nemi DAQ nano

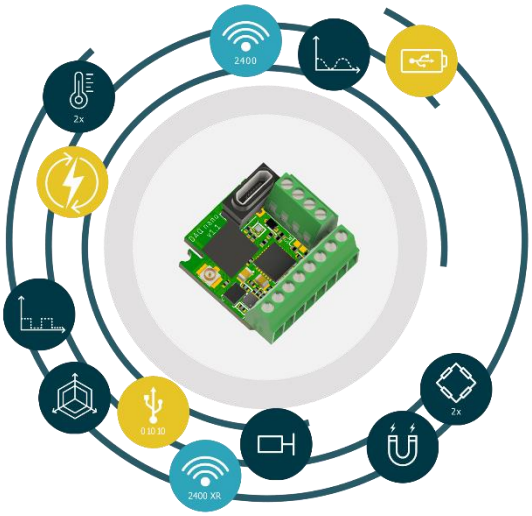
Tiny wireless Multi Sensor with Energy Harvesting Module for Measuring and Monitoring Strains, Forces, Displacements and much more

Description

nemi DAQ nano is i4M's first integrated sensing product in terms of wireless Data AcQuisition. It is a highly compact DAQ multi-sensor module with a wide range of connection options to measure and monitor e.g. strains, forces, displacements or temperatures. In addition to that, various other digital and analog 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, very long battery runtimes can be achieved. With solar energy harvesting battery runtimes can be extended. Under good conditions, nemi DAQ nano can even be operated self-sufficiently in terms of energy thanks to energy harvesting.

Key Features

- **Compact & lightweight design**
  21 x 21 x 11 mm, < 6 grams
  (without connectors: 5.6 mm, < 3 grams)
- **Multi-sensor module** with variety of connection options for data collection to choose from
- **Completely wireless and maximized battery life** due to radio technology nemi Link 2400 and **solar panel**
- **Energy harvesting:** solar panel offers **unlimited run times**
- Transmission of **live raw data** or **smart data** pre-evaluated by edge computing



Connection of up to **2 wheatstone / strain gauge full bridges**	Connection of up to **2 potentiometer sensors**
Connection of up to **2 temperature sensors** (Pt100 / Pt1000, thermocouples or 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 **2 analog sensors** with 0 - 10 V output	Triaxial **magnetometer**; measuring range up to 16 Gauss
Connection of up to **2 sensors with digital output** with 5 - 24 V signal level	**nemi Link 2400** - i4M's own robust and **flexible radio technology** in the 2.4 GHz frequency band

Solar **Energy Harvesting** with MPPT

Power supply / battery charging via **Micro USB**

Optional Connector for **battery** (with charger)

ESD (Electrostatic Discharge) Sensitive device:

These devices have limited built-in ESD protection and damage may thus occur on devices subjected to high-energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

Quick-Start

- Connect an antenna and a secondary cell. **A rechargeable battery must have its own protection circuit!**
- Connect USB or solar panel to start nemi DAQ nano. The LED should now blink continuously.
- Disconnect USB and/or solar panel if desired. nemi DAQ nano remains switched on as long as the battery is connected and has a sufficient charge.
- Follow step 1 - 4 of Wireless Sensor Plot (V7.0 or higher).

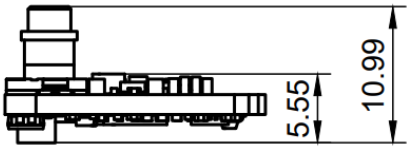
Specifications

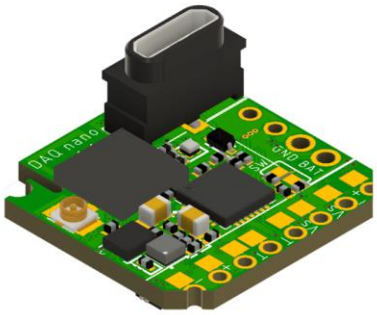
General information		
Dimensions (without connectors)	21 x 21 x 11 (21 x 21 x 5.6)	mm
Weight (without connectors)	<6 (< 3)	grams
Power supply	Connectors for battery (with charger)	-
Charging speed	up to 100	mA
External power supply	5 (Micro USB) Solar panel (details see below)	V
Temperature range permitted during operation	-25 to 85	°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	Without housing	-

