

TECH NOTE :: QuantumX in RLDA together with Kistler RoaDyn® Wheel Force Transducers

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Abstract

This TECH NOTE gives you an overview of typical vehicle chassis and steering testing approaches and methods. It focusses on integrating Kistler IGeL wheel force transducers (WFT) named RoaDyn® into QuantumX Data Recorder CX22-W from HBM for mainly Road Load Data Acquisition (RLDA).

General

Several engineering methods have been established in optimizing dynamics and durability of vehicle chassis and its components.

1. **Multi Body Simulation (MBS)**, which deals with computer, based numerical simulation in which several systems are composed of various rigid or elastic bodies. Connections between the bodies can be modelled with kinematic constraints such as joints or force elements such as spring dampers analysing its overall motion. It is used to evaluate characteristics of comfort, safety, and performance, for example in automotive suspension design.
2. **Life cycle simulation**, which deals with Finite Element Method (FEM) simulating mechanical system parts under stress in a short period of time discovering weak points of mechanical constructions, predicting the life cycle of vehicle components.
3. **Road Load Data Acquisition (RLDA)**, which deals with generating a condensed mechanical load data file of the vehicle under development. For this purpose mainly wheel force transducers, strain gages, displacement and acceleration sensors are used in chassis, axles, suspension and other components. Data is acquired on test tracks and proving grounds with typical road and ground conditions of the vehicle under investigation and processed afterwards to a so called "golden file".
4. **Durability Lab Testing**, which deals with replayed mechanical road load data over hydraulic or electrical actuators stressing components, system parts or overall vehicles in labs or test stands predicting life cycle.
5. **Ride & Handling**, which deals with mobile vehicle testing in general on proving grounds in a variety of different pre-defined and standardized manoeuvres or on regular roads optimizing vehicles overall driving behaviour, noise and vibration and performance.

QuantumX is a freely scalable and synchronized data acquisition system for in vehicle mobile data acquisition AND lab based testing. The modules are distributable, easy to install and can be powered by battery. catmanEasy can acquire, analyse and process data which can be stored in many different file formats such as RPC III, to be replayed by MTS shaker and durability test systems. For lab based testing all sensor inputs can be viewed and analysed as well but also directed to outputs like analog voltage, CAN bus or EtherCAT real-time bus to be integrated into durability test stations.

QuantumX / catmanEasy can acquire data from:

- analog inputs and digital counters: sensors or transducers acquiring mechanical, electrical or thermal inputs
- vehicle busses: CAN, CCP, xCP-on-CAN
- position or 6 DOF sensors based on GPS or Inertial Measurement Units (IMU): NMEA over RS232 or CAN
- digital video: USB or Ethernet based
- wheel forces: proprietary Ethernet protocol (System 2000 from Kistler RoaDyn®)

All QuantumX analog inputs offer 24 Bit aliasing free sampling with configurable filters. Universal sensor support including voltage, acceleration, strain, temperature, pressure, displacement and wheel forces and time synchronized CAN bus input. Analysis can be done with the powerful software GlyphWorks for durability, noise, vibration, performance and handling.

Wheel force transducers are mounted on any kind of test vehicles from F1 race cars over cars to trucks and the vehicle is driven along a predetermined course for force and torque analysis on two or four wheels of the vehicle together with other physical quantities acquired in parallel. In this special field HBM and Kistler are partners to promote a common solution.

RoaDyn® WFT is an established product from Kistler measuring wheel forces (F_x , F_y and F_z) as well as moments / torques (M_x , M_y , M_z). System 2000 is the central electronic system and interface transferring telemetric data from all corners to a proprietary Ethernet based protocol.

This Tech Note describes how to connect and acquire data from RoaDyn® / System 2000 synchronous do other physical quantities with the central Data Recorder CX22-W from HBMs QuantumX series or directly to a Notebook running minimum catmanEASY with plug-in “EASYRoadload”.

Other Tech Notes

- QuantumX and GPS
- QuantumX and CCP or XCP-on-CAN
- QuantumX Data Recorder

System Overview

QuantumX modules can be connected over FireWire to the Data Recorder CX22-W and are sync'd in this way.

The Kistler WFT is connected over System 2000 in two ways:

- direct clock line to one QuantumX MX840A or any other voltage input
- Ethernet UDP/IP protocol to CX22-W directly or over Ethernet switch

All incoming data from System 2000 is time stamped directly with the catman kernel task. Run-time variances on package based Ethernet protocol lead to a small time jitter but time synchronization channel to channel is $\leq 1\text{ms}$.

