## nemi DAQ

Wireless multi sensor for measuring and monitoring strains, forces, displacements and much more

Description

nemi DAQ is i4M's compact all-rounder in terms of **D**ata **A**c**Q**uisition. It is a telemetry module with a wide range of connection options to measure strains, forces, displacements or temperatures. In addition to that, various other analog and digital sensors can be connected. With its integrated IMU, it also measures accelerations, rotation rates, rotation angles and magnetic fields. Due to the highly efficient nemi Link 2400 radio technology, the nemi DAQ has a very long battery life.

Key Features

- **Compact & lightweight design** (85 x 72 x 19) mm, 150 grams
- **Variety of connection options** for data collection to choose from
- **Completely wireless and maximized battery life** due to our radio technology nemi Link 2400
- Transmission of **live raw data** or **smart data** pre-evaluated by edge computing
- **Weather resistant box** on request
- **Permanent installation** possible with wide range voltage input
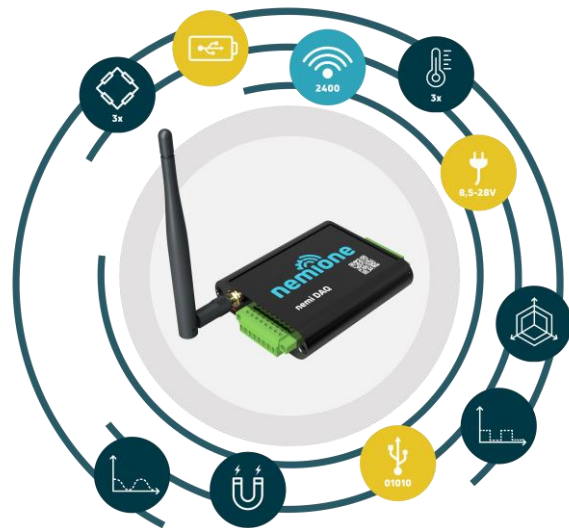
Connection of up to **3 Wheatstone / strain gauge full bridges**

Connection of up to **3 potentiometer sensors**

Connection of up to **3 temperature sensors** (Pt100 / Pt1000, thermocouples, thermistors);

IMU sensor module for measuring accelerations and rotation rates in and around 3 axes each; ACC up to 16 g; GYR up to 4000 °/s

Connection of up to **3 analog sensors** with 0 - 10 V signal

Triaxial **magnetometer**; measuring range up to 16 Gauss

Connection of up to **6 sensors with digital output** with 5 - 24 V signal

nemi Link 2400 - i4M's own robust and **flexible radio technology** in the 2.4 GHz frequency band

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Power supply/ battery charging via **USB-C**

Internal rechargeable battery with more than 14 days continuous runtime at a sampling rate of 100 Hz

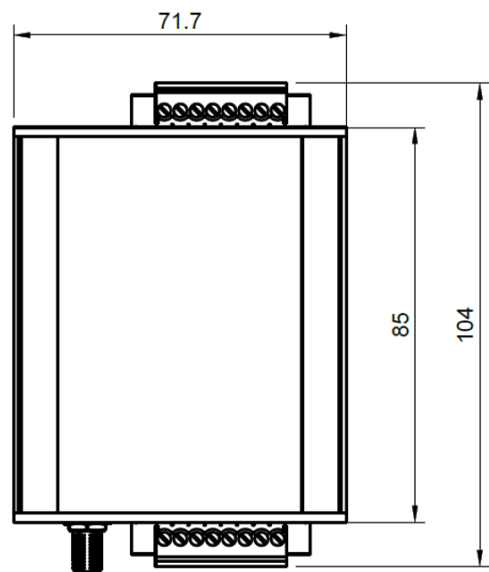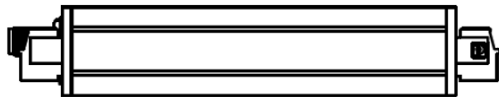Continuous operation with **wide range voltage input** 8.5 - 28 V DC

