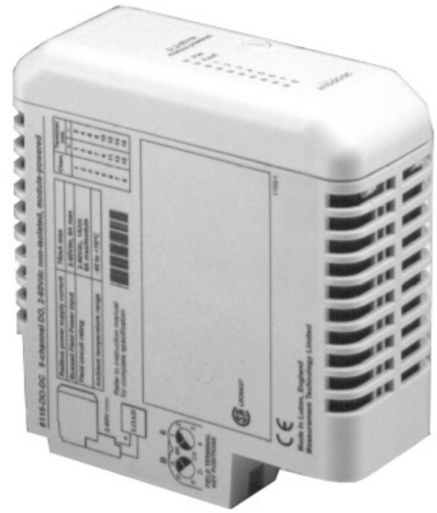


I/O Modules

Overview

GENERAL

All I/O modules are connected to the Bus Interface Module (BIM) or Controller via a proprietary bus system called 'Railbus' and one BIM can control up to 64 modules. The module carrier provides the transmission medium for the Railbus and, by plugging a module onto a carrier, connections are made between the module and the bus. The connectors on the carrier also provide the power supply links to the module and, when required, power for the field wiring.

Addressing of I/O modules

Modules are addressed by the BIM or Controller in terms of their position, or slot, in the total chain of 64 modules not by individual module types. As a result, a module can be removed and replaced by another of its own type without the need to 'tell' the system of the change. During configuration, the node is told the characteristics of each necessary module position whether or not the module is present at the time. Consequently, if a module is removed for service replacement, the properties of the 'slot' are still retained.

IMPORTANT MODES

Output failsafe mode

Output modules have the ability to assume a failsafe state. This can happen for two reasons.

1) A module can be forced in to failsafe state by issuing a specific command to it.
2) Modules have a configurable "timeout" parameter. This defines the maximum time period of communication inactivity. If this period is exceeded the module adopts a failsafe state.

The different module types have their own response to a failsafe command, and those responses are described in the individual sections that follow.

Input fail values

In the event of failure of an input module, the reported value is forced to a predefined state – low, high or hold last value. This ensures that the host adopts a state consistent with safe operation of the plant.

Power-up/initialization state

When powering-up a node it is essential for plant safety that the state of each of the outputs is known. While the node is initializing, the I/O modules are held in the power-up state (see following pages). After node initialization and before establishing external communication, the outputs are set to predefined "initialization" states. This "safe-state" can be defined by the user for each output channel.

Non-volatile configuration memory

The configuration information for all I/O modules in a node is stored in non-volatile memory (NVM). When a module is replaced, when the node is powered up or following a reset, the node will download the stored configuration information to the relevant I/O modules. Visual indicators LEDs are provided on each module to indicate Power, Fault and channel Status information. These are based on the NAMUR NE44 specification for LED indicators. The Power and Fault indicators are common to all I/O modules and their states are shown in the following tables.

MODULE 'FAULT' LED (RED)

On	• Failsafe • A/D error on AI • BFP failure on 2/2 AI
Off	Normal
Flashing	Initialization error

BFP = Bussed Field Power of 2/2 modules

MODULE 'POWER' LED (GREEN)

On	Power OK
Off	Power failure

Module 'Status' LED (yellow)

The channel "Status" indicators have different meanings according to the module type and are described in the individual module sections.

Important note

If, when using the 8502-BI-DP Profibus BIM, the node is configured over Profibus, a reduced set of configuration parameters is available. In this case, the module specifications should be read in conjunction with the Profibus BIM instruction manual INM8502 which explains the configuration options.

Alternatively, if the 8455 Configurator Software is used to configure a Profibus node, a fully detailed range of module configuration parameters is available.

GSD files are available for either of the above options.

Analog Input Modules

4-20mA

GENERAL

The 4–20 mA AI modules provide digitized data and status information from 4–20 mA current loop sensors.

HART® capability

AI modules "with HART" can obtain information from HART instruments of protocol revision 5.0 or later. Each channel can communicate with a single HART instrument. HART universal command 3 is used to gather up to 4 dynamic variables and status from each HART instrument. This provides more process information to the control system from each device. Greater accuracy can also be achieved by eliminating A/D and D/A errors. In addition, HART pass-through may be used for device configuration, calibration and advanced diagnostics.

