Drive Electronics Manual

ACTIVE OPTICAL SYSTEMS
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Version 1.1 – 6/27/07

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1.1 Warnings

HIGH VOLTAGE: The AOS Drive Electronics produces high voltage! High voltage can cause injury or death. Please use the AOS Drive Electronics only with an AOS deformable mirror properly attached to minimize the risk of injury.

USING HYPERTERM: The Microsoft Windows Hyperterminal program can be used to interface to the AOS Drive Electronics, but it cannot send the character 0x00, even using the Alt+000 on the numeric keypad.

FUSE: This device contains a fuse to prevent damage to the internal components. If the device is not responding, check the fuse.

1.2 Quick-Start Instructions

Details for each of the following steps are shown in the following document.

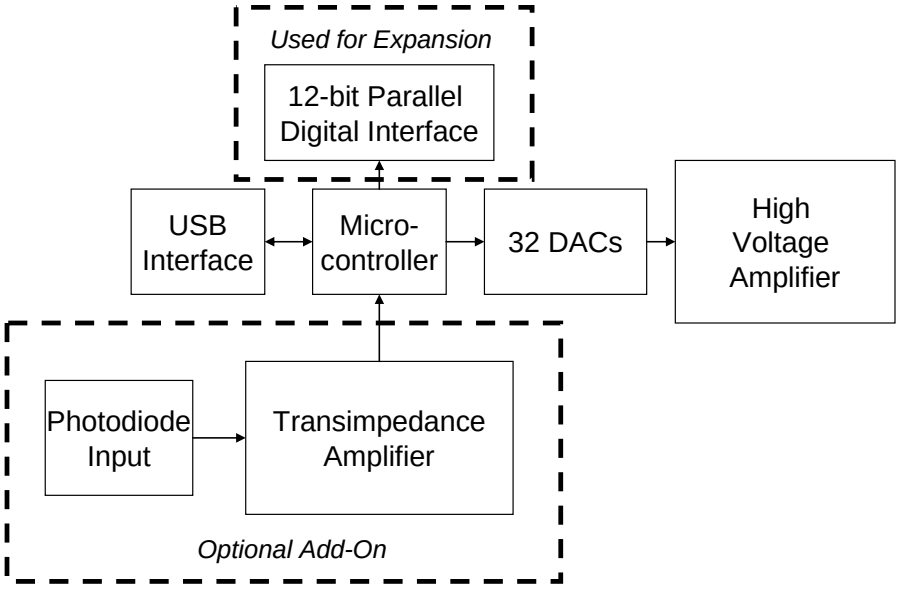
1. Install the AOS software.
2. Attach the Drive Electronics to the deformable mirror, the USB port of the control computer, and then to the power.
3. Turn on the Drive Electronics. The computer should recognize the drive electronics upon power-up. Follow the driver installation instructions.
4. Run the DM Controller software.
    a. Make sure that the software has properly connected to the drive electronics.
    b. Load the *.AOS file associated with your deformable mirror.
5. At this point, the deformable mirror should be responding to computer commands.

2 Introduction

This manual covers model number DE1-32-0001. It begins with a brief introduction to the Drive Electronics including a summary of device operation. The introduction concludes with some important warnings about the usage of the AOS Drive Electronics. Then a description of the software installation is provided. Finally, a description of the DMController software and its features are included. This manual should be read in its entirety before using the AOS Drive Electronics.

2.1 Device Operation

The AOS Drive Electronics (DE) is designed to be used to drive the AOS membrane deformable mirrors (MDMs). An operational schematic is shown below. The USB input from the computer sends a command to the firmware inside the DE. Some commands are documented below. This command is then interpreted by the on-board microcontroller and sent to the 32 channels of low-voltage DACs on the board. The low-voltage signals are then amplified by a factor of 72 up to a peak of 295V. There is a 12-bit parallel digital interface in the drive electronics that is used for expanding the capability of the single board. For example, additional drive electronics boards can be commanded using the digital interface so that a user can command additional drive electronics boards to get more channels. The drive electronics board is also optionally equipped with a transimpedance amplifier and a photodiode input to enable the board obtain feedback and do metric based control.



Schematic View of the AOS Drive Electronics

2.1.1 Automatic Reset

The AOS Drive Electronics firmware is setup for an automatic command reset if a command has not been completed in 1 second. This was setup to avoid the firmware

locking-up if a command is interrupted. This feature can be toggled on and off using the "T" command.

