TECH NOTE #009:: Integrating Kistler RoaDyn® Wheel Force Transducers (WFT) via KiRoad Performance into QuantumX / SomatXR Data Recorder

Version: 2022-08-31
Status: public

Abstract

Vehicles and their components undergo numerous test runs – from concept, over component and overall prototype testing towards production; from simulation conducted on a computer to real physical testing in test stands and mobile test runs in the field.

For all kind of physical testing, measurement equipment and data acquisition systems (DAQ, DAS) are needed, analysing components or overall vehicles in real conditions of use. Whether you are testing passenger cars, commercial vehicles, military vehicles, or trains, each vehicle places special demands on field testing and requires testing in line with the target application, validating **key attributes of the products**. HBK has a great reputation in [mobile vehicle testing] delivering state of the art signal quality, easy to use operational software and powerful post-processing data analysis tools used in teams collaboration.

Wheel Force Transducers (WFT) play an essential role in mobile vehicle testing, especially in **Road Load Data Acquisition** (RLDA) on test tracks in proving grounds but also in the field, measuring vehicle response to typical load cases; but also in testing **Vehicle Dynamics** focusing on vehicles kinematics with brakes (ABS, ESP), steering, tyres, but also in Advanced Driver Assistance (ADAS)

This Tech Note describes how to connect and acquire data from RoaDyn / KiRoad Performance in a time synchronous way to all other physical quantities with the central Data Recorder CX22B / -W / -R-W from the QuantumX or the ruggedized SomatXR series. There is another Tech Note available addressing Kistler System2000 integration, the KiRoad Performance predecessor.

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, wheel force transducers, strain gages, displacement and acceleration sensors are used and measure on 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. Vehicle Dynamics, 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 and SomatXR are freely scalable and fully time synchronized data acquisition systems for in-vehicle mobile data acquisition and lab-based testing. SomatXR is the rugged variant of QuantumX. The modules are distributable, easy to install and can be powered by battery. Catman AP can acquire, analyse and process data which can be stored in many different file formats to be replayed in durability lab testing, performing lifetime and fatigue testing. 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 Industrial Ethernet (EtherCAT® or PROFINET) real-time bus to be integrated into durability test stations.

QuantumX / SomatXR and catman can acquire data from:

- Analog sensors and digital timer-based inputs acquiring mechanical, electrical or thermal inputs
    - Strain, force, moments, displacement / height, acceleration / vibration and many more
    - Rotational speed and angle
    - Voltage, current, temperature and others
- Vehicle busses: CAN and CAN FD (incl. CCP and xCP-on-CAN)
- Wheel Force Transducers (WFT) connection by voltage inputs, CAN or Ethernet bus
- Kinematics and absolute position by 6 DOF Inertial Measurement Units (IMU) in combination with GNSS sensors (GPS, Glonass, Baidu, Galileo, …) and its NMEA protocol based data transfer via RS232, USB, Ethernet or CAN bus
- Digital video: USB or Ethernet based

All QuantumX / SomatXR analog inputs offer 24 bit aliasing free sampling with configurable embedded filters. Data analysis can also be done with the powerful software GlyphWorks for durability, noise, vibration, performance and handling.

WFTs are typically 6 component transducers measuring 3 forces and 3 moments, plus rotational angle and speed in a car or commercial vehicle. WFT can be used spinning / rotating in mobile testing or static in structural durability bench testing. WFTs are mounted on any kind of vehicles from F1 race cars over regular cars to commercial vehicles like tractors, trucks or harvesting machines. In most of the test cases vehicles with WFTs are driven along a predetermined proving ground track for force and torque analysis on one or two axles or two or four wheels together with other physical quantities acquired in parallel.

WFTs are available from many suppliers like AIM, A&D, CAEMAX, Datron, Kistler, Michigan Scientific, PCB, Kyowa, and others – all supported by QuantumX / SomatXR and its software catman by different integration aspects.

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). **KiRoad Performance** is the central electronic system and interface transferring telemetric data from all corners to an Ethernet based Kistler proprietary protocol. In this special field HBK and Kistler are partners giving the end user and customer an easy to integrate solution via a single Ethernet fully digital solution together into their data recorder QuantumX / SomatXR data recorder in terms of an open eco system aspect. RoaDyn wheel force transducers are available for several different vehicles like passenger cars, SUVs, trucks, agricultural and off-highway vehicles, and race cars. The acquired wheel forces are transferred wirelessly from the turning wheel to the vehicle (telemetry) and are then transferred to a central gateway.

System Overview

SomatXR measurement modules can be connected via a single cable KAB272 to the Data Recorder CX22B and are synchronized, powered and data linked. The Kistler mobile control unit KiRoad Performance is connected to the SomatXR in the following way:

- Direct clock and sync line from Kistler KiRoad Performance to MX840B-R (or any other voltage input)
- Ethernet TCP/IP connection to CX22B directly

All incoming data from KiRoad Performance is time stamped directly with the catman kernel task. Run-time variances on package-based Ethernet protocol leads to a little time shift. Time shifts in the signals can generally occur by inappropriate filter settings caused by different measurement electronics.

Telemetry system and Kistler KiRoad Performance

The telemetry counterparts of the WFTs are installed in the chassis and all components are wired to **KiRoad Performance**, which is the central control unit. KiRoad Performance consists of an integrated voltage supply unit, network connection and signal conditioning to convert force and torque signals from the wheel force transducer into data signals referenced to its origin. Parameterization is mainly done via web-based graphical user interface.

The preferred connection of KiRoad Performance to the SomatXR system is via Ethernet. Alternatively, it may also be integrated via CAN bus to SomatXR module MX840B port 1 or any of the MX471C CAN ports.