IMPORTANT MODES

Output failsafe mode

The AI modules have eight user-channels that are sampled every 27 ms (2/2) or 33 ms (2/1).

Data format

The input signal is stored as a 16-bit unsigned value. In this range 0 is equivalent to 0mA and 65,535 is equivalent to 25mA. Any digital HART data is stored in its original IEEE754 floating point format.

Filtering

The Analog Input modules use a first-order software filter that provides 12 dB attenuation at the Nyquist frequency of the algorithm. The filter supports a set of options that can be matched with control algorithm execution rates.

Input alarms

Four configurable alarm levels are provided for each channel—two high and two low (see figure below). When an input value exceeds an alarm limit a flag is set and the BIM gets a new alarm status.

Alarm deadband

The Alarm Deadband prevents the alarm from tripping on and off because of system noise. It can be configured for each channel and is always set on the 'inner' side of the alarm limit to be, typically, greater than the system noise in the plant. If an alarm is activated, it will remain until the input moves the full extent of the deadband towards a "safer" value.

The Hi-Hi and Lo-Lo alarms support the NAMUR recommendations, i.e. if the alarm limit is set less than 3.6 mA (Lo-Lo), or greater than 21.0 mA (Hi-Hi), the alarms must be active for 4 seconds before the alarm is set. The Deadband does not apply to NAMUR alarms. If the alarm limits are set at values between the NAMUR limits, the alarms function normally.

Dead zone

Each channel has a definable "dead zone". This is to reduce the need for the module to report every minor change in input value. If the input value differs by the amount defined by the Dead Zone, or more, then the new value is reported, otherwise it is not. This reduces traffic on the internal bus which improves the system response time. If the Dead Zone value is set to zero (the default), then every input value read cycle will set a 'New Data' flag, and be reported.

MODULE OPERATING STATES

Normal/Failsafe mode

The AI modules support failsafe mode as defined in the earlier I/O module introductory section. When not in failsafe the module adopts Normal mode.

Channel Active/Inactive

A channel can be made active or inactive individually. When a channel is made inactive inputs will not be processed.

Default/Power-up conditions

These modules use the following values when they power up.

Module mode
Normal (not "failsafe")

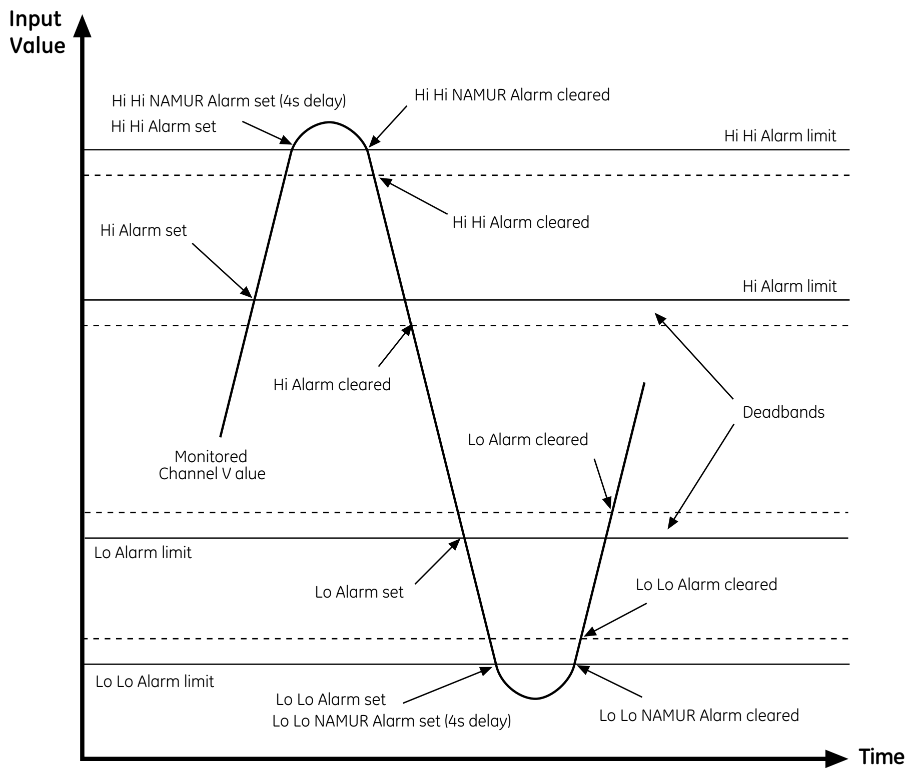
Active/inactive
All channels power up in the active state.