Specifications

General information		
Dimensions (without antenna and connectors)	85 x 72 x 19	mm
Weight	approx. 150	grams
Internal power supply	Lithium-ion battery, 1 cell	-
Runtime with full battery at 100 Hz	> 14 Up to several weeks depending on configuration	days
Charging time (0 - 100 %)	approx. 5	hours
External power supply (USB-C)	5	V
External power supply (wide range voltage input)	8.5 - 28	V
Temperature range permitted during operation	-20 to 60	°C
Onboard MCU, usable for edge computing	64 MHz ARM Cortex M4F, 1 MB Flash, 256 KB RAM; various hardware crypto features	-
Housing protection rating	IP 41	-
External analog sensors		
Connectable analog sensors	• Reference voltage sensors (e.g. wheatstone / strain gauge full bridges, potentiometer sensors or thermocouple (e. g. Type K) and thermistors) • Reference current sensors (e.g. Pt100 / Pt1000 resistance thermometers) • Analog sensors with 0 - 10 V voltage output	-
Number of analog channels	max. 3	-
Max. Sampling rates (with active channels)	6,400 (1 channel); 1,296 (3 channels)	Hz
Stability of sampling rate (over the entire temperature range)	± 50	ppm
Selectable signal gains	128 / 64 / 32 / 16 / 8 / 4 / 2 / 1	-
Possible feed currents	1,000 / 750 / 500 / 250 / 100 / 50	µA
Wheatstone bridge supply voltage	2.5 or 1	V
Signal resolution	24	bit
Analog measurement error	<< 1	%

External digital sensors		
Examples for digital sensors	Switching displacement, distance, level or angle of rotation sensors, TTL / NPN sensors	
Number of digital channels	max. 6	-
Sampling rate	2,000	Hz
Sensor switching voltage High-Level Low-Level	5 - 24 < 2	V
Additionally integrated 9-DoF IMU **3-axis MEMS accelerometer (ACC) / gyrometer (GYR) / magnetometer (MAG) each**		
Sampling rates	3,332 / 1,666 / 833 / 416 / 208 / 104 / 52	Hz
Selectable measuring ranges ACC	± 16 / 8 / 4 / 2	g
Selectable measuring ranges GYR	± 4.000 / 2.000 / 1.000 / 500 / 250 / 125	°/s
Selectable measuring ranges MAG	± 16 / 12 / 8 / 4	Gauss
Signal resolution	16	bit
Internal temperature sensor		
Measuring range	-20 to 60	°C

Dimensions

(All dimensions in mm)

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External power supply

If the power is supplied from a USB power supply without grounding, make sure that nemi DAQ is additionally grounded.

Connection and configuration options for external sensors

The nemi DAQ offers various connection options for external sensors with analog and digital outputs. Only the following combinations of sensor inputs are possible. First, the number of analog or digital inputs must be defined:

- 3 x analog and 2 x digital input **or**
- 2 x analog and 6 x digital input

Subsequently, it must be determined how the analog inputs are configured. The following options are available:

- Up to 3 reference voltage sensors (e.g. wheatstone / strain gauge full bridges, potentiometer sensors or thermocouple (e. g. Type K) and thermistors)
- Up to 3 reference current sensors (e.g. Pt100 / Pt1000 resistance thermometers)
- Up to 3 sensors with analog output 0 -10 V

For the digital inputs on nemi DAQ there is the following option:

- Up to 6 switching digital sensors with switching voltage level 5 - 24 V (e.g. switching displacement, distance, level or angle of rotation sensors) or TTL / NPN sensors

The options for setting gain and sampling rate by the customer are described in the next section.

Only the configuration of the analog and digital inputs must be defined and specified before delivery of the nemi DAQ. Subsequent modification is only possible by i4M technologies.

The following graphic shows the different configuration options K1 - K12. A combination of reference voltage sensors and reference current sensors on one nemi DAQ is not possible.

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Configuration options nemi DAQ

Pin assignment

nemi DAQ has 16 pins. Of these, 14 pins can be used to connect external sensors. The other two pins are used for the wide-range voltage input.

Channel 1 (pins 1 - 4) and channel 2 (pins 5 - 8) provide an analog input each. This can be - as already explained under connection and configuration options for external sensors - either a reference voltage or a reference current **or** a sensor with analog input 0 - 10 V.

For channel 3 (pins 9 - 12), four digital inputs with signal levels of up to 24 V can be connected as an alternative to one analog input.