2.2 Warnings about the AOS Drive Electronics

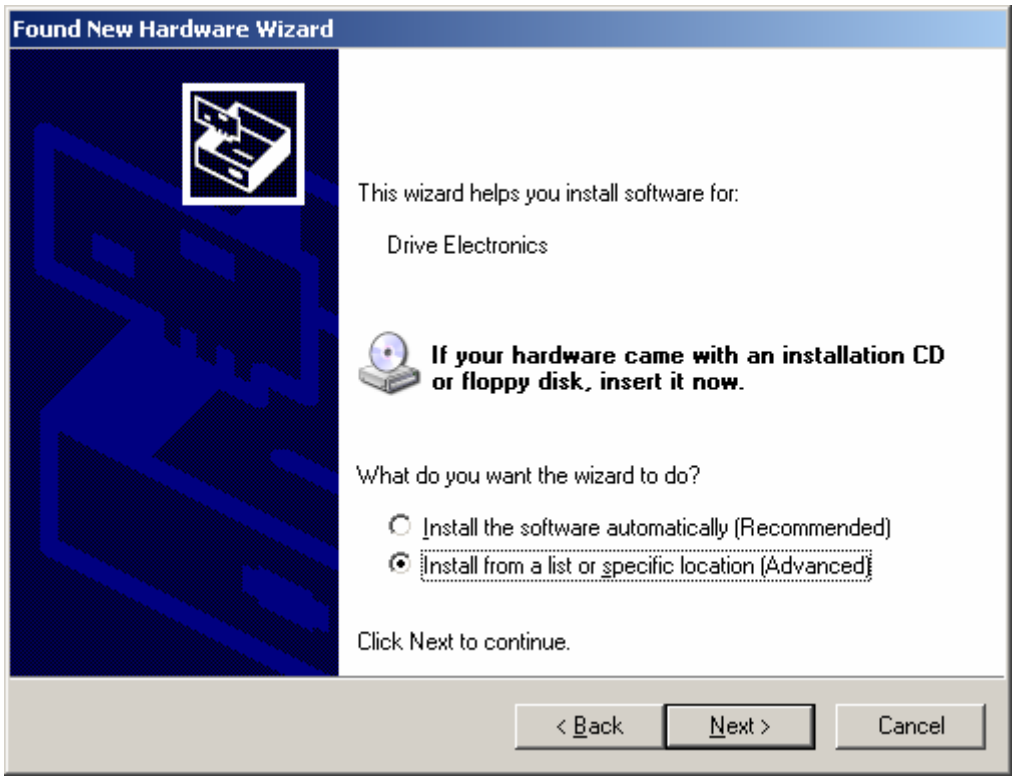
- **HIGH VOLTAGE:** The AOS Drive Electronics produces high voltage! High voltage can cause injury or death. Please use the AOS Drive Electronics only with an AOS deformable mirror properly attached to minimize the risk of injury.

3 AOS Drive Electronics Software Installation

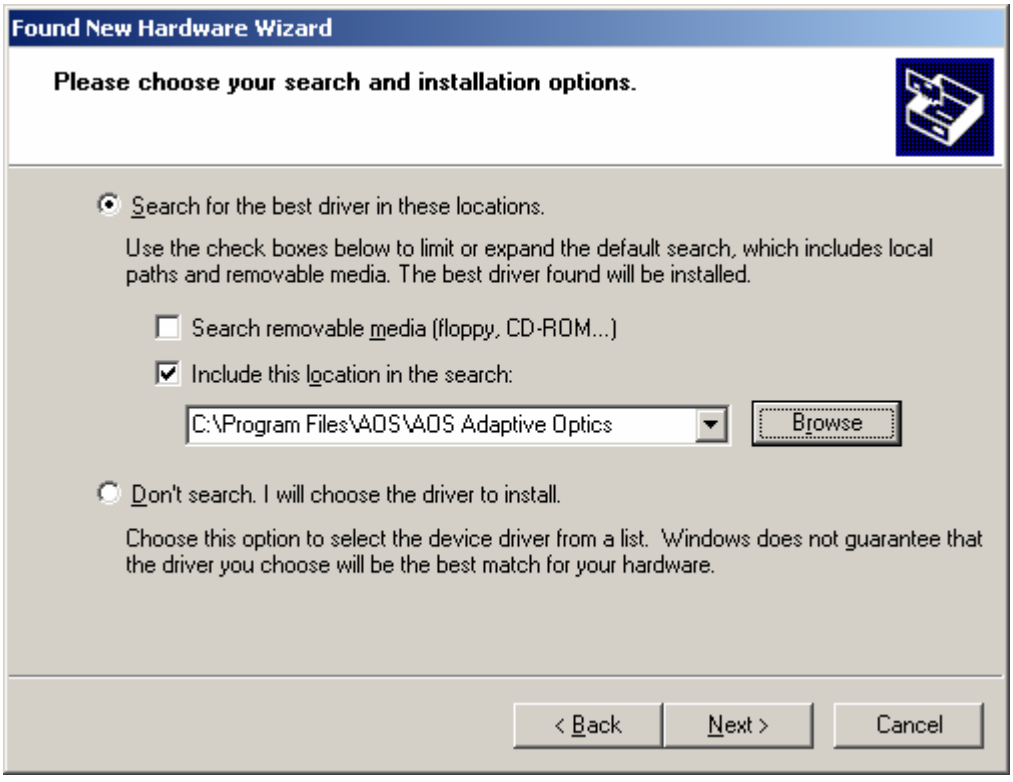
- To install the software provided by AOS, insert the provided disk and run the installer.
- Plug in the Drive Electronics to the wall socket (120 VAC).
- Connect the USB port of the drive electronics to the computer using the cable provided.
- Turn on the Drive Electronics.
- The following message box should appear off of the task bar:

- Then the following dialog box may appear. Choose “No, not this time”.

