GE
Intelligent Platforms

Programmable Control Products

High-speed Counter Modules

for PACSystems* RX3i and Series 90*-30

User Manual, GFK-0293E

Nov 2015

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Note: Notes merely call attention to information that is especially significant to understanding and operating the equipment.

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	support.jp.ip@ge.com (Japan)
	support.in.ip@ge.com (remaining Asia customers)
Customer Care Email	customercare.apo.ip@ge.com
	customercare.cn.ip@ge.com (China)

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- Module Specifications
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High-speed Counter Module

The IC693/IC694APU300 High-speed Counter module, for Series 90-30 and PACSystems RX3i controllers provides direct processing of rapid pulse signals up to 80 kHz for industrial control applications such as: turbine flowmeter, meter proving, velocity measurement, material handling and process control.

Direct processing means that the module is able to sense inputs, process the input count information, and control the outputs without needing to communicate with a CPU.

The High-speed Counter uses 16 words of input memory. This consists of 16 bits of discrete input memory (%I) and 15 words of analog input memory (%AI). These inputs are updated once per CPU sweep. The High-speed Counter also uses 16 bits of discrete output memory (%Q) which are transferred once per sweep.

The High-speed Counter module is configured by the Proficy* Machine Edition programming software. Many features can be configured from the application program as well. Each feature is set to a factory default configuration, which is suitable for many applications. There are no DIP switches to set on the module.

Note: The High-speed Counter modules IC693APU300-MA and later; IC694APU300-CA and later do not support configuration by the Hand Held Programmer.

LEDs indicate the operating status of the module and the status of configuration parameters.

Power to operate the module’s logic circuitry is obtained from the baseplate backplane’s 5 VDC bus. Power sources for input and output devices must be supplied by the user or by the +24 VDC Isolated output of the power supply.

Classic Version (IC693APU300-LA and earlier; IC694APU300-BA and earlier)

Enhanced Version (IC693APU300-MA and later; IC694APU300-CA and later)

Figure 1-1. PACSystems RX3i High-speed Counter Modules

Status LEDs

Enhanced Version

Module Status LEDs

S1 (MODULE OK)	Green	The High-speed Counter is powered up and has completed its internal diagnostics.
	Red	The watchdog timer circuit has detected a module failure.
	Off	Module is not powered up correctly or internal diagnostics failed.
S2 (CONFIG)	On	A user configuration has been downloaded to the module.
	Off	A configuration has not been downloaded; the default configuration is in effect.
S3 (FIELD POWER)	On	Output field power present
	Off	Output field power not present

Input Status LEDs

A status LED is provided for each of the 12 input points.

1 -12	On	Input is on
	Off	Input is off

Output Status LEDs

A status LED is provided for each of the four output points.

1-4	Green	Output is on
	Amber	Output has overcurrent fault
	Off	Output is off

Classic Version

MODULE OK	Green	The High-speed Counter is powered up and has completed its internal diagnostics.
	Off	Module is not powered up correctly or internal diagnostics failed.
CONFIG	On	A user configuration has been downloaded to the module.
	Off	A configuration has not been downloaded; the default configuration is in effect.

Counter Types

A counter type must be selected when the module is configured. The choices are:

- Type A – selects four identical, independent simple counters.
- Type B – selects two identical, independent more complex counters.
- Type C – selects one complex counter.
- Type Z – selects a simple counter with Clock Z input. (Enhanced mode only.)

Type A Configuration

When used in this basic configuration, the module has four identical programmable up or down counters. Each counter:

- Can be programmed to count either up or down.
- Has three inputs: a Preload input, a Count Pulse input, and a Strobe input.
- Has one output, with programmable on and off Output Presets.

Type B Configuration

In this configuration, the module has two identical bidirectional 32-bit counters.

- The count inputs can be configured to accept Up/Down, Pulse/Direction, or A Quad B signals.
- Each counter has two completely independent sets of Strobe inputs and Strobe registers.
- Each counter has two outputs; each output has programmable on/off Presets.
- Each counter has one Disable input that can be used to suspend counting.

Type C Configuration

The Type C configuration is suitable for applications requiring motion control, differential counting, or homing capability.

In this configuration, the module has one 32-bit counter with four outputs.

- Each output has programmable on/off output presets, three strobe registers with strobe inputs, and two Preload values with Preload inputs.
- Two sets of bidirectional counter inputs can be connected to operate in a differential fashion. Each set of inputs can be configured for A Quad B, Up/Down, or Pulse/Direction operation.
- The module has a Home Position register for preloading the Accumulator to the Home Position value.

Type Z Configuration (Enhanced Mode)

Type Z is a simple counter that uses a pair of clock inputs to perform Up/Down. Pulse/Direction, or A Quad B Counting. A special Clock Z input combines the functions of a Strobe input (copies the current count value to a Strobe register), Disable input (optionally suspends counting), and Clear input (optionally resets the Accumulator to zero).

Counter Features, Classic Mode

Positive Logic (Source) Inputs with Selectable Input Voltage Range

The module provides 12 inputs that can be used as count signals, direction, disable, edge-sensitive strobe, and preload inputs depending on the counter type selected.

The module provides a selectable threshold voltage to allow the inputs to respond to either 5 VDC signal levels or 10 to 30 VDC signal levels. The 5 VDC threshold is selected by connecting a jumper between two terminals on the detachable terminal board connector. Leaving the threshold selection terminals unconnected places the inputs in the default 10 to 30 VDC voltage range. The terminal board connector allows prewiring to the module or replacing the module without disturbing the field wiring. It is important to note that ***10 to 30 VDC must not be applied when the threshold terminals are jumpered to select 5 VDC***.

Positive Logic (Source) Outputs

The module provides 12 outputs can be used to drive indicating lights, solenoids, relays, and other devices.

Selectable Counter Operation

Counters can be configured to count either up or down, count both up and down, or count the difference between two changing values (*depending on counter type selected*).

Counts per Timebase Register for Each Counter

For each counter, a Counts per Timebase register stores the number of counts in a given time interval. The Counts per Timebase data is a 16-bit signed number. The sign indicates up counts (+) or down counts (-).

The Counts per Timebase register value returned in the %AI register will update at the timebase interval. Counts per Timebase values are retrieved by the CPU update during the normal PLC sweep.

Continuous or Single-shot Counting

Each counter can be configured to operate in either continuous or single-shot mode:

Continuous Counter Mode: If either the upper or lower count limit is exceeded, the counter wraps around to the other limit and continues.

Single-Shot Counter Mode: The counter counts to either limit and stops. When the counter is at the limit, counts in the opposite direction back it off the limit. The Accumulator can also be changed by loading a new value from the CPU or by applying a Preset Input.

Accumulator for Each Counter

Each counter's accumulated count is stored separately. The CPU can read the value in the accumulator, or set it from the application program. The accumulator value can be either positive or negative. When negative, the value is two's complement.

Accumulator Adjust

For each counter, the Accumulator may be adjusted. The adjustment is an 8-bit signed offset value that is sent from the CPU whenever an adjustment is required.

Selectable Input Filters

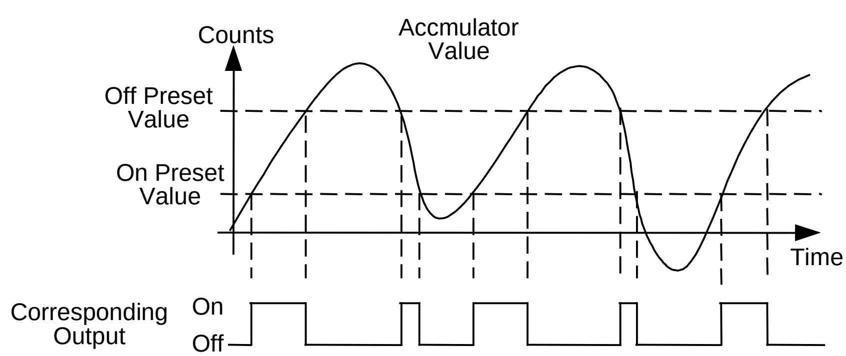
The Count and Control inputs for each counter can be configured for a high-frequency filter (2.5µS) or a low-frequency filter (12.5mS).

Count Rate

Maximum count rates are 80 kHz with the high-frequency filter and 30 Hz with the low-frequency filter.

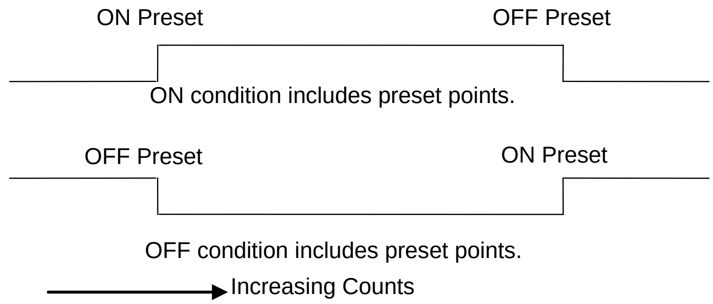
Selectable On/Off Output Presets

Each counter output has two Preset points, ON and OFF. The output state indicates when the counter accumulator value lies between the defined points. For example:



The output polarity may be configured to be either on or off between points by the relative location of the ON/OFF presets as shown below.

Preset Closest to Low Limit	***Output ON***	***Output OFF***
ON	> = ON Preset	> OFF Preset
	< = OFF Preset	< ON Preset
OFF	< OFF Preset	< = ON Preset
	> ON Preset	> = OFF Preset



Strobe Register

Each counter has one or more strobe registers that capture the current Accumulator value when a Strobe input transitions in the direction selected during the last configuration of the module. It is recommended that the rising edge of the strobe input be used for best performance.

Internal Module Diagnostics

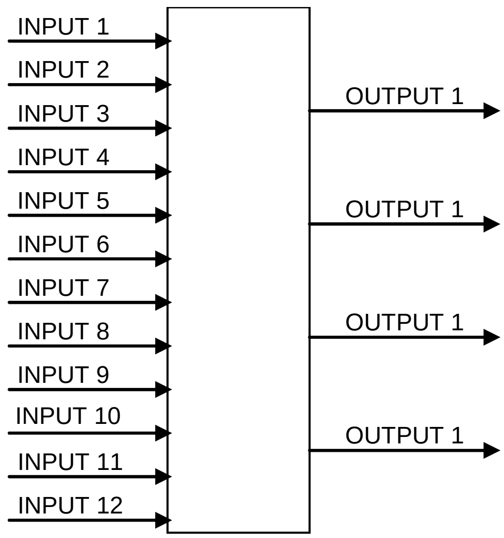
Operation of the High-speed Counter module is monitored by a watchdog timer circuit which, if it detects a module failure, will force all outputs off.

Oscillator

The module provides an internal square wave oscillator output that can be configured as a count input for the **first counter only** and used as a timing reference for measurement. The output is set for a default frequency of 1 kHz. A higher or lower frequency can be selected or by the application program.

Module Inputs and Outputs

The High-Speed Counter Module accepts 12 input signals, and provides 4 output signals.



Inputs

Inputs include count signals, Direction, Disable, edge-sensitive Strobe, and other inputs, which can be configured for the application. Input filters can be configured for high frequency or low frequency operation.

Count Inputs

A rising edge on a count input will increment or decrement its Count Accumulator. The method of counting depends upon the counter type and the count mode configuration.

The Count input is positive-edge sensitive. It may be configured to have either the high-frequency (2.5µS) or low-frequency filter (12.5mS). The default filter is high-frequency.

Preload Inputs

Each counter has a configurable preload register. The contents of this register determine the value the counter resets to when the Preload input goes active. The default value of the Preload register is zero.

The Preload input is positive-edge sensitive. It may be configured to have either the high-frequency (2.5µS) or low-frequency filter (12.5mS). The default is high-frequency.

If Preload occurs during counting, preload data with a resolution of ±1 count is stored in the accumulator and a Preload flag is set to indicate to the CPU that a Preload occurred.

Strobe Inputs

Strobe inputs are edge-sensitive. They may be configured to respond to either the positive or negative edge. Strobe inputs always have the 2.5µS high-frequency filter enabled. On counter types with multiple strobe inputs, the strobes may occur simultaneously without affecting the integrity of the data strobed. When the strobe signal goes active, count data with a resolution of one count is stored in the associated Strobe register and a Strobe flag is set to indicate to the CPU that a strobe value was captured. ***This value remains in the Strobe register until the Strobe signal goes active again, at which time it is overwritten.*** Each time the CPU acknowledges receipt of the Strobe flag, the application program should clear it.

If a Strobe input and Preload input both go active simultaneously both the Accumulator and Strobe register will be set to the Preload value.

Other Inputs

These are described under the discussion of operation for each counter type.

Outputs

The module's four outputs can be used to drive indicating lights, solenoids, relays, and other devices. The outputs are also capable of driving CMOS level loads. Each output is a positive logic (source) output, with power supplied from a user supplied power source. The outputs are protected from over current fault. Diodes protect outputs against transients going below output common. Each output can source a maximum of 1.5A at 4.7V to 40 VDC.

Note: For older versions, (IC693APU300-LA and earlier; IC694APU300-BA and earlier), outputs are limited to 500 mA at 10V-30V and 20mA at 5 V.

The module's outputs can be programmed to turn on or off when the accumulated count reaches appropriate values. The count input-to-output delay is 1mS maximum (200mS minimum) plus the configured Input Filter Time.

Counter Features, Enhanced Mode

Note: Enhanced mode operation, available with the Enhanced RX3i version (IC694APU300-CA and later) provides additional features. These features are supported only in an RX3i system. For details on the operation of these features, refer to chapter 6, “Enhanced Mode Operation.”

- Support for up to 1 MHz input frequency.
- Expanded input filtering to 5 ms, 500 μs, 10 μs and no filter.
- Support for both Single Ended and Differential Encoders.
- Support for 32 bit counters.
- Support for Z input events.
- Windowing feature that allows you to define a range of counter accumulator values wherein the strobe is recognized as valid input.
- ESCP outputs with 1.5 amps per point minimum.
- Configurable inputs and outputs.
- Roll over detection flag.
- Support for COMMREQ functions and Module Control Data commands.
- The module reports the part number, serial number and revision to the CPU.
- Firmware updates supported over the backplane from the RX3i CPU.

All Classic mode features are available in the Enhanced mode.

Module Specifications

<table>
<tr><th></th><th colspan="2">Classic (-L / -B and earlier)</th><th>IC693 Enhanced
(-MA and later)</th><th colspan="2">IC694 Enhanced
(-CA and later)</th></tr>
<tr><td>General</td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td>Power Consumption</td><td colspan="2">250 mA (1.25 watts) from 5 V bus on the backplane</td><td>Same as Classic version</td><td colspan="2">250 mA (1.25 watts) from 5 V bus on the backplane</td></tr>
<tr><td>Output Points</td><td colspan="2">Powered by user supplied 5V, or 10 – 30 VDC</td><td>Powered by user supplied 4.7 to 40 VDC</td><td colspan="2">Powered by user supplied 4.7 to 40 VDC</td></tr>
<tr><td>Maximum Count Rate</td><td colspan="2">80 kHz</td><td>Same as Classic version</td><td colspan="2">1 MHz (duty cycle 25% to 87%)</td></tr>
<tr><td>LEDs</td><td colspan="2">BOARD OK and CONFIG OK</td><td>BOARD OK, CONFIG OK, Field Power OK, Input Status, Output Status</td><td colspan="2">BOARD OK, CONFIG OK, Field Power OK, Input Status, Output Status</td></tr>
<tr><td>Isolation</td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td>Field to Backplane (optical) and to frame ground</td><td colspan="2">250 VAC continuous,
1500 VAC for one minute</td><td>Same as Classic version</td><td colspan="2">250 VAC continuous,
1500 VAC for one minute</td></tr>
<tr><td>Group to Group</td><td colspan="2">250 VAC continuous, 1500 VAC for one minute</td><td>Same as Classic version</td><td colspan="2">250 VAC continuous,
1500 VAC for one minute</td></tr>
<tr><td>Inputs</td><td colspan="2"></td><td></td><td colspan="2"></td></tr>
<tr><td>Voltage Range</td><td colspan="2">5 VDC (TSEL jumpered to INCOM)</td><td>Same as Classic version</td><td colspan="2">5 VDC (TSEL jumpered to INCOM)</td></tr>
<tr><td></td><td colspan="2">10 to 30 VDC (TSEL open)</td><td>Same as Classic version)</td><td colspan="2">10 to 30 VDC (TSEL open)</td></tr>
<tr><td>Number of Positive Logic Inputs</td><td colspan="2">12 (Single Ended)</td><td>Same as Classic version</td><td colspan="2">12 (Single Ended) or 6 (Differential)</td></tr>
<tr><td>Input Thresholds (I1 to I12)</td><td>5 VDC Range</td><td>10–30 VDC Range</td><td rowspan="5">Same as Classic version</td><td>5 VDC Range</td><td>10–30 VDC Range</td></tr>
<tr><td>Von</td><td>3.55 V min.</td><td>8.35 V min.</td><td>3.55 V min.</td><td>8.35 V min.</td></tr>
<tr><td>Ion</td><td>3.2 mA min.</td><td>3.2 mA min.</td><td>3.2 mA min.</td><td>3.2 mA min.</td></tr>
<tr><td>Voff</td><td>1.5 V max.</td><td>2.4 V max.</td><td>1.5 V max.</td><td>2.4 V max.</td></tr>
<tr><td>Ioff</td><td>0.8 mA max.</td><td>0.8 mA max.</td><td>0.8 mA max.</td><td>0.8 mA max.</td></tr>
<tr><td>Survivable Peak Voltage</td><td colspan="2">± 500 V for 1µSec</td><td>Same as Classic version</td><td colspan="2">± 500 V for 1µSec</td></tr>
<tr><td>Transient Common Mode Noise Rejection</td><td colspan="2">1000 V/ µSec minimum</td><td>Same as Classic version</td><td colspan="2">1000 V/ µSec minimum</td></tr>
<tr><td>Input Impedance</td><td colspan="2">See Figure 1-2 for V-I characteristics</td><td>Same as Classic version</td><td colspan="2">See Figure 1-2 for V-I characteristics</td></tr>
</table>

Outputs			
Voltage Range	10 to 30 VDC @ 500 mA maximum	4.7 to 40VDC @ 1.5A maximum	4.7 to 40 VDC @ 1.5A maximum
Voltage Range	4.75 to 6 VDC @ 20 mA maximum		
Off State Leakage Current	10µA maximum per point	Same as Classic version	10µA maximum per point
Output Voltage Drop	0.5 V maximum at 500 mA	Same as Classic version	0.5 V maximum at 500 mA 1.5 V maximum at 1.5 A*
Inrush current	–		1.6A without ESCP tripping
CMOS Load Drive Capability	Yes	Same as Classic version	Yes
Positive Logic Outputs	Four	Same as Classic version	Four
Output protection	Outputs are short circuit protected by a 3 A pico fuse common to all four outputs	Outputs are protected for overcurrent (ESCP) with self-healing capability.	Outputs are protected for overcurrent (ESCP) with self-healing capability.
Reverse Polarity Protection	None	Outputs protected from reverse wiring between OUTPWR and OUTCOM terminals	Outputs protected from reverse wiring between OUTPWR and OUTCOM terminals

* Note: The output voltage drop should be considered while driving full load (> 1 A) at low voltage below 6V.

For product standards and general specifications, refer to:

PACSystems RX3i System Manual, GFK-2314

(Series 90-30) *Installation for Conformance to Standards,* GFK-1179

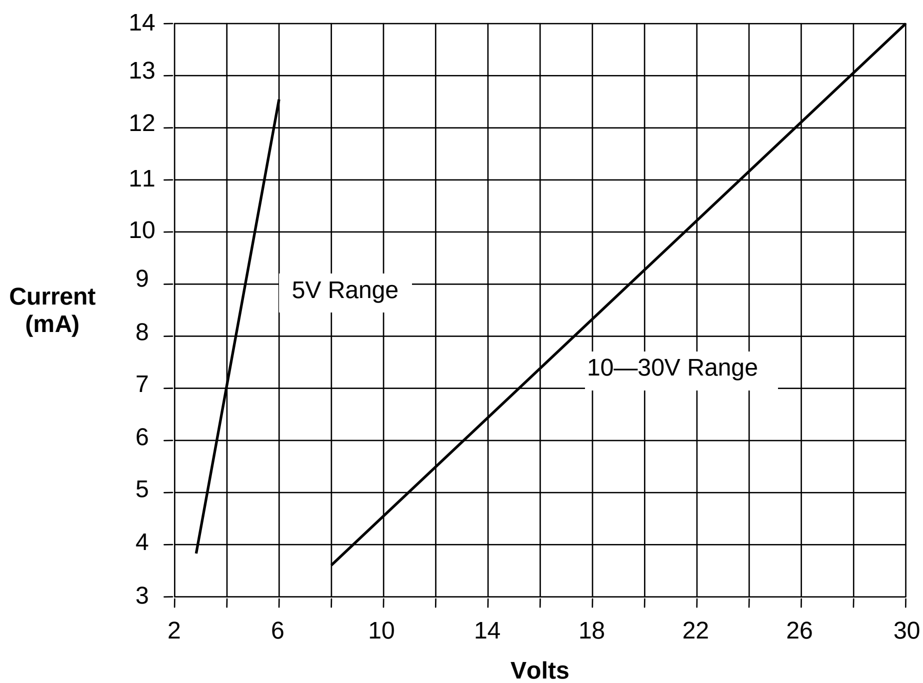


Figure 1-2. Input V-I Characteristics

I/O Performance Specifications

The time shown in Table 1-1 is the maximum delay in microseconds. All performance data specifications assume that the default high frequency filter is used on input points, unless otherwise stated.

Table 1-1. I/O Performance for Classic Versions (–L / -B and earlier)

Parameter	***Timing Specification***		
	Input Voltage		
INPUT POINTS	5 VDC	10 VDC	30 VDC
With High Frequency Filter Selected:			
Maximum Turn On Period (I1 – I4)	2 µsec	3 µsec	3 µsec
Maximum Turn Off Period (I1 – I4)	5 µsec	4 µsec	6 µsec
Maximum Turn On Period (I5 – I12)	5 µsec	10 µsec	5 µsec
Maximum Turn Off Period (I5 – I12)	120 µsec	100 µsec	120 µsec
Maximum I1 – I4 Rate	80 Khz (50 Khz in A Quad B Mode)		
Maximum I5 – I12 Rate	4 Khz		
With Low Frequency Filter Selected:			
I1 – I8 Turn On Period	9 mSec (min), 16.5 mSec (max)		
I1 – I8 Turn Off Period	9 mSec (min), 15.5 mSec (max)		
Typical On/Off Period	12.5 mSec		
Maximum I1 – I8 Rate	30 Hz		
OUTPUT POINTS			
Turn On Delay *	10 mSec maximum		
Turn Off Delay *	150 mSec maximum		
Maximum time between HSC output point updates	0.5 mSec		

* Switch circuit delay only.

Total Input-to-Output delay = Input filter time + 200 µsec minimum

Total Input-to-Output delay = Input filter time + 1 mSec maximum

Table 1-2. I/O Performance for Enhanced Versions (–MA / -CA and later)

Parameter	***Timing Specification***
INPUT POINTS	
Turn On Delay	Input filter time + 150 nSec
Turn Off Delay	
OUTPUT POINTS	
Turn On Delay *	0.5 mSec maximum
Turn Off Delay *	0.5 mSec maximum
Maximum time between HSC output point updates	0.5 mSec

* Switch circuit delay only.

Total Input-to-Output delay = Input filter time + 125 µsec minimum

Total Input-to-Output delay = Input filter time + 500 µsec maximum

Chapter 2

Installation and Wiring

This chapter contains information on installing the High-speed Counter module and information relevant to field wiring to and from the modules.

Installation and Removal of I/O Modules

The High-speed Counter module can be installed in any I/O slot in a CPU baseplate, expansion baseplate, or remote baseplate. The following procedures and recommendations should be followed when installing and removing I/O modules.

The RX3i system supports hot swapping (installing and removing with power applied) of the High-speed Counter module. The module ***cannot*** be hot swapped in a Series 90-30 system.

Inserting a Module

Use the following instructions as a guide when inserting a module into its slot in a baseplate.

WARNING

In a Series 90-30 system, do not insert or remove modules with power applied. This could cause the PLC to Stop, cause damage to the module, or result in personal injury.

- If installing in a Series 90-30 system, make sure that power to the PLC is turned off.
- Select the slot into which the module is to be inserted. Grasp the module firmly with terminal board toward you and with rear hook facing away from you.
- Align module with desired base slot and connector. Tilt module upwards so that top rear hook of module engages slot on baseplate.
- Swing module downward until connectors mate and lock-lever on bottom of module snaps into place engaging the baseplate notch.
- Visually inspect the module to be sure that it is properly seated.

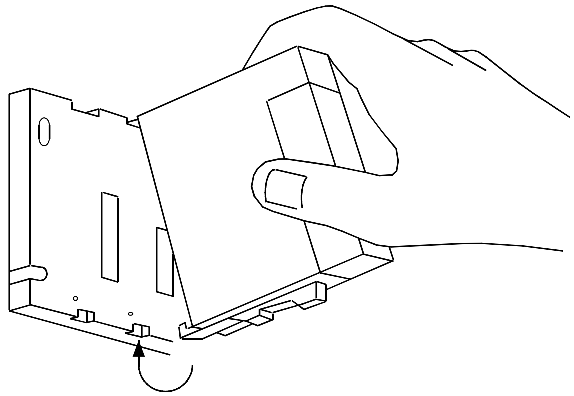


Figure 2-1. Inserting a Series 90-30/RX3i Module

Removing a Module

Use the following procedure to remove a module from its slot.

- Locate release lever at bottom of the module and firmly press it up - towards the module.
- While holding the module firmly at top and fully depressing release lever, swing the module upward (release lever must be free of its retaining slot).
- Disengage hook at top rear of module by raising the module up and moving it away from faceplate.

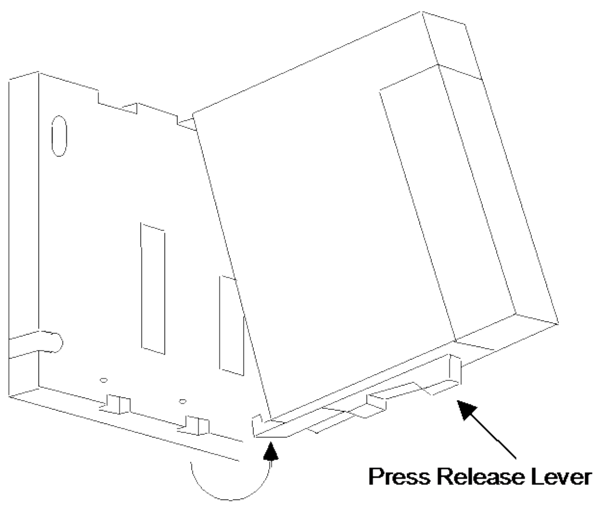


Figure 2-2. Removing a Series 90-30/RX3i Module

WARNING

Voltages from user devices may be present on a module's screw terminals even though power to the rack is turned off. Care must be taken any time you are handling the module's removable terminal board or any wires connected to it.

Wiring to I/O Modules

Wiring connections to and from user supplied input and output field devices are made to the detachable terminal board supplied with each I/O module. This removable terminal board makes it easy to prewire field wiring to user supplied input and output devices, and to replace modules in the field without disturbing existing field wiring.

