**Module Overview**

The AMCI 4501 rev A module can be used to capture events. This can be either the number of encoder counts or the time of or between two events. The module can be programmed to operate in one of six modes. The programmed mode determines what event is being captured.
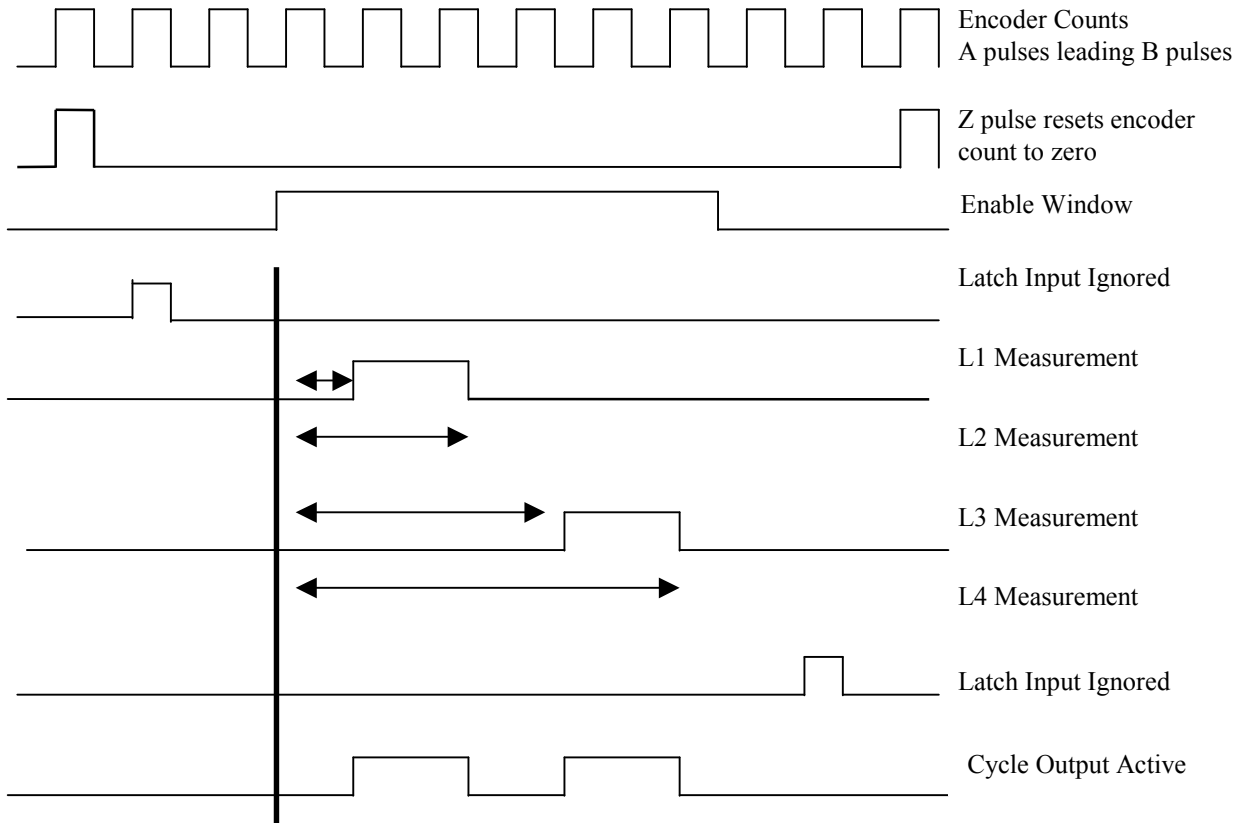
Mode 1: Registration Function