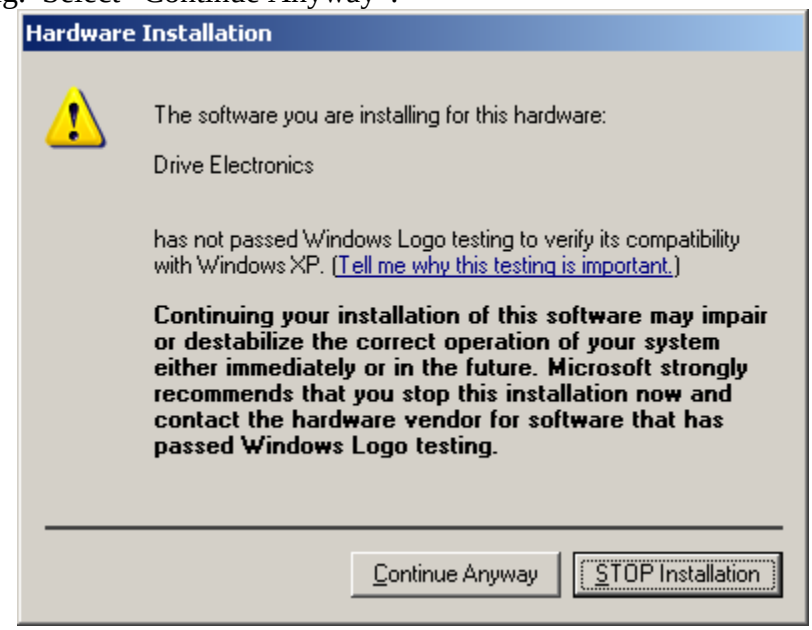
- Then the following dialog box will appear. Choose to install from a specific location.



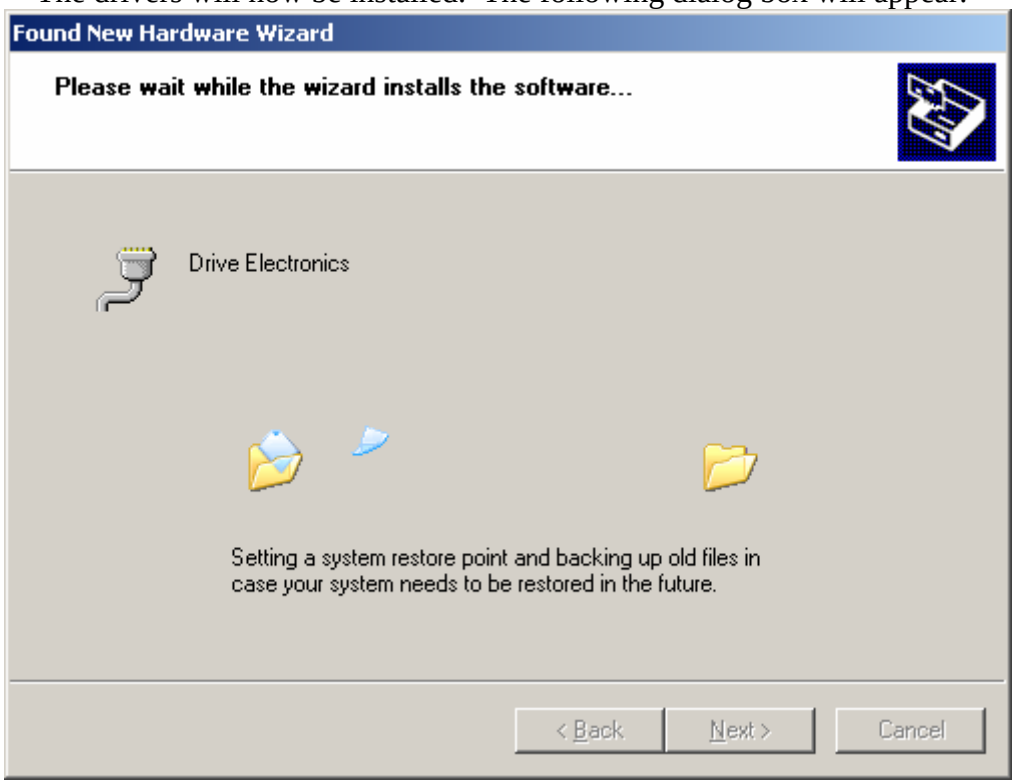
- When the following dialog box appears, do not search removable media. Instead, specify the location "C:\Program Files\AOS\AOS Adaptive Optics" and select "Next".



- Windows will then warn you that this driver has not passed Windows Logo testing. Select "Continue Anyway".

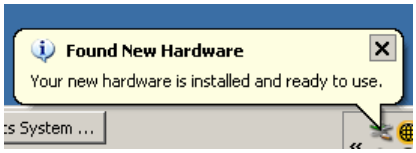


- The drivers will now be installed. The following dialog box will appear.



