calculation Time
      - Rms=sqrt(NewValue x NewValue + CollectedValue x (Factor-1)) / Factor



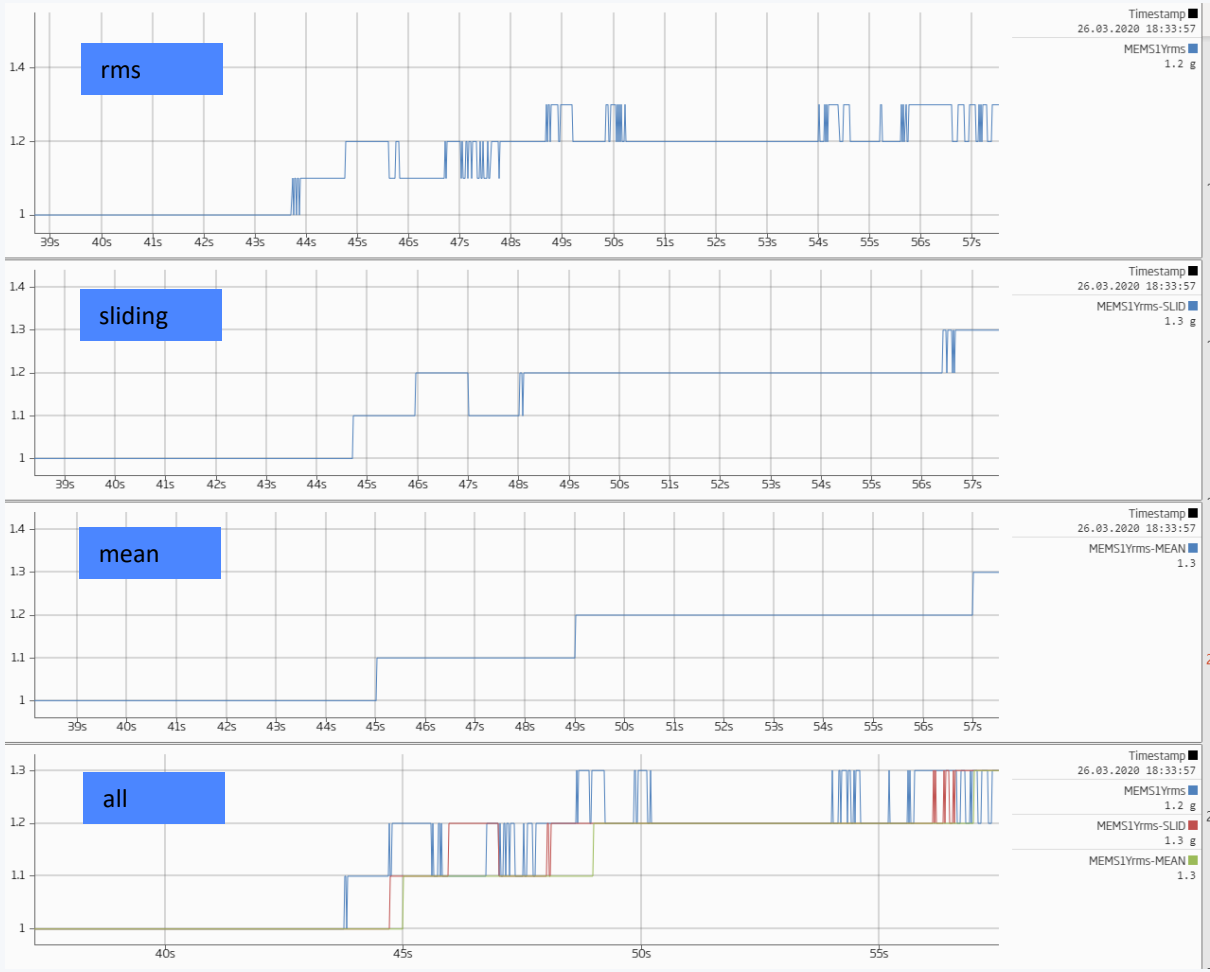
Configuration with GI.bench

Statistics in time domain – **rms**

- **On Q.station as arithmetic variable**
  - Formula

```
? True RMS value (Value[; Type;] AddParam)
        Value
        Type:
                [if not present]
                        AddParam = TimeConstTau [s]
                0 ... Lowpass
                        AddParam = TimeConstTau [s]
                1 ... Sliding
                        AddParam = Count (1...9999)
                2 ... Arithmetic mean
                        AddParam = Count (1...9999)
```

  - Differences between Types

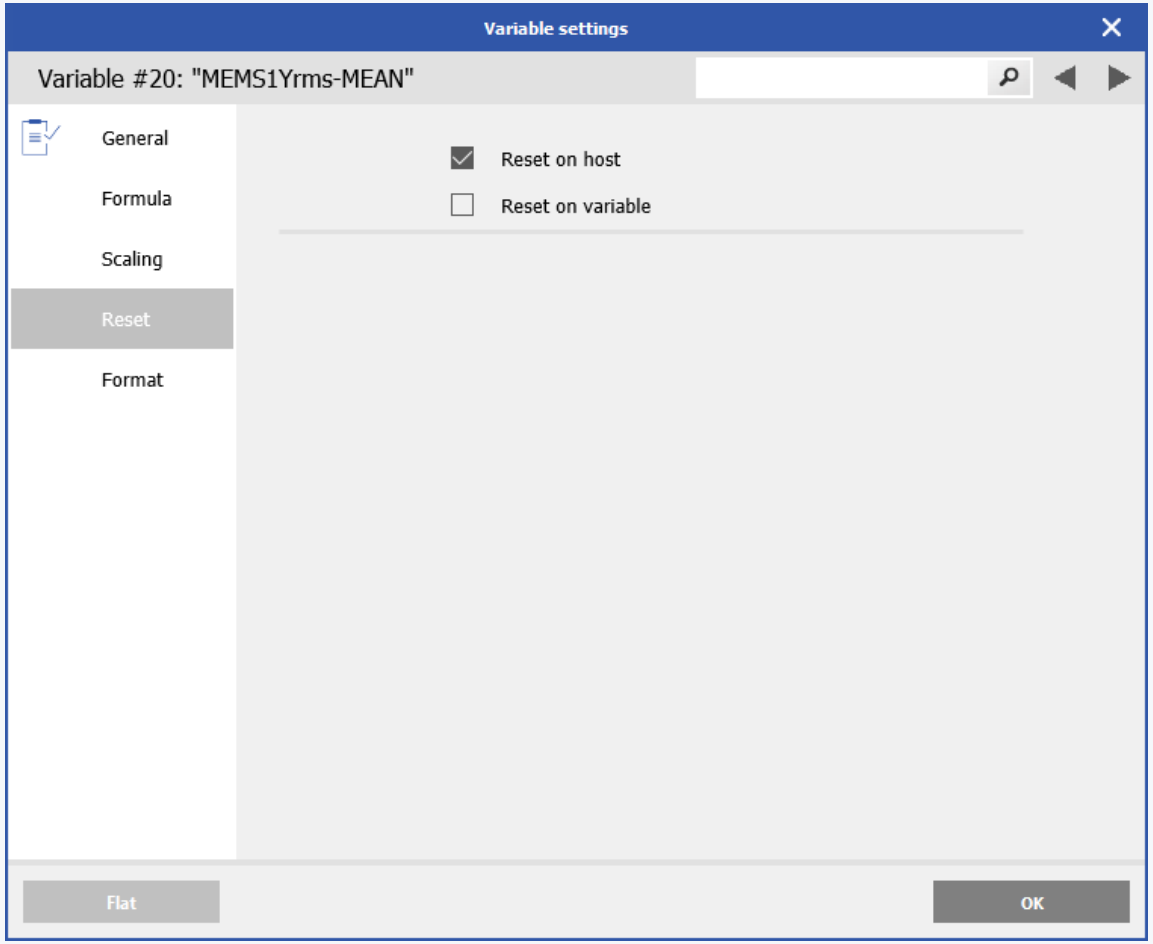


Configuration with GI.bench

Statistics in time domain – **peak / envelope, Average**

- **On Q.station as arithmetic variable**
  - Formula `? Max. hold value (Value)`
  - Value = Input channel on module
  - Needs reset function, otherwise it is peak hold forever
  - Select Reset on host or on variable.
    - On host: reset is performed with the CPU calculation rate. CPU Calculation rate 1 kHz, sampling rate 10 kHz means max value over 10 samples.
    - On variable: define any condition the reset the max hold e.g. by time in seconds, or on digital I/O.
  - Same applies for Min.
  - For peak-to-peak calculation use additional arithmetic function Max-Min
  - Formula

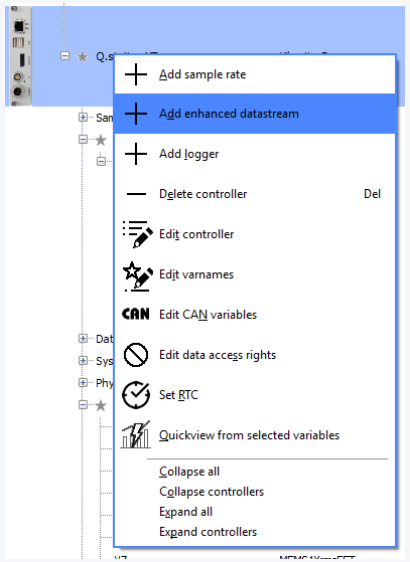
```
? Averaging value (Value; Type[; AddParam])
        Value
        Type:
                0 ... Lowpass
                        AddParam = -3dB edge frequency
                1 ... Sliding
                        AddParam = Buffer depth
                2 ... Event driven
                3 ... North step
                4 ... Arithmetic mean
                        AddParam = Weighting number
```

