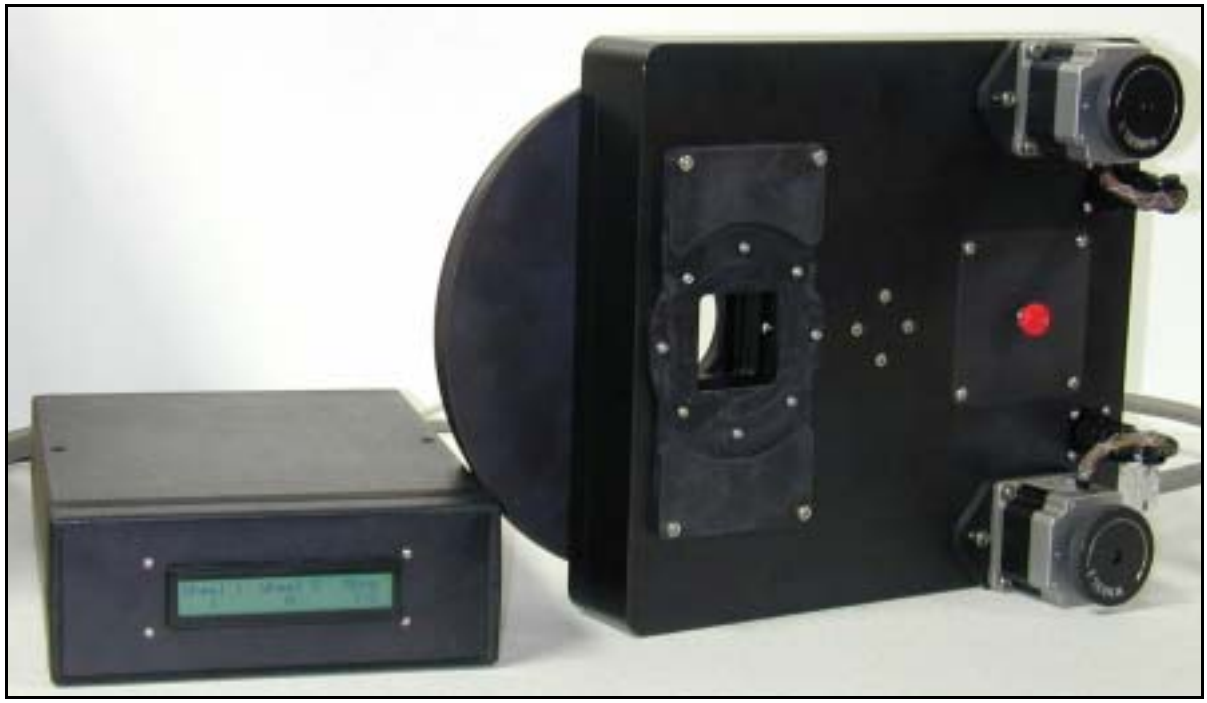
ACE SmartFilter™

Filter Wheel System

Dual Filter Wheel
2 x 8 Position 50.8 mm square or round
14 available filter positions

Technical Reference Manual



Release Date 15 May 2003

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Chapter 1
SmartFilter™ Overview

1.1 Introduction

Thank you for purchasing a custom filter wheel with an ACE SmartFilter™ controller from Astronomical Consultants & Equipment, Inc. The SmartFilter™ allows communication between a computer and the filter wheel using an RS232 serial communications port.

1.2 Shipping

The following items have been shipped with your order:

Item	ACE Part Number	Qty	Description
1	ACE-DFW-8-50-S	1	8 Position 50.8 mm square dual wheel filter box with custom telescope interface adapter and one camera adapter plate
2	ACE-SFC-D	1	SmartFilter™ Controller for dual wheel
3	ACE-SCC-20	1	20-m control cable
4	ACE-PWR-115	1	120 VAC molded power cord
5		2	Camera Adapter Plates
6	ACE-FWA-50-SR	14	Square to Round 50 mm adapter jackets
7		1	1.8-m RS-232 communications cable
8		1	CD-ROM with support files / documentation
9	SmartFilter_LOT_DFW8x50S.doc	1	This user manual

1.3 Assembly

All the connectors are unique. It is not possible to incorrectly assemble the equipment . After assembly plug in the power cord to a suitable (115 VAC) outlet.

