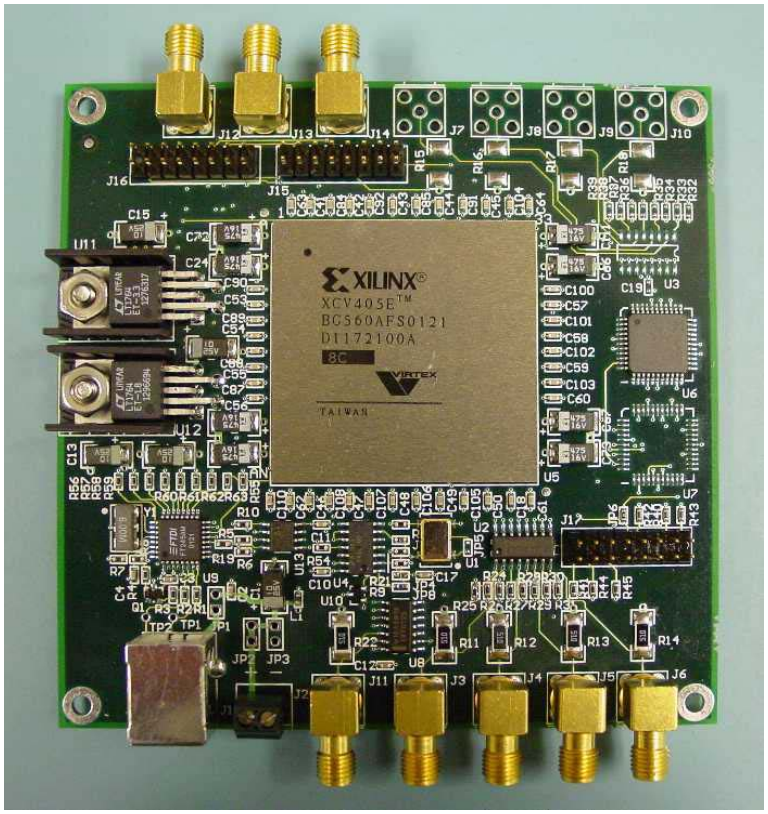
AMCS-USB

Advanced Multichannel Scaler – 4 Channel USB



USER'S MANUAL

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ASRC AEROSPACE
6303 Ivy Lane
Suite 800
Greenbelt, Maryland 20770
http://www.akspace.com

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1 Overview

The AMCS-USB is a four input multichannel scaler card to be used in pulse counting, integrating, and histogramming applications. The AMCS-USB accepts four different pulse inputs that are counted simultaneously based upon a single Sync input signal. In addition, there are two generic pulse outputs and a third accumulation delay pulse indicating the start of an integration cycle. Parameters such as time resolution per bin, number of bins, accumulation delay, number of accumulations, and pulse polarity are set by the user via software control. At the end of an integration cycle, data is transmitted to a host CPU via the USB 1.1 bus. The AMCS-USB card has a small (4.2" x 4.2") form factor and is intended to be connected to a PC via a standard USB compliant A-B cable.

1.1 Operational Scheme

Upon system power-up, the AMCS-USB card is reset and configured via software control executing on the host CPU. After the host CPU sends the "Start Acquisition" command the AMCS-USB begins to detect input Sync signals, and the first detector pulse accumulation cycle begins (based on the CPU-set parameters). This continues until a full integration cycle is complete (i.e. until the last bin of the last accumulation cycle is reached). When the integration cycle ends, the AMCS-USB card begins to transmit acquired data back to the host.

The AMCS-USB card utilizes a ping-pong memory approach. The A-side memories are first used in holding the acquired data. While the data is being transferred to the host from the A-side memories, B-side memories begin to acquire data for the subsequent integration cycle. *In this "ping-pong" approach, the AMCS-USB card allows for continuous data acquisition with no data loss as long as the data transfer time to the host requires less time than an integration cycle.* Data transfers to the host PC will continue at the end of each integration cycle such that the internal ping-pong memory scheme is transparent to the host PC software.

Note the following:

```
# of bytes to transfer each integration = ( # of bins) x (2 bytes/bin) x (# of channels)

Available transfer time = (# of accumulations) x (1/laser PRF)
```

The AMCS-USB card sends data for only the channels used. That is, if only three of four channels are selected, for example, the AMCS-USB card will first send channel 1 data, then channel 2 data and finally channel 3 data in sequence. Software on the host PC is made known of this data transfer via USB bus messages and by employing drivers provided by FTDI (http://www.ftdichip.com) at no cost. FTDI is the manufacturer of the USB bus controller used on the AMCS-USB card.