The I/O terminal board has 20 screw terminals. Each terminal accepts up to one AWG #14 wire using ring or lug type terminals. Minimum recommended wire size is AWG #22. These terminals require a flat or Phillips head screwdriver for installing field wiring. An Isolated 24 volt DC supply is available on the power supply. Wires are routed to and from the terminals out of the bottom of the terminal board cavity.

Installing a Terminal Board

To install a terminal board with no wires attached:

- Hook the hinge, located on the bottom of the terminal board, to the lower slot on the module.
- Push the terminal board towards the module until it snaps into place.
- Open the terminal board cover and ensure that the latch on the module is securely holding the terminal board in place.

When installing a terminal board that has wiring attached verify that the terminal board is connected to the proper module type.

CAUTION

Check the label on the hinged door and the label on the module to ensure that they match. If a wired terminal board is installed on the wrong module type, damage to the module may occur.

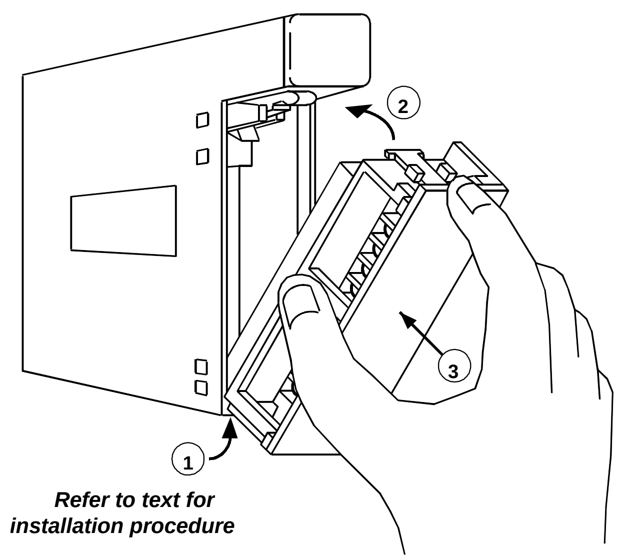
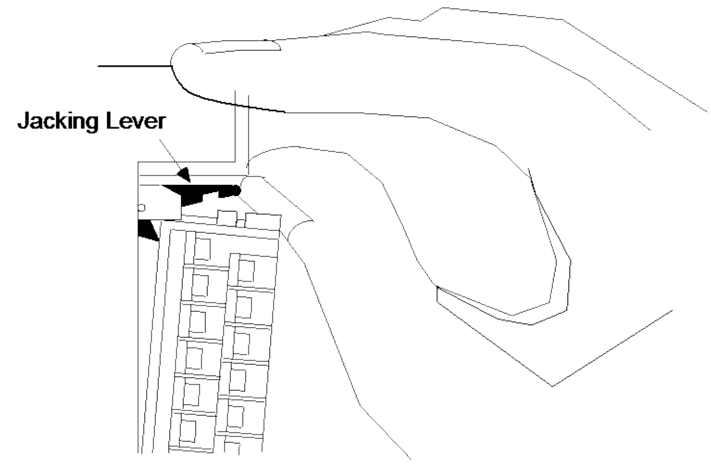


Figure 2-3. Installing a Terminal Board

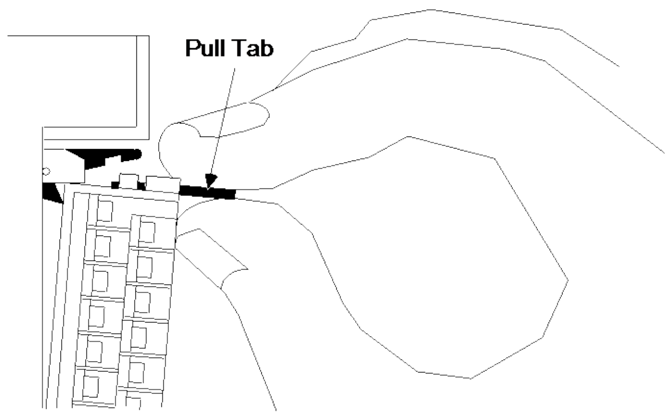
Removing a Terminal Board

To remove a terminal board:

- Open the plastic terminal board cover.
- Push up on jacking lever to release the terminal block.



- Grasp tab and pull toward you until contacts have separated from module housing and hook has disengaged for full removal.



Field Wiring Considerations

It is recommended that the following procedures be followed when routing and connecting field wiring from user devices to the PLC or to Output devices to be controlled by the PLC.

- All low level signal wires should be run separately from other field wiring.
- AC power wiring should be run separately from DC field wiring.

WARNING

You should calculate the maximum current for each wire and observe proper wiring practices. Failure to do so may cause injury to personnel or damage to equipment.

- Field wiring should not be routed close to any device that could be a potential source of electrical interference.
- If severe noise problems are present, additional power supply filtering or isolation transformer may be required.
- Ensure that proper grounding procedures, as previously described, are followed to minimize potential safety hazards to personnel.
- Label all wires to and from I/O devices. Record circuit identification numbers or other pertinent data on the inserts, which go in the module's faceplate door.

Conformance to Requirements

To meet the European EMC Directive requirements, shielded cable must be used for all cables connecting to the APU300 High-speed Counter. The shielded cable must have a high frequency ground within 5.24 cm (6 in) of the APU300 module. The cable's length is limited to 30 m (98.43 ft).

For cable clamping assembly to ground shielded cables, refer to the following documents:

Installation Requirements for Conformance to Standards (GFK 1179) (Series 90-30)

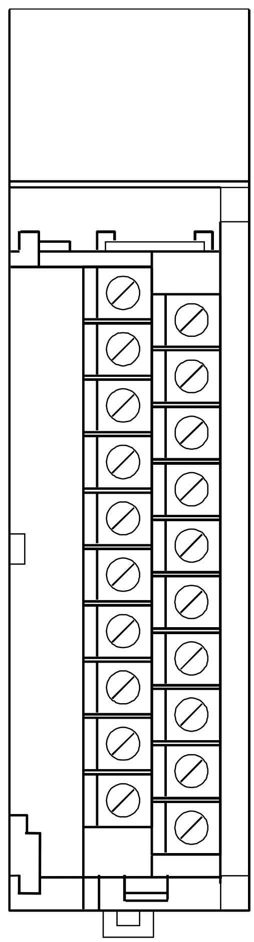
PACSystems RX3i System Manual (GFK-2314)

Terminal Board Pin Assignments

The High-speed Counter Module has a removable terminal strip for connection to field devices. High-speed Counter terminal board pin assignments for field wiring connections are shown in the following figure.

CAUTION

For Classic versions (IC693APU300-LA and earlier; IC694APU300-BA and earlier): Do not apply loads greater than 500 mA to the OUT1 through OUT4 outputs (terminals 16 through 19). Doing so may damage the module.



PIN	NAME
1	I1
2	I2
3	I3
4	I4
5	I5
6	I6
7	I7
8	I8
9	I9
10	I10
11	I11
12	I12
13	INCOM
14	OUTPWR
15	TSEL
16	O1
17	O2
18	O3
19	O4
20	OUTCOM

Figure 2-4. Terminal Board Pin Assignments

Field Wiring Information

Input Characteristics

The High-speed Counter uses single-ended positive logic (source) type inputs.

- Transducers with CMOS buffer outputs (74HC04 equivalent) can directly drive the High-speed Counter inputs using the 5 V input range.
- Transducers using open collector outputs must include a 470 ohm pullup resistor to 5V to guarantee compatibility with the High-speed Counter inputs.
- Transducers using high voltage open collector (sink) type outputs must have a 1K pullup resistor to +12 V for compatibility with the High-speed Counter 10 to 30 volt input range.

Note: Classic versions of the APU300 required that transducers using TTL totem pole outputs include a 470 ohm pull-up resistor (to 5 V) to guarantee compatibility with the High-speed Counter inputs. Enhanced versions do not require a 470 ohm pull-up resistor with transducers using TTL totem pole outputs.

Input Voltage Ranges

The default voltage range is 10 to 30 VDC. To use this voltage range, leave the threshold selection terminals (pins 13 and 15) unconnected.

To select the 5 VDC threshold, connect a jumper between two terminals on the detachable terminal board connector.

CAUTION

Do not connect 10 to 30 VDC to the module inputs when the 5 VDC input range (pins 13 to 15 jumpered) is selected. Doing so will cause damage to the module.

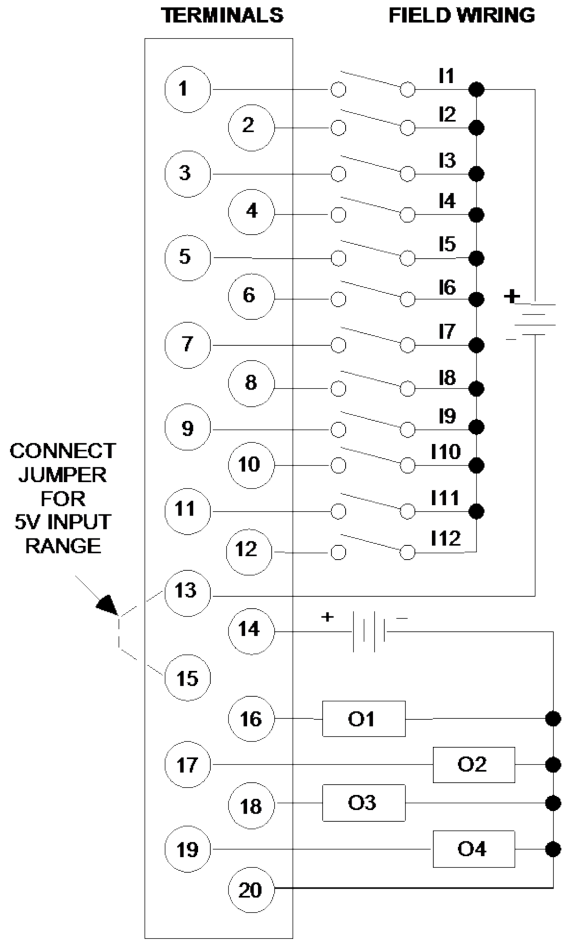


Figure 2-5. Field Wiring for the High-speed Counter

Terminal Assignments for Counter Types

The following table defines which terminals to use for the type of counter selected during module configuration.

Table 2-1. Pin Assignments for Each Counter Type

Pin Number	Signal Name	Pin Definition	Use in Counter Type		
			Type A	**Type B** [(1)]	**Type C** [(2)]
1	I1	Positive Logic Input	A1	A1	A1
2	I2	Positive Logic Input	A2	B1	B1
3	I3	Positive Logic Input	A3	A2	A2
4	I4	Positive Logic Input	A4	B2	B2
5	I5	Positive Logic Input	PRELD1	PRELD1	PRELD1.1 [(4)]
6	I6	Positive Logic Input	PRELD2	PRELD2	PRELD1.2
7	I7	Positive Logic Input	PRELD3	DISAB1	DISAB1
8	I8	Positive Logic Input	PRELD4	DISAB2	HOME
9	I9	Positive Logic Input	STRB1	STRB1.1 [(4)]	STRB1.1 [(4)]
10	I10	Positive Logic Input	STRB2	STRB1.2	STRB1.2
11	I11	Positive Logic Input	STRB3	STRB2.1	STRB1.3
12	I12	Positive Logic Input	STRB4	STRB2.2	MARKER
13	INCOM	Common for positive logic inputs	INCOM	INCOM	INCOM
14	OUTPWR [(3)]	DC+ Power for positive logic outputs	OUTPWR	OUTPWR	OUTPWR
15	TSEL	Threshold select, 5V or 10 to 30V	TSEL	TSEL	TSEL
16	O1	Positive Logic Output	OUT1	OUT1.1 [(4)]	OUT1.1 [(4)]
17	O2	Positive Logic Output	OUT2	OUT1.2	OUT1.2
18	O3	Positive Logic Output	OUT3	OUT2.1	OUT1.3
19	O4	Positive Logic Output	OUT4	OUT2.2	OUT1.4
20	OUTCOM	DC- Common for positive logic outputs	OUTCOM	OUTCOM	OUTCOM

(1). Type B counter:
A1, B1 are the A and B inputs for counter 1.
A2, B2 are the A and B inputs for counter 2.

(2) Type C Counter:
A1, B1 are the A and B count inputs for (+) loop
A2, B2 are the A and B count inputs for (-) loop

(3) OUTPWR ***does not*** source power for user loads. Output power ***must be supplied*** from an external supply.

(4) Inputs and outputs identified by two numbers separated by a decimal point indicate the counter number to the left of the decimal point and the element number on the right. For example, STRB1.2 indicates Counter 1, Strobe 2 input.

ESCP Outputs with 1.5 Amps per Point Minimum

The Enhanced APU300 modules support ESCP (Electronic Short Circuit Protection) for all four outputs. The ESCP fault will be detected if the output channel is shorted to OUTCOM. The module will report ESCP fault condition in the I/O status data – **Bit 24 to Bit 27** corresponding to **Output1 to Output4** respectively. Also, the output LEDs O1 to O4 will be amber during the short circuit condition.

Chapter 3

Classic Mode Counter Operation

Each counter type (A, B, and C) is described on the following pages. Functionality of each type is described beginning with the simplest (Type A) and progressing to the most complex (Type C).

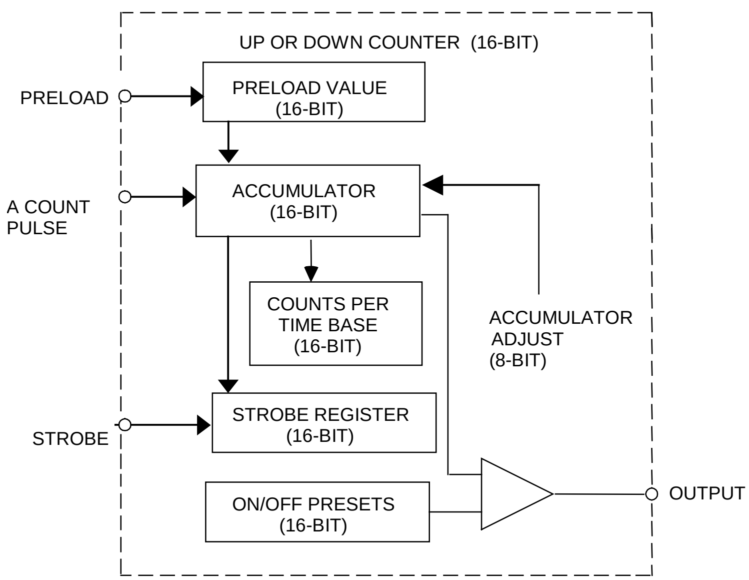
For Type Z counter operation (available in Enhanced mode), refer to chapter 6.

Operation of a Type A Counter

To operate as **four 16-bit unidirectional counters**, select Type A during module configuration.

When configured as Type A, each counter may be independently configured to count either up or down. Details of each counter are shown below. Each counter has an Accumulator register, Counts per Timebase register, one Strobe register and one set of on/off Preset values. Each counter has three inputs: Preload, Count Pulse, and Strobe, and one output.

Elements of a Type A Counter (four per module)



Since the Preload input is normally used to perform the reset function for each counter, the Preload default value has been set to 0. However, the Preload may be configured to any value within the counter's selected range. The Preload for each counter is edge-sensitive, and is active on the positive edge only. When a preload input occurs, the configured preload value is inserted into the Accumulator and a Preload flag is set to indicate this to the CPU. If the application program uses this flag indication, then it should clear the flag before the next preload occurs. **A rising edge on the Preload input always preloads the Accumulator regardless of the state of the Preload flag.**

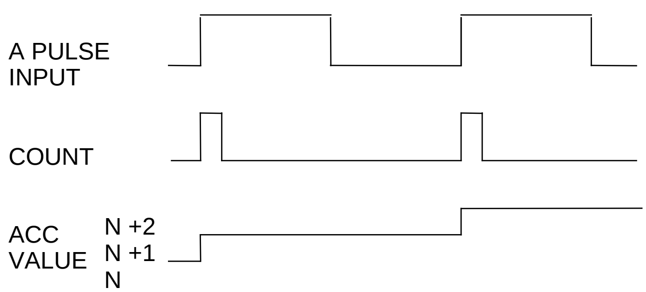
Each counter's Strobe input is also edge-sensitive, and can be configured to respond to either a positive edge or a negative edge. When the Strobe signal goes active, the current value in the accumulator is stored in the associated Strobe register and a Strobe flag is set to indicate to the CPU that a strobe value was captured. This value remains in the Strobe register until the Strobe signal goes active again and is overwritten. Each time the CPU acknowledges receipt of the Strobe flag, the application program should clear it. **The Strobe input always updates the Strobe register with the latest Accumulator value regardless of the state of the Strobe flag.**

The Strobe input always has a 2.5mS high-frequency filter. Preload inputs and Count inputs can be configured to use either the high-frequency filter, or a 12.5mS low-frequency filter. The low-frequency filter reduces the effect of signal noise. Maximum count rates are 80 kHz with the high-frequency filter and 30Hz with the low-frequency filter.

The value in the Accumulator may be adjusted by writing an offset adjustment value to the Accumulator. This adjustment may be any value between -128 and +127. The adjustment value is added to the contents of the accumulator.

Timing for Type A Counter

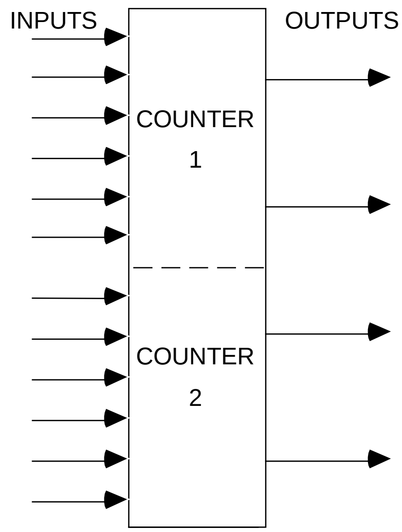
The Count signal shown in the following illustration represents an internal signal that indicates where counting occurs with respect to the pulse input. Counting always occurs on the low-to-high transition of the Pulse input.



Operation of a Type B Counter

If the module is to operate as **two 32-bit bidirectional counters**, select Type B during module configuration.

TYPE B



Each Type B counter has six inputs and two outputs, and may be separately configured for Up/Down, Pulse/Direction, or A Quad B operation. Details of each Type B counter are shown below.

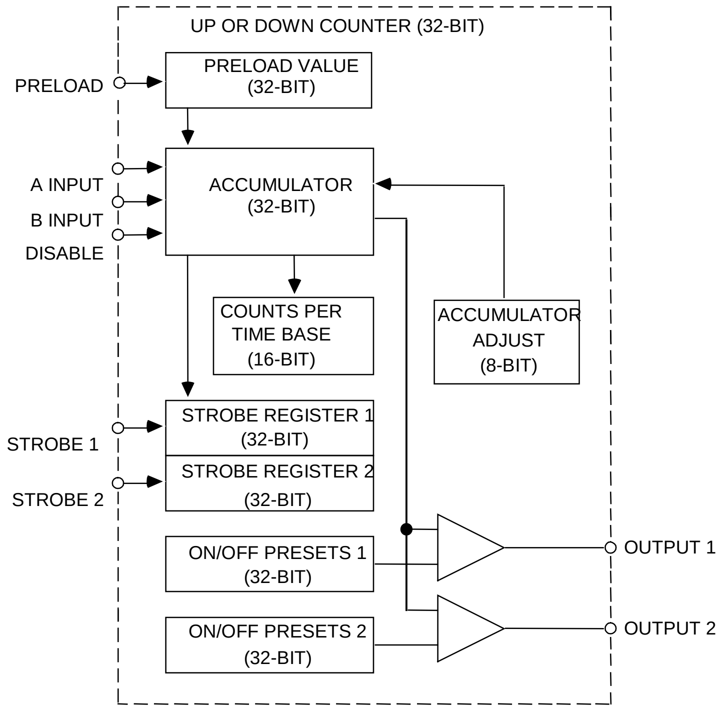
Each counter has one Preload input and two completely independent sets of Strobe inputs with storage registers and on/off Presets for each output. Refer to the Type A counter description in this chapter for details of the Preload and Strobe input operation. The Disable input, which is not available in the Type A configuration, can be used to inhibit counting. When the Disable input is applied, it will inhibit all counting and the Counts/Timebase register will go to zero. This also applies for Counter 1 when the internal oscillator is selected as its count source.

The Disable input is level sensitive, and active when high. All other inputs are positive edge-sensitive except Strobe input which can be configured to be active on either the rising or the falling edge. The Strobe inputs always use the 2.5mS high-frequency filter. A high-frequency filter or a 12.5mS low-frequency filter can be independently selected for each of the following signals:

- Preload input
- Disable input
- Both count inputs

The low-frequency filter reduces the effect of signal noise. Maximum count rates are 80 kHz with the high-frequency filter and 30 Hz with the low-frequency filter.

Elements of a Type B Counter (two per module)

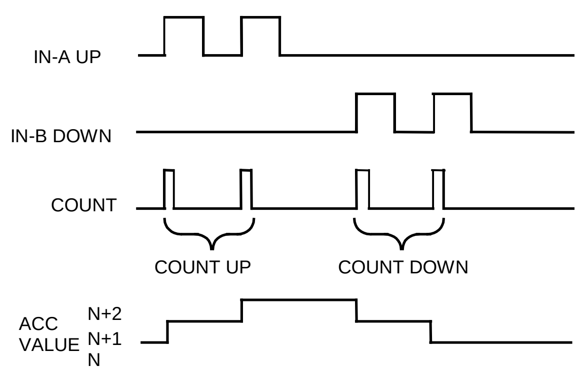


Timing for Type B Counter

The Count signal shown in these illustrations represents an internal signal that indicates where counting occurs with respect to the user inputs. In the Pulse/Direction mode, the direction input may be changed while in use, without affecting proper operation of the counter.

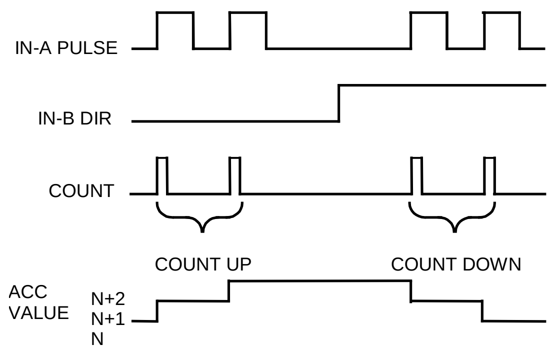
Operating in UP/DOWN Mode

Up-counting occurs on the low-to-high transition of the Up input. Down counting occurs on the low-to-high transition of the Down input. The accumulator automatically tracks the difference between the number of counts received by the Up channel and the Down channel. Simultaneous inputs on the up channel and down channel will cause a net accumulator change of zero.



Operating in Pulse/Direction Mode

Counting always occurs on the low-to-high transition of the Pulse input. Count direction is up for a low level on the Direction input and down for a high level on the Direction input. Avoid changing the DIR signal coincidentally with the rising edge of the Pulse input.

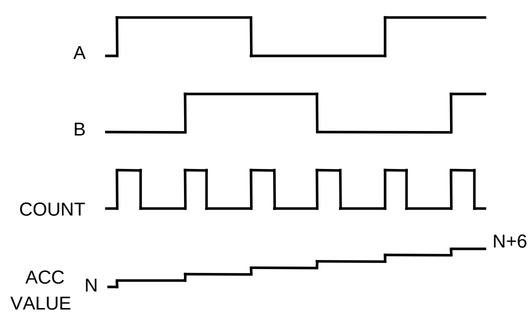


Operating in A Quad B Mode

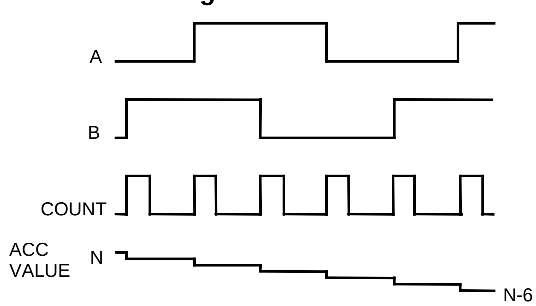
In A Quad B mode, there are four counts for each A Quad B cycle. A count occurs for each transition of either A or B. The counts will be evenly spaced with respect to the input waveforms when the phase relationship between A and B is shifted by 1/4 cycle.

The phase relationship between A and B determines count direction, as shown in the following timing diagrams.

The count direction is up if A leads B.

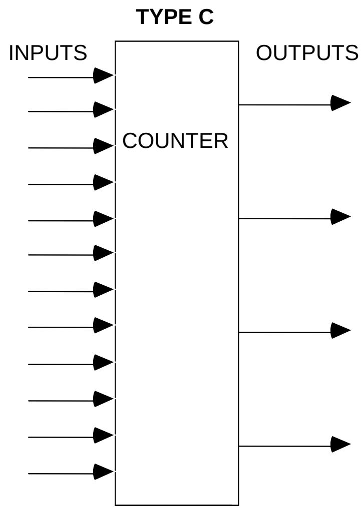


The count direction is down if A lags B.



Operation of a Type C Counter

If the module is to operate as one 32-bit differential counter, select Type C during module configuration. This configuration is suitable for applications requiring motion control, differential counting, or homing capability. The accumulator is the summing function of the + loop and the - loop. The + loop is made up of inputs A1 and B1; the - loop is made of inputs A2 and B2.



This counter uses all 12 of the module's inputs and all four outputs. Counter details are shown below. There are:

- Four on/off Presets with outputs;
- Three Strobe registers with corresponding Strobe inputs;
- Two Preload inputs with separate Preload values;
- A Home Position register for preloading the accumulator to the Home Position value within 1 count period when the Enable Home input is active and the Marker pulse occurs;
- Two sets of bidirectional Count inputs that can be connected to operate in a differential fashion. Each set can be configured for A Quad B, Up/Down, or Pulse/Direction mode.

All inputs are edge sensitive, except Enable Home and Disable. Either the rising or falling edge of each Strobe input can be configured as active.