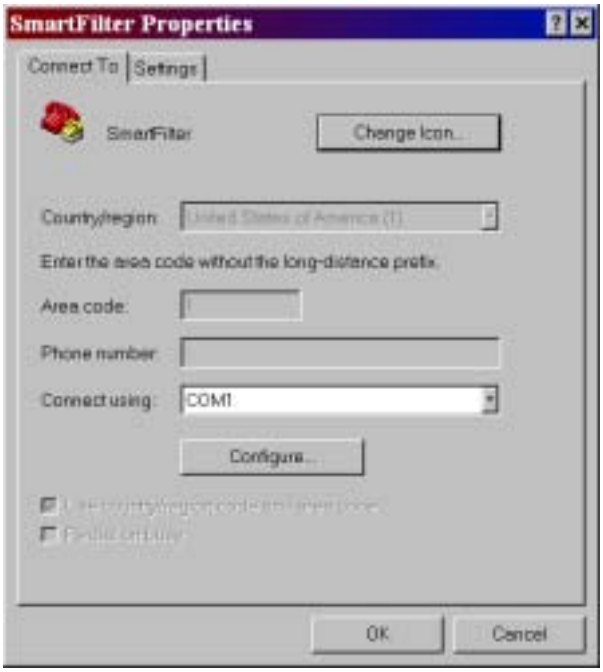
1.4 Software Communications

Connect the ACE SmartFilter™ to an available computer serial port or 4895A GPIB interface controller. The port settings are:

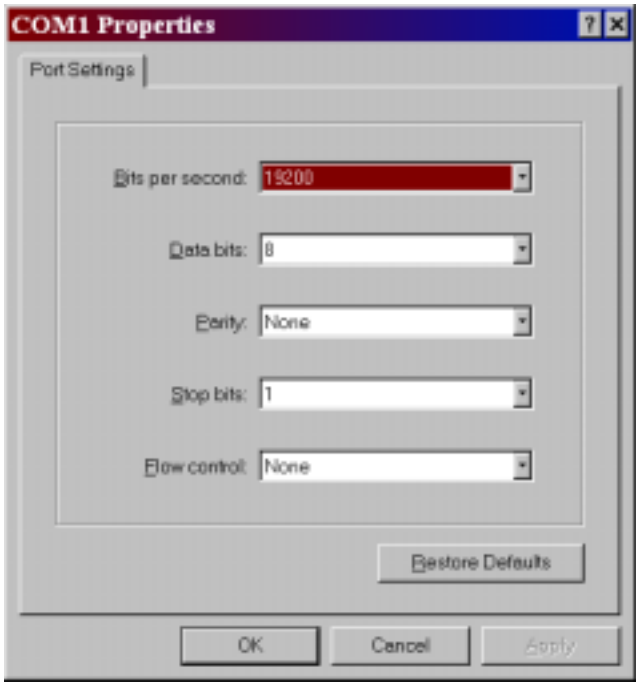
Baud Rate	19200
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

The system can be tested using a basic communications program such as HyperTerminal which is supplied with 32-bit Microsoft® Windows operating systems. If using HyperTerminal please ensure that the following setup information is correct:

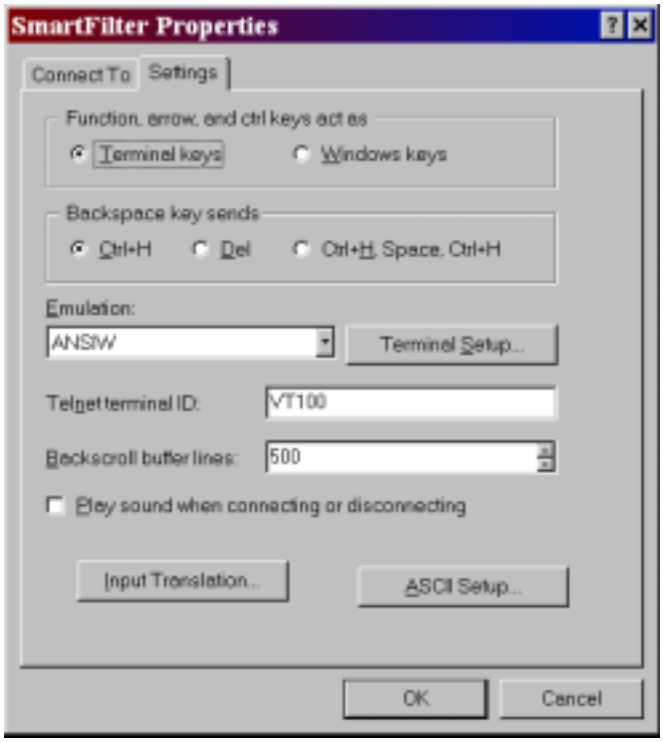
a) Display the following dialog using the **File->Properties** menu and choose the required Comport which must physically exist on the computer.