The firmware of KiRoad Performance should have as a minimum the following firmware version:

- Firmware version: 2.0.0.6 or higher
- Kernel version: 1.0.8.27 or higher

Check latest firmware on: https://www.kistler.com/en/product/type-9817a/

The Ethernet interface supports

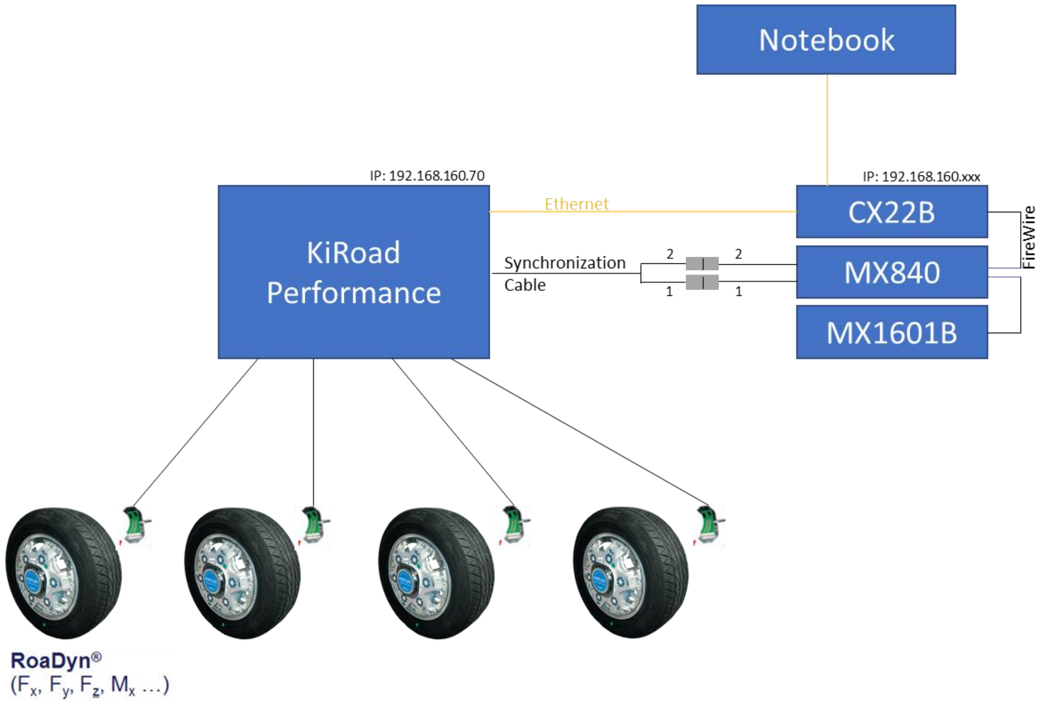
- TCP/IP communication for fast data streaming and for communication
- Pre-configured net mask: **255.255.255.0**
- Pre-configurable IP address: **192.168.160.70** (default)
- Integrated web server for functional check
- Used Ethernet ports: 6155 - Control (EMCOP), 6157 - Status (EMCOP) and 6158 - Data (DAQ streaming protocol) for communication over TCP/IP
- Data format of measurement quantities: FLOAT with 4 Byte

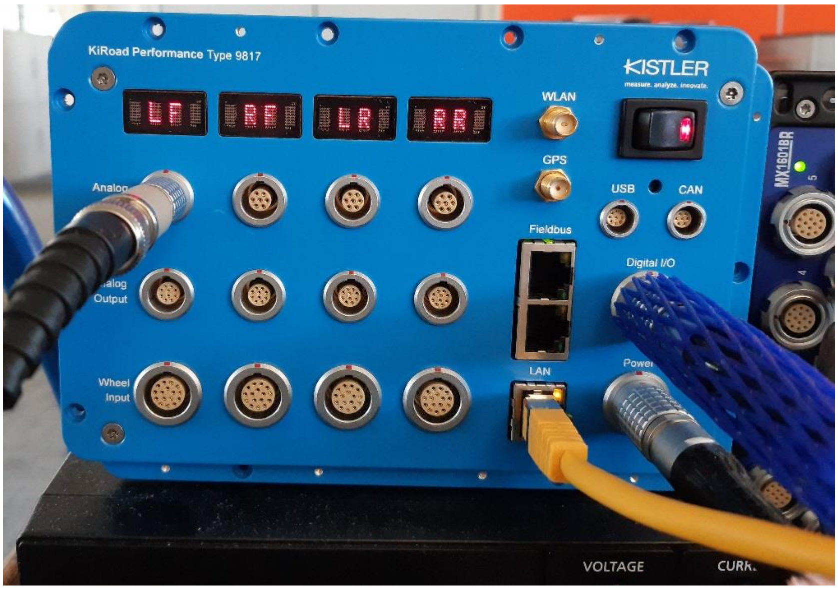
Synchronisation with SomatXR: direct trigger line (start) and clock

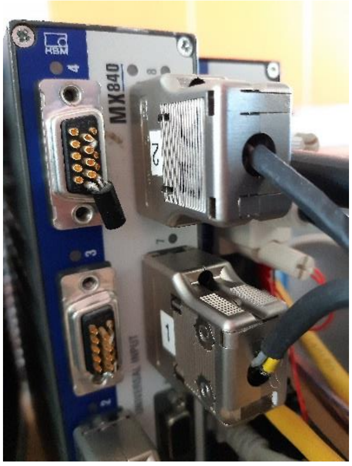
SomatXR Data Recorder CX22B can acquire up to 5 MS/sec as sum data rate. The AD inputs deliver 4 Byte per sample. KiRoad Performance delivers also 4 Byte per sample.

Step by Step integration of KiRoad Performance via Ethernet to QuantumX CX22B-W

1. **Cabling**
   - Connect all measurement modules via KAB272 to the CX22B data recorder and power them. All modules can be powered with 10 - 30 V DC.
   - Connect *Kistler KiRoad Performance* via Ethernet (LAN port) to CX22B data recorder. KiRoad Performance device can be powered with max. 36 V DC (max. 150 W).
   - Connect your Notebook via Ethernet (port 2 or WLAN) to CX22B for configuration. Alternatively, you can directly connect a display or touch screen (USB, DVI-D), keyboard and mouse to CX22B.
   - To connect KiRoad Performance to MX840B module, use *'Kistler KiRoad Performance Synchronization Cable'*. An adapter cable is needed to connect both devices. According to the labelling, line 1 (***trigger signal***) connects to MX840B connector 7 and line 2 (***clock signal***) to MX840 number 8 connector.







