ACE SmartFilter™

Dual Filter Wheel
8 Position 50 mm square capacity

Technical Reference Manual

Release Date 04 MAR 2019

Created By:
Astronomical Consultants & Equipment, Inc.
2901 W. Sahuaro Divide
Tucson AZ, 85742
U.S.A.

Table of Contents

FIGURES

TABLES

1.0 INTRODUCTION

1.1 OVERVIEW

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 a USB-connected RS232 serial communications port.

This Technical Reference Manual describes how to operate and maintain the equipment.

> If you are experiencing trouble please contact support@astronomical.com *before* attempting diagnostics or repairs. Thank you.

1.2 SHIPPING

The following items have been shipped with your order:

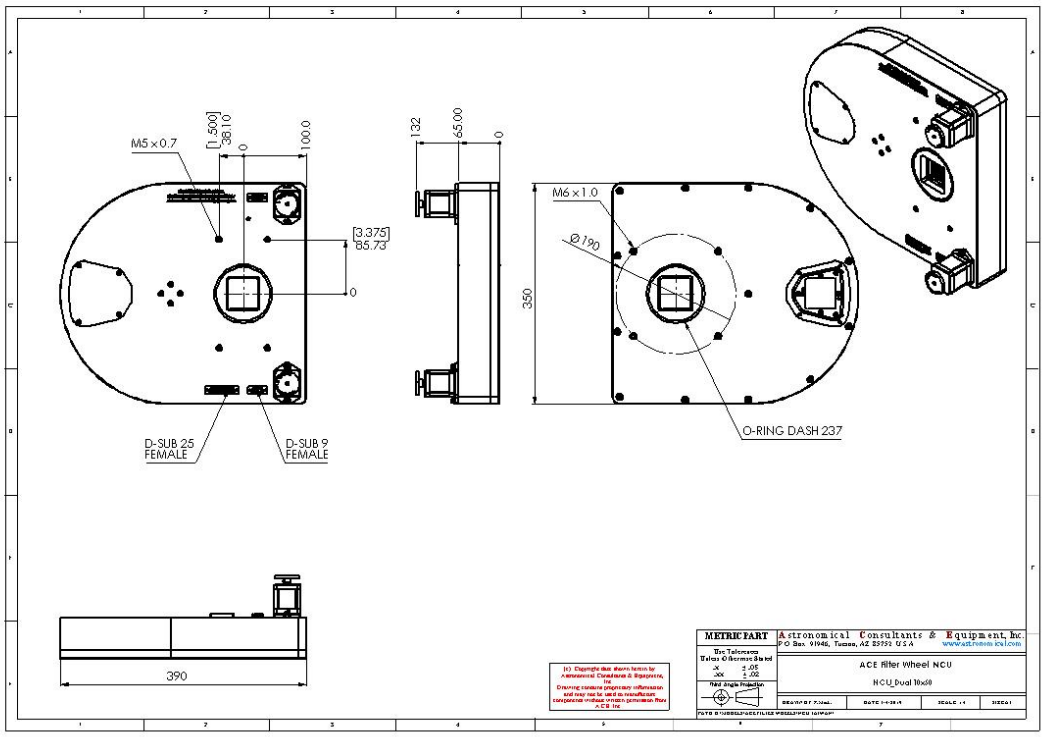
Item	ACE Part Number	Qty	Description
1	ACE-DFW-10-50	1	10 Position 50 mm capacity dual wheel filter box
2	ACE-FJL-50S-3	26	Filter Jacket Lid with 3mm pocket for 50mm sq. filters
3	ACE-FJB-50S-5	20	Filter Jacket Base, for 3mm and 5mm filters, 50mm sq.
4	ACE-FJB-50S-10	6	Filter Jacket Base, for 3mm and 10mm filters, 50mm sq.
5	ACE-FJL-50R-3	4	Filter Jacket Lid with 2.9mm pocket for 50mm Ø filters
6	ACE-FJB-50R-5	2	Filter Jacket Base, for 3mm and 5mm filters, 50mm Ø
7	ACE-FJB-50R-10	2	Filter Jacket Base, for 3mm and 10mm filters, 50mm Ø
8	ACE-CIP-NCU	1	Interface plate to the camera
9	ACE-SFC-D	1	SmartFilter™ Controller for a dual wheel
10	ACE-SCC-10	1	10-m control cable
11	ACE-IEC320-C13	1	240 VAC Euro molded power cord
12	ACE-FWB-32-425T	3	Spare drive belt

1.3 FILTER BOX

The following description is applicable to custom-configured ACE Dual Filter Wheel Box with 10 positions for 50mm square or round filters, for the NCU, Taiwan. Metric fasteners are used throughout.