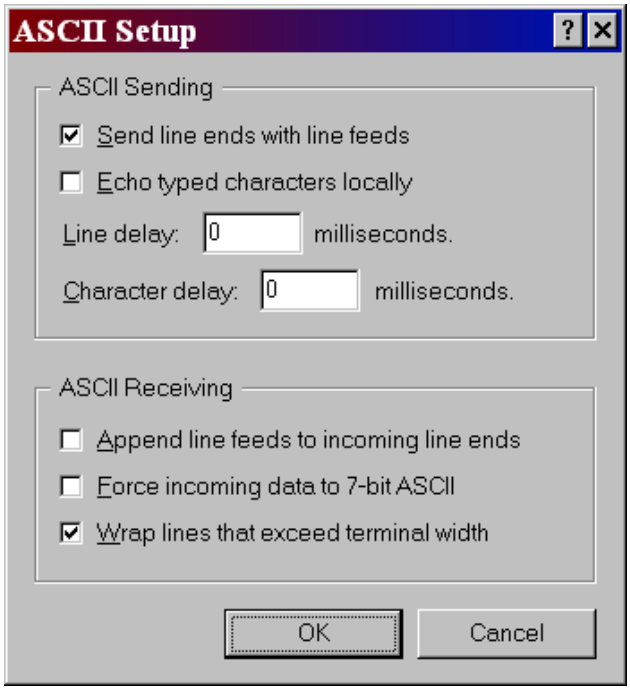
b) Using the **Configure…** button set the following parameters and press **OK**.



c) Using the **Settings** tab set the following parameters:



d) Using the **ASCII Setup button** set the following parameters:



When the communications are correct pressing the Enter (<CR>) key should produce output to the RS232.

Chapter 2
SmartFilter™ Commands

2.1 Introduction

The ACE SmartFilter™ is designed to control up to two filter wheels. All characters are converted to upper case. All command entry lines start with a > prompt and complete with the same prompt. Conversations on the RS232 are shown in `Courier New 10 point text`. *Examples shown here are typical and may not correspond with the number of filters in your system. For output from your system see the* **Certificate of Inspection.**

2.2 Initialization

On power startup or after performing a reset (RS) command (which takes a few seconds) the following message is displayed to the terminal:

```
A.C.E Smart Filter Wheel (TM)
www.astronomical.com
15-May-03 Copyright(c)
System INIT
>
```

2.3 HELP Command

Type HELP produces the following output to the RS232 port.

```
>HELP
     ?      Prints out a short status report
     +      Prints out a full  status report
     x NW   Number of wheels where x=1 or x=2
     x UW   Using Wheel where x=1 or x=2
     x NF   Number of Filters per wheel (4 <= x <= 10)
     x MV   Move to filter number x
     HM     Initialize wheel to nearest filter slot
     CS     Check System, visit all filters
     x EX   Exercise x sets of 50 random moves where x <=20
     x EO   Engraving Offset x=0 or x=1 for filter index
     x FL   Fault on last move x=0 FALSE, x=1 TRUE
     RS     Reset the CPU
     HELP   Prints out this menu
            Support information at www.astronomical.com

            Note: any invalid command behaves like the ? command
                  and produces the output which appears below....
W1 = 3
W2 = 0
UW = 1
>
```

The > prompt appears at the completion of each task and is the indication the system is ready to accept another command. Status information is returned at the completion of each command.

2.4 ? Short Status Command

The ? command is used to get a short status report:

```
>?
W1 = 3
W2 = 0
UW = 1
>
```

where:

W1 = Filter position for Wheel 1
W2 = Filter position for Wheel 2 (only reported for dual wheel systems)
UW = Using Wheel (only one wheel is active at a time - reported only for dual systems)

The filter positions are numbered 0, 1, 2…. to (Number of Filters per wheel -1). However, if there is a fault, such as the wheel is not at a filter detent, then the filter is reported as -1.

2.5 + Full Status Command

The + command is used to get a full status report:

```
>+
W1 = 3
W2 = 0
UW = 1
NF = 8
NW = 2
EO = 2
FL = 0
Version: 28-Sep-02 Copyright(c) A.C.E.
Type HELP for a list of all valid commands
>
```

The first three lines are identical to the short status report (? command).

Thereafter:

NF	=	Number of Filters (4 <= NF <= 10)
NW	=	Number of wheels (1 <= NF <= 2)
EO	=	engraving offset - factory set - do not adjust
FL	=	FAULT (TRUE when last move failed, else FALSE)

Note: If only one wheel is present then by definition UW = 1 and it does not appear in the printout. For more information including sample output please refer to the NW command.

2.6 NW (Number of Wheels) Command

Set the Number of Wheels present. When only one wheel is present the UW command does not appear in either the short or long status commands.

