RIO-CU5
RIO-CU24
RIO-CU5L
RIO-CU24L

"How to Use" Guide

April/29/2002

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1. Product Overview

1.1. System Overview

The Counter Modules are inserted into the EH-RIO product platform, which provides common packaging, terminal bases, and communications. The microprocessor provides the Backplane bus interface and supervisory functions needed to communicate the counter ASIC's information. The Counter Modules contain the I/O circuitry, counter ASIC, and the Backplane bus interface, and when plugged into its EH-RIO terminal base, allows connectivity between the Backplane bus and the customer field input and output devices.

1.2. Module Overview

The Counter Modules install into the EH-RIO Terminal Base (RIO-BSC/BSP or -BSC3/BSP3) and interface with the EH-RIO DeviceNet Pass-through (RIO-DNP), the EH-RIO DeviceNet Adapter (RIO-DNA) or Profibus-Adapter (RIO-PBA). The Counter Module serves as a "signal conditioner" and "function block" (i.e. a counter) between the customer process signals on the Terminal Base and the Backplane bus containing the command information. The three main functional blocks are the customer digital I/O interface, the counter "ASIC" and the microprocessor.

1.3. Functional Overview

The Counter Module accepts feedback from an encoder (either single ended or differential), pulse generators, or mechanical limit switches at frequencies up to 1 MHz. A filter is available with four settings (50Hz, 500Hz, 5kHz or 50kHz) or may be turned off to achieve the fastest counting rate. The input voltage range is 5Vdc (RIO-CU5 or RIO-CU5L) or 15-24Vdc (RIO-CU24 or RIO-CU24L). The module returns the count or frequency in the form of a 24 bit binary number (0 - 16,777,215) expressed in a 32 bit long word. Each counter has a user selectable Preset and Rollover value associated with it.

The RIO-CU5/RIO-CU24 have 2 outputs that access Customer Power from the Backplane bus to facilitate various output device's voltage requirements. The outputs are rated to source 0.5Amp at 10Vdc to 28.8Vdc. The outputs (RIO-CU24 & RIO-CU5) have been designed so that it is possible to tie them to an input (RIO-CU24 & RIO-CU24L) which allows the user to cascade counters of multiple modules. The counter has four user-selectable On-Off values (i.e. windows) associated with it. Either output may be tied to any or all of the window signals.

1.4. Operating Mode Overview

Counter Mode -	Read incoming single phase pulses, return a binary count.
Encoder Mode -	Read incoming 2 phase quadrature pulses, return a binary count.
Period / Rate Mode -	Count internal clocks during the On period, return a frequency. Outputs updated only at the end of the period.
Continuous / Rate Mode -	Count internal clocks during the On period, return a frequency. Outputs updated continuously during the period.
Rate Measurement Mode -	Read pulses during the sample period, return a frequency.
PWM Mode -	Generate a pulse width modulated signal (RIO-CU5 & RIO-CU24 only).
Pulse Generator Mode -	Generate a pulse, return width and quantity of trigger (RIO-CU5 & RIO-CU24 only).

2. Operating Modes

There are 7 operating modes in the RIO-CU5, -CU24 modules and 4 in the RIO-CU5L, -CU24L modules:

Counter, Encoder, Period / Rate, Continuous / Rate, Rate Measurement, PWM and Pulse Generator Modes.

The operation of the Counter and Encoder modes is nearly identical. The only difference between the two modes is in the type of feedback - 1 phase vs. 2 phase - for the count direction (up or down). That is, in Encoder mode, a transition is expected on B for counting to proceed in a direction, whereas, in Counter mode, the B input may be left at a static level.

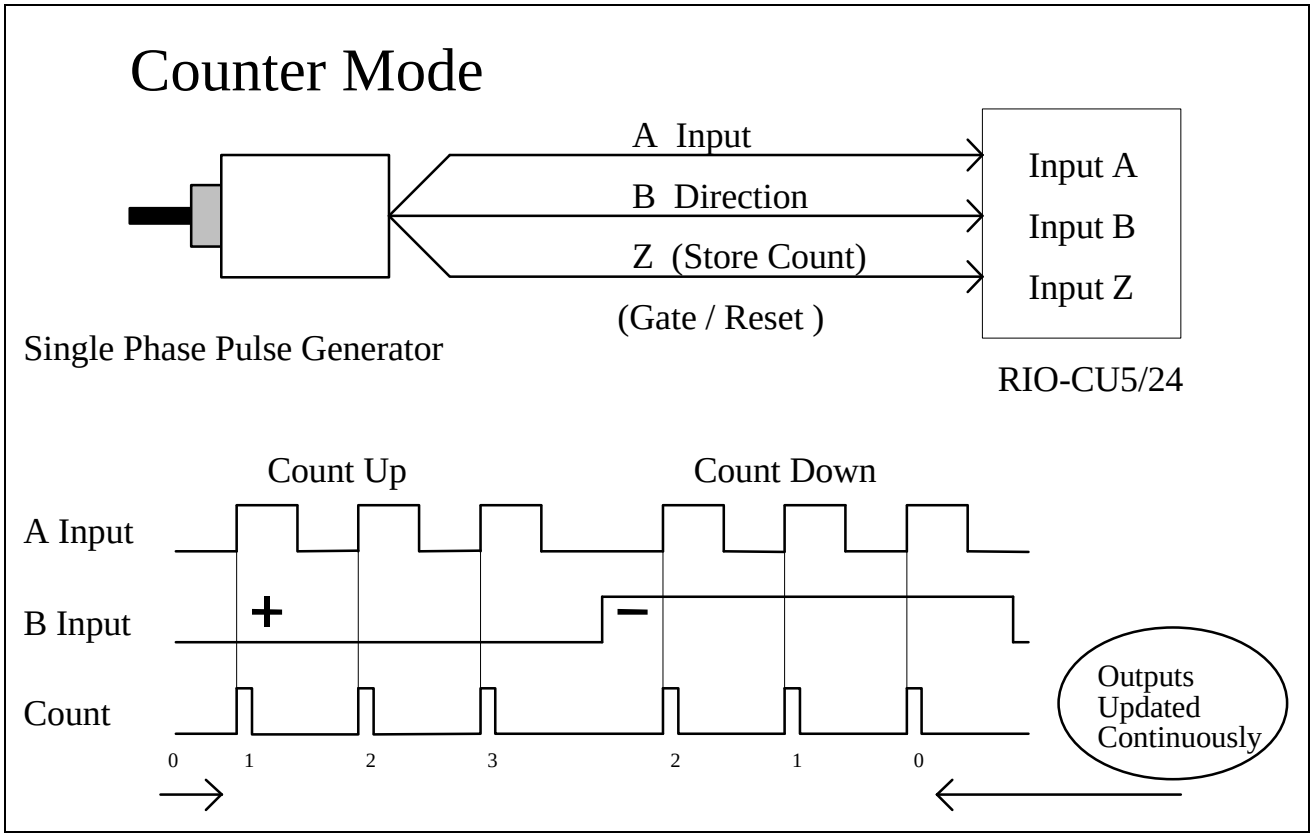
All operating modes are selected by writing appropriate configuration data to the module.

2.1. Counter Mode

The Counter Mode reads incoming pulses and returns a binary number (0 - 16,777,215$_{max}$) to the Backplane bus. The Counter mode accepts only single phase inputs. The module will determine the Phase B input state, and count up or down accordingly.

Channel A Input is used as the counting pulse while channel B is used to determine the direction.
[B = High, Count = Down; B = Low or floating (not connected), Count = Up]

The Channel B input may be tied high or low for unidirectional counting, or toggled for bi-directional counting.



2.2. Encoder Modes

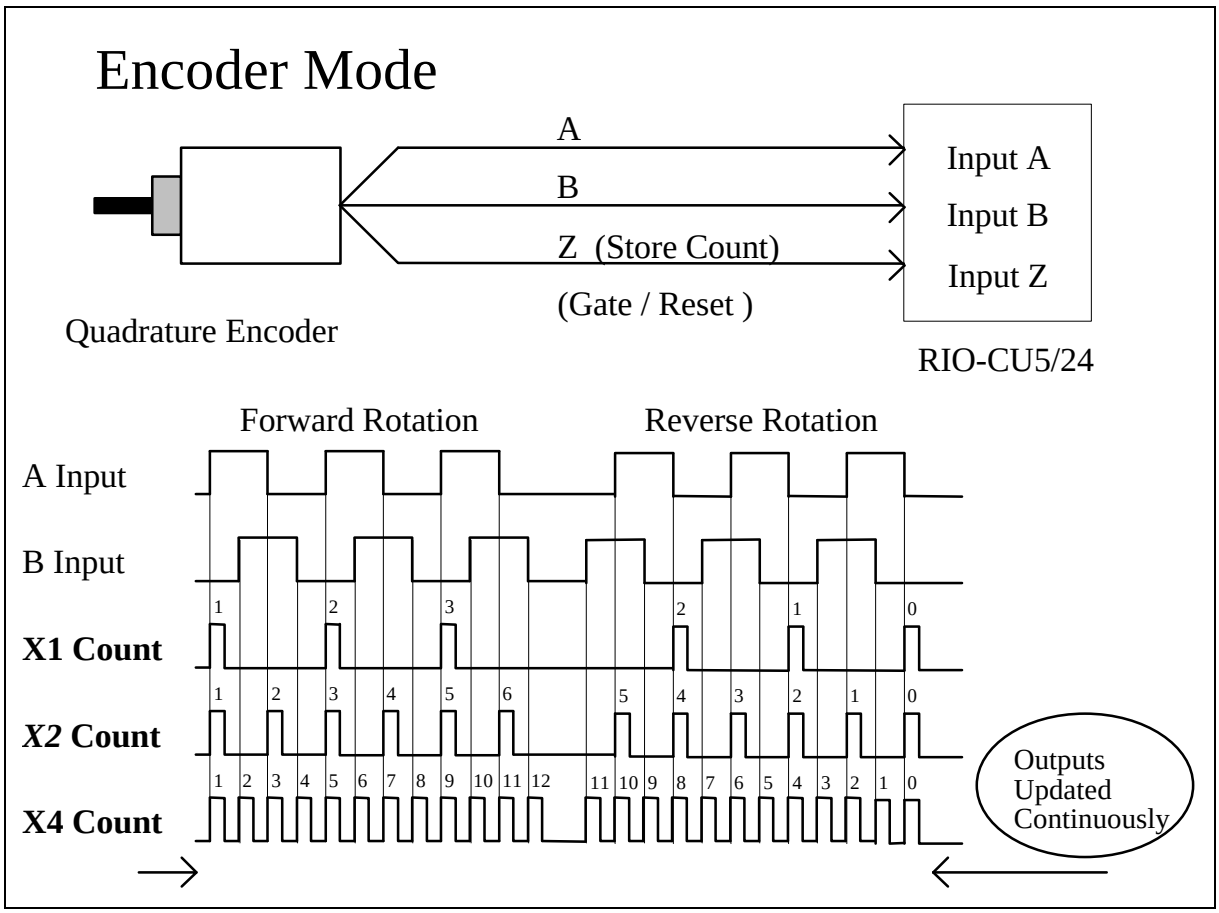
The Encoder Mode reads incoming pulses and returns a binary number (0 - $16{,}777{,}215_{max}$) to the Backplane bus. The Encoder mode will accept only 2 phase quadrature inputs. The module will sense the relationship between the 2 phases, and count up or down accordingly.

There are two basic encoder types, absolute and incremental. A single output incremental encoder is called a tachometer encoder. A dual channel incremental encoder with one channel leading the other by 90° is called a quadrature encoder.

A system using a quadrature encoder may include an optional zero pulse, or index, serving as a reference mark for system reset. The principal disadvantage of a system using incremental encoders is that a power interruption causes the loss of position reference, so a system must be reinitialized or returned to a known zero position.

