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# **MODEL USB-DA12-8A**

**Eight Channel Digital to Analog Converter  
with ARB (Arbitrary Waveform Generator)**

## **USER MANUAL**

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# Chapter 1: Introduction

## Features

- High-speed USB 2.0 device, USB 1.1 compatible
- Small, portable 8-channel, 12-bit, digital to analog converter outputs
- Double-buffered allowing simultaneous update of all DAC's
- Up to 125K conversions per DAC per second
- Streaming USB waveform data at over 400,000 DAC outputs per second total
- ILDA (International Laser Display Association) compatible outputs
- 256K byte buffer on-board, or infinitely long streaming waveforms
- Buffered waveforms at up to 1 million DAC conversions per second total
- Analog output ranges of 0-2.5V, 0-5V, 0-10V,  $\pm 2.5V$ ,  $\pm 5V$ ,  $\pm 10V$
- Single-ended and differential outputs on separate connectors
- Custom high-speed function driver
- PC/104 module size and mounting compatibility
- Small (4"x4"x1.75") rugged industrial enclosure
- DB25M and DB25F enclosure mounted I/O connectors

## Applications

- Portable / Laptop
- Education / Laboratory
- Industrial Automation
- Embedded OEM
- ILDA Laser Driver

## Functional Description

The USB-DA12-8A is an ideal solution for adding portable, easy-to-install analog outputs to any computer with a USB port. The unit is a high speed USB 2.0 device, offering the highest speed available with the USB bus. It is fully compatible with both USB 1.1 and USB 2.0 ports. The board is plug-and-play allowing quick connection whenever you need additional I/O on a USB port.

This product features 8 digital-to-analog converters (DACs) with both differential and single-ended outputs on separate connectors. The board features unipolar and bipolar ranges for each DAC giving the user a variety of options. The DACs can be updated individually or simultaneously. To ensure that there will not be excessive outputs to external circuits when the board is plugged in, automatic circuits limit analog outputs to zero volts. Five Volt (5V) Power is supplied to the board by an external regulated power supply which powers DC/DC converters to provide  $\pm 12V$  to the operational amplifiers on the board. The I/O wiring depends on the model option(s) ordered. For the OEM version, connections are via industry standard, IDC type 26-pin, 16-pin and 10-pin connectors. For full, standard versions, connections are made to the IDC connectors on-board via internal cables from enclosure mounted DB25 connectors, with one screw terminal accessory being included (model ADAP25).

The USB-DA12-8A is designed to be used in rugged industrial environments but is small enough to fit nicely onto any desk or testing station. The board is PC/104 sized (3.550 by 3.775 inches) and ships inside a steel powder-coated enclosure with an anti-skid bottom.

### Model Options

USB-DA12-8A	Module installed in an enclosure with two (2) DB25 I/O connectors and one (1) screw terminal accessory (ADAP25)
-OEM	Board only version with I/O headers
-PR	Power Adaptor, AC/DC 5V regulated.

### Special Order

Resistors in series with differential connector for impedance matching, contact factory with your requirement.

### Included with your shipment

The following components are included with your shipment, depending on options ordered. Please take the time now to ensure that no items are damaged or missing.

- USB-DA12-8A
- ADAP25, Screw Terminal Adaptor, qty 1
- 6' USB cable
- 115VAC to 5VDC Regulated Power Supply wall adaptor
- Software Master CD
- USB I/O Quick-Start Guide

### Optional Accessories

- ADAP25(M), Screw Terminal Adaptor (an additional unit could be needed if you intended on using the Single-Ended *and* the Differential Analog Outputs).
- -DIN DIN Rail Mounting Provision

## Specifications

### Analog Outputs

Number of Outputs:	8 channels
Type of Outputs:	Single-ended and differential
Resolution:	12-bit resolution
Unipolar Ranges:	0-2.5V, 0-5V, 0-10V
Bipolar Ranges:	±2.5V, ±5V, ±10V
Conversion Rate:	125kHz, all channels simultaneous
Relative Accuracy:	±2 LSB typical
Differential Non-linearity:	±0.2 LSB typical
Settling Time:	8us typical, 10us max
Output Current:	6mA per channel

