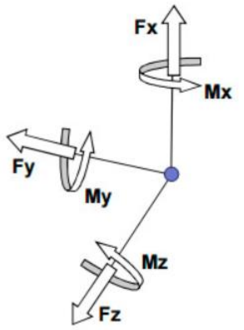
TECH NOTE #121:: QuantumX and Multi-Component Sensors (MCS)

Version: 2020-12-14
Status: public

Introduction

Many tasks in testing and measuring require the use of multi-component sensors (MCS) for the metrological analysis of forces and moments with typically 3, 4, 5, or 6 spatial degrees of freedom addressed in the application.



Apart from the forces in the corresponding axial direction, MCS can also measure torque values that act around the axes. Thus, an MCS can capture a maximum of six dimensions: F_x, F_y, F_z, M_x, M_y, M_z.

If there is a need to measure forces or torques along multiple vector axes in robotics, for example, the use of such MCS is recommended. Multi-axis sensors save a lot of space and installation work in comparison with installing several single-axis sensors. Thus, a single MCS enables the multidimensional measurement of physical quantities. This feature makes multi-axis sensors ideally suited for applications that involve determining a multidimensional load described in the form of x-, y- and z-vectors.

However, there are numerous other applications such as:
- Aircraft fuselage assembly
- Wind tunnel balances
- Tunnel boring machines
- Tire test benches
- Balancing machines
- Centering in the offshore area
- Trailer tests
- and much more

HBK builds and markets MCS10 and also offers the complete measurement chain up to the measurement analysis software.

MCS10 details: LINK

In the field of **Testing & Measuring**, the modules of the **QuantumX** series are primarily used in measuring applications, and the **catman Easy/AP** software is used for the visualization and analysis of measured data. In parallel, the MCS10 can be integrated in **real-time**, for example, to automate test sequences or to regulate superstructures.

In applications with MCS10, the topic of "**crosstalk**" is particularly important. This Tech Note looks at the measuring chain setup, highlighting the details of this aspect and its compensation for obtaining highly accurate measurement results.