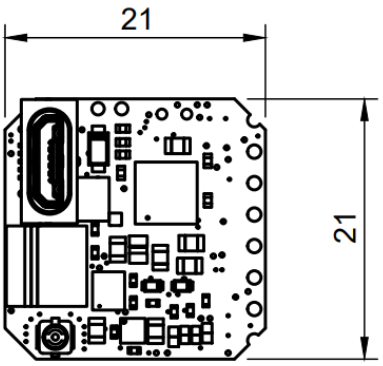
External digital sensors		
Examples for digital sensors	Switching displacement, distance, level or angle of rotation sensors, TTL / NPN sensors	
Number of digital channels	2	-
Sampling rate	2,000	Hz
Sensor switching voltage (logic high) High-Level Low-Level	 5 - 24 < 2	V
External analog sensors		
Connectable 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	2	-
Maximum Sampling rates (with active channels)	6,400 (1 channel), 1,944 (2 channels)	Hz
Stability of sampling rate (over the entire temperature range)	± 50	ppm
Selectable signal gains	128 / 64 / 32 / 16 / 8 / 4 / 2 / 1	-
Reference currents / supply currents	1,000 / 750 / 500 / 250 / 100 / 50	µA
Reference voltage / supply voltage	2.5	V
Signal resolution	24	bit
Analog measurement error	<< 1	%
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
Solar Energy Harvesting		
Input voltage (V_{Solar})	0.05 to 5	V
Maximum input current	110	mA
Input power	0.003 to 550	mW
Maximum powerpoint tracking (MPPT)	75 % x input voltage (max. 4)	V
Battery		
Charging cut-off voltage	4.2	V
Discharge cut-off voltage	3.3	V
Charge ready voltage	3.35	V

Dimensions

(All dimensions in mm)







Connection and configuration options for external sensors

nemi DAQ nano offers various connection options for external sensors with analog and digital outputs. There are 2 analog and 2 digital inputs. The following options are available to configure the analog inputs:

- Up to 2 reference voltage sensors (e.g. wheatstone / strain gauge full bridges, potentiometer sensors or thermocouple (e.g. Type K) and thermistors)
- Up to 2 reference current sensors (e.g. Pt100 / Pt1000 resistance thermometers)
- Up to 2 sensors with analog output 0 -10 V