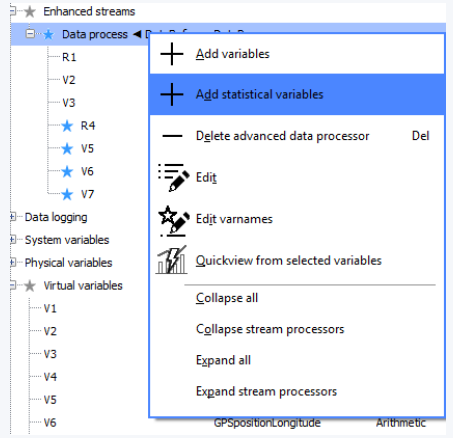


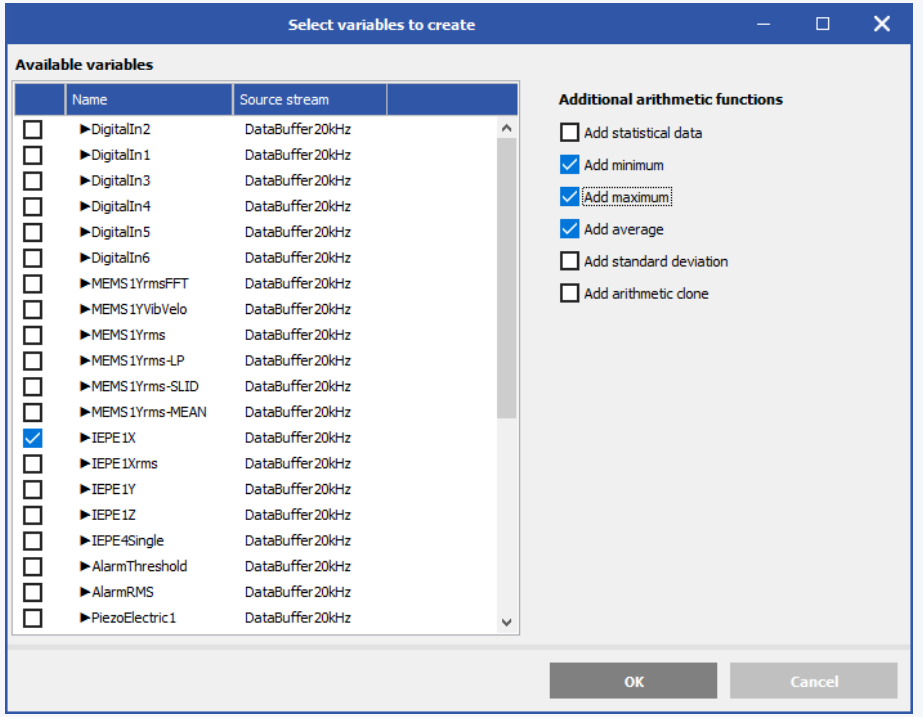
Configuration with GI.bench

Statistics in time domain – **peak / envelope, Average**

- **On Q.station or GI.bench Project level as enhanced stream**
  - Formula is generated automatically by the enhanced stream.
  - Right click on Controller and choose *Add enhanced data stream* and select databuffer and channels in the data processor settings. The stream will be generated.
  - Right click on the new stream and choose *Add statistical variable* and select the parameters to be calculated
  - For Envelope choose *minimum* and *maximum*



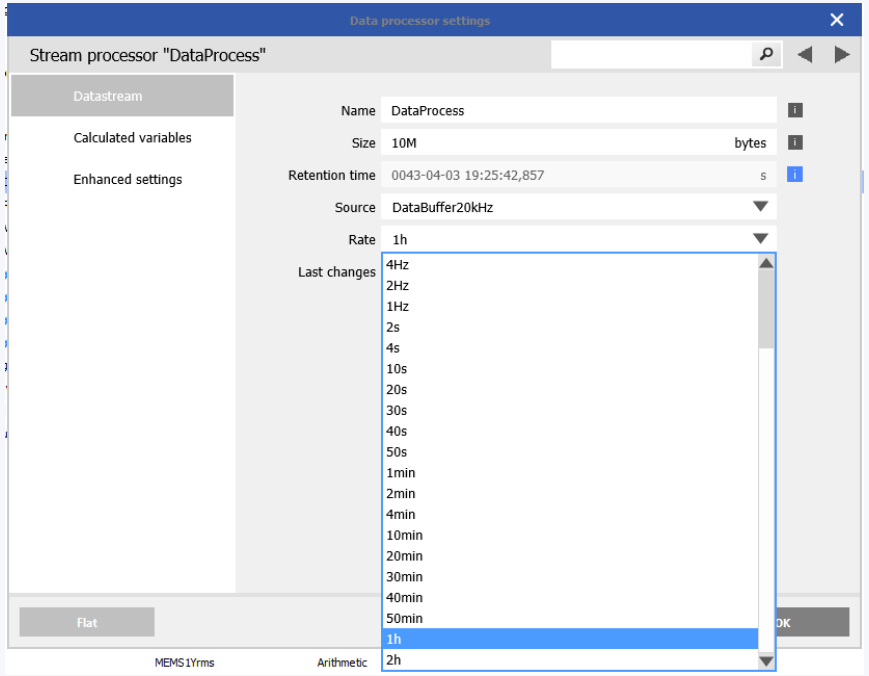




Configuration with GI.bench

Statistics in time domain – **peak / envelope, Average**

- **On Q.station or GI.bench Project level as enhanced stream**
  - The reset parameter is set automatically to *Reset on handling interval*.
  - For statistical application choose 1 min or 1h as *Rate*. That defines the handling interval.
  - The used number of samples for Max, Min or Avg is equal to the source rate. If the source is rate is 20 kHz and Rate is set to 1 Minute, then 20,000 samples/s x 60 s = 1,2 Mio Samples are used.
  - For visualizing the envelope choose a rate e.g. 100 times lower the source rate.



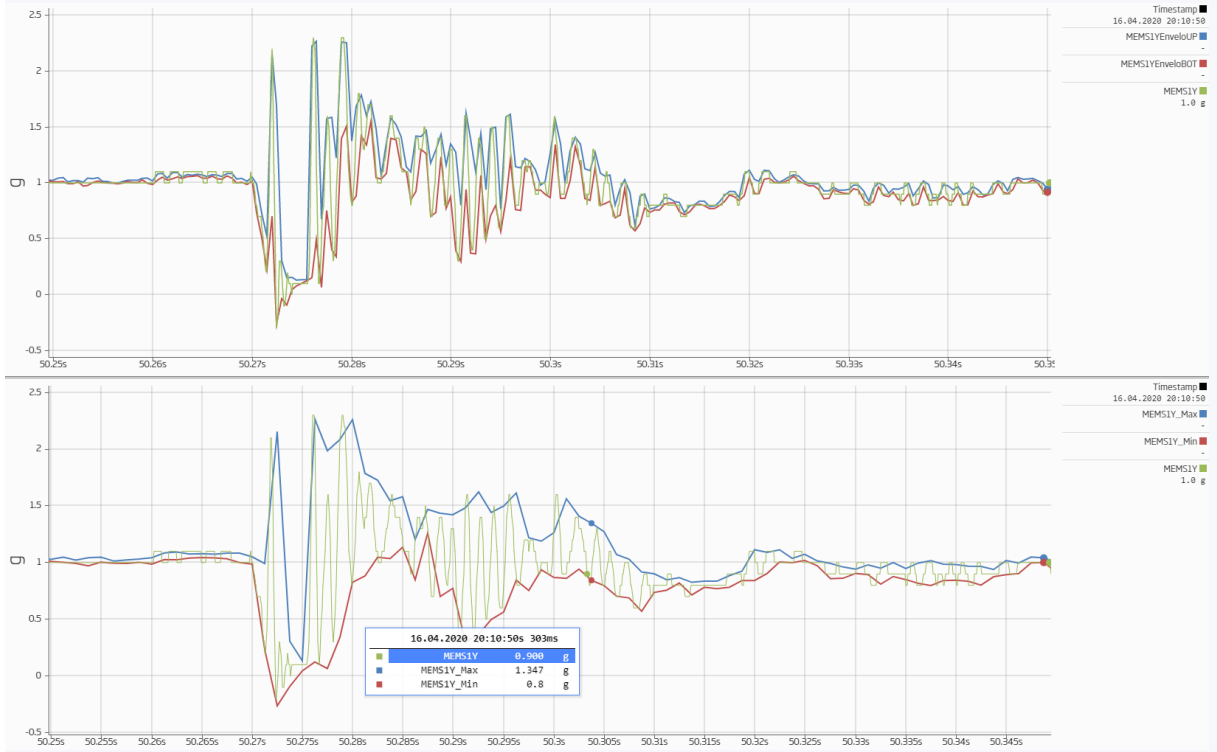
Tipp:
If the desired *Rate* is not available and you cannot change the source rate, use the *Prescaled source rate* parameter in the Enhanced settings. With this parameter the source rate is devided and more slower Rates become available. Keep in mind that the prescaler is not an averaging, it just choose every n sample, with n equal to prescaled source rate.