Alarms
All alarms are made inactive by having their values set to high or low extremes, as appropriate.

Dead Zone
0 (i.e. all changes of A/D data are reported for an active channel)

Software Filtering
Disabled.

Passthrough
Passthrough messages to HART instruments are always allowed.



Visual indicators

CHANNEL "STATUS" LED (YELLOW)

On	Sensor loop OK
Off	Open circuit sensor and channel inactive
Flashing	Open circuit sensor and channel active OR Error condition

An error – i.e. a flashing LED – could be as a result of any of the following conditions:

a) a loss of HART signal,
b) an error in the A/D converter,
c) a NAMUR alarm or
d) a Hi (-Hi) or Low (-Low) alarm.

Analog Input Modules

THC and RTD

GENERAL

These modules provide digitised data and status information of analog measurements from thermocouples, mV sources, RTDs and resistance sources.

Thermocouple modules provide four or eight channels for monitoring input signals from thermocouples or mV sources. The function of the module is set up during configuration. Cold junction compensation for thermocouple applications is provided by means of a sensor in the field terminal. Only the recommended field terminals can be used with these modules.

RTD modules provide four or eight channels for monitoring input signals from RTD or resistance sources. The function of the module is set up during configuration. The RTD can be 2-, 3- or 4-wire type. Only the recommended field terminals can be used with these modules.

Input sampling

Thermocouple modules sample at intervals of 60 ms per channel. In addition, the module has cold junction temperature compensation that is refreshed every 1.8 seconds for 4-channel modules and every 2.4 seconds for 8-channel modules. The sampling technique for the RTD module is similar where samples of the voltage across, and the current through, the RTD are measured at intervals of 60 ms per channel. Compensation methods reject the effect of resistance in the cable conductors for 3-wire and 4-wire RTD/Resistance.

Data format

The 8105/6 and 8132 modules store data as 15-bit plus sign integers (–32768 to +32768). The 8205/6 modules store data as 16-bit unsigned integers (0 to 65535).

Filtering

An Infinite Impulse Response (IIR) filter is used on the input data before it reaches the A/D converter. Depending upon the coefficients selected, the output from the filter will be:

a) the input value (filter OFF)
b) an average of the last two readings (filter ON - setting 1)
c) a running average of readings (filter ON - setting 2)

The coefficients can be selected individually for each channel.

Input alarms

Four configurable alarm levels are provided for each channel—two high and two low (see figure below). When an input value exceeds an alarm limit a flag is set and the BIM gets a new alarm status.

Alarm deadband

The alarm deadband (not shown on the diagram) is fixed at 1%.

Dead zone

Each channel has a definable “dead zone”. This is to reduce the need for the module to report every minor change in input value. If the input value differs by the amount defined by the Dead Zone, or more, then the new value is reported, otherwise it is not. This reduces traffic on the internal bus which improves the system response time. If the Dead Zone value is set to zero (the default), then every input value read will set a ‘New Data’ flag, and be reported.

Open sensor detection

When configured to do so, the modules will detect an open circuit sensor and report it within 10 seconds. When this occurs a status bit is set in the module and the affected channel LED flashes. The detection options for the two module types are configurable as follows:

THC and mV
Off, drive upscale or drive downscale

RTD and resistance
Off or drive upscale
These choices can be made for each channel.

MODULE OPERATING STATES

Normal/Failsafe mode

The THC and RTD modules support failsafe mode as defined in the earlier I/O module introductory section. When not in failsafe the module adopts Normal mode.

Channel Active/Inactive

A channel can be made active or inactive individually. When a channel is made inactive inputs will not be processed.

Power-up conditions

The module uses the following values when it powers up.

Module mode
Normal (not "failsafe")

Active/inactive
All channels power up in the active state.