For only one wheel the short and long status commands have the following output:

```
>?
W1 = 5
>+
W1 = 5
NF = 8
NW = 1
EO = 2
FL = 0
Version: 28-Sep-02 Copyright(c) A.C.E.
Type HELP for a list of all valid commands
>
```

whereas with two wheels present the same commands produce the following output:

```
>?
W1 = 5
W2 = 0
UW = 1
>+
W1 = 5
W2 = 0
UW = 1
NF = 8
NW = 2
EO = 2
FL = 0
Version: 28-Sep-02 Copyright(c) A.C.E.
Type HELP for a list of all valid commands
>
```

2.7 UW (Using Wheel) Command

Set the active wheel. Valid for dual filter wheels where NW is set to 2. Only one wheel can be controlled at a time as there is only one motor driver in the ACE SmartFilter™. To swap between wheels use the UW command.

The wheels are called 1 and 2. The format of the command is n UW where (1 <= n <= 2).

Typical conversation:

```
>1 UW
W1 = 5
W2 = 4
UW = 1
>2 MV
Moving to  1-2
W1 = 2
W2 = 4
UW = 1
```

```
>2 UW
W1 = 2
W2 = 4
UW = 2
>1 MV
Moving to  2-1
W1 = 2
W2 = 1
UW = 2
>
```

2.8 NF (Number of Filters) Command

The Number of Filters (NF) command sets the number of filters in each wheel. ACE currently manufactures wheels with 4 to 10 slots per wheel for use with the ACE SmartFilter™. This value is written to memory and should not have to be altered.

Typical conversation:

```
>8 NF
W1 = 2
W2 = 1
UW = 2
>+
W1 = 2
W2 = 1
UW = 2
NF = 8
NW = 2
EO = 2
FL = 0
Version: 28-Sep-02 Copyright(c) A.C.E.
Type HELP for a list of all valid commands
>
```

2.9 MV Command

The Move (MV) command moves the current wheel (UW) to the desired position. Filter positions have a zero based index. Hence positions are labeled 0, 1, 2, 3, …. to (NF-1).

Typical conversation:

```
>7 MV
Moving to  1-7
W1 = 7
W2 = 3
UW = 1
>
```

2.10 HM Command

The Home (HM) command moves the current wheel (UW) to the nearest filter position. It is possible to move the filter wheels by hand. If a wheel has been left out of a detent (locked position) it can be restored using the HM command. The wheel to be homed is pre-set using the UW command.

Note that the status of the wheels on the LCD display show as “not home” when not at a detent and requiring homing. The status of the wheels on the RS232 port reads -1 when not at a detent.

Typical not home example using the ? command (wheel 1 is not home, wheel 2 is at home):

```
>?
W1 =-1
W2 = 3
UW = 1
>
```

Typical conversation to restore wheel to the nearest home position:

```
>HM
W1 = 7
W2 = 3
UW = 1
>
```

2.11 CS (Check System) Command

The Check System (CS) command can be used to initialize the system. It visits all the filters by first driving to filter 1-0, cycling through all the filters and back to 1-0. It then repeats for filter 2 if the second wheel is installed (NW = 2). There is a pause of 1000 ms at each filter to aid with manual observation of the system checkout. Also see section 2.16 for **Timeout** conditions.

Typical conversation:

```
>CS
Visiting all filters...
Moving to  1-0
Moving to  1-1
Moving to  1-2
Moving to  1-3
Moving to  1-4
Moving to  1-5
Moving to  1-6
Moving to  1-7
Moving to  1-0
Moving to  2-0
Moving to  2-1
Moving to  2-2
Moving to  2-3
Moving to  2-4
Moving to  2-5
Moving to  2-6
Moving to  2-7
Moving to  2-0
W1 = 0
W2 = 0
UW = 1
>
```

2.12 EX (EXercise) Command

The EXercise (EX) command is an engineering task used to test and qualify ACE Filter Boxes. It contains a crude random number generator so that both wheels are visited (for dual wheel systems) and all filters are visited from random rotation directions.