RoaDyn® wheel force transducer and telemetry

RoaDyn® wheel force transducers are available for a number of different vehicles like passenger cars, SUVs, trucks, agricultural and off-highway vehicles and race cars. The acquired wheel forces are transferred wireless from the turning wheel to the vehicle (telemetry) and are then transferred to a central gateway.

System 2000

The System 2000 is a central gateway. To parameterize this gateway and for data acquisition, Ethernet offers the best performance and can be connected directly to QuantumX Data Recorder CX22-W.

If only CAN bus is available it can also be integrated to QuantumX module MX840A or MX471 CAN ports.

The System 2000 gateway consists of voltage supply unit, network connection for communication and signal conditioning to convert the force and torque signals from the wheel force transducer into data signals referenced to its origin.

The firmware of the System 2000 should have the following firmware version:

- Board electronic: 4.01
- Ethernet card version: 1.19

The Ethernet interface supports

- Net datarate around 4,7 Mbit/s
- Pre-configured to class C networks: 192.xxx.xxx.xxx to 223.xxx.xxx.xxx
- Pre-configured net mask: 255.255.255.0
- Pre configurable IP address: **192.168.160.70** (default)
- Integrated web server for functional check
- Proprietary UDP communication for fast data streaming and for communication
- Used Ethernet ports: 8888 and 8889 for communication over UDP
- Data format of measurement quantities: FLOAT with 3 Byte
- **Synchronisation** with QuantumX: direct trigger line (start)

Only the Ethernet connection enables transferring 160 signals from RoaDyn® in an economically way with data rates up to 1250 Hz each signal.

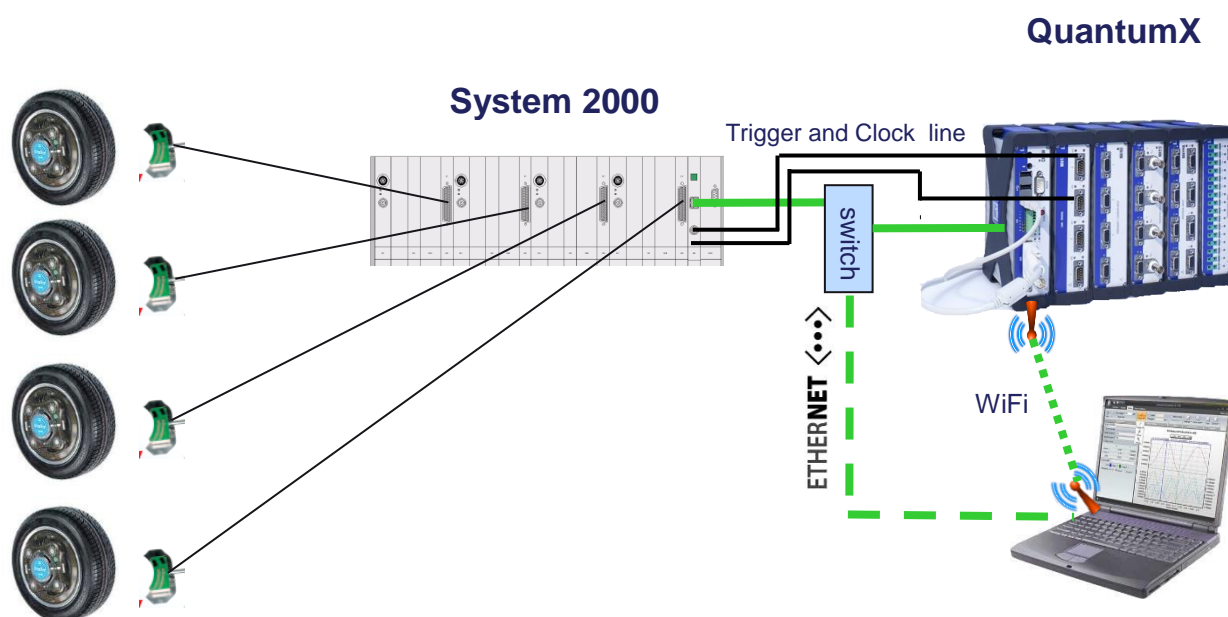
Maximum sum datarate of QuantumX Data Recorder

QuantumX Data Recorder CX22/W can acquire data with a maximum sum datarate of 400 kS/sec. The sum data rate can be lower depending on the number of signals. QuantumX DAQ modules deliver 4 Byte per sample. System 2000 delivers 3 Byte per sample.

