BX8 Counter / Frequency / Quadrature Encoder Input

Requirements: Hardware BX8 HD44/HD15/AS
Device firmware: Version >=1.45

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Description

BX8 measuring amplifiers can evaluate incremental encoders such as rotary encoders ("QEI"). Up to two quadrature-encoding pulse generators, each with A, B & optional reset input I can be connected.
Also pulses of digital square wave signals can be counted, e.g. for measuring the angle of rotation or displacement. In this case, input A is the pulse input and B determines the counting direction. Also, the frequency and the quantities attributed thereto (e.g., rotational or translatorial speed) can be detected by the BX8, and the sign of the measured value indicates the direction.

For this, one or two separate measuring channels are used, which are only available after the function has been activated. These are always the last two measurement channels in the measurement data frame, or the last one.

The first encoder "QEI 1" can be used to measure either counter, frequency or counter and frequency / speed at the same time. In the latter case, two measurement channels are generated.

Encoders can be connected directly that generate single-ended square-wave signals that have the states 0V (connected to GND) and 5V or 0V and high-impedance, i.e. 5V TTL push-pull outputs or open-drain. A voltage supply with 5V and max. 20mA is available[1]. The maximum input frequency is 10 MHz.

The second encoder "QEI 2" can only be used if the first "QEI 1" is also activated.
If only one pulse generator is used, it must be connected to QEI 1.
For the pin assignment: see general operating instructions.

This function can be configured from version 1.43 with the **BlueDAQ** application program.
You can access the configuration dialog via the menu bar of the program:
Device -> Advanced Settings ... -> Value Mode -> Counter / Frequency / Speed.

For self-programming users, the following also contains information on programmatic configuration (in smaller font), see also the protocol documentation ba-gsvcom.pdf.

The connection of the encoder cable to the **BX8** DigitalI/O module is described in the general manual.

Default Settings

The counter / frequency measurement is **off** by default.
Manufacturer-Default-Settings:
Save counter value is activated, so is counter saturation.
Frequency measurement method is counting.
QEI-Mode = x1
Pullup-Resistors = enabled.
Index-Input not used

Encoder can be activated with SetCountFreqMode at index 0:
Bit 1 = 1: Counter / counter measurement activated

1 If no significant load is applied to any DIOs configured as outputs, the maximum current can be up to 70mA.

Bit 2 = 1: Frequency / speed / speed measurement activated
Counter and frequency measurement are only possible at QEI No. 1 at the same time.
See details below.

Layout of the measuring data frame

The measured values of the counter / frequency measurement are always the last and possibly the penultimate value in the measured value frame. The number of measurement channels in the measurement data frame can be configured; when the function is activated / deactivated with the GetCountFreqMode device command, the number of measuring channels changes automatically.

Assignment og the measuring channels:
- Only QEI 1 used, counter *or* frequency measuring: Last value in the data frame is counter- or frequency value.
- Only QEI 1 used, both Counter *and* frequency measuring: Penultimate value in the data frame is the counter value, the last one the frequency value.
- Both QEI 1 and 2 used: Penultimate value in the data frame is the counter- or -frequency value of QEI 1, the last one is the counter- or frequency value of QEI 2.

Required data type

Frequency / speed measurement with the method of period measurement (see below) or via configured gate time is only possible if the data type of the measured value frame is set to float (default). The data types Int16 and Int24 are also possible with counter or frequency using a simple counting function.

Operating parameters

The counter / frequency values have the following individual operating parameters, to which input channel 9 or 10 is permanently assigned (regardless of the position in the measured value frame):
- Unit-Number (Enum)
- User-Scaling
- User-Offset

Assignment of the channels indices
- Only QEI 1 used, counter or frequency measurement: channel index 9
- Only QEI 1 used, counter and frequency measurement at the same time: channel index 9 for counter value, channel index 10 for frequency value
- QEI 1 and 2 used: channel index 9 for QEI 1, channel index 10 for QEI 2

Counter input counting mode (QEI decoder mode)

The counting mode applies to both measurement types (counter and frequency) and determines how the square-wave signals at counter inputs A and B are evaluated. It is read with the FW command GetCountFreqMode at index 0 in bits <4:3> and set with SetCountFreqMode.
Mode b00: The QEI encoder evaluation is switched off, a square-wave signal is expected at input A. Input B determines the counting direction (or the sign for frequency measurement): High = left open: forwards. Low = Grounded: Reverse
Mode b01: x1: Increment by 1 for a complete encoder quadrature cycle. This consists of 4 different states of the two A / B signals offset by 90°.
Mode b10: x2: Advances by 2 for a full quadrature cycle
Mode b11: x4 (Default): Increment by 4 in a complete quadrature cycle

Input configuration, hardware properties

There are 6 QEI connections: 3 per QEI, namely A, B and (optional) I. By default, pull-up resistors are activated on all inputs, so that an open input results in a logical 1. The pull-up resistors can be disabled with SetCountFreqMode at index 0:

Bit 10: =0: Pullups enabled (default). =1: Pullups disabled.