When used in this mode, the 4501 module counts the number of encoder pulses between the activation of one input (START) and the activation of a second input (LATCH). The Start input does not have to be off when the Latch input turns on. The number of pulses counted is placed into the input image table of SLC 500 PLC and is called the Measurement Value. This number can have a maximum value of 65,535 counts. While the encoder pulses are being counted, the module's Cycle Output is active. The 4501 module uses X4 decoding when counting encoder inputs, so that a 1,024 pulse encoder will give 4,096 counts per revolution. Mode 1 is the only functionality available with the previous version of the 4501 module. The following timing diagram illustrates mode 1 functionality.
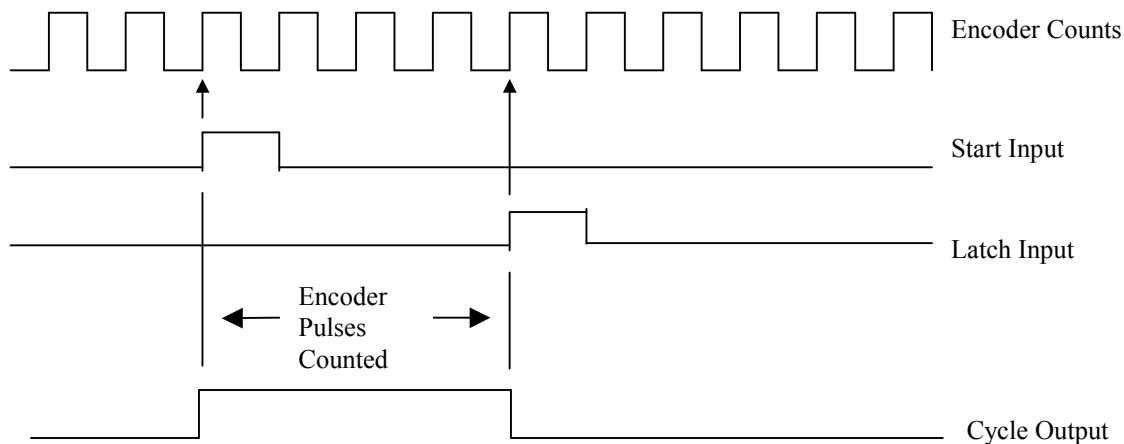
Mode 2: Registration Function with Enable Window

In this mode, programmable on and off setpoints define an enable window. When the encoder position is within this window, the module measures the number of pulses, again using X4 decoding, from the time the window became active, until the leading and trailing edges of up to two transitions of the Latch Input. The Start Input is not used in Mode 2. The module measures the number of encoder pulses from the start of the enable window to the leading edge of the first transition of the Latch input, the L1 measurement, and from the start of the enable window to the trailing edge of the first transition of the Latch input, the L2 measurement. A second transition of the Latch input will generate the L3 and L4 measurements. Any additional transitions of the Latch input while still in the enable window will be ignored. The cycle output will match the latch input during the first two transitions of the latch input in the enable window. The cycle output will turn off at the end of the enable window, even if the latch input is on through the end of the enable window. The measurement cycle is complete when the encoder position reaches the off setpoint of the enable window, at which time the measured data for both transitions of the Latch input will be placed in the input image table. The encoder position is reset to zero by the Z pulse of the encoder. Please note that in this mode, the encoder counts must be increasing. That is, the A pulses must be leading the B pulses for the mode to function properly. The following timing diagram illustrates mode 2 functionality.

Mode 2 Timing Diagram

Encoder Counts
A pulses leading B pulses

Z pulse resets encoder count to zero

Enable Window

Latch Input Ignored

L1 Measurement

L2 Measurement

L3 Measurement

L4 Measurement

Latch Input Ignored

Cycle Output Active

Mode 2 Notes:

- If the Z (index) pulse is used, the upper enable window should be less than the number of encoder counts.
- The velocity data will jump because of the zeroing operation of the Z pulse.