The filter wheel rides on a precision SKF 16008 deep groove ball bearings. These are sealed for life and should not need further attention. The wheel is held in place by a spring-loaded radial ball bearing which seats in a specially designed detent. When the wheel is moved to a new position it stops at each detent and reads the position. The position of the wheel is sensed 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™ controller using a USB connection. It can also be turned using the knobs on the motors. The engraving on the wheel allows the filter slot to be identified. By convention, Slot 0 on each wheel should be left empty.

1.3.1 Mechanical Interface



The filter box dimensions are shown above. The bolt pattern to attach to the telescope is four equally-spaced holes tapped M6 x 1.0 on a 190mm bolt circle. The bolt pattern to the camera adapter is four holes tapped M5X0.7 on a rectangle of 6.75 x 3.0 inches.

An O-Ring, size Dash Number 237, is used as a light seal on both faces.

1.3.2 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.

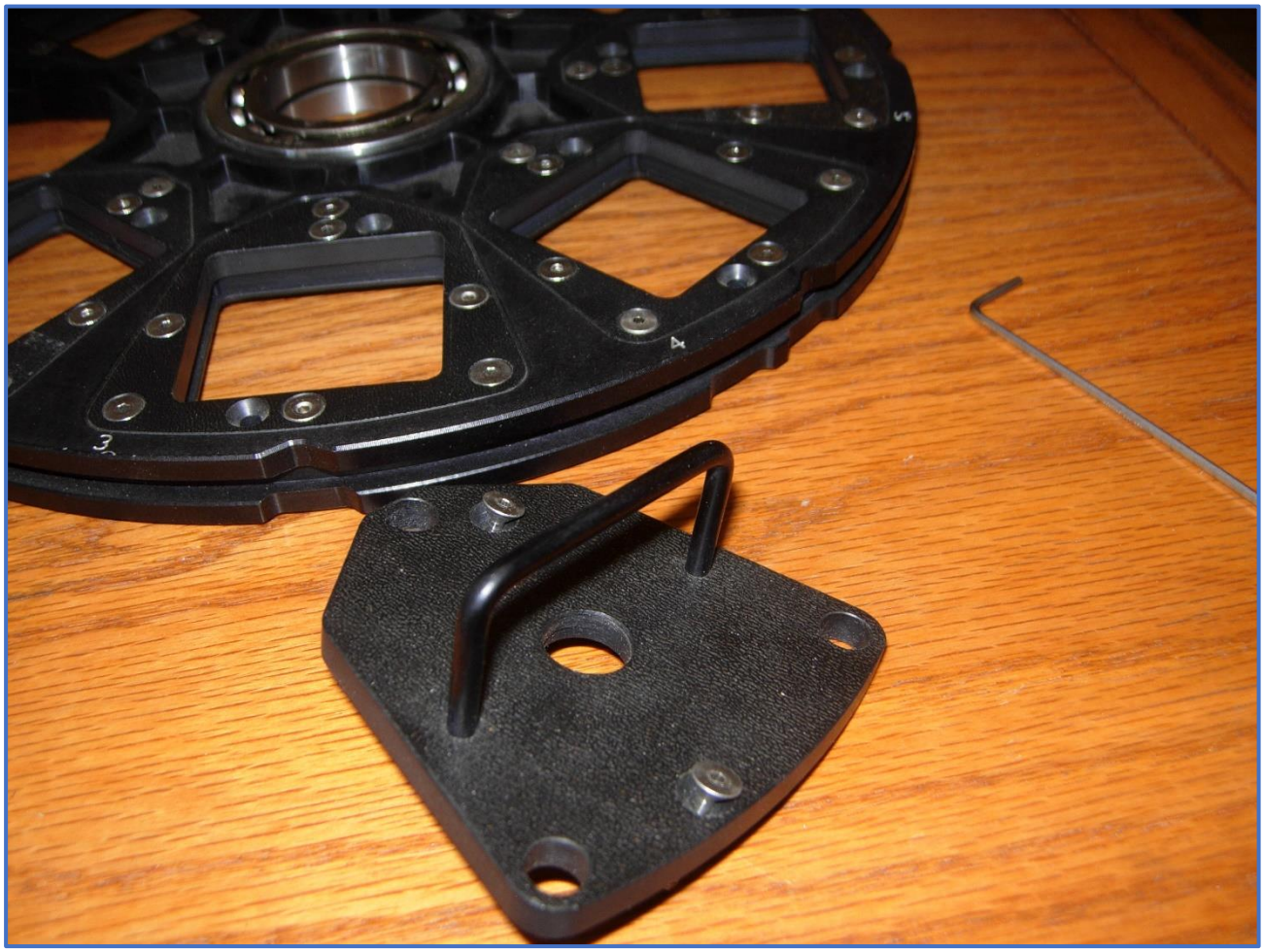
Part number is ACE-FWB-32-425T

The drive sprocket is a 32-pitch 24-tooth pinion type 32B104-24 (modified).