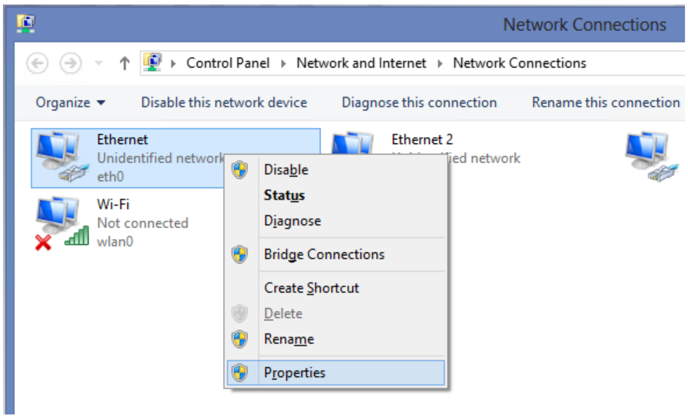
2. IP address configuration

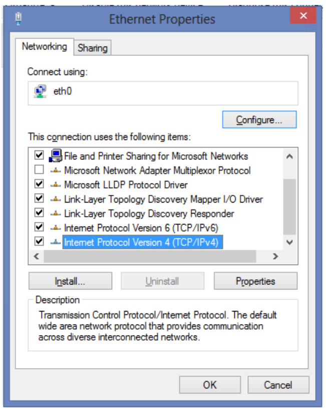
*Note: Make sure to configure **both** used Ethernet interfaces of CX22B!*

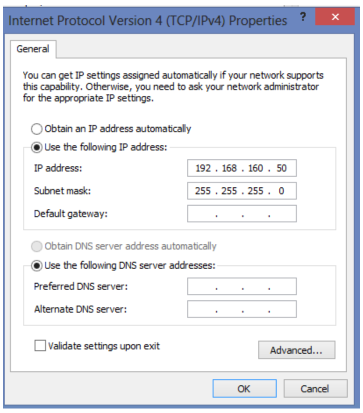
Start *'HBM Device Manager'* software on your PC and search your network for CX22B.

- configure Ethernet adapter you work with,
  recommended: **dynamic IP addressing (DHCP/APIPA)**
- connect KiRoad Performance to the second Ethernet adapter of your recorder, go to Windows and configure IP address,
  recommended: **192.168.160.50** subnet mask: 255.255.255.0

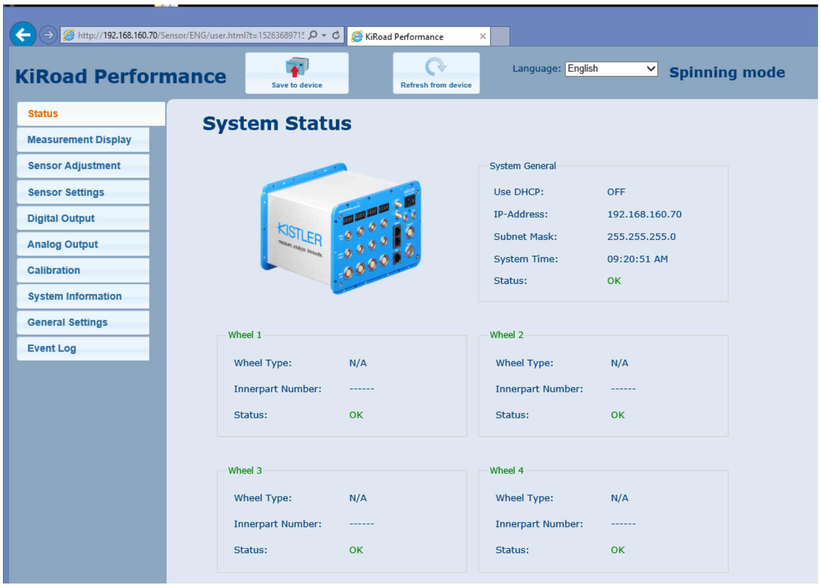
KiRoad Performance is configured with a static IP address:
KiRoad Performance: **192.168.160.70** fix subnet mask: 255.255.255.0





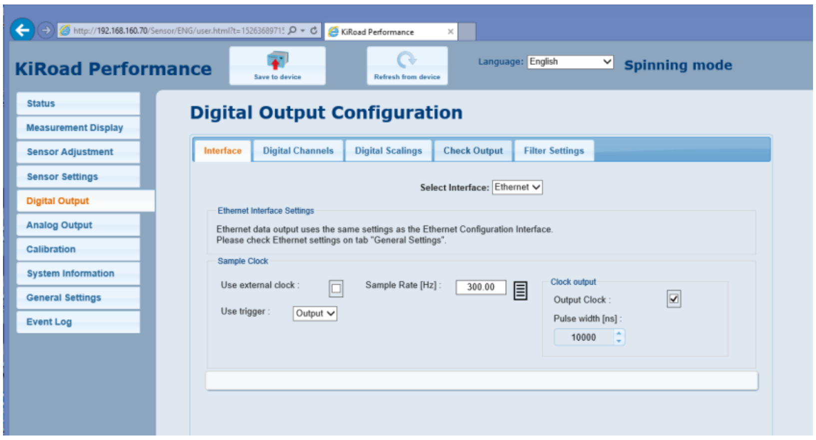


3. **Configure RoaDyn system** (number of channels or signals, etc.) using the associated configuration software or remote control.
   Therefore enter IP-address of the KiRoad Performance in a browser (http://**192.168.160.70**). In order to be able to change settings you must have admin rights (see General Settings), the default password is 'kistler'.