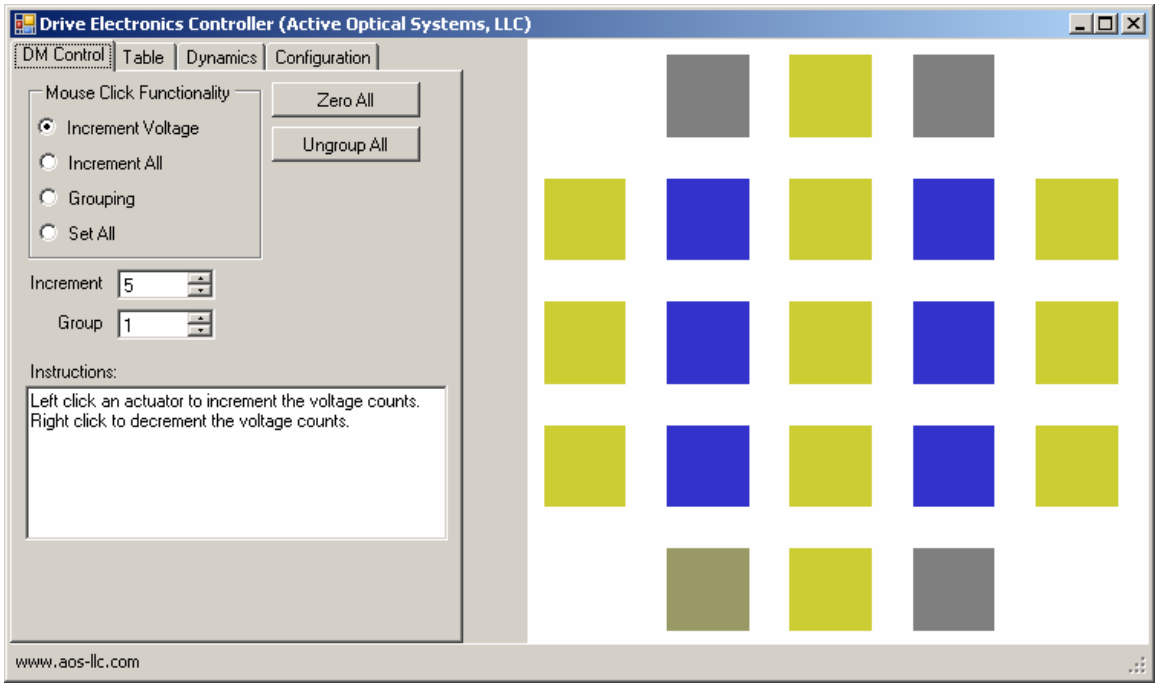
- When the installation is complete, the following dialog box will appear. Select "Finish".

- A pop-up from the task bar (shown below) will appear to inform you that the hardware is ready to use.



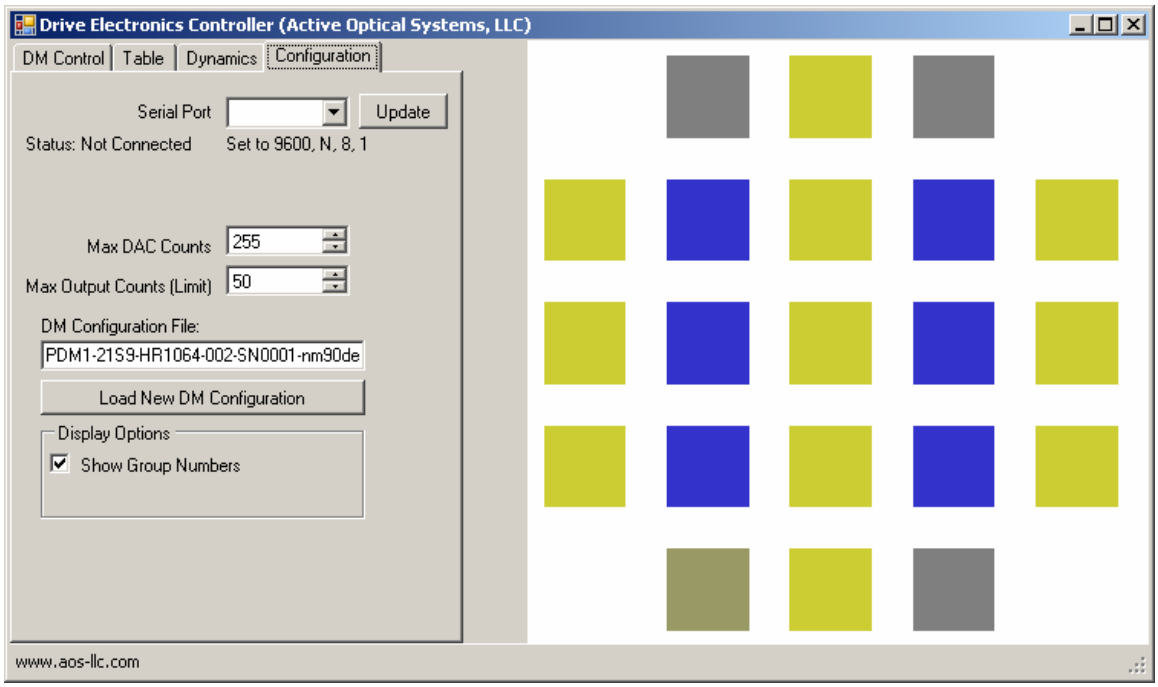
4 DM Controller Software

The software package that is provided for sending commands to the AOS Drive Electronics is called DM Controller. The main program window is shown here:



4.1 The Configuration Tab

Upon launching DM Controller, the program searches for the drive electronics by opening every port and sending it the letter “I”. Ports with attached drive electronics will be listed in the list box on the Configuration tab, as shown here:



In the case shown here, there was no drive electronics connected to the computer, so the serial port list box is empty. If the drive electronics is connected after running the software, the list box can be updated using the update button. If a successful connection is able to be established, the status will change to Connected.