Each set consists of 50 random moves (including moving to the current position). Up to 20 sets can be commanded without pausing. Results for your system are shown in the **Certificate of Inspection.**

Note: The stepper motors driver system was designed for 50% duty cycle. This means that within any 10 minute period it will only be turning the motors for 5 minutes. For this reason the total number of sets that can be exercised is limited to 20 or less, or a total of 20 x 50 = 1000 moves. ***Do not program the ACE SmartFilter™ to continuously exercise the wheel for hours on end****. It may cause the motor driver to become excessively hot and fail. Having performed an EX command that lasts 10 or more minutes please wait 10 minutes before starting the same test again.*

Typical conversation (see Section 2.16 for **Timeout** conditions):

```
          >2 EX
          Exercise  2 sets of 50 moves

          Set  1/ 1:
          Moving to  1-1
          Set  1/ 2:
          Moving to  1-2
          Set  1/ 3:
          Moving to  2-4
          Set  1/ 4:
          Moving to  1-4
          ::::::::::::::
          ::::::::::::::
          ::::::::::::::
          Set  1/ 50:
          Moving to  2-4
          Set  2/ 1:
          Moving to  1-4
          ::::::::::::::
          ::::::::::::::
          ::::::::::::::
          Set  2/ 46:
          Moving to  2-0
          Set  2/ 47:
          Moving to  1-2
          Set  2/ 48:
          Moving to  2-6
          Set  2/ 49:
          Moving to  1-5
          Set  2/ 50:
          Moving to  1-7
          Successfully completed  2 sets of 50 moves
          W1 = 7
          W2 = 0
          UW = 1
>
```

2.13 EO (Engraving Offset) Command

The absolute encoder can have a zero offset to permit mounting at different locations inside the filter box. The EO command is factory set. The actual value is shown in the long status command. You should not alter this factory setting. If in doubt contact ACE.

2.14 FL (Fault) Command

The FL command is a read-only FAULT parameter available through the long status (+) command. When a move is completed in a normal manner FL = 0. When the desired filter location cannot be found within the factory-set timeout period the system faults and then FL = 1. The system recovers by homing the wheel to a valid encoder position. As soon as another move command is initiated the value of FL is reset to 0. For complete fault tolerance use the long status command to determine the position of the wheel and examine the FL parameter.

2.15 RS (Reset) Command

The RS command resets the CPU. It has the equivalent effect of performing a power recycle.

```
>RS
A.C.E Smart Filter Wheel (TM)
www.astronomical.com
28-Sep-02 Copyright(c)
System INIT
>
```

2.16 TIMEOUT conditions

The ACE SmartFilter™ has a factory set timeout period. This is typically long enough for the wheel to move 1.5 times around so that the correct detent must have been passed over. If the command has not been successfully completed within the timeout period then a timeout error is generated.

The action taken by the timeout period depends on the command:

2.16.1 Timeout during the MV command

When making a regular move (MV) command the "Moving to…" message is appended with "Timeout". The value of the FAULT parameter (FL) is set to TRUE in the long status (+) command. The nearest filter is located after the timeout flag is set.

```
>3 MV
Moving to  1-3 Timeout
W1 = 6
W2 = 1
UW = 1
>+
W1 = 6
W2 = 1
UW = 1
NF = 8
NW = 2
EO = 2
FL = 1
Version: 28-Sep-02 Copyright(c) A.C.E.
Type HELP for a list of all valid commands
>
```

2.16.2 Timeout during the CS command

If a timeout occurs during the Check System (CS) command the filter position which has faulted is reported with "Timeout". The check continues until all positions have been tested. The FL parameter will be reset unless the fault occurs on the last move. Therefore use the "timeout" message to check for faults.

A definitely not so typical output (created by holding the detent switches) follows:

```
>CS
Visiting all filters...
Moving to  1-0
Moving to  1-1 Timeout
Moving to  1-2
Moving to  1-3 Timeout
Moving to  1-4
Moving to  1-5 Timeout
Moving to  1-6
Moving to  1-7 Timeout
Moving to  1-0
Moving to  2-0
Moving to  2-1
Moving to  2-2
Moving to  2-3
Moving to  2-4 Timeout
```

```
Moving to  2-5 Timeout
Moving to  2-6 Timeout
Moving to  2-7 Timeout
Moving to  2-0
W1 = 0
W2 = 0
UW = 1
>
```

In the above example the least significant bit of wheel 1 encoder is faulty and the most significant bit of wheel 2 is faulty. The encoder uses a simple binary pattern.

2.16.3 Timeout during the EX command

If a timeout occurs during the Exercise (EX) command the system stops at that point. Hence the FL flag is still set. A typical conversation follows:

```
>2 EX
Exercise  2 sets of 50 moves

Set  1/ 1:
Moving to  1-7
:::::::
:::::::
Set  2/ 44:
Moving to  2-3
Set  2/ 45:
Moving to  1-1 Timeout
stopping
W1 = 0
W2 = 3
UW = 1
>
```

Chapter 3
ACE Filter Box

3.1 Introduction

The following description is applicable to ACE Dual Filter Boxes with wheel model DFW8x50S.