Bus Type                      USB2.0 High-speed, USB1.1 Full-speed compatible

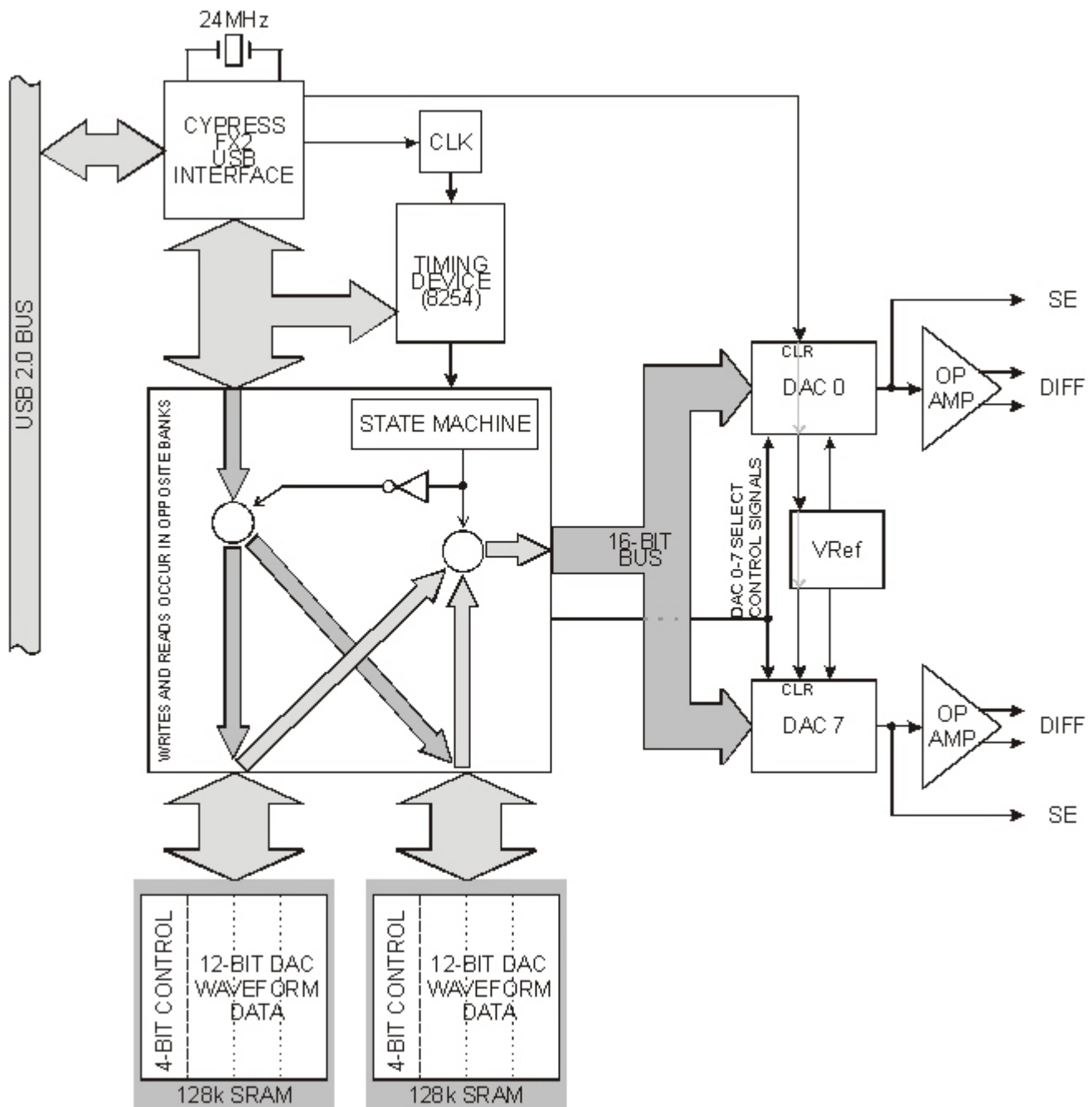
### Environmental

Operating Temperature:	0° to 70°C
Storage Temperature:	-40° to +85°C
Humidity:	5% to 95% non-condensing
Board Dimension:	3.550 x 3.775 inches
Box Dimension:	4 x 4 x 1.75 inches tall

### Power

+5VDC @ ~520mA typical, no-load on DAC outputs\*\*

\*\* Regulated AC/DC adapter should be ordered (“-PR” option) together with the board as the minimum current draw exceeds that which the USB port can provide by default.



