

INSTRUCTION MANUAL

Sensoray Model 626

PCI Multifunction I/O Board

Revision F

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1. Limited Warranty

Sensoray Company, Incorporated (Sensoray) warrants the Model 626 hardware to be free from defects in material and workmanship and perform to applicable published Sensoray specifications for two years from the date of shipment to purchaser. Sensoray will, at its option, repair or replace equipment that proves to be defective during the warranty period. This warranty includes parts and labor.

The warranty provided herein does not cover equipment subjected to abuse, misuse, accident, alteration, neglect, or unauthorized repair or installation. Sensoray shall have the right of final determination as to the existence and cause of defect.

As for items repaired or replaced under warranty, the warranty shall continue in effect for the remainder of the original warranty period, or for ninety days following date of shipment by Sensoray of the repaired or replaced part, whichever period is longer.

A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the outside of the package before any equipment will be accepted for warranty work. Sensoray will pay the shipping costs of returning to the owner parts that are covered by warranty.

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2. Special Handling Instructions

The Model 626 circuit board contains CMOS circuitry that is sensitive to Electrostatic Discharge (ESD). Special care should be taken in handling, transporting, and installing the 626 to prevent ESD damage to the board. In particular:

- Do not remove the circuit board from its protective anti-static bag until you are ready to configure the board for installation.
- Handle the circuit board only at grounded, ESD protected stations.
- Remove power from the PCI system before installing or removing the circuit board.

3. Introduction

The Sensoray model 626 is a Multifunction I/O card.

Some of the features include:

- 48 digital I/O channels.
- 20 of the digital I/O channels have edge detection and interrupt capability.
- 7 of the digital Outputs can be used as counter overflow outputs.
- Digital I/O connectors are industry standard pinouts.
- Watchdog timer with several selectable reset periods that can reset the PCI bus.
- Six 24 bit up/down counters arranged in 3 pairs with:
 - Inputs that can be driven in various modes (1x, 2x, 4x) from incremental encoders inputs, the digital inputs, the paired counter's overflow, the system clock or software driven.
 - Can generate an interrupt on counter overflow or encoder/digital input index.
 - Can be preloaded/cleared on an overflow.
 - Output of second counter can be captured on the overflow of the first.
 - Can be used as a programmable periodic interrupt generator.
 - Counter circuitry can be battery backed up to prevent count loss during a power failure.
- Charge control of the backup Ni-Cad battery.
- 16 differential analog inputs (14 bit resolution).
- 4 analog outputs (13 bit resolution) with remote sense inputs to compensate for any external output resistance.

4. Device and Vendor Identification

This is the information that identifies the 626 board in the PCI system.

Device ID: 7146(hex)
Vendor ID: 1131(hex)

5. Installation

The installation of the Model 626 into a PCI system is straight forward as no special adjustment (jumpers) are required.