Absolute encoders typically have higher speed requirements (200 KHz typical) for motion control applications. An absolute encoder has a unique code associated with each position, so the exact position is always known, even if the system power is turned off.

2.2.1. Encoder Mode - X1, X2, X4 Multiplying



X1 Multiplying Encoder Mode
Quadrature input signals are used to count on the Leading (up direction) OR Trailing (down direction) edge of A for a bi-directional count, and channel B is used to determine the direction.
[B = leads A, Count = Down; B = follows A, Count = Up]

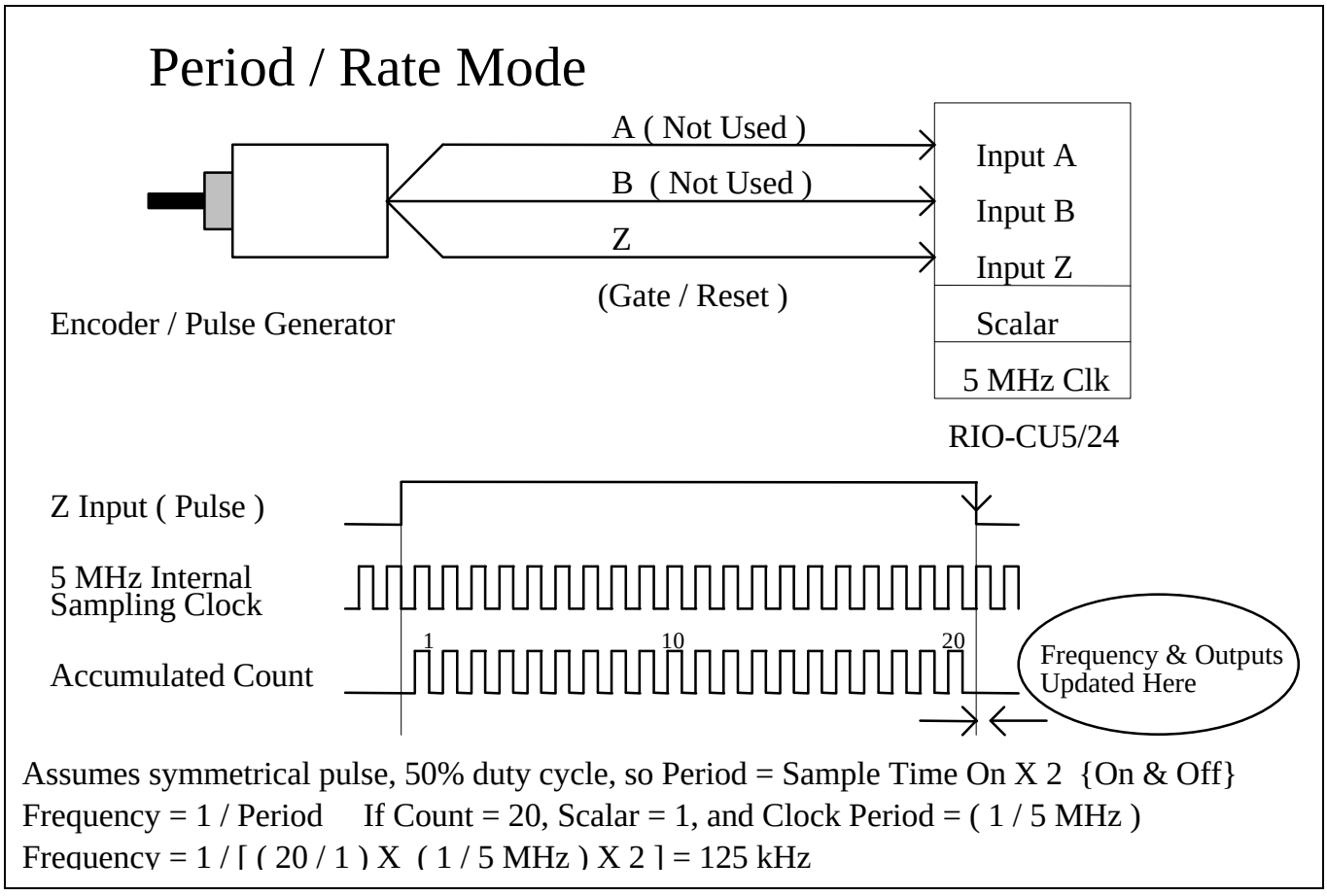
X2 Multiplying Encoder Mode
Quadrature input signals are used to count on Leading AND Trailing edges of A for a bi-directional count, and channel B is used to determine the direction.
[B = leads A, Count = Down; B = follows A, Count = Up]

X4 Multiplying Encoder Mode
Quadrature input signals are used to count on Leading AND Trailing edges of A AND B for a bi-directional count, and channel B is used to determine the direction.
[B = leads A, Count = Down; B = follows A, Count = Up]

2.3. Period / Rate Mode

The Period / Rate Mode will return an incoming frequency and a total accumulated count to the Backplane bus, by gating an internal 5MHz internal clock with an external signal.

This mode determines the frequency and total number of input pulses by counting the number of internal 5MHz clock pulses over a user-specified number of input signal pulses. At the end of the specified number of pulses, the module returns the frequency (0 - 1MHz). When the frequency is updated, both outputs are checked against their associated presets.



As the frequency of the incoming pulse train at the Z (Gate / Reset) terminal increases, the number of sampled pulses from the 5MHz clock decreases. Since accuracy is related to the number of pulses received over the sample period, the accuracy will decrease with increasing frequencies at the Gate / Reset terminal. Refer to the following Scaling table.

Relationship Between Sampled Pulses and Input Frequency

Input Frequency at Z Gate / Reset Terminal in Hz	Sample Pulses for 1/2 Cycle of Z Gate / Reset Pulse
2.5	1 M
5	500 k
10	250 k
20	125 k
50	50 k
100	25 k
200	12.5 k
500	5 k
1 kHz	2.5 k
2 kHz	1.25 k
5 kHz	500
10 kHz	250
20 kHz	125
50 kHz	50
100 kHz	25

To some extent, scaling the input frequency through the use of a scalar can lessen the decrease in accuracy. A scalar value of 1 will only return an accurate input frequency if incoming input pulses have a 50% duty cycle.

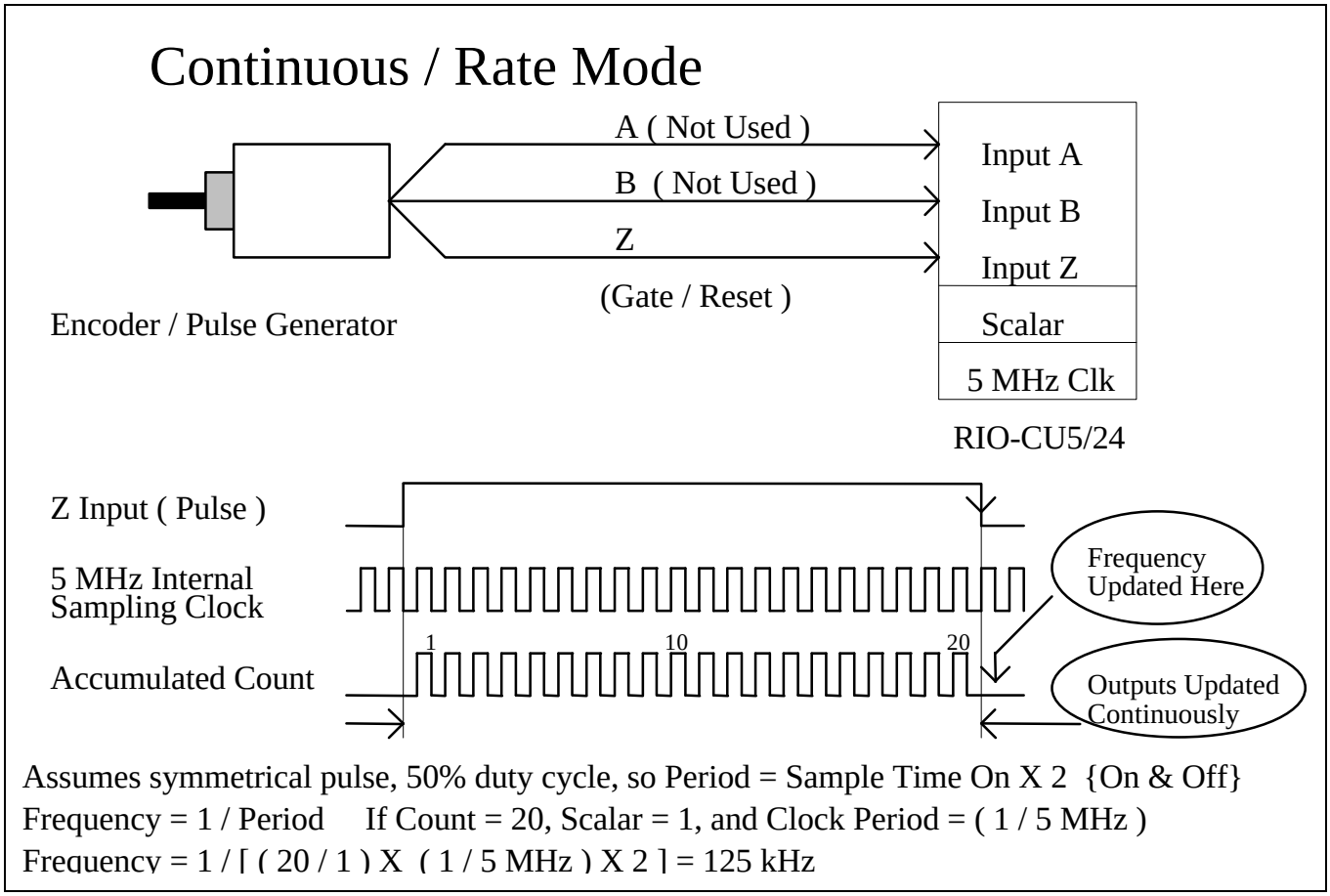
Operation of Scalar
In the Period / Rate and Continuous / Rate modes, the scalar lets the incoming pulse train at the Z Gate / Reset pin be divided by a user defined number. There is one scalar value for each counter. Acceptable values for the scalar are 1, 2, 4, 8, 16, 32, 64, and 128. The default value for each scalar is 1. Note that a “0” scalar is equivalent to a “1”.

The product of the Sample Period times the scalar should be less than 6.71 seconds in order to avoid a zero frequency detect indication.
(5 MHz sample time = 200ns; 16,777,216 counts x 200ns x 2 half cycles of Z = 6.71 seconds)

2.4. Continuous / Rate Mode (RIO-CU5 & RIO-CU24 only)

The Continuous / Rate Mode will return an incoming frequency and a total accumulated count to Backplane bus, by gating an internal 5MHz internal clock with an external signal.

Similar to the Period / Rate mode except outputs in this mode are updated continuously. This mode determines the frequency and total number of input pulses by counting the number of internal 5MHz clock pulses over a user-specified number of input signal pulses. Each output is turned on as soon as the turn-on count is reached, and turned off as soon as the turn-off count is reached. As the internal 5MHz clock is counted, the outputs dynamically track the 5MHz count.