Mode 3: Time Measurement, One Direction

This mode does not use the encoder inputs. It instead measures the time, with 1μs resolution, between when the Start Input becomes active and when the Latch Input becomes active. The Start input does not have to be off when the Latch input turns on. The measurement cycle will be complete, and the measured time value placed in the input image table after the Latch input becomes active. The following timing diagram illustrates mode 3 functionality.
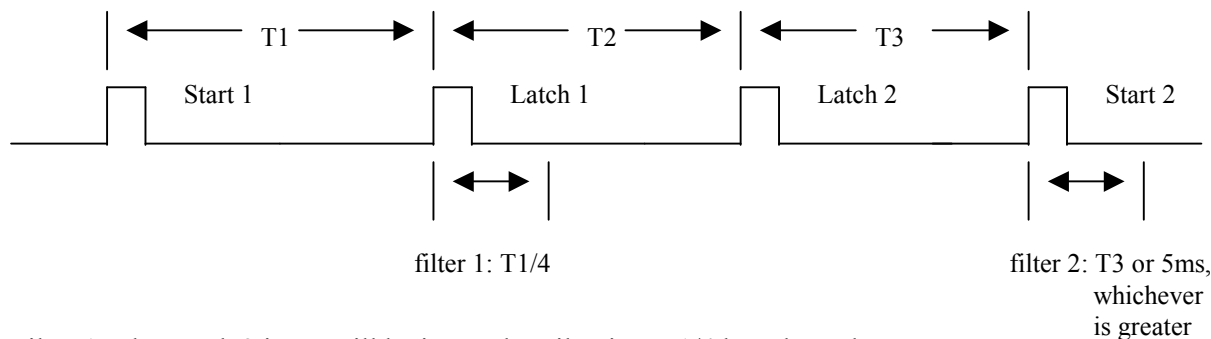

Start Input

Latch Input
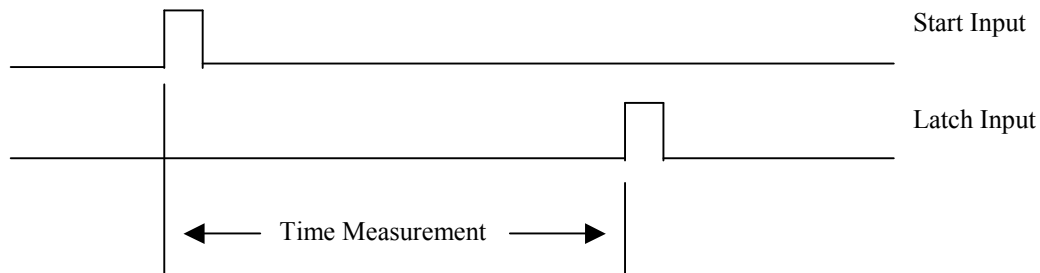
Time Measurement

Mode 4: Time Measurement, Two Directions

This mode is similar to Mode 3 except that two time values, each with 1μs resolution, are measured in one measurement cycle. The first consists of the time between when the Start Input becomes active and when the Latch Input becomes active. The second is the time between when the Latch Input becomes active a second time, and when the Start Input becomes active. The input that initiates the timing operations does not have to be off when the second input turns on. The measured times will be placed in the input image table only after both time measurements are made. The following timing diagram illustrates mode 4 functionality.
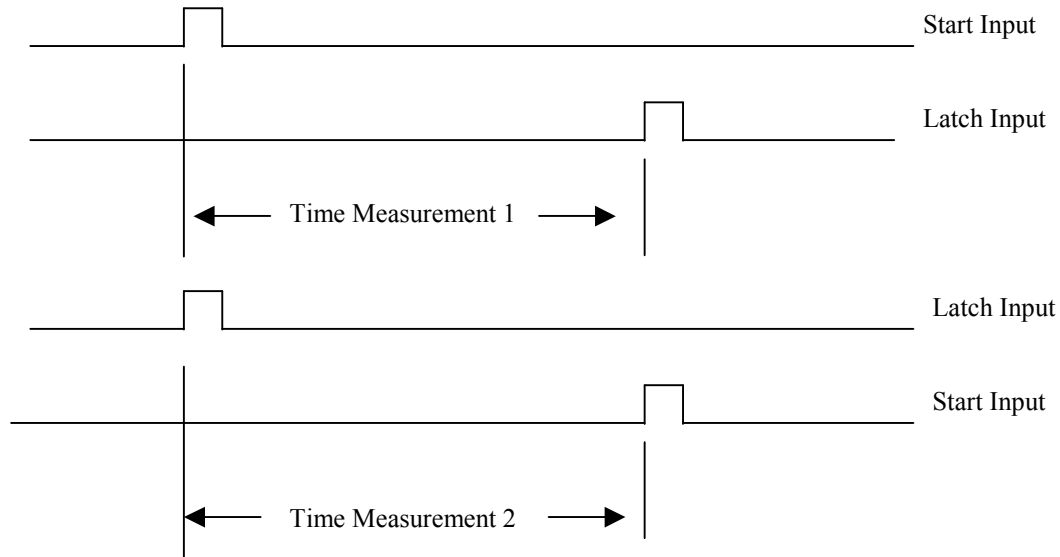
With version 2 of the firmware, a filter was added to the mode 4 functionality. This filter is designed to ignore the second pulse in two consecutive pulses if the second pulse is very close to the first one. The following diagram illustrates the filtering function. In this diagram, T1, T2, and T3 are time measurement values.