The AMCS-USB precedes each integration cycle's data with a 2-byte header such that the receiving software can stay synchronized with incoming data. The data format returned, then, is:

```
Header Byte 1:     0xA & 4-bit integration cycle counter
Header Byte 2:     0x5 & 4-bit integration cycle counter
Byte 1:            Low-Data Byte of Bin #1
Byte 2:            High-Data Byte of Bin #1
...                ...
Byte n-1:          Low-Data Byte of Bin #(n/2)
Byte n:            High-Data Byte of Bin #(n/2)
```

Where `n` =
(Total number of bytes transferred to host after each integration) =
(number of bins)x(2 bytes/bin)x(number of channels)

When data acquisition has completed, the host CPU sends the "Stop Acquisition" command, and all subsequent incoming Sync pulses will be ignored. Note that the host PC software may need to flush its USB data buffers in order to ensure that data from the "last" acquisition cycle is discarded.

2 Card I/O

The AMCS-USB utilizes a USB B-type connector compliant with the USB 1.1 specification. In addition to the bus interface, the AMCS-USB has other inputs and outputs located on SMA connectors on the card.

The AMCS-USB external signal description is shown in Table 1.

Signal Name	Type	Connector	Polarity	Description
+5V Power	Input	Terminal Block (J2)	Positive	External power ~ 4 Watts (for margin)
USB Data +/-	Bi-dir	USB B-Type (J1)	N/A	USB Data +/- for Tx and Rx
Sync Pulse	Input	SMA (J11)	User Selectable	Output from laser indicating light emission forthcoming
Detector Pulses 1:4	Input	SMA (J3-J6)	Positive	Active high pulses from detectors At least 1V in amplitude
Accumulation Delay Pulse	Output	SMA (J14)	Positive	Output indicating start of accumulation cycle for given Sync input
Pulse A	Output 50 ohm	SMA (J12)	User Selectable	Fixed output pulse of 161 ns accompanying each Sync input – User selectable delay from Sync
Pulse B	Output 50 ohm	SMA (J13)	User Selectable	Fixed output pulse of 5.12 us accompanying each Sync input – User selectable delay from Sync

Table 1: AMCS-USB Signal I/O

2.1 Card Inputs

The Sync input is a pulse that commences an accumulation sequence if the "Start Acquisition" command has been issued. The Sync signal must be a pulse with at least 2V in amplitude and at least 25 ns wide. Furthermore, the AMCS-USB card presents a 50 ohm load on this input. The AMCS-USB card will respond to either the rising edge or the falling edge of the Sync pulse depending on the pulse polarity register's Sync pulse polarity setting. The period of subsequent Sync pulses must not be less than the ([time per bin] x [number of bins]) or the AMCS-USB card will not function properly. In a lidar application, the Sync pulse indicates imminent firing of the laser.

The four Detector inputs are accumulated and integrated by the AMCS-USB card. Each of these pulses must be an active high pulse with at least 1V in amplitude and with a nominal width of 10 ns. Subsequent

Detector pulses must be no less than 25 ns apart (rising edge-to-rising edge). Exceeding any of these limits may result in incorrect pulse counts. Furthermore, the AMCS-USB card presents a 50 ohm load on each detector input.

EG&G single photon counting module (SPCM) detectors with output widths of 9 ns as well as Hamamatsu photomultiplier tubes (PMT) with output widths of 10.5 ns would work well as Detector inputs..

As there is a single Sync input, all four channels are operated concurrently using the selected card settings.