Configuration with GI.bench

Statistics in time domain – **peak / envelope, Average**

- **On Q.station or GI.bench Project level as enhanced stream**
  - For visualizing the envelope choose a rate e.g. 20-50 times lower the source rate.
  - The Yt-Chart on top shows the Envelope with 2kHz, the bottom Envelope (Min) is the red, the top Envelope (Max) is the blue curve and in light green is the raw signal sampled with 20 kHz
  - The Yt-Chart on the bottom shows the same values but the Envelope (Min/Max) is computed with 800 Hz only

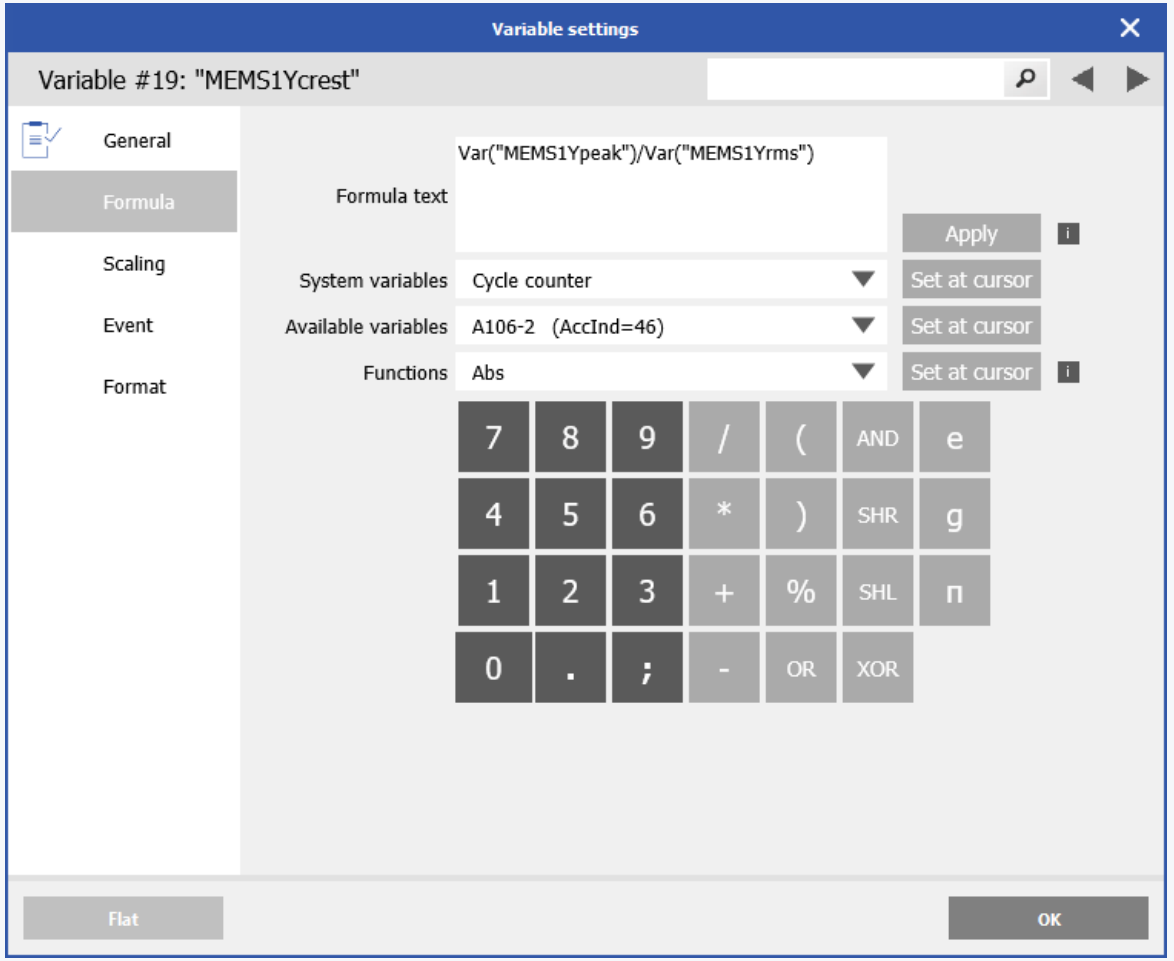
Note:
The minimum and maximum function used here as an envelope is not 100% correct. In the curves you see the delay in peaks, caused by the lower sampling rate for these values



Configuration with GI.bench

Statistics in time domain – **crest**

- **On Q.station as arithmetic variable**
  - Formula: *crest = peak / rms*
  - Calculate rms and peak with arithmetic function first, then define a new arithmetic variable for the crest factor
  - Formula: Var("MEMS1Ypeak")/Var("MEMS1Yrms")
  - Crest factor indicates how extreme the peaks are in the time series signal. It is sometimes called peak-to-rms ratio. Crest factors of two or 3 are normal and begin to increase when the signal contains more, and higher peaks.



Configuration with GI.bench

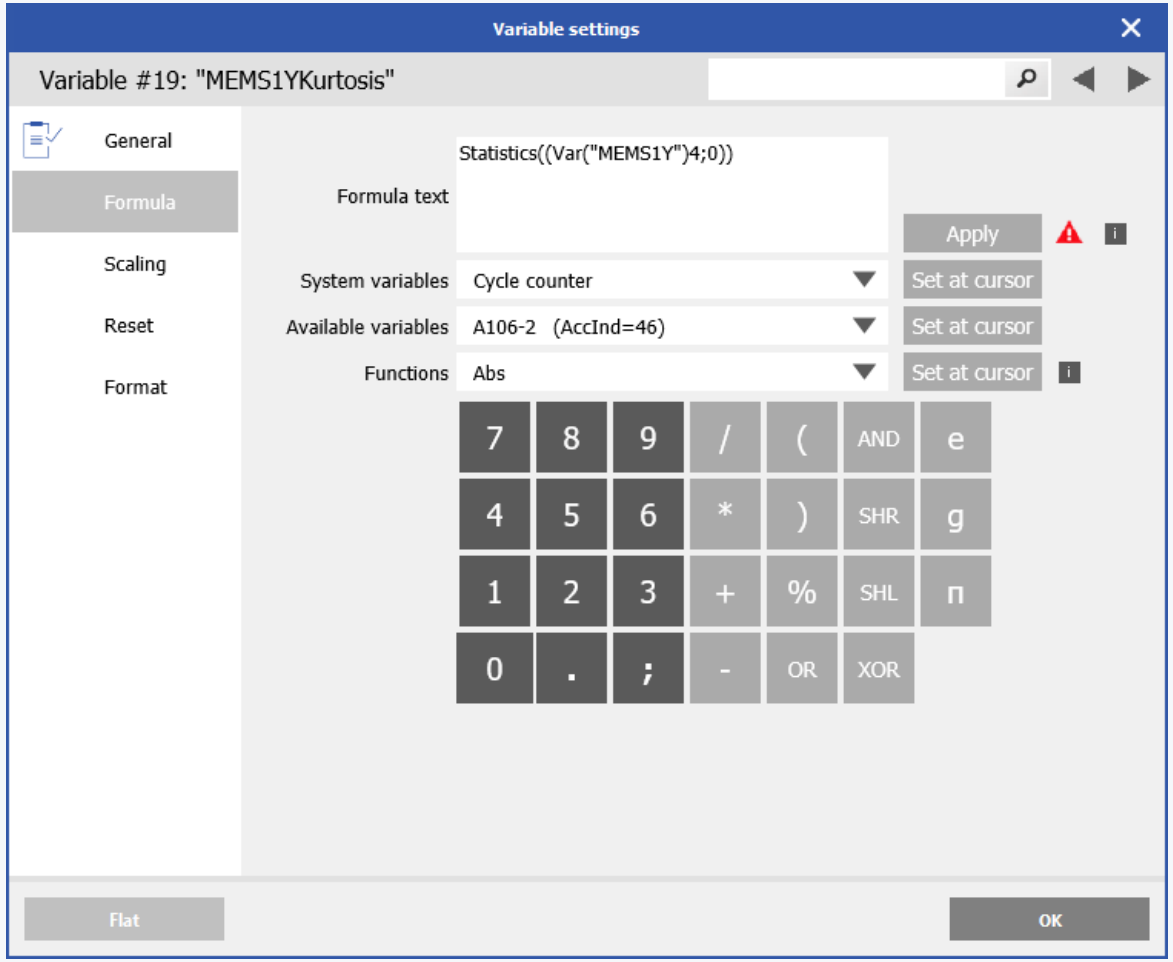
Statistics in time domain – **Kurtosis**

- **On Q.station as arithmetic variable**
  - Formula

  - Kurtosis can be used to differentiate between similar types of vibration signals and indicates the ‘spikiness’.
  - Kurtosis *k* is a unitless parameter that quantifies the distribution shape of a signal relative to a Gaussian distribution.

$$k = \frac{n\sum_{i=1}^{n}(x_i - \bar{x})^4}{\left(\sum_{i=1}^{n}(x_i - \bar{x})^2\right)^2} - 3$$

  - The current data point minus the mean, divided by the standard deviation, to the fourth power, and normalized by the number of data points is the Kurtosis. If the result is then subtracted by 3 to ensure the kurtosis of a Gaussian distribution is equal to zero we call it Kurtosis excess.
  - Vibration signals can have high Kurtosis numbers e.g. 80 or 120. It is often used in vibration control in combination with a shaker.



Parameters in frequency domain – FFT Fundamentals

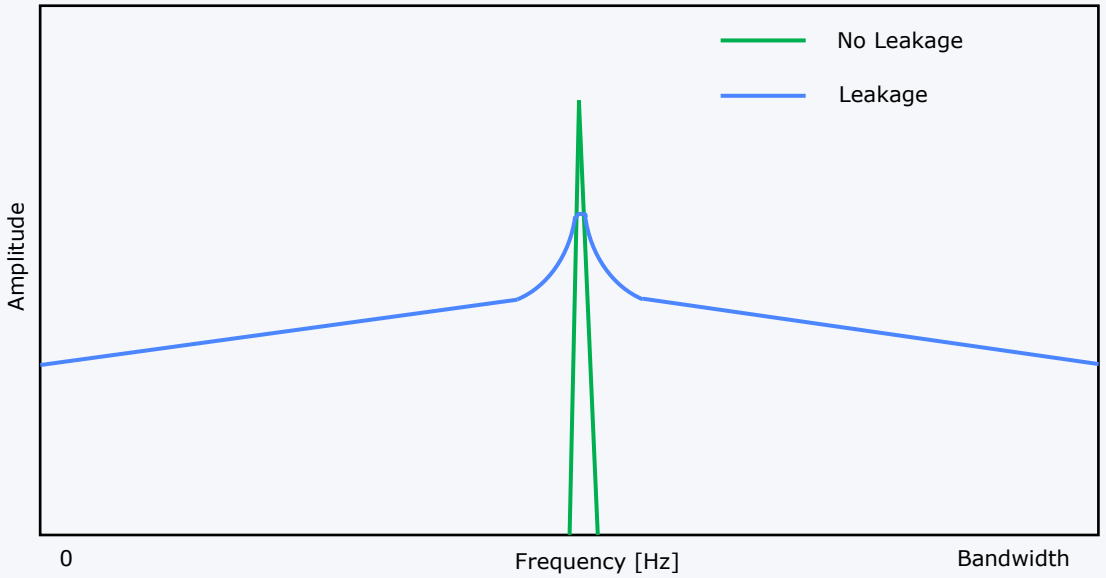
Windows and Leakage

FFT spectra shows amplitudes according to the set frequency resolution. Frequencies with are not integer multiples of the resolution will leak from over the complete frequency range.