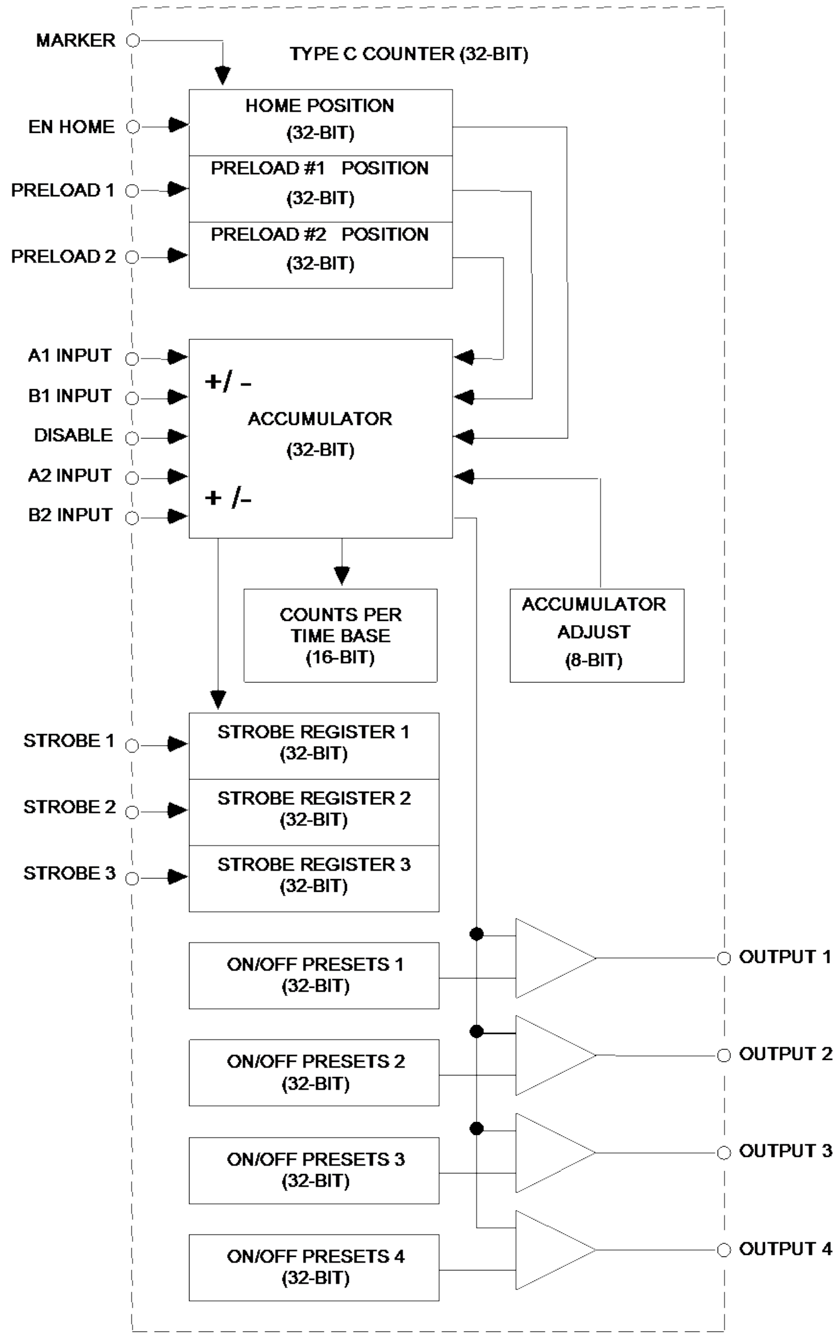
The Marker input and Strobe inputs always use the 2.5mS high-frequency filter. The Enable Home input always uses the 12.5mS low-frequency filter. The high- or low-frequency filter can be separately configured for each set of Count inputs, for the Disable input, and for both Preload inputs. Refer to the Type A counter description in this chapter for details of the Preload and Strobe input operation.

If any of Preload 1, Preload 2, or Home Found Marker inputs go active simultaneously, the Accumulator will be set to the value according to the following priority:

- Home Found
- Preload 1
- Preload 2

Each output turns on or off as determined by its own Preset values.

Elements of a Type C Counter (one per module)

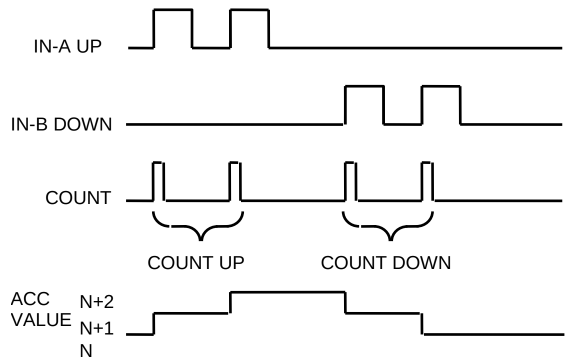


Timing for Type C Counter

The following information applies to the positive (+) loop of a type C counter. The relationship between the input signals and the internal count pulse remains the same in the negative (-) loop, but the effect of the pulse is opposite (i.e. count pulses that would result in an increment to the accumulator value on the (+) loop will result in a decrement on the (-) loop, and vice-versa).

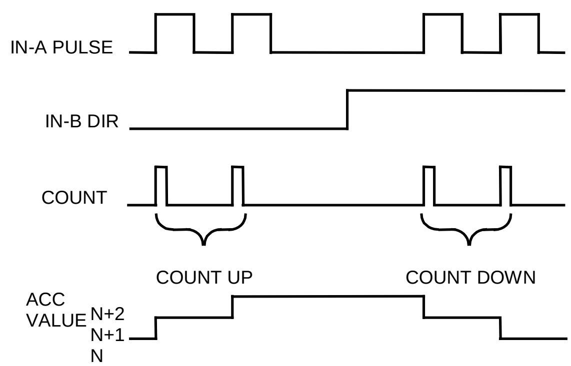
Operating in UP/DOWN Mode

Up-counting occurs on the low-to-high transition of the Up input. Down counting occurs on the low-to-high transition of the Down input.



Operating in Pulse/Direction Mode

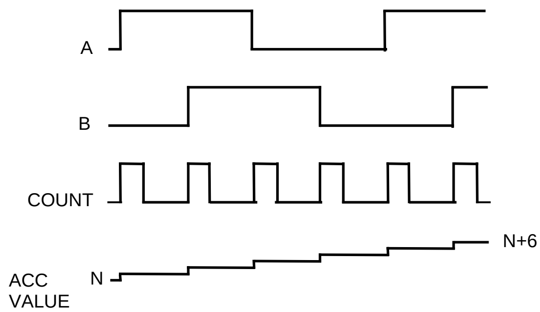
Counting always occurs on the low-to-high transition of the Pulse input. Count direction is up for a low level on the Direction input and down for a high level on the Direction input. Avoid changing the DIR signal coincidentally with the rising edge of the Pulse input.



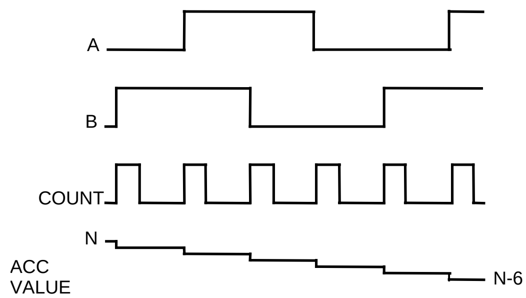
Operating in A Quad B Mode

In A Quad B mode, there are four counts for each A Quad B cycle. A count occurs for each transition of either A or B. The counts will be evenly spaced with respect to the input waveforms when the phase relationship between A and B is shifted by 1/4 cycle. The phase relationship between A and B determines count direction, as shown in the following timing diagrams.

The count direction is up if A leads B.



The count direction is down if A lags B.



Type C Counter Plus and Minus Loop

In the Type C counter configuration, the plus (+) and minus (-) loops may be set up to operate independently in any mode (Up/Down, Pulse Direction, or A Quad B).

Count Direction		***ACCUMULATOR FUNCTION x = counts on (+) loop y = counts on (-) loop***
(+) Loop A1, B1	***(-) Loop A2, B2***	
Up	Up	Differential (x-y)
Up	Down	Additive (x+y)
Down	Up	Additive -(x+y)
Down	Down	Differential (y-x)
Up	no connection	Counts Up (x)
Down	no connection	Counts Down (-x)
no connection	Up	Counts Down (-y)
no connection	Down	Counts Up (y)

Type C Counter Home Sequence

The following is a description of how to enable and use the Home cycle of a Type C counter.

The %Q14 bit (Home command) should be enabled before an input to the HOME terminal (pin 8) on the module is made. This Home command output is sent to the module at the PLC sweep rate.

An external event then causes the HOME input to go true, this enables the next event. The HOME input is always set to use the low frequency filter. Switching specifications can be found in “I/O Performance Specifications” in chapter 1.

The next occurrence of the MARKER input after HOME (HOME input must be maintained on until the MARKER pulse occurs) will copy the contents of the Home Position Register to the counter accumulator; this event is called *Home Found*. This event has priority over the Preload events. The MARKER input always uses the High-Frequency filter. See “I/O Performance Specifications” in chapter 1 for specifications..

The Home Found (%I4) status is sent to the PLC and will be read at the PLC sweep rate.

For more information on the Home Position, refer to chapter 5.

Chapter 4

Classic Mode CPU Interface

Data Transfer Between High-speed Counter and CPU

During each I/O scan, the High-speed Counter module automatically sends 16 status bits (%I) and 15 words (%AI) of register data values to the CPU. The format of this input data depends on whether the counter is configured as Type A, Type B, or Type C. In return, during each I/O scan, the CPU sends 16 bits (%Q) of output data to the module. COMMREQ function blocks in the user program can be used to send additional commands to the module.

Data Automatically Sent by the HSC

The 15 register data words (%AI) represent:

- Latest Counts per Timebase value
- Contents of the Accumulator(s)
- Contents of the Strobe registers
- Error code
- The 16 status bits (%I) represent:
- Strobe flag status
- Preload flag status
- Disable status
- Output status
- Module ready status
- Home input status (Type C counter only)
- Error status

These status bits are sent to the CPU as inputs, and can influence outputs sent from the CPU to the module. Data formats for the High-speed Counter modules Type A, Type B, and Type C configurations are shown on the following pages.

Data Automatically Sent to the High-speed Counter

The 16 output bits (%Q) represent:

- Strobe flag reset
- Preload flag reset
- Clear error flag
- Output enable
- Home command (Type C counter only)

All of this data is transferred from the High-speed Counter to the CPU once per I/O scan. The I/O scan is active while the CPU is in the RUN mode or STOP ENABLED mode.

Additional Data Sent to the HSC Using a COMMREQ Function Block

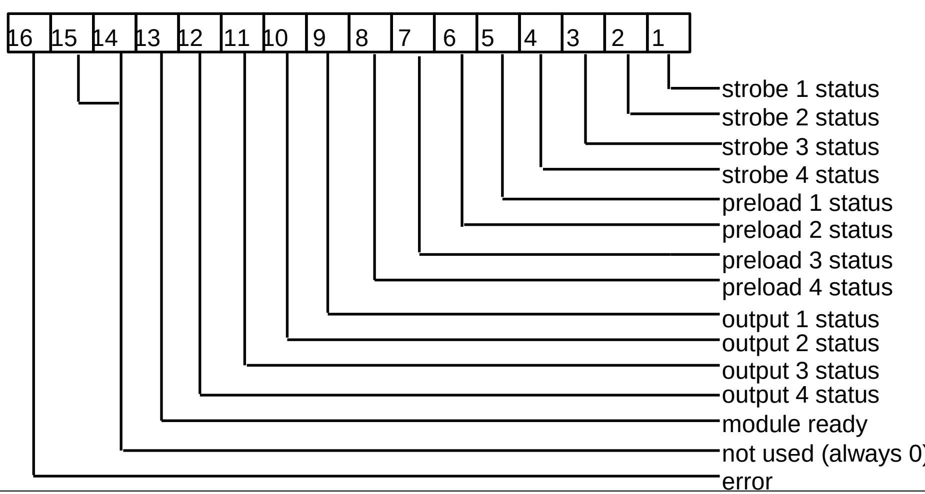
- Load Accumulator
- Load count limits
- Load Accumulator increment
- Load output presets
- Load Accumulator Preload
- Load time base
- Load Oscillator divider ratio
- Count Direction (Type A only)

%AI and %I Data Sent by a Module Configured as Type A

%AI Data – Type A Counter

Word	Description
01	Module Status code
02	Counts per timebase for counter 1
03	Counts per timebase for counter 2
04	Counts per timebase for counter 3
05	Counts per timebase for counter 4
06	Accumulator for counter 1
07	Strobe register for counter 1
08	Accumulator for counter 2
09	Strobe register for counter 2
10	Accumulator for counter 3
11	Strobe register for counter 3
12	Accumulator for counter 4
13	Strobe register for counter 4
14 – 15	Not used (set to 0)

Status bits (%I) – Type A Counter



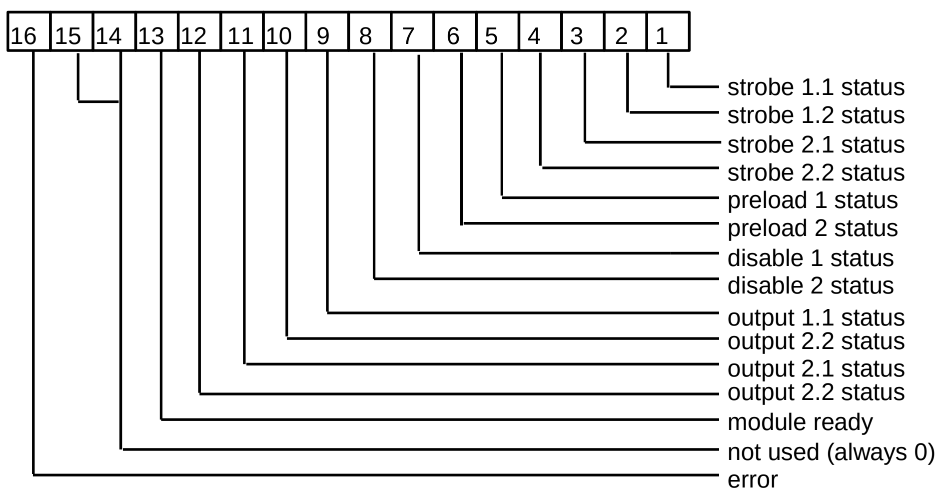
Strobe/Preload Status:	The module sets one of these bits when a strobe or preload occurs. The CPU must clear the bit using the corresponding Reset Strobe/Reset Preload output.
Output Status:	The module uses these four bits to indicate the ON or OFF commanded status of each output.
Module Ready:	The module sets this bit to 1 after successfully completing its power-up tests.
Error:	Set to indicate an error condition. When this occurs, the error code is returned in the Module Status code (word 1). See page 4-9 for definitions of the module status codes. When the error is acknowledged by the CPU, it should be cleared by sending the Clear Error output.

%AI and %I Data Sent by a Module Configured as Type B

%AI Data – Type B Counter

Word	Description
01	Module Status code
02	Counts per timebase for counter 1
03	Counts per timebase for counter 2
04–05	Accumulator for counter 1
06–07	Strobe register 1 for counter 1
08–09	Strobe register 2 for counter 1
10–11	Accumulator for counter 2
12–13	Strobe register 1 for counter 2
14–15	Strobe register 2 for counter 2

Status bits (%I) – Type B Counter



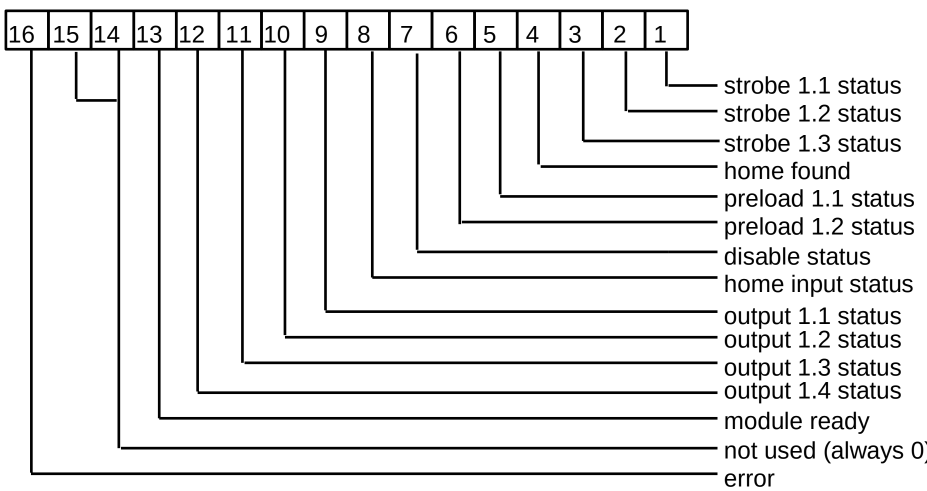
Strobe/Preload Status:	the module sets one of these bits when a strobe or preload occurs. The CPU must clear the bit using the corresponding Reset Strobe/Reset Preload output.
Disable Status:	the module uses these bits to indicate the present status of each Disable input.
Output Status:	the module uses these four bits to indicate ON or OFF commanded status of each output.
Module Ready:	the module sets this bit to 1 after successfully completing its power-up tests.
Error:	set to indicate an error condition. When this occurs, the error code is returned in the Module Status code (word 1). See page 4-9 for the definition of these module status codes. When the error is acknowledged by the CPU, it should be cleared by sending the Clear Error output.

%AI and %I Data Sent by a Module Configured as Type C

%AI Data – Type C Counter

Word	Description
01	Module Status code
02	Counts per timebase for counter 1
03	Not used (set to 0)
04–05	Accumulator for counter 1
06–07	Strobe register 1
08–09	Strobe register 2
10–11	Strobe register 3
12–15	Not used (set to 0)

Status bits (%I) – Type C Counter

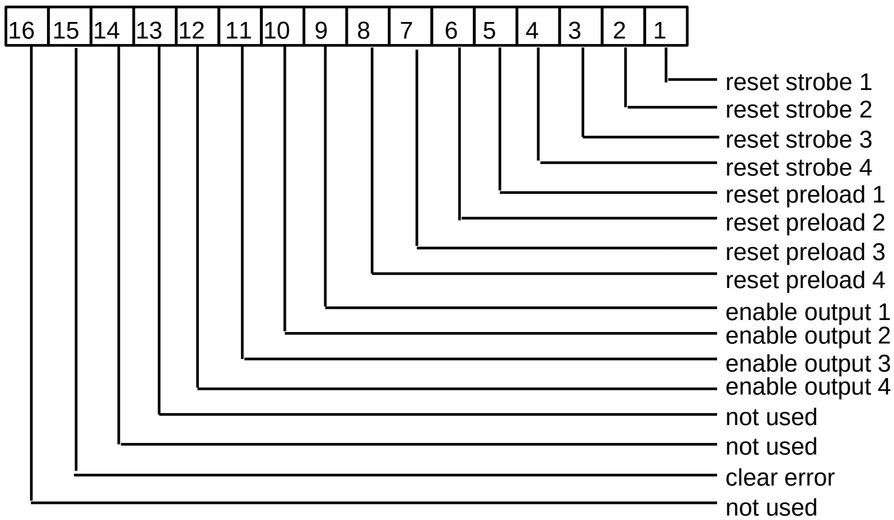


Strobe/Preload Status:	The module sets one of these bits when a strobe or preload occurs. The CPU must clear the bit using the corresponding Reset Strobe/Reset Preload output.
Disable Status:	Indicates the present status of the Disable input.
Home Input Status:	Indicates the present status of the Home Limit Switch input.
Home Found:	Indicates the Home position has been reached.
Output Status:	These four bits indicate the on or off commanded status of each output.
Module Ready:	The module sets this bit to 1 after successfully completing its power-up tests.
Error:	Set to indicate an error condition. When this occurs, the error code is returned in the Module Status code (word 1). See page 4-9 for the definition of these module status codes. When the error is acknowledged by the CPU, it should be cleared by sending the Clear Error output.

%Q Data Sent from CPU to High-speed Counter

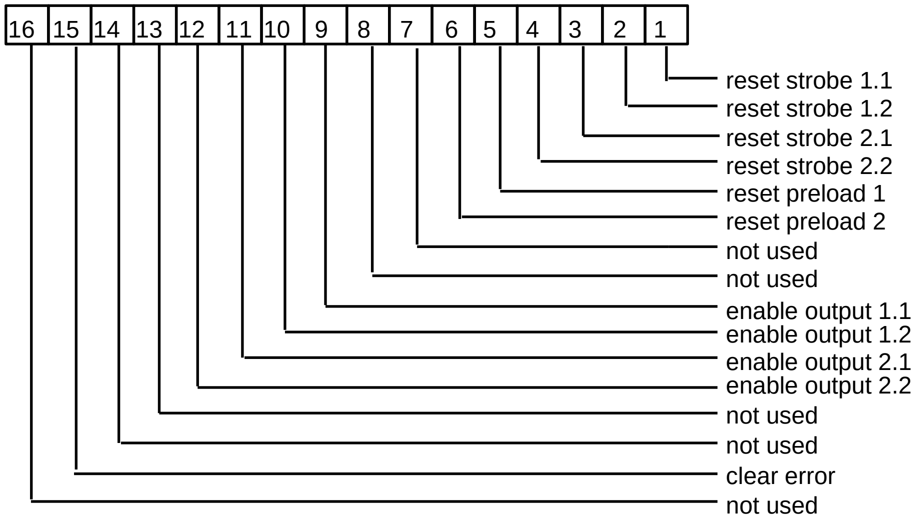
Once each I/O scan, the CPU sends 16 bits (%Q) of data to the High-speed Counter Module. The application program can use these outputs to send commands to the module. The %Q data formats for each counter type are shown on the following pages.

%Q Data – Type A Counter



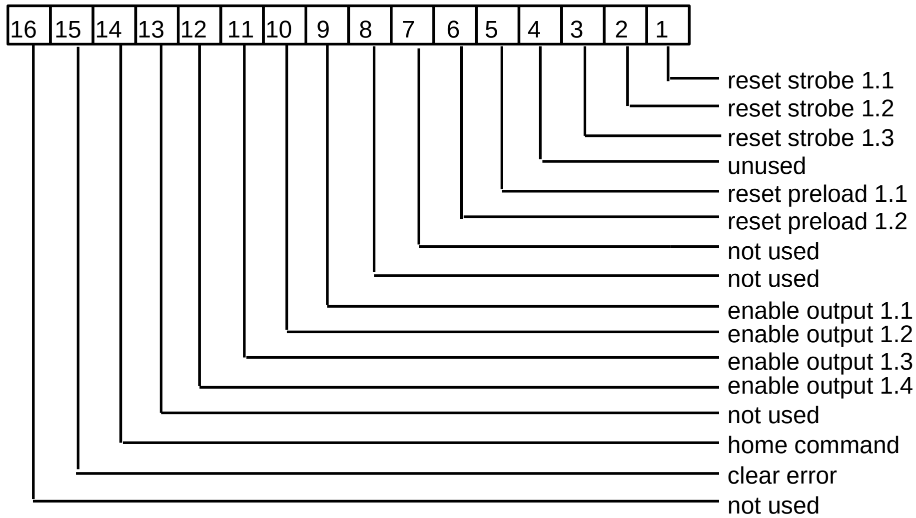
Reset Strobe:	Clears the module's corresponding Strobe input status bit (as described on the previous pages). For example, Reset Strobe bit 2 is used to reset the module's Strobe status bit 2. If the corresponding Strobe input status changes to 1, the program logic should set this bit to 1 and then back to 0 on the next I/O scan.
Reset Preload:	Clears the module's corresponding Preload input status bit. For example, reset Preload bit #5 is used to reset the module's Preload status bit 5. If the corresponding Preload input status changes to 1,the program logic should set this bit to 1 and then back to 0 on the next I/O scan.
Outputs En/Disable:	Bits 9 to 12 are used to enable or disable the module's outputs. If these bits are 0, the corresponding output will not turn on.
Clear Error:	Set by the CPU to clear error after it has been acknowledged.

%Q Data – Type B Counter



Reset Strobe:	Clears the module's corresponding Strobe input status bit (as described on the previous pages). For example, Reset Strobe bit 2 is used to reset the module's Strobe status bit 2. If the corresponding Strobe input status changes to 1, the program logic should set this bit to 1 and then back to 0 on the next I/O scan.
Reset Preload:	Clears the module's corresponding Preload input status bit. For example, reset Preload bit #5 is used to reset the module's Preload status bit 5. If the corresponding Preload input status changes to 1,the program logic should set this bit to 1 and then back to 0 on the next I/O scan.
Outputs En/disable:	Bits 9 to 12 are used to enable or disable the module's outputs. If these bits are 0, the corresponding output will not turn on.
Clear Error:	Set by the CPU to clear error after it has been acknowledged.

%Q Data – Type C Counter



Reset Strobe:	Clears the module's corresponding Strobe input status bit (as described on the previous pages). For example, Reset Strobe bit 2 is used to reset the module's Strobe status bit 2. If the corresponding Strobe input status changes to 1, the program logic should set this bit to 1 and then back to 0 on the next I/O scan.
Reset Preload:	Clears the module's corresponding Preload input status bit. For example, reset Preload bit #5 is used to reset the module's Preload status bit 5. If the corresponding Preload input status changes to 1,the program logic should set this bit to 1 and then back to 0 on the next I/O scan.
Outputs En/Disable:	Bits 9 to 12 are used to enable or disable the module's outputs. If these bits are 0, the corresponding output will not turn on.
Home Command:	(Module configured as type C only) For position monitoring and control applications, the program should set this bit before the Home limit switch is actuated. If this is done, when the Home limit switch is actuated, the next Marker input will cause the Home Count value to be loaded into the counter and the Home flag will be set.
Clear Error:	Set by the CPU to clear error after it has been acknowledged.

Module Status Codes

The Module Status Code in the %AI Input Data contains the error code returned to the PLC. These codes are set as a result of message or configuration command errors. To clear this code, the clear error bit in the discrete outputs (%Q) should be set. These codes are defined the same for counter types A, B and C. Note that fatal (RAM, EPROM) errors have no codes associated with them. These errors cause the watchdog timer to time out. Following is a list of error codes returned:

Table 4-1. Error Codes Received

Code	***Description***	***Code***	***Description***
0	No Errors	7–9	Reserved
1	Unused	10	Home Position Error
2	Unused	11	Counter 1 Limit Error
3	Invalid Command	12	Counter 2 Limit Error
4	Invalid Parameter	13	Counter 3 Limit Error
5	Invalid Sub-Command	14	Counter 4 Limit Error
6	Invalid Counter Number		

Error codes are defined as follows:

Invalid Command:	Command number received was invalid for the High-speed Counter module.
Invalid Parameter:	Configuration parameter received was invalid for the counter type selected.
Invalid Sub-Command:	Sub-Command code in the Data Command Word was invalid for the counter type selected.
Invalid Counter Number:	Counter number in the Data Command Word was invalid for the counter type selected.
Home Position Error:	Home Command was aborted (turned off) by the PLC before the Home Position was located (Type C counter only).
Counter_ Limit Error:	Counter configuration limit was rejected because the new limit set would be incompatible (High limit < Low limit).

Sending COMMREQ Commands to the High-speed Counter

In addition to the %Q discrete output data which is sent every sweep to the High-speed Counter, there are a series of commands which can be sent by the PLC (using the COMMREQ function block) to change the various operating parameters of the counters. These commands are all 6 bytes in length.

The format for COMMREQ Commands is as follows:

	MSB	LSB	
command word	0n	cc	where: n = counter 1 - 4 cc = sub-command code
data word (LSW)	dd	dd	dd = data type
data word (MSW)	dd	dd	← Always 0000 for Type A counters

The commands must be placed in registers within the COMMREQ command block before it is sent to the High-speed Counter. It is easier to correlate the data to register size by using hexadecimal data.

The following tables list the Data Command words for each of the 3 counter types in both decimal and hexadecimal numbers. Each table is immediately followed with a description of each command, as it applies to that counter Type, and a simple example.