2.2 Card Outputs

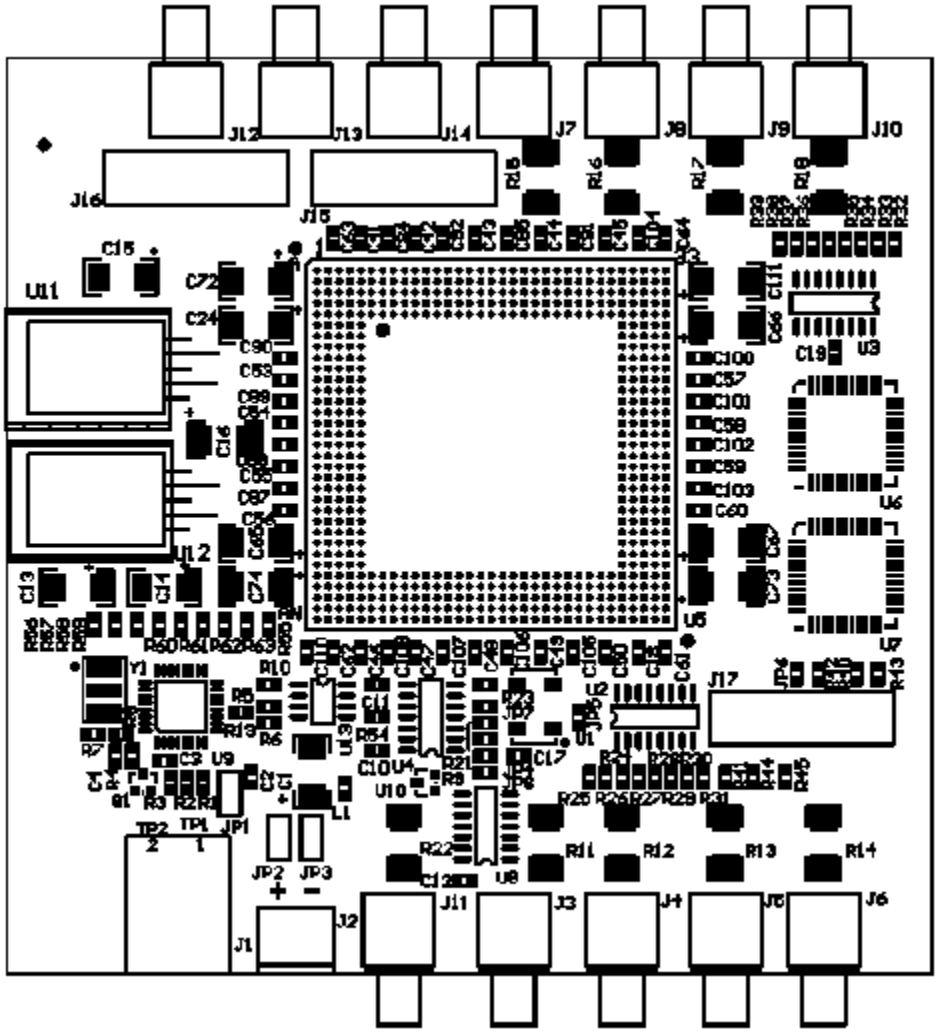
The Accumulation Delay Pulse is an active high output that indicates the point at which the AMCS-USB card begins an acquisition cycle. After the AMCS-USB card receives the Sync pulse, the accumulation delay register is used to wait a predetermined amount of time. When this time elapses, the start of the accumulation cycle (and the start of the first bin) begins as signified by the rising edge of the pulse. This output pulse is a high going 10 ns wide pulse. It is intended to be a guide for setting the accumulation delay parameter in that the user may view both the laser sync pulse and the accumulation delay pulse with an oscilloscope in determining specific mission needs. There is exactly one Accumulation Delay pulse output for each recognized Sync pulse input.

The Pulse A signal is an output pulse with a fixed width of 161 ns. This output provides a high output between 2V to 3.1 V and a low output between 0.2 V and 0.55V. It can drive a 50 ohm load. This pulse has a tolerance of +/- 160 ns. The polarity of this pulse may be set either active high or active low as per the board pulse polarity register. After the AMCS-USB card receives the Sync pulse, the Pulse A delay register is used to wait a predetermined amount of time. When this time elapses, the Pulse A signal is generated. There is exactly one Pulse A output for each recognized Sync pulse input (once the “Start Acquisition” command has been issued) such that this pulse may be used for a general-purpose applications.