A signal with leakage has lower amplitude and a broader frequency response than a signal with no leakage. This makes it difficult to quantify the signal properly in the frequency domain.

To avoid those leakages, apply a window before processing the FFT:

Hanning Window is used for general data evaluation for random transients and has a good mix between frequency and amplitude accuracy.



Parameters in frequency domain – FFT Fundamentals

Key Terms

Sampling Rate F_S: Number of acquired samples per second
Frame Size *F*: Amount of time data collected for FFT
Block Size *B*: Total number of data samples acquired during frame
Bandwidth F_{max}: Highest Frequency that is captured by FFT, Must be maximal half of F_S.
Spectral Lines *SL*: total number of frequency domain samples, number of bins
Frequency Resolution *df*: spacing between frequency domain samples, bin frequency

The frame size *F* indicates the time to compute the FFT. When the block *B* has a size of 2000 samples and the sampling rate F_S is 1 kHz, it takes 2 seconds to get the 2000 samples.

The number of spectral lines *SL* is half the block size *B* because the FFT results in amplitude and phase. If converted to an auto-power it eliminates the phase.

The frequency resolution df equals the bandwidth divided by the spectral lines or sampling frequency divided by block size.

→ The finer the resolution, the longer the acquisition time

$$F = B / F_S$$

$$SL = 0.5 \times B$$

$$df = F_S / B$$

Configuration with GI.bench

FFT Processor & Evaluator on Q.station

Signal evaluation in frequency domain is done by the Controller Q.station with an FFT Processor to convert the timeseries signal into the frequency domain.

NOTE: Auto-power is used here and not the spectrum (phase information is not available).

With several FFT Evaluator functions the auto-power spectral band can be evaluated.

NOTE: the FFT Evaluator gives a single value as result. E.g. when using effective vibration velocity it returns the value over the selected spectral band and does not provide a new auto-power spectra.

For FFT processor and FFT Evaluator configuration, double click on the Controller Q.station to open the setting window and choose *Functions*.

Configuration with GI.bench

FFT Processor

For FFT processor and FFT Evaluator configuration, double click on the Controller Q.station to open the setting window and choose *Functions*.

Data Buffer defines Sampling Rate F_S

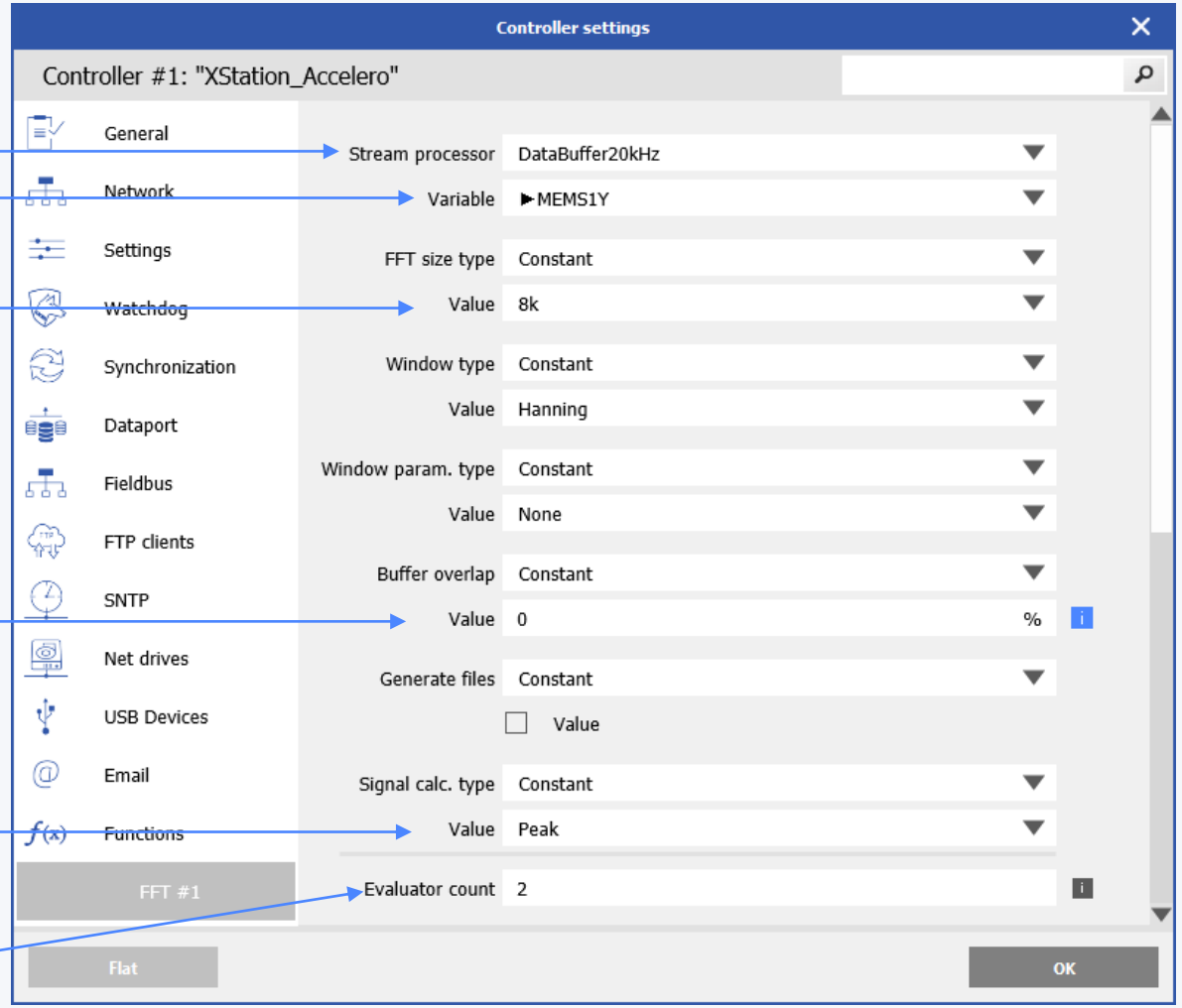
Input Variable (Sensor)

Block Size *B (1kSample to 1MegaSample)*

Overlapping of Block Size for each FFT computation in %

Time domain data as peak or peak-to-peak (rms not yet available)

Activation of FFT Evaluator, up to 10 can be used on the same Input Variable



Configuration with GI.bench

FFT Evaluator

Possible Evaluator Functions

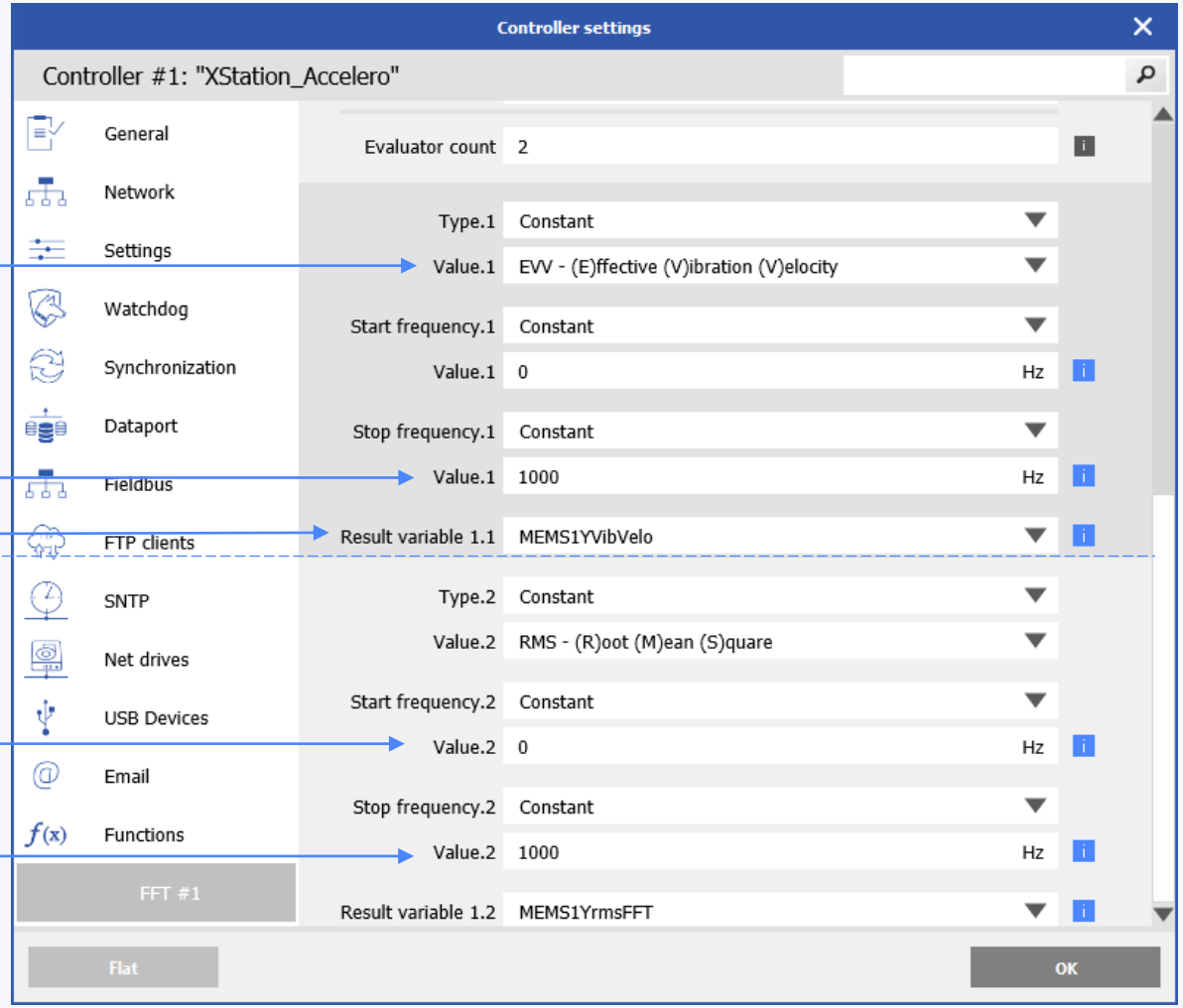
- FFTErrorStates
- Minimum
- Maximum
- Integral
- RMS - (R)oot (M)ean (S)quare
- SINAD - (S)ignal to (I)nterference ratio including (N)oise (A)nd (D)istortion
- ENOB - (E)ffective (N)umber (O)f (B)its
- SNR - (S)ignal to (N)oise (R)atio
- THD - (T)otal (H)armonic (D)istortion
- SFDR - (S)purious (F)ree (D)ynamic (R)ange
- EVV - (E)ffective (V)ibration (V)elocity
- EVD - (E)ffective (V)ibration (D)isplacement
- TimeDomainBufferLosslessAndOverlappingHealth