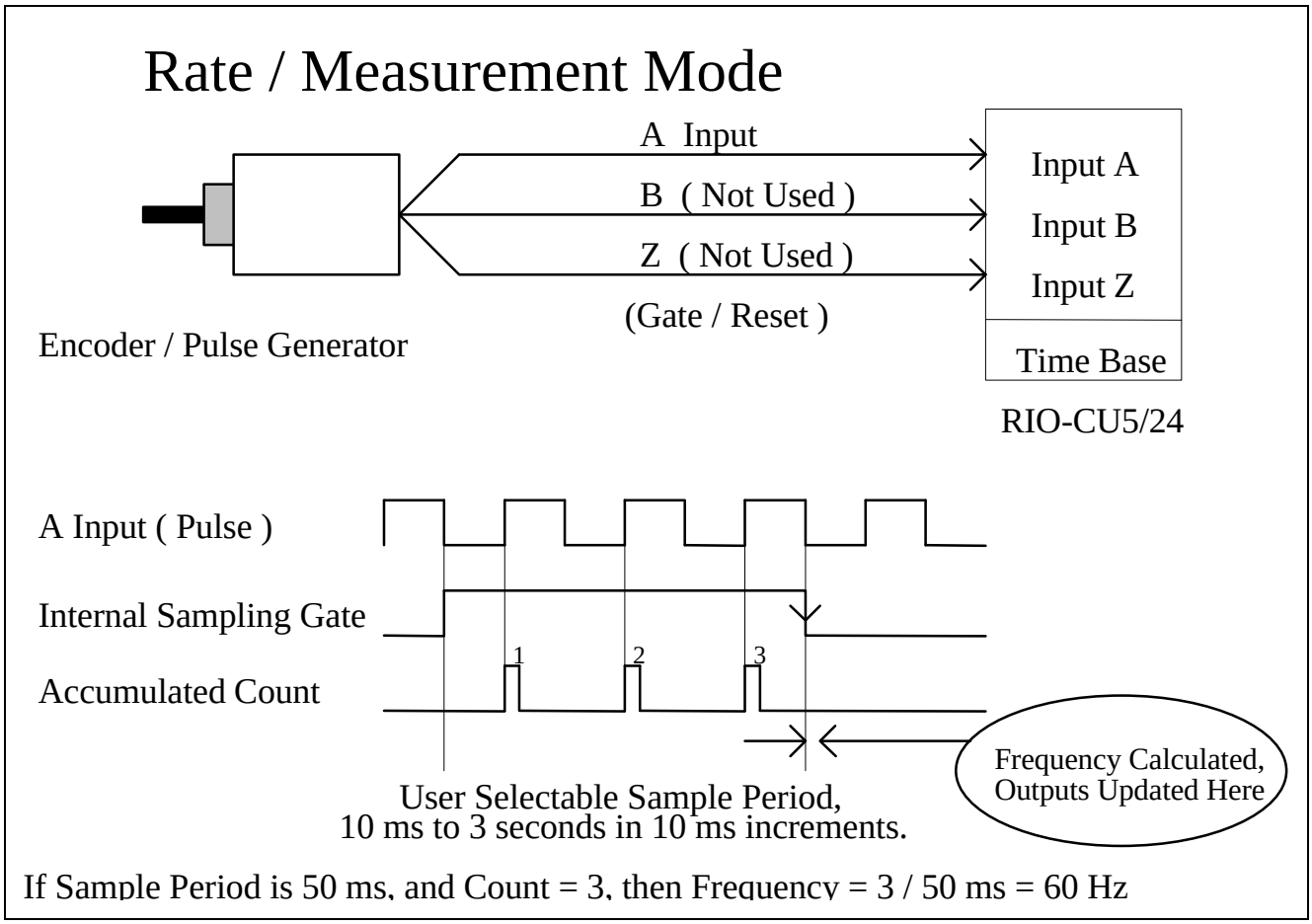
As the frequency of the incoming pulse train at the Z Gate / Reset terminal increases, the number of sampled pulses from the 5MHz clock decreases. Since accuracy is related to the number of pulses received over the sample period, the accuracy will decrease with increasing frequencies at the Gate / Reset terminal.

Refer to the “Operation of Scalar” information and table in the Period / Rate Mode.

2.5. Rate Measurement Mode

The Rate Measurement Mode will return an incoming frequency and a total accumulated count to the Backplane bus, based upon a user selected sample period.

This mode determines the frequency and total number of input pulses by counting the number of incoming pulses over a user-specified sample period. At the end of the interval, the module returns a value representing the sampled number of pulses and a value indicating the incoming frequency. When the count and frequency are updated, any associated outputs are checked against their associated presets. Frequency is calculated by dividing the accumulated count by the user selected time period, and is returned in the read data. Allowable time periods are 10 milliseconds to 3 seconds in 10 millisecond increments, with a default value of 1 second. Note that a "0" time period is equivalent to the 1 second default.



2.6. PWM Mode (RIO-CU5 and RIO-CU24 only)

The Pulse Width Modulation mode uses the counter to generate a continuous rolling sequence of numbers. The real-time PWM value written to the module is converted to a window edge so that a variable duty cycle signal can be generated. The counter will reset to zero based upon the PWM Period programmed into the module. Any output tied to Window 0 will transmit the PWM signal.

By specifying the PWM mode (configuration word 0), a period (configuration word 2) and a gate interval (configuration word 3 or 4), the counter its rollover and its first On/Off compare window (Window 0) is assigned (for internal use by the module). If an output is tied to compare window 0, that output will have a duty cycle controlled by the PWM output value (*output* word 2 or 3). Additionally, the remaining three compare windows associated with the channel (i.e. the counter), may be programmed with On and Off values, thereby providing signals related to the PWM signal generated by compare window 0.

When using a counter in PWM mode, its rollover is internally set to:

PWM period x 5MHz = rollover [i.e. 0 to (rollover-1)]
Example: 100ms x 5MHz = 500,000 [0 to 499,999]

where: PWM period is the product of the time base times the gate interval.
5MHz is the internal sample rate.

Thus, to generate additional signals from a counter set up for PWM, compare windows 1 through 3 may be programmed for On and Off values in the range of 0 to rollover-1.

2.7. Pulse Generator Mode (RIO-CU5 and RIO-CU24 only) *New for Series C*

The Pulse Generator Mode uses the Z input to enable the counter. Specifying the window compare values appropriately may then be used to generate a pulse. When the Z input is “inactive”, the counter is cleared and held at zero. Once the Z input goes “active”, the counter begins incrementing at a 1.25MHz rate until the Z input returns to its inactive state. If the Z input remains active greater than 13.4 seconds, the counter will saturate at 0x00FFFFFF and remain there - providing a timeout-hold function. This state can be exited by toggling the Counter Preset bit once an appropriate Preset Value has been initialized (usually zero). It should be noted that, opposed to the other modes, the CP bit must be explicitly set and cleared.

This mode may also be used to count the “active” duration of the Z input trigger (Present Channel Data) and the number of triggers received (Stored Channel Data). Counts cannot be attenuated in this mode.

The Z input invert works in this mode, so that a de-energized Z input may be recognized as “active”.

The scalar is available in this mode, which permits output pulses to be generated over multiple Z activations.

2.8. New Data Indicator

A two bit counter, C1 & C0, will be available, which will be updated every time an "event" occurs indicating that new data is available in the Stored/Accumulated Count words. Events are defined by:

- Any active gate transition in any of the **Store Count** (Counter or Encoder) modes;
- The end of the gate sample period in either the **Period / Rate**, **Continuous / Rate** or **Pulse Generator** modes;
- The end of the programmed sample period in the **Rate Measurement** or **PWM** mode.

To use these bits reliably, acquisition of data from the Counter Module must occur faster than the events, which cause C1/C0 to increment. When C1/C0 is updated, a Change Of State (COS) message can be sent.

2.9. Default Configuration

The module's default configuration will be:

VHSC:

Counter Mode = 0x00
50Hz filter on A, B and Z = 0x78
Decimal Position = 0x00
Active Output Assembly is 105 = 0x00
No time base = 0x0000
No gate interval = 0x00
No scalar = 0x00
Output 0 untied = 0x00
Output 1 untied = 0x00
Rollover = 0x00FFFFFF
Preset = 0x00000000
Window comparators = 0x00000000 (all)
PWM Safe State = 0x0000
Counter Control Safe State = 0x00
Output Control Safe State = 0x00

RIO-CU5L & RIO-CU24L:

Counter Mode = 0x00
50Hz filter on A, B and Z = 0x78
Decimal Position = 0x00
Reserved = 0x00
No time base = 0x0000
No gate interval = 0x00
No scalar = 0x00
Rollover = 0x00FFFFFF
Preset = 0x00000000
Counter Control Safe State = 0x00

2.10. Application of New Configurations

When a configuration is sent to the RIO-CU5/24, it is checked for consistency before being applied. If an error is found in the configuration, the PE bit is asserted and the module locally retains its previous configuration. To isolate any problems an improperly configured module may have, the user application program (i.e. ladder program) should monitor this error.

If the configuration is considered acceptable, the counter ASIC is disabled (i.e. counting is suspended and outputs are shut off), while the ASIC is loaded with the new operational parameters.

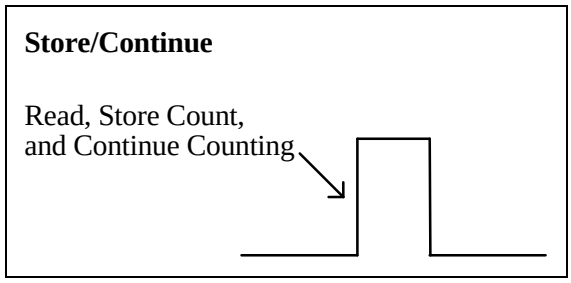
3. Operating Mode Features

3.1. Operating Mode Features

The Z Gate/Reset Terminal will operate in one of four modes when the Store Count feature is in use. The four figures below detail the operation in each mode.

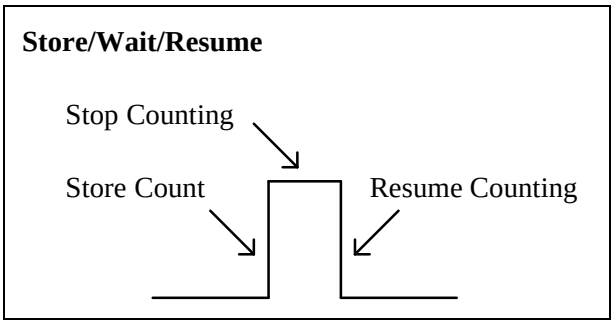
Store Count Mode 1: Store/Continue

In mode 1, the rising edge of a pulse input on the Z Gate/Reset terminal will cause the current counter value to be read and stored in the Read Data file. The counter will continue counting. The stored count will be available in the Stored/Accumulated Count word. The stored count information will remain until it is overwritten with new data.



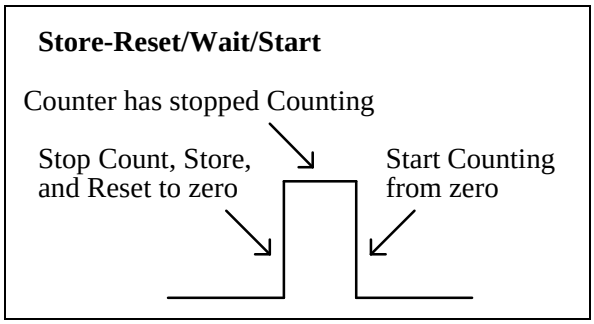
Store Count Mode 2: Store/Wait/Resume

In mode 2, the rising edge of a pulse input on the Z Gate/Reset terminal will read and store the current counter value in the Stored/Accumulated Count word and inhibit counting while the Z Gate/Reset terminal is high. Counting resumes on the falling edge of the pulse at the Z Gate/Reset terminal. The stored count information will remain until it is overwritten with new data.



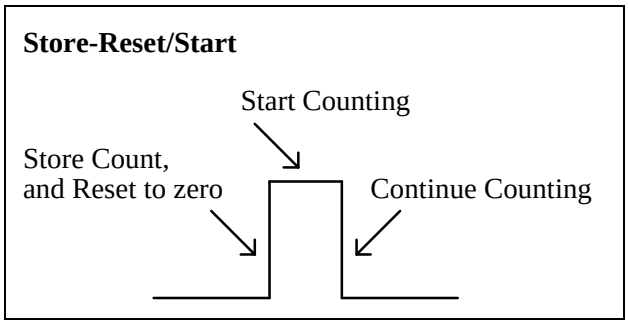
Store Count Mode 3: Store-Reset/Wait/Start

In mode 3, the rising edge of a pulse input on the Z Gate/Reset terminal will stop counting, read and store the current counter value in the Stored/Accumulated Count word, and reset the counter to zero. The counter does not count while the input pulse on the Z Gate/Reset terminal is high. Counting resumes from zero on the falling edge of the pulse at the Gate/Reset terminal. The stored count information will remain until it is overwritten with new data.