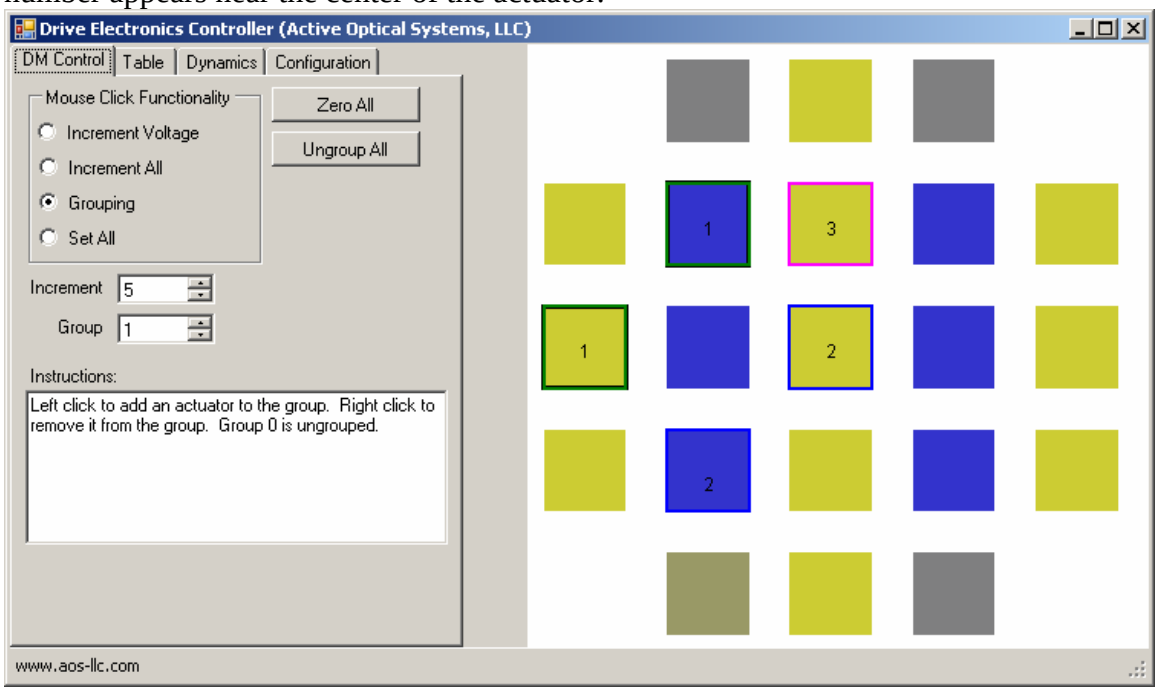
The Drive Electronics is designed to be built with variable levels of accuracy on the digital to analog converters (DACs). The user can specify the maximum DAC counts that can be sent to the device using the Max DAC Counts box. This should be normally be set to 255 and should only be adjusted by advanced users. If the user wants to setup a limit on the output voltage, they can specify this limit in counts in the Max Output Counts (limit) box.

The DM configuration can be changed or new voltages or groupings can be restored by load a new AOS file by pressing the Load New DM Configuration button.

4.2 DM Control

There are several ways to control the DM by clicking on the actuator picture window interface. The modes of operation can be selected in the “Mouse Click Functionality” group box. The most common use is the “Increment Voltage” mode. In this mode the user can click on any of the actuator with the left mouse button to add an increment (specified by the “Increment” box) or right click to decrement the voltage. The “Increment All” mode works in a similar way except all the actuators are incremented or decremented when any one of them is clicked.

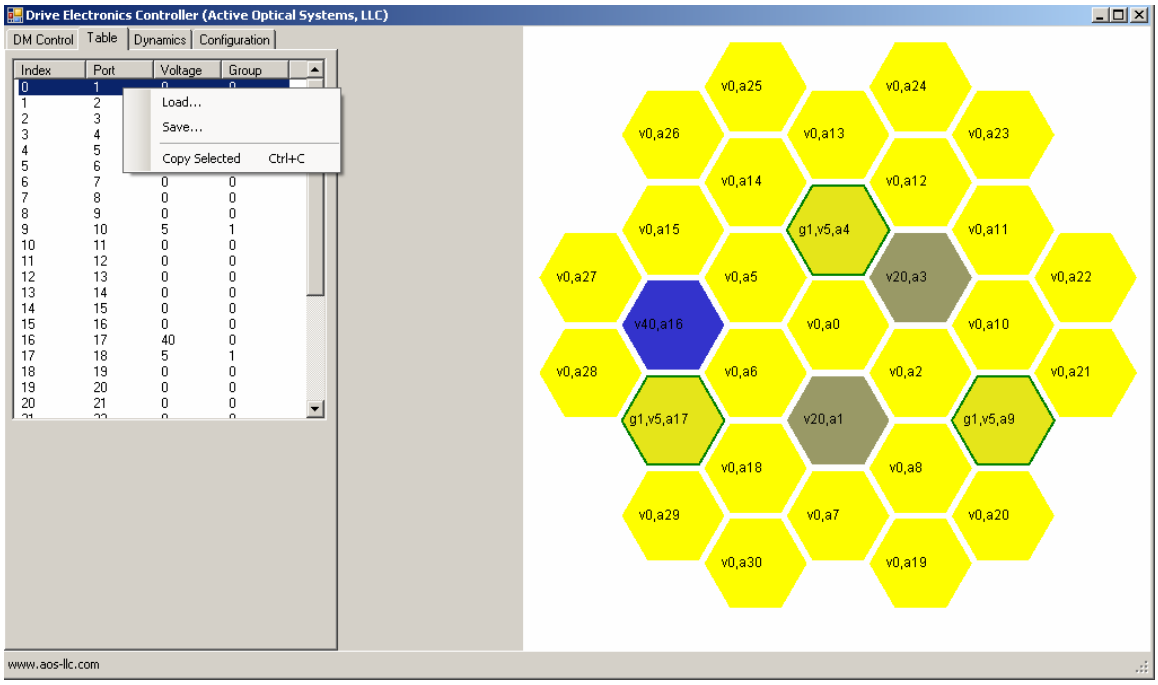
The “Grouping” mode allows the user to gang together any set of actuators so that and operation done on any one of them affects all of them in the same way. To begin grouping a set of actuators together, start by select the “Grouping” mode from the “Mouse Click Functionality” group box. Then choose a group number for the actuators in the “Group” box. The 0 group is reserved for ungrouped actuators. When a group number is selected, click on any of the actuators with the left mouse button to add them to the group. Right click on an actuator to remove it from all groupings. The “Ungroup All” button removes all actuators from any groups. As actuators are grouped, the border of each of the actuators changes color and, if selected in the Configuration tab, the group number appears near the center of the actuator.