Defines the Bandwidth F_{max}

Variable used for the FFT result

Note: define the resutlt varibale bevor configuring the FFT

Start and Stop Frequency defines the spectral band the rms is calculated for



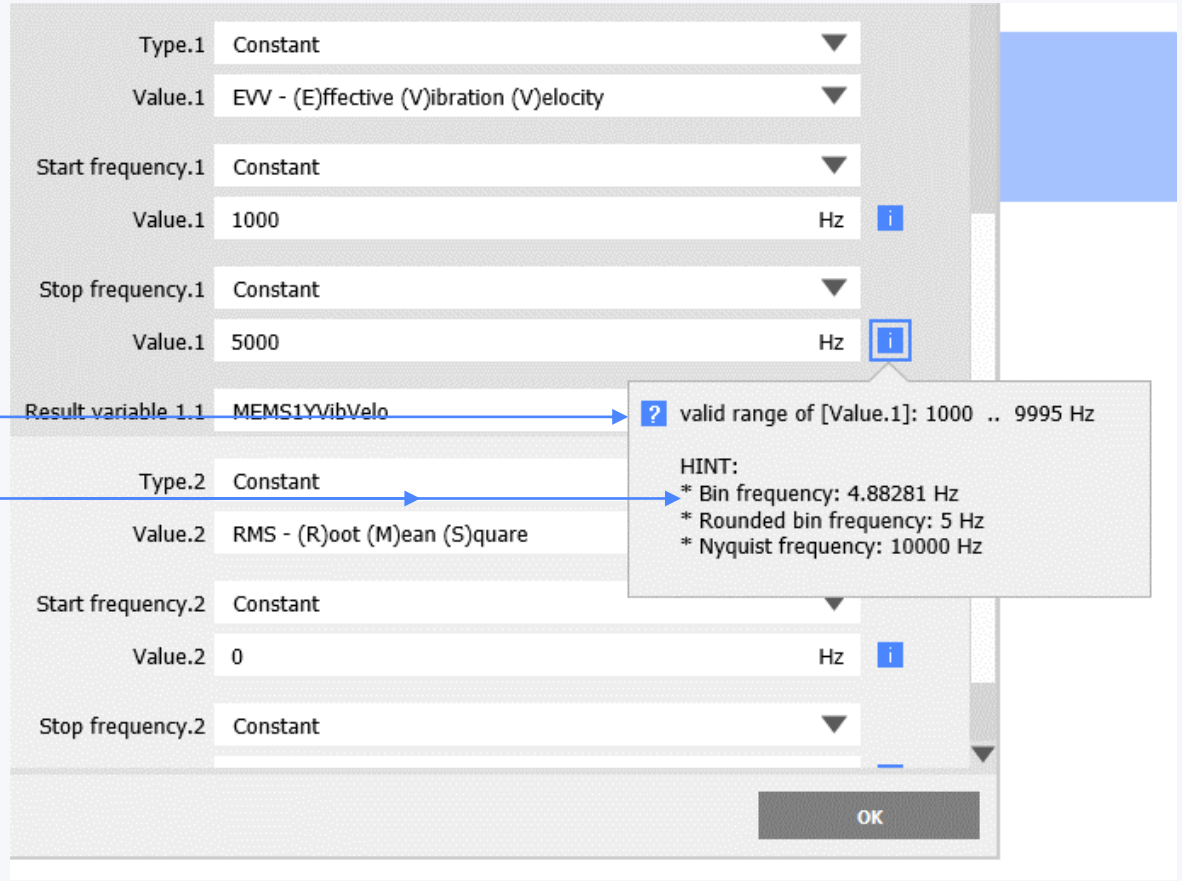
Configuration with GI.bench

FFT Evaluator

Get information by pressing the blue info box:

Bandwidth – frequency resolution

Frequency Resolution *df*



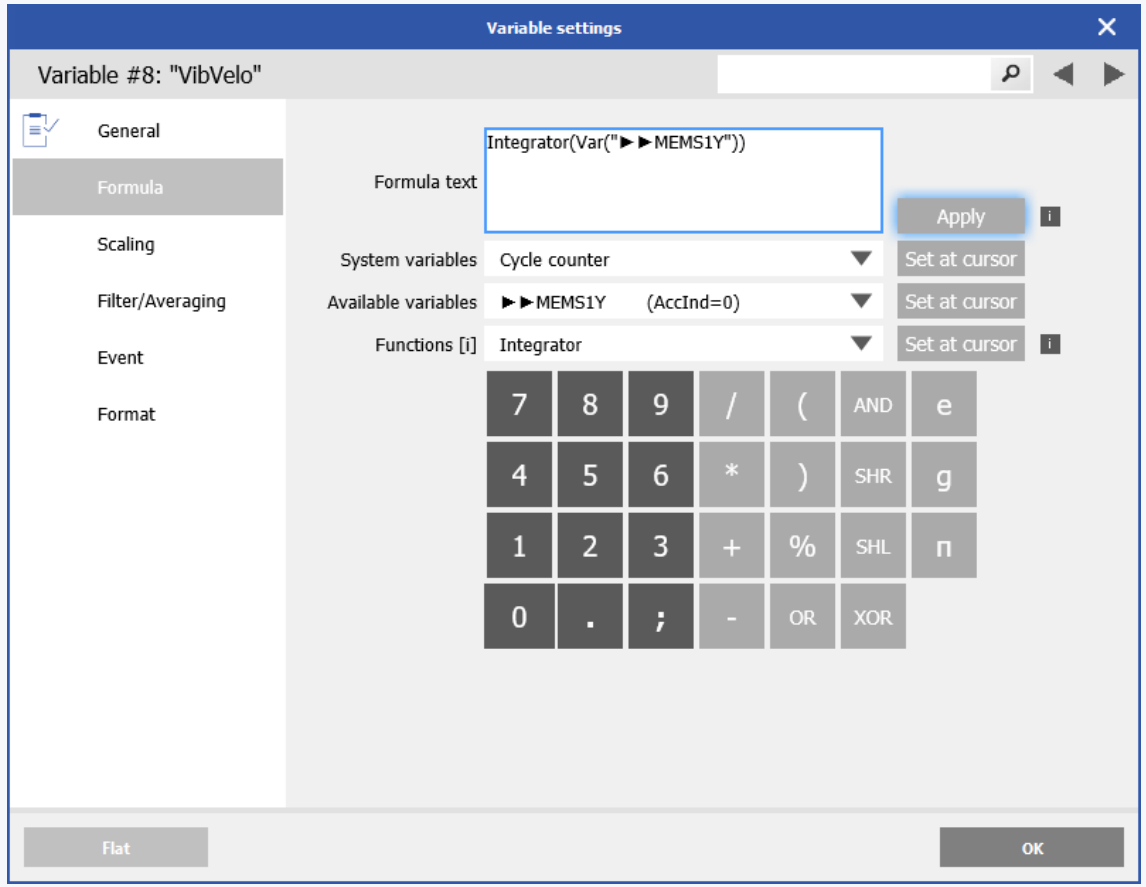
In this example the Sampling Rate F_S is 20 kHz and the block size *B* is 4 kSample. In reality the block size is always multiples of power 2 and in this case exactly 4096 samples. The Frequency resolution $df = F_S / B$ is 20,000 Sample/s / 4096 Sample = 4.88281 1/s = 4.88281 Hz

Enhanced Streams Configuration with GI.bench

Enhanced Streams

Using enhanced stream for signal integration, to calculate velocity and displacement

- Right click on Controller and choose *Add enhanced data stream* and select databuffer and channels in the data processor settings. The stream will be generated.
- Right click on the new stream and choose *Add variable* and select the parameters to be calculated
- Configure this variable and use arithmetic function *Integrator*
- Set physical unit in *Scaling* to *mm/s*



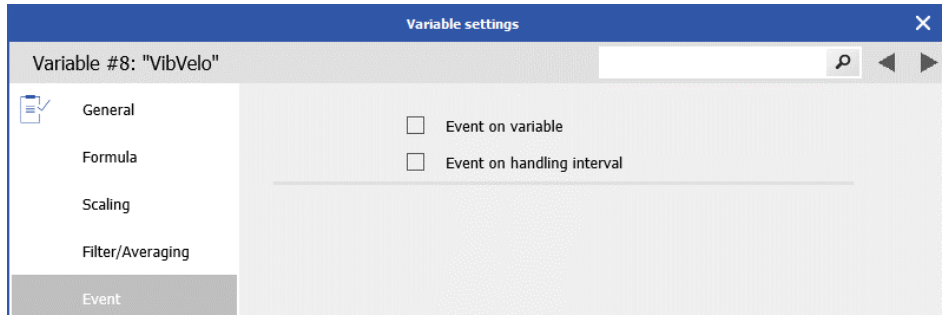
Enhanced Streams Configuration with GI.bench