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

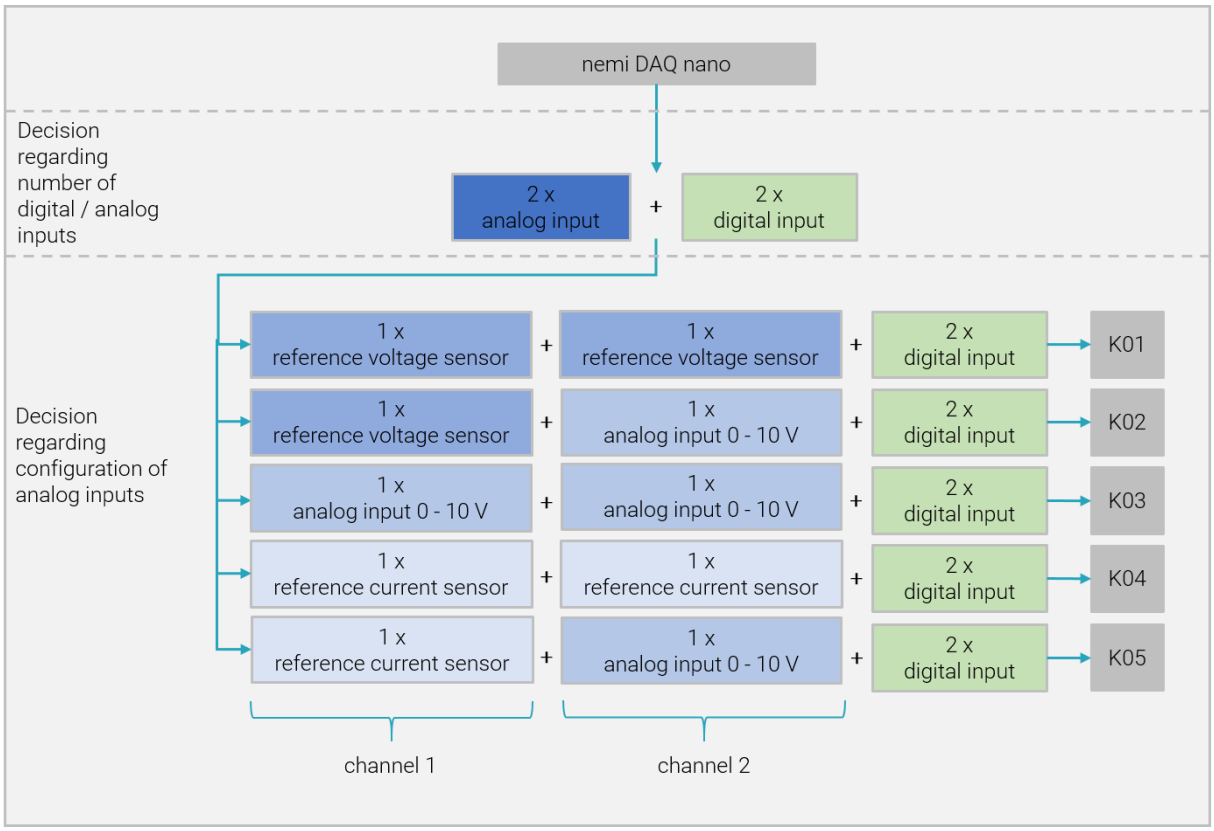
- Up to 2 switching digital sensors with switching voltage level 5 - 24 V (e.g. switching displacement, distance, level or angle of rotation sensors) or TTL / NPN sensors

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

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

The following graphic shows the different configuration options K1 – K5. A combination of reference voltage sensors and reference current sensors on one nemi DAQ nano is not possible.