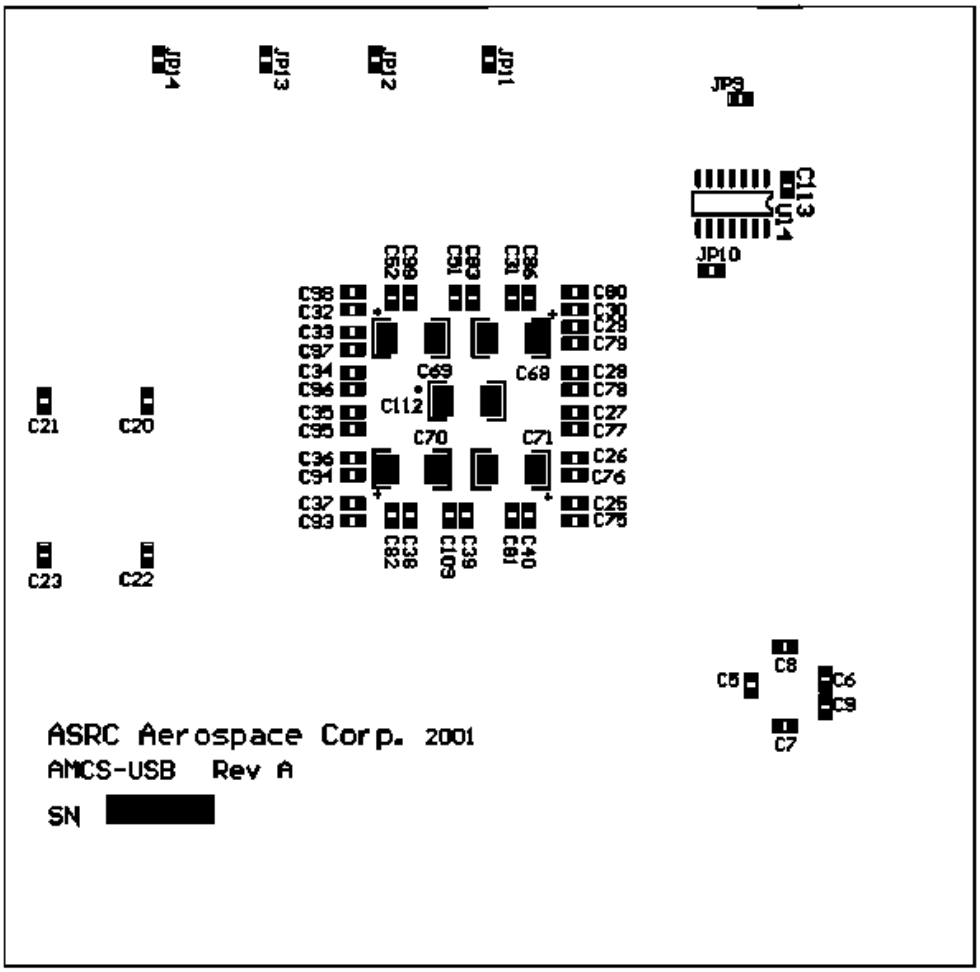
The Pulse B signal is an output pulse with a fixed width of 5.12 us. This output provides a high output between 2V to 3.1 V and a low output between 0.2 V and 0.55V. It can drive a 50 ohm load. This pulse has a tolerance of +/- 160 ns. The polarity of this pulse may be set either active high or active low as per the board configuration register. After the AMCS-USB card receives the Sync pulse, the Pulse B delay register is used to wait a predetermined amount of time. When this time elapses, the Pulse B signal is generated. There is exactly one Pulse B output for each recognized Sync pulse input (once the “Start Acquisition” command has been issued) such that this pulse may be used for a general-purpose applications.

3 Assembly Drawings

Top Side



Bottom Side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ASRC Aerospace Corp. 2001
AMCS-USB Rev A
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4 Card Setup

The AMCS-USB card acts like a self-powered USB peripheral device. External power (+5V @ ~4 W) is provided at the terminal block. Before using the AMCS-USB card, a host computer must be setup to utilize its USB 1.1 port and must have the drivers installed. Software running on the host must utilize drivers provided by the USB controller's manufacturer. These may be downloaded royalty free from FTDI at http://www.ftdichip.com.

5 Host –to- AMCS-USB Commands

The AMCS-USB card is a USB peripheral and responds to a set of commands that are issued via CPU control across the USB. These commands are described below and are summarized in Table 2.