For spares contact ACE.

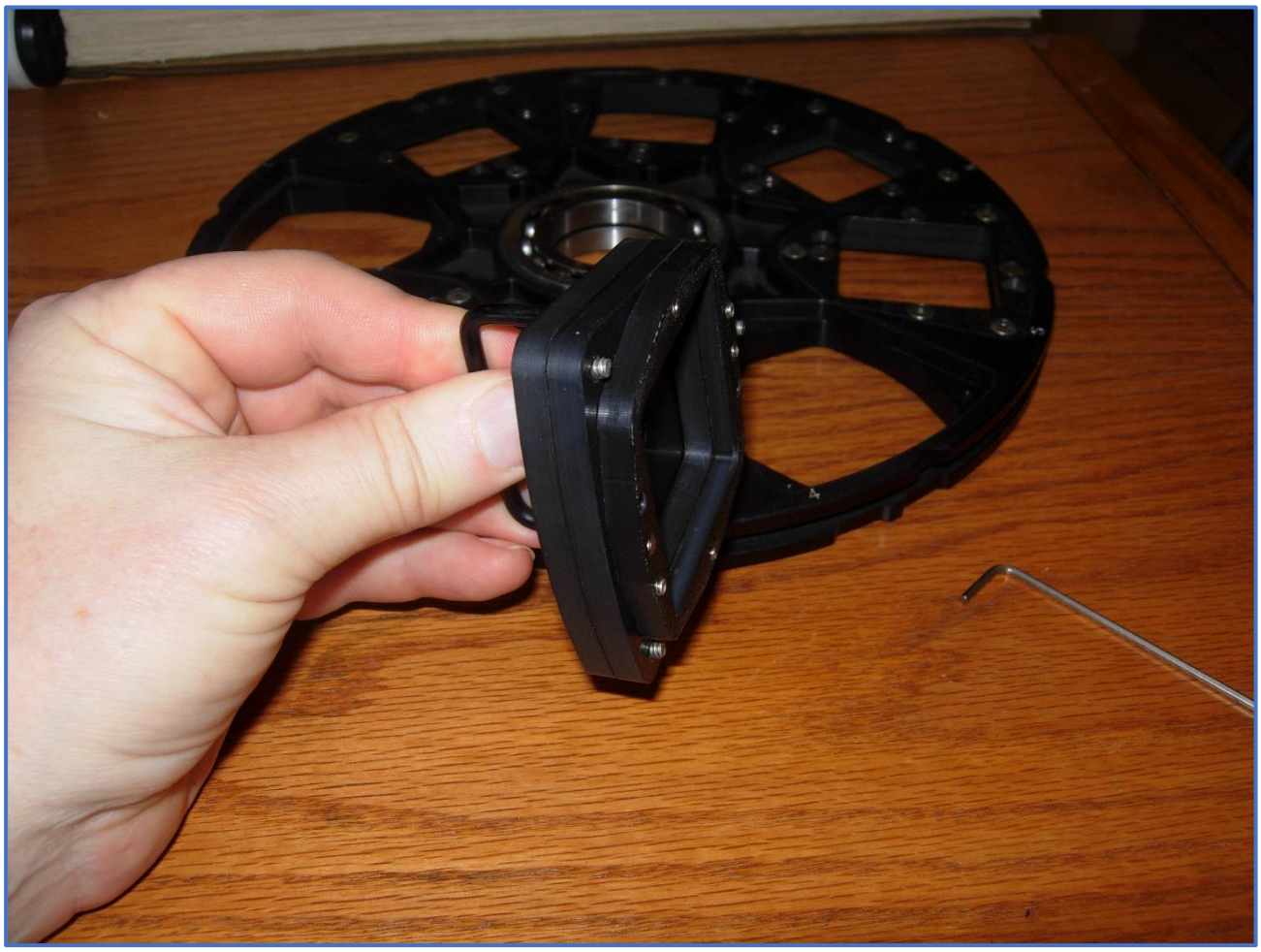
1.3.3 How to change filters

The filters are held in plastic jackets.



The plastic jackets are inserted and removed through a change door using a handler tool.

The screws that hold the jacket to the filter wheel are captive, as are the screws in the handler.



Attach the handler to the jacket, then loosen the three captive screws holding the jacket to the wheel. Once on a suitable clean bench, remove the handler from the jacket, disassemble the jacket and insert or remove the filter. To attach a filter to the wheel simply attach the handler and then insert into the wheel. The wheel is engraved 0 through 7.