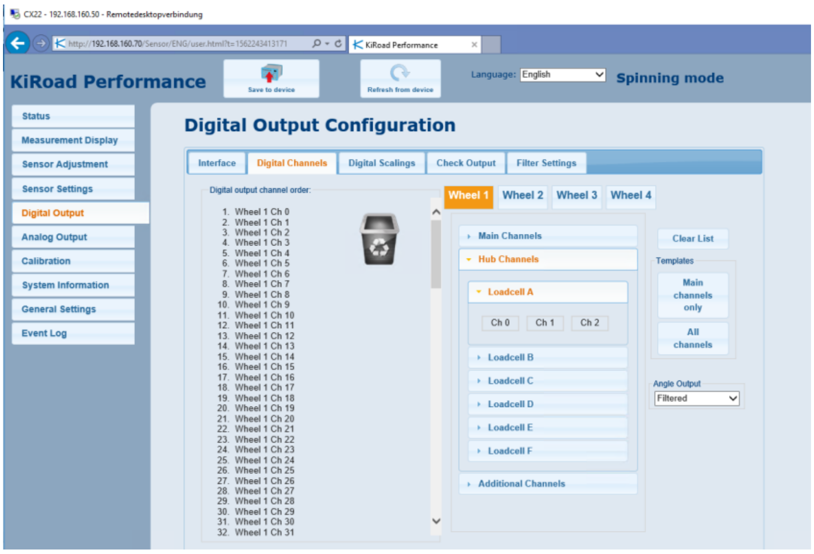


In 'Digital Output' panel, set

- Sample rate = 300.00 (recommended)
- Use trigger = Output
- Tick *'Output Clock'*
- Pulse width = 10000 (recommended).



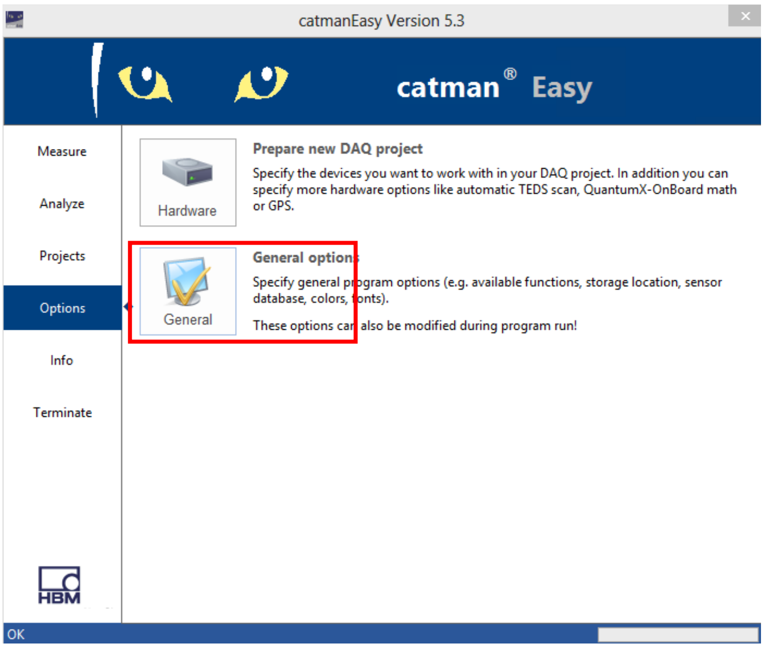
In '*Digital Channels'* tab select the channels you wish to have available in catman. The sample rate is of no concern, it will later on be modified by catman.



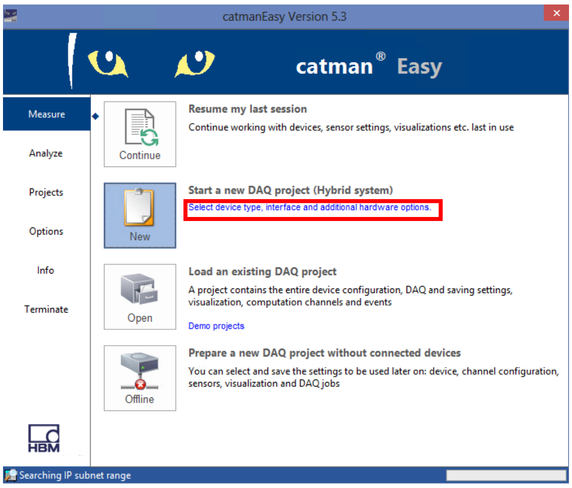
! Do not forget to save your changes via *'Save to device'.*

4. **CX22B-W / catman software requirements**
   Ensure that you use the latest version of catman on your CX22B-W.
   Ensure that you have a catman AP license.

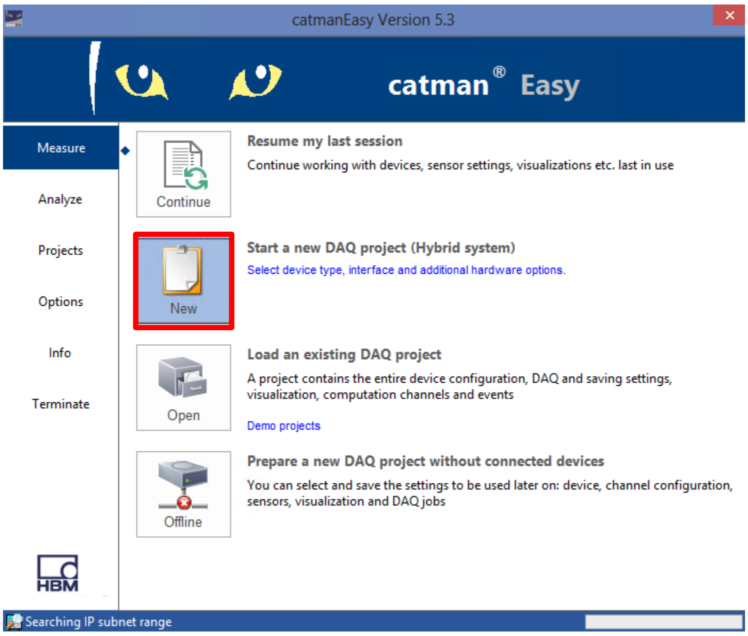
5. **Start catman** on Data Recorder and open dialogue *'General Options'*.