6. System Block Diagram

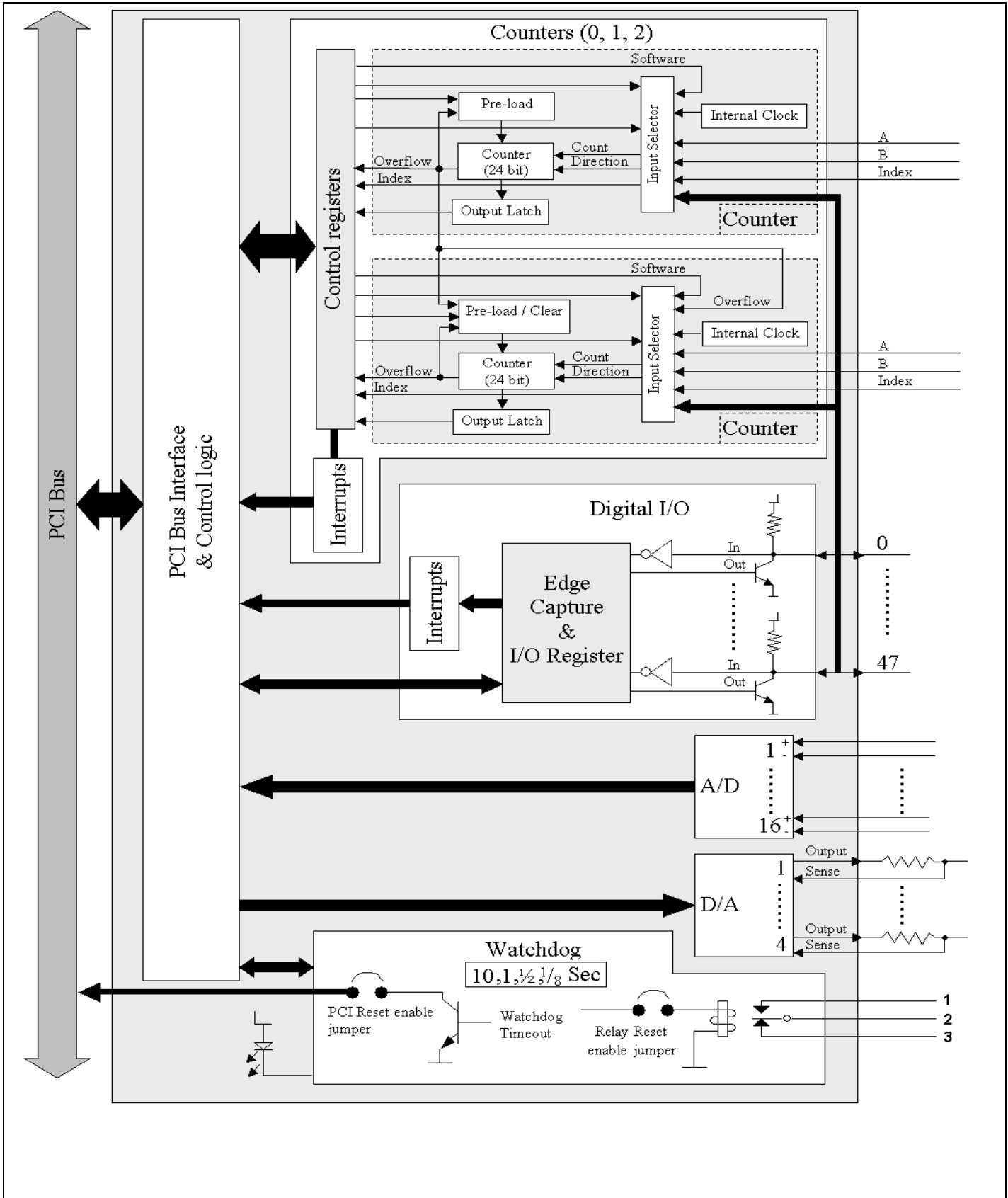


Figure 1 - System Block Diagram

7. Board Layout

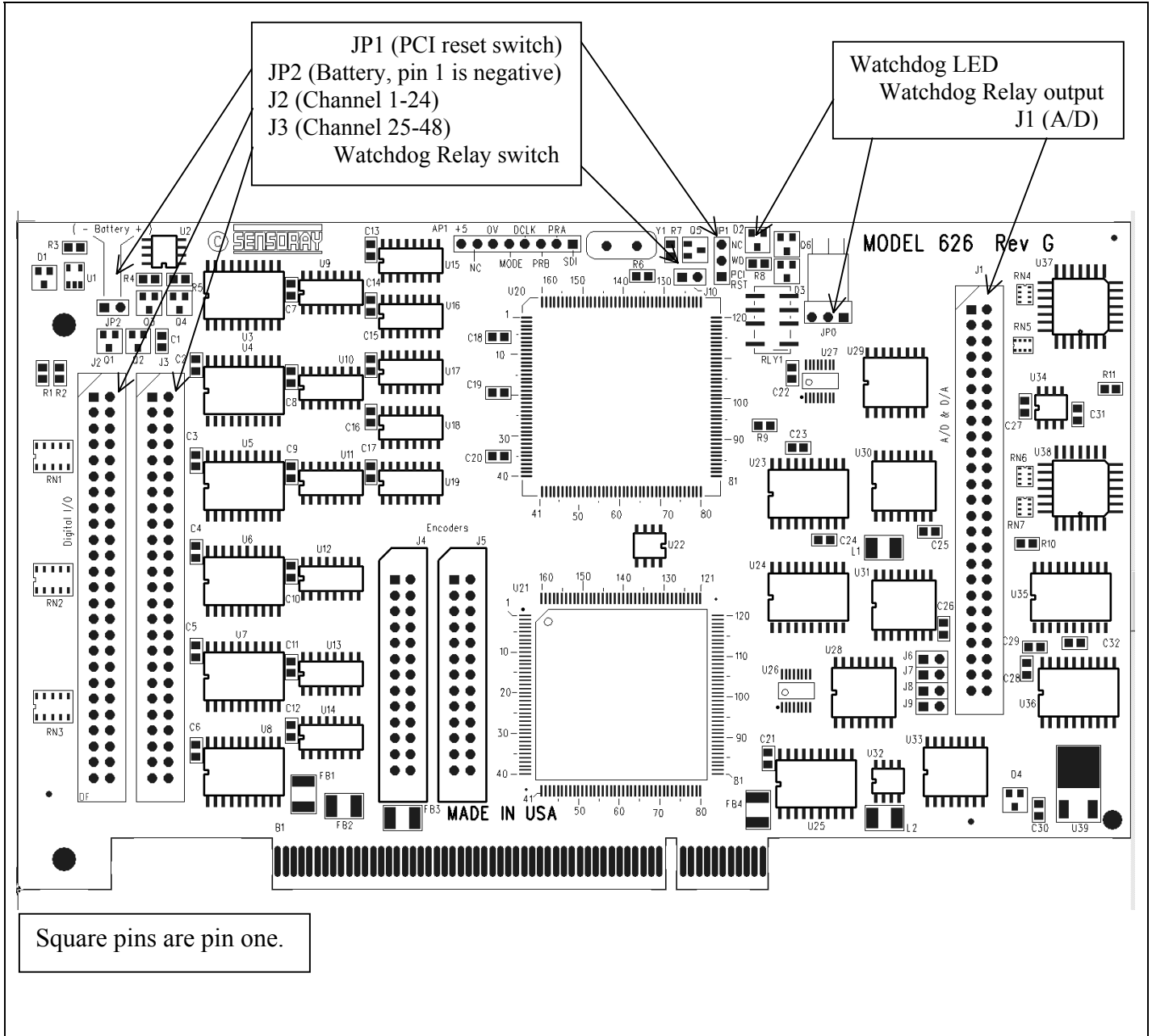


Figure 2 - Board Layout

8. Initial States After Reset

8.1 Miscellaneous Registers

Table 1 MISC1 & MISC2 Registers Initial States			
Register or I/O	State	See	Page
Watchdog oscillator	Oscillator 1 is selected.	Watchdog/Miscellaneous Registers	23
Watchdog	Disabled		
MISC1 Write Enable	Disabled.		
Watchdog period	$\frac{1}{8}$ th second		
EDCAP	0		

8.2 Digital I/O

Table 2 Digital I/O Initial States			
Register or I/O	State	See	Page
Digital I/O 0-7	All inputs. (pull up resistors enabled)	Digital I/O	9
Digital I/O 8-47	Indeterminate (will depend on the inputs during reset)		
Digital I/O 0-5	Will work as digital inputs <u>not</u> counter overflows		
EDGSEL INTSEL CAPSEL	Cleared		

8.3 Counters

If there is a charged external battery connected to the system, then most of the functionality of the counters is held through a reset/power failure. The interrupts are disabled to allow the system time to get back up and running.

Table 3 Counter Initial States			
Register or I/O	State	See	Page
Counter input selection	Unchanged	Counters	14
Edge detection			
Multiplier			
Clear Counter B			
Pre-load trigger			
Pre-load registers			

9. Digital I/O

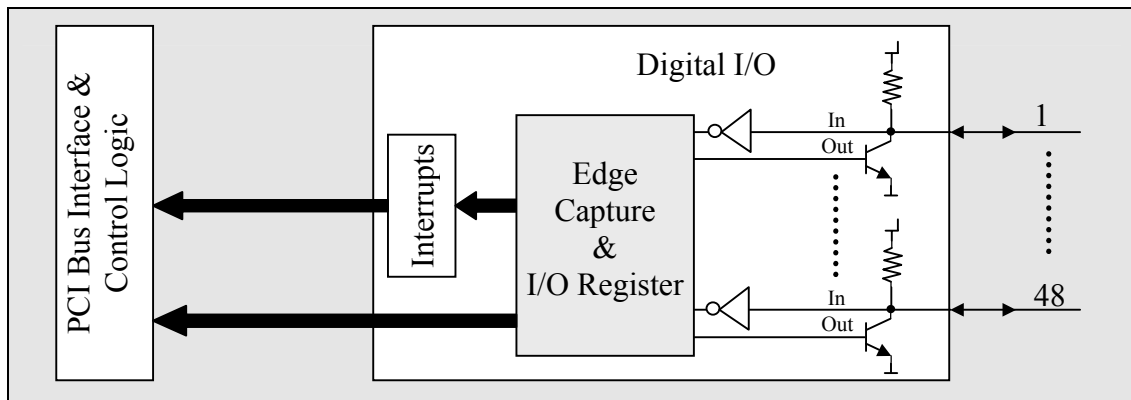


Figure 3 - Digital I/O Channels

9.1 Overview

The 626 board provides 48 digital I/O channels. 40 of these channels (Channels 0-39) offer edge detection & interrupt on edge detection. Either a positive or negative edge can be detected. The other 8 channels (40-47) have simple input/output functionality only.

Each channel can function as an input or an output.

NOTE: Any channel that is to be used as an input must have a '0' written to its output control register. This ensures that the output transistor is turned off allowing the pull-up resistor to pull the channel high. If this is not done the transistor will have to sink high currents if the input is driven high externally.

Write				Read			
Offset (Hex)	Register	Description		Offset (Hex)	Register	Description	
40		Not used		40			
42	WRINTSELA	Interrupt Enable	(0-15)	42	DINA	Status of digital inputs	(0-15)
44	WREDGSELA	Edge Selection	(0-15)	44			
46	WRCAPSELA	Capture Enable	(0-15)	46			
48	DOUTA	Write to Digital Output	(0-15)	48	RDCAPFLGA	Edges captured so far	(0-15)
4A		Not used		4A	RDINTSELA	Status of interrupt enable register A	
4C				4C	RDEDGSELA	Status of edge selection register A	
4E				4E	RDCAPSELA	Status of capture enable register A	
50				50			
52	WRINTSELB	Interrupt Enable	(16-31)	52	DINB	Status of digital inputs	(16-31)
54	WREDGSELB	Edge Selection	(16-31)	54			
56	WRCAPSELB	Capture Enable	(16-31)	56			
58	DOUTB	Write to Digital Output	(16-31)	58	RDCAPFLGB	Edges captured so far	(16-31)
5A		Not used		5A	RDINTSELB	Status of interrupt enable register B	
5C				5C	RDEDGSELB	Status of edge selection register B	
5E				5E	RDCAPSELB	Status of capture enable register B	
60				60			
62	WRINTSELC	Interrupt Enable	(32-47)	62	DINC	Status of digital inputs	(32-47)
64	WREDGSELC	Edge Selection	(32-47)	64			
66	WRCAPSELC	Capture Enable	(32-47)	66			
68	DOUTC	Write to Digital Output	(32-47)	68	RDCAPFLGC	Edges captured so far	(32-47)
6A		Not used		6A	RDINTSELC	Status of interrupt enable register C	
6C				6C	RDEDGSELC	Status of edge selection register C	
6E				6E	RDCAPSELC	Status of capture enable register C	

9.2 Writing to the Digital Outputs

There are 3 digital output registers used to write to the outputs. The format of the data to be written to each register is shown below.