**Figure 1-1: Block Diagram**




# Chapter 2: Installation

## Software CD Installation

This paragraph is intended to detail the software installation steps.

The software provided with this board is contained on one CD and must be installed onto your hard disk prior to use. To do this, perform the following steps as appropriate for your software format and operating system. Substitute the appropriate drive letter for your CD-ROM or disk drive where you see d: in the examples below.

### WIN95/98/Me/NT/2000/XP/2003

- a. Place the CD into your CD-ROM drive.
- b. The CD should automatically run the install program. If the install program does not click START | RUN and type d:install, click OK or press .
- c. Follow the on-screen prompts to install the software for this board.

## Hardware Installation

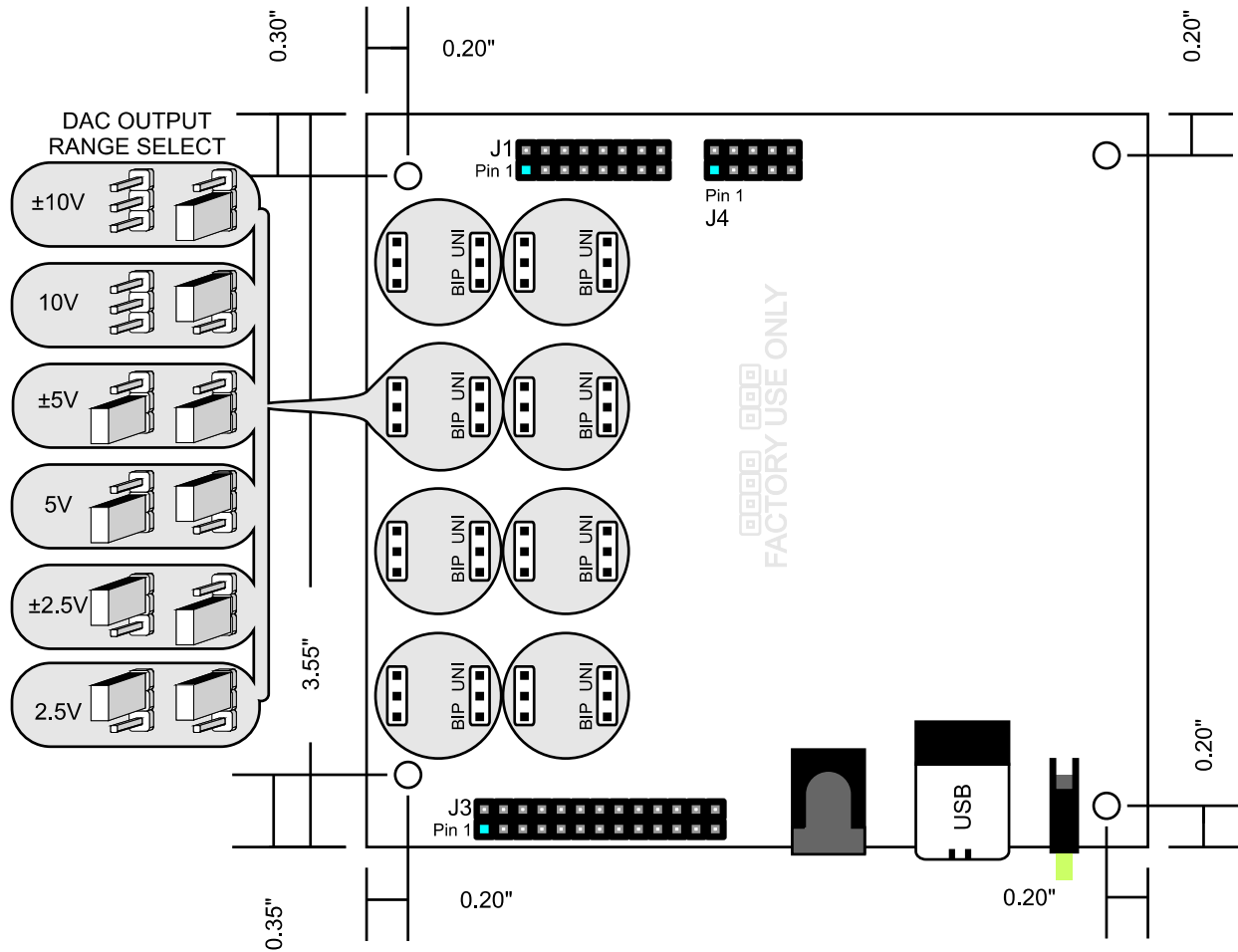
The USB-DA12-8A board can be installed in any USB 2.0 or USB 1.1 port. Please refer to the USB I/O Quick Start Guide which can be found on the CD, for specific, quick steps to complete the hardware and software installation.