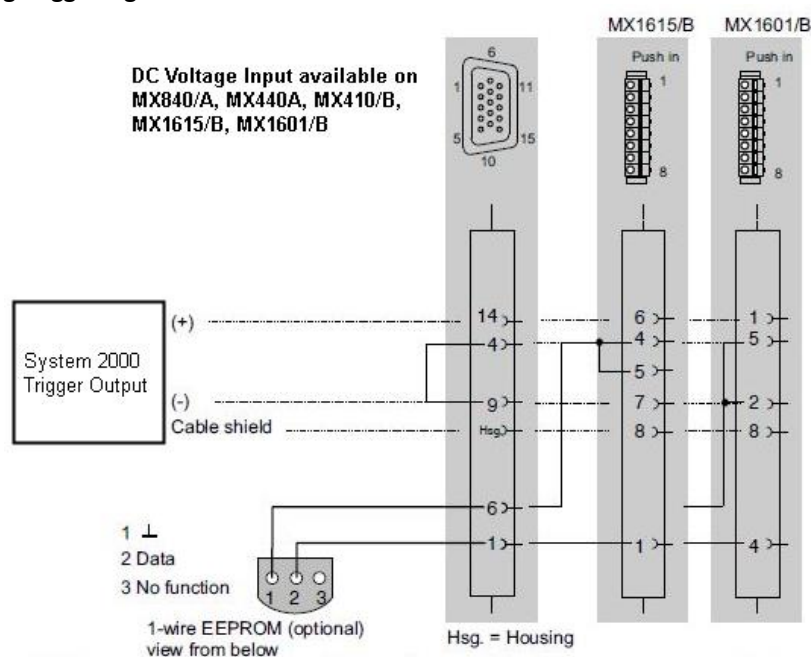
Step by Step integration of Ethernet based RoaDyn® / System 2000

1. Cabling

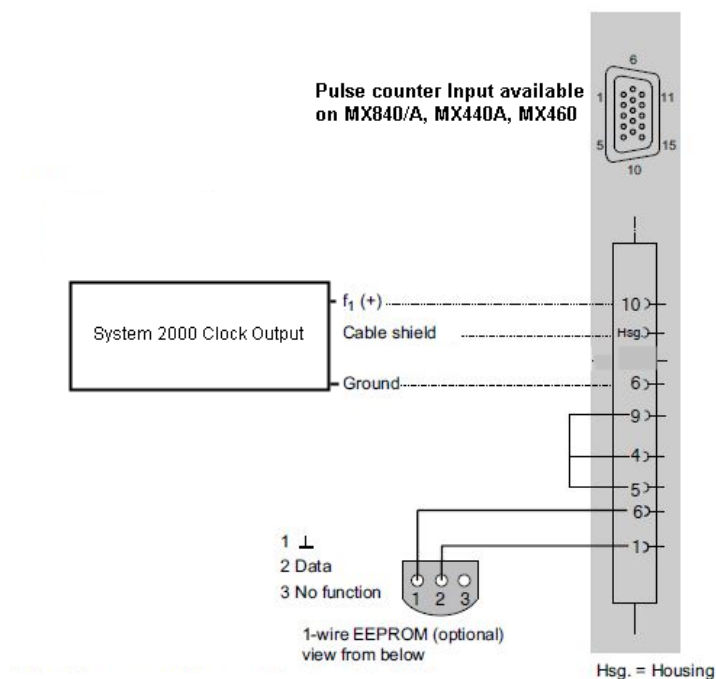
- Connect all QuantumX measurement modules over firewire to the CX22 data recorder.
- The CX22 data recorder and the Kistler System 2000 are connected to the same Ethernet switch
- A PC or Notebook is also connected to the Ethernet network. You can use the same switch or WiFi. The Notebook is used to connect to the CX22 for configuration. Alternatively you can directly connect display, keyboard and mouse to the CX22.
- Connect the Trigger output of the System 2000 to a QuantumX measurement input. In this example we use connector 7 of a MX840A.
- Connect the Clock output of the System 2000 to another QuantumX measurement input (MX840A/MX440A/MX460). In this example we use connector 8 of a MX840A.