The pullups can be used to connect encoders with open drain outputs that are either open or connected to GND.

There is also the option of activating an input filter. If it is active, short interference pulses are suppressed, but the maximum frequency of the inputs is reduced to 200kHz in all modes and the measuring accuracy for period duration measurement is reduced (see below).

The filter is activated with SetCountFreqMode at index 0:

Bit 12: =0: filter off (default); =1: Filter activated

Counter Measuring

The counter can be configured to evaluate angle of rotation or position sensors. It is useful to adapt the user-scale value (with channel no. 7) in such a way that, taking into account the sensor properties (pulses / QEI cycles per revolution for rotary encoders or the width of the QEI cycle for linear position sensors) and the counting mode (see 6.) the desired physical value is calculated by the measuring system by multiplying the raw count value by the user scale. The BX8 does this independently if the measured value data type = float (default).

Saturation

The count value is saturated when exceeding the maximum and falling below the minimum; this saturation value depends on the set measured value data type and corresponds to the

numerical maxima / minima. When the counting direction reverses and it re-enters the representable range of values, the saturation state is automatically reset. It is also reset when the Set Zero command is executed.
The saturation behavior can be read with the device command GetCountFreqMode at index 0 in bit 6 and set with SetCountFreqMode:
Bit 6 =0: saturation off.
Bit 6 =1: saturation on (default)
When saturation is off, the counter overflows, i.e. from high positive or negative values to zero and when the internal 32-bit counter overflows, from high positive values to negative and vice versa.

Storing the count value

By default, the counter is configured so that the last counter value is saved in non-volatile memory when the device is switched off and restored the next time it is switched on. Provided that the position of a mechanical sensor (angle of rotation / linear) does not change when the **BX8** is switched off, the correct position can thus be displayed again after the device was off.
The storage behavior can be read with the device command GetCountFreqMode at index 0 in bit 7 and set with SetCountFreqMode:
Bit 7 =0: Save off. After switching on, the counter is set to 0.
Bit 6 =1: save on (default)

Zeroing the counter

The counter can be set to 0 at any time with the device command SetZero (No. 0x0C).

Using the Reset/Index connector

It is possible for the counter to copy a pre-configured counter value into the counter register with an active pulse at the index input. Some rotary encoders or linear displacement sensors provide this output, which is activated when a certain position or angle of rotation is reached. The "Active" state is configurable:
Not inverted (Bit 11 =0): Active= high or open (default)
Inverted (Bit 11 =1): Active= low or connected to GNDD
To activate this option, the SetCountFreqMode device command must be set to bit 5 at index 0 and the counter value to be copied must be transferred to index 2. This must be within the value range of the raw values of the meter.
When using the Reset/Index connection, the **BX8** cannot be configured as a synchronization slave.
By default, the Home/Index input is not used.

Frequency / Speed / Rotational Speed

With this type of measurement, the sign of the measured value indicates the direction of rotation. If the user scale value is set to 1 (default), the measured values are given in the unit counts/s = Hz. User scale can be used to convert to other units.

There are 3 different measurement methods available. In any case, the basic unit is Hz, i.e. the calculation of the user scale value is the same for every measurement method. Calculation examples see below.

Frequency / Spped measuring by counting

Here, the difference between 2 counter readings within a measurement data period is evaluated. The frequency to be measured must therefore be higher than the measurement data rate.
The connection assignment of the sensor/rotary encoder is identical to the counter measurement, and the 4 different counting modes (see 6.) are all available. This mode is suitable if high frequencies are to be measured at a relatively low data rate, e.g. which a rotary encoder delivers with many pulses per revolution.