### USB I/O Quick-Start Guide

Provides quick and straight-forward steps to complete the software and hardware installation of this product in your system.

# Chapter 3: Option Selection

Refer to the setup programs on the CD provided with the board. Also, refer to the Block Diagram and the Option Selection Map when reading this section of the manual.



**Figure 3-1: Option Selection Map**

**DC Power Jack**

This is the DC input connector used to provide a regulated +5V power supply to the card without using the USB bus. Be sure to order option -PR so this wall adaptor will be included with your shipment.

**Output Voltage Range Jumpers**

Use the jumpers to select the range that you wish to use. Each channel is configured individually for the following output possibilities.

0 to 2.5V	0 to 5V	0 to 10V	-2.5 to 2.5V	-5 to 5V	-10 to 10 V
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**Differential Outputs (J3)**

These are the Differential DAC outputs.

**Control and Monitoring (J4)**

This 10-pin connector provides an alternate means to start and stop the ARB and monitor it's status.

**Single Ended Outputs (J1)**

These are the Single Ended DAC outputs.

**USB Connector**

The USB connector on this board is a USB type B.

**LED Light**

LED indicates Power and Activity

## Chapter 4: USB Address Information

Use the provided driver to access the USB board. This driver will allow you to determine how many supported USB devices are currently installed, and each device's type. This information is returned as a Vendor ID (VID), Product ID (PID) and Device Index.

The board's VID is "0x1605", and its PID is "0x8001".

The Device Index is determined by how many of the device you have in your system, and provides a unique identifier allowing you to access a specific board at will.

## Chapter 5: Programming

The installation program on the CD will install four PDF manuals to your hard drive. These are the USB I/O Quick-Start Guide, User Manual, Software Reference Manual, and super-software-tech manual; Vendor Requests.

### Software Reference Manual

Details our various drivers and sample programs in a number of programming languages as well as providing insight into the most optimum combination of language, environment/OS and hardware selection available.

### Vendor Requests

This file provides information on a RAW USB INTERFACE for very low-level programming, generally in Operating Systems other than Windows.

### USB-DA12-8A Vendor Request document text

This device was originally designed for ILDA waveform playback. ILDA is used heavily in the laser "movie" environment, for laser light-shows. As a result, much of the terminology used in this document refers to a "movie" file. In every case where "movie" occurs you can use "waveform" just as precisely. Where you see movie-centric terms like "play" you can substitute "start" or "run".

Vendor Specific (endpoint 0, control) Requests B0, B1, B2, B3, B4, and B5 (hex) are defined by the firmware.

(Just to define some terms:

setupdat[5] is MSB of "index", setupdat[4] is LSB of index.

setupdat[3] is MSB of "value", setupdat[2] is LSB of value.

)

### Endpoint 0 Vendor Requests:

**B0:** One byte passed down in Value (setupdat[2]). Bit 7 is "reset", d6 is "pause", d0 is "play"

If D7 is set, the cpld is reset, run is stopped, and the LEDs are reset to off.