Host -to- AMCS-USB Commands					
USB Host-To-Card 8-Bit Opcode	**Command Description**	**# of Data Bytes Allocated**	**Data Field Parameters**	**Data Field Description**	**Default Data Field (Hex and Decimal Values Shown)**
XXXX0001	**Write Configuration Registers**	**1**	**14-bytes in order below; 2-byte paramters are little endian**	**The following 14 bytes must follow immediately after command byte**	
	Write Pulse Polarity	1	3-Bit Register	3-Bit Register [2] = Sync Pulse Polarity [1] = Pulse A Polarity, [0] = Pulse B Polarity,	0x7 = 7
	Write Number of Channels Used	1	2-Bit Register	Value = (n-1) where n = 1 to 4 channels	0x3 = 3
	Write Number of Bins	2	12-Bit Register	Value = 2 to 4095	0x682 = 1666
	Write Number of Accumulates	2	15-Bit Register	Value = 1 to 32767	0x1F4 = 500
	Write Time Per Bin	2	10-Bit Register	Value = 5 to 1023 @ 10 ns	0xA = 10 (@ 10 ns = 100 ns)
	Write Accumulation Delay	2	7-Bit Register	Value = 1 to 127 @ 10 ns	0x14 =20 (@ 10 ns = 200 ns)
	Write Pulse A Delay	2	12-Bit Register	Value = 1 to 4095 (+1 to 2) @ 80 ns	0xD =13 (@ 80 ns = 1.04 us)
	Write Pulse B Delay	2	12-Bit Register	Value = 1 to 4095 (+1 to 2) @ 80 ns	0x84D = 2125 (@ 80 ns = 170 us)
XXXX0010	**Software Reset of All FIFOs**	**0**	**[No Data Parameters]**	-	-
XXXX0011	**Software Reset of Card**	**0**	**[No Data Parameters]**	-	-
XXXX0100	**Start Acquistion**	**0**	**[No Data Parameters]**	-	-
XXXX0101	**Stop Acquisition**	**0**	**[No Data Parameters]**	-	-
XXXX0110	**Read Configuration Registers**	**14**		**(Configuration register data sent to host in same byte order as written above)**	

Table 2: Host-to- AMCS-USB Commands

5.1 Detailed Command Descriptions

Command: Write Configuration Registers

The host writes to the configuration registers with one single command followed by 14-bytes immediately following the command opcode. Failure to comply with this sequence will result in improper operation of the AMCS-USB card. The 8-bit opcode is: XXXX0001, where "X" signifies a "don't care" value. In cases where a full byte is allocated to a register value but where the register has a maximum of less than one byte, the unused bits are don't care values.

Note that if the minimum value specified below for any parameter is violated, the AMCS-USB restores the register contents to the default (reset) value.

Write Pulse Polarity (Byte 1)
One byte is allocated. This 3-bit register is mapped as follows:

[7:4]	-	Unused
[3]	-	Sync Pulse Polarity
[2]	-	Pulse A Polarity
[1]	-	Pulse B Polarity

When the Sync Pulse Polarity bit is set to a logic 1, the polarity is high. Otherwise, the polarity of the signal is low.

When the Pulse A or Pulse B Polarity bit is set to a logic 1, the polarity is low. Otherwise, the polarity of the signals is high.

The default value is 0x7.

Write Number of Channels Used (Byte 2)
One byte is allocated. This 2-bit register is set to a value of n-1 where n = 1 to 4 channels. For example, for 4 channels, this register should be set to a value of 0x3.

Write Number of Bins (Bytes 3-4)
Two bytes are allocated. This 12-bit register is set between 2 and 4095 bins. Each bin represents a duration of time as determined by the Time Resolution Per Bin register. This register has a value of 0x682 (1666 bins) upon reset.

Write Number of Accumulat*es (Bytes 5-6)*
Two bytes are allocated. This 15-bit register is set between 1 and 32767 accumulations per integration cycle. This register has a value of 0x1F4 (500 accumulates) upon reset.

Write Time Resolution Per Bin (Bytes 7-8)
Two bytes are allocated. This 10-bit register is set between 5 and 1063. This written value is multiplied by the AMCS-USB internal clock rate of 10 ns such that the valid range is from 50 ns to 10.63 us. This register has a value of 0xA (10) upon reset such that the default time per bin is 100 ns.

Write Accumulation Delay (Bytes 9-10)

Two bytes are allocated. This 7-bit register is set between 1 and 127. The written value is multiplied by the AMCS-USB internal clock rate of 10 ns such that the valid range is from 10 ns to 1.27 us. This register has a value of 0x14 (20) upon reset such that the default accumulation delay is 200 ns. Refer to the Accuracy section in this document for additional notes.

The Accumulation Delay Pulse output serves as an indication of when the integration cycle (i.e. the start of the first bin time) begins. The start of the first bin occurs coincident with the *falling* edge of this active high pulse.

Write Pulse A Delay (Bytes 11-12)

Two bytes are allocated. This 12-bit register is set between 1 and 4095. The written value is multiplied by the AMCS-USB internal clock rate of 80 ns such that the valid range is from 80 ns to 327.6 us. This register has a value of 0xD (13) upon reset such that the default accumulation delay is 1.04 us. Note that the Pulse A generator uses a coarser clock than the other time-critical signals on the card and may vary by up to two 80 ns clocks. Refer to the Accuracy section in this document for additional notes.