Store Count Mode 4: Store-Reset/Start

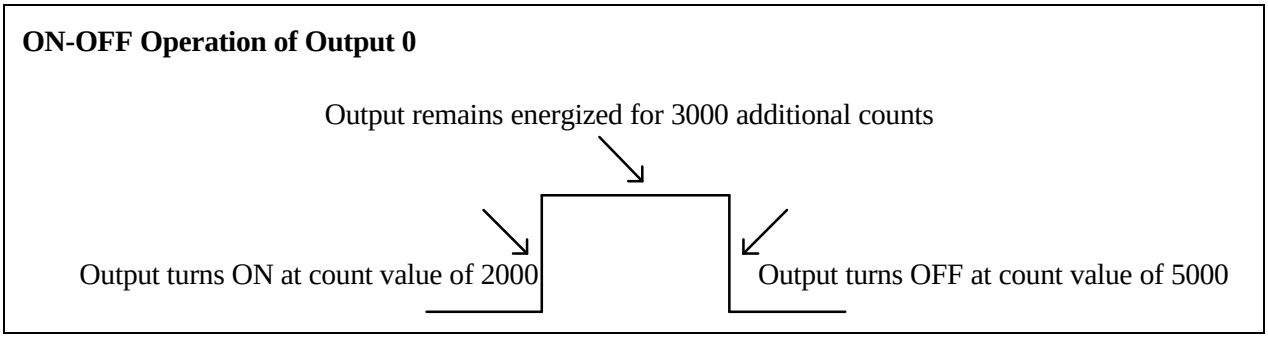
In mode 4, the rising edge of a pulse input on the Z Gate/Reset terminal will store the current counter value in the Stored/Accumulated Count word and reset the counter to zero. The counter will continue counting while the Z Gate/Reset terminal is high. The stored count information will remain until it is overwritten with new data.



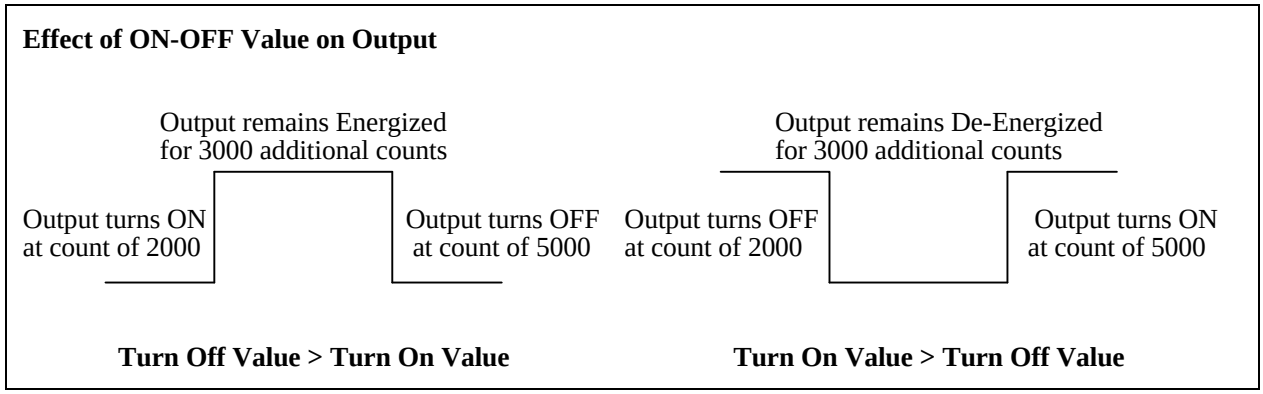
3.2. Output Control

To connect an output to a compare window, the user could program the module accordingly:

Tie Output 0 to Window 0
Program Window 0 ON Value to 2000
Program Window 0 OFF Value to 5000



If the OFF value is greater than the ON value, the output turns ON at 2000 and OFF at 5000 (Left figure). If the ON value is greater than the OFF value, the output turns OFF at 2000 and ON at 5000 (Right figure).



4. Product Specifications

4.1. I/O Interface Specifications

4.1.1. 5 / 15-24 VDC Input Point Features / Considerations

The input circuitry of RIO-CU5 and RIO-CU5L modules will be compatible with a 5Vdc differential line driver, single ended driver, open collector circuit and electromechanical switches. The input circuitry of RIO-CU24 and RIO-CU24L modules will be compatible with a 15-24Vdc differential line driver, single ended driver, open collector circuit and electromechanical switches.

To turn on an input circuit, the user must source current through the input resistors sufficient to turn on the opto-isolator in the circuit.

If no connection is made to a pair of input terminals, no current will flow through the photodiode of the opto-isolator and that channel will be off. Its corresponding input status indicator will be off.

All 3 Inputs are electrically identical (A, B, Z) and consist of the following:

Channel A and A return, Channel B and B return, Gate Z and Z return

There are 2 basic classes of driver devices built into encoders and other pulse sources: single-ended and differential. A single-ended driver output consists of a signal and a ground reference. A differential driver consists of a pair of totem-pole outputs driven out of phase. One terminal actively sources current while the other sinks, and there is no direct connection to ground.

Differential line drivers provide reliable, high-speed communication over long wires. Most differential line drivers are powered by 5V, and are more immune to noise than single-ended drivers at any operating voltage.

4.1.2. Lead Breakage / Missing Pulse / Zero Frequency Considerations

First, a few definitions are needed to define the intended operation of the Counter Modules:

Lead Breakage
Typically requires a shunt resistor (across the load) to detect 3 levels of current / input states - Open (Wire Off, Device = ?), Off (Wire OK, Device Off), On (Wire OK, Device On). This method does not check the input against a time base, only that the device wiring (current loop) is intact.

Missing Pulse
Typically uses an input pulse to reset a watchdog timer (fixed or programmable HW).
This method does detect “Lead Breakage”, since a broken wire will time-out the watchdog.

Zero Frequency
Typically uses an input pulse to calculate an input frequency and verify it is above an error threshold. This method does detect "Lead Breakage", since a broken wire will generate a 0 Hz. frequency.

"Missing Pulse" or "Zero Frequency" will also detect a customer device stuck "high' or "low", since the counter is monitoring for a change in the input state. Currently, the Counter / Encoder Modes **do not** have Zero Frequency Detection - the "A" & "B" inputs are time independent, only looking for input edge changes to increment / decrement the count value.

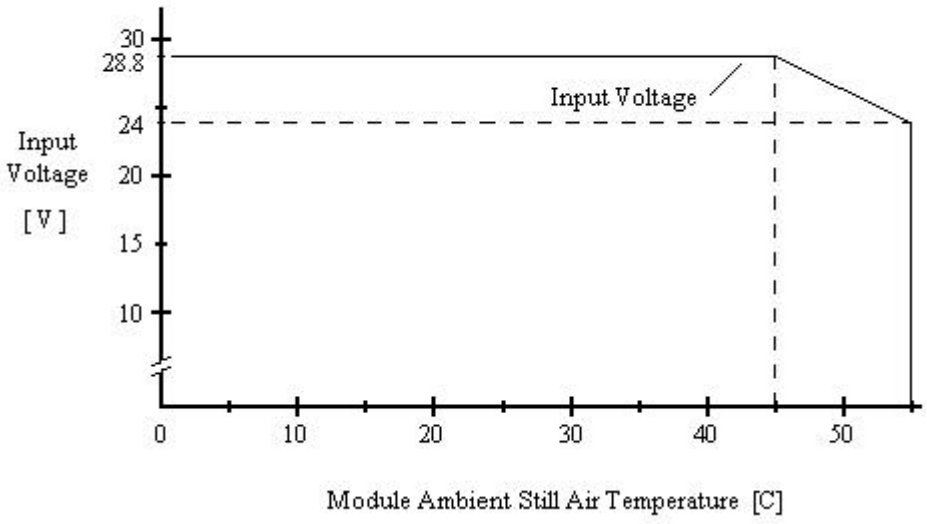
The Period / Rate and Continuous Rate modes **do** have Zero Frequency Detection, since the "Z" input is monitored for Zero Frequency in Firmware (A and B inputs not used, and not monitored).

The Rate Measurement mode inherently has Zero Frequency Detection, since no "A" pulses in any sample period are = 0 Hz (B and Z inputs not used, and not monitored).

Operational Mode	Zero Frequency Detection	Input Monitored
Counter	N	None
Encoder	N	None
Period / Rate	Y	Z Only
Continuous / Rate	Y	Z Only
Rate Measurement	Y	A Only
PWM	N	None
Pulse Generator	N	Z only

4.1.3. Input Specifications

Number of Counters	1
Maximum Count Value	16,777,215 (24 bit counter)
Number of Inputs	1 group of A/A_{return}, B/B_{return} and Z/Z_{return}.
Input Voltage	5Vdc (RIO-CU5 & RIO-CU5L) or 15-24Vdc (RIO-CU24 & RIO-CU24L)
Input Current	19.1mA @ 5Vdc, 25.7mA @ 6Vdc (RIO-CU5 & RIO-CU5L), 6.1mA @ 15Vdc, 10.2mA @ 24Vdc (RIO-CU24 & RIO-CU24L)
Input Off-State Current	≤ 0.250mA
Input Off-State Voltage	≤ 1.25Vdc (RIO-CU5 & RIO-CU5L), ≤ 1.8Vdc (RIO-CU24 & RIO-CU24L)
Input On-State Current	≥ 5mA
Input On-State Voltage	≥ 2.6Vdc (RIO-CU5 & RIO-CU5L), ≥ 12.5Vdc (RIO-CU24 & RIO-CU24L)
Maximum On-State Voltage[1]	± 6V (RIO-CU5 & RIO-CU5L), See derating figure below (RIO-CU24 & RIO-CU24L).
Input Filter Selections	5 selections: OFF or 10µs/100µs/1.0ms/10.0ms per A/B/Z group. See text for details.
Maximum Input Frequency	1.0MHz counter and encoder x1configurations (no filters), 500kHz encoder x2 configuration (no filters), 250kHz encoder x4 configuration (no filters).



4.1.4. Output Specifications (This section only applies to RIO-CU5 & RIO-CU24)

Number of Outputs	1 isolated group of 2 capable of 0.5A max. @ 24Vdc.
Output Control	Outputs may be tied to any of 4 compare windows.
Output-Supply Voltage Range	10-28.8Vdc
Off-State Leakage Current	≤ 0.5mA
On-State Voltage Drop	≤ 0.3Vdc @ 0.5A.
On-State Current Maximum	0.5A
Max Module Output Current	1.0A
Short Circuit Current	~6A *Outputs are short circuit protected and, based upon programming, either cycle until the fault is corrected or latch off.* Short circuit detected when output is turned ON.
Open Wire Detection	Open wire detected when output is turned OFF.
Delay Time, Off /On	25µs (load dependent)
Delay Time, On/Off	150µs (load dependent)

[1] Exceeding the maximum input voltage may cause permanent damage to the input.