Table 5 Writing to Digital Outputs																	
Offset (Hex)	Register Name	Output Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
48	DOUTA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
58	DOUTB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
68	DOUTC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

Writing a “0” to a bit in the output register will cause the corresponding output to turn off and thus give an output of 5V. When a ‘1’ is written then the output transistor is turned on causing the output channel to give an output of 0V.

When an I/O channel is to be used as an input then a ‘0’ must be written to the corresponding bit of that channels output register. This is to prevent high currents caused if the output transistor is turned on while a 5V input signal is being applied to the input.

9.2.1 Digital Outputs 0-5 used as Counter Overflows

Digital outputs 0-5 can be setup to pull the corresponding output load low for a short pulse (500nsec) when the counters overflow.

9.3 Reading the Digital Inputs

There are three digital input registers used to read the inputs. The format of the data returned by each register is shown in the table below.

Table 6 Reading Digital Inputs																	
Offset (Hex)	Register Name	Input Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
40	DINA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
50	DINB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
60	DINC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

Each digital input has a 10K Ohm pull-up resistor to +5V. With a 5V input or no input connected a ‘0’ will be read from the digital input register. Pulling the input to ground will cause a ‘1’ to be read from the digital input register. The corresponding output register must have “0” written to it before it can be used as an input.

9.4 Capture Digital Input Edges

This feature is not available on inputs 20-23 and 44-47 (The grayed out areas of the tables). Reading any edge capture data or interrupt data from these inputs will always return 0. Writing to any of edge capture or interrupt register for these inputs will have no effect.

9.4.1 Selecting Positive or Negative Edge Capture

Table 7 Selecting Positive or Negative Edge Capture																	
Offset (Hex)	Register Name	Input Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
44	WREDSELA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
54	WREDSELB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
64	WREDSELC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

Write to the WREDSEL register with a ‘0’ to select negative edges (transition from 1 to 0) or a ‘1’ to select positive edges (transition from 0 to 1). Note that these will take effect once edge capturing for a particular channel has been enabled.

9.4.2 Edge Capture Interrupt

A captured edge is usually set up to be accompanied by an interrupt. (See “Selecting Interrupt on Edge Capture” P13). If this is not done then the RDCAPFLG will need to be polled to see if an edge has occurred.

9.4.3 Enabling and Disabling Edge Capture

Table 8 Enabling & Disabling Edge Capture																	
Offset (Hex)	Register Name	Input Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
42	WRCAPSELA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
52	WRCAPSELB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
62	WRCAPSELC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

Before any edges can be captured the channel/s that are to be captured from must be enabled. Using the EDCAP bit of MISC1 to do this is a means of ‘masking out’ the other channel’s WRCAPSEL bits while modifying a selected channel.

To Enable a channel for edge capture:

1. First the EDCAP bit of the MISC1 register must be setup.
 - ‘1’ is used to enable one or more channels.
 - ‘0’ is used to disable one or more channels.
2. Now write to the WRCAPSELA, B or C to apply the above command to the corresponding channels selected with a ‘1’ in WRCAPSELA, B or C.

9.5 Reading Edge Capture Status Registers

9.5.1 Reading which channels have Captured Edges

Table 9 Reading Captured Edges																	
Offset (Hex)	Register Name	Input Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
48	RDCAPFLGA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
58	RDCAPFLGB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
68	RDCAPFLGC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

RDCAPFLGA, B & C are used to determine which, if any, channels have captured edges. A ‘1’ shows an edge has been captured for the corresponding channel.

9.5.2 Reading the Status of the Interrupt Enable Registers

Table 10 Reading the Status of the Interrupt Enable Registers																	
Offset (Hex)	Register Name	Input Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
4A	RDINTREGA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5A	RDINTREGB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
6A	RDINTREGC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

RDINTREGA, B & C are used to determine which, if any, channels will generate an interrupt on an edge capture. A ‘1’ shows that the corresponding channel will generate an interrupt on edge capture (if the channel is enabled).

9.5.3 Reading the Status of the Edge Selection Register

Table 11 Reading the Status of the Edge Selection Registers																	
Offset (Hex)	Register Name	Input Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
4C	RDEDGREGA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5C	RDEDGREGB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
6C	RDEDGREGC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

RDEDGREGA, B & C are used to determine which channels will capture positive edges and which will capture negative edges(when they are enabled). A transition from 0 to 1 is considered a positive edge.

9.5.4 Reading the Status of the Capture Enable Register

Table 12 Reading the Status of the Capture Enable Registers																	
Offset (Hex)	Register Name	Input Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
4E	RDCAPSELA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5E	RDCAPSELB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
6E	RDCAPSELC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

RDCAPSELA, B & C are used to determine which, if any, channels have edge capturing enabled. A ‘1’ shows that the corresponding channel has edge capturing enabled.

9.5.5 Clearing a Captured Edge

Once an edge has been captured it can be cleared by disabling it in its WRCAPSEL register. Doing this will also clear any accompanying interrupt. Obviously it will need to be re-enabled if another edge is to be captured.

9.6 Digital Input Interrupts

9.6.1 Selecting Interrupt on Edge Capture

Table 13 Selecting Interrupt on Edge Capture																	
Offset (Hex)	Register Name	Input Channel Number															
		Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
42	WRINTSELA	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
52	WRINTSELB	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
62	WRINTSELC	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32

Write to the correct WRINTSEL register with a ‘1’ to enable and ‘0’ to disable interrupts on that channel. An interrupt will only occur if the channel has been enabled using one of the WRCAPSEL registers & the WREDCAP register. The interrupts do not have to be enabled to capture an edge, an edge can still be captured but the RDCAPFLG registers will have to be polled to see if an edge capture has occurred.

9.6.2 Digital Input Interrupt Handling

There is only one main interrupt to the system from the 626. Once this interrupt has been received it is up to the user to determine whether it originated from the counters (See “Counter Interrupt Handling” P22) or the digital inputs.

The RDCAPFLG registers and the corresponding RDINTREG registers need to be logically ‘anded’ together to determine if an interrupt has occurred on a particular digital input channel.

An interrupt must be cleared once it has been handled to prevent it from causing multiple interrupts.

10. Counters

10.1 Overview

The Model 626 has six counters arranged in 3 pairs : 0A, 0B, 1A, 1B, 2A, and 2B. One of these pairs is shown in Figure 6 P17. They can be used in pairs or “stand alone”. Each counter can be used with the internal quadrature encoder interface for positioning systems, as timers using the internal clock, or as external (hardware) or internal (software) event counters. When paired a 48 bit counter can be achieved and development of functions like frequency counting is easy as one counter in the pair can feed the other either as a count, clear or latch input.