If D6 is set nothing particular happens. This bit is reserved for future use.

If D0 is set the DAC reference voltage is woken up (voltage starts coming out the DACs), and the SRAM starts playing.

**B1:** setupdat[4] is LSB and setupdat[5] is MSB, of the location in the onboard SRAM that bulk transfers should load into. Each bank is 0x1FFF in size. Bank 0 through Bank 7 map contiguously to create a 0xFFFF byte buffer. Writing to the 0xFFFFth byte causes the SRAM to toggle to the other SRAM. Setupdat[3] is the "bank", and only 0-7 are valid. B1 must be called before endpoint 2 can be used to load the data into the SRAM.

**B2:** Index holds the counter load value for the "RATE" counter. This divisor controls the rate at which the SRAM will feed out into the DACs. A load value of 190h works out to 30KHz update rate.

**B3:** reserved for future use

**B4:** this causes the endpoint to lockup until the SRAM switches from the current to the next.

**B5:** reserved for future use

### Endpoint 2: Bulk Data In

Does nothing (and probably hangs) if you haven't called Vendor Request B1

Takes the blocks of data and writes them into the SRAM. Don't load more data than the sum of both SRAMs.

### How to use this information:

To use the card, issue a Vendor request B0-reset, issue a Vendor request B2 to select the rate you want the counters to run, then load the onboard memory.

This board contains two SRAMs, each 64KBytes long, for a total of 64KWords of onboard storage. The board has two internal pointers, a "play" pointer, and a "write" pointer. Calling VR B1 sets the write pointer. So does issuing a reset via VR B0 (to zero). The play pointer is set to zero, in the \*other\* SRAM. Setting the write pointer to the last spot in SRAM and issuing a write swaps the SRAMs the two pointers refer to. It is not possible for the write and play pointer to be pointing to the same SRAM. This memory acts like a circular buffer, where the head and tail can't be in the same half of the buffer. If you reset then load 64KWords-1, the Play pointer will be at Zero in SRAM0, the write pointer will be at 0xfffe in SRAM1, effectively one word away, but still in the other half of memory.

A program to control the DACs must generate a "movie" file.

This file consists of an array of DAC data words.

**The format of one word** is both binary and bit-mapped as follows:

D15	D14	D13	D12	D11 through D0
EOM	EOF	EOD	LOOP	DAC Value 0-FFF, hex 0-4095 dec

**EOM is "end of movie"**. Set this bit to cause the DAC waveforms to halt. If you do not set EOM on the last data in your array the DACs will continue to read out uninitialized SRAM and simply repeat forever.

**EOF is "end-of-frame"**. Set this bit to cause a particular digital output bit to indicate the bit was set during playback.

**EOD is “end-of-DACs”.** Set this bit to indicate “start counting DACs over at zero” (see below)

**LOOP is “loop”**, and can be set to cause the circuit to set the internal pointer into the current location in SRAM back to “zero” in the first SRAM. If you load a small array of DAC data and set loop on the last data point, it will simply play forever (unless EOM was set somewhere before loop)

**The format of the array:**

The array contains data for all DACs interleaved. The simplest possible array would look like this:

0	0	0	0	DAC 0 value
0	0	0	0	DAC 1 value
0	0	0	0	DAC 2 value
0	0	0	0	DAC 3 value
0	0	0	0	DAC 4 value
0	0	0	0	DAC 5 value
0	0	0	0	DAC 6 value
1	0	0	0	DAC 7 value

Running this movie would cause the card to initialize the 8 dac values then stop, effectively creating a DC output on all DACs. (Note, you could have cleared EOM and set LOOP for the same effect, but you would then waste cycles repeating the same DC data)

If you wanted to produce a square wave on all DACs you could double the waveform buffer and loop:

0	0	0	0	DAC 0 value
0	0	0	0	DAC 1 value
0	0	0	0	DAC 2 value
0	0	0	0	DAC 3 value
0	0	0	0	DAC 4 value
0	0	0	0	DAC 5 value
0	0	0	0	DAC 6 value
0	0	0	0	DAC 7 value
0	0	0	0	DAC 0 value
0	0	0	0	DAC 1 value
0	0	0	0	DAC 2 value
0	0	0	0	DAC 3 value
0	0	0	0	DAC 4 value
0	0	0	0	DAC 5 value
0	0	0	0	DAC 6 value
0	0	0	1	DAC 7 value