The Filter Box contains two wheels with 8 positions, capable of holding 50.8 mm filters up to 10 mm thick. The filters are retained using plastic jackets. They are inserted and removed through a change door. The box is black anodized with stainless steel fasteners.

The filter wheel rides on deep groove ball bearings and does not need to be lubricated. The wheel is held in place by a spring loaded radial ball bearing which seats in a specially designed pocket. The position of the wheel is read by an absolute encoder to ensure that the wheel cannot become lost. The wheel is rotated using a timing belt and a sprocket gear. The precision of the wheel position is not determined by the timing belt but rather by the detent. Under normal operating conditions no regular maintenance is required.

The wheel can be turned under computer control by sending commands to the ACE SmartFilter™ using the RS232 port. This can be done with a "dumb" terminal or with a full user interface program such as Maxim-DL (not supplied).

3.2 Mounting the Filter Box to the telescope.

The filter box has an interface flange to the telescope. This has been custom designed based on customer supplied information.

3.3 Belt Drive System

The filter wheel employs a chain belt drive. Do NOT lubricate the belt. The correct belt tension is such that the wheel will turn and at the end of the move the spring will pull the wheel into the home detent. Belt tension is adjusted at the motor mount. It has been factory set and should not require adjustment. If adjustment is made and the wheel slips the belt is too loose. If the wheel will not fall into a detent the belt is too tight. The maximum recommend operating load on the belt is 3 kg.

For spares contact ACE. Part number is ACE-FWB-32-327

Chapter 4

Controlling ACE SmartFilter™ with Maxim-DL®

4.1 Introduction

Maxim-DL is an image acquisition and processing package used to control many CCD cameras. The ACE filter wheels can be controlled through Maxim-DL. To purchase Maxim-DL visit www.cyanogen.com.

4.2 ACE Plug-in

The file CCDPlugACEFW.dll should be copied from the CD-ROM to the main program directory for Maxim-DL.

4.3 ACE Initialization File

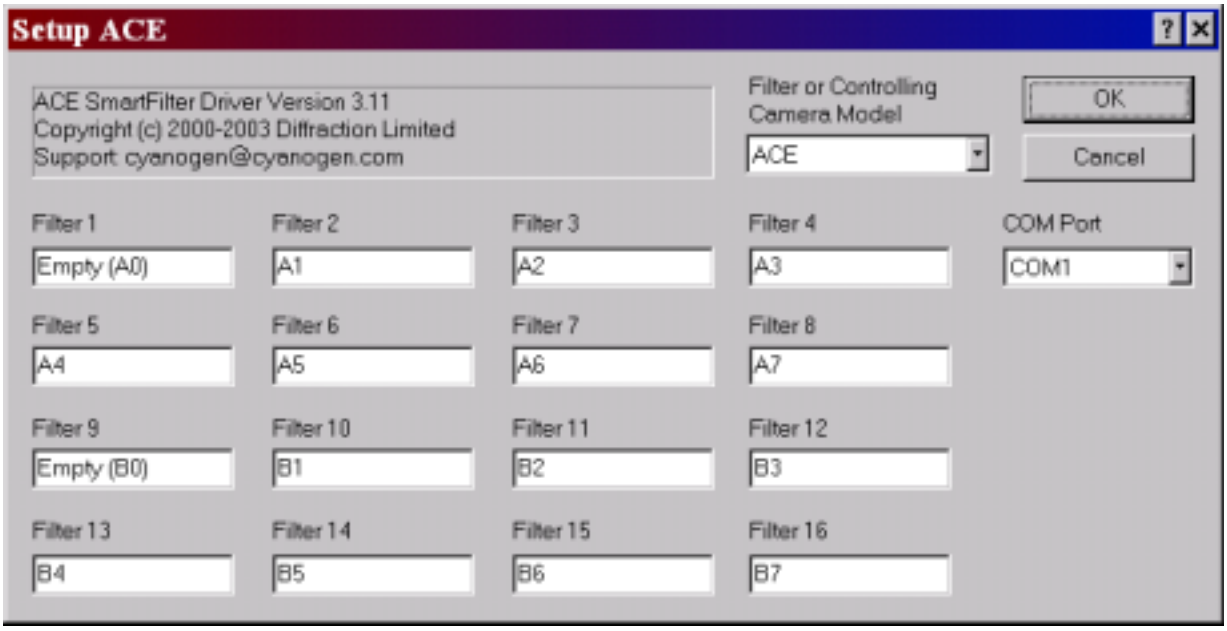
The file ACE.ini should be copied from the CD-ROM to the main program directory for Maxim-DL. It has the following format:

```
1,0
2,0
3,0
4,0
5,0
6,0
7,0
0,0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
```

The format is (wheel 1, wheel 2).
When filter wheel 1 is in use filter wheel 2 is set to 0 and vice versa.