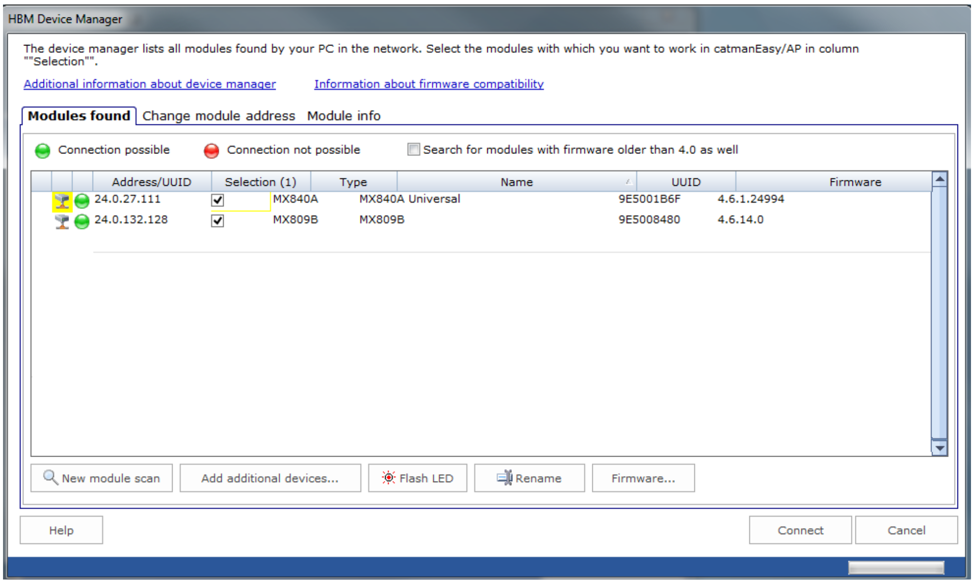
6. Open *'Configure device scan'* dialogue.



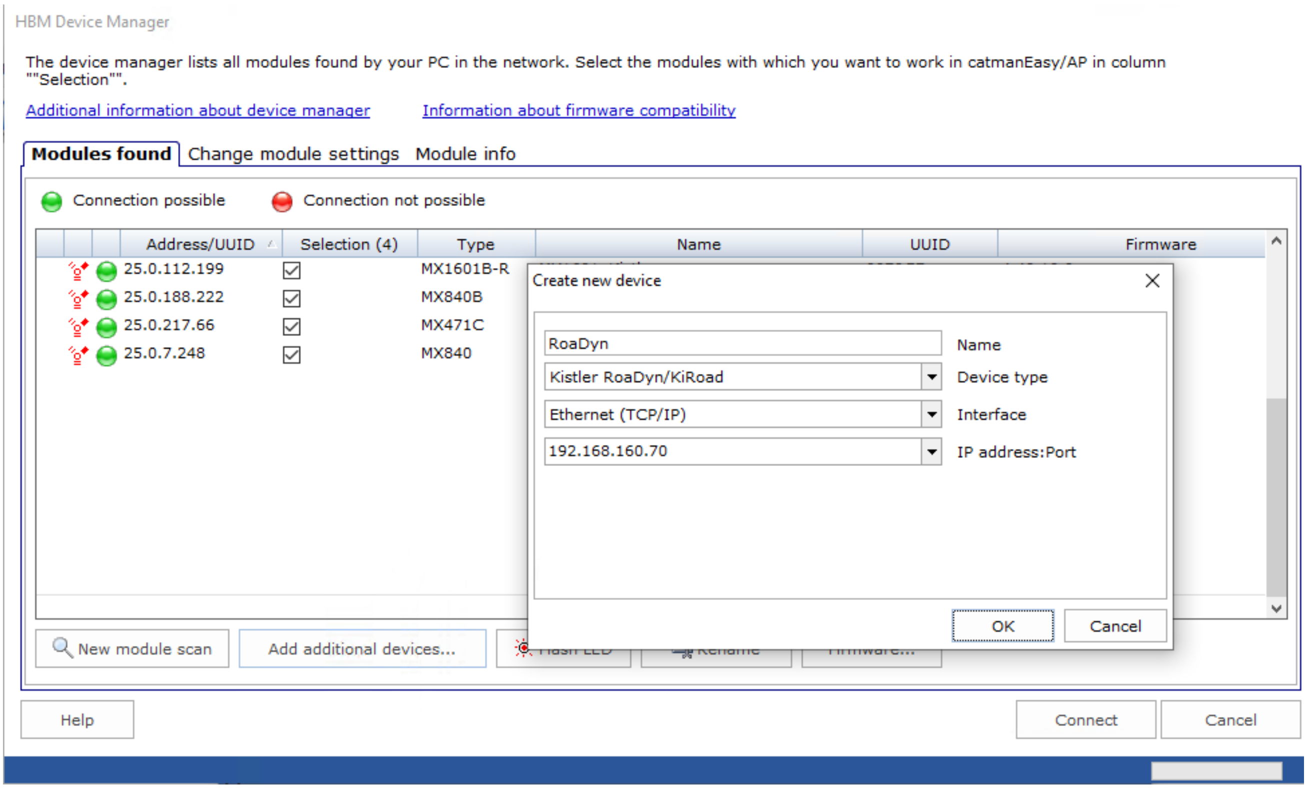
7. Start *'New DAQ project'*.



8. Connect to the HBK devices you want to work with.



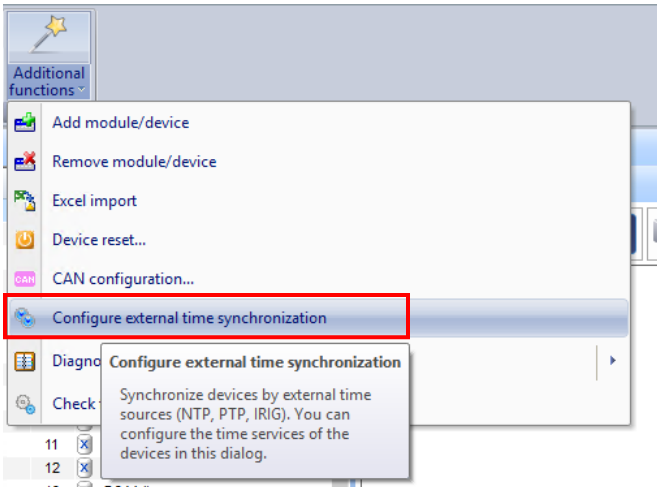
9. Add additional device in catman



10. After device scan you see all DAQ channels. Select the channels you connected **start** and **clock signal** coming from KiRoad Performance with and rename them to '**Trigger**' and '**Clock**' for better traceability.