If you don't want to use all 8 DACs you can set EOD on the last DAC you do want to use. If you were using 3 DACs your waveform array might look like this:

0	0	0	0	DAC 0 value
0	0	0	0	DAC 1 value
0	0	1	0	DAC 2 value
0	0	0	0	DAC 0 value
0	0	0	0	DAC 1 value
0	0	1	1	DAC 2 value

This EOD functionality allows complex relationships between rates of output. If DAC 1 is going to output at one-third the rate of DAC 0:

0	0	1	0	DAC 0 value
0	0	1	0	DAC 0 value
0	0	0	0	DAC 0 value
0	0	1	0	DAC 1 value
0	0	1	0	DAC 0 value
0	0	1	0	DAC 0 value
0	0	0	0	DAC 0 value
0	0	1	1	DAC 1 value

Careful understanding of this EOD functionality is critical to correctly creating a waveform/movie buffer. Here's a more complex example.

0	0	1	0	DAC 0 value
0	0	0	0	DAC 0 value
0	0	0	0	DAC 1 value
0	0	1	0	DAC 2 value
0	0	1	0	DAC 0 value
0	0	0	0	DAC 0 value
0	0	0	0	DAC 1 value
0	0	0	0	DAC 2 value
0	0	0	0	DAC 3 value
0	0	0	0	DAC 4 value
0	0	1	0	DAC 5 value
0	0	0	0	DAC 0 value
0	0	1	0	DAC 1 value
0	0	0	1	DAC 0 value

If you never set EOD the DACs \*should\* increment from 0 to 7, wrap to 0, and repeat, but this is untested. It's a good idea to simply always set EOD on the last DAC's data value.



## Loading the array:

The array is loaded by issuing a vendor request (VR) B1 to specify the starting location of the next buffer in the SRAM. Typically VR B1 with "0000" and "bank 0" in the parameters (refer to the discussion of VR B1, above) is the first instruction issued.

Then, EP2 bulk transfers are initiated for the first 64KWords of your waveform file. If your waveform is smaller than 64KWords, simply load the entire waveform (and you'll want EOM or LOOP set to avoid playing uninitialized SRAM.)

If your waveform is smaller than 32KWords you must take an extra step: Issue a VR B1 with 1FFE/Bank7, then EP2 a single WORD. This sets the internal "write" pointer into the second SRAM. This is necessary because the "Play" pointer is always in the SRAM you're NOT writing into.

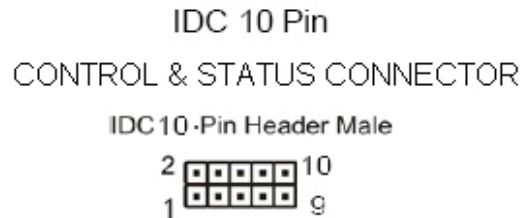
If your waveform is smaller than 64KWords there is no streaming needed, simply issue a VR B0 "run" command to cause the DACs to start outputting data.

If your waveform is larger than the onboard memory, load more than one 32KWords but less than 64KWords with your file, then issue a "run", then continue loading your file.

The EP2 Bulk transfers to load the SRAM will \*hang\* until there is room in the SRAM for more data. Your code must handle this apparent lockup. Multithreaded is recommended.

# Chapter 6: Connector Pin Assignments

Three header connectors provide a means to interface with the on-board signals. There is a 26 pin header for differential analog outputs, a 16 pin header for single ended analog outputs and a 10 pin header for control and status of the board's functions. When ordered as a standard unit (no options selected) the board is installed in a steel powder coated enclosure with mounted DB25 connectors. One ADAP25 screw terminal accessory is included and can be plugged onto the single ended outputs/ control and status DB25M (male) connector. The second DB25F (female) is the opposite of the first, to avoid plugging onto the wrong connector which has a different pinout than the first.