Pin 13 and pin 14 each have a digital input with signal levels of up to 24 V.

Pin 15 and pin 16 are used for the wide range voltage input for permanent voltage supply. (Pin 15 "+" 8.5 - 28 V, on request also 5 V; Pin 16 "-" with GND)

The possible pin assignments of the analog and digital inputs are shown in the following figure.

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Pin assignments of the analog and digital inputs

		analog inputs		
		Reference Voltage	Reference Current	0 – 10 V	
Channel 2	GND	GND	NC	pin 8
	-	-	-	pin 7
	+	+	+	pin 6
	V_s	NC	NC	pin 5
Channel 1	GND	GND	NC	pin 4
	-	-	-	pin 3
	+	+	+	pin 2
	V_s	NC	NC	pin 1

	analog inputs			digital inputs	
	Reference Volltage	Reference Current	0 – 10 V		
pin 9	V_s	NC	NC	DIN 6	Channel 3
pin 10	+	+	+	DIN 5	
pin 11	-	-	-	DIN 4	
pin 12	GND	GND	NC	DIN 3	
pin 13	DIN 2				
pin 14	DIN 1				
pin 15	$V_{IN}+$				
pin 16	GND				

GND ≙ Ground

V_S ≙ Supply Voltage

$V_{IN}+$ ≙ Positive Input Voltage

NC ≙ Not Connected

DIN ≙ Digital Input

Example for pin assignment of configuration option K01

strain gauge full bridges   potentiometer

V_m ≙ Measuring Voltage

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Example for pin assignment of configuration option K12

$I_{CONST} \triangleq$ Constant Current $I_{COMP} \triangleq$ Compensation Current

Setting of the live radio transmitted sampling rate and signal amplification

The sampling rate of AD converter and IMU, the signal amplification of the AD converter, the measuring range of the IMU and the High-Levels of the digital inputs can be configured via our software.

Sampling rate of the external, analog sensors

The sampling rate of the external analog sensors transmitted live via radio applies to all active channels, but depends on the number of active channels. The more active channels are selected, the lower the sampling rate.

The active channel(s) can be freely selected between the three sensors via software configuration. If the highest possible sampling rate is required, we recommend activating only one channel. Then several channels can be activated again at a lower sampling rate.

The following table shows that the highest sampling rate of 6400 Hz is achieved when the ODR setting (ODR = Output Data Rate) is set to 2 and one active channel is selected. With three active channels and ODR Setting 1, the maximum sampling rate of the external analog sensors is 1,296 Hz.

ODR Setting	Mode	Number of active channels / live sampling rate [Hz]		
		1	2	3
0	from	AD off		
1	High Res		1,944	1,296
2	High Res	6,400	1,074	716
3	High Res	4,800	742	495
4	High Res	3,200	567	378
5	High Res	2,400	459	306
6	High Res	1,600	385	257
7	High Res	800	332	221
8	High Res	400	291	194
9	High Res	200	235	156
10	High Res	100	196	131
11	Ultra Low Power	100	100	100
12	Ultra Low Power	75	75	75
13	Ultra Low Power	50	50	50
14	Ultra Low Power	25	25	25
15	Ultra Low Power	1	1	1

The signal bandwidth (at -3 dB attenuation) corresponds to the sampling rate multiplied by a factor of 0.23. Accordingly, the -3 dB signal bandwidth at 6,400 Hz sampling rate is 1,472 Hz, and at 100 Hz sampling rate it is 23 Hz.

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Signal amplification of the external, analog sensors

With our software, the signal gain can be configured separately for each channel. According to the following table, if the gain setting is 1, the signal amplification is 1 and the measuring range for reference voltage sensors in relation to the supply voltage is thus 1000 mV / V. With a supply voltage of 2.5 V, this corresponds to a measuring range of the analog inputs of 0 - 2.5 V. Using a PT100 reference current sensor the absolute measuring range is 0 - 249 mV. By selecting a configuration for 10 V inputs, the measuring range of the analog inputs can be extended to 0 - 10 V by activating an attenuator.