The features include:

- Counters can be completely software driven.
- Counters can be driven from digital inputs 0-15.
- Counters can be driven from the internal clock creating timers.
- Counters can be driven from encoder inputs.
- Encoder input buffers interface directly to TTL, CMOS, or differential RS422 signals
- Quadrature decoder logic to detect and convert encoder edges into clock and direction signals.
- Encoder quadrature multiplier (x1, x2, x4)
- 24-bit up/down counters that can be pre-loaded by various triggers.
- Counters can be read on the fly or captured by various triggers to be read later.
- Selectable counter direction for timer and event counting modes.
- Index input or overflow count can re-load counter with preset values.
- Programmable interrupt on rollover or index pulse.
- 5 Volt encoder power is available at encoder connector.

10.1.1 Latches

From Figure 6 (Block diagram of a counter pair) it can be seen that there is 1 latch per pair of counters. Counter A or B can cause it's own count to be latched on receiving an index pulse or an overflow from counter A can cause counter B's count to be latched. These latches can be accompanied with an interrupt and the value captured in the latch can be read later.

The latches can also be setup to latch as they are read. This allows the present value of the selected counter to be read.

10.1.2 Clear/Pre-load

The system can be programmed so that an overflow from Counter A will clear counter B. This is useful for frequency counting where counter B is latched & cleared at an interval determined by the time it takes for counter A to overflow.

Both counters can be programmed so that an index or overflow from a counter will pre-load itself with the contents of its pre-load register. This feature could be used to clear the counter by loading it with 0. This feature would be used for setting up a programmable interval timer. Both the clear & pre-load can be accompanied by an interrupt.

10.1.3 Interrupts

Each counter can generate an interrupt on overflow, index or both.

10.1.4 Overflow Outputs

The overflow output of each counter can be individually connected to a digital output. When the counter overflows a single pulse will occur pulling the output load low for 2 clock cycles (500nsec).

10.1.5 Index Inputs

Each counter has a hardware or software controlled index input that can be programmed to perform clear, pre-load or latch functions.

10.1.6 Counter Inputs

Each counter has various input modes including:

- Quadrature encoders with hardware or software controlled index.
- Single ended event & direction & index inputs.
- System clock with hardware or software control of direction & index for event timing.

Each counter channel has two clock input phases (referred to as channels in this manual) named “A” and “B”. Depending on the application, one or both of these signals may be connected to an encoder or to a pulse source.

If both phases are used, they are assumed to be quadrature encoded, meaning that they are 90 degrees out of phase. In this case, counters will count both up and down based on the timing relationship of the two-phase inputs.

If only one phase is used, the input is said to be single-phase. In this case, counter channels will count either up or down for each pulse on the phase input depending on the polarity of the direction input. This configuration is typically used to count pulses from devices that produce a single clock output.

Quadrature encoders for positioning systems have advantages over single-phase encoders. Counters will not accumulate errors when an encoder changes direction or dithers about a state transition boundary. Also, it is possible to increase encoder resolution by clocking the counters at a multiple of the single-phase clock rate.

10.1.7 Power failure

If an external NiCad battery is connected and fully charged and the Battery Enable bit of MISC2 is set, then if power is lost, all the counter registers will be held and the counters will continue to operate even though the rest of the system is down.

Note the counter interrupts are disabled when the system powers up but if an interrupt occurred during power down then it will occur the moment the interrupts are re-enabled.

Table 14 Counter Registers					
Write			Read		
Offset (hex)	Register Name	Description	Offset (hex)	Register Name	Description
0	CR0A	Counter 0A setup register	0	CR0A	Counter 0A setup register
2	CR0B	Counter 0B setup register	2	CR0B	Counter 0B setup register
4	CR1A	Counter 1A setup register	4	CR1A	Counter 1A setup register
6	CR1B	Counter 1B setup register	6	CR1B	Counter 1B setup register
8	CR2A	Counter 2A setup register	8	CR2A	Counter 2A setup register
A	CR2B	Counter 2B setup register	A	CR2B	Counter 2B setup register
C	PRE0ALSW	Pre-loads 0A lsw	C	LATCH0ALSW	Reads Latch 0A lsw
E	PRE0AMSW	Pre-loads 0A msw	E	LATCH0AMSW	Reads Latch 0A msw
10	PRE0BLSW	Pre-loads 0B lsw	10	LATCH0BLSW	Reads Latch 0B lsw
12	PRE0BMSW	Pre-loads 0B msw	12	LATCH0BMSW	Reads Latch 0B msw
14	PRE1ALSW	Pre-loads 1A lsw	14	LATCH1ALSW	Reads Latch 1A lsw
16	PRE1AMSW	Pre-loads 1A msw	16	LATCH1AMSW	Reads Latch 1A msw
18	PRE1BLSW	Pre-loads 1B lsw	18	LATCH1BLSW	Reads Latch 1B lsw
1A	PRE1BMSW	Pre-loads 1B msw	1A	LATCH1BMSW	Reads Latch 1B msw
1C	PRE2ALSW	Pre-loads 2A lsw	1C	LATCH2ALSW	Reads Latch 2A lsw
1E	PRE2AMSW	Pre-loads 2A msw	1E	LATCH2AMSW	Reads Latch 2A msw
20	PRE2BLSW	Pre-loads 2B lsw	20	LATCH2BLSW	Reads Latch 2B lsw
22	PRE2BMSW	Pre-loads 2B msw	22	LATCH2BMSW	Reads Latch 2B msw

10.2 Encoder connections

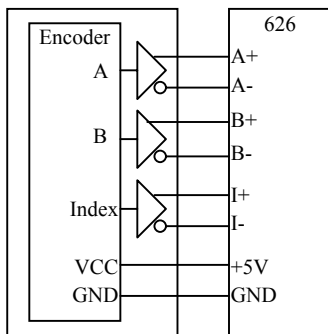


Figure 4
Differential pair encoder.
(Output with complement)

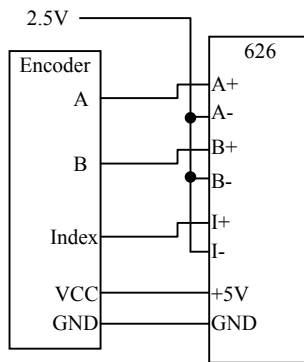


Figure 4
Single ended encoder. (TTL or CMOS)

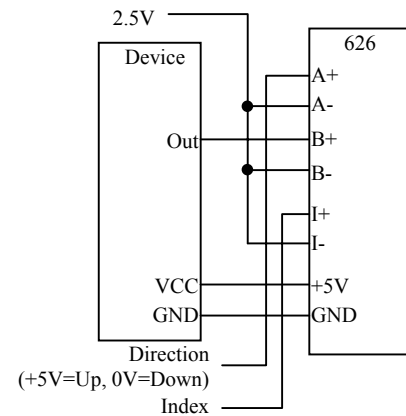


Figure 5
Single ended event counter with external count direction & index control. (TTL or CMOS)

Note: If the counters are driven in a single ended mode as shown in Figure 4 and Figure 5, then the unused phase inputs do not have to be biased at 2.5V. Each encoder input has two 100K resistors that bias the input to 2.5V when no driving source is present.