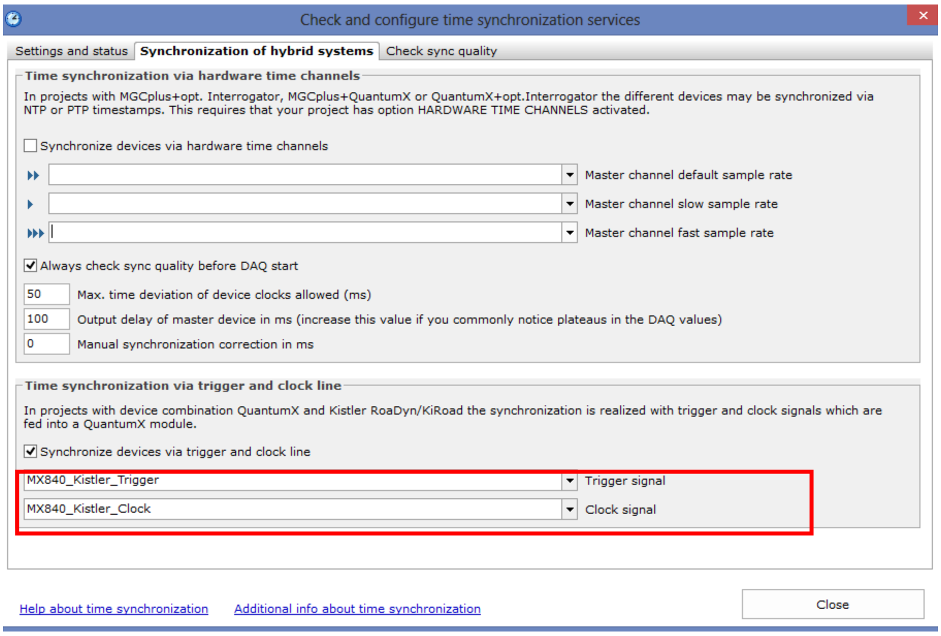
11. Configure external time synchronization

Open synchronization dialog via *'Additional Functions'*:

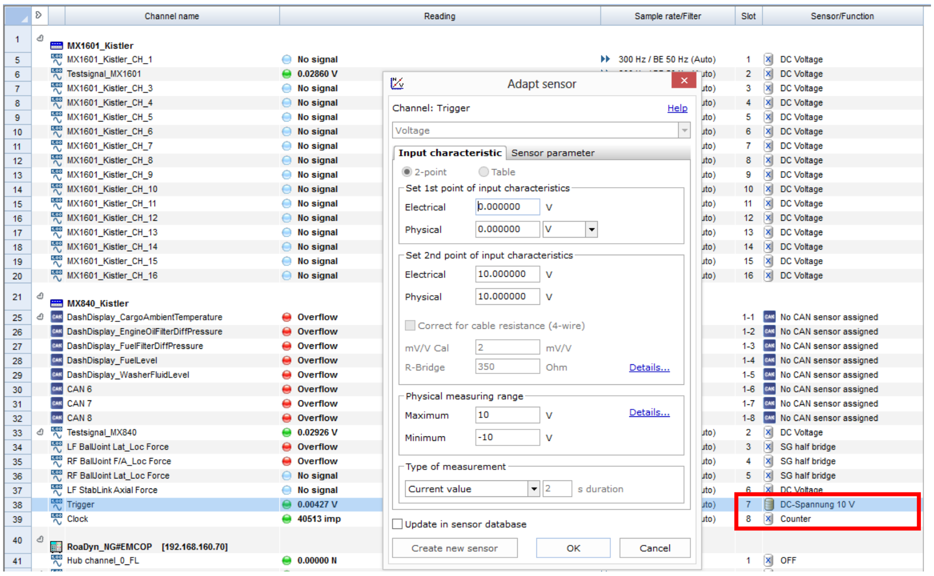


Go to *'synchronization via trigger and clock line'* tab:

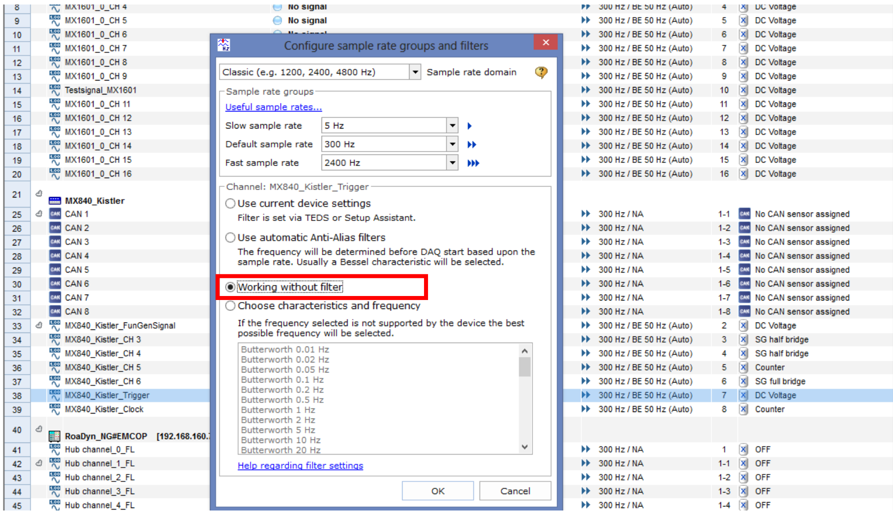
Choose 'Trigger' as input for Trigger signal and 'Clock' as *input for Clock signal*.



12. Configure Trigger channel as a *10V DC Voltage* input and Clock input as a *counter* by double-clicking on currently selected sensor/function.