4.4 Using Maxim-DL

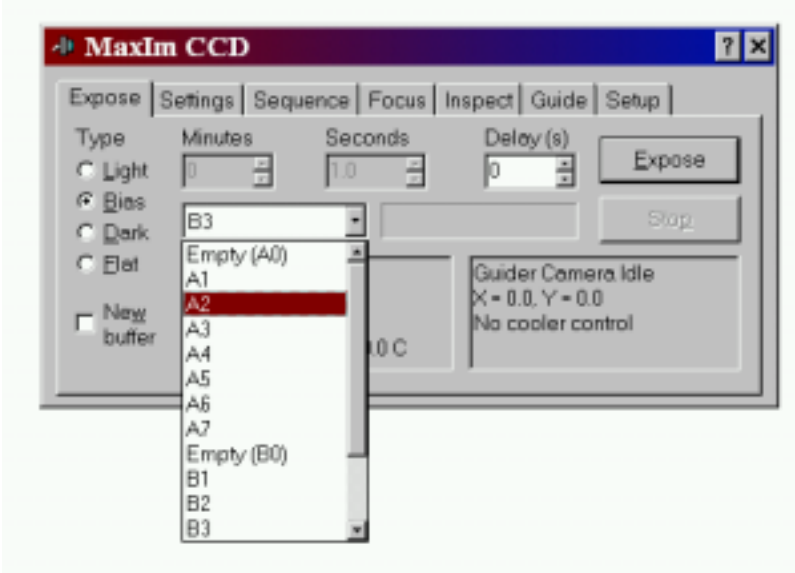
Power up the ACE SmartFilter™ and make all the connections before stating Maxim-DL.
From the menu select View->CCD Control Window (CTRL-W). Inside the MaxIm CCD window select the Setup tab.



The filters appear from 1 to 16 as if it were a large single wheel. The dialog above shows the scheme for wheel A and wheel B where the first slot (0) of each wheel is empty. Thus selecting "Filter 3" (A2) will move wheel 1 to slot 2 and wheel 2 to slot 0 assuming the ACE.ini file shown above.

To test the filter wheel without a CCD select the "Simulator" in the camera setup.

To change filters select the expose tab and then select the desired filter from the drop-down box.



For further information please refer to the Maxim-DL on-line help system.

Chapter 5
Electronics Connections

5.1 Introduction

The following information is provided for ACE reference only. It is not intended that the customer diagnose and troubleshoot the equipment. In the event of a problem please contact ACE *before* attempting any corrective action. Refer to the **Warranty and Repair** section below.

5.2 Filter Wheel Encoder

Each filter wheel is encoded using three micro-switches that ride in specially machined detent pockets. Each switch is active (closed) when the roller falls into a detent pocket. In addition, a Home switch monitors the detent locking mechanism. The SmartFilter™ only reads the binary pattern when the filter is at a home (detent) position. A simple binary pattern is produced:

Position (Engraved)	Home	Bit 2	Bit 1	Bit 0	Position
1-0, 2-0	1	0	0	0	0
1-1, 2-1	1	0	0	1	1
1-2, 2-2	1	0	1	0	2
1-3, 2-3	1	0	1	1	3
1-4, 2-4	1	1	0	0	4
1-5, 2-5	1	1	0	1	5
1-6, 2-6	1	1	1	0	6
1-7, 2-7	1	1	1	1	7

5.3 Filter Wheel Motor

The motors are mounted on the outside of the main housing using an adjustable belt tension plate. The motor driver module (located in the SmartFilter™ controller) has the ENON/ENOFF set to ENON. Power is only applied to the motor when the wheel is turning. It is otherwise de-energized and free to turn by hand. The motors are Intelligent Motion model MH2-2218-S.

Notes:

a) Motors are wired in series with center-taps co-joined. Specifically, motor wires BLACK/WHITE joined to ORANGE/WHITE and RED/WHITE joined to YELLOW/WHITE.

b) The INT-481 driver has been set to 400 steps per revolution

5.4 SmartFilter™ Controller to Filter Box Connection

There is only one connector between the SmartFilter™ controller and the Filter Box. It is safe to make/break the connection with the power on if no motion is in progress. However, ACE recommends removing the power from equipment when making or breaking a connection.