10.3 Block Diagram

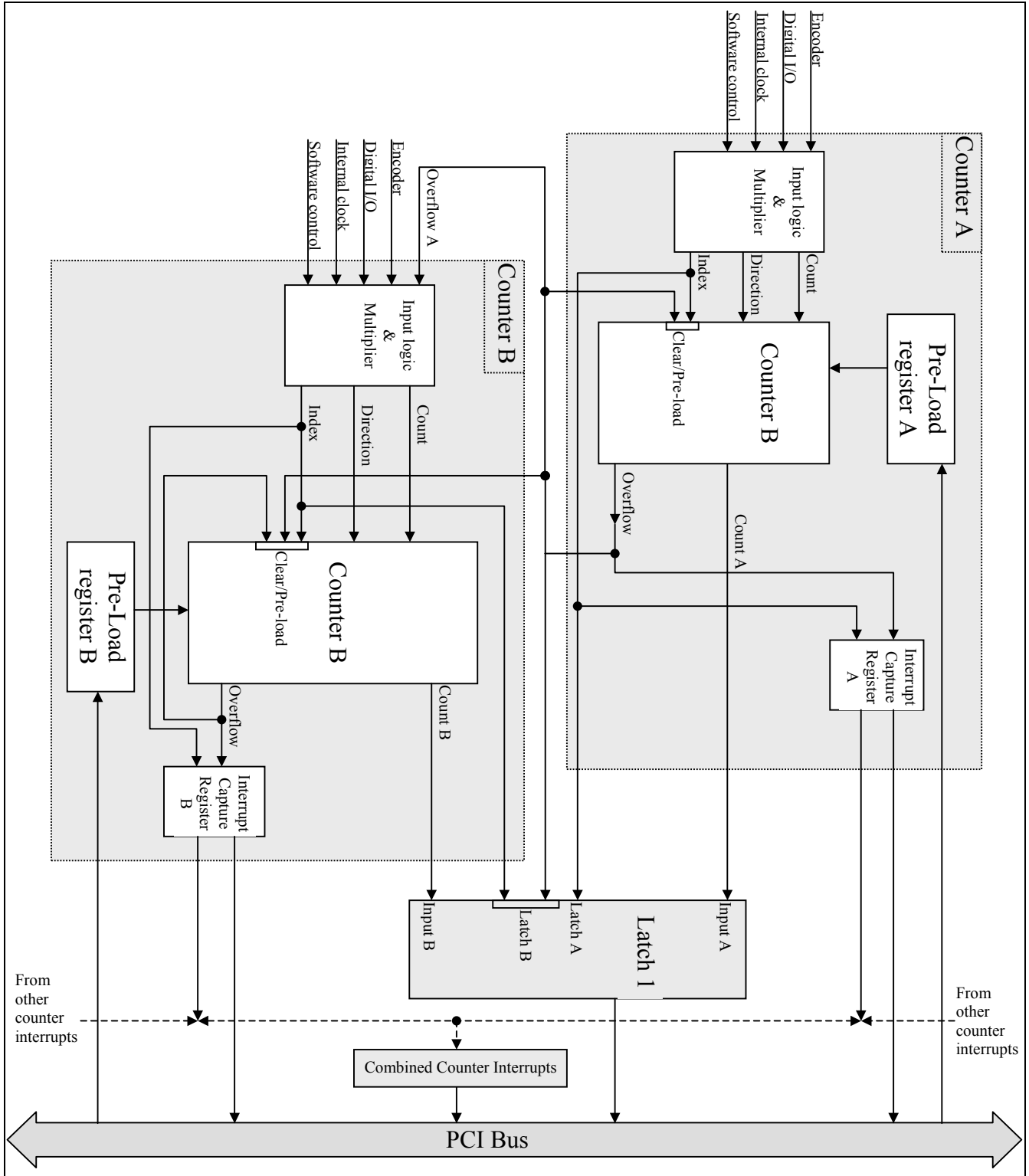


Figure 6 - Block diagram of a counter pair

10.4 Counter Setup Registers

Table 15 CR0A 00 (hex) Read/Write							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
Counter B index source		Counter B source		Counter A Index edge selection	Counter A pre-load trigger source		Counter A multiplier
00=Encoder 01=Digital inputs 10= Controlled by bit 1 of CR1B 11= Index disabled		00=Encoder 01=Digital inputs 10=Up Count with System clock 11=Down count with System clock (10 & 11 gated by bit 1 of CR1B)		0=Positive 1=Negative (Also used for software control of Counter A Index, 1=index)	00=Counter A index pulse 01=Counter A overflow 10=Disabled 11=Disabled		00=4x 01=2x 10=1x 11=Channel A is direction Index is count pulse
Bit 6	Bit 5	Bit 4		Bit 3	Bit 2	Bit 1	Bit 0
Counter A interrupt source		Counter A source edge selection		Counter A Index source		Counter A source	
00=None 01=Overflow only 10=Index only 11=Index & Overflow		0=Positive 1=Negative Also software control of Counter A count pulse. 1=enable when running with the system clock.		00=Encoder 01=Digital inputs 10= Controlled by CR1A bit11 11= Index disabled		00=Encoder 01=Digital inputs 10= System clock up (gated by bit4) 11= System clock down (gated by bit4)	

Table 16 CR0B 02 (hex) Read/Write						
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9
Clear Interrupt	Select Interrupt B	Select interrupt A	Counter A Enable	Counter B interrupt source	Latch source	
1=Clear Used with bit 13 or 14	1=Selected Used with bit 15	1=Selected Used with bit 15	0=Enabled 1=Only enabled if index A is high	00=None 01=Overflow only 10=Index only 11=Index & Overflow	00=Depends on latch read address 01=A's index latches A 10=B's index latches B 11=Counter A overflow captures B	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
Counter B pre-load trigger source	Clear Counter B	Counter B multiplier		Counter B Enable	Counter B index edge selection	Counter B source edge selection
00=Counter B index pulse 01=Counter B overflow 10= Counter A overflow 11=Disabled	1=Counter A overflow clears Counter B 0=Not Cleared	00=4x 01=2x 10=1x 11=Channel A is direction Counter A overflow is count pulse		0=Enabled 1=Only enabled if index B is high	0=Positive 1=Negative (Also software control of Counter B Index, 1=index)	0=Positive 1=Negative Also software control of Counter B count pulse. 1=enable when running with the system clock.
The grayed bits read back different information to that which was written to them. (See "Table 17 CR0B 02 (hex) Read" below).						

Table 17 CR0B 02 (hex) Read		
Bit 15	Bit 14	Bit 13
Counter B Direction	1=Counter A overflow routed to digital output	1=Counter B overflow routed to digital output
0=Down 1=Up		

Counters 1 & 2 have the same register layout but with different Read/Write addresses.

In the following examples groups of bits will be referred to using their name and set to a binary value. For example 'Counter B Multiplier'=10 means bit 4 =1 and bit 3=0.

'X' is used to show the value of a bit in one of the counter registers that is not important to the example being discussed. This is not to say it should be ignored. The value of these bits will depend on other functions being used and writing to any bit in the configuration example will always have an effect. Some bits have dual functions depending on the present settings of other bits.

Many of the counter examples will only deal with counter 0A. Unless otherwise stated the function being discussed can also be applied to counter 0B. The correct register & bit/s just need to be used by looking at the applicable tables. Counters 1A, 1B, 2A & 2B will function in the same way just controlled using different register addresses.

Do not be confused by the naming of registers CR0A & CR0B. They are simply the A & B parts of the single register CR0 (Counter Register 0) and do not refer specifically to counter A and counter B.

10.5 Setting Up the Counter Source

Counter A & counter B can be driven by a differential or single ended encoder, the digital inputs, software or from the system clock. Each counter's input logic has a count, direction & index line that can be controlled.

The 'Counter A Source' bits are used to select counter A's source. (See Table 15 & Table 16 P18)

If 'Counter A Source'=00 then encoder inputs are selected.

If 'Counter A Source'=01 then the digital inputs control the counters.