Filter 1: The Latch 2 input will be ignored until a time T1/4 has elapsed.
Filter 2: A third transition of the Start input will be ignored until a time T3 or 5ms, whichever is greater, has elapsed.

Note: The version 3 firmware changed the way that mode 4 dealt with a timeout error. See the input data section of the specifications for an explanation of this functionality.

Mode 5: Time Measurement, Input Active Time

Mode 5 also does not use the encoder inputs. In this mode, the Start and Latch inputs are independent of each other, and the time values measured, again with 1μs resolution, is the time that the input is active. When used in this mode, there is no measurement cycle, and the value placed in the input image table is the latest one received on the Start and Latch inputs. If the Start or Latch inputs stop receiving signals, then the data that was last measured will remain in the input image table. Because of the 100μs throughput time of the module, the maximum input frequency in this mode is 10KHz. The following timing diagram illustrates mode 5 functionality.
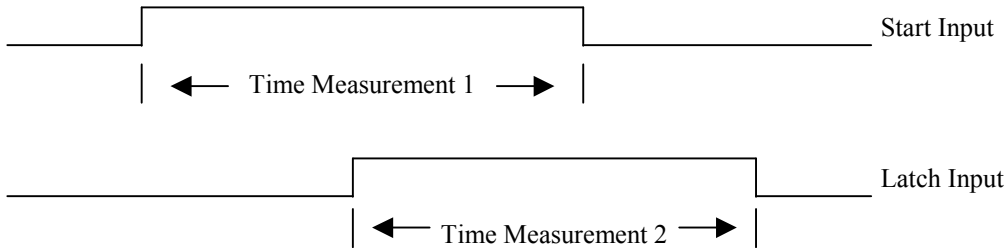
Mode 6: Counts Measured When Inputs Active

Mode 6 is similar to mode 5, except that instead of measuring the time that the input is active, it measures the number of encoder counts, again using X4 decoding, that have elapsed while the input is active. If the A pulse leads the B pulse, than the reported count value will be positive. If the B pulse leads the A pulse, than the reported count value will be negative. As with mode 5, the start and latch inputs are independent of each other, there is no measurement cycle, and the value placed in the input image table is the latest one received on the Start and Latch inputs. If the Start or Latch inputs stop receiving signals, then the data that was last measured will remain in the input image table. The following timing diagram illustrates mode 6 functionality

Mode 6 Timing diagram
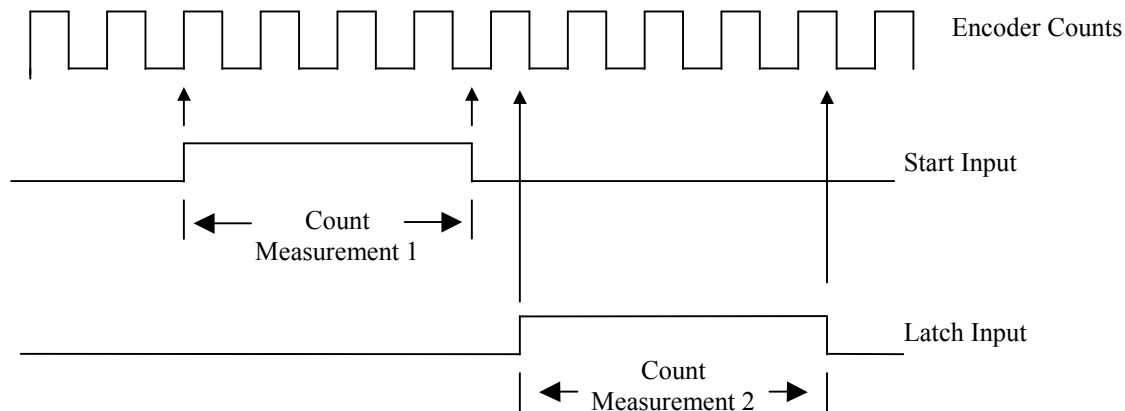
Input Data (Eight Data Words Sent from the 4501 module to the PLC)

The function of input words 1 to 7 changes, depending on in which mode the module is operating. The following table outlines the use of each word depending on the mode.