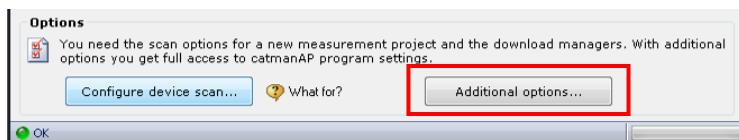
Pining Trigger Signal



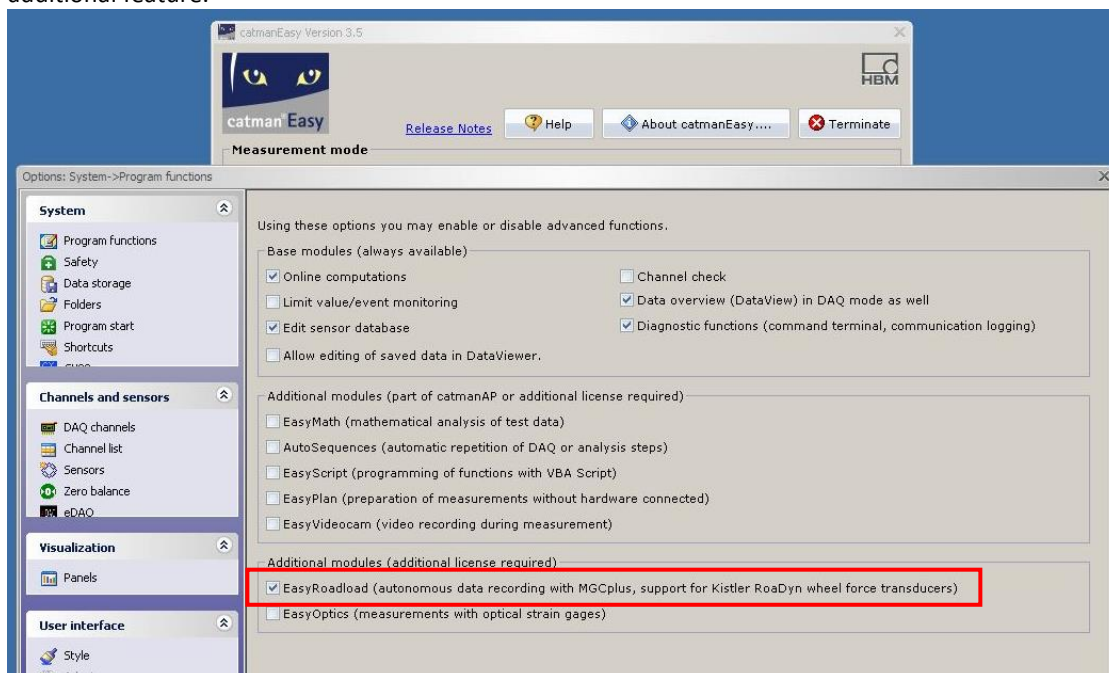
Pining Clock Signal



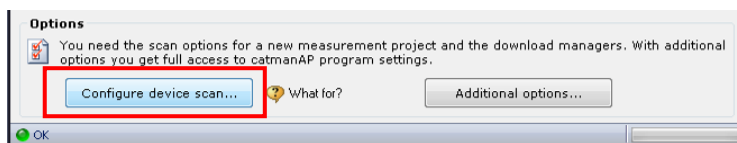
2. Configure the RoaDyn[®] system (number of channels or signals, etc.) using the associated configuration software.
3. **catman / CX22 Software Requirements**
Ensure that you have installed minimum **catman Version 4.0** (CX22 image Version 4.0).
4. **IP address configuration**
System 2000 is configured with a static IP address; all other participants have to be parameterized accordingly so that communication in the private network is possible. In case the PC is connected wirelessly to the Data Recorder this can be done individually.
 - System 2000: **192.168.160.70** fix (subnet mask: 255.255.255.0)
 - PC / Notebook: 192.168.160.10 alternative (subnet mask: 255.255.255.0)
5. Start the software “Data Recorder Assistant” on your PC or Notebook, search for CWX22-W and configure its IP address
 - Data Recorder CX22-W: 192.168.160.20 (subnet mask: 255.255.255.0)
6. Start catman on the Data Recorder and open the dialogue “Additional Options”.