COMMREQs for Type A Counters

Table 4-2. COMMREQs – Type A Counter

Command Name	Command Word	
	Decimal	**Hexadecimal**
Load Accumulator n	0n 01	0n 01
Load Hi Limit n	0n 02	0n 02
Load Lo Limit n	0n 03	0n 03
Load Acc n Increment	0n 04	0n 04
Set Cntr n Direction	0n 05	0n 05
Load Timebase n	0n 06	0n 06
Load ON Preset n	0n 11	0n 0B
Load OFF Preset n	0n 21	0n 15
Load Preload n	0n 31	0n 1F
Load Osc Freq Divisor	00 50	00 32

Note: n = Counter #1 – 4

The bytes in the command word are always treated as independent bytes – a counter ID byte and a command code byte.

COMMREQ	Details
Load Accumulator	Command Code = 01H Used to set any value within counter limits directly into the Accumulator. Example: To set Counter 3 to 1234H, load COMMREQ command registers with: Command word: 0301 LS data word: 1234 MS data word: 0000
Load Hi Limit	Command Code = 02H
Load Lo Limit	Command Code = 03H Used to set the Hi and Lo limits to any value within the counter range. Example: To change the upper limit of counter 4 to 10000 (2710H), load registers with: Command word: 0402 LS data word: 2710 MS data word: 0000 Note: If the limits are loaded in the wrong order, they may be rejected and an error flag will be set. To avoid this, remember to always move the Lo Limit first when shifting the limits down or the Hi Limit first when shifting the limits up.
Load Acc Increment	Command Code = 04H Used to offset a counter accumulator by a small number of counts (up to +127 or -128). Only the least significant byte of data is used with this command. Example: To offset counter 3 by -7 counts, load: Command word: 0304 LS data word: 00F9 MS data word: 0000 This may be done at any time, even while the counter is counting at maximum rate. If the offset causes the counter to exceed its limits, the excess will be treated just like any other overflow, i.e., if the Continuous mode is selected, the counter will wraparound through the other limit, or if the Single-Shot mode is selected the counter will stop at the limit.

COMMREQ	*Details*
Set Cntr Direction	Command Code = 05H
	Used to change the count direction (up or down) of a Type A counter. Only the LSB of the first data word is used for this command (00 = up, 01 = down). Example: To set the direction of counter 4 to down, load: Command word: 0405 LS data word: 0001 MS data word: 0000
Load Timebase	Command Code = 06H Used to change the time interval referenced by the counter when computing its counts/timebase register data. Example: To change the timebase for counter 2 to 600 ms (258H), load: Command word: 0206 LS data word: 0258 MS data word: 0000 Note: The maximum range of the counts/timebase (CTB) register is +32767 and -32768 counts. The length of the timebase and the maximum count frequency should be coordinated so that these limits are not exceeded. The indication will roll over from (+) to (-) or (-) to (+) if exceeded.
Load ON Preset	Command Code = 0BH
Load OFF Preset	Command Code = 15H Used to set up the output turn on/off points within the counter range. For Type A, there is one output associated with each counter. Example: To set counter 3 output to turn on at 5000 (1388H) counts, load: Command Code: 030B LS data word: 1388 MS data word: 0000 and off at 12000 (2EE0H) counts, load: Command Code: 0315 LS data word: 2EE0 MS data word: 0000
Load Preload	Command Code = 1FH Used to change the count value that will be loaded into the counter accumulator when the preload input is activated.
	Example: Make counter 2 start at 2500 (09C4H) counts at its preload signal, load: Command word: 021F LS data word: 09C4 MS data word: 0000
Load Osc Freq Divisor	Command Code = 32H Used to change the frequency of the internal square wave oscillator signal that can be configured to drive the 1 counter input. The frequency (f) = 660/d Khz, where d = the Osc Freq Divisor. Example: To change the frequency to 10 Khz (d = 66 decimal, 42H), load: Command word: 0032 LS data word: 0042 MS data word: 0000

COMMREQs for Type B Counters

Table 4-3. COMMREQs – Type B Counter

Command Name	Command Word	
	Decimal	**Hexadecimal**
Load Accumulator n	0n 01	0n 01
Load Hi Limit n	0n 02	0n 02
Load Lo Limit n	0n 03	0n 03
Load Acc n Increment	0n 04	0n 04
Load Timebase n	0n 06	0n 06
Load ON Preset n.1	0n 11	0n 0B
Load ON Preset n.2	0n 12	0n 0C
Load OFF Preset n.1	0n 21	0n 15
Load OFF Preset n.2	0n 22	0n 16
Load Preload n	0n 31	0n 1F
Load Osc Freq Divisor	00 50	00 32

Note: n = Counter #1 or 2

The bytes in the command word are always treated as independent bytes - a counter ID byte and a command code byte.

COMMREQ	Details
Load Accumulator	Command Code = 01H Used to set any value within counter limits directly into the Accumulator. Example: To set Counter 2 to 44332211H, load COMMREQ command registers with: Command word: 0201 LS data word: 2211 MS data word: 4433
Load Hi Limit	Command Code = 02H
Load Lo Limit	Command Code = 03H Used to set the Hi and Lo limits to any value within the counter range. Example: To change the upper limit of counter 1 to 1000000 (F4240H), load registers with: Command word: 0102 LS data word: 4240 MS data word: 000F Note: If the limits are loaded in the wrong order, they may be rejected and an error flag will be set. To avoid this, remember to always move the Lo Limit first when shifting the limits down or the Hi Limit first when shifting the limits up.

COMMREQ	*Details*
Load Acc Increment	Command Code = 04H Used to offset a counter accumulator by a small number of counts (up to +127 or -128). Only the least significant byte of data is used with this command. Example: To offset counter 2 by 9 counts, load: Command word: 0204 LS data word: 0009 MS data word: 0000 This may be done at any time, even while the counter is counting at maximum rate. If the offset causes the counter to exceed its limits, the excess will be treated just like any other overflow, i.e., if the Continuous mode is selected, the counter will wraparound through the other limit, or if the Single-Shot mode is selected the counter will stop at the limit.
Load Timebase	Command Code = 06H Used to change the time interval referenced by the counter when computing its counts/timebase register data. Example: To change the timebase for counter 2 to 600 ms (258H), load: Command word: 0206 LS data word: 0258 MS data word: 0000 Note: The maximum range of the counts/timebase (CTB) register is +32767 and -32768 counts. The length of the timebase and the maximum count frequency should be coordinated so that these limits are not exceeded. The indication will roll over from (+) to (-) or (-) to (+) if exceeded.
Load ON Preset	Command Code = 0BH/0CH
Load OFF Preset	Command Code = 15H/16H Used to set up the output turn on/off points within the counter range. For Type B, there are two outputs associated with each counter. Example: To set counter 2 output 2 to turn on at 5000 (1388H) counts, load: Command word: 020C LS data word: 1388 MS data word: 0000 and off at 12000 (2EE0H) counts, load: Command word: 0216 LS data word: 2EE0 MS data word: 0000
Load Preload	Command Code = 1FH Used to change the count value that will be loaded into the counter accumulator when the preload input is activated. Example: Make counter 2 start at 2500000 (2625A0H) counts at its preload signal, load: Command word: 021F LS data word: 25A0 MS data word: 0026
Load Osc Freq Divisor	Used to change the frequency of the internal square wave oscillator signal that can be configured to drive the counter 1 input. The frequency (f) = 660/d Khz, where d = the Osc Freq Divisor. Example: To change the frequency to 10 Khz (d = 66 decimal, 42H), load: Command word: 0032 LS data word: 0042 MS data word: 0000

COMMREQs for Type C Counters

Table 4-4. COMMREQs – Type C Counter

Command Name	Command Word	
	Decimal	Hexadecimal
Load Accumulator	01 01	01 01
Load Hi Limit	01 02	01 02
Load Lo Limit	01 03	01 03
Load Acc Increment	01 04	01 04
Load Timebase	01 06	01 06
Load Home Position	01 08	01 08
Load ON Preset 1.1	01 11	01 0B
Load ON Preset 1.2	01 12	01 0C
Load ON Preset 1.3	01 13	01 0D
Load ON Preset 1.4	01 14	01 0E
Load OFF Preset 1.1	01 21	01 15
Load OFF Preset 1.2	01 22	01 16
Load OFF Preset 1.3	01 23	01 17
Load OFF Preset 1.4	01 24	01 18
Load Preload 1.1	01 31	01 1F
Load Preload 1.2	01 32	01 20
Load Osc Freq Divisor	00 50	00 32

The bytes in the command word are always treated as independent bytes – a counter ID byte and a command code byte.

COMMREQ	Details
Load Accumulator	Command Code = 01H Used to set any value within counter limits directly into the Accumulator. Example: To set Counter to 44332211H, load COMMREQ command registers with: Command word: 0101 LS data word: 2211 MS data word: 4433
Load Hi Limit	Command Code = 02H
Load Lo Limit	Command Code = 03H Used to set the Hi and Lo limits to any value within the counter range. Example: To change the lower limit of the counter to -50000 (FFFF3CB0H), load registers with: Command word: 0103 LS data word: 3CB0 MS data word: FFFF Note: If the limits are loaded in the wrong order, they may be rejected and an error flag will be set. To avoid this, remember to always move the Lo Limit first when shifting the limits down or the Hi Limit first when shifting the limits up.

COMMREQ	*Details*
Load Acc Increment	Command Code = 04H Used to offset a counter accumulator by a small number of counts (up to +127 or -128). Only the least significant byte of data is used with this command. Example: To offset the counter by 19 counts (13H), load: Command word: 0104 LS data word: 0013 MS data word: 0000 This may be done at any time, even while the counter is counting at maximum rate. If the offset causes the counter to exceed its limits, the excess will be treated just like any other overflow , i.e., if the Continuous mode is selected, the counter will wraparound through the other limit, or if the Single-Shot mode is selected the counter will stop at the limit.
Load Timebase	Command Code = 06H Used to change time interval referenced by counter when computing its counts/timebase register data. Example: To change the timebase for the counter to 600 ms (258H), load: Command word: 0106 LS data word: 0258 MS data word: 0000 Note: The maximum range of the counts/timebase (CTB) register is +32767 and -32768 counts. The length of the timebase and the maximum count frequency should be coordinated so that these limits are not exceeded. The indication will roll over from (+) to (-) or (-) to (+) if exceeded.
Load Home Position	Command Code = 08H Used to change the count value that will be loaded into the counter accumulator at the home position. Example: To assign the counter home position as 1000000 (0F4240H) counts, load: Command word: 0108 LS data word: 4240 MS data word: 000F
Load ON Preset	Command Codes = 0B/0C/0D/0E
Load OFF Preset	Command Codes = 15/16/17/18 Used to set up the output turn on/off points within the counter range. For Type C, there are four outputs controlled by the counter. Example: To set counter output 4 to turn on at 5000 (1388H) counts, load: Command word: 010E LS data word: 1388 MS data word: 0000 and off at 12000 (2EE0H) counts, load: Command word: 0118 LS data word: 2EE0 MS data word: 0000

COMMREQ	Details
Load Preload	Command Codes = 1F/20 Used to change the count value that will be loaded into the counter accumulator when the preload input is activated. The Type C counter has two preload inputs. Example: To make the counter start at 2500000 (2625A0H) counts at its preload 2 signal, load: Command word: 0120 LS data word: 25A0 MS data word: 0026
Load Osc Freq Divisor	Command Code = 32 Used to change the frequency of the internal square wave oscillator signal that can be configured to drive the counter input. The frequency (f) = 660/d Khz, where d = the Osc Freq Divisor. Example: To change the frequency to 10 Khz (d = 66 decimal, 42H), load: Command word: 0032 LS data word: 0042 MS data word: 0000

Sending Data with the COMMREQ Function

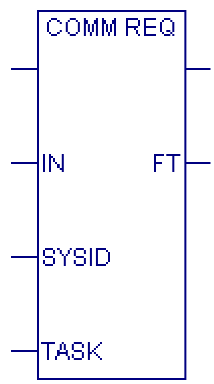
The PLC ladder program sends the commands using the COMMREQ (Communication Request) function. The COMMREQ requires that all its command data be placed in the correct order in the CPU memory before it is executed. It should then be executed by a one-shot to prevent sending the data to the High-speed Counter multiple times. A description of the COMMREQ function and its command block data follows along with a ladder example which uses registers %R0001 to %R0014 for the COMMREQ command block & status register.

COMMREQ Function Block Description

The Communications Request (COMMREQ) function is a conditionally executed function that communicates a particular request, through the ladder logic program, to the High-speed Counter.

Communications Request Function Block Format

The ladder logic representation of the COMMREQ is as follows:



The Communications Request function block has four inputs and one output. The first input is an enable input. Generally a one-shot coil is used to enable the COMMREQ function. This prevents multiple messages from being sent. The second input (IN) is the starting location of the COMMREQ command block. The SYSID input is used to indicate which rack and slot to send the message to (physical location of High-speed Counter module).

In the above example, the SYSID (0107 (in Hexadecimal)) points to rack 1, slot 7 and the COMMREQ command block starts at Register 0001. The last input (TASK) is ignored during High-speed Counter communications and should be set to zero.

Command Block

The command block for COMMREQs is composed of 10 words of information arranged in the following fashion: (all values in hexadecimal unless otherwise indicated). Use the Block Move command to move these values to the Register tables. Refer to the programming software documentation for information on using the Block Move function.

Location	Data	Description
%R0001	0004	Always 0004 for this High-speed Counter application
%R0002	0000	Not used (Always zero)
%R0003	0008	COMMREQ status data type (8 = registers), see Table 4-5
%R0004	000D	COMMREQ status location -1 (%R0014)
%R0005	0000	Not used
%R0006	0000	Not used
%R0007	E201	Command type (E2 - message ID for 6 byte Data Command to High-speed Counter) and Command Parameter (1 = write)
%R0008	0006	Byte length of data to High-speed Counter
%R0009	0008	Data type (8 = registers), see Table 4.5
%R0010	000A	Start location of data -1 (%R0011)
%R0011	nnnn	Command word (Tables 4-2, 4-3, 4-4)
%R0012	nnnn	LS data word
%R0013	nnnn	MS data word

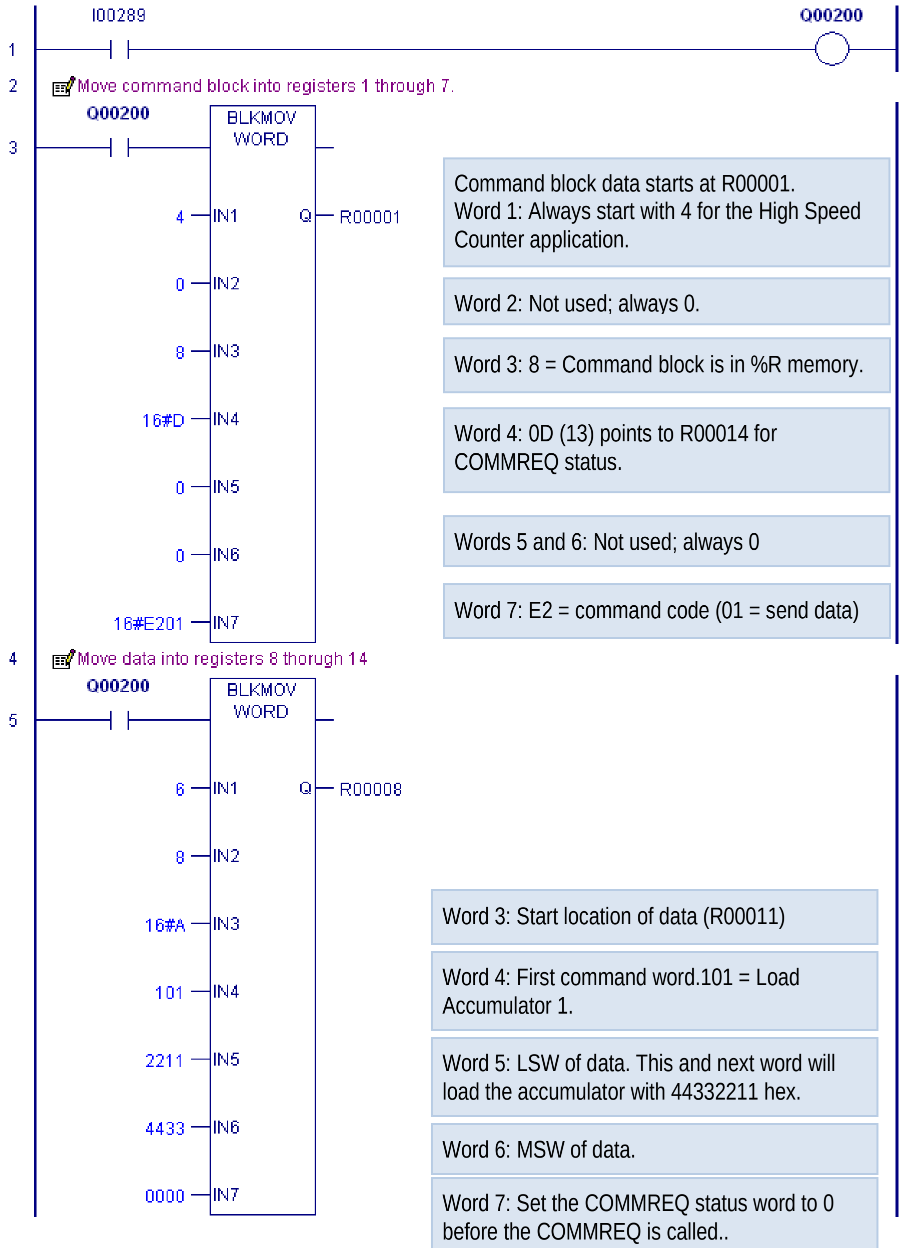
Table 4-5. COMMREQ Data Type Codes

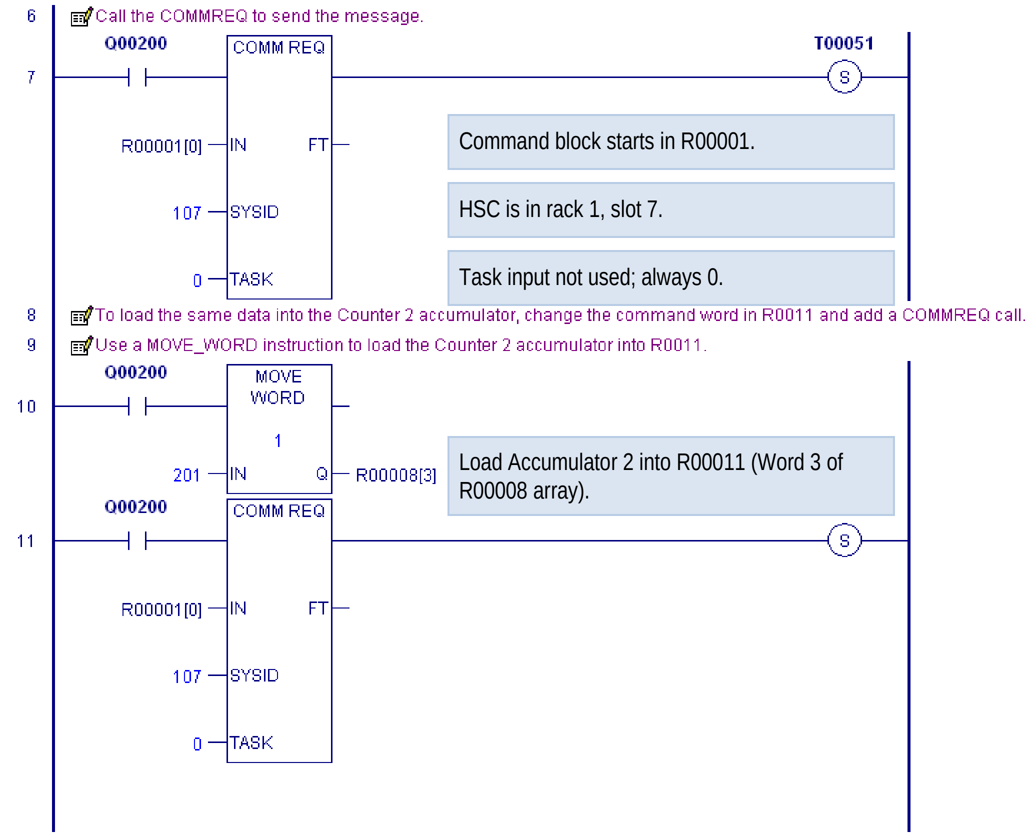
For This Data Type		Enter This Number	
		Decimal	Hexadecimal
%I	Discrete Input	28	1C
%Q	Discrete Output	30	1E
%R	Register	8	08
%AI	Analog Input	10	0A
%AQ	Analog Output	12	0C

Example – Sending COMMREQs

An example of ladder logic for sending commands to the High-speed Counter using COMMREQ function blocks is shown below. In this example, the COMMREQ command block is located in registers %R0001 through %R0013 and the COMMREQ status is returned in %R0014. The command to send the data is initiated by the conditional input %I0289 which sets output %Q0200 for one sweep. The High-speed Counter is located in Rack 1, slot 7.

Note that register reference pointers in the COMMREQ command block are one less than the register number pointed to, for example 000D (decimal 13) indicates R0014 as the COMMREQ status register.





Note: It is important when executing multiple COMMREQ functions to confirm successful status prior to executing successive COMMREQs. The COMMREQ fault output will be ON when the status is IOB_BUSY and OFF in case of IOB_SUCCESS.

In the above example, communication failure is indicated if %T0051 or %T0052 is set.

Table 4-6. Status Word Fault Codes for High-speed Counter

Fault	***Value***	***Description***
IOB_BUSY	1	Module is reconfiguring
IOB_SUCCESS	1	COMMREQ executed successfully.
IOB_PARITY_ERR	-1	A parity error occurred while communicating with an expansion rack.
IOB_NOT_COMPL	-2	After the communication was over, the module did not indicate that it was complete.
IOB_MOD_ABORT	-3	For some reason, the module aborted the communication.
IOB_MOD_SYNTAX	-4	The module indicated that the data sent was not in the correct sequence.
IOB_NOT_RDY	-5	The RDY bit in the module's status was not active.
IOB_TIMEOUT	-6	The maximum response time elapsed without receiving a response from the module.
IOB_BAD_PARAM	-7	One of the parameters passed was invalid.
IOB_BAD_CSUM	-8	The checksum received from the DMA protocol module did not match the data received.
IOB_OUT_LEN_CHGD	-9	The output length for the module was changed, so normal processing of the reply record should not be performed.

Chapter 5

Classic Mode Configuration

All configuration parameters for the module are downloaded from the host controller to the High-speed Counter after it passes its internal diagnostics and the S1 (MODULE OK) indicator has turned on. An initial (default) set of configuration parameters is loaded during diagnostics. These default settings may be used as-is or modified through a download from the host controller. When the user configuration is complete, the S2 (CONFIG) LED will turn on.

The configurable features of the High-speed Counter in Classic mode are:

- Counter type (Type A, B, or C)
- Oscillator Reference Input
- Oscillator frequency
- Strobe edge active
- Disable, Preload, and Count input filters
- Count direction (Type A only)
- Count Signal mode (Types B and C only)
- Continuous or Single-Shot counting
- Timebase for measuring count rate
- Upper and lower count limits
- On and off presets for outputs
- Home position (Type C only)
- Preload counter value
- Output Fail Mode

Configurable Features

The following table summarizes all configuration features and default configuration values.

Features	Selections	Default
Counter Type	A, B, C	Type A
Failure mode	Normal, OFF, hold	Normal
Oscillator Input	OFF, ON	OFF
Oscillator Divider	4 to 65535	660 (1 kHz)
Count input filter	high/low frequency	high frequency
Preload Input filter	high/low frequency	high frequency
Disable Input filter **	high/low frequency	high frequency
Count Up or Down *	Up/down	up counter
Count input signals **	UP/DN, PUL/DIR, A QUAD B	PUL/DIR
Count mode	Continuous/single-shot	continuous
Counter timebase	1 – 65535mS	1000mS
Count limits	A: -32768 to +32767 B/C: -2147483648 to +2147483647	A: upper = +32767, lower = 0 B/C: upper = +8388607, lower = 0
Output Preset positions	select ON and OFF positions	A: ON = +32767, OFF = 0 B/C: ON = +8388607, OFF = 0
Home value ***	enter home count value	0
Strobe edge	positive/negative	positive
Preload value	A: -32768 to +32767 B/C: -2147483648 to +2147483647	0

* for Type A configuration only; ** for Type B or Type C configuration; *** for Type C configuration only

Counter Type

The module's counter type must be selected. Each type is represented by a letter, either A, B, or C:

Function	Counters	Counter Type
Unidirectional counters	4	A
Bidirectional counters	2	B
Differential counter	1	C

Oscillator Frequency Divider and Input

The High-speed Counter module generates an internal square wave signal which can be switched into the count input in place of I1 to be used as a timing reference for measurement applications. This is controlled by the Oscillator Frequency Input configuration option (***this is available only on Counter 1 and may not be used for Counter 2 – 4***). OFF allows the normal user input to drive I1. ON selects the internal reference frequency as the input.

The Oscillator output frequency is determined by the configured divider number (N) as indicated below:

Osc Freq = 660/N kHz

The range for N is 4 to 65535. The default setting for N is 660 to provide 1 kHz.

Strobe Edge

Strobe inputs are edge sensitive. Each Strobe input on the module can be individually configured to have either the positive or the negative edge active. By default, they are positive-edge sensitive.

Input Filters

By default, each input has a built-in high-frequency (2.5∝S) filter. For the following groups of inputs, this can be changed to a 12.5mS low-frequency filter (the Strobe input always uses a high-frequency filter). The low-frequency filter reduces the effect of signal noise. Maximum count rate for the low-frequency filter is 30Hz. Input Filter selections are grouped as follows:

- IN1, IN2 – Count Inputs
- IN3, IN4 – Count Inputs
- IN5, IN6 – Preload Inputs
- IN7 – Preload (A), or Disable (B & C)
- IN8 – Preload (A), or Disable (B)

(A), (B), and (C) above refer to the selected counter type. See Table 3-1 for input designations for each counter type. The Home input filter (IN8 for Type C) is always low frequency.

Counter Direction – Type A

If the module is used in its Type A configuration, it provides four individual unidirectional counters. Each of the four counters can be configured to count either up or down. The default is Up.

Count Signal Mode – Types B and C

For a Type B or Type C module configuration, select how each counter will be used; choices are:

- Up/Down mode
- Pulse/Direction mode
- A Quad B mode

Continuous or Single-Shot Counting

Each counter on a module has programmable count limits that define its range. The counter can either count continuously within these limits, or count to either limit, then stop.

Continuous Counting

In the continuous counting mode, if either the upper or lower limit is exceeded, the counter wraps around to the other limit and continues counting. Continuous counting is the default mode.

Single-Shot Counting

If single-shot is selected, the counter will count to its upper or lower limit, then stop. When the counter is at the limit, counts in the opposite direction will count it back off the limit. The Accumulator can also be changed by loading a new value from the CPU or by applying a Preset Input.

Counter Timebase

For each counter, the timebase represents a span of time which can be used to measure the rate of counting. For example, the program may be required to monitor the number of count pulses which are occurring every 30 seconds.

A timebase from 1 msec to 65535 msec can be selected for each counter. The counter timebase is set to 1 second (1000 msec) by default. The module stores the number of counts that occurred during the last-completed timebase interval in the Counts/Timebase register. The range of the Counts/Timebase register is -32768 and +32767 counts. The timebase value selected should not allow the Counts/Timebase register to overflow at the maximum count frequency. If it does, the sign of the Counts/Timebase will change from (+) to (-) or (-) to (+).