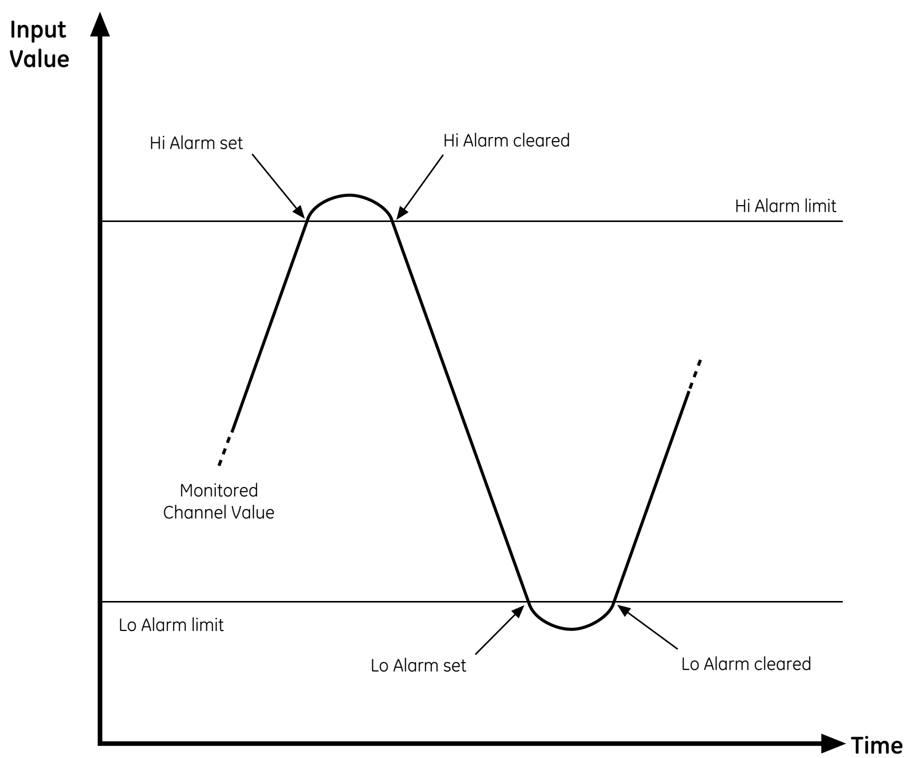
Alarms
All alarms are made inactive by having their values set to high or low extremes, as appropriate.

Dead zone
0 (i.e. all changes of A/D data are reported for an active channel)

Software filtering
Disabled

Channel type
Type K thermocouple or 3-wire RTD - Pt100

O/C sensor
Off



Visual indicators

CHANNEL "STATUS" LED (YELLOW)

On	Sensor loop OK
Off	Open circuit sensor and channel inactive
Flashing	Open circuit sensor and channel active OR Error condition

Analog Output Modules

4-20mA

GENERAL

The 4–20 mA AO modules use a single D/A converter in a sample-and-hold configuration to drive each of the output channels. The processor sets the current value for each of the active channels once every 20 ms. Any requested output values below 1mA are clamped to 1mA to ensure that the open-loop detection mechanism is always operable.

To verify that active output channels have current flowing to the field, the processor reads a hardware signal every time an output is written to the D/A converter. If the signal indicates "no current flowing", i.e. < 1 mA, for 50 consecutive scans (i.e. one second), an Open-Loop Detection failure is set for that channel.

HART® capability

AO modules "with HART" are compatible with all HART devices of protocol revision 5.0 or later. Each channel can communicate with a single HART instrument and supports HART communication with the wide range of HART valve positioners now available. HART universal command 3 can be used to gather up to 4 dynamic HART variables such as valve position, air pressure, etc., together with HART status variables. These are scanned by the BIM or Controller and may be communicated over the LAN for easy integration into the control system. In addition, HART pass-through may be used for device configuration, calibration and advanced diagnostics.

Data format

The output data has a resolution of 12 bits but is stored as a 16-bit unsigned value. In this range 0 is equivalent to 0mA and 65,535 is equivalent to 25mA.

MODULE OPERATING STATES

Failsafe mode

The module supports failsafe mode as defined in the earlier I/O module introductory section. When put in failsafe mode the output can be made to adopt one of the following options.

1) **Use configured failsafe values**
   In this (default) mode, the module forces the output to a predefined percentage value. The default value is 0%.

2) **Hold last value**
   In this mode the channel holds the last value it output. When not in failsafe the module adopts Normal mode.

Channel Active/Inactive

Each channel can be made active or inactive individually. When a channel is made inactive the output is disabled, i.e. deenergized.