Table 18 Digital inputs as Counter input controls		
Digital Input Channel	Counter	Counter Input Function
1	0 A	Count or direction input
2	0 A	Count input
3	0 A	Index input
4	0 B	Count or direction input
5	0 B	Count input
6	0 B	Index input
7	1 A	Count or direction input
8	1 A	Count input
9	1 A	Index input
10	1 B	Count or direction input
11	1 B	Count input
12	1 B	Index input
13	2 A	Count or direction input
14	2 A	Count input
15	2 A	Index input
16	2 B	Count or direction input
17	2 B	Count input
18	2 B	Index input

When the digital inputs are selected as the source then the corresponding digital inputs can be used to control the counters in much the same way as when the encoder inputs are used. This mode also gives software control of the counters. This is achieved by writing to the corresponding digital output that in turn will change the digital input and thus the counter. The disadvantage to doing this is the fact that the digital output is now used for counter control & cannot be used for normal I/O functions.

In mode 00 & 10 above, the 'Counter A Source Edge Selection' is used to select positive '0' or negative '1' edge selection.

If 'Counter A Source' =10 then the counter will count down with the system clock.

If 'Counter A Source' =11 then the counter will count up with the system clock.

In both these modes the 'Counter A Multiplier' must be 10 and 'Counter A Source Edge Selection' must be 1. These two bits become part of the oscillator feedback loop. 'Counter A Source Edge Selection' could be used as an enable. The timer will only run when it is '1'.

'Counter A Enable' is used to gate the counter under normal counting operation. When cleared counting is enabled and when set counting is disabled. When using software to control counter A, 'Counter A Enable' must be '1' to enable counting.

The 'Counter A Index Source' bits are used to select counter A's index source.

If 'Counter A Index Source'=00 then the encoder index input will control indexing.

If 'Counter A Index Source'=01 then the digital inputs control the indexing. While in this mode

'Counter A Index Edge Selection'=0 will index on the positive edges while 1 will index on the negative edges.

10.5.1 Software Control of the Index

If 'Counter A Index Source'=10 or 11 then an index is caused by toggling the 'Counter A Index Edge Selection' bit. When this kind of software control of the index pulse is needed it is recommended that the 'Counter A Index Source' is set to 10. Then setting 'Counter A Index Edge Selection' will set the index input to the counter & clearing it will clear the index input to the counter. If the 'Counter A Index Source' be set to 11 then setting 'Counter A Index Edge Selection' will clear the index input to the counter & clearing it will set the index input to the counter.

10.5.2 Multiplier

The 'Counter A Multiplier' bits are used to multiply counter A's incoming pulses by 1, 2 or 4 or to allow software count control.

The 'Counter B Multiplier' bits are used to multiply counter B's incoming pulses by 1, 2 or 4 or to allow an overflow from counter A to cause counter B to count 1.

The multiplying feature is only used when the encoder or digital inputs are used to drive the counters. If only a count and direction input is being used then the multiplier should be 1x or 2x. Channel A is the direction & channel B the count.

10.5.3 Software Control Of Direction & Count Generation

This mode is only available on counter A. Direction control & a count pulse can be generated completely under software control for counter A. This mode uses the counters index interface to generate the count pulse. As a result, while in this mode, the index cannot cause an interrupt, a latch or a pre-load of counter A. To place counter A in this mode 'Counter A Enable' must be 1 and 'Counter A Multiplier' must be 11.

Channel A & B combined, of counter A will now control the count direction. They can be connected to the channel A encoder inputs, the channel A digital inputs or can be software controlled. To use software control for the direction, 'Counter A Edge Selection' must be 0. To set the count direction down 'Counter A Source' must be 10. To set the count direction up 'Counter A Source' must be 11. When using the encoder or digital inputs then channel A & B must be connected in parallel to form a single direction control.

The index channel of counter A will control the counting. It can be connected using the encoder index channel, the digital input index pin or it can be software controlled. To use software control for the count pulse, it is recommended that the 'Counter A Index Source' be set to 10. Then setting 'Counter A Index Edge Selection' will set the index input & clearing it will clear the index input, thus creating a count pulse. If the 'Counter A Index Source' is set to 11 then setting 'Counter A Index Edge Selection' will clear the index input & clearing it will set the index input also creating a count.

10.6 Driving Counter B From Counter A's Overflow

This mode is only available on Counter B. Counter B can be setup so that it will count every time counter A overflows. To do this 'Counter B Multiplier' must be 11, which will cause the count input to counter B to come from counter A's overflow.

Channel A of counter B will now control the count direction. It can be connected to the channel A encoder input, the channel A digital input or it can be software controlled. To use software control for the direction, 'Counter B Source Edge Selection' must be 0. To set the count direction to down 'Counter B Source' must be 11. To set the count direction to up 'Counter B Source' must be 10.

10.7 Triggering A Counter Load

Each counter has a pre-load register that can be loaded into the counter when triggered by various events. Each counter's pre-load register is set up by simply writing the 24 bit value to the lsb & msb of the pre-load register.

Pre-loading counter A can be triggered by an index or overflow of counter A. Pre-loading counter B can be triggered by an index or an overflow of counter A or B. A load must not be set to be triggered from counter A's index if the index is being used to run the counter under software control. Doing so will cause a load every time counter A counts.

10.8 Clearing Counter B From Counter A's Overflow

Setting 'Clear Counter B' to 1 will allow an overflow from counter A to clear counter B. This is only available for counter B. Of course the same effect could be achieved by pre-loading the counter with 0.

10.9 Latching The Counters

Each pair of counters 0, 1 & 2 have one latch between them. There are two distinct sets of modes of operation for the latches.

Mode 1: 'Latch Source'=00 allows either counter A or counter B to be captured any time. The least significant word (lsb) must be read first. This causes the entire 24 bit count to be latched allowing the most significant word (msb) to be read later without causing the count to be re-latched. The read address will decide which counter will be latched. (See "Table 14 Counter Registers" P16 for the read addresses).

Mode 2: In the second set of modes the appropriate counter is latched by an event that would usually be programmed to also create an interrupt. This interrupt then prompts the user to read the latched count before it is overwritten by the next event. To read the count the lsb and msb of either latch A or B for the appropriate counter can be read. (See "Table 14 Counter Registers" P16 for the read addresses). In this mode it does not matter which order the lsb & msb are read as they will have already been latched.

'Latch Source'=01 will latch counter A when there is a counter A index.

'Latch Source'=10 will latch counter B when there is a counter B index.

'Latch Source'=11 will latch counter B when counter A overflows.

(Useful when frequency counting).

10.10 Interrupts

10.10.1 Interrupts While Under Battery Backup

If there is a power failure while an external NiCad battery is connected and fully charged and the 'Battery Enable' bit of MISC2 was set, then when power is restored the interrupts are automatically disabled. Any interrupts that occurred while the power was down will cause an interrupt the moment interrupts are re-enabled.

10.10.2 Interrupt source Selection

If 'Counter A (or B) Interrupt Source'=00 then no interrupt will occur. An index and/or an overflow can still be captured but they will not generate an interrupt. The Misc2 register will have to be polled to see if an index or overflow has occurred.

If 'Counter A (or B) Interrupt Source'=01 an interrupt will occur when the counter overflows.

If 'Counter A (or B) Interrupt Source'=10 an interrupt will occur when the counter receives an index pulse.

When 'Counter A (or B) Interrupt Source'=11 an interrupt will occur when the counter overflows or receives an index.

10.10.3 Clearing An interrupt

There are 3 bits per counter pair that are used to clear the interrupts. . The 'Select Interrupt A or B' bits (bit 13 & 14) are used to select which interrupts must be cleared. A '1' in either register will allow it to be cleared. Then writing a '1' to the 'Clear Interrupt' will clear the interrupts selected with a '1' in their 'Select Interrupt A or B' bit. If the 'Clear Interrupt' bit is clear it has no effect.