Count Limits

Each counter can be assigned upper and lower count limits. All Accumulator preload values and output on/off preset values must lie within these limits. The upper (high) limit is the most positive, and the lower limit is the most negative. Both can be positive, or both can be negative, but the high limit is always greater than the low limit.

If the Accumulator value is outside the new limits when the limits are changed it is automatically adjusted to the low limit value. If the new limits are incompatible, that is, (high < low or Low > high), then they will be rejected and the old limits retained. In this case a counter limit error code will be returned. To avoid this situation when the limits are changed one at a time, a good rule to follow is: always move the high limit first when shifting the limits up and always move the low limit first when shifting them down.

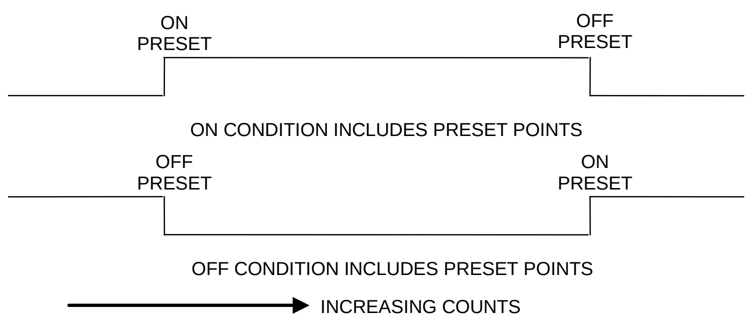
- For Type A (16-bit) counters, the limit range is -32,768 to +32,767.
- For Type B and C (32-bit) counters, the limit range is -2,147,483,648 to +2,147,483,647.

Output Preset Positions

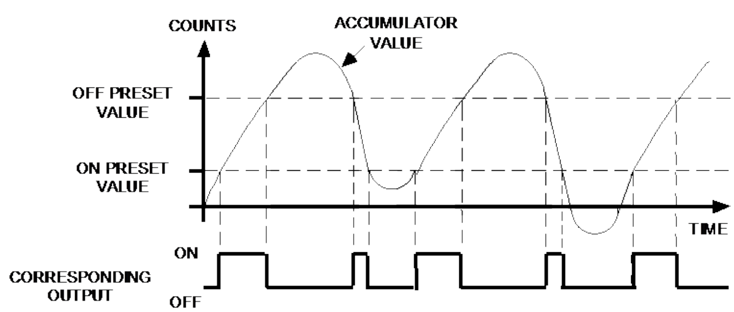
Each counter output has a preset ON and OFF position. The output state indicates when the counter accumulator value is between the ON and OFF points.

Preset closest to low limit	***Output ON***	***Output OFF***
ON	> = ON Preset < = OFF Preset	> OFF Preset < ON Preset
OFF	< OFF Preset > ON Preset	< = ON Preset > = OFF Preset

The output may be either on or off when the accumulator value lies between the Preset points.



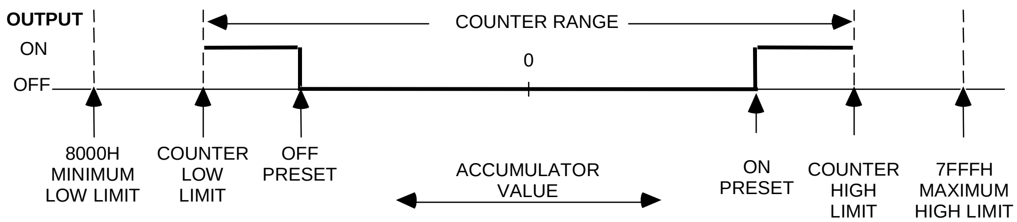
For example:



Location of Preset Points

The Preset points may be located anywhere within the counter range. When the accumulator value is between the Preset points, the output ON/OFF state will always be that of the lowest (most negative) Preset point. When the accumulator value is *not* between the Preset points, the output ON/OFF state will be that of the most positive preset. This is true regardless of the counter direction.

The following example compares the output state and accumulator value of a 16-bit counter.



If both preset points are within the counter range, the output always switches at the Preset points. If only one of the Preset points is programmed within the counter range, then the counter limits will function as the other Preset point. In the continuous mode, the output will switch when wraparound occurs.

If neither of the Preset points is in the counter range then the output state will not change; it will always be the state of the most positive Preset. If both Preset points are equal and out of range, the output will always be OFF. If both Preset points are equal and within the counter range, then the output will only be on for one count value – as defined by the Preset points.

Separation of Preset Points

The count accumulators are compared to the Presets at 0.5 msec intervals. Therefore, to guarantee that the outputs will always switch, the Preset points must be separated by at least the number of counts received in a 0.5 msec time period. For example:

If maximum count rate = 10kHz;
then minimum count separation = (10,000 Hz x .0005 sec) = 5 counts.

Home Position

If the module has been set up to operate as a Type C counter, a Home Position can be selected. The default for the Home Position is 0. The counter will be set to this value when all three of the following events occur:

1. Home command is given by the CPU;
2. Home Limit Switch input is present;
3. Next Marker input pulse occurs.

Additional markers will be ineffective until the Home Command is removed and the Home Command sequence is repeated. If the Home Command is removed before the Home Position marker is found, a ***Home Position Error*** will be returned.

Preload Value

For each counter, a starting count value can be specified which will be used when the Preload input is activated. If the counter should be reset to 0, enter 0 as the Preload value; this is the default value. For a differential (Type C) counter module, two different Preload values can be selected for the same counter. For Type A (16-bit) counters, the preload range is -32,768 to +32,767. For Type B or C (32-bit) counters, the preload range is -2,147,483,648 to +2,147,483,647.

Preload values within the configured counter limits should always be used. When preload values outside the counter limits are used, a preload input will have the following effect:

- A preload value greater than the counter high limit initially sets the Accumulator to the preload value. If down counts are being received every 0.5 ms then the Accumulator is counted down from the preload value. Whenever a 0.5 ms period occurs during which no counts are received or up counts are received the Accumulator is immediately adjusted for overflow. The overflow adjustment depends on the counter mode selected (continuous or one-shot).
- A preload value less than the counter low limit initially sets the Accumulator to the preload value. If no counts are currently being received the Accumulator stays at the preload value. If up counts are currently being received the Accumulator is counted up from the preload value. When down counts are received the Accumulator is immediately adjusted for underflow according to the selected counter mode (continuous or one-shot).

Output Fail Mode

If the module detects a loss of the CPU, it can respond in three different ways:

- It can continue to operate normally, processing the inputs and controlling the outputs according to its configuration (NORMAL);
- It can force all four outputs to turn off (FRCOFF);
- The module can hold the outputs at the current state (HOLD).

These responses remain in effect until the CPU returns to operation or the module is power-cycled.

Chapter 6

Enhanced Mode Counter Operation

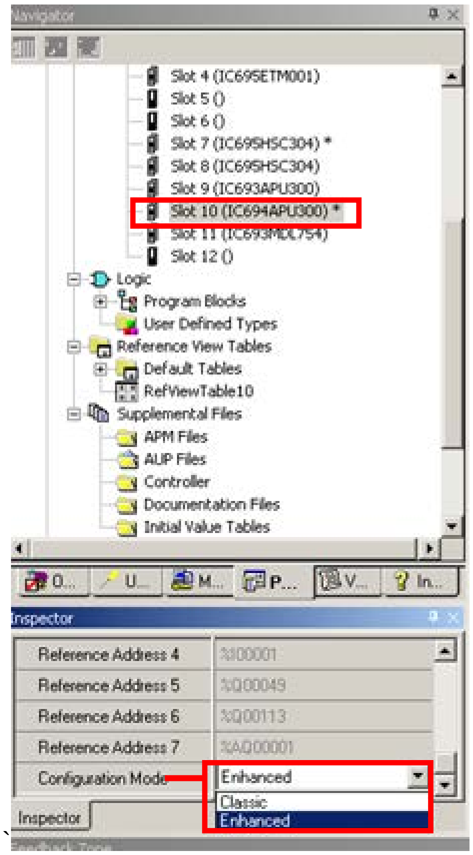
The Enhanced APU300 module supports the newer advanced features only when configured in Enhanced mode in an RX3i system.

Features supported in the Enhanced mode are:

- Support for up to 1 MHz input frequency.
- Expanded input filtering to 5 ms, 500 μs, 10 μs and no filter.
- Support for both Single Ended and Differential Encoders.
- Support for 32 bit counters.
- Support for Z input events.
- Windowing feature that allows you to define a range of counter accumulator values wherein the strobe is recognized as valid input. (For details, see chapter 7).
- ESCP outputs with 1.5 amps per point minimum.
- Configurable inputs and outputs.
- Roll over detection flag.
- Support for COMMREQ functions and Module Control Data commands. (For details, see chapter 8).
- The module reports the part number, serial number and revision to the CPU.
- Firmware updates supported over the backplane from the RX3i CPU.

Enabling Enhanced Mode

To enable these features, select Enhanced mode from the Proficy Machine Edition software's property inspector.



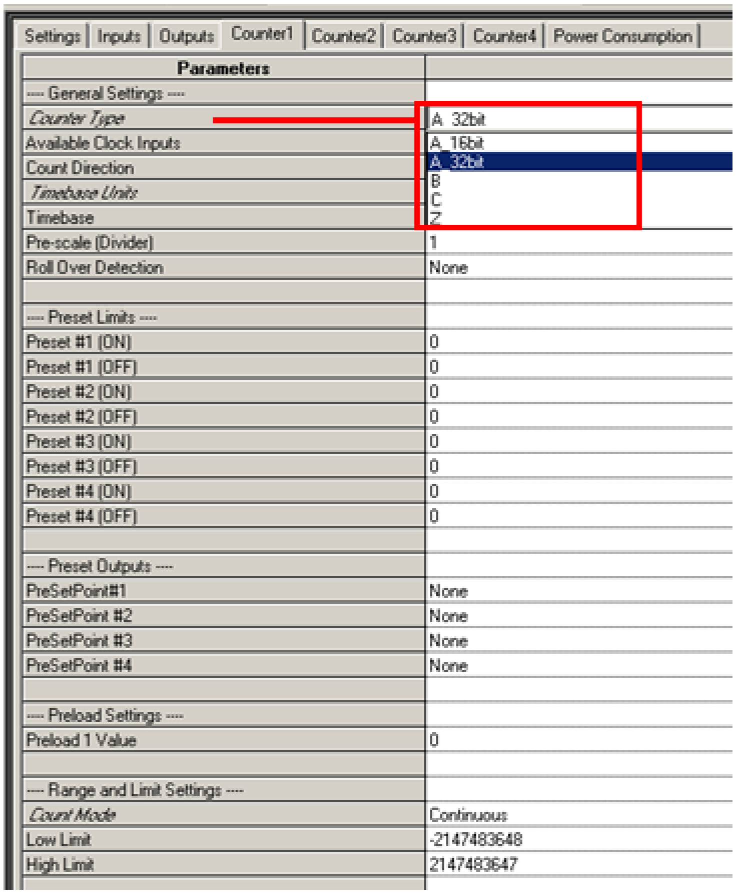
Note: The parameter settings for Classic and Enhanced modes are preserved when changing from Classic mode to Enhanced mode and back to Classic mode.

Counter Types

In Enhanced mode, the module supports four Type A counters with 16 bit and 32 bit accumulator width.

All other types of counters (B, C, Z) support 32 bit accumulator width by default.

The type of counter can be selected from the respective **Counter** tab.



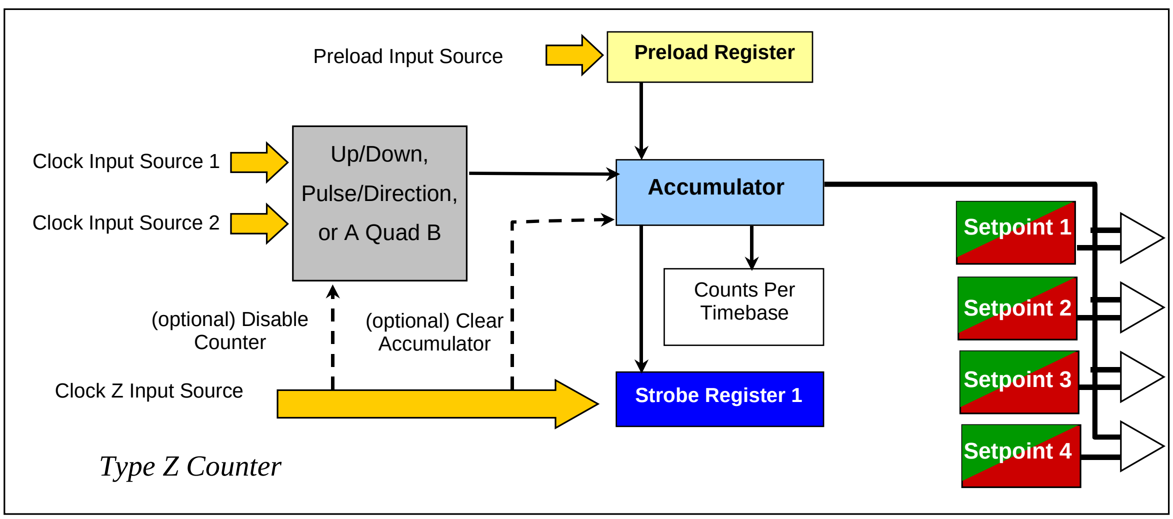
Type A, B and C Counters

There is no change in the functionality of Type A, Type B and Type C counter compared to the Classic mode.

Type Z Counter

An RX3i Type Z Counter uses one of the High-Speed Counter Module's internal counters. The Type Z Counter has:

- Two Clock Inputs that work together to increment or decrement the count value in the Accumulator for Up/Down, Pulse/Direction, or A Quad B counting.
- One Preload Input (with one Preload register) that can be used to set the Accumulator to a configured Preload Value.
- A Clock Z Input that combines the functions of a strobe input, disable input (suspends counting) and clear input (resets the Accumulator to zero). When the Clock Z Input source is active, the Clock Z Input stores the current Accumulator value in the counter's Strobe 1 register. Optionally, the Clock Z Input can also be configured to disable counting while it is active, and/or to clear the Accumulator to zero (configured as Resume mode).
- A Counts per Timebase register that captures the current count rate.
- Up to four Setpoint On/Off values that can control external output points.



Additional configurable features of a Type Z Counter are:

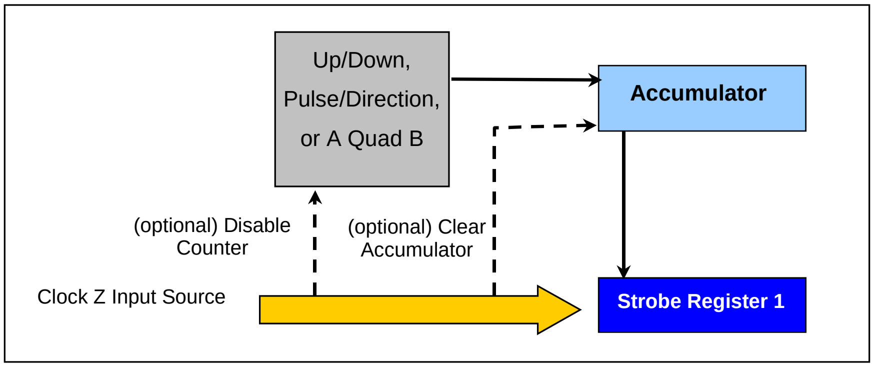
- Timebase Units
- Prescale Divider, used to scale down high count rates
- Strobe Overwrite for the Clock Z Input, with or without Acknowledgement
- Continuous or One-Shot Count Mode, either within or beyond the counter's Range Limits
- High Range and Low Range Limits
- Rate of Change monitoring
- Fault Reporting
- Interrupts

Please see chapter 3 for descriptions of these High-Speed Counter features.

Operation of the Clock Z Input

The Type Z Counter is the only Counter Type with a Clock Z Input. This special input can be used to trigger a store of the current Accumulator value to the counter's Strobe 1 memory. Both the source and the polarity of the Clock Input Z are configurable. The stored count value is retained in memory until another store occurs.

In *Store/Continue* mode, Clock Input Z triggers a store and the counter continues counting.



In *Store/Wait/Resume* mode, Clock Input Z triggers a store, but counting stops for as long as the selected Clock Input Z source remains in the configured Polarity. For example, if the source of the Clock Input Z signal is an Overflow condition on the module's Counter 2, when an overflow condition occurs on Counter 2, the Type Z counter will store the current value and stop. It will not resume counting until the Overflow fault is cleared.

In *Store-Reset/Wait/Start* mode, Clock Input Z triggers a store and resets the counter to zero. The counter stops counting for as long as the selected Clock Input Z source remains in its configured Polarity. For example, if the source of the Clock Input Z signal is Setpoint 1 of Counter 1, and the Polarity is selected to be Rising Edge/High Level, then when Counter 1 counts to its Setpoint 1 On value, the Type Z counter will store the current value and reset to zero. The Type Z counter will not start counting again until Counter 1 reaches its Setpoint 1 Off value.

In *Store-Reset/Start* mode, Clock Input Z triggers a store and resets the counter to zero, The counter immediately resumes counting. For example, if the source of the Clock Input Z signal is External Input #4 and the Polarity is set to be Falling Edge/Low Level, when Input 4 goes Off the Type Z counter will store the current value, reset to zero, and continue counting.

Chapter 7

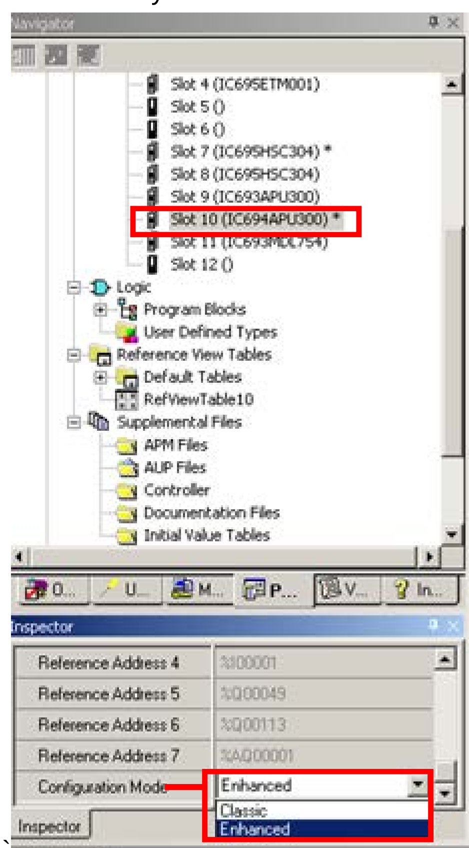
Enhanced Mode Configuration

This chapter discusses the following:

- Enabling Enhanced mode
- Configuring Counters
- Configuring Module Inputs
- Configuring Module Outputs

Enabling Enhanced Mode

Select Enhanced mode in the Proficy Machine Edition software's property inspector.



Note: The parameter settings for Classic and Enhanced modes are preserved when changing from Classic mode to Enhanced mode and back to Classic mode.

Configuring Counters

The counters can be configured to operate as different counter types with many selectable parameters. Sources for each counter are subsequently configured on each counter's Counter tab.

Counter General Settings

Counter Type: The module can be configured for a combination of Type A, Type B, Type C, and Type Z Counters.

Type A Counter can be configured on all four counters in single ended mode.

Type B and Type Z Counters can only be configured on odd-numbered counter tabs (Counter 1, 3) when Input mode is selected as Single ended. Type C counter is available on Counter 1 only when Input mode is selected as Single ended.

When Input mode is selected as Differential, Type A Counters can only be configured on odd-numbered counter tabs (Counter 1, 3). Type B and Type Z Counters can only be configured as Counter 1. Type C counter is not available for this mode.

The choice made for Counter Type determines which additional features can then be configured. Only features that are appropriate for a counter type can be selected.

If a counter's Counter Type is changed after its Counter parameters and Sources have been entered, those entries are retained for the new Counter Type. So it is possible to configure a standard Counter Type, then change the Counter Type to other Counter and assign additional features.

Available Clock Inputs: The number of Clock Inputs that will update the Counter Accumulator. Counter Type A has one Counter Clock Input. Counter Types B and Z each have two Counter Clock inputs.

A Type C Counter requires four Counter Clock Inputs. The first pair increments the Counter Accumulator and the second pair decrements the Accumulator. Operation of the two input pairs is defined by the Counter Clock Type and the Second Counter Clock Type parameters.

This parameter is only displayed for information and cannot be modified by the user.

Count Direction (Type A only): A Type A Counter can be configured to increment (Up) or decrement (Down) its Accumulator on a Count Pulse input transition. It defaults to Up.

Counter Clock Type: Determines the association between Clock Inputs 1 and 2. Each pair of clock inputs can be associated in three ways:

- Up/Down mode
- Pulse/Direction mode
- A Quad B mode

Second Counter Clock Type (Type C Only): Determines the association between Clock inputs 3 and 4 on a Type C Counter.

Timebase Units: The units in which the configured Timebase parameter (below) will be measured. It defaults to 1ms, and can be changed to 1us or 100ns.

Examples:

To set the Timebase value to 1 microsecond, set the Timebase Units value to 1 µs, and set the Timebase value to 1.

To set the Timebase value to 10 seconds, set the timebase Units to 1ms, and set the Timebase value to 10000.

Timebase: A Timebase from 100ns to 429496 milliseconds can be selected for each counter. Timebase is the number of timebase units the module will use to count the number of pulses per timebase or the width of pulses. The Timebase defaults to 1000ms. The timebase used should not allow more counts in a timebase period than the 32–bit Counts per Timebase register can hold, otherwise it will overflow.

Timebase unit	***Timebase value***	
	Low Limit	***High Limit***
100 ns	10	4294967295
1 us	1	429496729
1 ms	1	429496

Roll Over detection: Roll over flag can be used to drive outputs at the terminal block. Refer to “Outputs with Roll Over Detection Flag” on page 6-16 for details.

Preset Limits

Each counter can be configured to have four Preset ON values and four Preset OFF Values. Presets are Accumulator values at which the counter’s associated Preset Outputs will go ON and OFF. For details of Preset operation, please refer to section “**Outputs with PreSet Points**”.

Presets may be located anywhere within the count limits.

Preset #1-4 (ON): The value at which the associated Preset point goes On.

Preset #1-4 (OFF): The value at which the associated Preset point goes Off.

Preset Outputs

Presetpoint #1-4: This selection assigns one of the module’s external outputs to the counter’s Preset 1 – 4 outputs. For all Counter types, each preset point defaults to None. It can be changed to any of the module’s outputs. To use these preset point values, the output must be configured on the Outputs tab with its Output Source set to Presetpoint.

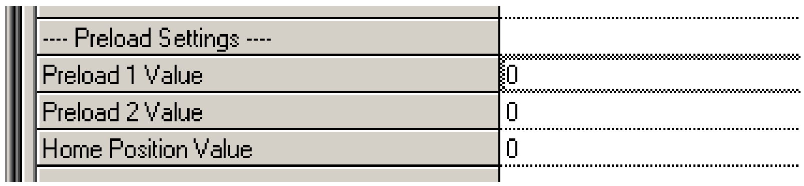
Multiple Presetpoint Outputs can be mapped to the same external output point. The signals from each Presetpoint Output are logically ORed on the external output. Any or all Presetpoint Outputs can be ORed together.

Preload Settings

For each counter, starting, or Preload, values can be set up for use when the corresponding Preload Input is activated. The Counter Types provide different Preload Value options.

Counter Type	Configurable Preload Values
A	Preload 1
B	Preload 1
C	Preload 1, 2, Home Position
Z	Preload 1

For example, the Preload Settings parameters for a Type C Counter are shown below.



Preload Value(s) selected here must lie within the configured range limits.

Home Position Value: The value to which the Accumulator will be set during a homing operation. This parameter is only available for a Type C when the Homing feature is enabled. It defaults to 0.

Range and Limit Settings

The Range and Limit Settings establish determine how counting will be affected by those values.

Count Mode: This defaults to Continuous. The configuration choices are:

- Continuous mode: The counter counts continuously within its range. If either the High Range or the Low Range value is exceeded, the counter rolls over to the other limit and continues counting.
- Single Shot mode: The counter count to its configured High Range or Low Range value and stops. When a Single shot counter is at the High Range or Low Range limit, the direction can be reversed and the counter will back away from the limit.

Low Limit, High Limit: Each Counter Type has a default Low Range and High Range limit.

Type of Counter	Default Low Limit	Default High Limit
Type A_16 Counter	-32768	32767
Type A_32, B, C, Z	-2147483648	2147483647

These values are the lower and upper boundaries of its normal operating range. Both range values can be positive or negative, but the High Range value must always be greater than the Low Range value. If Counter Low Limit and High Limit are equal then the counter will not increment or decrement and Roll over flag will be continuously ON if the count mode is continuous.

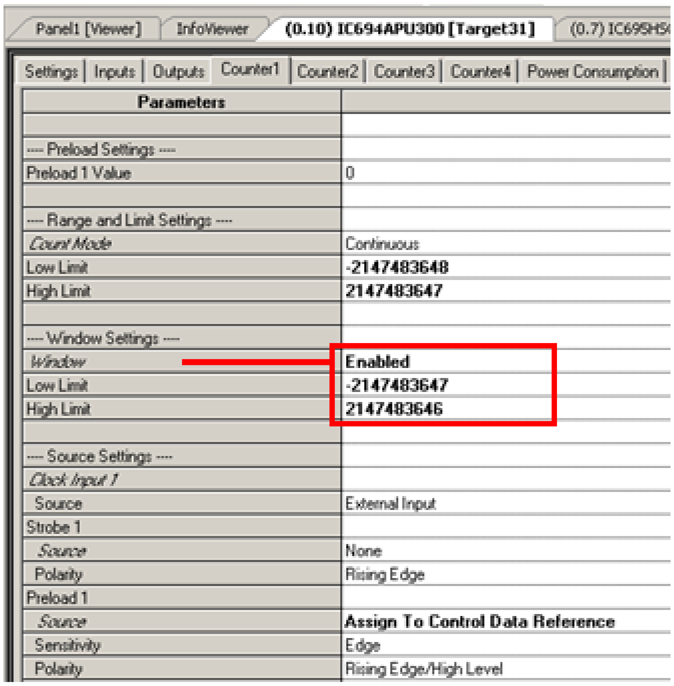
Window Limits

Window: If enabled, the strobe input can be configured to be recognized only in the window (low limit – high limit) specified in the below settings. The strobe input will be invalid outside the window.

Window Low Limit, High Limit: The strobe inputs will be valid only within the specified Low limit and High limit values.