Example setup of MCS and QuantumX

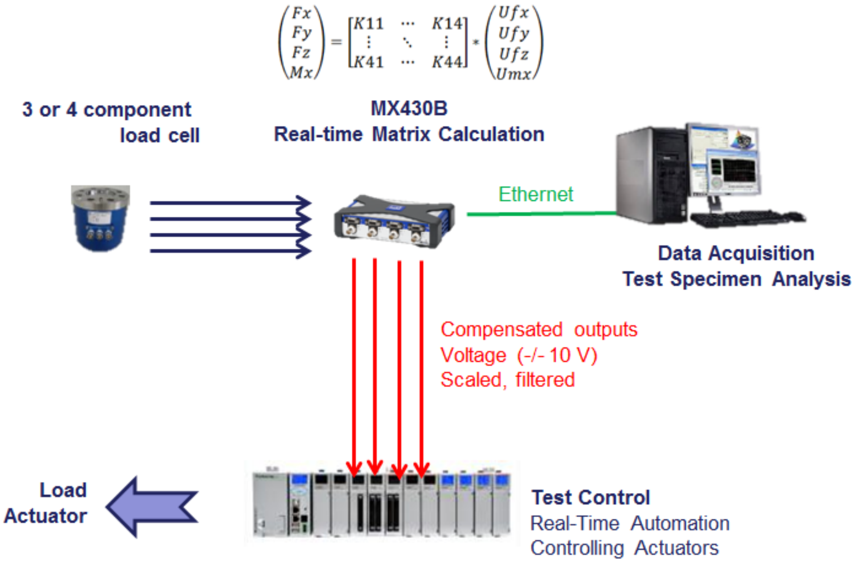


Figure 1: Wind tunnel balance

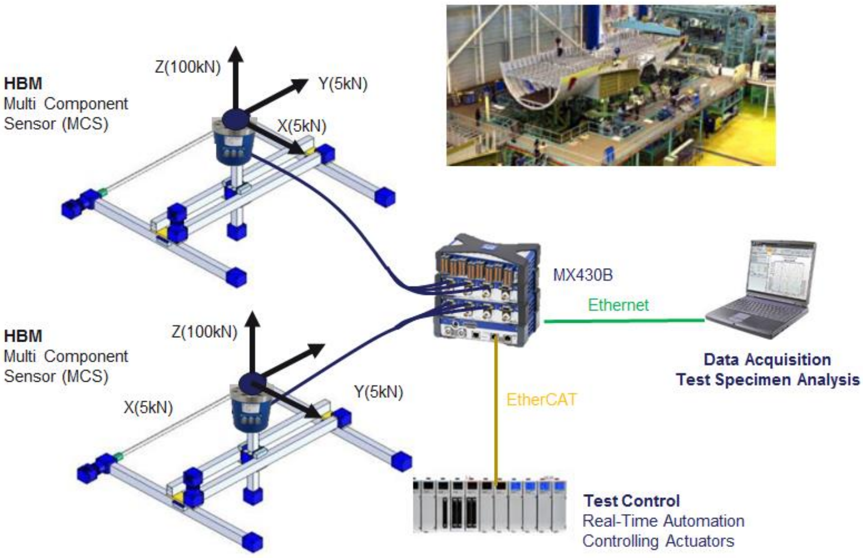


Figure 2: Aircraft fuselage testing

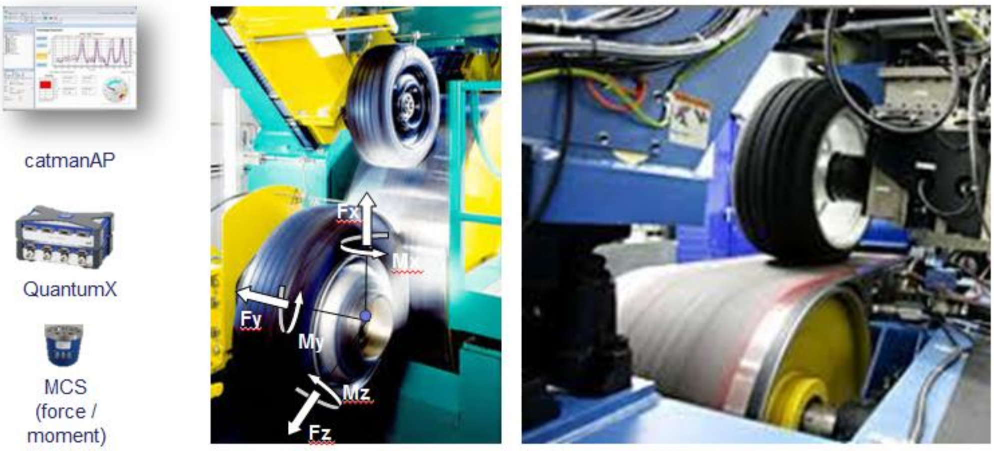
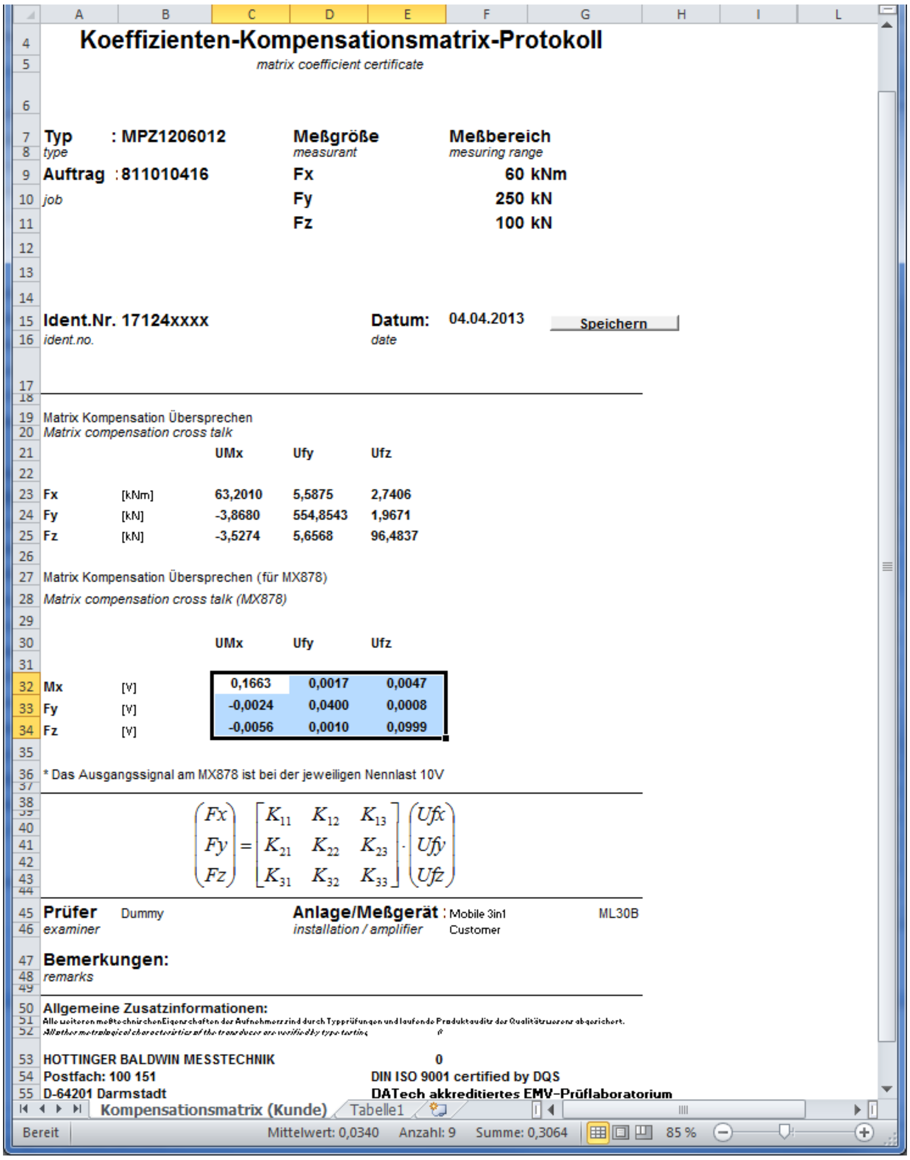