10.10.4 Counter Interrupt Handling

There is only one main interrupt to the system from the 626. Once this interrupt has been received it is up to the user to determine whether it originated from the counters or the digital inputs.

The 'Counter Overflow Interrupt' flags (COINT) and the 'Index interrupt' flags (INDINT) of the MISC2 register (See "Table 22 Read from MISC2 92 (hex)" P23) must be checked to determine which counter & what event may have caused the interrupt. An interrupt must be cleared once it has been handled to prevent it from causing multiple interrupts.

11. Watchdog/Miscellaneous Registers

Table 19 Write to MISC1 88 (hex)							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
1=Write enable	Not used	Not used	EDCAP (See P 11)	Not Used	Not Used	Not Used	Not Used
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used

Table 20 Read from MISC1 88 (hex)							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
1=Write Enabled	1=Watchdog Timed out	Internal Register	EDCAP (See P 11)	Internal Register	Internal Register	Internal Register	Internal Register
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Internal Register	Internal Register	Internal Register	Internal Register	Internal Register	Internal Register	Internal Register	Internal Register

Table 21 Write to MISC2 90 (hex)							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
1=Clear watchdog	1=Charge Enable	Not used	Not used	Not used	Not used	0=Digital output 5	0=Digital output 4
						1=Counter 5 Overflow	1=Counter 4 Overflow
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0=Digital output 3	0=Digital output 2	0=Digital output 1	0=Digital output 0	1=Backup Battery Enabled	1=Watchdog Enabled	Watchdog period selection 00= $\frac{1}{8}$ th second 01= $\frac{1}{2}$ second 10=1 second 11=10 seconds	
1= Counter 3 Overflow	1= Counter 2 Overflow	1= Counter 1 Overflow	1= Counter 0 Overflow				

Table 22 Read from MISC2 92 (hex)							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
COINT2B	COINT2A	COINT1B	COINT1A	COINT0B	COINT0A	INDINT2B	INDINT2A
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
INDINT1B	INDINT1A	INDINT0B	INDINT0A	1=Backup Battery Enabled	1=Watchdog enabled	Watchdog period selection 00= $\frac{1}{8}$ th second 01= $\frac{1}{2}$ second 10=1 second 11=10 seconds	

The grayed bits do not read back the same registers.

11.1 Battery Charging

Bit 14 “Charge Enable” of MISC2 (92 hex) turns the trickle charging of an optional external backup battery on and off. The system will default to “Charging off” after a reset.

Before writing to any of the bits of MISC2, except bit 15 (Clear watchdog), the write enable (bit 15) of MISC1 must be set. This is to prevent accidental modification of the watchdog settings by a crashed CPU. It is a good idea to clear this bit immediately after writing to MISC2.

11.2 Watchdog Oscillator

11.2.1 Overview

Embedded systems often include a watchdog timer to regain program control following an unplanned loss of control by the PCI bus master. In such systems, the CPU is responsible for periodically clearing the watchdog timer. Should the CPU crash, the watchdog won't be cleared and will eventually overflow and cause the CPU to be reset through the PCI bus.

After a reset the watchdog timer is disabled and the watchdog oscillator selection is cleared.

To use the watchdog, it needs to be enabled and the watchdog period needs to be set.

Any external hardware also may be reset by the watchdog timer with the additional relay. This relay has one switched contact group insulated from internal circuit.

11.2.2 Testing the Watchdog Without Resetting the Host

Under normal conditions a watchdog time-out will cause the PCI bus to be reset. By removing jumper JP1 no PCI reset will occur although the watchdog will be fully functional internally. This may be useful during development as the status of the watchdog can be obtained from bit 14 of Misc1. A '1' means it has timed out. The watchdog output at JP1 is an 'open collector' output.

The relay watchdog output may be disabled by removing jumper J10.

11.2.3 Watchdog Enable & Period Selection

Bits 1 & 0 of MISC2 (92 hex) are used to select a period of $\frac{1}{8}$, $\frac{1}{2}$, 1 or 10 seconds while bit 2 is used to enable the watchdog. (See "Table 21 Write to MISC2 90 (hex)" P23).

Before writing to any of the bits of MISC2, except bit 15 (Clear watchdog), the write enable (bit 15) of MISC1 must be set. This is to prevent accidental modification of the watchdog settings by a crashed CPU. It is a good idea to clear this bit immediately after writing to MISC2.

Although the Enable and period selection bits are in the same register, first the register must be written to with the 'Watchdog Enable' bit = '1' (bit 2) and then the register must be written to again with bit 2 again = '1' and the period selection bits set as desired. This is because the period selection bits are held in a cleared state ($\frac{1}{8}$ th of a second) and cannot be changed until the 'Watchdog enable' bit is = '1'.

11.2.4 Clearing the Watchdog

To prevent a PCI reset the watchdog timer must be cleared at least once within the period of the watchdog timer. To do this bit 15 ("Write Enable") of MISC1 (88 hex) must first be cleared and then bit 15 (Clear watchdog) of MISC2 (92 hex) must be set. The clear watchdog bit is automatically cleared after the watchdog has been cleared.

11.2.5 Watchdog LED Status

If the watchdog is disabled the red LED will be off continuously.

When the watchdog is enabled the LED will be off for $\frac{1}{2}$ the selected watchdog period, then on for $\frac{1}{2}$ the period and then the watchdog will reset the PCI bus (Pulled low) if JP1 is inserted or if the jumper is not inserted then bit 14 of Misc2 will go high and the LED will flash at $\frac{1}{2}$ the selected watchdog period.

11.3 Digital Outputs 0-5 Source Selection

Bits 4-9 of MISC2 (90 hex) are used to select the function of Outputs 0-5.

They can be setup either as standard digital outputs or to pull the output load low for a short pulse when the corresponding counter overflows.

Before writing to any of the bits of MISC2, except bit 15 (Clear watchdog), the write enable (bit 15) of MISC1 must be set. This is to prevent accidental modification of the watchdog settings by a crashed CPU. It is a good idea to clear this bit immediately after writing to MISC2.

MISC2 can not be used to read back the value that bits 4-9 were previously set to. This has to be done by reading the Counter Register B of each counter as shown below.

Register	Bit	Digital I/O PIN	Function
CR0B (02 Hex)	14	0	0=Digital input, 1= Counter 0A Overflow
	13	1	0=Digital input, 1= Counter 0B Overflow
CR1B (06 Hex)	14	2	0=Digital input, 1= Counter 1A Overflow
	13	3	0=Digital input, 1= Counter 1B Overflow
CR2B (0A Hex)	14	4	0=Digital input, 1= Counter 2A Overflow
	13	5	0=Digital input, 1= Counter 2B Overflow

12. Battery Backup

A 3.6V Nickel Cadmium battery can be connected to the 626 using JP1. Make sure that it is connected correctly or damage will occur. It will be trickle charged at approximately 100mA if the “Charge Enable” bit of MISC2 is set.(See “Battery Charging” P23).

While the backup battery is connected & charged the system clock can be made to run during a power failure to ensure that the counters do not loose counts. To do this the “Battery Enable” bit of Misc2 must be set to enable the backup battery. In this state the counter setup registers and the count that the counter were at when the power failed will be held and the counters will continue to count so no counts will be lost. If a counter interrupt occurs during backup (like a counter overflow) then the appropriate interrupt register will be set (Counter overflow or index) but the interrupt enable is cleared when the main power to the system is restored and the system is booted. This is done to allow the user time to initialize everything. The moment the interrupts are re-enabled, the interrupt will be passed on to the system.