Function	Pin	Pin	Function
DAC 0	1	2	Ground
DAC 1	3	4	Ground
DAC 2	5	6	Ground
DAC 3	7	8	Ground
DAC 4	9	10	Ground
DAC 5	11	12	Ground
DAC 6	13	14	Ground
DAC 7	15	16	Ground

Function	Pin	Pin	Function
EOF	1	2	EOD
Status	3	4	Blank
Ext. Trigger	5	6	Pause
Interlock	7	8	Loop
Ground	9		

**Table 6-1: J4, Control/Status 10-Pin IDC**

**Table 6-2: J1, S.E. Outputs, 16-Pin IDC Assignments**

DB25M	Function	IDC	DB25M	Function	IDC
1	DAC 0	J1-1	14	Ground	J1-2
2	DAC 1	J1-3	15	Ground	J1-4
3	DAC 2	J1-5	16	Ground	J1-6
4	DAC 3	J1-7	17	Ground	J1-8
5	DAC 4	J1-9	18	Ground	J1-10
6	DAC 5	J1-11	19	Ground	J1-12
7	DAC 6	J1-13	20	Ground	J1-14
8	DAC 7	J1-15	21	Ground	J1-16
9	EOF	J4-1	22	EOD	J4-2
10	Status	J4-3	23	Blank	J4-4
11	Ext. Trigger	J4-5	24	Pause	J4-6
12	Interlock	J4-7	25	Loop	J4-8
13	Ground	J4-9			

**Table 6-3: S.E. Outputs, Control/Status, DB25 Male Connector Pin Assignments**

#### J4 Signal descriptions (Control / Status)

Outputs:	EOF	“End of Frame”, output every time EOF is issued.
	EOD	“End of DAC”, output every time DAC starts at 0.
	STATUS	User controlled via Firmware.
	BLANK	Output blanking signal from top bits of EOM, EOF, EOD....
Inputs:	EXT. TRIGGER	To Ctr 0, starts D/A conversions.
	PAUSE	To gate 0 of counter.
	INTERLOCK	“Shutdown” Digital Input (Firmware controlled).
	LOOP	Loops contents of SRAM, resets pointer to beginning of SRAM 0.

All signals at J4 pass through a line buffer, and all input signals are pulled to +5V through 47Kohms each. Activate input signals by applying 0V or a ground to the associated pin.

IDC 26 Pin ILDA DB25 Compatible  
DIFFERENTIAL CONNECTOR



Function	Pin	Pin	Function
DAC 0 +	1	2	DAC 0 -
DAC 1 +	3	4	DAC 1 -
DAC 2 +	5	6	DAC 2 -
Interconnect	7	8	Interconnect
DAC 3 +	9	10	DAC 3 -
DAC 4 +	11	12	DAC 4 -
DAC 5 +	13	14	DAC 5 -
DAC 6 +	15	16	DAC 6 -
DAC 7 +	17	18	DAC 7 -
N/C	19	20	N/C
N/C	21	22	N/C
N/C	23	24	N/C
Ground	25	26	Ground

**Table 6-4: J3, Differential Analog Outputs, 26-Pin IDC Assignments**

DB25F	Function	IDC	IDC	Function	DB25F
1	DAC 0+	1	2	DAC 0-	14
2	DAC 1+	3	4	DAC 1-	15
3	DAC 2+	5	6	DAC 2-	16
4	Interlock	7	8	Interlock	17
5	DAC 3+	9	10	DAC 3-	18
6	DAC 4+	11	12	DAC 4-	19
7	DAC 5+	13	14	DAC 5-	20
8	DAC 6+	15	16	DAC 6-	21
9	DAC 7+	17	18	DAC 7-	22
10	N/C	19	20	N/C	23
11	N/C	21	22	N/C	24
12	N/C	23	24	N/C	25
13	Ground	25	26	N/C	N/C