Configuration options nemi DAQ nano



Pin assignment

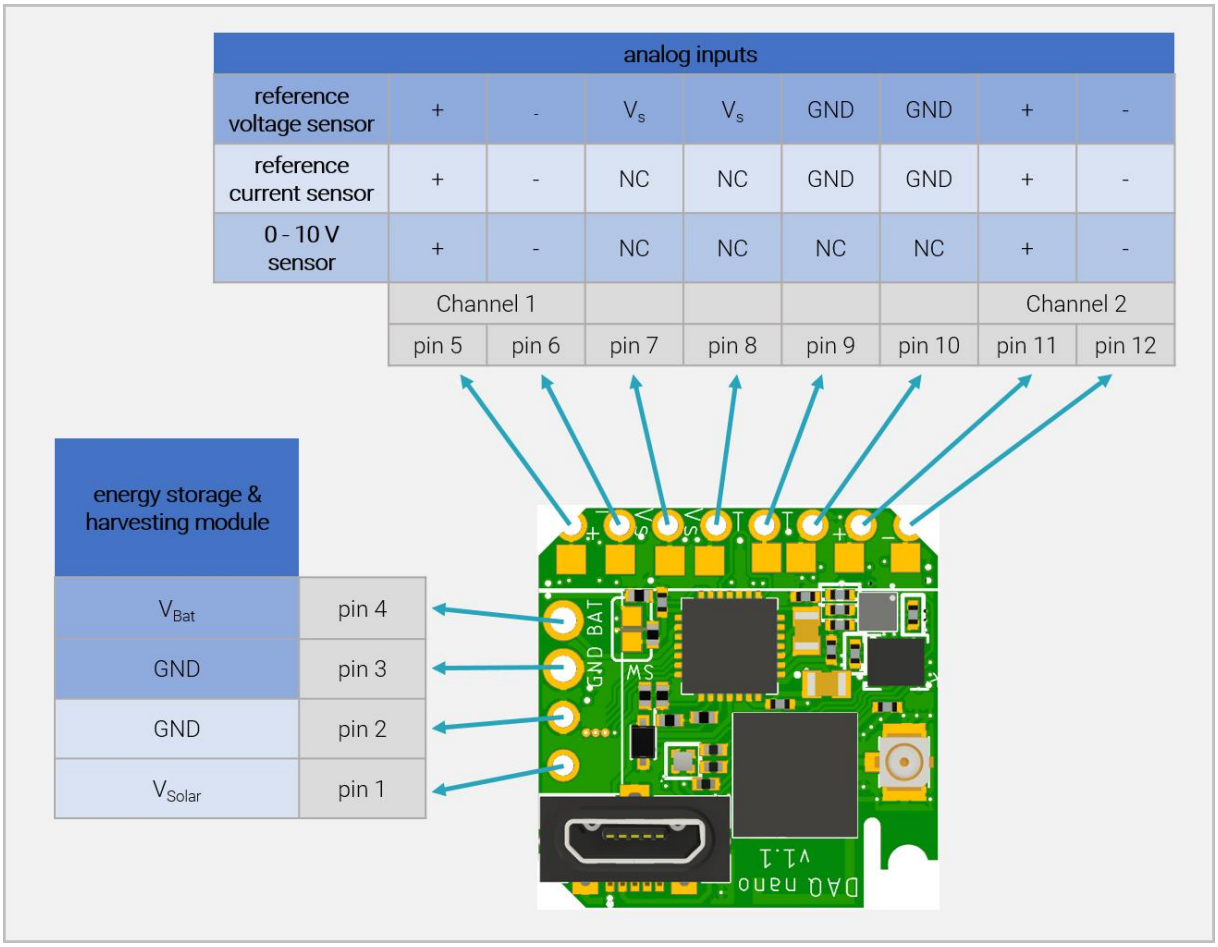
nemi DAQ nano has 15 pins.

- Pin 1 and pin 2 are used for the harvesting module.
- Pin 3 and pin 4 are used for the energy storage.
- Pins 5 - 12 provide two analog inputs. Each input can either be a reference voltage sensor (e.g. wheatstone / strain gauge full bridge, potentiometer sensor or thermocouple (e. g. Type K) and thermistors) or a reference current sensor (e. g. Pt100 / Pt1000 resistance thermometer) or a sensor with an analog input of 0 - 10 V.
- To pins 13 – 15, two digital inputs with signal levels of up to 24 V can be connected.

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

Pin assignments of analog inputs, energy storage and harvesting module

Analog inputs, energy storage and harvesting module are to be connected at the top side of the board.