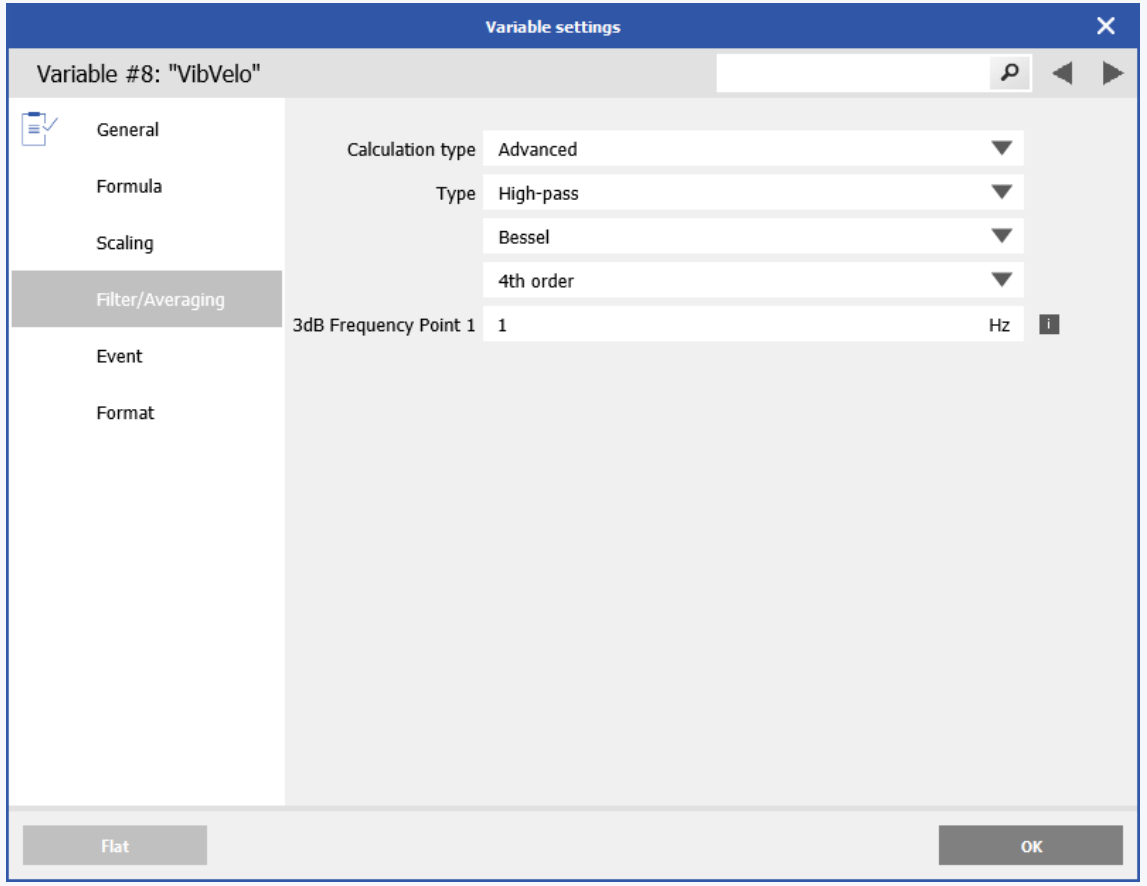
Enhanced Streams

Using enhanced stream for signal integration, to calculate velocity and displacement

- Set a high-pass or bandpass filter to eliminate the DC content in the signal (that accumulates an error in the integration process)
- Choose 1Hz or 0.5Hz as filter frequency if you use High-pass
- You can derive the vibration displacement out of this variable by making a new arithmetic function and choose the velocity channel and integrate and filter again.

Note: Do not activate any seetings on *Event*. Otherwise the integration does not work





Summary: where parameters can be configured

- On Project level / local computer
  - Statistic parameter *Min, Max, Avg,*
  - Arithmetik Variable *Kurtosis, Crest-Factor, rms*
  - Integration and Filter for *vibration velocity, vibration displacement*
- On Q.station level
  - Statistic parameter *Min, Max, Avg,*
  - Arithmetik Variable *Kurtosis, Crest-Factor, rms*
  - Integration and Filter for *vibration velocity, vibration displacement*
  - *FFTProcessor* and *FFTEvaluator*
  - Control of digital/analog ouputs e.g. for alarming
- On I/O-Module level
  - Statistic parameter *Min, Max,*
  - Arithmetik Variable *rms*
  - Signal Filtering

Accelerometer Signal Conditioning

A111

A108+

A141

A111

IEPE, 4 Ch

A108 4M1 / 2M3

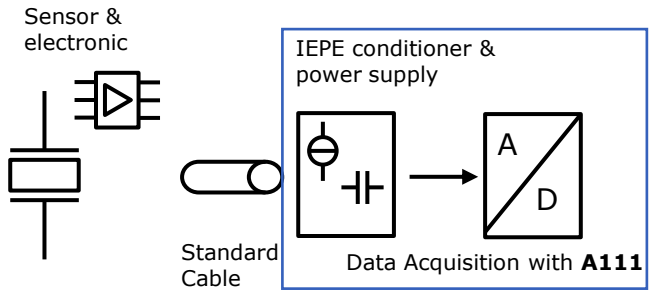
MEMS, 4/6 Ch

A141

Piezo, 4 Ch

IEPE (PiezoStar, Piezotron, DeltaTron, ICP®, ISOTRON®)

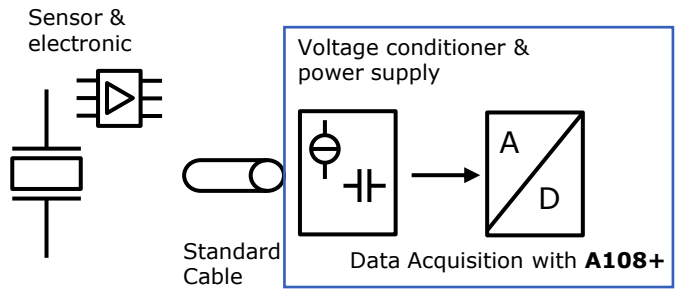
(Integrated Electronics PiezoElectric)



- Sensor contains internal charge to voltage converter
- Standard cable for sensor connection
- DAQ system with integrated IEPE power supply (e.g. 4mA const.) required for operation
- Only dynamic measurements possible
- Measuring range is fixed
- Temperature range limited with integrated electronics

MEMS (K-Beam)

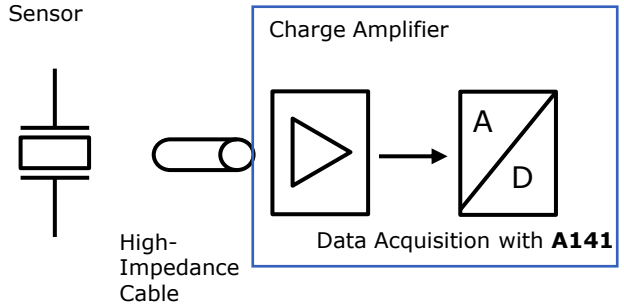
(Micro Electro Mechanical System)



- Sensor contains internal charge to voltage converter
- Standard cable for sensor connection
- DAQ system with integrated power supply (e.g. 10-30V unregulated) required for operation
- Quasi-static (DC) measurements possible
- Measuring range is fixed
- Temperature range limited with integratedelectronics

PE

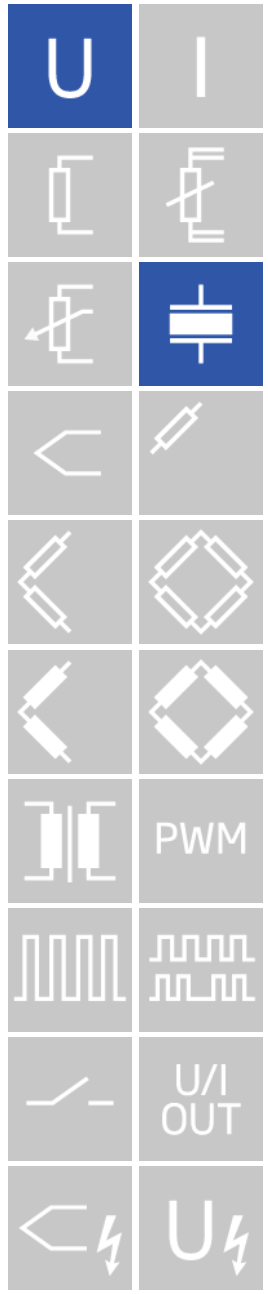
(PiezoElectric)



- Sensor does not contain electronics
- Very wide temperature range
- Very broad measuring range
- Quasi-static up to very dynamic measurements possible
- High impedance cable required
- Charge amplifier required

I/O Modules
Q.series XL/XE A108 4M1 / 2M3

- 2M3: I/O Module for 2 tri-axis MEMS sensors
  - 6+2 Analog Input channels with 20 kS/s each
    - AI1, AI2, AI3 differential/ single-ended switchable in groups
    - AI5, AI6, AI7 differential/ single-ended switchable in groups
    - AI4, AI8 single-ended (e.g. for temperature compensation)
- 4M1: I/O Module for 4 single-axis MEMS sensors
  - 4+4 Analog Input channels with 20 kS/s each
    - AI1, AI2, AI3, AI4 differential/ single-ended switchable in groups
    - AI5, AI6, AI7, AI8 single-ended (e.g. for temperature compensation)
- All analog inputs:
  - Input range ±10 VDC
  - Margin of error ± 2 mV
  - Resolution 1.5 µV
- Sensor excitation for each sensor
  - 15 V max. 40 mA (short circuit proof)
- Available in 2M3 (DB9) and 4M1 (MicroCom CMR)