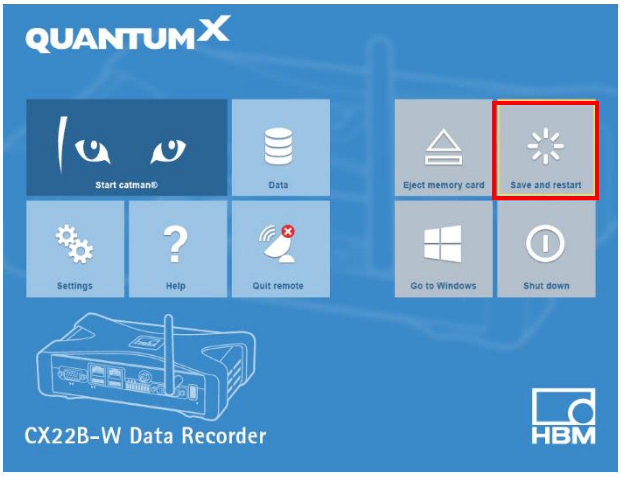


13. Disable filter for Trigger and Clock channel.



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

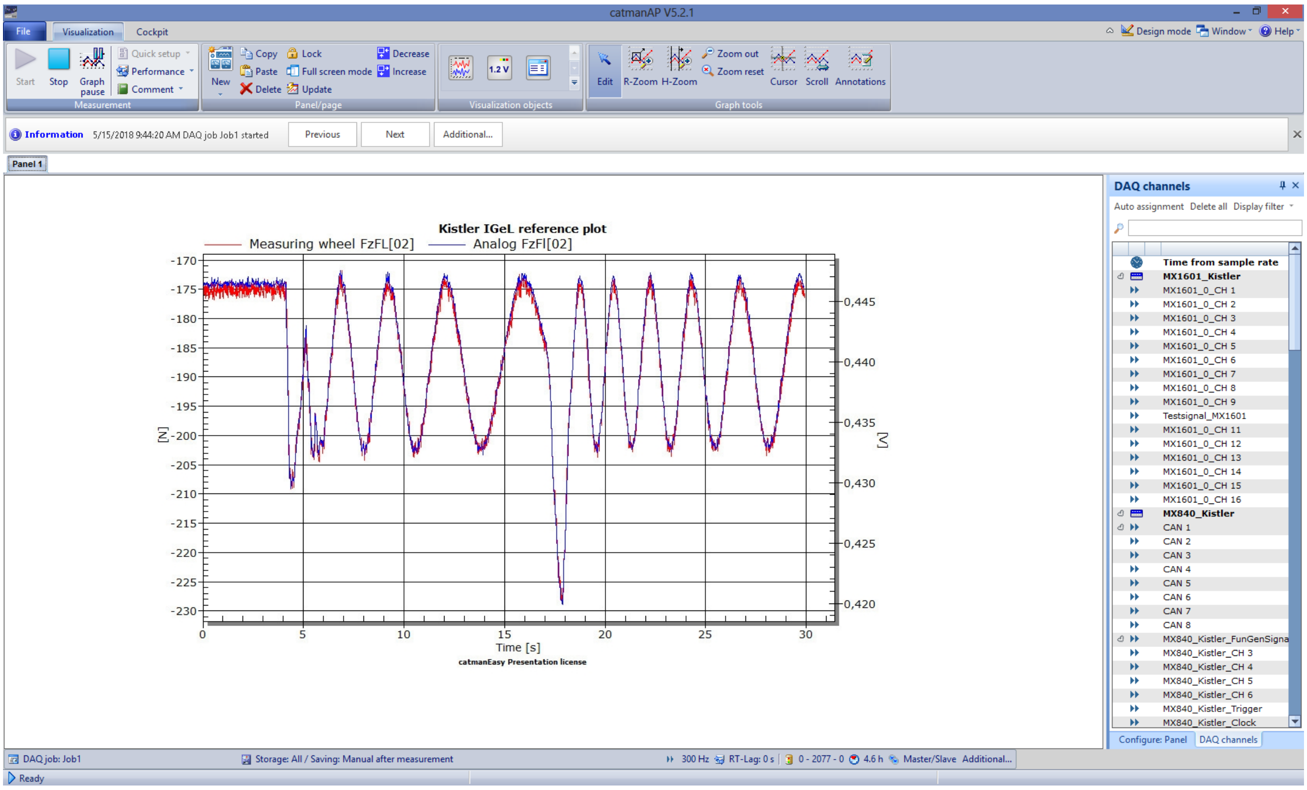
15. Finalize all settings by saving everything permanently and restarting the unit!



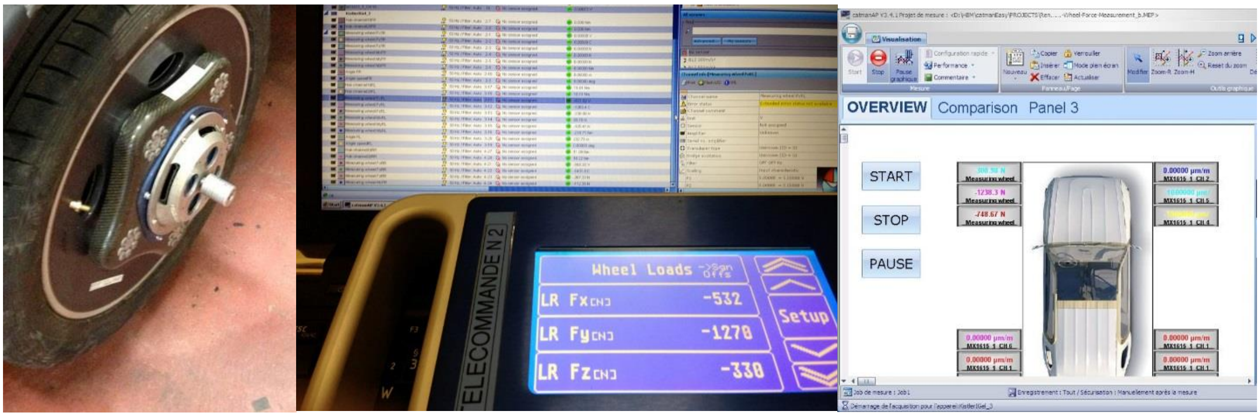
Proof of Time Synchronization

Synchronization between analog 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 an MX module
- Force z-direction front left tire digital Ethernet TCP/IP protocol to CX22B Data Recorder
- Both inputs compared to each other with different signal load to the Recorder.