Write Secondary Pulse Delay (Bytes 13-14)

Two bytes are allocated. This 12-bit register is set between 1 and 4095. The written value is multiplied by the AMCS-USB internal clock rate of 80 ns such that the valid range is from 80 ns to 327.6 us. This register has a value of 0x84D (2125) upon reset such that the default accumulation delay is 170 us. Note that the Pulse B generator uses a coarser clock than the other time-critical signals on the card and may vary by up to two 80 ns clocks. Refer to the Accuracy section in this document for additional notes.

Command: Software Reset of All FIFOs

The host writes this command with a single opcode and no data parameters. The 8-bit opcode is: XXXX0010, where "X" signifies a "don't care" value. Upon issuing this command, the AMCS-USB card resets both the A and B side FIFOs of each of the four data collection channels.

Command: Software Reset of Card

The host writes this command with a single opcode and no data parameters. The 8-bit opcode is: XXXX0011, where "X" signifies a "don't care" value. Upon issuing this command, the AMCS-USB card resets such that all card-level parameters are restored to their default values.

Command: Start Acquisition

The host writes this command with a single opcode and no data parameters. The 8-bit opcode is: XXXX0100, where "X" signifies a "don't care" value. Upon issuing this command, the AMCS-USB card commences acquisition. Any input Sync pulses to the card are acknowledged after this command is received, and data collection commences.

Command: Stop Acquisition

The host writes this command with a single opcode and no data parameters. The 8-bit opcode is: XXXX0101, where "X" signifies a "don't care" value. Upon issuing this command, the AMCS-USB card commences acquisition. Any input Sync pulses to the card are ignored after this command is received, and data collection commences. Note that due to the serial nature of the USB interface, the a Sync signal may be acknowledged (and a new data collection cycle started) after the stop command has been issued by the host but before it has been received by the AMCS-USB. Therefore, the host software should flush its data buffer and ignore any data returned by the AMCS-USB after the stop command has been issued.

Command: Read Configuration Registers

The host writes this command with a single opcode and no data parameters. The 8-bit opcode is: XXXX0110, where "X" signifies a "don't care" value. Upon issuing this command, the AMCS-USB card sends the contents of all configuration registers back to the host. This 14-byte message is presented to the host in the same order that it was written as in the "Write Configuration Registers" command.

6 Accuracy

The AMCS-USB card utilizes digital logic schemes to recognize the input Sync pulse and to capture, accumulate, and integrate incoming Detector pulses. Therefore, variance on a pulse-to-pulse basis should be considered with regard to the sampling clock. The AMCS-USB card operates at a clock speed of 100 MHz thereby providing a clock period of 10 ns. The AMCS-USB card detects the Sync input as well as the Detector pulse inputs within one to two clock periods.

The variability with regard to the Sync input suggests that one should compensate by reducing the accumulation delay register value by one as set via the host CPU. This would yield a variance between zero and one clock for each incoming Sync pulse.

The variability with regard to the Detector pulse inputs suggests that one should shift all bins back in time by one clock. This would yield a variance between zero and one clock for each incoming Detector input pulse and help to prevent detector pulses from being placed improperly in the "next" bin.

As the effect of the Sync input variability is to shift the bins in time by zero to one clock (given the [n–1] clock accumulation delay register value), the Sync pulse inaccuracy and Detector pulse inaccuracy counter-balance each other. This yields an overall inaccuracy of zero to one clock for each input signal.

The Pulse A and Pulse B outputs use a clock period of 80 ns and exhibit one to two clocks of variability. Again, the host CPU may write a value of (n-1) to the start delay register and the secondary delay register to attain zero to one clock of variance. These pulses are meant to be used on a per shot basis for such applications as A/D conversion on every laser shot where high precision per shot is not required.

7 Power / Environment / Usage

The AMCS-USB card is intended to be used with a host PC such as a laptop PC. It must receive +5V power externally. While the AMCS-USB card's power is low, it exceeds the USB bus-powered specifications. Total power consumption for the card while acquiring data has been measured at approximately 3.2 W @ 5V. At least a 4 W supply is recommended for margin.

The AMCS-USB card has been tested in ambient laboratory conditions at room temperature. The parts used on the AMCS-USB card are rated for operating temperatures beyond commercial specifications. Industrial components have been used where possible. In other cases, commercial parts have been de-rated to account for temperature variation or extended-commercial components have been used. Please contact ASRC Aerospace Corporation if there are any environmental concerns.

Adequate airflow should be provided if the AMCS-USB card is placed in an enclosure such that all devices operate at low operating temperatures.