$M_{+/-}$ ≙ Measured Voltage

V_S ≙ Supply Voltage

GND ≙ Ground

NC ≙ Not Connected

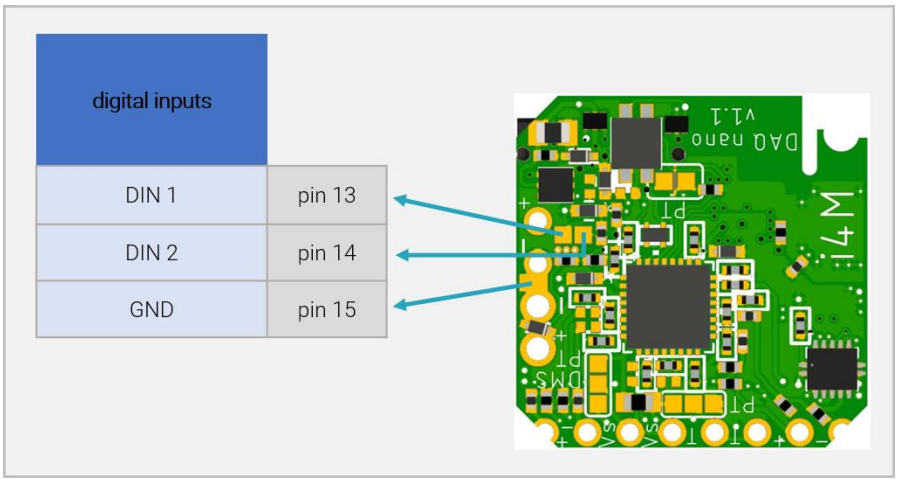
V_{Bat} ≙ Battery Voltage

V_{Solar} ≙ Solar Module Voltage

⚠ Reversing the polarity of pins 1-4 can damage nemi DAQ nano!

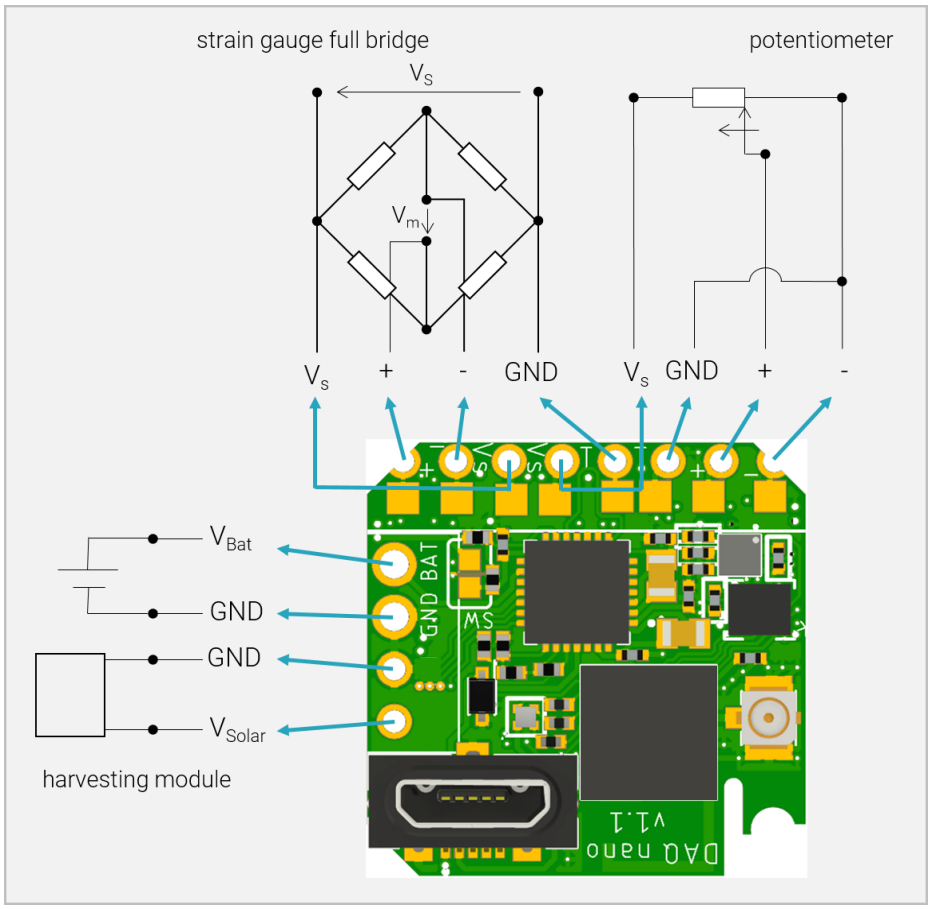
Pin assignments of digital inputs

Digital inputs are to be connected at the bottom side of the board.