When a channel is made Active again the output is driven based upon the current configuration.

Default/Power-up conditions

The module uses predefined values when it powers up. The following parameters summarize the state of the module when it powers up.

Module mode:
Normal (not "failsafe")

Active/inactive:
All channels power up in the Inactive state.

Visual indicators

CHANNEL "STATUS" LED (YELLOW)

On	Field circuit OK
Off	Open circuit field loop and channel inactive
Flashing	Open circuit field loop and channel active OR Error condition

On the AO modules the yellow "Status" LED reacts in the following way to module conditions.

An error condition – i.e. a flashing LED – could be as the result of the loss of the HART communications signal.

Discrete Input Modules

GENERAL

DI modules can accept up to 8, 16, or 32 discrete inputs, depending upon module type, from dry contacts, NAMUR standard proximity detectors, or switched voltages. The source voltage for field switching can be provided through the module or from an independent supply out in the field.

In operation, the input voltage is compared against a threshold voltage to create a 'true' or 'false' condition. If the inputs are from Zone 2/ Zone 1 or Zone 0 hazardous areas, the appropriate (2/1) module provides certified isolation for these signals. A pulse counter is also included which can count the number of input pulses for each of the channels.

Input filter

An input filter can be set individually for each channel to introduce a delay period that allows the input to settle to a stable value.

When switched off, the bandwidth of the DI input is 250 Hz (100 Hz for 2/1 modules). The timeout filter can introduce a timeout delay of between 2 and 512 ms in 2 ms steps for 2/2 modules and between 3 and 512 ms in 3 ms steps for 2/1 modules. Alternatively, preset values of "Fast" (22 ms) or "Slow" (258 ms) may be used.

Latch

Any channel input can be configured to be "real time" or latched. If the latch feature is enabled, the polarity can also be set so that an input signal that goes:

- High will be held high
- Low will be held low

until the latch is released by a command from the controller. All channels are latched independently and can be cleared simultaneously, or independently, by a Write instruction to the module's latch reset register. If controlled by a BIM (rather than a Controller) this will occur automatically in 2 to 3 seconds.

Line fault detection (2/1 only)

When enabled, this will cause a flag to be set to indicate a short or open circuit fault.

Low-frequency pulse

Counter The DI modules contain a continuously running 16-bit pulse counter that counts each low-frequency pulse received on the input. The maximum pulse rate, with the timeout filter switched off, depends upon the module selected; consult the individual data sheets for details. With the filter active, the maximum pulse rate will be determined by the timeout period used. In order to start a particular count the counter must be reset to zero by a host instruction. When the counter overflows (i.e. > 65,536 counts) it will restart from zero.

MODULE OPERATING STATES

"Failsafe" mode

The module supports failsafe mode as defined in the earlier I/O module introductory section.

Channel Active/Inactive

Each channel can be made active or inactive individually. When a channel is made inactive:

- Inputs are not processed—i.e. the last input value is held and not refreshed
- Channel events are not generated
- The counter is not incremented

Power-up conditions

On power-up, or if a reset is executed, the configuration will automatically adopt predefined states:

Module mode:
Normal (not "failsafe")

Channel types:
All latches and filters are off

Active/Inactive:
All channels power-up in the Active state

Visual indicators

On	Channel input "high" or latched
Off	Channel input "low"
Flashing	Line fault detect (2/1 only)

Channel "Status" LED (yellow)

On the DI modules the yellow "Status" LED reacts in the following way to module conditions.

NOTE: *The LED may appear to flash when the input goes high and low repeatedly.*

Discrete Output Modules

GENERAL

DO modules can provide up to 4 or 8 discrete outputs, depending upon module type. Line fault detection is also provided on the 2/1 modules for both open- and short-circuit conditions.

Output Mode

The DO module outputs may be configured for one of three different types of output:

- Discrete
- Single pulse
- Continuous pulse

Discrete

The Bus Interface Module (BIM) or Controller signals an ON or OFF condition on demand.