Screenshots



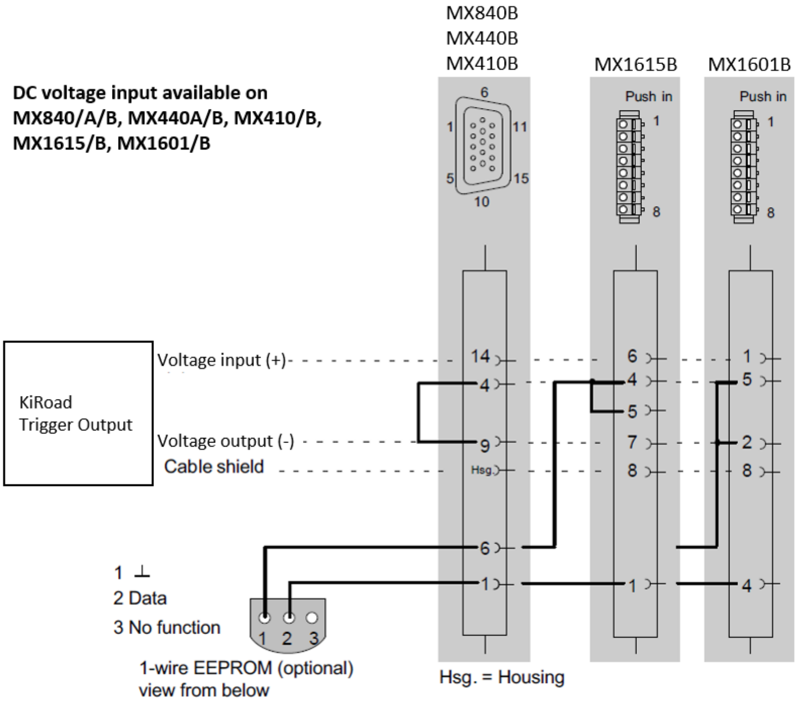
Picture: Kistler wheel, remote control and screenshot showing live data acquired over Ethernet

Troubleshooting

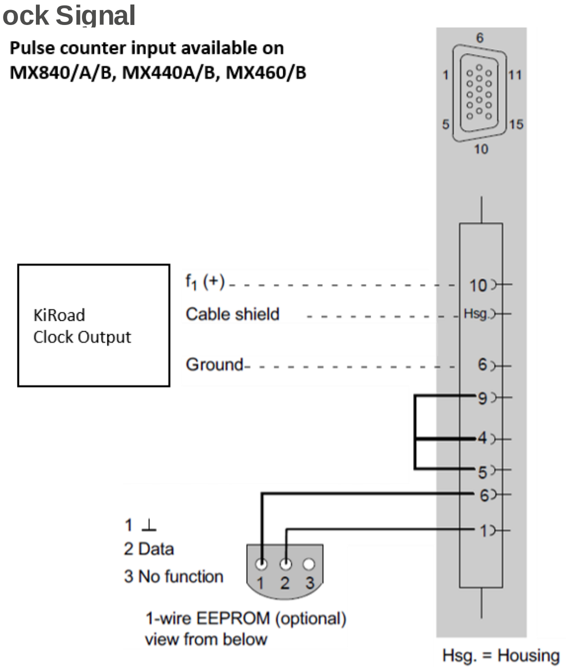
If connection to RoaDyn electronics is missing please check the IP address and parameterize accordingly with software or handheld device from Kistler.

Inputs QuantumX

Pining Trigger Signal



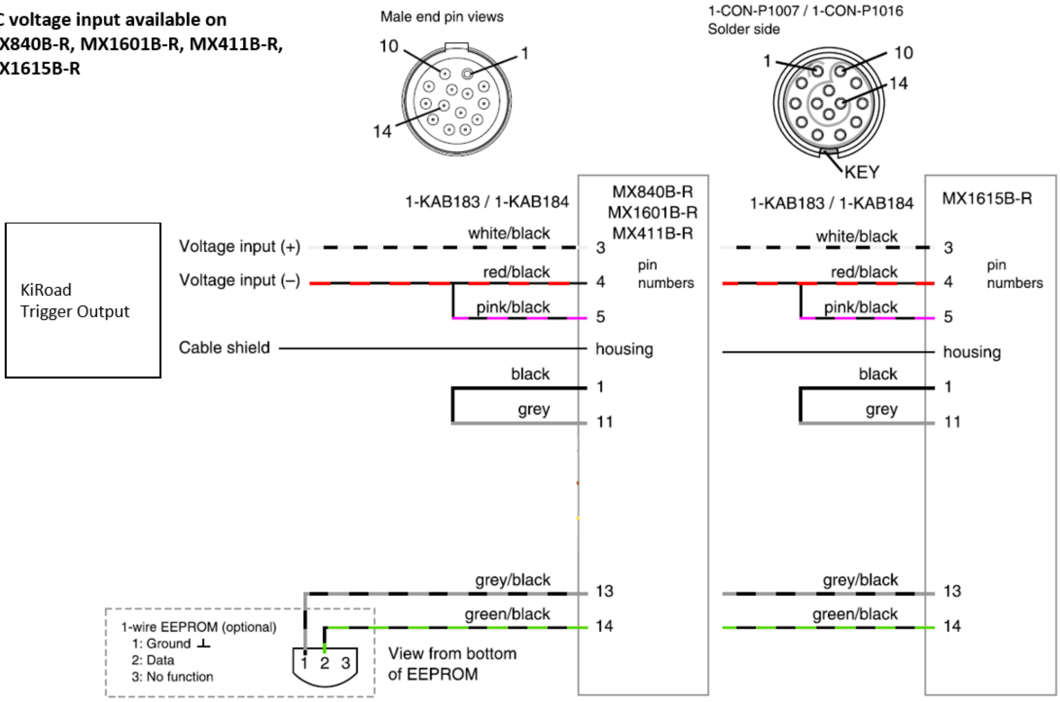
Pining Clock Signal



Inputs SomatXR

Pining Trigger Signal

DC voltage input available on MX840B-R, MX1601B-R, MX411B-R, MX1615B-R



Pining Clock Signal

Pulse counter input available on MX840B-R, MX460B-R