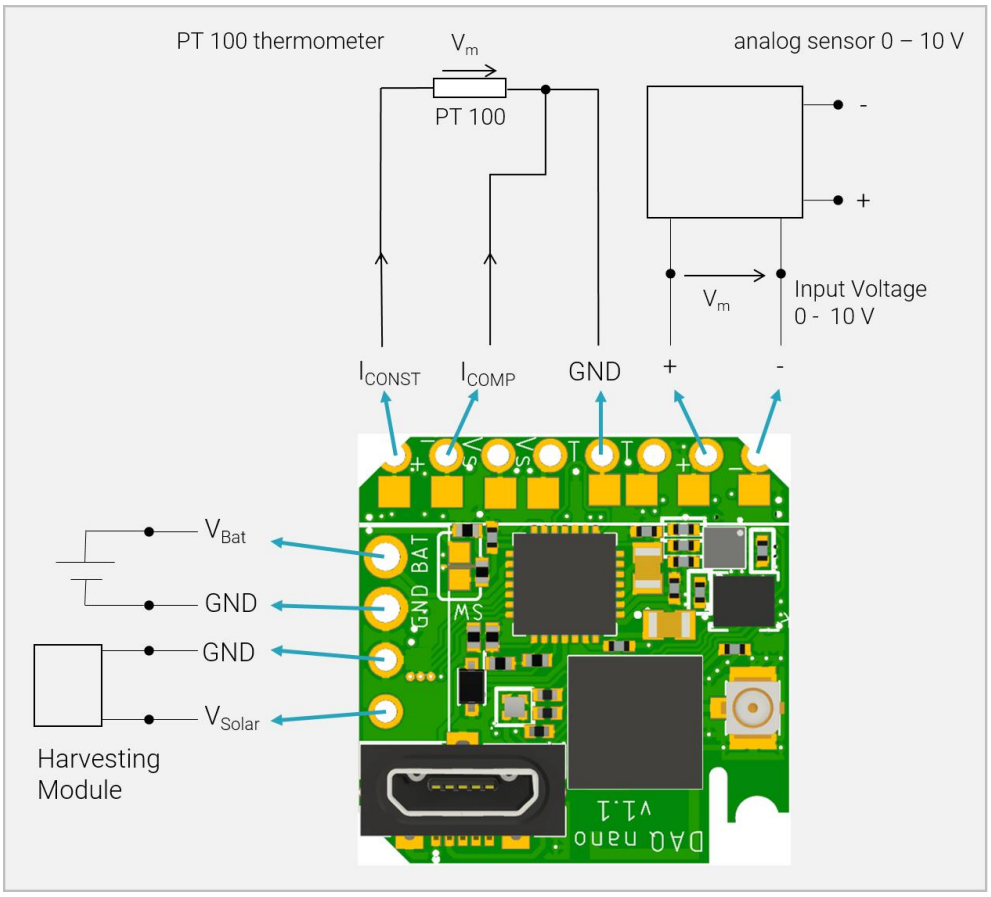
GND ≙ Ground DIN ≙ Digital Input

Example for pin assignment of configuration option K01



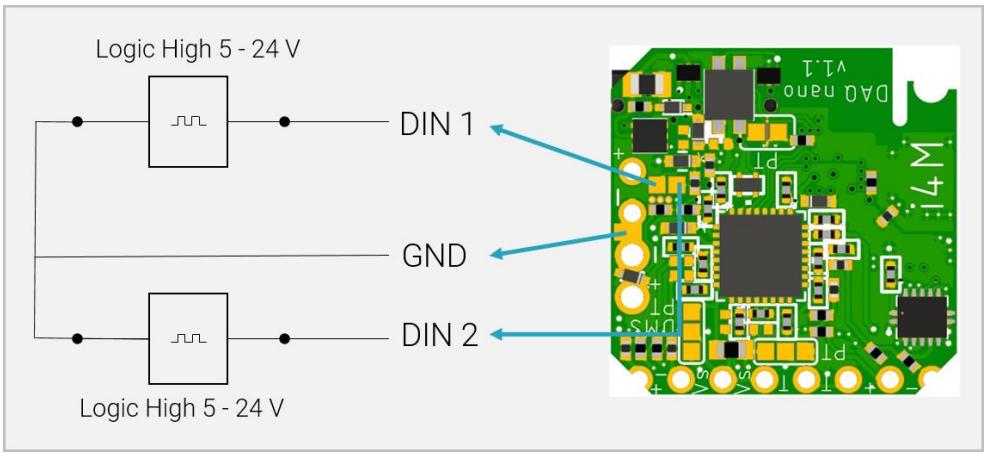
V_m ≙ Measuring Voltage

Example for pin assignment of configuration option K05



I_{CONST} ≙ Constant Current I_{COMP} ≙ Compensation Current

Example for pin assignment of digital inputs



Setting of the live radio transmitted sampling rate and signal amplification

The level of 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 two 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 6,400 Hz is achieved when the ODR setting (ODR = Output Data Rate) is set to 2 and one active channel is selected. With two active channels and ODR Setting 1, the maximum sampling rate of the external analog sensors is 1,944 Hz.

		Number of active channels / live on air sampling rate [Hz]	
ODR Setting	Mode	1	2
0	Off	AD off	
1	High Res		1,944
2	High Res	6,400	1,074
3	High Res	4,800	742
4	High Res	3,200	567
5	High Res	2,400	459