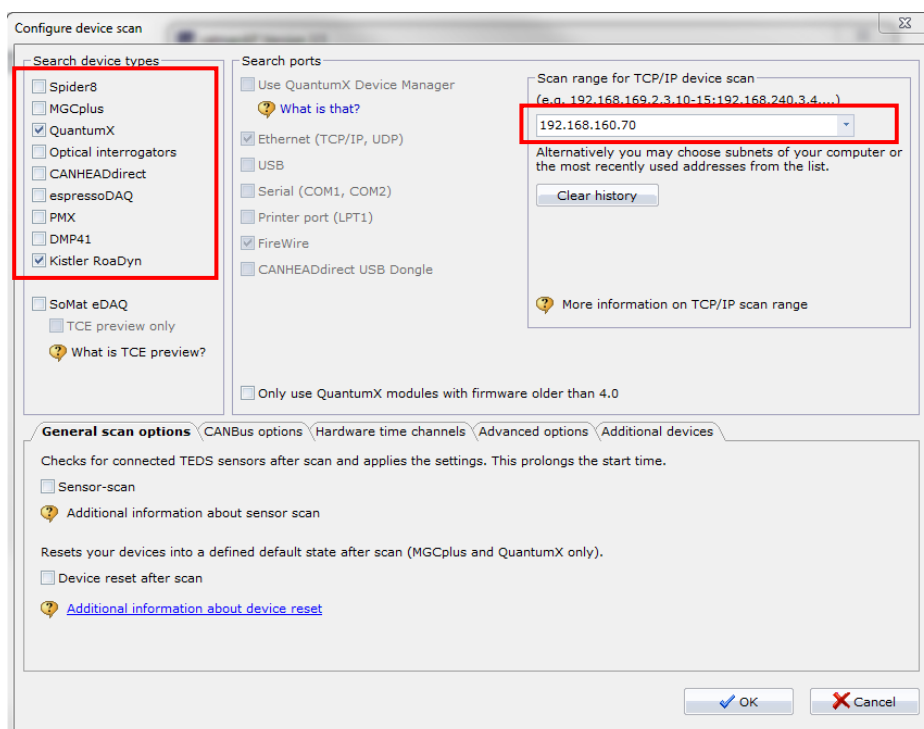
- Switch to “Program Functions” and activate “EasyRoadLoad” module. You need a license key activating this additional feature.