5.4.1 Filter Box Connector Table

The Filter box has only one external connector, a 26-pin high density DB connector

Pin	Function	Color	Notes
1	Motor 1 Phase A+	Black	The micro-switches are all wired normally closed. Hence the circuit is made when the switch is in an encoder detent or at a home position
2	Motor 1 Phase A-	Orange	
3	Motor 1 Phase B+	Red	
4	Motor 1 Phase B-	Yellow	
5	Motor 2 Phase A+	Black	
6	Motor 2 Phase A-	Orange	
7	Motor 2 Phase B+	Red	
8	Motor 2 Phase B-	Yellow	
9-17	No Connection		
18	+5 VDC	Green	
19	W1 Bit 2	White	
20	W1 Bit 1	Violet	
21	W1 Bit 0	Red	
22	W1 Home	Yellow	
23	W2 Bit 2	Grey	
24	W2 Bit 1	Orange	
25	W2 Bit 0	Brown	
26	W2 Home	Blue	

5.4.2 ACE SmartFilter™ Connector Table

The **SmartFilter™** has a male Circular Plastic Connector for the main control cable. The following documents connections inside the SmartFilter™ controller and is intended for ACE reference only.

Part Number AMP 206838-1
24-Pin Panel Mount CPC Series I

Pin	Function	Internal Color	Route to:	Notes
1	Motor 1 Phase A+	Black	Port 2-4	
2	Motor 1 Phase A-	Orange	Port 2-3	
3	Motor 1 Phase B+	Red	Port 2-2	
4	Motor 1 Phase B-	Yellow	Port 2-1	
5	Motor 2 Phase A+	Black	Port 1-3	
6	Motor 2 Phase A-	Orange	Port 1-4	
7	Motor 2 Phase B+	Red	Port 1-2	
8	Motor 2 Phase B-	Yellow	Port 1-1	
9-15	no connection			
16	+5 VDC	Green	J12-1	
17	W1 Bit 2	White	J7-4	
18	W1 Bit 1	Violet	J7-3	
19	W1 Bit 0	Red	J7-2	
20	W1 Home	Yellow	J7-1	
21	W2 Bit 2	Grey	J7-8	
22	W2 Bit 1	Orange	J7-7	
23	W2 Bit 0	Brown	J7-6	
24	W2 Home	Blue	J7-5	

Other connections inside the ACE SmartFilter controller

Pin	Function	Color	SmartFilter™ Board	Relay Board
IMS P1-1	Phase B-	Yellow	J2-1	
IMS P1-2	Phase B+	Red	J2-2	
IMS P1-3	Phase A-	Orange	J2-3	
IMS P1-4	Phase A+	Black	J2-4	
IMS P1-5	Enable	Violet	J4-3	
IMS P1-7	+5V	Red	J11-1	
IMS P1-8	Direction	Brown	J4-2	
IMS P1-9	Step	Yellow	J4-1	
IMS P1-12	+24 VDC	Brown		
IMS P1-13	Supply Ground	Grey		
IMS P1-14	Resistor 1.8k	13/14		
J11-1	+5V	Red		Power-1
J11-2	Ground	Black		Power-2
J11-3	Wheel 2	Blue		Power-3

Note ribbon cable for LCD. Yellow at top of LCD connector to left (near R5) of filter board.

All switches to “ON” INT-481

5.4.3 ACE SmartFilter™ Control Cable

20-m long control cable Carol-Columbia E18621-7 Style 2343

CPC Socket AMP 206837-1	Function	HD DB-26 Socket Female solder cup type.
1	Motor 1 Phase A+	1
2	Motor 1 Phase A-	2
3	Motor 1 Phase B+	3
4	Motor 1 Phase B-	4
5	Motor 2 Phase A+	5
6	Motor 2 Phase A-	6
7	Motor 2 Phase B+	7
8	Motor 2 Phase B-	8
9-15	no connection	9-17
16	+5 VDC	18
17	W1 Bit 2	19
18	W1 Bit 1	20
19	W1 Bit 0	21
20	W1 Home	22
21	W2 Bit 2	23
22	W2 Bit 1	24
23	W2 Bit 0	25
24	W2 Home	26

5.5 SmartFilter™ RS232 Interface

Industry standard cable:

SmartFilter™:	DB9 Female connector
Cable:	DB9 Male connector, Female at Computer end

5.6 Warranty and Repair

SmartFilter™ and the Filter Box are warranted against defects in manufacture for a period of one year from the shipping date. For technical assistance please visit www.astronomical.com for current phone numbers. Please do not open the SmartFilter™ module to attempt any repairs without first contacting ACE. The warranty does not cover damage caused by unauthorized attempts at repair. The warranty does not apply to defects resulting from improper or inadequate handling by the customer including unauthorized modification or misuse.

All repairs require a Return Merchandize Authorization (RMA).