Singe Pulse *(See Notes 1 & 2)*

This is an individual "single-shot" action, creating a single ON pulse of specified duration that occurs at a definable time. The pulse on-time can be varied between 2ms and 130s in increments of 2ms. If a new ON command (i.e. trigger) is given during the ON period the pulse will restart. If a new pulse width is supplied during the ON period, it will not take effect until the next ON period. A pulse can experience a small amount of time dither that depends upon the amount of Railbus activity. This can be ± 1% of the pulse width or ± 3.5 ms, whichever is the longer.

Continuous Pulse *(see Notes 2, 3 & 4)*

This type of output provides a continuous pulse train that is defined by the pulse ontime, and the pulse period (the time between the start of each ON time). The pulse period is configurable to any value between 4 ms and 130,000 ms in 2 ms steps. The pulse on-time is the same as for the momentary action described above. The on-time must not exceed the setting for the pulse period. (See also the above note regarding AC modules.)

Pulses can experience a small amount of time dither that depends upon the amount of Railbus activity. This can be ± 1% of the pulse period, or ± 3.5 ms, whichever is the longer.

Continuous pulse operation has two distinct modes—static and dynamic. When in static mode, the pulse parameters are cleared from memory when the channel is made inactive; in dynamic mode the values are retained for use when the channel is made active once again.

Line Fault detection (2/1 only)

When enabled, this will cause a flag to be set to indicate a short or open circuit fault even when channel output is in OFF state.

MODULE OPERATING STATES

Failsafe mode

The module supports failsafe mode as defined in the earlier I/O module introductory section, with the following two additions:

1) Channel using "Configured failsafe values"

In this mode, the module will force the outputs to predefined levels— defined on a per channel basis.

On entering "failsafe":

a) If channel is in **Static** mode of operation: Pulse mode is disabled and the channel is configured as a latched output and is driven to its failsafe value.

b) If channel is in **Dynamic** mode of operation: If in single pulse (momentary) mode, the configuration is not cleared, but the output is driven to its failsafe value.

On leaving failsafe:

Channel will adopt the mode defined below for a channel going from inactive to active state

2) Channel using "Hold last value"

If the module goes into failsafe during a single pulse, it is allowed to complete the pulse before adopting the failsafe state. A latched (discrete) output will remain at its current value.

Channel Active / Inactive

Each channel can be made active or inactive individually.

When a channel is made inactive the output is turned OFF (i.e. de-energized). When a channel changes from inactive to active the following situations apply:

- **a)** If channel is in Static mode of operation: It becomes a latched output and will remain so until reconfigured.
- **b)** If channel is in Dynamic mode of operation: The channel will resume operation with its previous configuration and output.

Power-up conditions

On power-up, or if a reset is executed, the configuration will automatically adopt predefined states:

Module mode:
Normal (not failsafe)

Channel types
All channels are configured as Discrete outputs

Active/Inactive
All channels power-up in the Inactive state

Line fault detection (2/1 only)
Disabled on all channels

Visual indicators

On	Channel input "high" or latched
Off	Channel input "low"
Flashing	Line fault detect (2/1 only)

On the DO modules the yellow "Status" LED reacts in the following way to module conditions.

NOTE: *The LED may appear to flash when the input goes high and low repeatedly.*

NOTES:

1. *This action is only available in Static mode.*
2. *AC modules will react differently to the on-time length and trigger time. The module can only be triggered ON during a zero crossing of the AC waveform; similarly, the module can only switch OFF at a zero crossing point. The minimum on-time is therefore restricted to half the total period of a regular waveform.*
3. *Continuous pulse operation is supported only by Version 2 models of BIMs 8502 and 8505.*
4. *On 2/2 modules, this action is only available in Static mode.*

Pulse Input Modules

2-channel pulse/quadrature

GENERAL

These modules are designed to meet the requirements of a very wide range of mechanical positioning and flow applications. When used separately, the two input channels will accept pulse inputs to measure:

- Frequency
- Acceleration / rate
- Number of pulses (i.e. counter)

When combined, they provide:

- Rotational position and direction data from quadrature encoding devices. In addition, the module has two digital outputs and one digital input to gate (start/stop) the channel 1 internal counter.

Pulse inputs

Pulse inputs can come from a range of sensors having different amplitudes, trigger levels and input impedance requirements.

Inputs types accepted are:

- Proximity detectors (NAMUR/DIN19234)
- Current inputs
- Voltage inputs
- Switch / electro-mechanical inputs

Threshold levels for the current and voltage input can be set to suit the application.