6	High Res	1,600	385
7	High Res	800	332
8	High Res	400	291
9	High Res	200	235
10	High Res	100	196
11	Ultra Low Power	100	100
12	Ultra Low Power	75	75
13	Ultra Low Power	50	50
14	Ultra Low Power	25	25
15	Ultra Low Power	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.

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) or the sampling rate of the gyrometer (GYR). The following table shows that when the IMU ODR setting is 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

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 nano 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

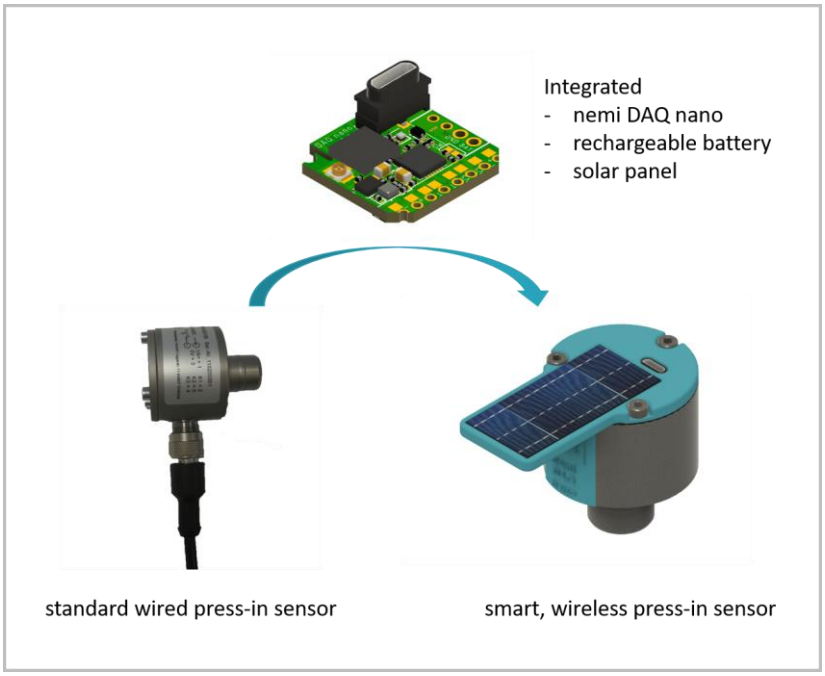
nemi Log (+ cellular)

Application

Because of the compact and lightweight design nemi DAQ nano can easily be integrated in smallest installation spaces and turns your components and machines into smart products. Due to its long battery life and our highly efficient nemi Link 2400 radio technology, nemi DAQ nano 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.