Figure 3: Tire test bench

Compensation matrix:

Strain gauges cannot be installed 100% exactly in the respective effective direction. Therefore, the compensation of crosstalk and thus the influence of one force or moment component on the other measuring circuits is helpful to obtain more precise results. The influences are determined during calibration using precision measuring amplifiers, such as QuantumX MX430B or MX238B. The resulting compensation matrix is used to mathematically compensate for the crosstalk of the other measuring circuits on the measured variable that needs to be compensated for, i.e., it compensates for the crosstalk of the other degrees of freedom, for example, Y on the X-axis, and so on. Computing the measured value using this matrix results in force or torque values in the X, Y, or Z direction. For mathematical compensation, the individually measured variables are multiplied by the corresponding coefficients of the compensation matrix.



Koeffizienten-Kompensationsmatrix-Protokoll

matrix coefficient certificate

Typ *type*	**: MPZ1206012**	**Meßgröße** *measurant*	**Meßbereich** *mesuring range*
Auftrag *job*	**:811010416**	**Fx**	**60 kNm**
		Fy	**250 kN**
		Fz	**100 kN**

Ident.Nr. 17124xxxx *ident.no.* — **Datum:** *date* 04.04.2013 — Speichern

Matrix Kompensation Übersprechen
Matrix compensation cross talk

		UMx	Ufy	Ufz
Fx	[kNm]	63,2010	5,5875	2,7406
Fy	[kN]	-3,8680	554,8543	1,9671
Fz	[kN]	-3,5274	5,6568	96,4837

Matrix Kompensation Übersprechen (für MX878)
Matrix compensation cross talk (MX878)

		UMx	Ufy	Ufz
Mx	[V]	0,1663	0,0017	0,0047
Fy	[V]	-0,0024	0,0400	0,0008
Fz	[V]	-0,0056	0,0010	0,0999

* Das Ausgangssignal am MX878 ist bei der jeweiligen Nennlast 10V

$$\begin{pmatrix} Fx \\ Fy \\ Fz \end{pmatrix} = \begin{bmatrix} K_{11} & K_{12} & K_{13} \\ K_{21} & K_{22} & K_{23} \\ K_{31} & K_{32} & K_{33} \end{bmatrix} \cdot \begin{pmatrix} Ufx \\ Ufy \\ Ufz \end{pmatrix}$$

Prüfer *examiner* Dummy — **Anlage/Meßgerät** *installation / amplifier* : Mobile 3in1 Customer — ML30B

Bemerkungen: *remarks*

Allgemeine Zusatzinformationen:

HOTTINGER BALDWIN MESSTECHNIK — 0
Postfach: 100 151 — DIN ISO 9001 certified by DQS
D-64201 Darmstadt — DATech akkreditiertes EMV-Prüflaboratorium

Kompensationsmatrix (Kunde) | Tabelle1

Bereit — Mittelwert: 0,0340 — Anzahl: 9 — Summe: 0,3064 — 85 %

Figure 4: Compensation matrix in Microsoft EXCEL format provided with the sensor by HBK

All MCS from HBK are delivered with this compensation matrix in Microsoft Excel format.