Word	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
0	Status (See Description Below)					
1	Registration Value	L1 measurement	upper 4 digits time measurement	upper 4 digits time measurement 1	upper 4 digits time measurement 1	Count Measurement 1
2	Velocity Data in Counts/50ms	L2 measurement	lower 3 digits time measurement	lower 3 digits time measurement 1	lower 3 digits time measurement 1	Count Measurement 2
3	0	L3 measurement	0	upper 4 digits time measurement 2	upper 4 digits time measurement 2	0
4	0	L4 measurement	0	lower 3 digits time measurement 2	lower 3 digits time measurement 2	0
5	0	Velocity Data in Counts/50ms	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0

Word 0: Status
    bit 0: New Measurement Value. This bit is set by the 4501 when it has sent new measurement values to the PLC. This bit will be reset when the PLC accepts the values and sets the Received Measurement Flag. This bit is not used in Modes 5 or 6.
    bit 1: No Response. This bit is set when the 4501 has completed five measurement cycles without the PLC acknowledging receipt of the data. These five cycles consist of the first one where the data is reported, and four others, where the data is missed. This bit will turn on at the end of the fourth missed cycle.
    bit 2: Start Mark. This bit will be set when the Start sensor is active.
    bit 3: Latch Mark. This bit will be set when the Latch sensor is active.
    bit 4: Command Error. This bit will be set if more than one of the mode bits, output word 0 bits 2 to 6, are set, or if any of the unused bits in output word zero are set when configuring the module
    bit 5: Parameter Error. This bit will be set if the enable window or time out values are outside of their allowable ranges, or if the enable window on setpoint is greater than or equal to the enable window off setpoint.
    bit 6: Time Out Error. Used in modes 1 to 4, this bit will be set if a measurement cycle begins, but does not end within the programmed timeout time.   This error must be cleared using the Clear Measurement Error bit in the output image table before normal operations can resume.

    Note: The version 3 firmware changed the way that mode 4 dealt with a timeout error.

- If only the first start signal is received, then both time measurement values will be zero when the timeout error bit is set.
- If only the first start and latch signals are received, then when the timeout error bit is set, the measured value of time measurement 1 will be reported to the PLC, and the time measurement 2 value will be zero.

- If only the second start signal is missing, then when the timeout error bit is set, the measured value of time measurement 1 will be reported to the PLC, and the time measurement 2 value will be zero.

bit 7: Reserved. Always equal zero
bit 8: Set when the 4501 module is operating in Mode 2, Registration Function with Enable Window.
bit 9: Set when the 4501 module is operating in Mode 3, Time Measurement, One Direction.
bit 10: Set when the 4501 module is operating in Mode 4, Time Measurement, Two Directions.
bit 11: Set when the 4501 module is operating in Mode 5, Time Measurement, Input Active Time.
bit 12: Set when the 4501 module is operating in Mode 6, Counts Measured When Inputs Active
bits 13 and 14: Reserved. Always equal zero
bit 15: Acknowledge Bit: This bit will be set by the module to indicate that configuration data has been received during a programming cycle. This bit will be reset when the Transmit bit in the output image table is reset.

Input Data Notes

1. In modes 1 and 2, the module also reports the velocity data of the encoder. This value has units of counts passed in 50ms. This value is updated every 50ms. In mode 1, if the encoder's B pulses lead the A pulses, than the velocity data will be negative. In mode 2, the encoder's A pulses must lead the B pulses. If the B pulses lead the A pulses, than the velocity data will be zero.
2. In mode 2, the count values of L1 to L4 are measured from when the enable window is reached until the leading and trailing edges of the first two transitions of the Latch input. These values are contained in one register and cannot exceed 32,767.
3. All of the time measurement values are divided into two words. The upper word contains the upper four digits, or the 1000s places of the value. The lower word contains the lower three digits, or the 1s, 10s, and 100s places of the value. For example, a value of 12,345μs would be reported at 12 in the upper word and 345 in the lower word.
4. The count measurement values in mode 6 have a maximum value of 32,767.
5. The Command and Parameter error bits will be reset when valid data has been sent to the 4501 module during a programming cycle.
6. The timeout error bit must be cleared from the PLC before the next measurement cycle can begin. The module will not update the input image table data until the timeout error has been cleared.
7. In modes 5 and 6, if signals are removed from the start and latch inputs, the last data measured will remain in the input image table.
8. In mode 6, if the encoder counts are decreasing, that is the B pulses lead the A pulses, than the count measurement values reported to the PLC will be negative.