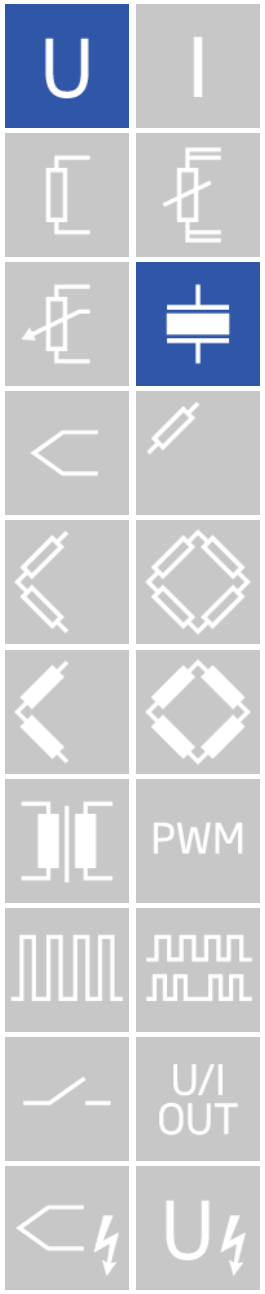
Q.bloxx XL/XE A108-2M3

Q.bloxx XL/XE A108-4M1

Click on image to download datasheet

I/O Modules
Q.series XL/XE A111 / A111 BNC

- Module for IEPE/ICP Sensors and Voltages with 4 Ch at 100 kS/s each
  - 4 galvanic isolated analog input channels:
    - IEPE
      - Input range ±1 V or ± 10 V
      - margin of error ±1 mV / ±10 mV
      - Sensor excitation with 4mA constant current
      - Compliance voltage 24 VDC ±10 %
      - Input frequency range 0.5 Hz to 20 kHz
    - Voltage
      - Input range ±100 mV, ±1 V or ± 10 V
      - margin of error ±20 µV / ±200 µV / ±2 mV
- Standard 10-pole screw terminals or BNC-Connectors



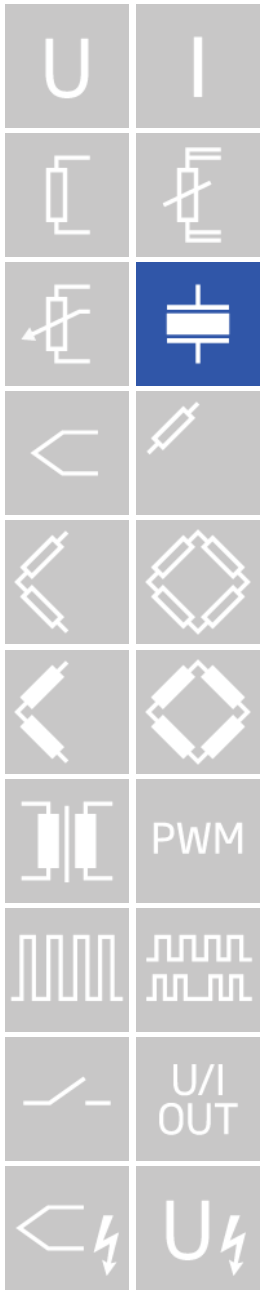
Q.bloxx XL/XE A111-BNC

Q.bloxx XL/XE A111

Click on image to download datasheet

I/O Modules
Q.series X A141

- Charge Amplifier Module for Piezoelectrical Sensors
- Engineered with Kistler
- 4 channel Charge Amplifier:
  - For Piezoelectric Sensor
    - Input Range: 1000 to 1000000 pC
    - Margin of error < ±1 % FSO
    - Drift 0.5 pCpp
    - Frequency range 0 Hz to 20 kHz
- 4x BCN Connector



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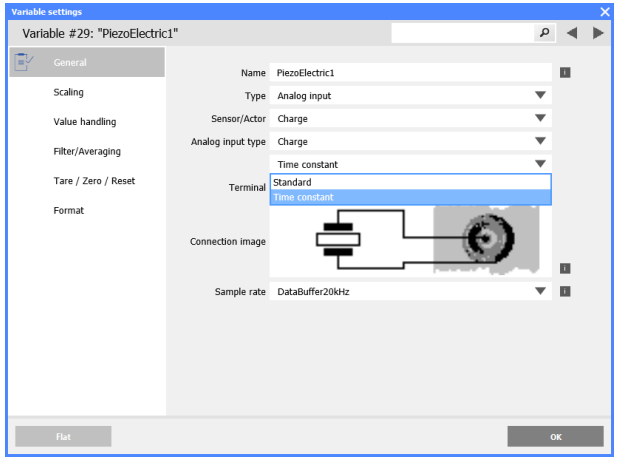
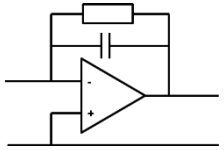
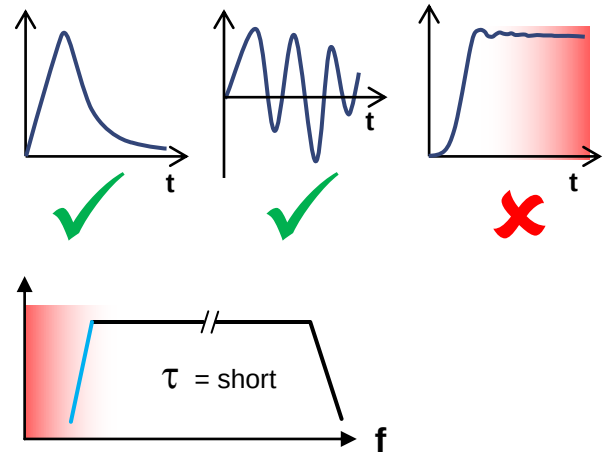
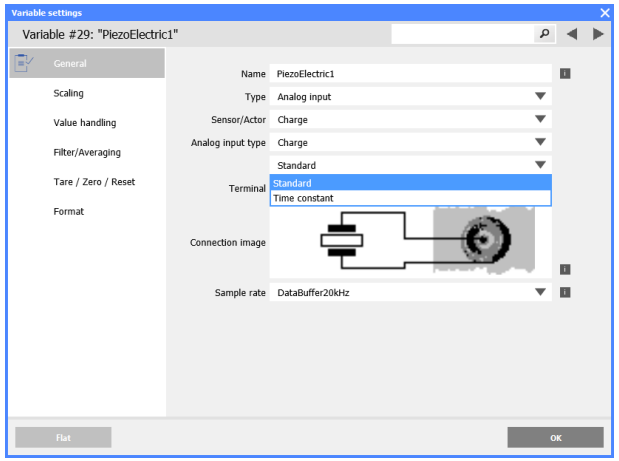
I/O Modules
Q.series X A141 – Measurement Modes



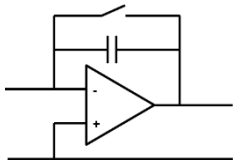
- Fast transient (typ. <500ms) or pulsating signals (typ. >0.5Hz)
  → Time constant (measuring mode «short»)
  - Integrated time constant filters any DC content
  - No drift due to High-Pass characteristic
  - No Reset/Measure required, continuous measurement

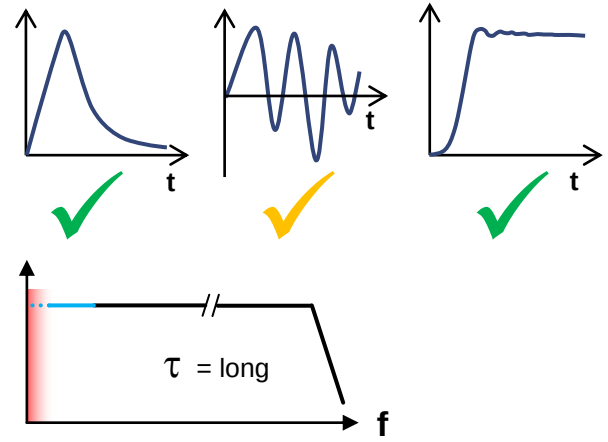






- Slow down to almost static measurements
  → Standard (measuring mode «long»)
  - For Low Frequency and Dynamic measurements
  - Reset/Measure signal required = «start measurement»
  - Drift become visible after long time