This so-called crosstalk can **be compensated for in real time** using the QuantumX measuring amplifier system from HBM or **online** in the catman Easy software. The parameterization is simple and intuitive via the software.

The measuring chain with QuantumX

QuantumX is the reference in measuring technology in terms of accuracy, flexibility, and efficiency.

MCS10 can be ordered individually with the desired number of measuring bridges, from the 2-component force transducers to the 6-component force and torque transducer. Each degree of freedom requires a measuring channel. MCS with up to 4 degrees of freedom can be connected directly to a QuantumX MX430B, a 4-channel precision measuring amplifier with analogue outputs, connected to the PC via Ethernet. The crosstalk of forces and moments can be compensated for directly on the module and in real time. The **compensation matrix** provided by HBK with the transducer is required for this purpose. For example, the compensated signals can be output directly as standardized voltage signals and made available to the automation system.

Other possible measuring amplifiers are the types MX238B, MX410B, MX840B or also MX1615B. The main differences here are in the accuracy, the additional channel properties, and the number of channels per module.

When using 5- and 6-component transducers, modules such as the MX430B or MX238B can also be used in combination, and the measurement signals can be transferred in real time via the system bus to a corresponding module with real-time function calculation and analogue outputs such as the MX878 or MX879. For instance, besides real-time mathematics and the eight analogue outputs, MX879 also offers 32 digital inputs or outputs for alarms.

Other options for integration include

- **CAN/CAN-FD** using the MX471C
- **EtherCAT** or **PROFINET** using CX27C.