Output Data (Eight Data Sent from the PLC to the 4501 module)

The function of input words 1 to 7 changes, depending on in which mode the module is operating. The following table outlines the use of each word depending on the mode.

Word	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
0	Control Word (See Description Below)					
1	timeout value	timeout value	timeout value	timeout value	0	0
2	0	upper four digits enable window on setpoint	0	0	0	0
3	0	lower three digits enable window on setpoint	0	0	0	0
4	0	upper four digits enable window off setpoint	0	0	0	0
5	0	lower three digits enable window off setpoint	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0

Word 0: Control
> bit 0: Received Measurement. Set this bit to tell the 4501 module that the measurement data has been received. The 4501 module will freeze the measurement values in the input image table until this bit is set. If the ladder logic program does not set this bit, the data in the input registers will not be updated during the next measurement cycle.
>
> bit 1: Clear Measurement Error. Set this bit to clear a "No Response" or a Timeout error. Note, the 4501 module will continue to operate normally when the "No Response" bit is set. However, it will not update the measurement data if the Timeout error bit is set.
>
> bit 2: Mode 2: Set this bit during a programming cycle to place the 4501 module in mode 2. When this bit is set, the module will look for data in output words 1 to 4.
>
> bit 3: Mode 3: Set this bit during a programming cycle to place the 4501 module in mode 3.
>
> bit 4: Mode 4: Set this bit during a programming cycle to place the 4501 module in mode 4.
>
> bit 5: Mode 5: Set this bit during a programming cycle to place the 4501 module in mode 5.
>
> bit 6: Set this bit during a programming cycle to place the 4501 module in mode 6.
>
> bit 7 to 14: Reserved. These bits must equal zero.
>
> bit 15: Transmit Bit: Set this bit to initiate a programming cycle.

Output Data Notes

1. Output bits 0 and 1 are not part of a programming cycle. These bits will be acted on immediately after being set.
2. Output word 0 bits 2 to 6 and words 1 to 5 require a programming cycle to be acted on. This consists of setting the bits and words to their desired values, and then setting the Transmit Bit. The module will respond by setting the Acknowledge bit in the input image table to indicate that the new data has been received. The transmit bit should then be reset, and the module will reset the Acknowledge bit. The programming cycle is now complete.
3. The time out value has a range of 0 to 32767ms. If a value of zero is entered, the module will use 10 seconds as the time out value.
4. As with the input time values, the enable window on and off setpoints are divided into two words. The upper word contains the upper four digits, or the 1000s places, of the value. The lower word contains the lower four digits, or the 1s, 10s, and 100s places, of the value. For example, a value of 34,567 counts would be programmed as 34 in the upper word and 567 in the lower word.
5. The enable window on setpoint must be less than the enable window off setpoint, or a Parameter Error will be generated.
6. The enable window's on and off setpoints have a range of 0 to 65,535.

   Note: There is a possibility of a race condition between when the Z pulse resets the encoder count to zero, and the opening the enable window. If this occurs, the enable window may not open, and the module may miss a mode 2 measurement cycle. To eliminate this, the enable windows on setpoint should not be programmed to be less than 1.

7. The module does not contain a non volatile memory and will always power up operating in mode 1. If this is not the desired mode of operation, a startup routine must be written to configure the module for the desired mode.
8. Any of the registers that contain zero in the above table will be treated as "don't cares." That is, any data written to these registers will be ignored.