4.1.5. General Specifications

Terminal Base Compatibility	RIO-BSC/BSP or RIO-BSC3/BSP3
Terminations	A (M1-0), A_{ret} (M1-1), B (M1-2), B_{ret} (M1-3), Z, (M1-4), Z_{ret}, (M1-5), Out 0/ChasGnd(opt) (M1-6), Out 1/ChasGnd(opt) (M1-7), ChasGnd (M2-0), ChasGnd (M2-1), Out 0 Return (M2-2), Out1 Return (M2-3), Vaux– (M2-4), Vaux– (M2-5), Vaux+ (M2-6), Vaux+ (M2-7)
Backplane bus Current	160mA (RIO-CU5L and RIO-CU24L), 180 mA (RIO-CU5 and RIO-CU24)
Power Dissipation	1.5W (RIO-CU5), 1.9W (RIO-CU24), 1.1W (RIO-CU5L), 1.5 W (RIO-CU24L),
Keyswitch Position	2
Indicators	3 Input status system side yellow LEDs; 2 Output status system side red/yellow LEDs; 1 Network status system side red/green LEDs; 1 Module status system side red/green LEDs.
Isolation Voltage	Modules are pre-qualified for 1250Vacrms between each of the four isolated areas: Module 1: a) System side (Backplane bus), b) A/B/Z inputs, c) O0/O1 and user power supply, d) Chassis Ground. Module 2: a) System side (Backplane bus), b) Chassis Ground, c) Vaux +/-, d) User power supply common.
External DC Power[2]	No additional external power is needed to power the module.
Field Power Bus	24Vdc nominal; range 10-28.8Vdc
Dimensions	2.97”L x 0.472”W x 2.21”H or 75.5*mm x 12mm x 56mm*

[2] Does not represent power required to supply the outputs.

Environmental Conditions		
	Operational Temperature	-20 to 55°C (-4 to 131°F)
	Storage Temperature	-40 to 85°C (-40 to 185°F)
	Relative Humidity	5 to 95% non-condensing (operating) 5 to 80% non-condensing (non-operating)
	Shock Operating	30g peak acceleration, 11(±1)ms pulse width
	Non-operating	50g peak acceleration, 11(±1)ms pulse width
	Vibration	Tested 5g @ 10-500Hz per IEC 68-2-6
Conductors	Wire Size	14 gauge stranded maximum 3/64 inch (1.2mm) insulation maximum
	Category	2

4.2. Pin and Wiring Assignments

4.2.1. High Speed Counter Module-to-Terminal Base Connector

The Counter Modules plug into a terminal base via a 20 position edge card connector, which enables the module to make connections to screw or spring clip terminals for customer field device I/O and power. In addition, Backplane bus signals also make connections through this interface. A signal description follows:

Module 1 (M1)

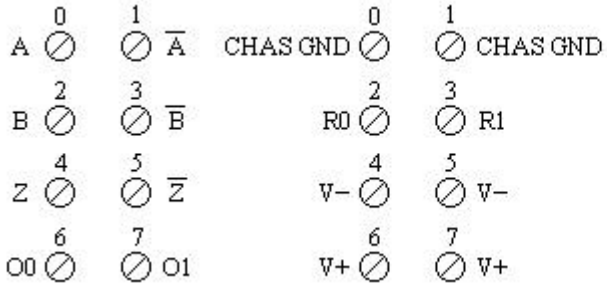
Pin Number	Description
1	Screw 0 - A
2	Screw 1 - A_{ret}
3	Screw 2 - B
4	Screw 3 - B_{ret}
5	Screw 4 - Z
6	Screw 5 - Z_{ret}
7	Screw 6 - Output 0 / Ground (-CU5L,-CU24L)
8	Screw 7 - Output 1 / Ground (-CU5L,-CU24L)
9	Chassis Ground
10	Chassis Ground
11	User_Supply (for outputs)
12	User_Supply (for outputs)
13	Common
14	Common
15	Bus_Can_H
16	Ground
17	Bus_Can_L
18	Vcc
19	Bus_Ena_In_L
20	Bus_Ena_Out_L

Module 2 (M2)

Pin Number	Description
1	Screw 0 - Chassis Ground (for shield)
2	Screw 1 - Chassis Ground (for shield)
3	Screw 2 - Common (output return)
4	Screw 3 - Common (output return)
5	Screw 4 - Vaux– (for encoder)
6	Screw 5 - Vaux– (for encoder)
7	Screw 6 - Vaux+ (for encoder)
8	Screw 7 - Vaux+ (for encoder)
9	Chassis Ground
10	Chassis Ground
11	No Connect
12	No Connect
13	Common
14	Common
15	No Connect
16	No Connect
17	No Connect
18	No Connect
19	Bus_En pass-thru
20	Bus_En pass-thru

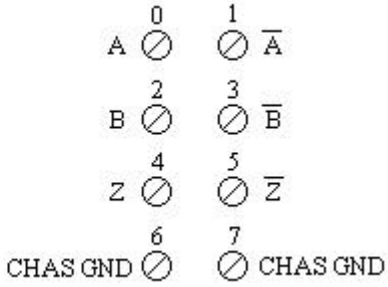
4.2.2. Terminal Base Field Wiring Assignments

The proposed terminal assignments for customer connections to the EH-RIO Terminal Base are shown below. To meet European standards, the terminal base assignments provide one location for every wire.



RIO-CU5/24 Terminal Wiring

Terminal Wiring



RIO-CU5L/-RIO-CU24L

4.3. Input/Output/Information/Configuration Data

The Counter Modules require several words to communicate real time input and output data as well as non-real time module information (i.e. description, revision, etc) and configuration. The following tables show the words, which must be exchanged.

Data may be read or written (get or set service) using an Explicit Message. For example, to read the Present Channel Data, Assembly 65_{16} (101_{10}) can be requested:

Service	Class	Instance	Attribute
0E (get)	04 (assembly)	65 (Present Data)	03 (Data Attribute)

Data is ordered accordingly:	8 bit byte	byte0
	16 bit word	byte0, byte1
where: byte0 is the LSB	32 bit long word	byte0, byte1, byte2, byte3

4.3.1 RIO-CU5 & RIO-CU24 Assemblies

Class Code: 04

Class Attributes
None

Class Services
None

Instance Attributes
3 Data Get/Set

Instance Services
0x0E Get Attribute Single
0x10 Set Attribute Single

Instantiated Instances

INSTANCE	Services	FIELD	BYTES
#101 (0x65)	Get	Present Channel Data	4
		Status	2
#102 (0x66)	Get	Stored Channel Data	4
		Status	2
#103 (0x67)	Get	Present Channel Data	4
		Stored Channel Data	4
		Status	2
#104 (0x68)	Get	Programming Error Code	2
#105 (0x69)	Set/Get	Counter Control	1
		Output Control	1
#106 (0x6a)	Set/Get	PWM Value	2
#107 (0x6b)	Set/Get	PWM Value	2
		Counter Control	1
		Output Control	1
#108 (0x6c)	Set/Get	Counter Configuration	1
		Filter Selection	1
		Decimal Position	1
		Active Output Assembly	1
		Time Base or PWM Period	2
		Gate Interval	1
		Scalar	1
		Output 0 Ties	1
		Output 1 Ties	1
		Rollover Value	4
		Preset Value	4
		ON Value # 1	4
		OFF Value #1	4
		ON Value # 2	4
		OFF Value #2	4
		ON Value # 3	4
		OFF Value #3	4
		ON Value # 4	4
		OFF Value #4	4
		PWM Safe State Value	2
		Counter Control SSV	1
		Output Control SSV	1

Assembly 101 is produced for a polled connection, Assembly 102 is produced for a COS connection, Assembly 103, 104, 107 and 108 are by Explicit message only and Assembly 105 & 106 are consumed in a polled connection (as directed by Parameter 4).

INSTANCE	Services	FIELD	BYTES
#123 (0x7b)	Set/Get	Counter Configuration	1
		Filter Selection	1
		Decimal Position	1
		Reserved (set to 0)	1
		Time Base or PWM Period	2
		Gate Interval	1
		Scalar	1
		Output 0 Ties	1
		Output 1 Ties	1
		Alignment (reserved = 0)	2
		Rollover Value	4
		Preset Value	4
		ON Value # 1	4
		OFF Value #1	4
		ON Value # 2	4
		OFF Value #2	4
		ON Value # 3	4
		OFF Value #3	4
		ON Value # 4	4
		OFF Value #4	4
		PWM Safe State Value	2
		Counter Control SSV	1
		Output Control SSV	1

Note: Assembly 123 was added at firmware revision 3.001. It was needed to provide long word alignment.

4.3.2 RIO-CU5/24 Parameter Classes

Class Code: 0F

Class Attributes
None

Class Services
None

Instance Attributes
1 Data Get/Set

Instance Services
0x0E Get Attribute Single
0x10 Set Attribute Single

Parameter #			
1	Set/Get	Counter Configuration	1
2	"	Filter Selection	1
3	"	Decimal Position	1
4	"	Active Output Assembly	1
5	"	Time Base or PWM Period	2
6	"	Gate Interval	1
7	"	Scalar	1
8	"	Output 0 Ties	1
9	"	Output 1 Ties	1
10	"	Rollover Value	4
11	"	Preset Value	4
12	"	ON Value # 1	4
13	"	OFF Value #1	4
14	"	ON Value # 2	4
15	"	OFF Value #2	4
16	"	ON Value # 3	4
17	"	OFF Value #3	4
18	"	ON Value # 4	4
19	"	OFF Value #4	4
20	"	PWM Safe State Value	2
21	"	Counter Control SSV	1
22	"	Output Control SSV	1
23	"	Requested Poll Produce Assy	1
24	"	Requested COS Produce Assy	1
25	"	Requested Poll Consume Assy	1

Note: Parameters 23, 24 & 25 are *new for Series C* - firmware revision 3.001.

4.3.3 RIO-CU5L & RIO-CU24L Assemblies

Class Code: 04

Class Attributes
None

Class Services
None

Instance Attributes
3 Data Get/Set

Instance Services
0x0E Get Attribute Single
0x10 Set Attribute Single

Instantiated Instances

INSTANCE	Services	FIELD	BYTES
#101 (0x65)	Get	Present Channel Data	4
		Status	2
#102 (0x66)	Get	Stored Channel Data	4
		Status	2
#103 (0x67)	Get	Present Channel Data	4
		Stored Channel Data	4
		Status	2
#104 (0x68)	Get	Programming Error Code	2
#105 (0x69)	Set/Get	Counter Control	1
#106 (0x6a)	Set/Get	Counter Configuration	1
		Filter Selection	1
		Decimal Position	1
		Reserved	1
		Time Base	2
		Gate Interval	1
		Scalar	1
		Rollover Value	4
		Preset Value	4
		Counter Control SSV	1
#123 (0x7b)	Set/Get	Counter Configuration	1
		Filter Selection	1
		Decimal Position	1
		Reserved	1
		Time Base	2
		Gate Interval	1
		Scalar	1
		Rollover Value	4
		Preset Value	4

		Counter Control SSV	1
		Alignment (reserved = 0)	1

Assembly 101 is produced for a polled connection, Assembly 102 is produced for a COS connection, Assembly 103, 104 and 106 are by Explicit message only and Assembly 105 is consumed in a polled connection.

Note: Assembly 123 was added at firmware revision 3.001.

4.3.4 RIO-CU5L/RIO-CU24L Parameter Classes

Class Code: 0F

Class Attributes
None

Class Services
None

Instance Attributes
1 Data Get/Set

Instance Services
0x0E Get Attribute Single
0x10 Set Attribute Single

Parameter #			
1	Set/Get	Counter Configuration	1
2	"	Filter Selection	1
3	"	Decimal Position	1
4	"	Reserved	1
5	"	Time Base	2
6	"	Gate Interval	1
7	"	Scalar	1
8	"	Rollover Value	4
9	"	Preset Value	4
10	"	Counter Control SSV	1
11	"	Requested Poll Produce Assy	1
12	"	Requested COS Produce Assy	1

Note: Parameters 11 & 12 are *new for Series C* - firmware revision 3.001.