The “Set All” mode is a way of setting all actuators to the same voltage as one of the other actuators. In this mode, simply select the actuator that you want all the others to mimic in voltage and all the voltages will change.

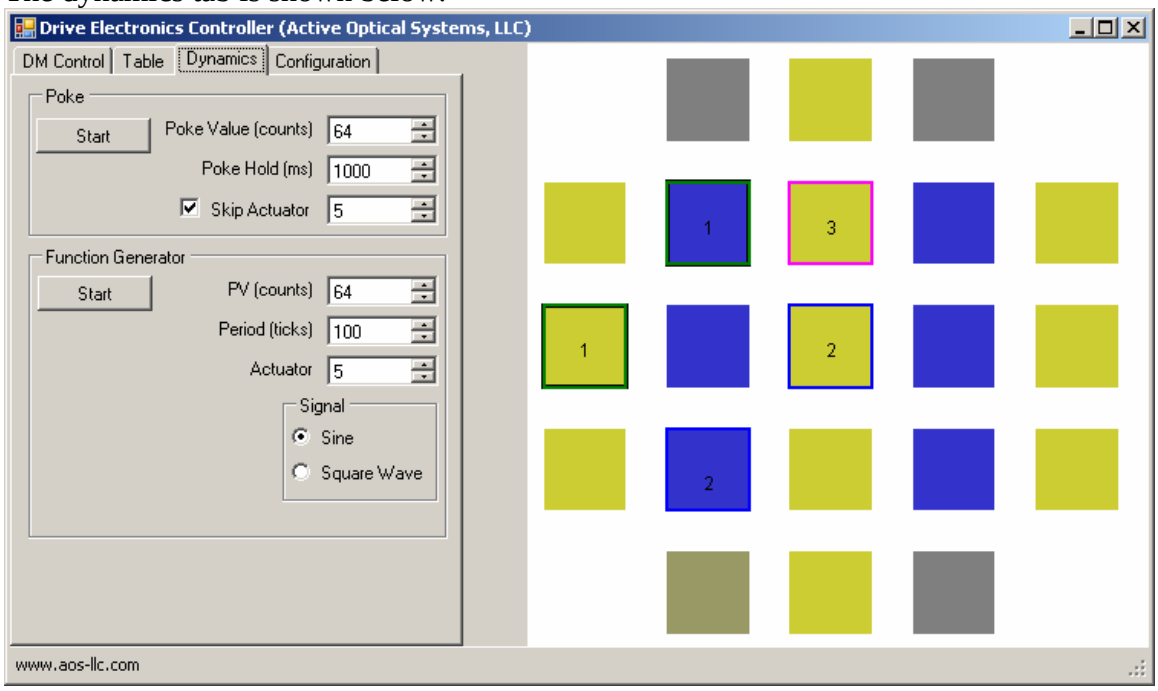
4.3 Table Tab

The Table tab is simply a convenient way to see the state of all the actuators numerically. There is no way to do any form of data entry in this tab at this time. To save or load the state of the drive electronics, right click on the table and a pop-up context menu will appear with these options. Be careful when loading a DM file because the voltages will automatically be written to the DM upon load.



4.4 Dynamics Tab

The dynamics tab is shown below.



In the Dynamics tab, the user can either poke each actuator or apply a function to a single actuator. In the poke mode, all the actuators are set to zero except one actuator that is set to the poke value. The actuator remains poked for the number of milliseconds specified

by the user in the “Poke Hold” box. Then the next actuator is poked. The user can specify to skip a single actuator (typically that corresponding to the mirror surface) by specifying that actuator in the “Skip Actuator” box and checking the check box adjacent to the label. The “Period” box allows the user to have some control over the frequency, but due to Windows timing issues, the number of ticks per millisecond varies from machine to machine. The “Actuator” box allows a user to select the actuator to fire. The Signal group box allows the user to select a sinusoidal voltage signal or a square-wave signal. There is no control possible for the offset. It always assumes that the lowest voltage is zero counts.