Type of Counter	*Default Window Low Limit*	*Default Window High Limit*
Type A_16 Counter	-32768	32767
Type A_32, B, C, Z	-2147483648	2147483647

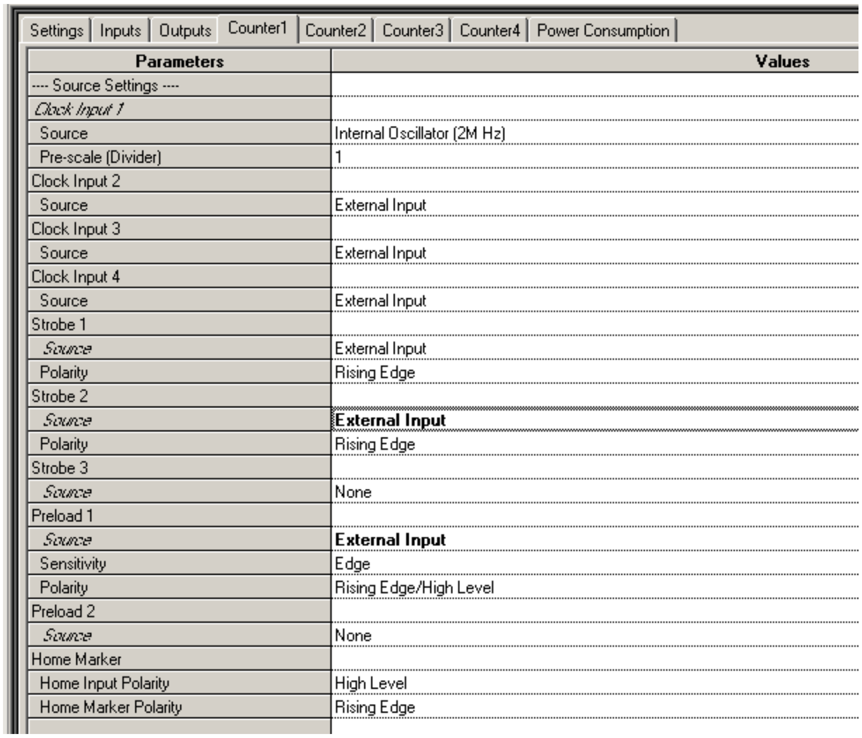
The Window limits should be always within the Counter Low limit and high limit values. If Window Low limit is set to Counter Low Limit and Window High limit is set to Counter High limit, then Window feature will be ineffective.



For example, if Window Low limit is set to 1000 and High limit is set to 2000, the strobe input will be recognized only when the accumulator value is between 1000 and 2000 and strobe register will be updated accordingly. The strobe input is ignored at all other values of the accumulator.

Source Settings

The number and types of sources that can be configured depend on the counter type that has been selected, and on some of the entries made on the Counter tabs. For example, the counter sources screen for a Type C Counter is shown below.


Settings | Inputs | Outputs | Counter1 | Counter2 | Counter3 | Counter4 | Power Consumption

Parameters	Values
---- Source Settings ----	
Clock Input 1	
Source	Internal Oscillator (2M Hz)
Pre-scale (Divider)	1
Clock Input 2	
Source	External Input
Clock Input 3	
Source	External Input
Clock Input 4	
Source	External Input
Strobe 1	
Source	External Input
Polarity	Rising Edge
Strobe 2	
Source	**External Input**
Polarity	Rising Edge
Strobe 3	
Source	None
Preload 1	
Source	**External Input**
Sensitivity	Edge
Polarity	Rising Edge/High Level
Preload 2	
Source	None
Home Marker	
Home Input Polarity	High Level
Home Marker Polarity	Rising Edge

The configuration settings for all the inputs are provided in the table below.

Type of Input	***Available Sources***	***Polarity settings***	***Sensitivity settings***
Clock Input 1	External Input	None	None
	Internal Oscillator[1]		
Clock Input 2	External Input	None	None
	Assign to Control Data Reference[1]		
Clock Input 3	External Input	None	None
Clock Input 4	External Input	None	None
	Assign to Control Data Reference[1]		
Strobe1,2,3	None	None	None
	External Input	Rising Edge Falling Edge Both Edges	None
	Assign to Control Data Reference	Rising Edge Falling Edge Both Edges	None
Preload1,2,3 [3]	None	None	None
	External Input	Rising Edge Falling Edge Both Edges	Edge
		High Level Low Level	Level
	Assign to Control Data Reference	Rising Edge Falling Edge Both Edges	Edge
		High Level Low Level	Level
Home Input	External Input[2]	High Level Low Level	Level[2]
Home Marker	External Input*[2]	Rising Edge Falling Edge	Edge[2]

[1] Input 1 can be configured as internal oscillator and input 2, 4 can be configured as Control data reference for Type B, C and Z only for Clock /Direction counter selection.

[2] Home Input and Home Marker are always driven by External Input and they are always level triggered. Hence these settings do not appear in the settings tabs.

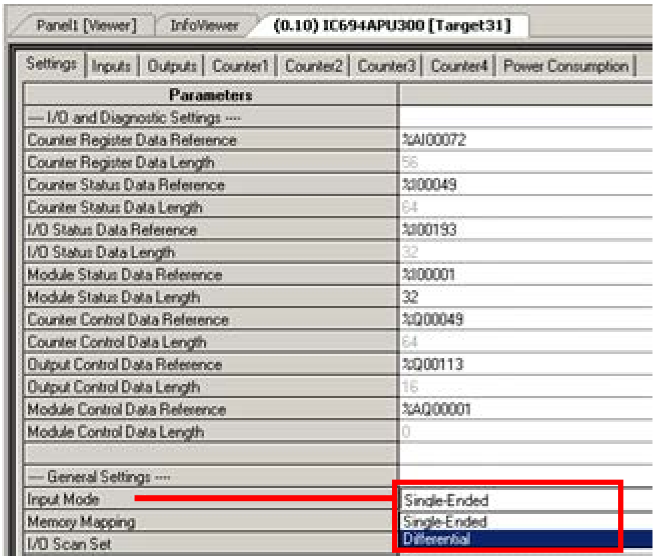
[3] For Type Z counter Preload input is always driven by Assign to control Data reference.

[4] Disable Input for Type B, C is always driven by External Input and it is always active when High. The source settings for Disable input are not available in the Counter tab.

Configuring the Module's Inputs

Input Mode

In the Enhanced mode, the module supports both single ended and differential inputs. The selection can be done in the **Settings** tab as below.



If Differential input mode is selected, the number of inputs is 6 instead of 12 as in the Single ended mode. Any one of the following combinations of counters is possible.

In single ended input mode:

Four Type A

Two Type B

One Type C

Two Type Z

Two Type A + One Type B

Two Type A + One Type Z

One Type B + One Type Z.

In differential input mode:

Two Type A

One Type B

One Type Z.

No Type C will be possible.

Single Ended Mode:

Counter Combinations			
Counter 1	***Counter 2***	***Counter 3***	***Counter 4***
A	A	A	A
A	A	B	Not used
A	A	Z	Not used
B	Not used	A	A
B	Not used	B	Not used
B	Not used	Z	Not used
C	Not used	Not used	Not used
Z	Not used	A	A
Z	Not used	B	Not used
Z	Not used	Z	Not used

Differential Mode:

Counter Combinations			
Counter 1	***Counter 2***	***Counter 3***	***Counter 4***
A	Not used	A	Not used
B	Not used	Not used	Not used
Z	Not used	Not used	Not used

Terminal Assignments for Counter Types

The table below lists terminal block pin assignments based on the counter type combinations and input mode setting.

Input	C1	C2	C3	C4	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
Single Ended	A	A	A	A	A1	A2	A3	A4	PRELD1	PRELD2	PRELD3	PRELD4	STRB1	STRB2	STRB3	STRB4
Single Ended	B	-	B	-	A1	B1	A3	B3	PRELD1.1*	DISAB1.1*	PRELD3.1*	DISAB3.1*	STRB1.1*	STRB1.2*	STRB3.1*	STRB3.2*
Single Ended	C	-	-	-	A1	B1	A2	B2	PRELD1.1*	PRELD1.2*	DISAB1	HOME	STRB1.1*	STRB1.2*	STRB1.3*	MARKER
Single Ended	A	A	B	-	A1	A2	A3	B3	PRELD1.1*	PRELD2.1*	PRELD3.1*	DISAB3.1*	STRB1.1*	STRB2.1*	STRB3.1*	STRB3.2*
Single Ended	A	A	Z	-	A1	A2	A3	B3	PRELD1.1*	PRELD2.1*	‡	‡	STRB1.1*	STRB2.1*	Z3.1*	‡
Single Ended	B	-	A	A	A1	B1	A3	A4	PRELD1.1*	DISAB1.1*	PRELD3.1*	PRELD4.1*	STRB1.1*	STRB1.2*	STRB3.1*	STRB4.1*
Single Ended	B	-	Z	-	A1	B1	A3	B3	PRELD1.1*	DISAB1.1*	‡	‡	STRB1.1*	STRB1.2*	Z3.1*	‡
Single Ended	Z	-	A	A	A1	B1	A3	A4	‡	‡	PRELD3.1*	PRELD4.1*	Z1.1*	‡	STRB3.1*	STRB4.1*
Single Ended	Z	-	B	-	A1	B1	A3	B3	‡	‡	PRELD3.1*	DISAB3.1*	Z1.1*	‡	STRB3.1*	STRB3.2*
Single Ended	Z	-	Z	-	A1	B1	A3	B3	‡	‡	‡	‡	Z1.1*	‡	Z3.1*	‡
Differential	A	-	A	-	A1+	A1-	A3+	A3-	PRELD1.1+	PRELD1.1-	PRELD3.1+	PRELD3.1+	STRB1.1+	STRB1.1-	STRB3.1+	STRB3.1-
Differential	B	-	-	-	A1+	A1-	B1+	B1-	PRELD1+	PRELD1-	DISAB1+	DISAB1-	STRB1.1+	STRB1.1-	STRB1.2+	STRB1.2-
Differential	Z	-	-	-	A1+	A1-	B1+	B1-	‡	‡	‡	‡	Z1+	Z1-	‡	‡

[1] Type B, Type Z counter:
A1, B1 are the A and B inputs for counter 1.
A3, B3 are the A and B inputs for counter 3.

[2] Type C Counter:
A1, B1 are the A and B count inputs for (+) loop
A2, B2 are the A and B count inputs for (–) loop

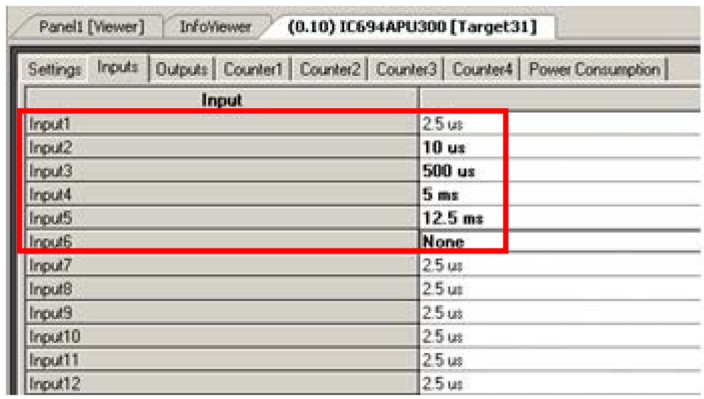
‡ No connection

* Inputs identified by two numbers separated by a decimal point indicate the counter number to the left of the decimal point and the element number on the right. For example, STRB1.2 indicates Counter 1, Strobe 2 input.

Input Filters

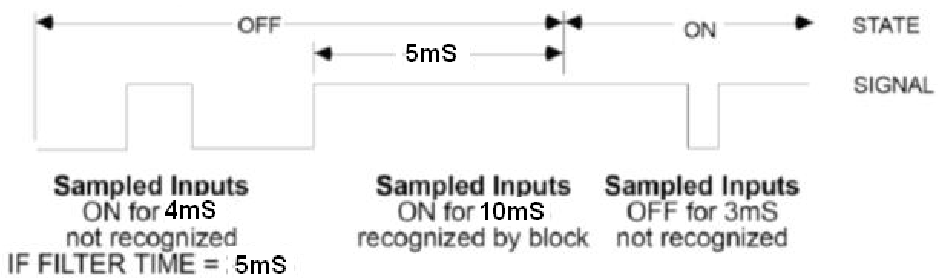
There are six options for applying filter at the inputs. The filters can be selected separately for each of the 12 inputs.

By default, each external input is set up to use a 2.5us filter. The filter time can be changed to: none, 12.5ms, 5ms, 500us or 10us in the **Inputs** tab.



Input	
Input1	2.5 us
Input2	10 us
Input3	500 us
Input4	5 ms
Input5	12.5 ms
Input6	None
Input7	2.5 us
Input8	2.5 us
Input9	2.5 us
Input10	2.5 us
Input11	2.5 us
Input12	2.5 us

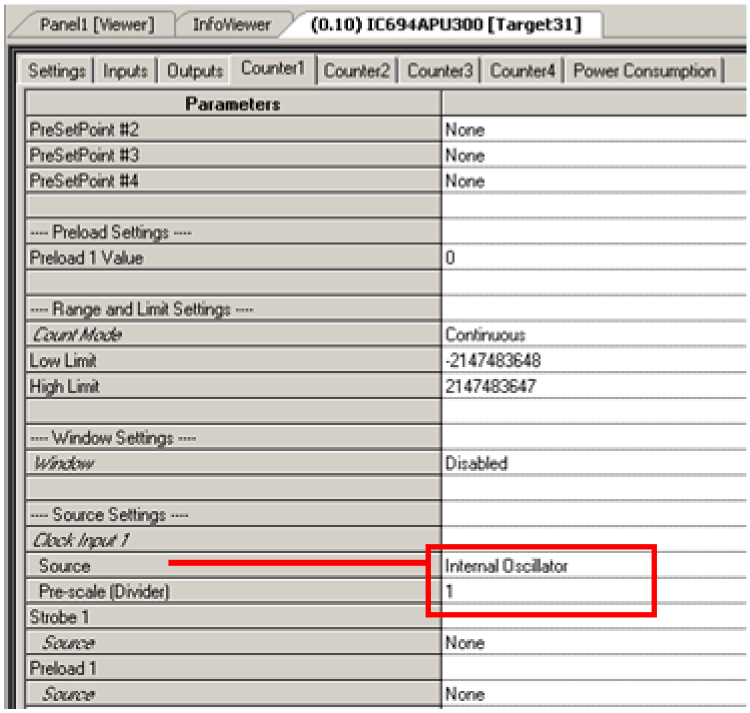
Using a lower–frequency filter can reduce the effects of signal noise. Filtering delays input transitions for approximately the selected filtering time. For example, if **5ms** filtering is selected, an input transition will not be recognized by the module until the transition has been stable for at least 5mS.



Internal Oscillator

In enhanced mode the module supports 1 MHz clock input at the external terminal block (I1 to I4). In addition, the module generates an internal square wave signal which can be switched into the count input in place of I1 to be used as a timing reference for measurement applications. The maximum frequency of this internal oscillator signal is 2 MHz.

This is controlled by the Oscillator Frequency Input configuration option in **Counter 1** tab as shown below (this is available only on Counter 1 and cannot be used for Counters 2 - 4).



The Oscillator output frequency is determined by the configured **Pre-scale divider** (N) as indicated below:

Osc Freq = 2000/N kHz

The range for N is 1 to 65535. The default setting for N is 1 to provide 2 MHz internal clock.

Configuring the Module's Outputs

Output Source

The outputs at the terminal block can be driven with any of the following sources – Control Data Reference, Presetpoint, Roll Over flag. The output source for each output can be selected separately in the **Outputs** tab.

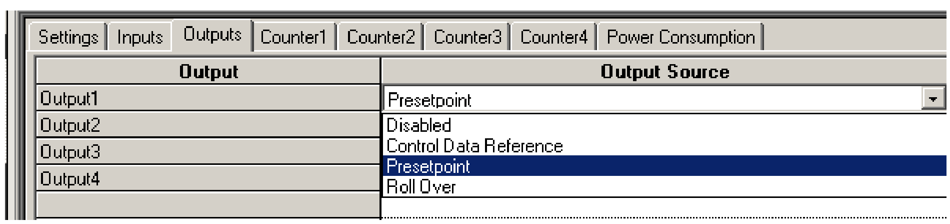
The outputs will be driven only when the output enable bits (Bit 8 to Bit 11) in the Output Control Data are set and Field power is present. Please refer to section "Output Control Data" for more details.

The details of each type of output source is as below.

Outputs with Preset Points

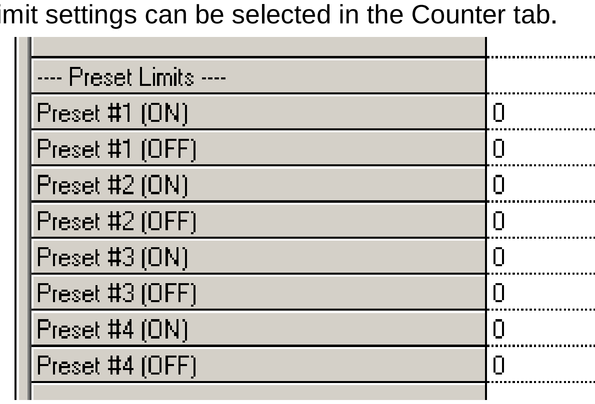
Counters can be configured to control multiple outputs (1 to 4) with independent Preset points. Module outputs can be mapped to any number of counter Preset point outputs in three steps.

Step 1: Each output can be configured to "Presetpoint" in the Outputs tab as shown below.



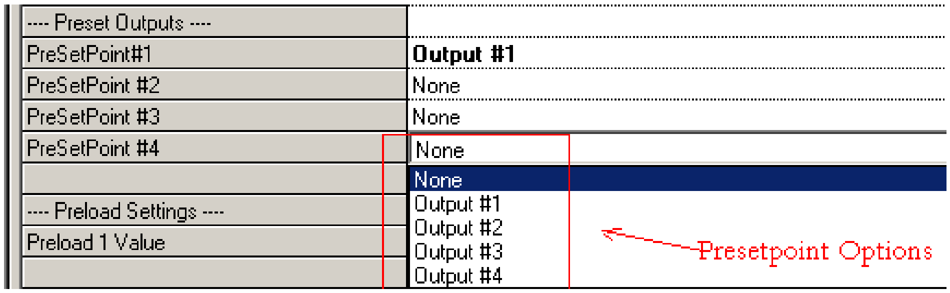
Step 2: There are four Preset Limits with ON and OFF values. The limits for these Preset points are based on the 16-Bit or 32-Bit type of counter. For 16 bit counter, its limits range from -32768 to 32767 and 32-bit's range is -2147483648 to 2147483647. The default value is 0.

Preset ON/OFF limit settings can be selected in the Counter tab.



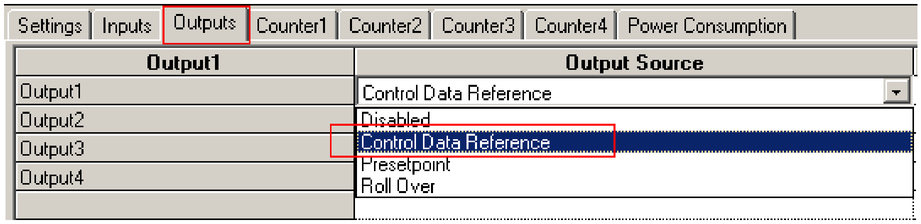
Step 3: Each counter has four Preset Outputs i.e. Presetpoint #1, Presetpoint #2, Presetpoint #3, Presetpoint #4. Each of the Preset Outputs can be configured to drive external outputs – Output #1, Output #2, Output #3 and Output #4. None is default setting.

Preset Outputs settings can be selected in the Counter tab.



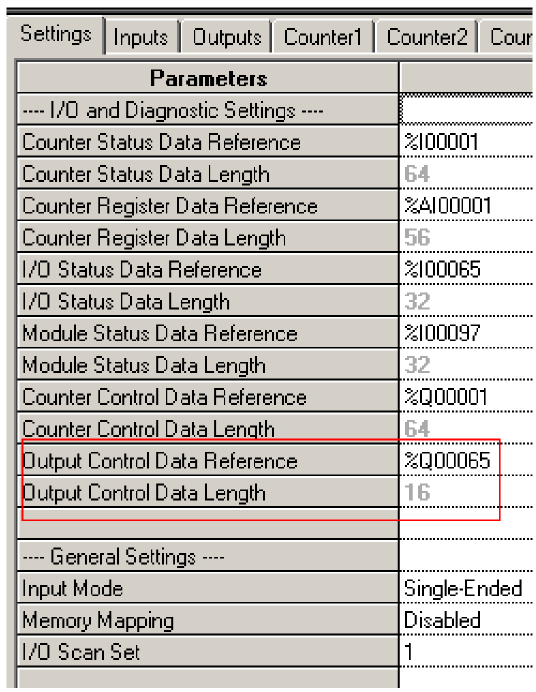
Outputs with Control Data Reference Configuration

Step 1: External outputs can be mapped to "Control Data Reference" in the **Outputs** tab as shown below.



Step 2: Additionally, in the Settings Tab of the Counter, two Parameters are provided: Output Control Data Reference and Output Control Data Length. The Output Control Data Reference can be assigned to any available reference in %Q, %M, or %T memory, or discrete I/O variables.

The example below shows the Output Control Data Reference configured for %Q memory type.



The first four bits of the Output Control Data Reference Variable are mapped to four outputs of the Module Counters. With these configurations done, the External Outputs can now be turned ON/OFF by changing these bits.

Outputs with Roll Over Detection Flag

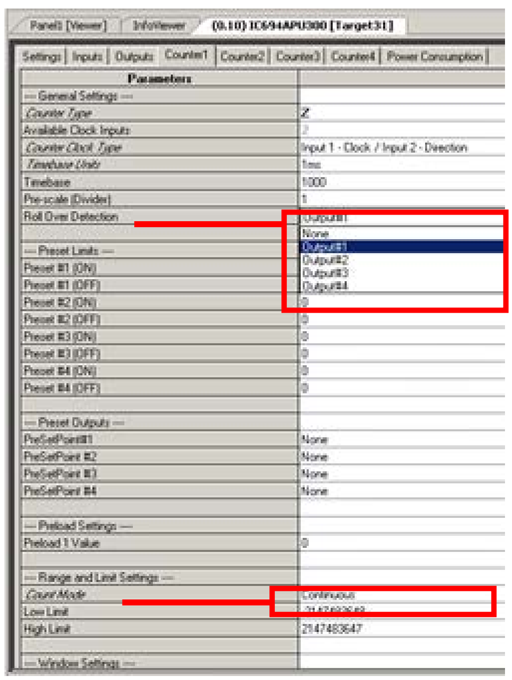
The Roll Over detection flag can be configured to drive an external output on the module.

The Roll over Flag status is also available in **Bit12** of the **Counter Status Data.** The Flag will be cleared by setting the corresponding Roll over acknowledge bit available in **Bit 11** of **Counter Control Data.**

The setting for external outputs can be done in two steps as below.

Step 1: Set the source of the output as Roll over Flag in the **Outputs** tab.

Step 2: Select the output which needs to be driven by the Counter's roll over condition. Also, make sure that the count mode is set to Continuous. This setting should be done in the **Counter** tab.

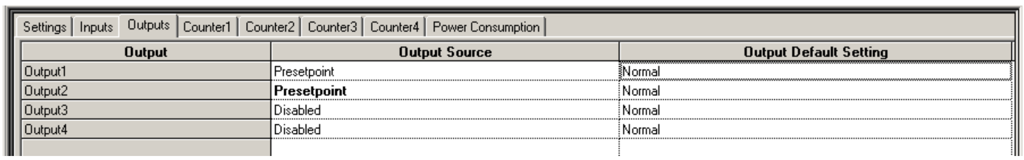


Output Default Setting

This setting determines the behavior of the output when backplane power remains after communications with the CPU are lost or the CPU is in output-disabled mode, which includes stop-disabled mode and run-disabled mode.

Below options are available for this setting.

- **Normal:** (Available only when the Output Source is set to Presetpoint.) The output continues to operate with the counter accumulator and Preset values.
- **Force Off:** The individual output is set to Off.
- **Hold Last State:** The output retains the state it was in before communications with the CPU were lost or the CPU was set to output-disabled mode.



Output	Output Source	Output Default Setting
Output1	Presetpoint	Normal
Output2	**Presetpoint**	Normal
Output3	Disabled	Normal
Output4	Disabled	Normal

Default setting is Normal.

Notes

If there is no backplane power, the outputs are forced off regardless of your selection.

During powerup and initial configuration, all outputs are forced off. Outputs remain forced off until the first transition into an Outputs Enabled mode (either Run-Enabled or Stop-Enabled).

Chapter 8

Enhanced Mode CPU Interface

In Enhanced mode, in addition to COMMREQ commands, the High-speed Counter supports Output Control Data, Counter Control Data and Module Control Data commands, which are sent with the data that is exchanged every sweep.

This chapter discusses:

- Data Transfer between High-speed Counter and CPU
- COMMREQ Commands Supported in Enhanced Mode
- Other Features

Data Transfer between High-speed Counter and CPU

When an RX3i High-speed Counter module is configured, the CPU automatically reserves several memory areas for the module's data. The lengths of these areas are fixed, as listed below. Starting reference addresses for each area are assigned by the configuration software, but can be changed as needed for the application.

This data is exchanged every PLC sweep.

Data Type	***Length***	***Memory Type***	***Used For***
Counter Register Data	56 words	%AI, %R, %W, or word I/O variables in Symbolic memory	Module counter register data returned to the CPU
Counter Status Data	64 bits	%I, %M, %T, or discrete I/O variables in Symbolic memory	Counter status data returned to the CPU
I/O Status Data	32 bits	%I, %M, %T, or discrete I/O variables in Symbolic memory	I/O Status input data and Output Fault Status data returned to the CPU
Module Status Data	32 bits	%I, %M, %T, or discrete I/O variables in Symbolic memory	Data that indicates the module status, returned to the CPU
Counter Control Data	64 bits	%Q, %M, %T, or discrete I/O variables in Symbolic memory	Data sent by the CPU to control counter operation
Output Control Data	16 bits	%Q, %M, %T, or discrete I/O variables in Symbolic memory	Data sent by the CPU to control outputs
Module Control Data	9 words	%AQ, %R, %W, or word I/O variables in Symbolic memory	Data sent by the CPU to control module operation

Counter Register Data

The Counter Register data from each counter has the format shown below. Each register is 32 bits in length. Depending on the configuration and Counter Type, some registers may not be used. Unused registers are set to 0.

Counter Reference Address	***Data***
Address + 0, Address + 1	Accumulator Value
Address + 2, Address + 3	Strobe 1 Register Value
Address + 4, Address + 5	Strobe 2 Register Value
Address + 6, Address + 7	Strobe 3 Register Value
Address + 8, Address + 9	Reserved
Address + 10, Address + 11	Counts per Time base Value
Address + 12, Address + 13	Reserved

Counter Status Data

Counter Status data is bit-type data that indicates the status of counter operations (16 bits for each counter).

Word Offset from Counter Status Data Starting Address	***Counter Data***
Address + 0	Counter 1
Address + 2	Counter 2
Address + 4	Counter 3
Address + 6	Counter 4

Depending on the type of counter some bits may not be used. Reserved bits are always 0. The following table describes the format of Counter Status data for each Counter.

Counter Reference Address	***Data***	***Definition***
Address +0 bits	Strobe 1 Status	0 – Strobe Has Not Occurred 1 – Strobe Has Occurred
Address +1	Strobe 2 Status	
Address +2	Strobe 3 Status	
Address +3	Home Input Status	0 – No Home Input 1 – Home Input Present
Address +4	Preload 1 Status	0 – Preload Has Not Occurred 1 – Preload Has Occurred
Address +5	Preload 2 Status	
Address +6	Disable Status	0 – No Disable Input 1 – Disable Input Present
Address +7	Preset 1 Compare Status	0 – Preset is Off 1 – Preset is On
Address +8	Preset 2 Compare Status	
Address +9	Preset 3 Compare Status	
Address +10	Preset 4 Compare Status	
Address + 11 Address +12	Reserved	Always 0
Address +13	Rollover Detection Flag	0 – Rollover Has Not Occurred 1 – Rollover Has Occurred.
Address + 14	Reserved	Reserved.
Address + 15	Home Found	0 – Home Not Found 1 – Home Found

Strobe Status: Each Strobe Status bit indicates that the Accumulator count value has been copied into corresponding Strobe Register. If an application program uses this bit, it should be cleared by setting the corresponding Strobe Acknowledge output bit.