| Gain Setting | Amplifi-cation | Reference Voltage Sensor | | Reference Current Sensor | | | Sensors with analog output 0 -10 V |
		Relative Measuring Range [mV / V]	Absolute Measuring Range [mV]	Absolute Measuring Range [mV]	Absolute Measuring Range PT100 [°C]	Absolute Measuring Range PT1000 [°C]	Absolute Measuring Range [V]
0	Channel off						
1	1	1,000.00	2,500.00	249	> 850	400	10.00
2	4	250.00	625.00	62.25	> 850	-	2.50
3	8	125.00	312.50	31.13	590	-	1.25
4	16	62.50	156.25	15.56	145	-	0.63
5	32	31.25	78.13	7.78	- 60	-	0.31
6	64	15.63	39.06	3.89	- 155	-	0.16
7	128	7.81	19.53	1.95	- 200	-	0.08

Sampling rate of the IMU

The sampling rate of the IMU can also be configured via the software. The sampling rate of the magnetometer (MAG) is always one eighth of the sampling rate of the accelerometer (ACC) and gyrometer (GYR). The following table shows that with a IMU ODR setting of 7, the sampling rate of the accelerometer and the gyrometer is 3,330 Hz and that of the magnetometer is 416 Hz.

IMU ODR Setting	ACC / GYR [Hz]	MAG [Hz]
0	IMU off	
1	52	7
2	104	13
3	208	26
4	416	52
5	833	104
6	1,660	208
7	3,330	416

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Radio technology nemi Link 2400

Our own radio technology nemi Link 2400 is a wireless, battery-powered sensor network in the 2.4 GHz frequency band with star topology and one receiver module. This high-speed network enables the reliable transmission of data at high sampling rates. The high efficiency of our robust radio technology enables very long battery runtimes of our products. Our wireless sensors synchronize their internal clocks to the clock of the receiver module with extremely small deviations.

To optimize the measurements of a use case, nemi Link 2400 offers the possibility to adjust the number of sensor nodes per radio channel and the radio speed to achieve the perfect balance between range, data rate and runtimes for each application.

Please find detailed information in the nemi Link 2400 info sheet.

Compatible receiver modules in the nemi Link 2400 wireless network

nemi DAQ is compatible with all receiver modules in i4M's nemi Link 2400 network. The following products are available under the nemione® trademark:

nemi EdgeBase   nemi Connect   nemi Log (+ cellular)

Application

Due to its long battery life and our highly efficient nemi Link 2400 radio technology, nemi DAQ is ideally suited for use in rotating or moving applications such as torsion / torque measurements in drive trains or load measurements on rotating or moving components. For permanent installations, it can be operated with a wide-range voltage input.

Examples of specific use cases for nemi DAQ are:

- Strain gauge measurements, for example, on streetcar wheels, in motor vehicle chassis springs or on lift bridge drives
- Long-term load measurements on rotor shafts, for example of wind turbines
- Dynamic monitoring for example of roller coasters

Download use case:

LED Blink Codes

The nemione® nemi DAQ has integrated LEDs that are visible through the housing. This flashing indicates the various operating states of the sensor node:

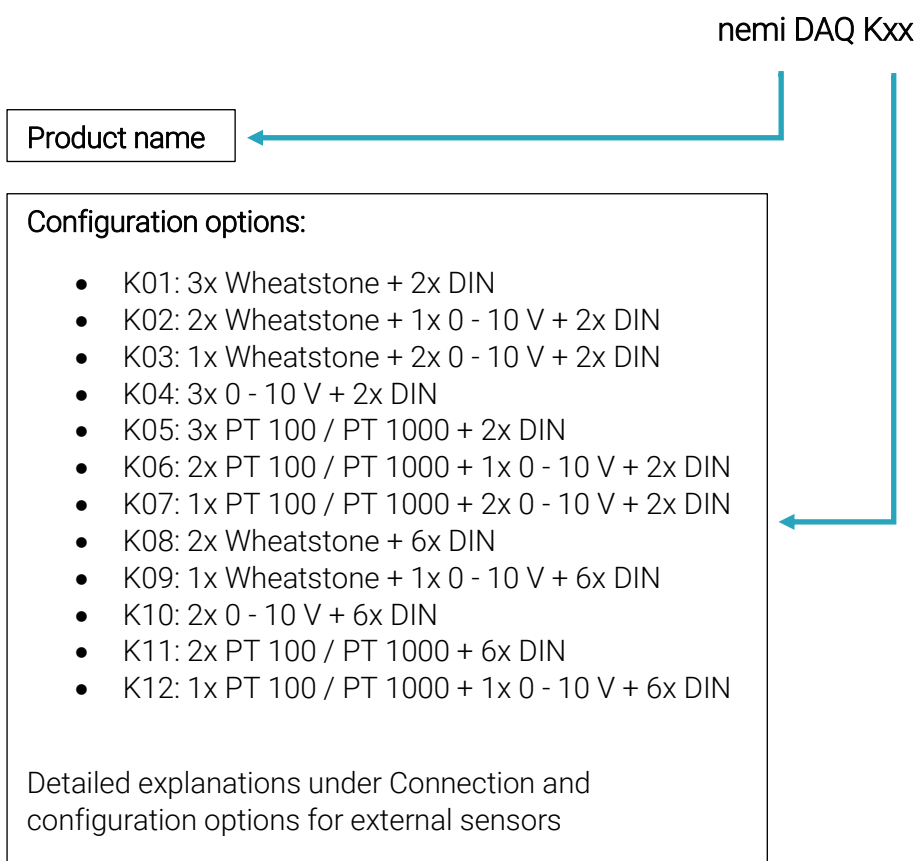| Operating Mode	Description
Rapid flashing in the sequence white, green, red, blue	Indicates a restart of the sensor node.
Red LED, continuously	The battery is charging, power supply via USB or wide-range voltage input.
Red LED no longer lights up continuously	The battery is fully charged.
Green lights up continuously, yellow flashes simultaneously	A USB port with a data connection has been detected. The sensor node is waiting for a virtual COM port to open.
Green lights up continuously, blue flashes simultaneously	The virtual COM port has been opened. The sensor node is waiting for new RF parameters or settings from the PC software.
Regular short red flashes for approx. 2 seconds	The sensor node samples and transmits measurement data.
Regular short green flashes all 10 seconds for approx. 1 second	The sensor node is in sleep mode.
Regular short blue flashes for approx. 1 second	The sensor node resynchronizes with the wireless network (time synchronization).
The green LED lights up temporarily or continuously in wireless mode	The internal data memory (ring buffer) is 80 % full as the data could not be transmitted via radio link. There is a risk of data loss.

Data Analysis

Upon request, we will be happy to support you with data analysis. The data analyses can be performed directly in the sensor or in the gateway by edge analytics as well as on the server or measuring computer. A great advantage of edge analytics is the **reduction of the transmitted data to the essentials** ("smart data"). This **reduces storage space** and **increases battery runtimes**.

Based on our knowledge from a multitude of previous projects, we have developed **algorithms for data evaluation** to generate **maximum added value** for our customers. We will gladly advise you on this. In addition to our existing algorithms we create **individualized scripts** upon request.

At the same time, the **data remains your capital**: We do not rely on big cloud providers but **keep the data in your IT ecosystem**. Alternatively, you can rely on our nemione® cloud solutions - hosted in the European Union.

Ordering options of nemi DAQ

nemi DAQ Kxx

Product name

Configuration options:

- K01: 3x Wheatstone + 2x DIN
- K02: 2x Wheatstone + 1x 0 - 10 V + 2x DIN
- K03: 1x Wheatstone + 2x 0 - 10 V + 2x DIN
- K04: 3x 0 - 10 V + 2x DIN
- K05: 3x PT 100 / PT 1000 + 2x DIN
- K06: 2x PT 100 / PT 1000 + 1x 0 - 10 V + 2x DIN
- K07: 1x PT 100 / PT 1000 + 2x 0 - 10 V + 2x DIN
- K08: 2x Wheatstone + 6x DIN
- K09: 1x Wheatstone + 1x 0 - 10 V + 6x DIN
- K10: 2x 0 - 10 V + 6x DIN
- K11: 2x PT 100 / PT 1000 + 6x DIN
- K12: 1x PT 100 / PT 1000 + 1x 0 - 10 V + 6x DIN

Detailed explanations under Connection and configuration options for external sensors

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