The “Function Generator” group box allows the user to apply a signal to a single actuator. In this mode, all actuators except one are set to zero. The “PV” box allows the user to specify the peak-to-valley amplitude of this signal.

5 Virtual COM Port Command Interface

The following commands are supported by the AOS Drive Electronics over the Virtual COM Port (VCP) interface:

5.1 Command Format

Commands are sent to the AOS Drive Electronics as a command byte followed by parameters if necessary. Some of the commands have return values that can be ignored or used for diagnostics. The table below describes all the commands implemented in the AOS Drive Electronics firmware. Commands should not be sent to the Drive Electronics that are not on the table below.

5.2 Commands

Description	Command	Parameters	Return Value
Set all channels to the same value.	A	Byte 1: DAC level	None
Zero all channels	R	None	None
Zero a single channel	Z	Byte 1: Channel	None
Set a single channel to a value	S	Byte 1: Channel Byte 2: DAC level	None
Turn the command timer off	T	None	"TIMER ON" if the timer has been turned on. "TIMER OFF" if the timer has been turned off. If a command is interrupted the timer will return "RESET" after ~1 second.
Request the type of device and version	I	None	"DE1.1\r\n" if the device is the drive electronics with version 1.1 of the firmware. The \r\n is a carriage return and a line feed.
Request the value of the photodiode input (if installed)	P	None	Text value of the measured photodiode input.
Optimization of the channels based on photodiode input	O	Byte 1: Type of optimization Byte 2: Number of milliseconds between	None *NOTE: Optimization is still under development and should not be attempted at*

(if installed)		sending the command and sampling the photodiode. Bytes 3 and up: To be determined in later versions.	*this time.*
Enter into firmware loading mode.	B	None	*NOTE: This is an advanced feature that should not be used at this time. Using this may cause the device to stop working until a double reboot is executed.*

6 DLL Interface

The DM is controlled by a C# class library DLL which issues the low-level DM commands to the selected COM port. All functions are members of the class DMInterface. Creating an instance of the class initializes the COM port settings and makes sure that the port is closed. After the class is created, the enumCOMPorts function will check all of the computer's COM ports to see if a DM controller module is attached. The function returns an array of ports with attached DM controllers. If no ports were found, the function returns an empty array. If ports were found but no DM controllers responded on any of them, the function returns an array of all COM ports found. This was done to handle the case where old revision DM firmware does not return an ID code when queried.

The user software should then call the OpenComPort function with the name of the desired port. If the function returns true, the DM controller is ready to receive commands. Next the software should call the SetVoltLimits function to set the maximum values for output. By default all outputs are clipped to 0. Reasonable values for MaxOutput and MaxDAC are 64 and 255, respectively.

At this point, the software may call the SetVoltage and SetAllVoltage functions as needed to control the DM.

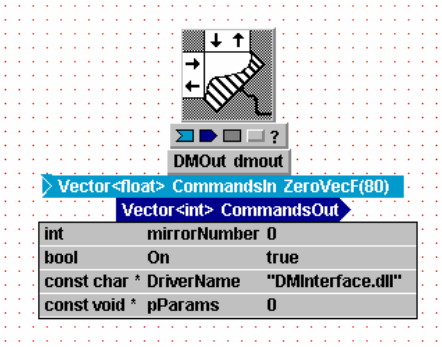
Deleting the instance of the DMInterface class will close the COM port. Before doing this, the software should set all of the DM channel voltages to zero .

6.1 DMInterface Functions:

Function	Description
public ArrayList enumCOMPorts()	Query all available COM ports for DM controller response.
public void SetVoltLimits(int MaxOutput, int MaxDAC)	Set the output voltage limits
public int SetAllVoltage(int val)	Set the voltage for all actuators
public int SetVoltage(int act, int val)	Set the voltage for one actuator.

7 WaveTrain Component

The figure to the right shows the DM control component in WaveTrain. The tempus system description (TSD) for this component is shown below. To operate this component in WaveTrain, a special interface DLL is required. This DLL can be obtained from MZA Associates Corporation (www.mza.com).



DMOut Component in WaveTrain

```
NAME = DMOut    [Interface: 15 Jun 2005 16:43:02 GMT]
[Implementation: 15 Jun 2005 16:43:02 GMT]   (*)

DESCRIPTION
Writes an input vector of commands out to a physical DM via a driver
DLL. The driver DLL may perform some limiting of the commands; the
output vector will contain the commands actually output.

C++ CODE
PARAMETERS
      int         mirrorNumber = 0 // Deformable mirror selection
      bool    On = true        // If false, DLL is not even loaded
      const char * DriverName = "HVDD.dll" // name of driver dll (see
dmdriver.h for spec)
      const void * pParams = 0 // optional parameter block for driver
init data

INPUTS
   Vector<float>  CommandsIn = ZeroVecF(80) // Vector of DM Commands

OUTPUTS
   Vector<int>  CommandsOut =  // Commands that were output (with
limiting)

SUBSYSTEMS

CONNECTIONS

PROPERTIES
#Sat Dec 15 16:45:09 MST 2007
CommandsIn.position=(46, 71)
CommandsOut.position=(49, 100)
Version=2007A\n
```