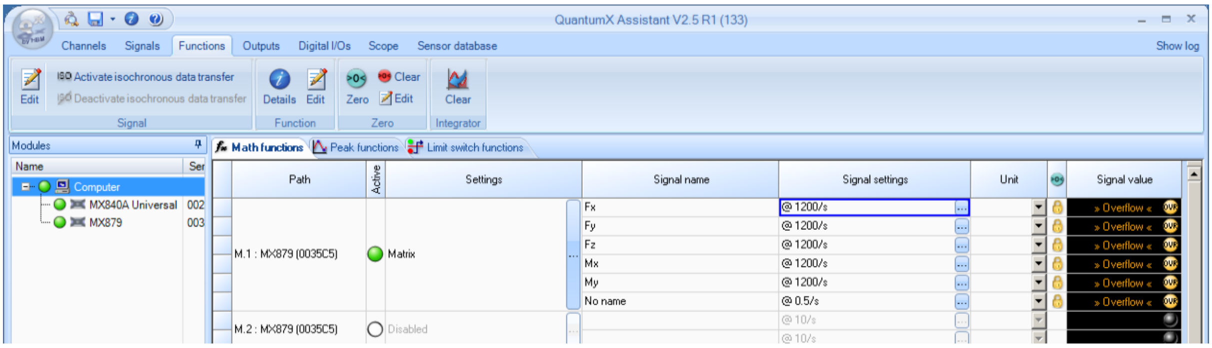
QuantumX details: LINK

Compensation or matrix calculation in real time

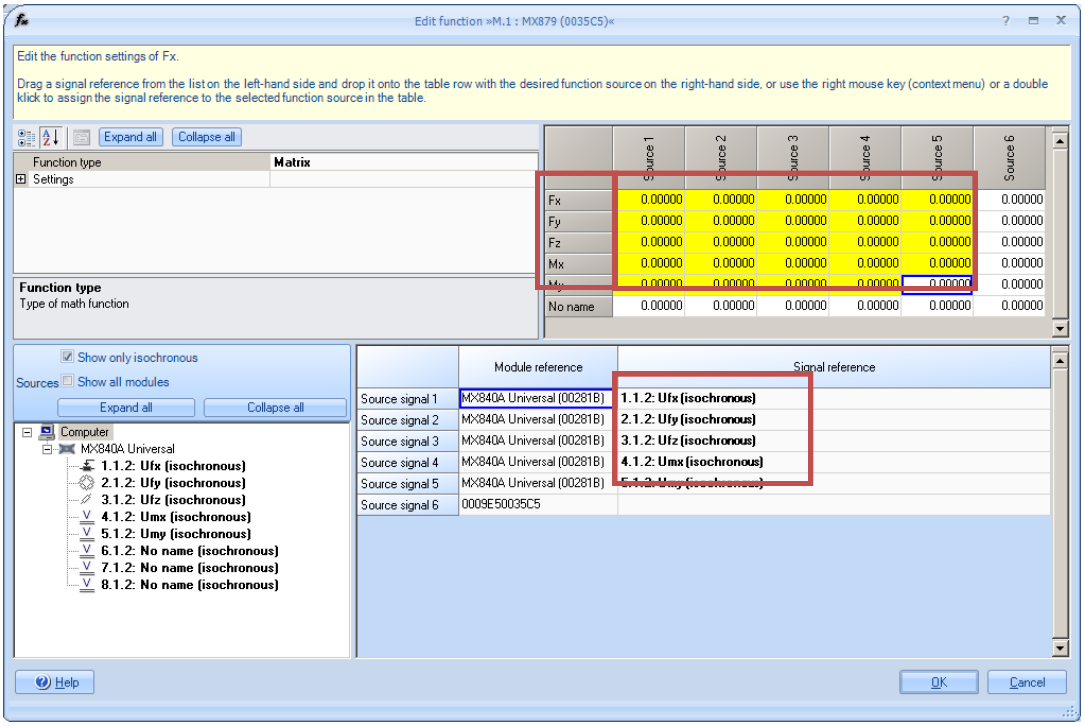
Real-time computation and output offer the advantage that the signals can be picked up by an overall control or test bench automation system. Since no PC is “in-between”, very short latency times of 4pprox.. 1 ms can be maintained. The compensated signals, such as torque M_x or force F_y, are received directly as actual values and control variables. Of course, the raw signals, as well as the compensated force and torque signals, can be analyzed, calculated, visualized and stored in parallel in the catman Easy PC software.

The real-time function is parameterized using the free MX Assistant software

1. Channels tab: Parameterize all input channels
2. Signals tab: Each QuantumX channel generates two signals – make the 2nd signal level visible. Switch the second signal of all relevant measuring inputs to “Isochronous mode” so that these signals are available in real time on the system bus.
3. Functions tab: Select the “MATRIX” function. Assign appropriate signal names for the signals resulting from the matrix calculation, such as Fx, Fy, and so on

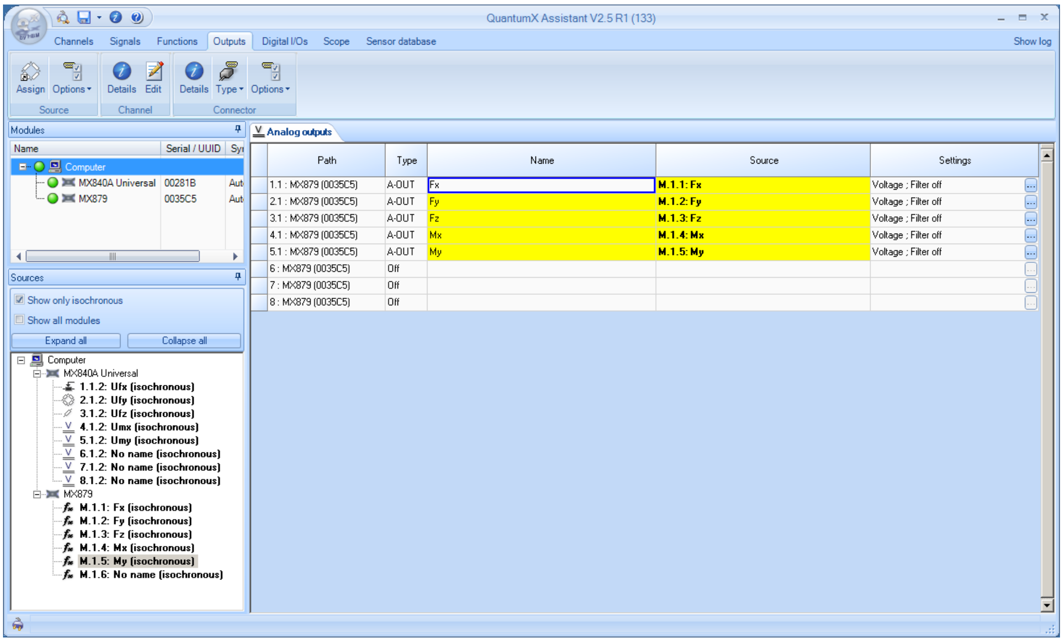


4. If the compensation matrix in Microsoft Excel format is available, copy the relevant part from it to the matrix parameterization of the Quantum X Assistant.