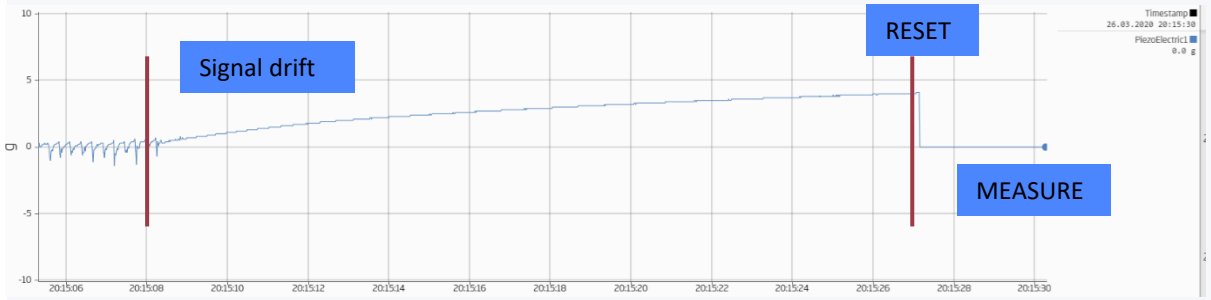




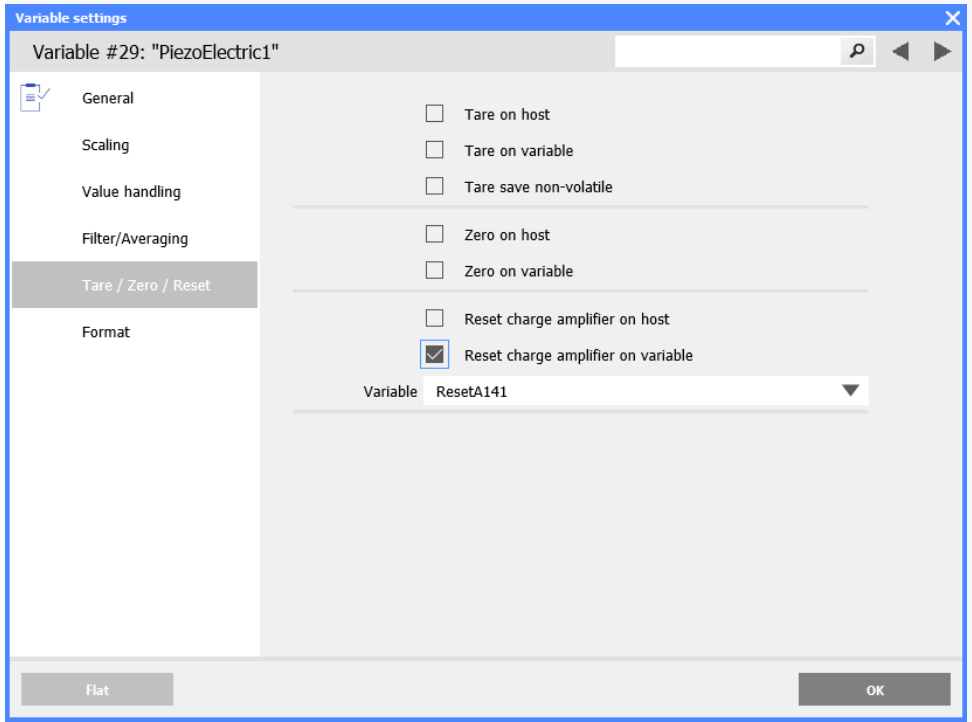
I/O Modules

Q.series X A141 – Measurement Modes

- In measurement mode standard RESET / MEASURE Signals must be set to A141 inputs



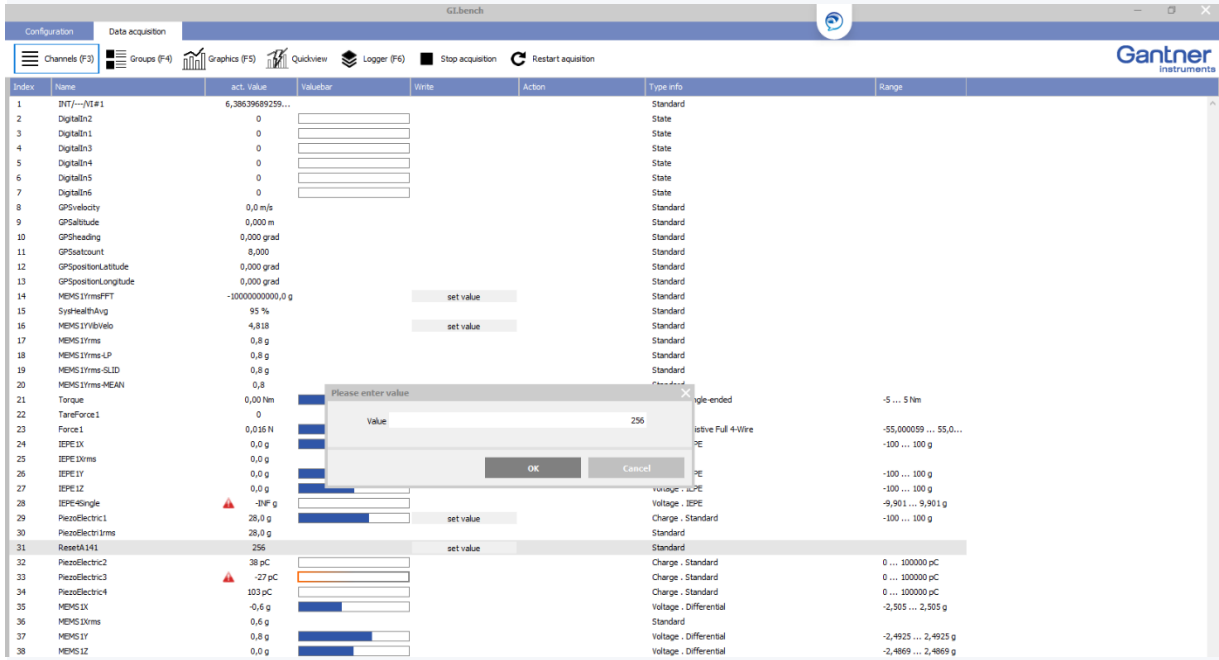
- Select Tare / Zero / Reset page and activate at least „Reset charge amplifier on variable“



I/O Modules

Q.series X A141 – Measurement Modes

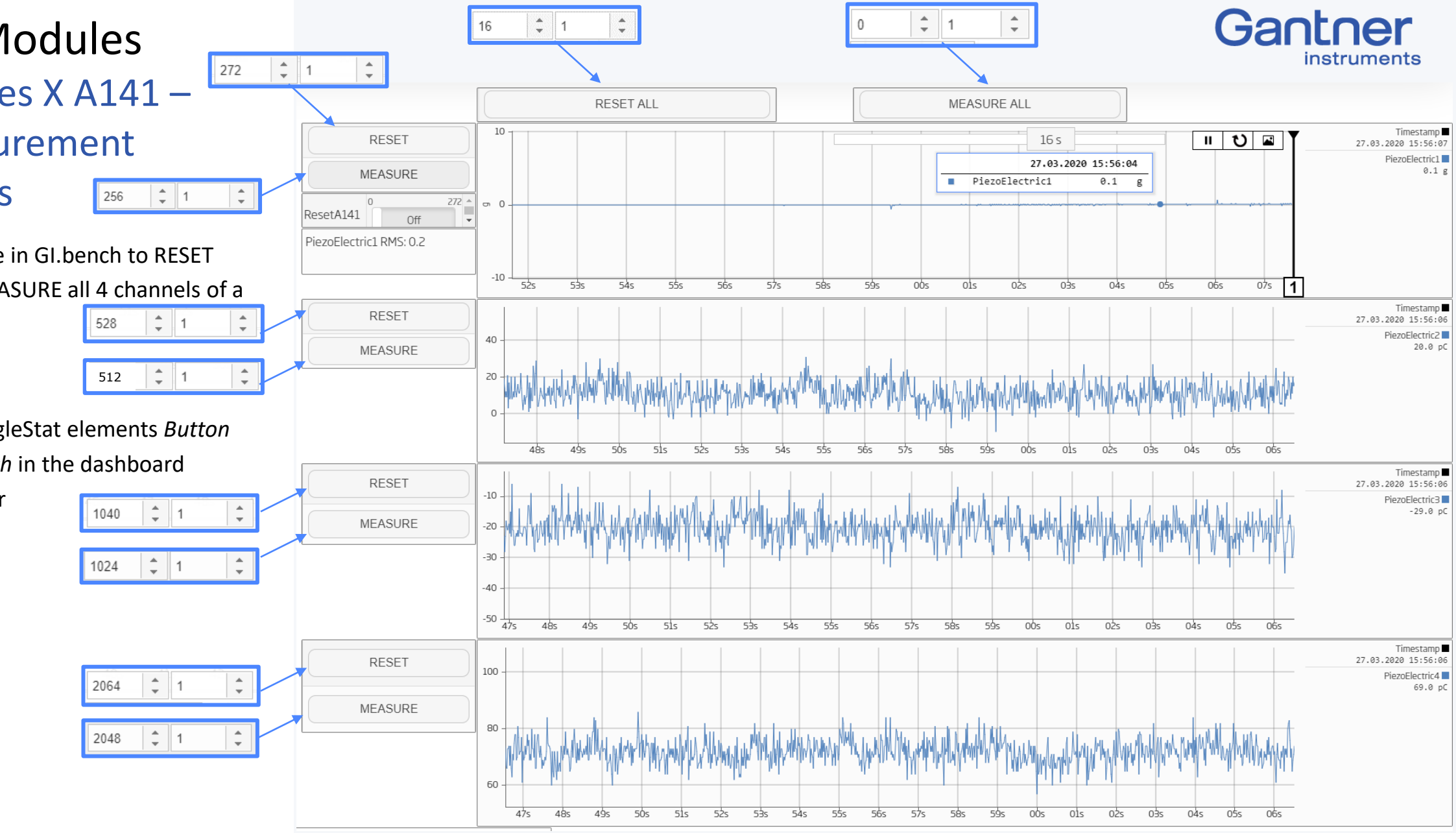
- In measurement mode standard RESET / MEASURE Signals must be set to A141 inputs e.g via setpoint variables
- When the signal is drifting, send bitset starting from Bit 8 (256) to RESET the input, channel LED is flashing light blue:
  → bitset 272 resets Channel 1
  256 (Bit 8) + 16 (Bit 4) for ch 1,
  → bitset 528 resets Channel 2
  512 (Bit 8) + 16 (Bit 4) for ch 2
- Set to MEASURE mode by bitset to re-active the measurement, channel LED shows light blue constantly:
  → bitset 256 active measurement
  256 (Bit 8) + 0 (Bit 0) for ch1
- All channels can be RESET by bitset 16 and set to MEASURE by bitset 0 by just using one variable.



I/O Modules

Q.series X A141 – Measurement Modes

- Example in GI.bench to RESET and MEASURE all 4 channels of a A141
- Use SingleStat elements *Button* or *Switch* in the dashboard designer



I/O Modules
Q.series X A141

- LED Codes
- Channel LED
  - Light Blue constant: mode MEASURE
  - Light Blue flashing: mode RESET
  - Red constant: overload channel input

Click on image to download datasheet

Good To Know

- Download and Support Tools:
  https://www.gantner-instruments.com/resources/downloads-and-support-tools/
- Product datasheets:
  https://www.gantner-instruments.com/resources/downloads-and-support-tools/product-datasheets/
- How-To Videos:
  https://www.youtube.com/user/GantnerInstruments/videos
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