4.3.5 Format of the Data

Input Information	
Present Channel Data	32 bit value of the present counter state
Stored Channel Data	32 bit value of the stored/accumulated count
Status	PE EF NR 0 FS FS OS OS 0 ZS BS AS C1 C0 ZD 0
Programming Error Code	PE 0 0 0 0 E_{10} E9 E8 E7 E6 E5 E4 E3 E2 E1 E0
Output Information	
Counter Control	0 0 0 0 0 VR CP CR
Output Control	DS ES OE FO DS ES OE FO
PWM Value	16 bit decimal value with range from 0-9500 (0-95.00%)
Configuration Information	
Counter Configuration	ZI MD MD MD CF CF CF CF
Filter Selection	0 ZF BF AF FS FS FS FS
Decimal Position	8 bit value used to modify the Present Channel Data display
Active Output Assembly	Assembly # (0, 105 or 106)
Time Base or PWM Period	16 bit value used to set the time base or PWM period
Gate Interval	8 bit value used to set the gate interval
Scalar	8 bit value used to divide the Z input by 2^n
Output 0 Ties	0 0 0 0 T3 T2 T1 T0
Output 1 Ties	0 0 0 0 T3 T2 T1 T0
Rollover Value	32 bit value at which the counter is commanded to rollover
Preset Value	32 bit value the counter is to be set when CP is asserted
ON Value # 1	\
OFF Value # 1	\
ON Value # 2	\
OFF Value # 2	\ 32 bit values that set the 4 compare windows
ON Value # 3	/
OFF Value # 3	/
ON Value # 4	/
OFF Value # 4	/
PWM Safe State Value	16 bit safe state value for the PWM signal
Counter Control Safe State Value	0 0 0 0 0 VR CP CR
Output Control Safe State Value	DS ES OE FO DS ES OE FO
Requested Poll Produce Assy	VHSCx - 101, 102 or 103; RIO-CU5L/RIO-CU24L - 101, 102, 103
Requested COS Produce Assy	VHSCx - 102 or 103; RIO-CU5L/RIO-CU24L - 102, 103
Requested Poll Consume Assy	VHSCx - 0, 105 or 106

4.3.6 ASA Information

Vendor ID = 1 (AB) Product Type = 109

RIO-CU5 Product Code = 13 RIO-CU24 Product Code = 14
RIO-CU5L Product Code = 15 RIO-CU24L Product Code = 16

4.3.7. Input Data

Present Channel Data

This is a 32 bit unsigned long word value representing the current count of the 24 bit counter *(configurations: count [0], x1 encoder [1], x2 encoder [2], PWM [3], x4 encoder [4], pulse generator [8])* **or** the frequency *(configurations: period/rate [5], continuous/rate [6], rate measurement [7])*. The range of values is 0 ≤ value ≤ 0x00FFFFFF (16,777,215).

Stored/Accumulated Channel Data

This is a 32 bit unsigned long word value representing the stored count of the counter at the time of some specified event. In counter configurations *(configurations: count [0], x1 encoder [1], x2 encoder [2], x4 encoder [4])* without store modes selected, these words are not updated. With store modes selected, they are the stored value of the counter at the time of the specified event (ex: rising edge of Z input). In *PWM [3]* configuration it is the counter value at the end of the period specified by the product of the time base x gate interval. In *period/rate [5]*, *continuous/rate [6]* and *pulse generator [8]* configurations it is the total accumulation of unscaled Z pulses (i.e. if scaling is set to 128, after 128 Z pulses the accumulator will increase by 128 counts). The maximum frequency that accumulation can follow in these modes is 200Hz x scalar value (ex: 200Hz x 128 is 25kHz). Finally, in *rate measurement [7]* configuration, it is the total number of pulses seen at the A input accumulated over each period as specified by the product of the time base x gate interval. The range of values occupy the entire 32 bit size from 0 ≤ value ≤ 0xFFFFFFFF (4,294,967,295). Changing the configuration does not clear these words.

Module/Channel Status

PE Programming Error bit. If an incomplete, incorrect or conflicting set of configuration parameters are sent to the module, the PE bit will be asserted and an error code will be placed in the Programming Error Code word (assembly 68_{16}). The module will **not** enter a normal operational state. Bit definitions for the error code are:

- E10: An invalid assembly was chosen for poll consumption (0, 105 or 106 are valid).
- E9: The decimal point position is outside of acceptable range.
- E8: Counter 0 window ON & OFF values are equal and not zero OR
  Counter 0 window ON or OFF value greater than the Rollover.
- E7: A tie has been connected to an unprogrammed window.
- E6: A configuration was selected that requires the scalar and none was programmed OR Multiple scalars were selected.
- E5: The preset is out of range (≥ Rollover).
- E4: A rollover of zero was programmed though PWM was not selected OR
  A rollover was programmed and PWM was selected OR
  Rollover is out of range (> 0x01000000).
- E3: A configuration requiring time base was selected and no gate interval was set OR
  Gate interval is out of range (> 200) OR
  Product of time base and gate interval is greater than 3 seconds.
- E2: A time base was entered that is not a multiple of 10 OR
  Time base is out of range (> 3000, i.e. 3 seconds).
- E1: ZF/BF/AF were selected and no filter was programmed OR

Multiple filters were selected.
E0: A reserved configuration/mode was programmed.

EF EEPROM Fault status bit. If a fault is detected with the EEPROM during power up tests, this bit is asserted to 1. It indicates that the content of the EEPROM has been corrupted, most likely caused by loss of power during an executing write.

NR Not Ready status bit. Whenever power is applied to the module, the hardware must be initialized. During this time, the NR bit will be asserted.

FS Output Fault Status indicators, where bit 11 is output 1 and bit 10 is output 0. A 1 indicates the output is either shorted or open.

OS Output Status indicators, where bit 9 is output 1 and bit 8 is output 0. A 1 indicates the output is ON, 0 it is OFF.

ZS Z input Status. This bit indicates the present status of the Z input. A 1 indicates Z is ON, a zero, that it is OFF. This bit is unaffected by Z Invert, ZI, in the Counter Configuration word.

BS B input Status. This bit indicates the present status of the B input. A 1 indicates B is ON, a zero, that it is OFF.

AS A input Status. This bit indicates the present status of the A input. A 1 indicates A is ON, a zero, that it is OFF.

C[1,0] Stored data count. This count cycles through [0 0], [0 1], [1 0], [1 1], [0 0]… Each time the stored/accumulated count words are updated, C[1,0] is incremented. This feature assumes the host's sample rate (including network delay and program scan) is as fast or faster than the frequency of the event which updates C[1,0].

ZD Zero frequency Detected. This bit becomes operational when frequency configurations are programmed *(configurations: period/rate [5], continuous/rate [6], rate measurement [7])*. In *period/rate [5]* and *continuous/rate [6]* configurations, counts are acquired during the **ON** state of the Z input. At very low frequencies the counter saturates, indicating a zero frequency detect. The time it takes to determine a zero frequency in these two configurations can be as long as 6.7 seconds (16,777,216 counts x 1/5MHz x 2 half cycles of Z). In *rate measurement [7]* configuration pulses on the A input are counted over a sample interval specified by the time base. The time it takes to determine a zero frequency in this configuration will be determined by the sample interval (ex: time base = 0.300 second ∴ 300 milliseconds to determine ZF).

4.3.8. Output Data

Counter Control

VR Value Reset of stored/accumulated count. The transition of this bit from a 0 ⇒ 1 clears the stored/accumulated count word. The module will return this bit to zero.

CP Counter Preset. The transition of this bit from a 0 ⇒ 1 sets the counter to the value specified by the Preset words. The module will return this bit to zero. Outputs are adjusted according to the window compare values. In configuration *pulse generator [8],* this bit must be returned to zero explicitly, 0 ⇒ 1 ⇒ 0, the module does not clear it.

CR Counter Reset. The transition of this bit from a 0 ⇒ 1 clears the counter. The module will return this bit to zero. Outputs are adjusted according to the window compare values.

Output Control (RIO-CU5 and RIO-CU24 only)

DS Diagnostic Speed. When this bit is set to 1, the short circuit and open wire diagnostics will be filtered (50ms) to prevent nuisance trips caused by noisy environments. When this bit is a zero, diagnostics will respond in under 8ms to a fault condition.

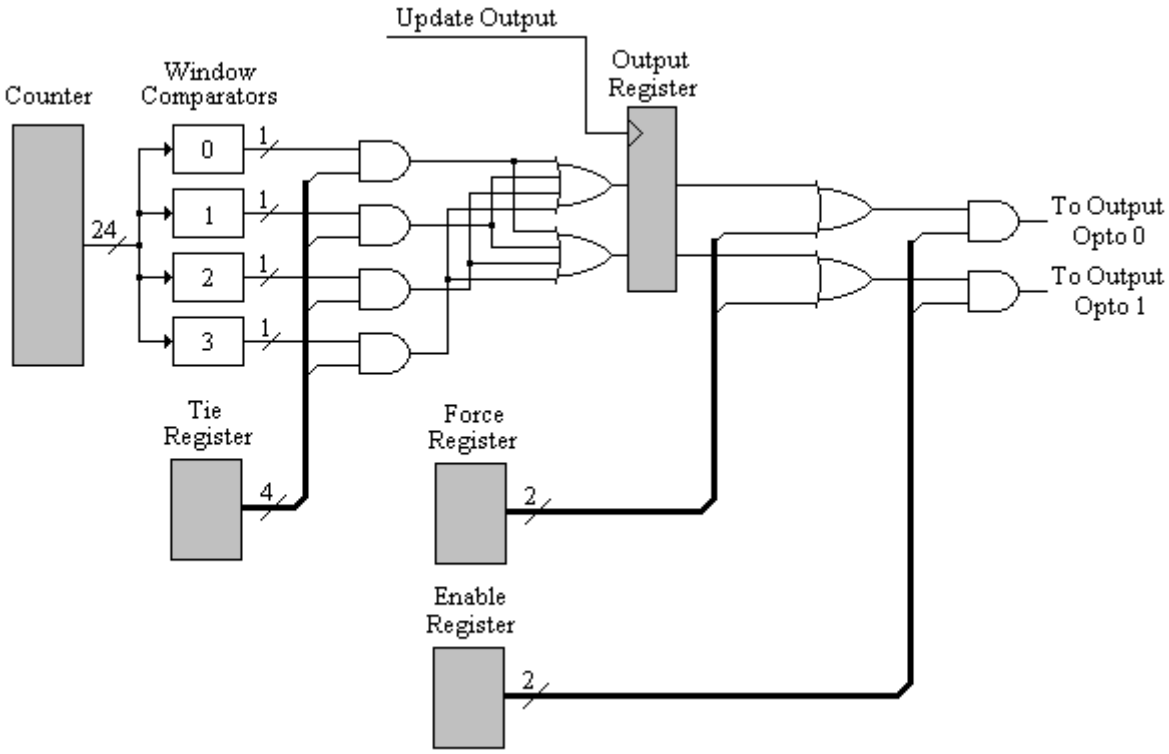
ES Electronic-fuse Select. When this bit is set to 1, outputs will be disabled upon the detection of a fault (short circuit or open wire) and the output fault status indicator, FS, will be latched. Recovery from a faulted state is achieved by sending ES=0 and OE=1 for the afflicted output. When ES equals zero, a faulted output will continue to operate as instructed until the fault is removed. In either case, FS is asserted to indicate a fault.

OE Output Enable. When this bit is set to 1, outputs are permitted to turn on from either a force on, FO, a compare match or as directed by the PWM settings. When OE equals zero, the module turns the associated output OFF. Bit 5 & 1 represent outputs 1 & 0 respectively.

FO Force Output. When this bit is set to 1, outputs are turned on if OE is 1. When FO equals zero, outputs may then be controlled by a compare match or as directed by the PWM settings. Bit 4 & 0 represent outputs 1 & 0 respectively.