Home Input Status: Indicates the present status of the Home Limit Switch input. This parameter is valid only for Type-C Counter.

Preload Status: Each Preload Status bit indicates the corresponding Preload Input has just copied its Preload Value into the counter Accumulator. If an application program uses this bit, it should be cleared by setting the corresponding Preload Acknowledge output bit.

Disable Status: This bit is used to indicate the present status of each Disable input. A Disable input can be used to suspend counting.

Preset / Compare Status: Each bit indicates whether the Preset Output is On or Off.

Rollover Detection Flag: This bit is set only if the counter rolls over from Low limit to High limit and vice-versa in continuous mode of operation. If an application program uses this bit, it should be cleared by setting the corresponding Rollover Acknowledge output bit.

Home Found: This bit indicates that the Home Position Value has just been copied into the counter Accumulator. The Home Found bit is set on the rising edge of the Home Marker input if the Home Command bit is set. When the Home Command bit is cleared and then set again, the Home Found bit is also cleared. This parameter is valid only for Type-C Counter.

I/O Status Data

The I/O Status Data indicates the present states and status of the module's external I/O points. The length of this data is fixed to 32 bits. Reserved bits are always 0. The following table describes the format of the I/O Status Data:

Module Reference Address	***Data***	***Definition***
Address +0 to Address + 12	External Inputs (From Input1 to Input12)	0 – External Input is de-asserted (low logic), 1 – External Input is asserted (high logic)
Address +11 to Address + 14	Reserved	Reserved.
Address +15 to Address + 18	External Outputs[1] (From Output1 to Output4)	0 – External Output is de-asserted (low logic) 1 – External Output is asserted (high logic)
Address +19 to Address + 23	Reserved	Always 0.
Address +24 to Address + 27	Output Fault Status Data (From Output1 to Output4)	0 – Circuit Fault Condition Not Detected 1 – Circuit Fault Condition Detected
Address +28 to Address + 31	Reserved	Reserved.

[1]The Output Status bits are set regardless of the source (Module Control data or Presets).

External Inputs: These bits indicate the present state of the module's external input points at the time I/O is serviced.

External Outputs: These bits indicate the present state of the module's output points at the time I/O is serviced.

Output Fault Status Data: These bits indicate the presence of faults on the output circuits. The module detects ESCP (Electronic Short Circuit Protection) faults

Module Status Data

The Module Status data provides the CPU with basic diagnostic information about module operation. The length of this data is fixed to 32 bits. The following table describes the format of Module Status Data:

Module Reference Address	***Data***	***Definition***
Address +0 bits	Module Ready	0 – Module Not Ready 1 – Module Read
Address +1	Reserved	Reserved
Address +2	Field Power Status	0 – No Field Power Present 1 – Field Power Present
Address +3	Reserved	Always 0.
Address +4	Command Error	0 – Command Error Has Not Occurred 1 – Command Error Has Occurred
Address +5 to Address +15	Reserved	Always 0.
Address +16 to Address +31	Error Description	If the module receives an invalid command, the module sets the Command Error bit to 1. It also sets the error description bits shown below to indicate which error has occurred.

Module Ready: The module sets this bit when it is ready to begin servicing requests from the CPU. This bit clears to 0 if the module is not configured or not present, or has a fatal error.

Field Power Status: The module sets this bit if it is receiving power from its external power source.

Command Error: The module sets this bit if it has received an incorrect command or was unable to process a command.

Error Description: If the module receives an invalid command, the module sets the command error bit to 1. It also sets the error description bits shown in the following table to indicate which error has occurred.

After the error condition has been corrected, the application program must acknowledge the error by setting the clear error bit in the Output Control (output) data to 1. See the section on **Output Control Data** for more information. The module will not log additional error codes until the error has been acknowledged by setting the clear error bit.

Fatal errors (RAM, EPROM) have no error codes because these errors cause the watchdog timer to expire and the module to go into failure mode (the Module Status LED blinks).

Error Description (16-Bit)

Bits	Data	Definition
0 to 7	Error Code	Contain an Error Code that specifies the error type. 0 – No error. 1 – Invalid command. 2 – Invalid counter. 3 – Accumulator value out of range. 4 – Preload 1 value out of range. 5 – Preload 2 value out of range. 6 – Reserved. 7 – Reserved 8 – High limit < Low limit. 9 – Invalid pre-scale value. 10 – Invalid input filter value. 11 – Invalid Time Base value. 12 – Reserved. 13 – Preset 1 ON value out of range. 14 – Preset 1 OFF value out of range. 15 – Preset 2 ON value out of range. 16 – Preset 2 OFF value out of range. 17 – Preset 3 ON value out of range. 18 – Preset 3 OFF value out of range. 19 – Preset 4 ON value out of range. 20 – Preset 4 OFF value out of range. 21 – Invalid Window High Limit. 22 – Invalid Window Low Limit. 23 – Home Position Error. 24 – Invalid Sub Command. 25 – Invalid Home Value. 26 – Invalid Counter Direction. 27 – Parameter out of Range. 28 to 255 – Reserved.
8 to 11	Counter Number	Contain the number of the counter on which the error occurred. 0 – No specific counter available. 1 to 4 – Counter Number. 5 to 15 – Reserved.
12 to 15	Error Source	Indicate whether the error occurred in Command Area 1 or 2. Command Areas are described in the output data section. 0 – Reserved. 1 – Command Area 1 Error. 2 – Command Area 2 Error. 3 – Commreq Command. 4 to 15 – Reserved.

Counter Control Data

Counter Control data contains commands to control operation of the module's counters. The length of this data is 64 bits (4 counters with 16 Counter Control bits per counter).

Word Offset from Counter Control Data Starting Address	***Counter Data***
Address + 0	Counter 1
Address + 2	Counter 2
Address + 4	Counter 3
Address + 6	Counter 4

Depending on the counter configuration, some bits may not be used. Unused bits are always 0. The following table shows the format of Counter Control Data for each counter.

Counter Reference Address	***Data***	***Definition***
Address +0 bits	Strobe 1 Trigger	0 – Do Not Trigger Strobe 1 – Trigger Strobe[1]
Address +1	Strobe 2 Trigger	
Address +2	Strobe 3 Trigger	
Address +3	Preload 1 Trigger	0 – Do Not Trigger Preload 1 – Trigger Preload*
Address +4	Preload 2 Trigger	
Address +5	Strobe 1 Acknowledge	0 – Do Not Acknowledge Strobe 1 – Acknowledge Strobe
Address +6	Strobe 2 Acknowledge	
Address +7	Strobe 3 Acknowledge	
Address +8	Preload 1 Acknowledge	0 – Do Not Acknowledge Preload 1 – Acknowledge Preload
Address +9	Preload 2 Acknowledge	
Address +10	Reserved	Reserved.
Address +11	Rollover Acknowledge	0 – Do Not Acknowledge Rollover 1 – Acknowledge Rollover
Address +12	Reserved	Reserved
Address +13	Direction Bit (Clock Input Pair 1 & 2)	0 – Up, 1 – Down*
Address +14	Direction Bit (Clock Input Pair 3 & 4)	
Address +15	Home Command	0 – Home Command is not Triggered 1 – Home Command is Triggered (If Homing feature is enabled)

[1]If Source is set to Control Data Reference, otherwise reserved and always 0.

Strobe Triggers: If a Strobe source is configured to be Control Data Reference, the application program can set its Strobe Trigger bit to strobe the current counter Accumulator Value into the corresponding Strobe Register. This causes the module to set the Strobe Status bit in its input data.

Preload Triggers: If a Preload source is configured to be Control Data Reference, the application program can set its Preload Trigger bit to preload the corresponding Preload Value into the counter Accumulator. This causes the module to set the corresponding Preload Status bit in its input data.

Strobe Acknowledge: Setting one of these bits clears the corresponding Strobe Status bit.

Preload Acknowledge: The application program uses these bits to clear the corresponding Preload Status bits. For example, if Preload 3 was triggered, the Preload 3 Status bit would be set. The Preload 3 Acknowledge can be used to clear the Preload 3 Status bit.

Rollover Acknowledge: Setting this bit clears the corresponding Rollover Status bit. Applicable only if the counter was configured for continuous mode of operation.

Counter Disable: If the Counter Disable source is set to Control Data Reference, the application program can use this bit to enable or disable counting.

Direction (Clock Input Pair 1 & 2), Direction (Clock Input Pair 3 & 4): These bits are used when Clock Input 2 or Clock Input 4 inputs are assigned to Control Data Reference and the Clock Type is configured for Clock/Direction mode. This command determines whether a counter's accumulator increments or decrements in response to the appropriate change on its Count Pulse input. The direction may be set at any time.

Home Command: If the Homing feature is enabled for a Type C Counter, the application program can use this bit to command a Homing operation.

Output Control Data

The Output Control data contains commands to turn On / Off and Enable / Disable the module's external output points. The length of this data area is 16 bits. The following table describes the format of Output Control data:

Module Reference Data	Data	Bit Number	Definitions
Address +0 bits	Output1	0	0 – External Output is Off 1 – External Output is On
Address +1	Output2	1	0 – External Output is Off 1 – External Output is On
Address +2	Output3	2	0 – External Output is Off 1 – External Output is On
Address +3	Output4	3	0 – External Output is Off 1 – External Output is On
Address +4	Reserved	4	Always 0
Address +5 to Address + 8	Disable Output1	8	0 – Output Point is Disabled 1 – Output Point is Enabled
Address +9	Disable Output2	9	0 – Output Point is Disabled 1 – Output Point is Enabled
Address +10	Disable Output3	10	0 – Output Point is Disabled 1 – Output Point is Enabled
Address +11	Disable Output4	11	0 – Output Point is Disabled 1 – Output Point is Enabled
Address +12 to Address + 14	Reserved	12	Always 0
Address +15	Clear Error Flag	15	0 – Do Not Clear Error Flag 1 – Clear Error Flag

Output 'x': These bits can be used to change the state of outputs – to either Turn On / Turn Off. To use this data to control output operation, the source of an output must be configured as Control Data Reference.

Disable Output 'x': These bits can be used to disable or enable the corresponding module output points. The default value is disabled. If any of the output is 'Disabled' then changing the state of respective Output 'x' does not have any impact.

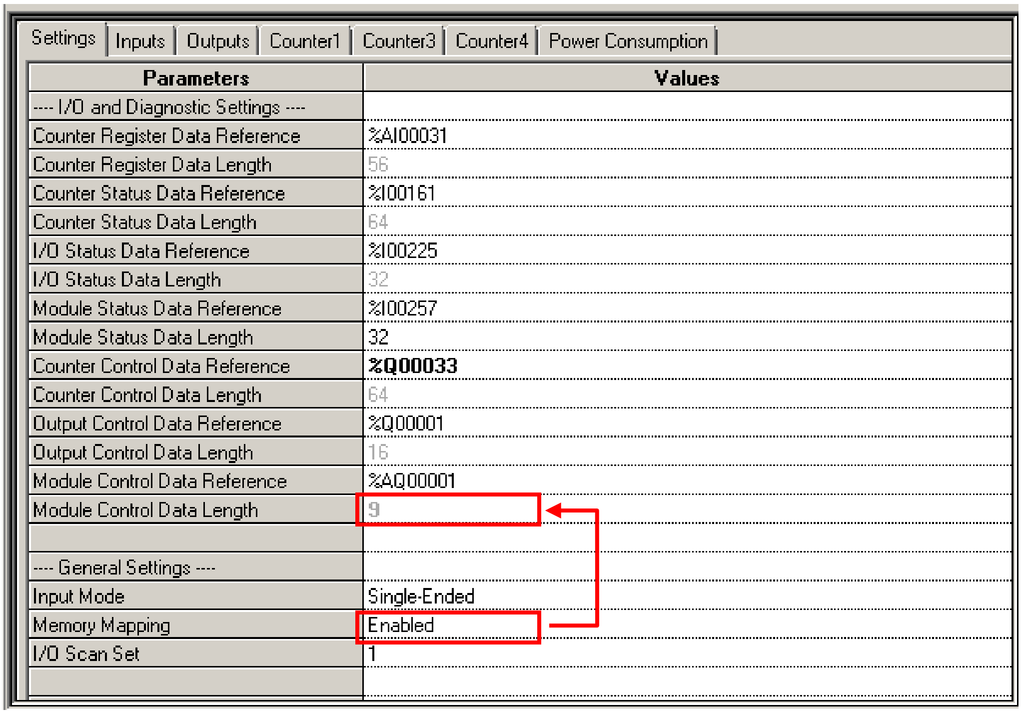
Clear Error Flag: This bit can be used to clear the error code in Module Status data (described above). After using the clear error flag bit to clear an error, the CPU must then clear (0) the Clear Error Flag bit itself. Otherwise, the next command error will automatically be cleared on the sweep immediately after it is processed. This will result in command errors that go undetected.

Module Control Data

Module Control Data can be used to send commands to the module to dynamically change counter parameters during operation.

Enabling Module Control Data

To use Module Control Data Commands, the Memory Mapping parameter on the Settings tab must be set to Enabled. Setting this parameter to Enabled allocates 9 words of Module Control Data Reference memory.



Parameters	Values
---- I/O and Diagnostic Settings ----	
Counter Register Data Reference	%AI00031
Counter Register Data Length	56
Counter Status Data Reference	%I00161
Counter Status Data Length	64
I/O Status Data Reference	%I00225
I/O Status Data Length	32
Module Status Data Reference	%I00257
Module Status Data Length	32
Counter Control Data Reference	**%Q00033**
Counter Control Data Length	64
Output Control Data Reference	%Q00001
Output Control Data Length	16
Module Control Data Reference	%AQ00001
Module Control Data Length	9
---- General Settings ----	
Input Mode	Single-Ended
Memory Mapping	Enabled
I/O Scan Set	1

Module Control Data Format

The following table shows the format used by this data:

Module Reference Address	***Data***	***Field Description***
Address + 0	Reserved	Always 0
Address + 1	Command Area 1 - Command	Details are given below.
Address + 4	Command Area 1 - Data	Details are given below.
Address + 5	Command Area 2 - Command	Details are given below.
Address + 7	Command Area 2 - Data	Details are given below.

The High-speed Counter module performs the commands first (in Command Areas 1 and 2), so that the Counter Control bits will operate on the newly-updated registers during the same sweep.

The High-speed Counter module checks each command it receives for validity. If the command syntax is incorrect, the module ignores the command and responds by setting the Error Status bits and returning a status code describing the error in the Module Status word. The Error can be cleared by resetting the Clear Error bit.

In addition to module control data, the High-speed Counter module also responds to COMMREQs (Communication Requests).

Caution

If identical commands with different values are sent to the module using these two mechanisms, the last command received by the module will be effective.

Command Area 1 / 2: The High-speed Counter has two independent command areas, so two commands can be sent to the module at the end of each CPU sweep. The command in Command Area 1 is executed first. If identical commands with different values are sent to the module simultaneously, the data in Command Area 2 overwrites the data set by Command Area 1.

Even though the data is sent each sweep, the module acts on a command ***only*** if the command has changed since the last sweep. If any part of a command changes, the module accepts the data as a new command. Each command area is two DWORDs in length. In each command area, the first double-word is the command and the second DWORD is the data, if any, associated with the command.

Module Control Data Commands

The following table lists the commands that can be sent to the module in Command Area 1 or 2. Note that changes made using data commands are not retained through a power cycle, hot swap, PLC clear, PLC reconfiguration, or reloading the module's configuration.

Command Definition	Command Data (DWord1)				Command (Dword0)		
	Word 1		Word 0		Word 1		Word 0
	Byte 3	Byte 2	Byte 1	Byte 0	Byte 3	Byte 2	
Null	N/A				N/A	N/A	0
Load Accumulator	Accumulator Value				N/A	Counter #	1
Load Low Range limit	Low Range Limit Value				N/A	Counter #	2
Load High Range limit	High Range Limit Value				N/A	Counter #	3
Load Timebase	Time base value				N/A	Counter #	4
Load Preset ON value	Preset Value				Preset #	Counter #	5
Load Preset OFF value	Preset Value				Preset #	Counter #	6
Load Preload	Preload Value				Preload #	Counter #	7
Load Pre-Scale[1]	Pre-scale value (1 to 65535)				N/A	N/A	8
Load Accumulator Increment	N/A	N/A	N/A	Increment Value (-128 to 127)	N/A	Counter #	9
Load Input Filter	Filter Value 0 – None /1 – 12.5mS /2 – 5mS /3 – 500uS / 4 – 10uS / 5 – 2.5uS.				N/A	Input #	10
Load Window Low Limit	Low Limit Value (< Low Range Limit)				N/A	Counter #	11
Load Window High Limit	High Limit Value (> High Range Limit)				N/A	Counter #	12
Load Home Position	Home Position Value				N/A	Counter #	13
Set Counter Direction[1]				0 – Up, 1 – Down.	N/A	Counter #	14

[1]This command can only be used with Counter Type-A.

Module Control Data Command Definitions

Null: This is the default data command. Because the Module Control data is transferred each PLC sweep, the Null command should be used when not executing a specific data command, to avoid inadvertent execution. All data is ignored with a Null command.

Load Accumulator: This command places a 32-bit value into a counter accumulator. The value must be within the Count Limits, or an error is returned and the command is ignored.

Load High / Low Range Limit: These two commands set the lowest and highest values between which a counter will normally operate. If the counter is configured for either Single Shot or Continuous mode, any counts that would cause the counter to go outside of these limits are ignored or cause the Accumulator to roll over to the other Limit.

A Range Limit can be any 32-bit value with the following restrictions:

- The Low Range Limit must be less than or equal to the High Range Limit.
- The counter's Preload values must lie between the Low Range and High Range Limits.

If any of these conditions is not met, an error is generated and the command is ignored. If the range between the new Low Range Limit and the High Range Limit excludes the Accumulator, the Accumulator is set to the Low Range Limit and no error is generated. To avoid errors, always move the high limit first when shifting the limits up and always move the low limit first when shifting them down.

Load Timebase: This command sets the time base value of the specified counter. Internally the module uses the time base units as specified by the counter configuration (which can be either of 100ns / 1us/ 1ms). The time base is the time during which the counter counts input pulses and then returns the value in the Counts per Time base register. Any non-zero 32-bit value may be used as the time base. The value is treated as an unsigned 32-bit integer.

Load Preset ON / OFF Value: These commands set the Preset Output's On and Off values. Presets can be any values within a counter's range.

Load Preload: This command changes the counter's configured Preload Value in the Accumulator when the Preload input trigger occurs. The value must be between the High and Low Range limits inclusive, or an error is returned and the command is ignored.

Load Pre-scale: This command is used to change the Pre-scale (divider) value from 1 to 65535 of first counter. If this command is used with other counters then the module will respond back with the error code 'Invalid Sub command'.

Load Accumulator Increment: The Accumulator Increment performs a one–shot adjustment to the accumulator. The one–shot increment may be performed at any time, even when counting at maximum rate. If the offset cause the counter to exceed its limits, the excess is treated just like any other overflow, i.e., in Continuous mode the Accumulator rolls over to the other limit and in Single–shot mode the Accumulator does not pass the limit.

Load Input Filter: This command loads a filtering value for an input. The filtering value can be: None / 12.5ms / 5ms / 500µs / 10us / 2.5µs. Using a lower–frequency filter can reduce the effects of noise.

Load Window High / Low Limit: These two commands set the lowest and highest values of the Window.

A Limit can be any 32-bit value with the following restrictions:

- The Low Limit must be greater than the Low Range Limit of the respective Counter.
- The High Limit must be less than the High Range Limit of the respective Counter.

If Window Low limit is equal to Counter Low limit and Window High limit is equal to Counter High Limit, the window feature will be ineffective.

Load Home Position: This command is used to change the count value that will be loaded into the counter accumulator at the home position.

Set Counter Direction: This command is used to change the count direction (Up/Down) of the Type A counter only and cannot be used with other counters. Only the LSB of the first command data word is used with this command.

COMMREQ Commands Supported in Enhanced mode

The format for COMMREQ commands in Enhanced mode is as follows:

	MSB	LSB	
command word	0n	cc	
data word (LSW)	dd	dd	
data word (MSW)	dd	dd	← Always 0000 for Type A_16 bit counters

where: n = counter 1 – 4
cc = sub–command code
dd = data type

COMMREQ Commands for Type-A Counter

Command Name	***Command Word***	
	Decimal	***Hexadecimal***
Load Accumulator	0n 01	0n 01
Load Hi Limit	0n 02	0n 02
Load Lo Limit	0n 03	0n 03
Load Accumulator Increment	0n 04	0n 04
Set Counter Direction	0n 05	0n 05
Load Timebase	0n 06	0n 06
Load Preset1 ON Value	0n 11	0n 0B
Load Preset1 OFF Value	0n 21	0n 15
Load Preset2 ON Value	0n 12	0n 0C
Load Preset2 OFF Value	0n 22	0n 16
Load Preset3 ON Value	0n 13	0n 0D
Load Preset3 OFF Value	0n 23	0n 17
Load Preset4 ON Value	0n 14	0n 0E
Load Preset4 OFF Value	0n 24	0n 18
Load Preload1	0n 31	0n 1F
Load Oscillator Frequency Divisor	00 50	00 32
Load Window High Limit	0n 33	0n 21
Load Window Low Limit	0n 34	0n 22
Load Input Filter Value	00 35	00 23

Note: n = Counter #1 TO 4

The bytes in the command word are always treated as independent bytes – a counter ID byte and a Command code byte.

COMMREQ Commands for Type-B Counter:

Command Name	Command Word	
	Decimal	**Hexadecimal**
Load Accumulator	0n 01	0n 01
Load Hi Limit	0n 02	0n 02
Load Lo Limit	0n 03	0n 03
Load Accumulator Increment	0n 04	0n 04
Load Timebase	0n 06	0n 06
Load Preset1 ON Value	0n 11	0n 0B
Load Preset1 OFF Value	0n 21	0n 15
Load Preset2 ON Value	0n 12	0n 0C
Load Preset2 OFF Value	0n 22	0n 16
Load Preset3 ON Value	0n 13	0n 0D
Load Preset3 OFF Value	0n 23	0n 17
Load Preset4 ON Value	0n 14	0n 0E
Load Preset4 OFF Value	0n 24	0n 18
Load Preload1	0n 31	0n 1F
Load Oscillator Frequency Divisor	00 50	00 32
Load Window High Limit	0n 33	0n 21
Load Window Low Limit	0n 34	0n 22
Load Input Filter Value	00 35	00 23

Note: n = Counter #1 or 3

The bytes in the command word are always treated as independent bytes – a counter ID byte and a Command code byte.

COMMREQ Commands for Type-C Counter

Command Name	Command Word	
	Decimal	**Hexadecimal**
Load Accumulator	01 01	01 01
Load Hi Limit	01 02	01 02
Load Lo Limit	01 03	01 03
Load Accumulator Increment	01 04	01 04
Load Timebase	01 06	01 06
Load Preset1 ON Value	01 11	01 0B
Load Preset1 OFF Value	01 21	01 15
Load Preset2 ON Value	01 12	01 0C
Load Preset2 OFF Value	01 22	01 16
Load Preset3 ON Value	01 13	01 0D
Load Preset3 OFF Value	01 23	01 17
Load Preset4 ON Value	01 14	01 0E
Load Preset4 OFF Value	01 24	01 18
Load Preload1	01 31	01 1F
Load Preload2	01 32	01 20
Load Oscillator Frequency Divisor	00 50	00 32
Load Window High Limit	01 33	01 21
Load Window Low Limit	01 34	01 22
Load Input Filter Value	00 35	00 23
Load Home Position Value	01 08	01 08

The bytes in the command word are always treated as independent bytes – a counter ID byte and a Command code byte.

COMMREQ Commands for Type-Z Counter

Command Name	Command Word	
	Decimal	**Hexadecimal**
Load Accumulator	0n 01	0n 01
Load Hi Limit	0n 02	0n 02
Load Lo Limit	0n 03	0n 03
Load Accumulator Increment	0n 04	0n 04
Load Timebase	0n 06	0n 06
Load Preset1 ON Value	0n 11	0n 0B
Load Preset1 OFF Value	0n 21	0n 15
Load Preset2 ON Value	0n 12	0n 0C
Load Preset2 OFF Value	0n 22	0n 16
Load Preset3 ON Value	0n 13	0n 0D
Load Preset3 OFF Value	0n 23	0n 17
Load Preset4 ON Value	0n 14	0n 0E
Load Preset4 OFF Value	0n 24	0n 18
Load Preload1	0n 31	0n 1F
Load Oscillator Frequency Divisor	00 50	00 32
Load Window High Limit	0n 33	0n 21
Load Window Low Limit	0n 34	0n 22
Load Input Filter Value	00 35	00 23

Note: n = Counter #1 or 3

The bytes in the command word are always treated as independent bytes – a counter ID byte and a Command code byte.

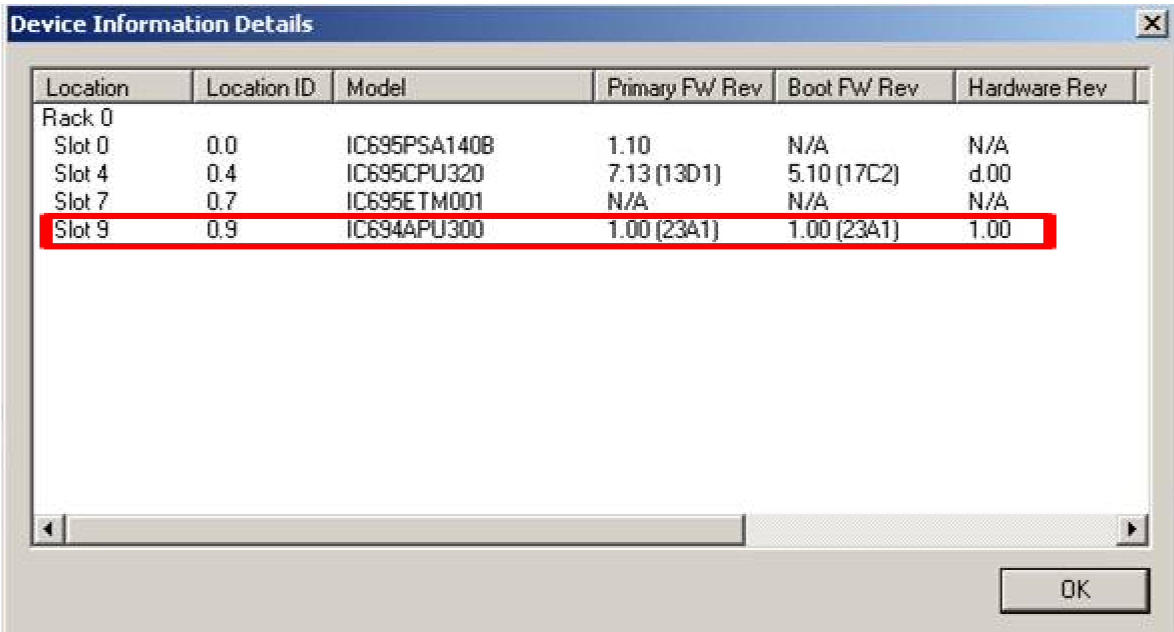
COMMREQ Structure for Load Input Filter

	MSB	**LSB**
Command word	00	0x23
Data word (LSW)	Input Number	
Data word (MSW)	Filter Value	

Other Features

Device Information Display

PME displays the part number, serial number and firmware revision information of the new IC694APU300 module when requested using “online command → Show Status”. An example is shown below.