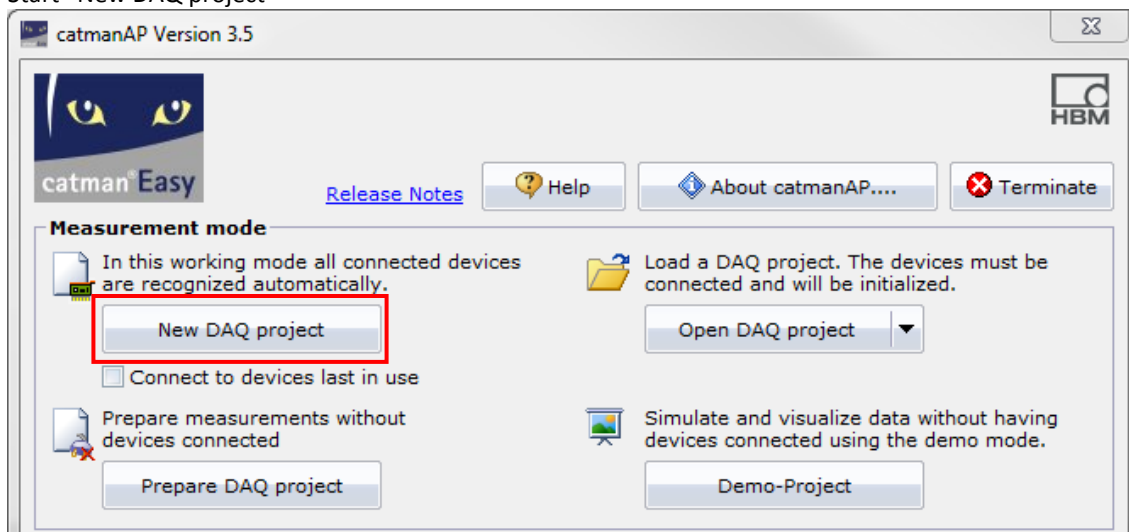
- Open “Configure device scan” dialogue



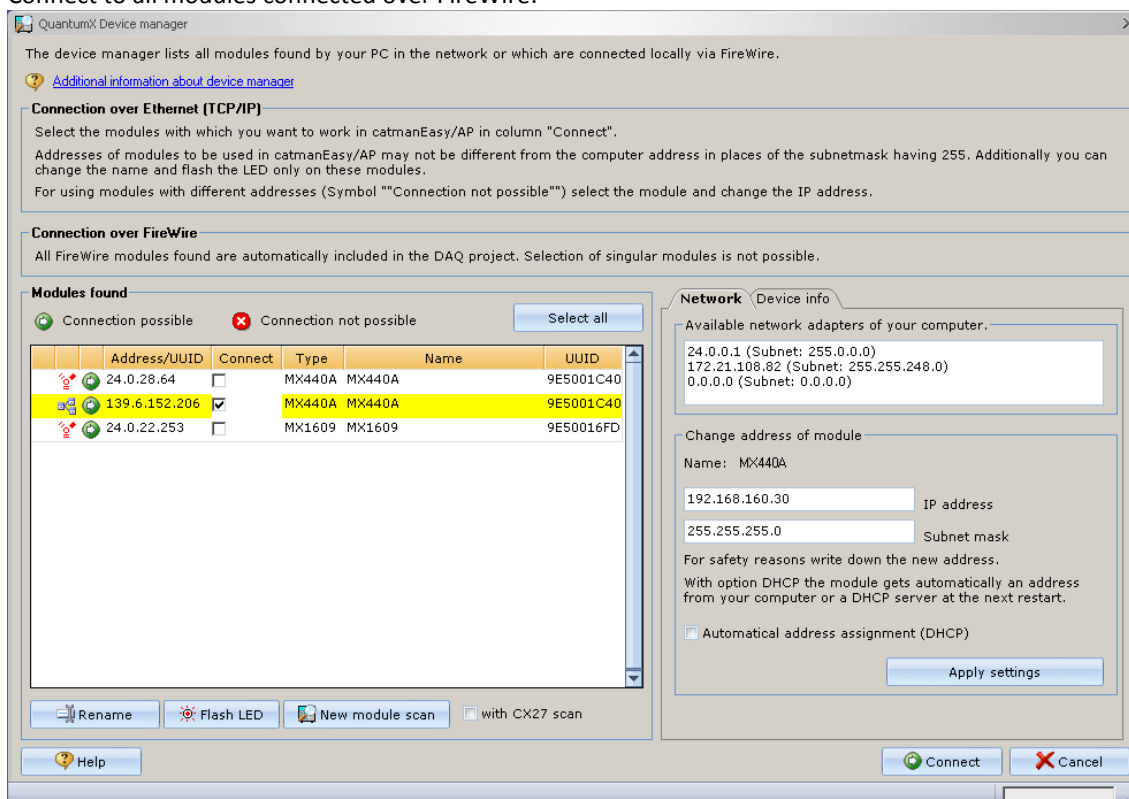
- In the scan dialogue highlight “QuantumX” and “Kistler RoaDyn” and enter IP address of the System 2000 accordingly (in this example 192.168.160.70).



10. Start “New DAQ project”



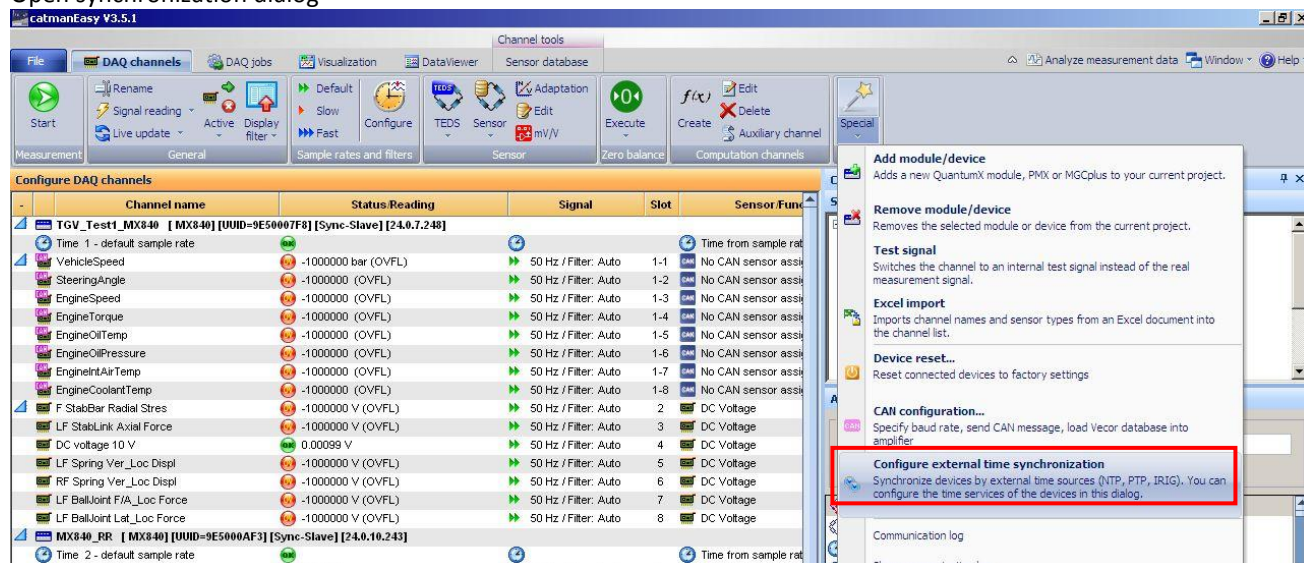
11. Connect to all modules connected over FireWire:



12. After device scan you see the DAQ channels. We recommend renaming Trigger channel to “Trigger” and Clock channel to “Clock” for a better traceability.

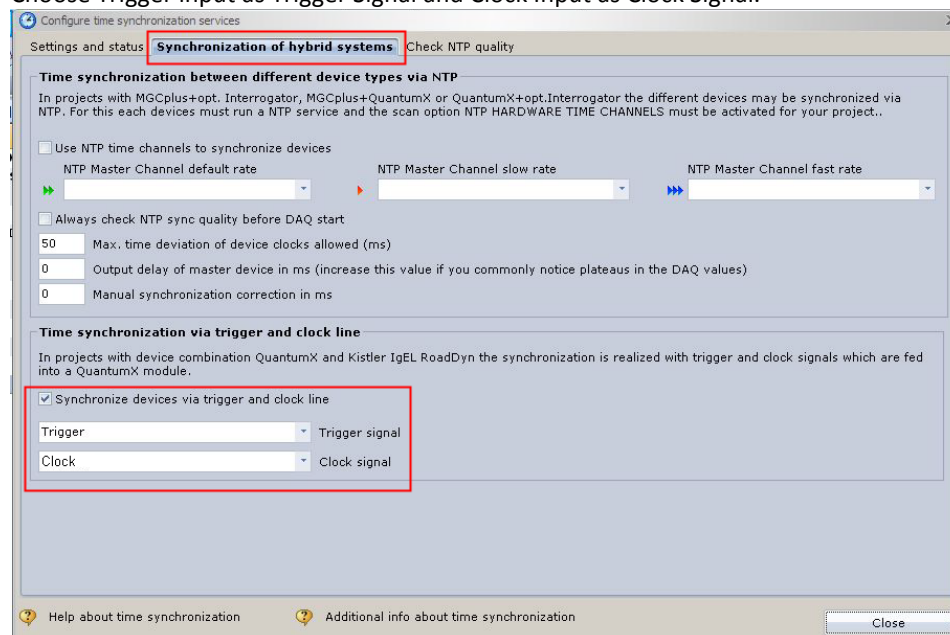
13. Configure external time synchronization

Open synchronization dialog



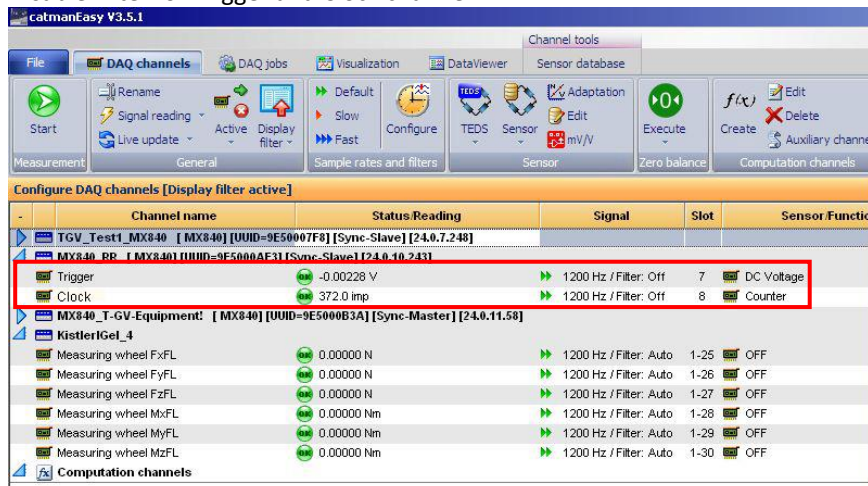
Enable “synchronization via trigger and clock line”.