PWM Value (RIO-CU5 and RIO-CU24 only)

When the module is programmed for a *PWM [3]* configuration, the time base is enabled, the counter for the respective channel, its rollover AND its 1st ON and 1st OFF value are utilized. Ties may be used to direct the PWM signal to any or both outputs. The range of PWM values is 0 ≤ value ≤ 9500 decimal (i.e. 0.00% ≤ value ≤ 95.00%). Entering a value “below” 0 will result in a PWM of 0%; a value greater than 9500 will result in a PWM of 95.00%. The actual duty cycle observed at the output will depend on the turn on and turn off times of the MOSFET, the energy storage capability of the cable/load and the resistance from output to return.



Counter to Output Logical Connectivity

4.3.9. Configuration Data

Counter Configuration

This byte sets the counter configuration.

```
 7   6   5   4   3   2   1   0 ⇐ COUNTER 0
ZI  |<-  MD ->| |<---  CF --->|

                0   0   0   0  counter
                0   0   0   1  encoder x1
                0   0   1   0  encoder x2
                0   0   1   1  pwm (RIO-CU5 and RIO-CU24 only)
                0   1   0   0  encoder x4
                0   1   0   1  period/rate *
                0   1   1   0  continuous/rate * (RIO-CU5 and RIO-CU24
only)
                0   1   1   1  rate measurement
                1   0   0   0  pulse generator
     0   0   0                 store count disabled
     0   0   1                 mode 1 - store/continue
     0   1   0                 mode 2 - store/wait/resume
     0   1   1                 mode 3 - store,reset/wait/start
     1   0   0                 mode 4 - store,reset/start
     1   0   1                 reserved
     1   1   0                 reserved
     1   1   1                 reserved
 0                             Z input is not inverted
 1                             Z input is inverted
```

Filter Selection

This byte sets the A/B/Z input filters.

```
 7   6   5   4   3   2   1   0 ⇐ COUNTER 0
 0  ZF  BF  AF  |<---  FS --->|

                0   0   0   0  no filter
                0   0   0   1  50kHz** (10µs +0µs / –1.6µs)
                0   0   1   0  5kHz** (100µs +0µs / –13.2µs)
                0   1   0   0  500Hz** (1.0ms +0µs / –125µs)
                1   0   0   0  50Hz** (10.0ms +0ms / –1.25ms)
            0                  A input not filtered
            1                  apply filter to A input
        0                      B input not filtered
        1                      apply filter to B input
    0                          Z input not filtered
    1                         apply filter to Z input
```

* See section **Real Time Input Data**, Stored/Accumulated Count and **Configuration Data**, Scalar.

** Assumes 50% duty cycle.

Decimal Position

This byte changes the significant digits of the frequency or counter display.

In the frequency modes (*period/rate [5]*, *continuous/rate [6]*, *rate measurement [7]*) for example, a -2 will move the decimal point left 2 places, dividing the frequency value by 100, a +1 moves it right, multiplying by 10. The firmware checks for placement to be in the range -4 ≤ value ≤ +2. A value outside the range will move the decimal point to the zero position and assert the programming error (PE) bit. Moving the decimal point to the left (i.e. negative), allows high frequencies, commonly present in rate measurement mode, to fit within a single 16 bit word. Moving the decimal point to the right (i.e. positive), allows low frequencies, commonly present in period and continuous rate modes, to have resolution displayed to 0.1Hz and 0.01Hz. Frequencies should be kept below 3.2kHz for 0.1Hz resolution and below 320Hz for 0.01Hz. Scalars of Z/128, Z/64, Z/32 and Z/16 should *not* be used when decimal positioning is applied. 0 is the default setting.

In the counter modes (*counter [0], x1 encoder [1], x2 encoder [2], pwm [3], x4 encoder [4]*), it attenuates the counter display, for example, 20 divides count+1 by 20. The value may be in the range 0 < value ≤ 255. The result of requesting a number other than 1 performs the function: (COUNT + 1) / ATTENUATION. This is useful for scaling a large counter value to a smaller 16 bit value or a percentage. 1 is the default setting and zero reverts to 1 to prevent a divide by zero.

This feature has no effect in *pulse generator [8]* configuration.

Active Output Assembly (RIO-CU5 and RIO-CU24 only)

This byte permits selection of either assembly 105 (0x69 - Counter/Output Control) or 106 (0x6A - PWM Value) for poll consumption. Entering a zero will cause the default assembly, 105, to be selected. This is available on the RIO-CU5/24s only. For Series C and later, Parameter 25 must be zero to access this legacy operation.

Time Base/PWM Period

This word sets the fundamental time base for the counter. Its resolution is in milliseconds with minimum 10ms intervals (i.e. an interval of 10 milliseconds is a value of 10, 1 second is 1000). The maximum value that may be programmed is 3 seconds (3000). The time base must be entered when the *PWM [3]* and *rate measurement [7]* configurations are used.

Gate Interval

This byte sets the counter's gate interval using the time base setting as its time unit. (i.e. its resolution is determined by the time base). The actual gate interval is the product of the time base and the gate interval (ex: 50ms gate interval may be produced with a time base of 10 and a gate interval of 5 or a time base of 50 and a gate interval of 1). The maximum value of the product of time base x gate interval is 3 seconds. The gate interval must be entered when the *PWM [3]* and *rate measurement [7]* configurations are used. The maximum value is 200.

Scalar

This byte scales the Z signal in the *period/rate [5]*, *continuous/rate [6]* and *pulse generator [8]* configurations. If the filter is applied, then the filtered Z is scaled. Only one bit of the scalar should be set. Selecting a scalar will cause accumulated counts to be adjusted accordingly (i.e. selecting a scalar of 128 will increase the accumulated count by 128 after 128 Z pulses have been received). ***It is highly recommended that anytime Z is scaled (divide by 2, 4, 8, etc), the Z input should be filtered, otherwise, noise could cause erroneous frequency readings.***

```
7    6    5    4    3    2    1    0
|    |    |    |    |    |    |    |
|    |    |    |    |    |    |    Z   Fmin = 0.149Hz
|    |    |    |    |    |    Z/2  Fmin = 0.298Hz
|    |    |    |    |    Z/4  Fmin = 0.596Hz
|    |    |    |    Z/8  Fmin = 1.192Hz
|    |    |    Z/16  Fmin = 2.384Hz
|    |    Z/32  Fmin = 4.768Hz
|    Z/64  Fmin = 9.537Hz
Z/128  Fmin = 19.073Hz
```

F_{min} indicates the frequency at which the 24bit counter overflows.

Output 0-1 Ties (RIO-CU5 and RIO-CU24 only)

The bits in these two bytes connect the specified output to the appropriate compare window. There are four windows associated with the counter. Each output may be connected to any number of windows, from one to all four. The bits are defined as follows:

T0 Tie Output to 1st Compare Window (also the PWM signal in *PWM [3]* configuration)
T1 Tie Output to 2nd Compare Window
T2 Tie Output to 3rd Compare Window
T3 Tie Output to 4th Compare Window

Rollover

This long word sets the number of counts the counter will accumulate before rolling over. For example, a value of 1000 will produce a count sequence of: 998, 999, 0, 1, 2… while incrementing or 2, 1, 0, 999, 998… while decrementing. Rollover is a 32 bit number with a useable range of 1 ≤ value ≤ 0x01000000 (16,777,216). In *PWM [3]* configuration, this value should be zero; in *count [0], x1 encoder [1], x2 encoder [2] and x4 encoder [4]* configurations, it should be specified to some non-zero value; and in *period/rate [5], continuous/rate [6], rate measurement [7]* and *pulse generator [8]* configurations is a 'don't care'.

Preset

This long word sets the preset value the counter will be loaded with, when a Counter Preset, CP, command is issued. Preset is a 32 bit number with a range of 0 ≤ value ≤ Rollover ($16{,}777{,}215_{max}$).

Counter ON and OFF Windows (RIO-CU5 and RIO-CU24 only)

These long words program the four compare window's ON and OFF values. The first compare window for each counter is utilized in *PWM [3]* configuration and, when PWM is programmed for a channel, the associated compare window should remain at 0. The range of each entry in configuration *count [0], x1 encoder [1], x2 encoder [2], x4 encoder [4]* is 0 ≤ value < Rollover. The range of each entry in configurations: *PWM [3], period/rate [5], continuous/rate [6], rate measurement [7]* is 0 ≤ value ≤ 0x00FFFFFF. The maximum value is 0x00FFFFFF (16,777,215). When a tie is connected to a window comparator, that window must be specified (i.e. ON value ≠ OFF value ≠ 0). These Windows are always interpreted as counts, regardless of the configuration setting and may be computed as follows:

counts = (scalar x 2.5E6) / desired_freq *period/rate [5], continuous/rate [6]*
counts = time_base [sec] x gate_interval x desired_freq *rate measurement [7]*

Safe State Values

When either the host transitions to PROGRAM mode or a communication fault (i.e. broken network cable) occurs, the module copies these safe state words into its real-time working buffer. The definitions are identical to those described under Real-time Output Data with the following exception: entering a PWM Safe State value outside of the range, 0-9500, will result in a **Hold Last State** to be executed.

4.4. Status / Diagnostic LEDs

The Counter Modules have several system side LEDs, which behave according to the "Common LED definitions" in FS#X0220.

1 red/green module status;
1 red/green network status;
3 yellow input status;
2 red/yellow output status (RIO-CU5 and RIO-CU24 only).

The behavior for these LEDs is described as follows:

Module Status

Solid Green	Module is operating normally
Flashing Green	Device in standby (needs commissioning or HW being programmed)
Solid Red	Unrecoverable fault
Flashing Red	Minor fault
Flash Red/Green	Device in self-test
Dark	No power

Network Status (firmware common to other modules will be employed)

Solid Green	On-line connected
Flashing Green	On-line not connected
Solid Red	Critical link failure (duplicate MAC ID, etc)
Flashing Red	Connection timed out
Flash Red/Green	Special fault - see DeviceNet specification
Dark	Not powered or not on-line

Input Status

Solid Yellow	Input is ON
Flashing Yellow	Input is toggling
Dark	Input is OFF

Output Status (RIO-CU5 and RIO-CU24 only)

Solid Yellow	Output is ON
Flashing Yellow	Output is toggling
Solid Red	--
Flashing Red	Output is faulted (open, short or no output power)
Flash Red/Yellow	Output is toggling and faulted (open)
Dark	Output is OFF

4.5. Isolation

The Counter Module's isolation barriers have been tested to 1100Vdc 1min for UL and 2200Vdc 1 minute for stress between the following areas:

Module 1:

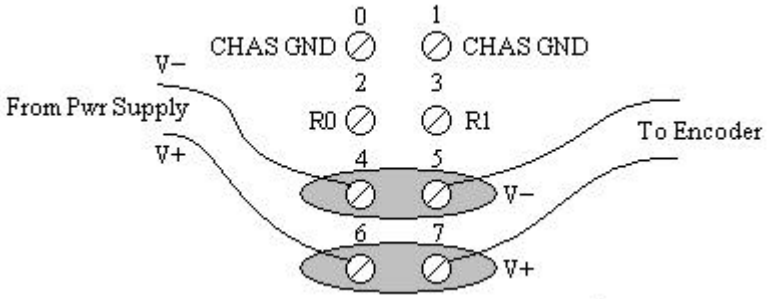
a) System side (Backplane bus),
b) A/B/Z inputs,
c) O0/O1 and user power supply,
d) Chassis Ground.

Module 2 (used with RIO-CU5 and RIO-CU24):

a) System side,
b) Chassis Ground,
c) User power supply common,
d) Vaux +/-.

4.6. Power Requirements and Connections

The Counter Modules will use System side power (+5Vdc @ < 180mA) provided on Backplane bus. Power for the two outputs (RIO-CU5 & RIO-CU24 only) will come from the User Power (10-28.8Vdc) connection on Backplane bus. Four screw terminals (Vaux+ and Vaux–) will be available to land wires from an auxiliary power supply to power an encoder or other input device. The VHSC does not use Vaux+/–; it is for customer wiring convenience only and may be expanded using the



RIO-SC/SP.