Field Upgradable Firmware

In the RX3i system, the module supports field upgradable firmware feature using Winloader. Both local processor firmware and FPGA firmware are field upgradable.

CPU and Programming Software Requirements

Programmer version requirements	
Classic mode	Any version of Proficy Machine Edition
Enhanced mode	Proficy Machine Edition version 7.00 SIM 10 or later
CPU requirements	
Classic mode	Any Series 90-30 or RX3i CPU
Enhanced mode	CPU315, CPU320, CRU320, NIU001+, CPE305 or CPE310 with firmware version 7.13 or later

Note: A *Loss of I/O Module* fault may occur in a Series 90-30 system that uses the new IC693APU300 module with IC693CPU331-CD or earlier. To avoid this fault, IC693CPU331 should be upgraded to version EE or later.

Appendix A

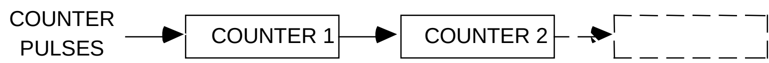
Application Examples

This appendix contains descriptions of several typical applications using the High-speed Counter. These application examples are:

- Counter Cascading
- Monitoring and Controlling Differential Speeds
- Direction-Dependent Positioning
- RPM Indicator
- Tolerance Checking
- Measuring Pulse Time
- Measuring Total Material Length
- Material Handling Conveyor Control
- Timing Pulse Generation
- Digital Velocity Control
- Dynamic Counter Preloading
- Carousel Tracking

Counter Cascading

Type A counters can be cascaded to accumulate greater count values than are possible with a single 2-byte counter. This can be accomplished by using the preset output of one counter for the count input of the next as shown below.

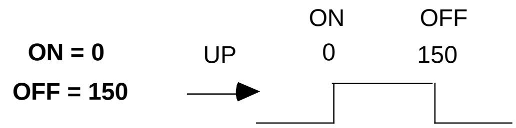


For example, if a 4-byte Up Counter is required, use two counters configured for the UP direction and:

1. Set the Count Limits for both counters at their maximum values:

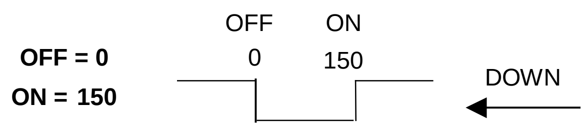
   LOW = -32768 and HIGH = +32767

2. Set the output preset for counter 1 at:



3. Connect counter 1 output to the counter 2 input.
4. Connect the count pulse stream to the counter 1 input.

Similarly, Down Counters can be cascaded by configuring all counters for the Down direction, setting the limits at the maximum values and reversing the output presets. For example:



Monitoring and Controlling Differential Speeds

Many industrial applications require machines such as cutters, conveyors, or nip rolls to operate at precise differential speeds. The Type C counter, which could be used with a minimum of controller support is most suited for this application. Type A or Type B counters could also be used with the aid of a controller.

The pulses representing the speed of each machine can be separately fed into the plus and minus loops of the Type C counter. The accumulator will automatically track and indicate the difference in speed of the two machines. The sign of the accumulator value will indicate which pulse stream count is greater and the accumulator will indicate the total accumulated count difference. The Counts/Timebase register (CTB) will indicate the present rate difference and its sign indicates which is greater.

Depending on the count signal types, each channel of the counter can be independently programmed to operate in any of its three modes:

1. Pulse/Direction
2. Up/Down
3. A quad B

The sign (+ or -) and magnitude of the deviation from the desired difference can be used as feedback to provide automatic control for the speed regulation of the machines.

Direction-Dependent Positioning

```
Features Used:         Counter Type:
----------------         ------------
Single-Shot Mode             B
Preload Inputs
Preset Outputs
```

Some applications require direction dependent positioning. An example is an operation where a crane on tracks has to perform certain maneuvers while traveling 100 feet in one direction and different ones while traveling 100 feet in the reverse direction.

This example uses the Type B configuration with two counters configured to operate in the A Quad B mode. Both counters should be driven by the same A Quad B signals and connected so they count in opposite directions when the crane is moving, as shown in Figure A-3 (Example of Terminal Connections).

The counter operating mode, limits and preload value can be set so that the preset outputs are direction sensitive. In this example, this is done by using the single-shot mode and preloading Counter 2 so that it only counts when the crane is moving in the reverse direction (right-to-left).

The counters are both preloaded at the start point and Counter 1 will count up from 0 to 100 for the left-to-right direction, and count down for travel in the right-to-left direction. Counter 2 will count up from (-100 to 0) only when the crane travels from right-to-left.

Table A-1. Counter Configurations

Parameter	Configuration
Counter Type	Type B (two counters)
Counter Operating Mode	A Quad B
Count Mode	one-shot (both counters), (non-continuous)
Counter 1 Preload	0
Counter 2 Preload	-100
Counter 1 Limits	0 to 100
Counter 2 Limits	-100 to 0

Table A-2. Operating Count Directions

Counter Number	***Crane Direction***	***Count Direction***
Counter 1	→	UP
Counter 2	→	Not counting
Counter 1	←	DOWN
Counter 2	←	UP

In this example, Counter 1 is configured with a preload value of 0. An ON condition for Preset 1 is selected which will turn on a loading device when the crane has traveled 75 feet to the right. Preset 2 (also for Counter 1) is selected to come on when the crane has traveled 100 feet to the right.

The direction of travel is reversed at the Stop point, and as the crane travels back from right-to-left, the ON Preset 1 of Counter 2 activates an unloading device when the crane has traveled 40 feet to the left (ON Preset is -60).

Finally, Preset 2 of Counter 2 turns its output on when the crane has traveled 75 feet to the left (ON Preset is -25).

The desired operation of the crane in this example is shown in the following figure.

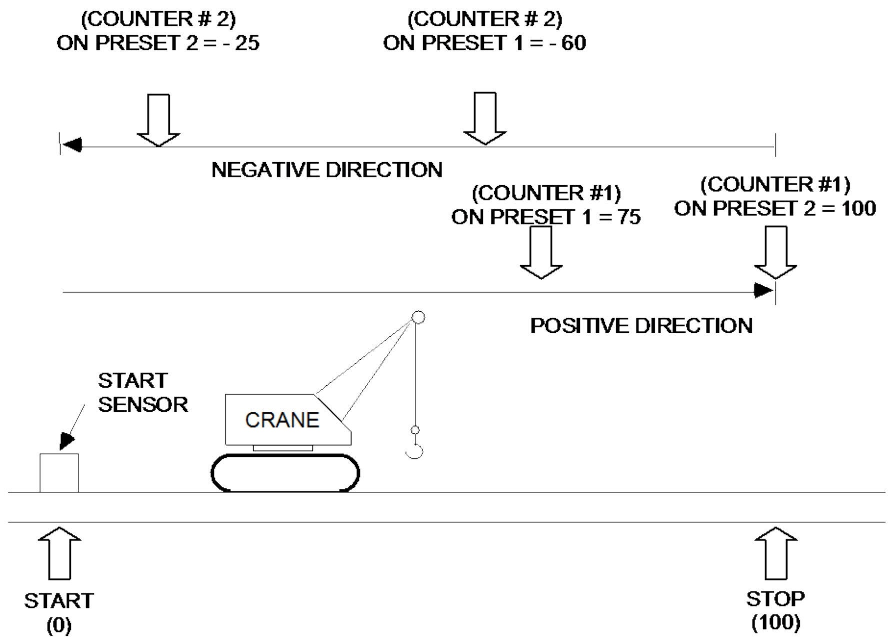


Figure A-1. Example of Direction-Dependent Sensing

Output Conditions

Counter 1:	
Output 1	ON for Counter 1 y75
	OFF for Counter 1 t75
Output 2	ON for Counter 1 y100
	OFF for Counter 1 <100
Counter 2:	
Output 3	ON for Counter 2 v-60
	OFF for Counter 2 >-60
Output 4	ON for Counter 2 v-25
	OFF for Counter 2 >-25

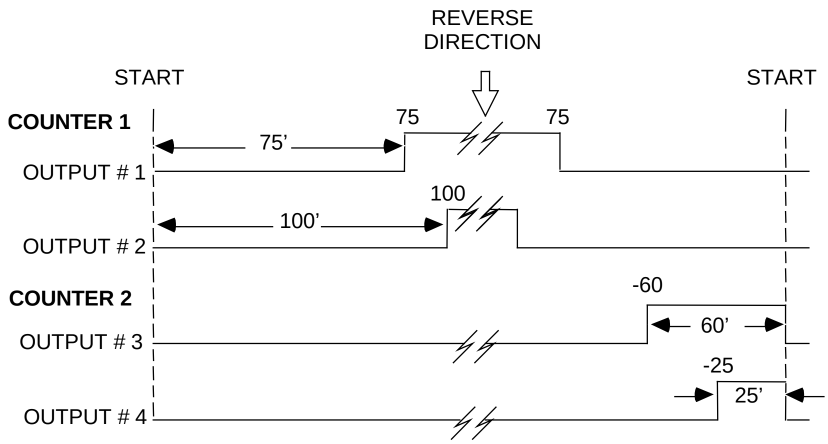


Figure A-2. Output Timing Conditions Example

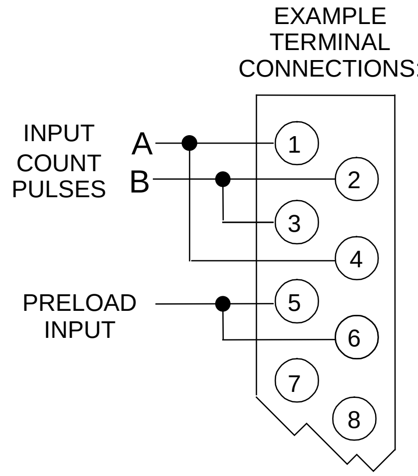


Figure A-3. Example of Terminal Connections

RPM Indicator

```
    Feature Used:              Counter Types:
 ------------------------       --------------
Counts/Timebase Register          A, B, C
```

The High-speed Counter can be used as a position/motion indicator when connected to a feedback device (such as an encoder) that is coupled to a rotary motion. RPM indication can be obtained directly from the counter's Counts/Timebase register (CTB) or derived from it by a simple calculation.

The RPM is given by:

```
         CTB     1
  RPM = ----- x ---
         PPR     T

 where: CTB = counts/timebase reading from the counter

        PPR = pulses/revolution produced by the feedback device

          T = timebase expressed in minutes
```

Note that if 1/T divided by PPR is some integer power of 10, then the CTB register gives a direct reading of RPM with an assumed decimal placement. Longer timebase settings will give better RPM resolution. This is illustrated in the following examples.

Example 1

If feedback produces 1000 pulses/revolution, CTB reading = 5212, and the timebase is configured for 600 ms:

T = 600 ms ÷ 60000 ms/min = .01 and 1/T = 100

RPM = 5212 ÷ 1000 x 100 = 521.2

CTB reading is RPM with .1 RPM resolution.

Example 2

Assume the same conditions as example 1, except the timebase is now set to 60 ms, which gives

T = 60 ÷ 60000 = 0.001 and 1/T = 1000.

Since the motion is turning at the same speed as in example 1, the CTB reading now equals 521,

and RPM = 521/1000 x 1000 = 521.

CTB reading is now RPM with 1 RPM resolution.

Tolerance Checking

```
 Features Used:            Counter Type:
----------------           -------------
 Strobe Inputs with             B
 Positive/Negative Strobe
 Edge Configuration
```

Parts can be measured by a counter for tolerance checking. This can be accomplished by coupling a pulse feedback device to the transport conveyor to provide count inputs representing increments of movement to the measuring counter.

For this example, a Type B counter is used and the same part sensing signal is connected to both strobe inputs. The first strobe input is configured to be active on the leading edge and the second on the falling edge. Then as each part passes through the sensor, its length is indicated by the difference between the two strobe register readings. Multiplying the difference by the known distance represented by each pulse gives the length in measurement units for comparison against the allowable tolerance. Parts out of tolerance may be marked or diverted into a separate reject storage area.

An illustration of this application is shown below along with an example of field connections to the High-speed Counter's terminal board.

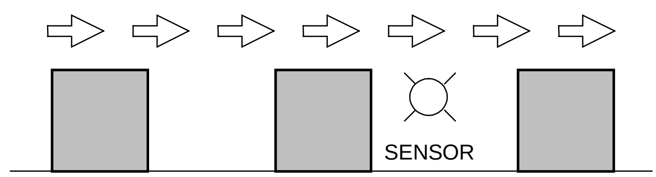


Figure A-4. Example of Tolerance Checking

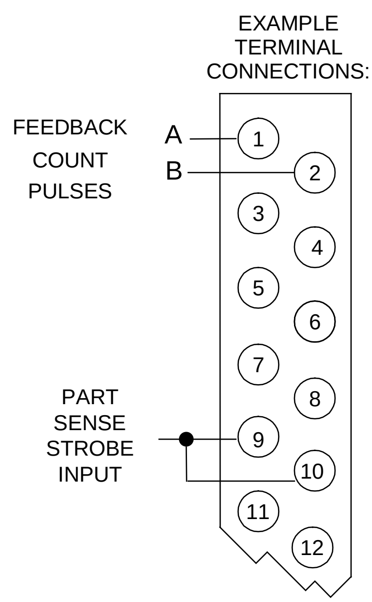


Figure A-5. Terminal Connections

Measuring Pulse Time

```
 Features Used:            Counter Type:
-------------            -------------
 Ref Osc Input                  B
 Strobe Inputs
```

ON/OFF time of input pulses can be accurately measured using the High-speed Counter. This can be done by configuring the Ref Osc input into Counter 1 and using the two Strobe inputs to capture the counter value on each of the input pulse edges.

For example, assume that an input pulse needs to be measured to the nearest 0.1 milliseconds; configure the High-speed Counter as follows:

```
Counter:  Type B
  Osc Freq Div = 66 (10 kHz)
  Osc IN 1 = ON (1)

For Counter 1:
  Mode = Continuous
  Strobe 1 Edge = Pos
  Strobe 2 Edge = Neg
```

Connect the pulse signal to both Strobe inputs. When the signal occurs, its duration (in tenths of ms) is now given by [Strobe Reg 2 - Strobe Reg 1] for positive going pulses or [Strobe Reg 1 - Strobe Reg 2] for negative going pulses.

Note that if the pulse spans the counter rollover point, the calculation becomes more complex, therefore it may be desirable to preload the counter to 0 shortly before the pulse is measured.

If only a positive-going pulse is measured, it could also be connected to the preload input. The Strobe Reg 2 reading would now give the pulse length directly.

Measuring Total Material Length

```
Features Used:          Counter Type:
-------------           -------------
 Disable Input                B
```

The total length of multiple pieces of material, such as plate glass, plastic strips, or lumber, can be measured with the High-speed Counter.

This application uses an encoder geared to a transport conveyor to provide the count input increments, and a sensor to detect material as it passes.

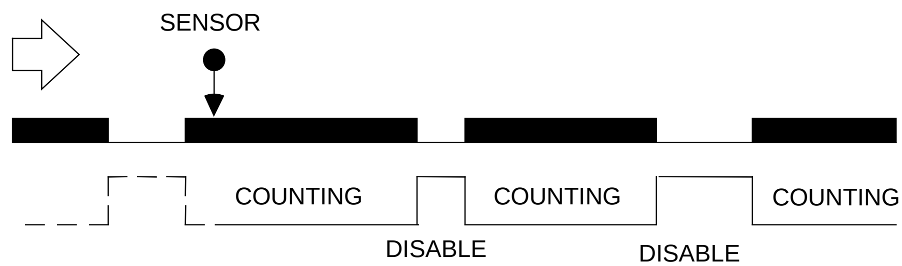


Figure A-6. Measuring Total Material Length

The High-speed Counter should be configured for Type B counter operation.

Connect the encoder to the counter's Count Input. Connect the sensor to the Disable Input.

Count inputs from the encoder will increment the Accumulator only while a piece of material is passing through the sensor. The total length of all pieces will be accumulated until the counter is reset (Preloaded) for the start of a new batch. The application program can convert the count units from the accumulator to the actual units of length being measured.

Material Handling Conveyor Control

```
Features Used:          Counter Type:
--------------          -------------
 Preset Outputs               B
```

When transported material must be stopped momentarily for inspection or modifications, the High-speed Counter's Preset outputs can control conveyor slowdown and stop points.

Use an encoder geared to the transport conveyor to provide the count input increments. Use a sensor to detect material as it passes on the conveyor.

Determine where the material should begin to slow down, and where the material should stop. Find out how many encoder counts are equivalent to each of these two distances.

The High-speed Counter should be configured for Type B counter operation.

Configure Preset Output 1 to turn on at the slowdown point, by entering the number of counts from the sensor to the point where slowdown should begin.

Configure Preset Output 2 to turn on at the stop point, by entering the number of counts from the sensor to the inspection station.

Connect the sensor to the Preload Input of the counter to restart the counter at 0 for each piece of material that passes (only one piece can be between the sensor and the stop point in this configuration).

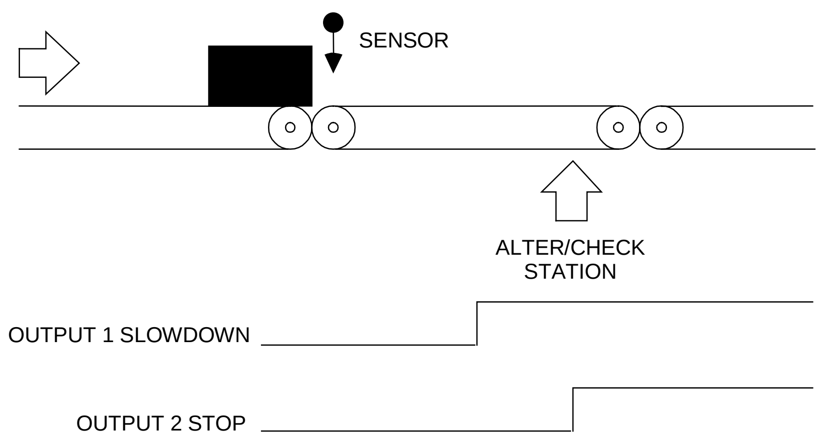


Figure A-7. Material Handling Conveyor Control

Timing Pulse Generation

```
Features Used:          Counter Type:
-------------           -------------
 Ref Osc Input                A
 Preset Output
```

Applications requiring an accurate timing pulse can use the High-speed Counter to generate the pulse at the required frequency. The specified pulse width will be accurate to 0.5 msec of resolution.

Assume that a pulse of 50 msec duration is needed every 1/2 second. The High-speed Counter could be configured as follows to give the desired pulse output.

Counter type A

Oscillator Frequency Divider (N) =66 (10kHz)

Oscillator Frequency Input 1 = ON (1)

For counter 1:

- mode = continuous
- high limit = 4999
- low limit = 0
- On Preset = 4499
- Off Preset = 0

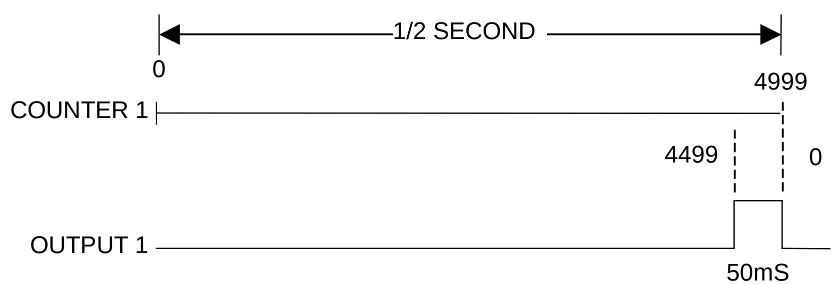


Figure A-8. Timing Pulse Generation

The counter's upper limit of 4999 represents 5000 counts, the number of counts in 1/2 second at 10kHz. (For this example, the Oscillator Frequency could also have been set to 1kHz. If that had been done, the upper limit would have been 499.)

Setting the lower limit to 0 establishes the counter start point for each output pulse period. The On Preset, 4499, determines that 4500 counts will pass before the beginning of the output pulse. Setting the Off Preset to 0 turns off the output pulse when the Accumulator reaches 5000 counts.

Digital Velocity Control

```
Features Used:            Counter Type:
-------------             -------------
 Ref Osc Input                  B
 Up/Down Mode
```

The High-speed Counter, together with an Analog Output module and a drive amplifier, can be used to provide accurate motor velocity control. The commanded velocity is generated by connecting the internal oscillator to the up count input of Counter 1.

The OSC input (or an external oscillator) provides a steady counting pulse to the up count input. The output of the counter provides the accumulator count value to the CPU. This data can be transferred by the CPU to an analog output module. An output from this module, in turn, controls the amplifier driving the motor.

During system operation, the motor’s velocity can be changed by changing the frequency of the OSC output.

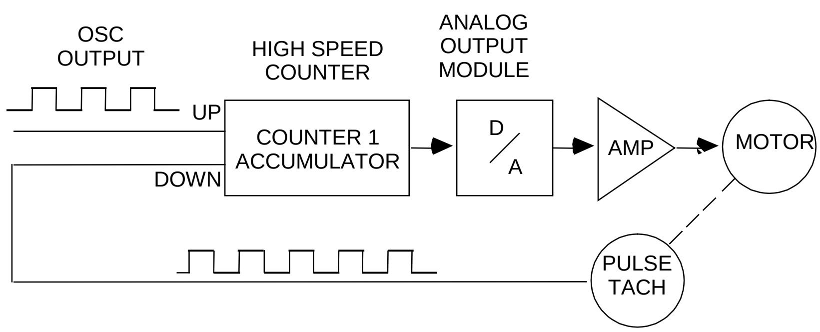


Figure A-9. Digital Velocity Control

A pulse tachometer is connected to the block’s down count input. This tachometer provides count pulses that are fed into the down count input of the same counter. As a result, the counter Accumulator reaches a stable value when the motor is turning at the commanded velocity.

Dynamic Counter Preloading

```
Feature Used:            Counter Type:
------------             -------------
 Home                          C
```

Applications using a High-speed Counter to track the position of a material conveyor or machine slide may need to be preloaded accurately at a given reference point while in motion. Simply connecting a limit switch to the counter's Preload Input does not give repeatable, accurate results because errors are introduced by:

1. Variations in the actuation point of the limit switch and
2. Preload Input Filter delay when actuated at different speeds.

For accurate repeatability, the Home feature of the Type C counter configuration should be used. This application requires a marker pulse (usually 1 per revolution) from the position feedback device (encoder). The limit switch should be placed so that it will be encountered approximately halfway between marker pulses. When the limit switch is reached, the next marker pulse causes the High-speed Counter to preload the Accumulator with the desired value. The limit switch should be connected to the High-speed Counter's Enable Home input.

The operation is as follows:

1. As the conveyor or slide moves toward the reference position, the CPU issues the Home Command (by setting output bit 14 to the High-speed Counter).
2. The Enable Home limit switch is actuated. This informs the High-speed Counter that the next marker pulse will be the reference marker.
3. When the next (reference) marker is reached, the High-speed Counter automatically transfers the Home value to the counter Accumulator.
4. The High-speed Counter informs the CPU that Home position has been found by setting input status bit 4.
5. The CPU may then clear the Home Command (output bit 14), causing the block to remove the Home Found indication.

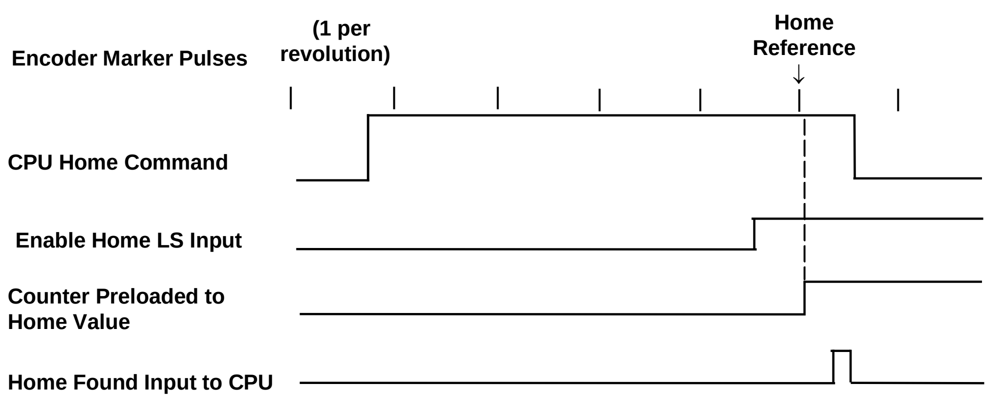


Figure A-10. Dynamic Counter Preloading

Carousel Tracking

```
Features Used:            Counter Type:
-------------             -------------
 Home Inputs                    C
 Strobe Inputs
 Continuous Mode
```

Items stored in a rotating carousel can be tracked and retrieved using a High-speed Counter. A feedback device coupled to the carousel rotation can be used to provide up/down count inputs. The counter limits are configured so that the increments produced by one complete revolution of the carousel cause one full cycle of the counter.

Type C counter configuration is best for this application, since it provides a homing capability. The homing capability makes it possible to synchronize the counter with the carousel position at a defined home location after powerup. From then on, any rotation of the carousel is tracked by the counter. Since the relative location of all entrance and exit points to the home position is known, the CPU can record the pocket location of each item entering the carousel. It can command any pocket to any exit for item retrieval.

If there are up to 3 entrance points, a different Strobe Input can be used to indicate when a pocket is loaded from each entrance. When the CPU detects the Strobe Set flag, it can record the pocket position into a memory table and mark it full. (The CPU records the pocket position by reading the value from the Strobe Register, then adding or subtracting the entrance offset from the home location.)

To retrieve an item from a particular exit, the CPU can locate the nearest full pocket to that exit, and generate the required rotation command to the carousel.

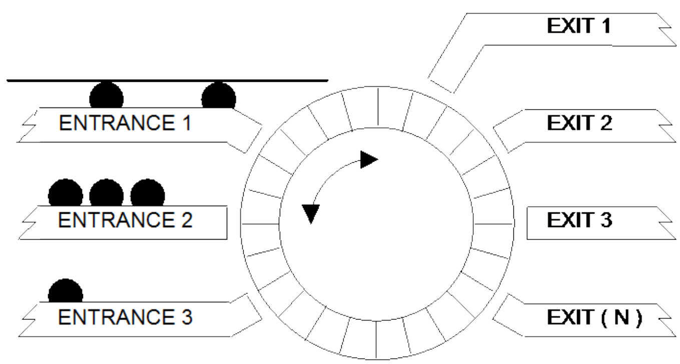


Figure A-11. Carousel Tracking

A

B

C

T

U

V

W