Gate time

In order for the frequency (or speed/rotational speed) to be displayed correctly, the raw counter value must have changed as often as possible within a data period, i.e. the absolute difference between a new counter value and the previous one must be >=1.
The data rate is generally the same for all channels, i.e. also for the evaluation of the counter. In order to also be able to measure relatively low speeds/frequencies at rather high data rates, there is the option of increasing the data period for the frequency measurement. This is done using an (integer) data period multiplier, the gate time counter. This is set at index 1 with the device command SetCountFreqMode and read with GetCountFreqMode.
The minimum frequency that can be measured is therefore calculated as follows:
fmin = data rate / gate time counter [Hz]
The maximum frequency is 10 MHz (without input filter) or the numerical maximum for Int16 and Int24 measurement data types, depending on which value is lower, see below.
The time interval at which the frequency value is updated slows down due to the gate time to: update interval = gate time counter / data rate [s].
Maximum frequencies:
Messured data type Float: Without input filter: ±10MHz, With input filter: ±200kHz
Messured data type Int24: ±8,3886 MHz
Messured data type Int16: -32768 .. 32787 Hz
<u>Example 1:</u> Let the data rate be 10 measured value frames/s and the data type = float (default). Then you can measure with Gate-Time-Counter =1 (default) in a frequency range from 10 Hz to 10 MHz.
<u>Example 2:</u> Like example 1, but gate time counter = 100: Frequency range from 0.1 Hz to 10 MHz can be measured with an update interval of 10s.

Measurement uncertainty

The measurement uncertainty of the frequency measurement results on the one hand from the reciprocal value of the time that a count requires (1/tn) and on the other hand from the measurement data period.
So (rotary) encoders that deliver as many pulses as possible per revolution or distance section are favorable for precise speed or speed measurements, since the period duration of the counts tn is short with these. In addition, a low measurement data rate is cheaper. Otherwise the period measurement or the "Auto-Period" mode can be used.

Frequency & (rotational) speed measurement by period measurement

Here, the period is measured at input A if the input count mode is =b00, i.e. without a quadrature decoder (see above). With each of the 3 QEI decoder modes, the time between an edge at input A and the next one at input B is evaluated.
In this measurement mode, the measurement data rate is independent of the accuracy and value range of the measurement, and also independent of the QEI decoder mode.
This mode is particularly suitable for speed measurement, in which only a few pulses (e.g. 1 pulse per revolution) are generated per revolution, e.g. by a magnetic switch that moves relative to a magnet on the revolution circle.
In this mode, the gate-time counter has a slightly different meaning: it determines the time after which the measured value is set to zero if there are no more pulses at measuring input I. At the same time, this determines the measurable minimum.
The measuring range is therefore: Data rate/GateTimeCounter up to 10 MHz.
With this measurement mode, the measurement accuracy is significantly higher at rather low frequencies than in the counting mode and is independent of the measurement data rate.
The measurement uncertainty can be estimated as follows:
1.) ±0,003% of f,real
2.) f,measured = 1 / (1/f,real ±t,err)
Whereby:
t,err = 1/70MHz = 14,2857ns with input filter off (see above) and
t,err= 64/70MHz = 914,28ns with input filter enabled
f,real: True frequency in Hz
So, the deviation depends because of 2.) on the true frequency f,real. The higher deviation from 1.) and 2.) applies.
Example without input filter:
f,real = 100Hz: f,measured: 1.) 99,997...100,003Hz. 2.) 99,99986..100,0001428 ->1) applies
f,real = 1MHz: f,measured: 1.) 0,999970...1,00003MHz. 2) 0,9859155...1,0144927 MHz -> 2) applies

In this measuring mode, too, the basic unit of the measured value is Hz (with UserScale=1).

Frequency/RPM measurement with "Auto-Period" mode

With this measurement method, the BX8 automatically decides based on the measured frequency whether the counter method or the period duration measurement is to be used. If the counter value is less than 2000 per data rate period, the period duration measurement is used, otherwise the counter method. For example, the threshold value is 20kHz for the default data rate of 10 frames/s. In this way, the measurement uncertainty can be kept below 0.05% in the entire measurement range.

The gate time is not used in this mode, nor does the QEI decoder mode have any effect.

Examples of setting the user scale factor to adapt to specific encoders:

Example 1: Revolutions/minute are to be measured with a rotary encoder (rpm unit). The encoder delivers 360 full quadrature cycles per revolution. The counting mode is x1 (b01, see 6.). Then UserScale is set to the following value:
60 rpm / 360 = 1/6 = 0.1666667 rpm.
Example 2: U/min = rpm should be displayed with the same encoder, but the counting mode is x4 (b11): Then UserScale is set to the following value:
60 rpm / (360*4) = 1/24 = 0.041666667 rpm.

Changelog

Version	**Date**	**Description**
BA-BX8-Incrementalencoder_en	2022/08/03	Initial release