5.0 Added Profiles for Series B

RIO-CU5 & RIO-CU24

Configuration

Profibus Configuration Message (38 bytes)

Product Code High Byte	DeviceNet Product Code
Product Code Low Byte	
D | R | Offset	Diag: 0 = off, R = Reserved, Offset; 1-63
Counter Configuration	default = 0
Filter Selection	default = 0x78
Time Base or PWM Period (2 bytes)	default = 0
Decimal Position	default = 0
Scalar	default = 0
Rollover Value (4 bytes)	default = 0x00FFFFFF
Preset Value (4 bytes)	default = 0
ON Value for Output Window 0 (4 bytes)	default = 0
OFF Value for Output Window 0 (4 bytes)	default = 0
ON Value for Output Window 1 (4 bytes)	default = 0
OFF Value for Output Window 1 (4 bytes)	default = 0
PWM Safe State Value (2 bytes)	default = 0
Counter Control Safe State Value	default = 0
Output Control Safe State Value	default = 0
Active Output Assembly	default = Assembly 105

Note: Gate Interval will default to 10ms.

GMM Configuration Assembly

Backplane bus attribute 10.

Counter Configuration	default = 0
Filter Selection	default = 0x78
Time Base or PWM Period (2 bytes)	default = 0
Decimal Position	default = 0
Scalar	default = 0
Rollover Value (4 bytes)	default = 0x00FFFFFF
Preset Value (4 bytes)	default = 0
ON Value for Output Window 0 (4 bytes)	default = 0
OFF Value for Output Window 0 (4 bytes)	default = 0
ON Value for Output Window 1 (4 bytes)	default = 0
OFF Value for Output Window 1 (4 bytes)	default = 0
PWM Safe State Value (2 bytes)	default = 0
Counter Control Safe State Value	default = 0
Output Control Safe State Value	default = 0
Active Output Assembly	default = Assembly 105

For definitions, see RIO-CU5/24 specification

Produced IO Message

high byte of high word								Counter value (4 bytes)
low byte of high word								
high byte of low word								
low byte of low word								
high byte of high word								Stored/Accumulated value
low byte of high word								(4 bytes)
high byte of low word								
low byte of low word								
PE	EF	NR	0	FS	FS	OS	OS	Module and Output Status
0	ZS	BS	AS	C1	C0	ZD	0	Input and Counter Status
Reserved						N	E	PSB Status

ZS – set if Z input is energized.
BS – set if B input is energized.
AS – set is A input is energized.
C1/C0 – event count (see manual for complete description).
ZD – set when, in certain modes, the signal frequency is "zero".
PE – set when the programming configuration is in error.
EF – set when an EEPROM fault has been detected.
NR – set when module is not ready.
FS – set when a fault is present on an output.
OS – set when an output is on.
Error Exists – set if any channel has an error.
New Status – set if the channel has new status (cleared when master reads Channel Status, attribute 11 of the Backplane bus Object.).

Consumed IO Message

DS	ES	OE	FO	DS	ES	OE	FO	Output Controls
					VR	CP	CR	Counter Controls

OR

MSB	PWM Value (2 bytes)
LSB	

VR – assertion causes the stored/accumulated value to be cleared.
CP – assertion causes the counter to be loaded with the preset value.
CR – assertion causes the counter to be cleared.
DS – assertion causes a 50ms filter to be placed on the output diagnostics.
ES – assertion causes the output to act as an electronic fuse.
OE – assertion allows any source to turn on the output.
FO – assertion causes the output to turn on, if enabled.

Channel Status Word

Backplane bus attribute 11 with channel number in the data field of the request message.

INPUT:

1	Rsvd		Channel Number = 0	Channel Direction = input
1	1	0	Error Code	Channel Type = 2 words, Error code

Possible error codes:

0	No Error
8	Lower Limit Exceeded (**ZD** asserted)
9	General Error (**EF** asserted)
10	Configuration Error (**PE** asserted)

OUTPUTS:

0	Rsvd		Channel Number = 1,2	Channel Direction = output
1	0	1	Error Code	Channel Type = word, Error code

Possible error codes:

0	No Error
9	General Error (**FS** asserted)

Profibus Identity

Backplane bus attribute 16. (Length + Identity)

7	6	5	4	3	2	1	0
cnsis	size	Direction		Length			

Length:	0	1 to 16 words or bytes
Direction:	00	01 – input, 10 output, 11 – in & out ,00 – special
Size:	1	0 – byte, 1 – word
Consistency:	1	0 – over byte/word, 1 – over length

Profibus ID= 0xC0, 0x40, 0xC4

RIO-CU5L & RIO-CU24L

Configuration

Profibus Configuration Message (18 bytes)

Product Code High Byte			DeviceNet Product Code
Product Code Low Byte			
D	R	Offset	Diag: 0 = off, R = Reserved, Offset; 1-63
Counter Configuration			default = 0
Filter Selection			default = 0x78
Time Base (2 bytes)			default = 0
Decimal Position			default = 0
Scalar			default = 0
Rollover Value (4 bytes)			default = 0x00FFFFFF
Preset Value (4 bytes)			default = 0
Counter Control Safe State Value			default = 0

Note: Gate Interval will default to 10ms.

GMM Configuration Assembly

Backplane bus attribute 10.

Counter Configuration	default = 0
Filter Selection	default = 0x78
Time Base (2 bytes)	default = 0
Decimal Position	default = 0
Scalar	default = 0
Rollover Value (4 bytes)	default = 0x00FFFFFF
Preset Value (4 bytes)	default = 0
Counter Control Safe State Value	default = 0

For definitions, see RIO-CU5L/RIO-CU24L specification

Produced IO Message

high byte of high word								Counter value (4 bytes)
low byte of high word								
high byte of low word								
low byte of low word								
high byte of high word								Stored/Accumulated value
low byte of high word								(4 bytes)
high byte of low word								
low byte of low word								
PE	EF	NR	0	0	0	0	0	Module Status
0	ZS	BS	AS	C1	C0	ZD	0	Input and Counter Status
Reserved						N	E	PSB Status

ZS – set if Z input is energized.
BS – set if B input is energized.
AS – set is A input is energized.
C1/C0 – event count (see manual for complete description).
ZD – set when, in certain modes, the signal frequency is "zero".
PE – set when the programming configuration is in error.
EF – set when an EEPROM fault has been detected.
NR – set when module is not ready.
Error Exists – set if any channel has an error.
New Status – set if the channel has new status (cleared when master reads Channel Status, attribute 11 of the Backplane bus Object.).

Consumed IO Message

	VR	CP	CR	Counter Controls
				Not Used

VR – assertion causes the stored/accumulated value to be cleared.
CP – assertion causes the counter to be loaded with the preset value.
CR – assertion causes the counter to be cleared.

Channel Status Word

Backplane bus attribute 11 with channel number in the data field of the request message.

INPUT:

1	Rsvd		Channel Number = 0	Channel Direction = input
1	1	0	Error Code	Channel Type = 2 words, Error code

Possible error codes:

0	No Error
8	Lower Limit Exceeded (**ZD** asserted)
9	General Error (**EF** asserted)
10	Configuration Error (**PE** asserted)

Profibus Identity

Backplane bus attribute 16. (Length + Identity)

7	6	5	4	3	2	1	0
cnsis	size	Direction		Length			

Length:	0	1 to 16 words or bytes
Direction:	00	01 – input, 10 output, 11 – in & out ,00 – special
Size:	1	0 – byte, 1 – word
Consistency:	1	0 – over byte/word, 1 – over length

Profibus ID= 0xC0, 0x40, 0xC4

6.0 Settable Assemblies *New for Series C*

The VHSC and RIO-CU5L/RIO-CU24L catalogs have an additional feature for series C. It is now possible to set the produce and consume (VHSC only) connection paths to the desired assembly.

On the RIO-CU5 and RIO-CU24, Parameters 23 through 25 specifies the requested assembly to be used.

23	Requested Poll Produce Assy (0x65, 0x66, 0x67)
24	Requested COS Produce Assy (0x66 and 0x67)
25	Requested Poll Consume Assy (0x00, 0x69, 0x6A, 0x6B)

On the RIO-CU5L and RIO-CU24L, Parameters 23 through 25 specifies the requested assembly to be used.

11	Requested Poll Produce Assy (0x65, 0x66, 0x67)
12	Requested COS Produce Assy (0x66 and 0x67)

These are available for the DeviceNet network. These parameters are stored in EEPROM but are over-ridden when the module is used with any other network.

7.0 Product Revision

RIO-CU5/A:

	Cat Rev	Package Assy		FW	Description
126590	A01	96355471	A01	1.001	Release
127099	B01	96355472	A01	1.001	Add UL/CUL
127423	C01	96355473	A01	1.001	Improve retention of writeable label
128487	D01	96355473	A01	1.001	Change shipping carton
128676	E01	96355473	A01	1.001	Add web address to carton
129038	F01	96355474	A01	1.002	Prevent incomplete data from being sent in poll message, add NVS

RIO-CU5/B:

128637	A01	96393871	A01	2.001	Hazardous rating, limit windows to rollover, GMM object

RIO-CU5/C:

130575	A01	96401671	A01	3.001	Pulse generator, settable assemblies, assembly 123, fast power up
131253	B01	96401672	A01	3.002	Permit faster input updates in GMM

RIO-CU24/A:

	Cat Rev	Package Assy		FW	Description
126590	A01	96351471	A01	1.001	Release
127099	B01	96351472	A01	1.001	Add UL/CUL
127423	C01	96351473	A01	1.001	Improve retention of writeable label
128487	D01	96351473	A01	1.001	Change shipping carton
128676	E01	96351473	A01	1.001	Add web address to carton
129038	F01	96351474	A01	1.002	Prevent incomplete data from being sent in poll message, add NVS

RIO-CU24/B:

128637	A01	96394071	A01	2.001	Hazardous rating, limit windows to rollover, GMM object, Assy 123

RIO-CU24/C:

130575	A01	96401871	A01	3.001	Pulse generator, settable assemblies, assembly 123, fast power up
131253	B01	96401872	A01	3.002	Permit faster input updates in GMM

1794-RIO-CU5L/A:

	Cat Rev	Package Assy		FW	Description
126590	A01	96355671	A01	1.001	Release
127099	B01	96355672	A01	1.001	Add UL/CUL
127423	C01	96355673	A01	1.001	Improve retention of writeable label
128487	D01	96355673	A01	1.001	Change shipping carton
128676	E01	96355673	A01	1.001	Add web address to carton
129038	F01	96355674	A01	1.002	Prevent incomplete data from being sent in poll message, add NVS

RIO-CU5L/B:

128637	A01	96394271	A01	2.001	Hazardous, limit windows to rollover, GMM object

RIO-CU5L/C:

130575	A01	96402071	A01	3.001	Pulse generator, settable assemblies, assembly 123, fast power up
131253	B01	96402072	A01	3.002	Permit faster input updates in GMM, consume LSB in GMM

1794-RIO-CU24L/A:

	Cat Rev	Package Assy		FW	Description
126590	A01	96352271	A01	1.001	Release
127099	B01	96352272	A01	1.001	Add UL/CUL
127423	C01	96352273	A01	1.001	Improve retention of writeable label
128487	D01	96352273	A01	1.001	Change shipping carton
128676	E01	96352273	A01	1.001	Add web address to carton
129038	F01	96352274	A01	1.002	Prevent incomplete data from being sent in poll message, add NVS

RIO-CU24L/B:

128637	A01	96394471	A01	2.001	Hazardous, limit windows to rollover, GMM object

RIO-CU24L/C:

130575	A01	96402271	A01	3.001	Pulse generator, settable assemblies, assembly 123, fast power up
131253	B01	96402272	A01	3.002	Permit faster input updates in GMM, consume LSB in GMM