**Table 6-5: Differential Analog Outputs, DB25F Connector Pin Assignments**

## ILDA DB-25 Pinout and Signal Description Standard Excerpts

Pins	Signal Names	Signal Description
1, 14	X+, X-	Controls the horizontal beam position. This is a bipolar analog signal whose voltage range is 10V peak-to-peak differential. A differential voltage level of -10V shall deflect the laser beam to the left side of the projection area. A differential voltage level of +10V shall deflect the signal to the right side. A differential voltage of +10V occurs if the normal signal line has a voltage level of +10V with respect to the voltage level of the inverted signal line. When compared to the ground level of the differential driver, the voltage level of the normal signal line shall be +5V and the level of the inverted signal shall be -5V.
2, 15	Y+, Y-	Controls the vertical beam position. This is a bipolar analog signal whose voltage range is 10V peak-to-peak differential. A differential voltage level of -10V shall deflect the laser beam to the bottom of the screen. A differential voltage level of +10V shall deflect the signal to the top of the screen. A differential voltage level of 0V shall place the beam in the center of the screen vertically. A differential voltage of +10V occurs if the normal signal line has a voltage level of +10V with respect to the voltage level of the inverted signal line. When compared to the ground level of the differential driver, the voltage level of the normal signal line shall be +5V and the voltage level of the inverted signal shall be -5V.
3, 16	Intensity + Intensity -	
4, 17	Interlock A Interlock B	These are intended to keep the projector from outputting light if inadvertently connected to nonlaser signal sources such as SCSI, Parallel or serial connectors. These signals are also a fail-safe should other control measures fail. These signals are tied together at the signal source. If this loop is broken, it is required that projectors close a shutter or turn off the laser or take other actions that prevent light from being emitted from the projector. It is important to note that this portion of the ISPDB25 is a projector interlock which may be separate from the remote interlock connector on a laser used with the projector.
5, 18	R+, R-	Controls the red intensity. This is a unipolar analog signal whose voltage range is 5V peak-to-peak differential. A differential voltage level of 0V shall produce no red output. A differential voltage level of +5V shall produce maximum red output. A differential voltage of +5V occurs if the normal signal line has a voltage level of +5V with respect to the voltage level of the inverted signal line. When compared to the ground level of the differential driver, the voltage level of the normal signal line shall be +2.5V and the voltage level of the inverted signal shall be -2.5V.
6, 19	G+, G-	Controls the green intensity. This is a unipolar analog signal whose voltage range is 5V peak-to-peak differential. A differential voltage level of 0V shall produce no green output. A differential voltage level of +5V shall produce maximum green output. A differential voltage of +5V occurs if the normal signal line has a voltage level of +5V with respect to the voltage level of the inverted signal line. When compared to the ground level of the differential driver, the voltage level of the normal signal line shall be +2.5V and the voltage level of the inverted signal shall be -2.5V.
7, 20	B+, B-	Controls the blue intensity. This is a unipolar analog signal whose voltage range is 5V peak-to-peak differential. A differential voltage level of 0V shall produce no blue output. A differential voltage level of +5V shall produce maximum blue output. A differential voltage of +5V occurs if the normal signal line has a voltage level of +5V with respect to the voltage level of the inverted signal line. When compared to the ground level of the differential driver, the voltage level of the normal signal line shall be +2.5V and the voltage level of the inverted signal shall be -2.5V.
8, 21	User-defined	signal 1+, 1-
9, 22	User-defined	signal 2+, 2-
10,23	User-defined	signal 3+, 3-
11,24	User-defined	signal 4+, 4-
12	Projector	Return signal
13	Shutter	Optical shutter intended to extinguish all light from the graphics scanners. This is a unipolar analog signal whose voltage range is 5 volts peak. The shutter signal is referenced to the Ground pin. A voltage level of 0 volts shall close the shutter so that no light is emitted from the graphics scanners. A voltage level of +5 volts shall fully open the shutter.
25	Ground	0 voltage potential reference and signal shield.

**Table 6-6: ILDA Signal Naming Standard, DB25F Signal Descriptions**

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**References:**  
**International Laser Display Association**  
**<http://www.laserist.org/index.htm>**

#### Customer Comments

If you experience any problems with this manual or just want to give us some feedback, please email us at: *tech@portwell.com*. Please detail any errors you find and include your mailing address so that we can send you any manual updates.