Connector Pin Out

1	
	2
3	
	4
5	
	6
7	
	8
9	
	10
11	
	12
13	
	14
15	
	16
17	
	18

1. 7 → 24 VDC User Power
2. No Connection
3. No Connection
4. -Cycle Output (modes 1 and 2 only)
5. +Cycle Output (modes 1and 2 only)
6. Start Input
7. Latch Input
8. No Connection
9. Connected internally to pin 18
10. No Connection
11. No Connection
12. -A 5 Vdc Differential Encoder Input
13. +A 5 Vdc Differential Encoder Input
14. +B 5 Vdc Differential Encoder Input
15. -B5 Vdc Differential Encoder Input
16. +Z 5 Vdc Differential Encoder Marker Input
17. -Z 5 Vdc Differential Encoder Marker Input
18. 0 V User Power (DC Common)

AMCI

LED Function

The 4501 modules
five status LEDs have
the following layout.

RUN ◯

REG ◯   ◯ ST

ERR ◯   ◯ FAULT
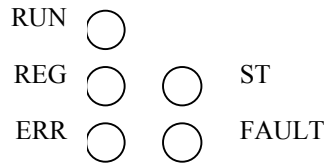
The following table describes the function of the 4501 modules 5 LEDs.

LED	Color	Function
RUN	green	This LED is on when the module is operational.
REG	green	This LED is on during a mode 1 registration cycle, or on when the enable window is active in mode 2. In modes 3 through 6 it is on when the latch input is active.
ST	green	This LED is on when the Start Input is active.
ERR	red	This LED turns on when the PLC has not read data from the module for five or more measurement cycles. This LED is not used in mode 5 and 6.
FAULT	red	This LED is on when there is a module hardware fault.

Measurement Cycle

Once the 4501 module has made a measurement, it places the data in the input image table and sets the New Measurement Value bit, word 0 bit 0. This data will remain in the input image table until the PLC acknowledges receipt of the data by setting the Measurement Received bit, word 0 bit 0, in the output image table. When the module sees the Measurement Received bit, it will respond by resetting New Measurement Value Input bit. If the PLC does not set the Measurement Received bit, the module will continue to make measurements, but the input data will not be updated. If the PLC misses five measurement cycles, the module will set the No Response error bit in the input image table. The measurement cycle varies depending on which mode that the module is operating in.

Mode 1: A cycle starts when the Start input transitions, and ends when the Latch Input Transitions. The data is placed in the input table when the cycle is complete.

Mode 2: A cycle starts when the encoder counts enters the Enable Window, and stops when the encoder counts exit the Enable Window. The data for both transitions of the Latch input are placed in the input table after the cycle is complete.   A value of zero will be placed in the appropriate input registers for any unused transitions of the latch input. For example, if the Latch input only transitions once, a value of zero will be reported to input words three and four when the measurement cycle is complete.

Mode 3: A cycle starts when the Start input transitions, and ends when the Latch Input Transitions.

Mode 4: A cycle starts on the first transition of the Start input, beginning of Time Measurement 1, and ends on the second transition of the Start input, ending of Time Measurement 2. The data for both time measurements is placed in the input image table only after the second transition of the Start Input.

Mode 5: No Measurement Cycle is used. The most current on time of the Start and Latch inputs is reported to the PLC as soon as it is calculated. If a measurement event occurs faster than the PLC scan, then the time measurement data will be missed.

Mode 6: No Measurement Cycle is used. The most current number of encoder pulses counted while the Start and Latch inputs are on is reported to the PLC as soon as it is measured. If a measurement event occurs faster than the PLC scan, then the count measurement data will be missed.

Input Polarity Jumpers

The module has two jumpers that determine which transition of the start and latch inputs start a measurement cycle. JP5 controls the latch input, and JP6 controls the start input. When installed on pins 1 to 2, the module acts on a positive transition of the input. When installed on pins 3 to 4, the module acts on the negative transition of the input.   If the jumper is set to act on a negative transition, then the status LEDs on the front of the module will be on when the input is not receiving power.

Specifications

Module Location

Any SLC 500 I/O rack, occupies one slot. ID code of 3512, which configures the rack for 8 input and 8 output words. Please note that this ID code will cause the rack's I/O configuration to show 1746-HSTP1 Stepper Controller Module in the slot where the 4501 module is located.