13. Analog Inputs

There are 16 analog input channels (0-15). Each channel can be set to have a $\pm 5V$ or $\pm 10V$ range, which will return a 16 bit value (including the sign) in the range ± 32767 .

A 'Poll List' is used to setup the A/D converter. This is a list containing 1-16 commands that will be executed sequentially every time the ReadADC command is used. Each command tells the converter which channel to convert (0-15) and what range to use ($\pm 5V$ or $\pm 10V$). The converter starts with the first command in the list and continues until it reaches a command with a '1' in bit 15 of the command or until the 16th command is executed. The results are placed in the array Data[0..15]. If the same set of channel & range combinations need to be read again the user needs only to execute another ReadADC command and the old Data will be overwritten with the new. When a new poll list needs to be set up, the CloseADC command needs to be executed to close the old list and then the ResetADC needs to be executed with the details of the new poll list. This poll list approach makes reading several channels much faster. Conversion takes approximately 20usec/channel. Once completely finished with the ADC the CloseADC command should be executed.

14. Analog Outputs

The analog channels have a 14 bit resolution (including sign).

It takes approximately 200 μ S to convert the digital value to an analog output voltage.

To use the Digital to Analog converter call the WriteDAC function and supply a channel and an output value between -8191 and $+8191$. This will be converted to an analog voltage between $\pm 10V$ at the specified output channel.

Each D/A has a sense input that should be connected to the D/A output at the end of the wire used to connect to whatever external circuit is used with the D/A. This will help keep noise down.

If this feature is not used then insert the jumpers which in effect connects the sense input to the D/A output right on the board.

J6, J7, J8 & J9 are inserted to disable the sense inputs for channels 0 -3 respectively.

Appendix A: Specifications

General

Interface	Parameter	Description
Bus	Type	PCI, 32-bit, 33MHz
Watchdog	Output characteristics	Open collector, Relay
	Timeout	1/8, 1/2, 1 & 10 seconds
Encoders	Input characteristics	Differential pair/TTL/CMOS compatible
	Counter size	24 bits
	Encoder channels	6
I/O	Input characteristics	TTL/CMOS compatible.
	Configuration	Each channel can be either input or output
	Number of I/O	48
Battery	Type	3.6V Nickel Cadmium rechargeable (Optional)
	Charge rate	62.5mA
A/D	Resolution	14 bits
	Input Range	Individually selectable between $\pm 5V$ and $\pm 10V$
	A/D Channels	16
	Conversion time	Approximately 20usec/channel
D/A	Resolution	14 bits including sign
	Output range	$\pm 10V$
	D/A Channels	4
	Conversion time	Approximately 200usec/channel

Limits

	Parameter	Typical	Min	Max	Units
I/O	Output sink current			100	mA
	Captured pulse width		250		ns
Watchdog	Max current sink			500	mA
Power	Operating range		+4.75	+5.25	V
	Operating range +12V		+11.6	+15	V
	Operating range -12V		-15	-11.6	V
	Quiescent current (not charging)	450			mA
Battery	Charging current	50	0	62.5	mA
	Battery drain under backup	60			mA
	Battery drain with charger off and not in backup mode	5			mA
Encoder	Internal timer mode			2	MHz
	Externally driven		0	500KHz	MHz
Temperature	Operating range		0	70	C

Appendix B: Digital I/O Connectors

J2		
50 pin IDC ribbon connector		
Digital I/O 1 - 24		
Pin	Function	User Designation
1	DIO23	
3	DIO22	
5	DIO21	
7	DIO20	
9	DIO19	
11	DIO18	
13	DIO17	
15	DIO16	
17	DIO15	
19	DIO14	
21	DIO13	
23	DIO12	
25	DIO11	
27	DIO10	
29	DIO9	
31	DIO8	
33	DIO7	
35	DIO6	
37	DIO5	
39	DIO4	
41	DIO3	
43	DIO2	
45	DIO1	
47	DIO0	
49	5V	
All even pins	Ground	

J3		
50 pin IDC ribbon connector		
Digital I/O 25 - 48		
Pin	Function	User Designation
1	DIO47	
3	DIO46	
5	DIO45	
7	DIO44	
9	DIO43	
11	DIO42	
13	DIO41	
15	DIO40	
17	DIO39	
19	DIO38	
21	DIO37	
23	DIO36	
25	DIO35	
27	DIO34	
29	DIO33	
31	DIO32	
33	DIO31	
35	DIO30	
37	DIO29	
39	DIO28	
41	DIO27	
43	DIO26	
45	DIO25	
47	DIO24	
49	5V	
All even pins	Ground	

Appendix C: Encoder Connectors

Table 24 Encoder Connectors					
J5					
26 pin IDC ribbon connector					
Encoder 1A – 3A					
Pin	Function	User Designation	Pin	Function	User Designation
1	Encoder (0A) A-		2	Encoder (0A) A+	
3	GND		4	Encoder (0A) B-	
5	Encoder (0A) B+		6	5V	
7	Encoder (0A) I-		8	Encoder (0A) I+	
9	GND		10	Encoder (1A) A-	
11	Encoder (1A) A+		12	5V	
13	Encoder (1A) B-		14	Encoder (1A) B+	
15	GND		16	Encoder (1A) I-	
17	Encoder (1A) I+		18	5V	
19	Encoder (2A) A-		20	Encoder (2A) A+	
21	GND		22	Encoder (2A) B-	
23	Encoder (2A) B+		24	5V	
25	Encoder (2A) I-		26	Encoder (2A) I+	

J4					
26 pin IDC ribbon connector					
Encoder 1B – 3B					
Pin	Function	User Designation	Pin	Function	User Designation
1	Encoder (0B) A-		2	Encoder (0B) A+	
3	GND		4	Encoder (0B) B-	
5	Encoder (0B) B+		6	5V	
7	Encoder (0B) I-		8	Encoder (0B) I+	
9	GND		10	Encoder (1B) A-	
11	Encoder (1B) A+		12	5V	
13	Encoder (1B) B-		14	Encoder (1B) B+	
15	GND		16	Encoder (1B) I-	
17	Encoder (1B) I+		18	5V	
19	Encoder (2B) A-		20	Encoder (2B) A+	
21	GND		22	Encoder (2B) B-	
23	Encoder (2B) B+		24	5V	
25	Encoder (2B) I-		26	Encoder (2B) I+	

In non-encoder modes A is direction, B is count and I is index.

The counter number is shown in brackets.

A+, B-, I+ etc shows the phase & polarity of the quadrature inputs.

Example: (2A) A+ is the positive line (Non inverted) of the A phase of counter 2A.

Appendix D: A/D and D/A Connectors

J1					
50 pin IDC ribbon cable connector					
Analog inputs & outputs					
Pin	Function	User Designation	Pin	Function	User Designation
1	Shield (Chassis)		2	Ground	
3	-AD0		4	+AD0	
5	-AD1		6	+AD1	
7	-AD2		8	+AD2	
9	-AD3		10	+AD3	
11	-AD4		12	+AD4	
13	-AD5		14	+AD5	
15	-AD6		16	+AD6	
17	-AD7		18	+AD7	
19	Ground		20	Ground	
21	-AD8		22	+AD8	
23	-AD9		24	+AD9	
25	-AD10		26	+AD10	
27	-AD11		28	+AD11	
29	-AD12		30	+AD12	
31	-AD13		32	+AD13	
33	-AD14		34	+AD14	
35	-AD15		36	+AD15	
37	Ground		38	Ground	
39	Ground		40	Ground	
41	Sense1		42	DAC0	
43	Sense2		44	DAC1	
45	Sense3		46	DAC2	
47	Sense4		48	DAC3	
49	Ground		50	Shield (Chassis)	