Choose Trigger input as Trigger Signal and Clock Input as Clock Signal.



14. Configure Trigger channel as a 10V DC Voltage Input and Clock Input as a counter

15. Disable Filter for Trigger and Clock channel.



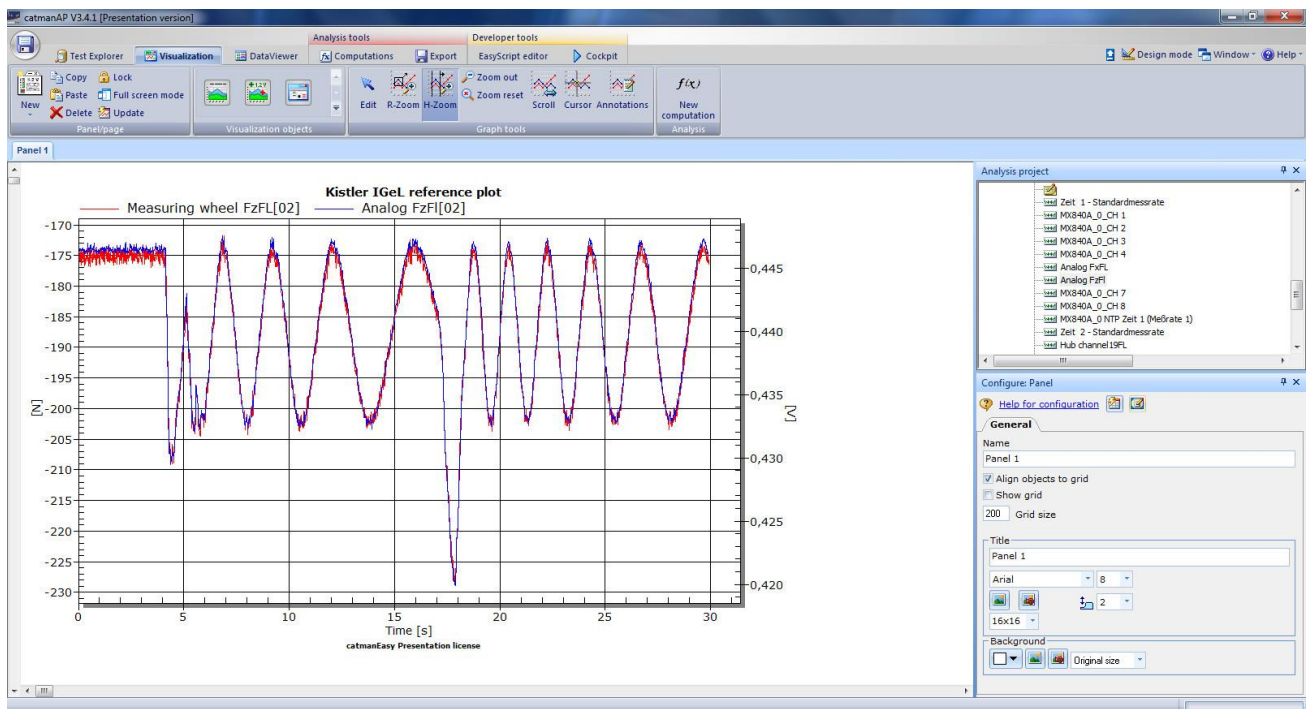
16. Start measurement.

With every measurement the Clock counter will be reset to zero automatically.

Proof of Time Synchronization

Synchronization between analog QuantumX inputs and digital Ethernet based RoaDyn® wheel force transducer has been tested in the following way:

- Force z-direction front left tire analog output from Kistler to analog input of QuantumX module MX840A
- Force z-direction front left tire digital Ethernet UDP/IP protocol to CX22-W Data Recorder
- Both inputs compared to each other with different signal load to the Recorder



Screenshots



Picture: Kistler wheel, remote control and screenshot showing live data acquired over Ethernet

Troubleshooting

If connection to RoaDyn® electronics is missing please check the IP address and parameterize accordingly with software or handheld device.

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