Example of a smart product:

Replacing the measurement equipment including wiring of a press-in sensor from Primosensor by a nemi DAQ nano, a battery of suitable size and a solar panel.



Primostrain® EPS Einpresssensoren - Primosensor

LED Blink Codes

The nemione® nemi DAQ nano 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.

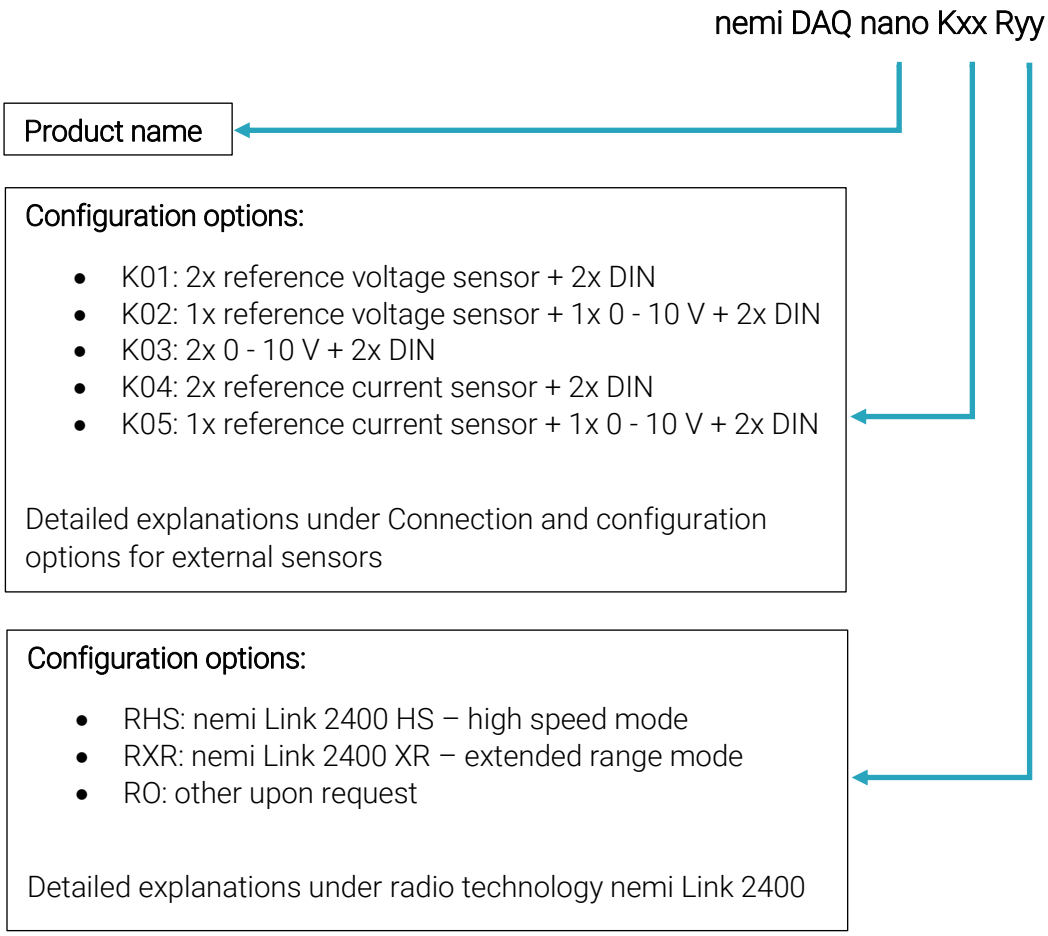
Data Analysis

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 nano



Contact

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