8 Matlab Interface

Matlab has a serial port interface that can be used to command the AOS Drive Electronics using the commands outlined in Section 0 above. Here is an example script on how to search for the drive electronics by opening a range of COM ports and looking for the response from the “I” command:

```
function [] = TestDM
% TestDM
% Demonstrate communication with DM via Matlab serial port interface
  ports = instrfind; % close all ports
  fclose(ports);
  for ii = 1:length(ports) % try to find DM on some port
      try
          port = ports(ii);
          set(port,'BAUD', 9600);
          % could also do port = serial('COM12', 'Baud', 9600);
          fopen(port); % open the port
          fprintf(port, 'I'); % send query character
          idn = fscanf(port); % read response
          if (strncmp(idn,'DE',2)) % response should be 'DE1.1' or similar
              disp(['Found DM on port ' get(port, 'Port')]); % report success
              break;
          end
      catch
          %disp(['No DM on port ' port]);
      end
      fclose(port); % close port and continue
  end
  fclose(port); % ensure port is closed on exit
return
```

9 Appendix: AOS File Format

The AOS file format provides the DMController with information about the deformable mirror and how to adjust the user interface. The first character if each line specifies the type of information that is on that line. The type specifers are as follows:

A = Actuator Definition
V = Voltage Information
G = Grouping Information
C = Communication Specification

Each line is comma delimited and terminated with a newline character.

"A" = Actuator Definitions

Following the A in this order is:

1. the number of points in the shape definition,
2. the channel number of the electronics that controls this actuator, and
3. a series of x and y coordinates for the shape representing that actuator.

The index number in the AOS DM Controller software is given by the order in which these actuators are read into the program.

"V" = Voltage Information

Following the V is a comma delimited list of the voltage on each of the actuators in counts on the DAC.

"G"=Grouping Information

Following the G is a comma delimited list of each actuator's group.

"C" = Communication Specification

Communication with the AOS Drive Electronics is done using a virtual COM port. The specifications for this communication is stored in the "C" section. The first line specifies the baud rate. Subsequent lines specify the parity, data-bits, and stop bits. Following lines are no longer used.

Example AOS File

Here is an example AOS file for a 31 actuator hex-grid DM:

```
A,7,1,3.034615,1.559956,2.965385,1.559956,2.930769,1.500000,2.965385,1.440044,3.034615,1.
440044,3.069231,1.500000,3.034615,1.559956,
A,7,2,3.034615,1.688527,2.965385,1.688527,2.930769,1.628571,2.965385,1.568616,3.034615,1.
568616,3.069231,1.628571,3.034615,1.688527,
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375759,3.180577,1.435714,3.145961,1.495670,
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311473,3.069231,1.371429,3.034615,1.431384,
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```

```
A,7,9,3.145961,1.752813,3.076731,1.752813,3.042115,1.692857,3.076731,1.632902,3.145961,1.
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.375759,2.735192,1.435714,2.700577,1.495670,
A,7,29,2.700577,1.624241,2.631346,1.624241,2.596731,1.564286,2.631346,1.504330,2.700577,1
.504330,2.735192,1.564286,2.700577,1.624241,
A,7,30,2.811923,1.817098,2.742692,1.817098,2.708077,1.757143,2.742692,1.697187,2.811923,1
.697187,2.846539,1.757143,2.811923,1.817098,
A,7,31,2.923269,1.881384,2.854039,1.881384,2.819423,1.821429,2.854039,1.761473,2.923269,1
.761473,2.957885,1.821429,2.923269,1.881384,
V,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
G,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
C,9600,
C,None,
C,8,
C,1,
C,1,
C,255,
```

10 Appendix B: Software Channel to 37-D Pin-Out Mapping

10.1.1 Software Channel to 37-D Pin Mapping

Software Channel	37D Pin
0	34
1	15
2	35
3	16
4	32
5	13
6	33
7	14
8	30
9	11
10	31
11	12
12	28
13	9
14	29
15	10
16	26
17	7
18	27
19	8
20	24
21	5
22	25
23	6
24	22
25	3
26	23
27	4
28	20
29	1
30	21
31	2
GND	17,36

11 Appendix C: Troubleshooting

Problem	Potential Resolution
The AOS Drive Electronics is not being recognized by my computer.	• Check that the USB cable is attached between the computer and the Drive Electronics. • Check that power is connected to the Drive Electronics and that the switch is turned on. • Check that Windows is responding. • Check to see if the Device Manager (Start-Control Panel-System-Hardware Tab-Device Manager Button) changes when the Drive Electronics is turned on. A COM port should appear under the Ports section. • Try connecting the hardware to another computer. • Remove the power connection. Check the fuse in the power entry module.
The DM does not appear to be moving in response to voltage commands.	• Check the USB and power connections to the Drive Electronics. Make sure the device is turned on. • Check that the computer is connected to the Drive Electronics in the Device Manager (Start-Control Panel-System-Hardware Tab-Device Manager Button) under the Ports section. • Start the DMController software. A message box should appear indicating that the software has found the drive electronics. If this does not appear, the device is not properly connected. • Apply up to 255 counts to each of the actuators and look either at any diagnostic like a focused spot reflected from the deformable mirror, an interferometer, or a Hartmann sensor.