Data Available to the Processor

Input Status, encoder registration and velocity data or time measurement data (mode dependent)

I/O Isolation

Optical, 1500 Vac minimum

Module Setup Parameter Storage

None, unless the module is used in mode 1, it must be configured at every power up

Programmable Parameters

Mode of Operation, Timeout Value, Enable Window (modes 1 and 2 only)

Environmental Conditions

Operating Temperature: 0 to 60 degrees Celsius
Relative Humidity: 5 to 95% (without condensation)
Storage Temperature: -40 to 85 degrees Celsius

Input Specifications

Start and Latch Inputs: Sinking Inputs
                    On State: 10 to 24Vdc @5mA
                    Off State: 0 to 2Vdc
                    Undefined logic State: 2 to 10Vdc

Encoder Inputs: One 5Vdc differential encoder with $\pm A$, $\pm B$, and $\pm Z$ inputs. A quadrature encoder, with A and B pulses out of phase, must be used. The module will not count if pulses are supplied to only the A or B inputs. Maximum input frequency is 250kHz.

Output Specification

One Registration Cycle Output. Used only in modes 1 and 2, this output is capable of sinking up to 20mA of current.

Throughput Time

125μs

DC Supply Voltage From Backplane

100mA @ 5Vdc

Additional Requirements

An external 7 to 24Vdc supply which powers the output registration cycle output, as well as the module's isolation circuitry.

AMCI

Programming Example

The three rung ladder logic program below can be, but does not have to be, used to configure the mode of operation of a 4501 module. This example assumes the module is located in slot 1 of the SLC rack and uses the following addresses.

N7:0/0   Manually set to initiate data transfer to the 4501 module.
N7:10 - N7:17   Holds data written to the 4501 module at output words O:1.0 - O:1:7.
I:1.0/15   4501 ACKnowledge bit.
O:1.0/15   4501 Transmit bit.

Manually set bit N7:0/0 to initiate the transfer of data to the 4501 module. Note that the data in N7:10 does not have transmit bit set. This rung is performed until acknowledge bit I:1/15 is set.

```
  Set to write to        4501
  4501 module           ACK bit                                    ┌─── COP ────┐
                                                                   │ COPY FILE  │
     N7:0                 I:1                                       │ Source: #N7:10
   ──┤ ├──────────────────┤/├─────────────────────────────────────── Dest:   #O:1.0 ──
                                                                   │ Length: 8  │
      0                   15                                       └────────────┘
```

When bit N7:0/0 has been manually set, this rung sets transmit bit O:1/15, which tells the 4501 module to act on the data located in the output image table. This rung is true as long as bit N7:0/0 is set, and the module has not responded by setting acknowledge bit I:1.0/15.

```
  Set to write to        4501
  4501 Module           ACK bit                              4501 Transmit
                                                                  Bit
     N7:0                 I:1                                      O:1
   ──┤ ├──────────────────┤/├──────────────────────────────────( )──────────────────
                                                                  15
      0                   15
```

The following rung unlatches bit N7:0/0 when the 4501 module has set acknowledge bit I:1/15 in response to the transmit bit being set in rung two. The Programming cycle is now complete.

```
  Set to write to        4501
  4501 module           ACK bit                              Set to write to
                                                             4501 Module
     N7:0                 I:1                                    N7:0
   ──┤ ├──────────────────┤ ├──────────────────────────────────( U )──────────────────
                                                                  0
      0                   15
```

Revision History

Revision 1.0 described the module's five new modes of operation.

Revision 2.0 added a programmable time out value and changed the data table layout.

Revisions 2.1 and 2.2 both changed mode 2 functionality slightly.

Revision 2.3 added the ability to clear the timeout error to the module.

Revision 2.4 added some details to the specification.

Revision 2.5 added a filter that rejected close transitions of the inputs in mode 4.

Revision 2.6 changed the function of the cycle output in mode 2 and reported the time 1 measurement value in mode 4 if a timeout error had occurred.

Revision 2.7 added a detail to the Output Data Notes stating that the minimum value of the enable window in mode 2 should be one and not zero.

Revision 2.8 was released on 8/8/08. This revision added the new header and footer, some details to the modes 1 and 2 descriptions, rearranged the input/output image table data, and added some specifications.

File: 4501_revA_specifications
date: 8/8/08