5. Outputs tab: You can now apply the results of the matrix calculation to the corresponding analogue channels.
   a. To do this, activate the isochronous data transfer in the Functions tab

b. In the Output tab, you can assign these signals to the corresponding analogue output.



If real-time and control or automation are not an issue, then the parasitic influences from the signal values can also be easily calculated in the powerful catman Easy measurement data acquisition software.

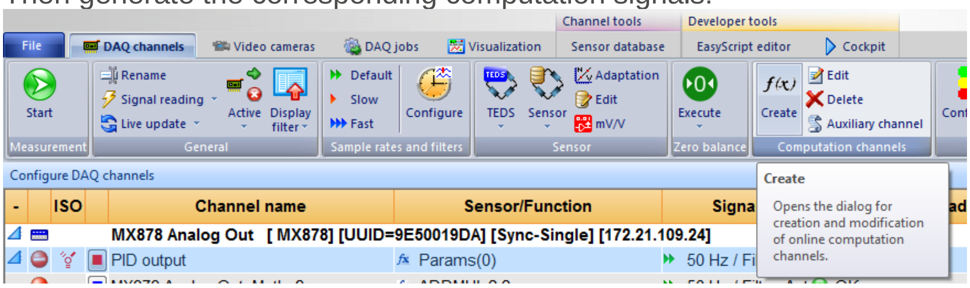
catman Easy

The calculation of the compensated force F x of a 3-component sensor is shown here as an example:

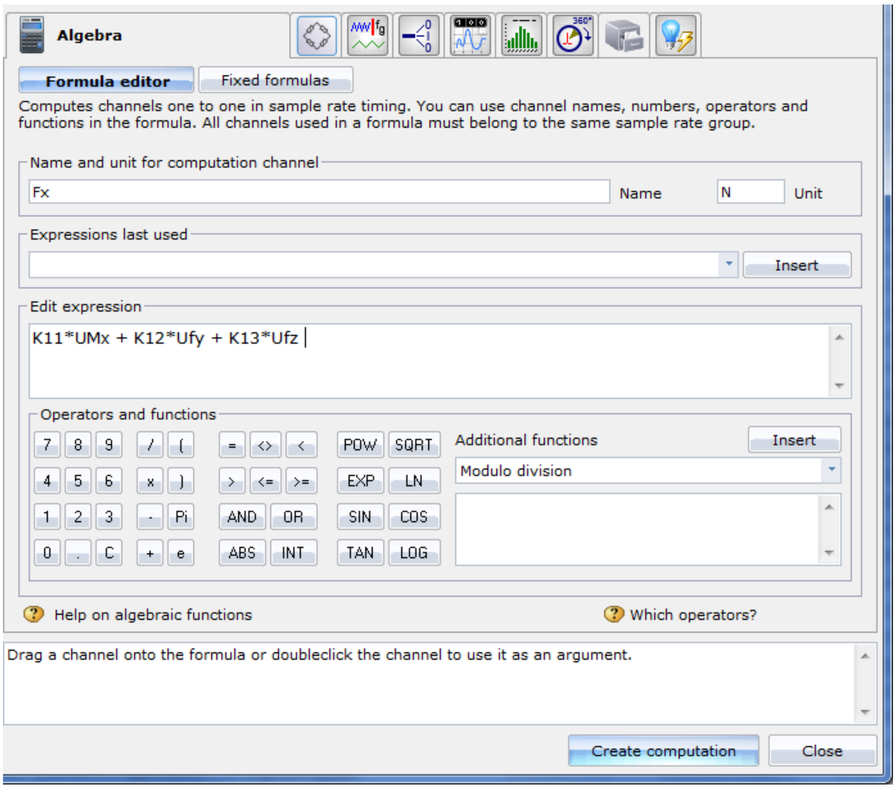
$F_x = K_{11}*U_{Mx} + K_{12}*U_{fy} + K_{13}*U_{fz}$

Working with catman Easy

1. Parameterize all channels of your measuring amplifier
2. Then generate the corresponding computation signals:



The editor allows you to create any algebraic calculations:



3. These newly created virtual signals are calculated online on the PC during the current measurement and can be visualized and analyzed, like a real measuring channel, for the time, frequency, and angle range or for another measurement variable such as distance.

Both approaches can also be pursued in parallel.

-- Ends