Dynamic data

Several values are calculated, for each channel, from the signal pulses received.

Frequency

This is calculated by measuring the time interval between pulses. An average is calculated over a period (20 ms to 200 s) defined by the user. The time interval is measured from the edge of one pulse to the same edge of the next pulse. The polarity (rising or falling edge) can be configured.

The default is the rising edge. There are ten frequency measurement ranges. They start at 0 – 100 Hz and rise in ratios of 3, 5 and 10. However, the maximum frequency of the module is 50kHz, so any values in the 100 kHz range that exceed this should be considered as “out-of-range”.

Acceleration

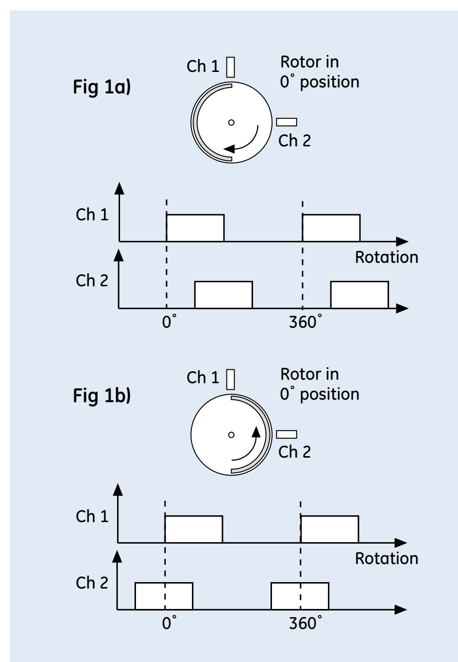
This is calculated from the difference in frequency from the start to the end of the sample period. A positive value indicates an increase in the rate of frequency and a negative value is a decrease in the rate.

Counting

Each channel has a 32-bit counter that indicates the total number of input pulses since the counter was reset. The counter on Channel 1 can be started and stopped by the control gate input and both channel counters can be started, stopped and reset by BIM commands. Counters can be configured to count up (the default) or down. If the quadrature calculation is enabled (see below) then the configured counter direction is ignored; instead counter direction is determined by the quadrature value (up for forward, down for reverse).

A counter preset value can be configured by a BIM command which also resets the counter. On reaching the preset count value an event is triggered which can also be passed to the channel’s digital output. This state is cleared by resetting the counter or assigning a new preset value.

Quadrature (rotation direction)



The second channel can be used to determine direction of rotation by comparing the phase of its input pulse with that of the first channel.

If the Ch 2 input is in a low state on the rising edge of the Ch 1 pulse then the rotation is forward (Fig 1a). If the Ch 2 input is high on the rising edge of the Ch 1 pulse then the rotation is backward (Fig 1b).

Filtering

The module has a hardware filter which can be used to minimise the effects of contact bounce. The available settings are 1, 5, 20 kHz and Off.

Alarms

High / Low alarms

High and low alarms can be configured for each channel. When the input value goes beyond an alarm limit, channel and module flags are set, the channel LED flashes and, if configured, the channel's digital output state will change.

Acceleration alarms

An acceleration alarm limit can also be set. If the limit is exceeded the actions taken are identical to those for the high/low alarms.

Alarm deadband

A deadband can be specified for the high, low and acceleration alarms. This provides hysteresis to avoid repetitive alarms in noisy signal environments.

Missing pulse alarm

Both channels can be configured to detect a "missing pulse". If no input pulse is detected for a defined time period an alarm is signalled in the same way as the high/low alarms. The alarm is cleared on receipt of a pulse or on reconfiguration of the alarm. The time period is restarted after each sample period in which at least one pulse occurs.

Line Fault Detect

Each channel can be configured to sense an open or a short circuit condition on inputs. On detection, the actions are those for the high/low alarms. On fault, the node can: report the frequency value as being at the top or the bottom of the range, freeze the counter, set the acceleration to zero; depending on how the BIM or Controller is configured.

Control data

The host can write data to control each channel counter. The available parameters are: start, stop, set, reset and preset value.

Digital outputs

Both digital output channels can reflect the status of the inputs by indicating:

- Frequency or acceleration alarm
- Counter preset value reached while the main channel can also output:
- Quadrature forward or reverse signal
- Scaled retransmission (a "divided by N" version of the input)