1.3.4 Choosing the correct filter jackets

The lid of each square filter jacket has a recessed pocket that is 2.9mm deep. The mating base has a pocket on one side that is 2mm deep and on the other side is flat. Therefore the combination of this lid and base can accommodate a 3mm or 5mm thick filter. Another mating base has the pocket 7mm deep and this allows both 3mm and 10mm thick filters to be used with it.

The round filter jackets accommodate 50mm or 50.8mm (2-inch) filters. The combination of lid and base accommodate 3mm, 5mm and 10mm thick filters.

1.4 ACE SMARTFILTER™

The ACE SmartFilter™ is a controller for the filter wheel. A 10-meter long multi-conductor cable is used between the controller and the filter box. A standard USB A-B cable connects the controller to your computer. It is assumed that the controller will reside close to the computer.

All the connectors are unique. It is not possible to incorrectly assemble the equipment. After assembly plug in the power cord to a suitable (115-240 VAC) outlet. Do connect or disconnect the main control cable with power applied to the system.

The rear of the ACE SmartFilter™ Controller showing the USB connection, 9-pin circular plastic connector and the power supply. The power inlet has a 5A fast fuse. The fan operates on 24 VDC and is always on.

Table 1-1 DUAL FILTER WHEEL WIRING TABLE				
D-SUB 25 Pin	Function	Internal Color	Belden 9519	Notes
1	W1 Motor A+	RED	BLK	D-SUB 9 Pin 1
2	W1 Motor A-	WHT	RED	D-SUB 9 Pin 2
3	W1 Motor B+	GRN	BLK	D-SUB 9 Pin 3
4	W1 Motor B-	BLK	WHT	D-SUB 9 Pin 4
5	W1 Home	YLW	BLK	
6	W1 Bit0	BLK	GRN	
7	W1 Bit1	BLU	BLK	
8	W1 Bit2	BRN	BLU	
9	W1 Bit3	GRY	BLK	
10	W2 Motor A+	RED	YLW	D-SUB 9 Pin 1
11	W2 Motor A-	WHT	BLK	D-SUB 9 Pin 2
12	W2 Motor B+	GRN	BRN	D-SUB 9 Pin 3
13	W2 Motor B-	BLK	BLK	D-SUB 9 Pin 4
14	W2 Home	YLW	ORG	
15	W2 Bit0	ORG	RED	
16	W2 Bit1	RED	WHT	
17	W2 Bit2	VLT	RED	
18	W2 Bit3	WHT	GRN	
19	Common (Wheel #1)	GRN	RED	
20	Common (Wheel #2)	GRN	BLU	
21	Common			
22	Common			
23	Common			
24	Common			
25	Common			

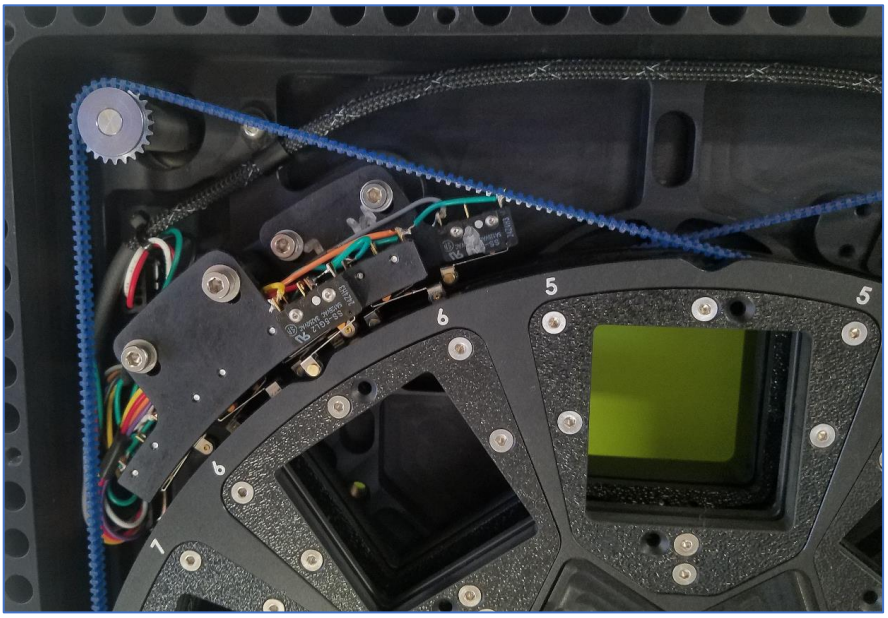


FIGURE 1-1 FILTER WHEEL ENCODING.

Each filter wheel uses 3 roller switches that ride in and out of a binary detent pattern to provide absolute positional encoding of the wheel.

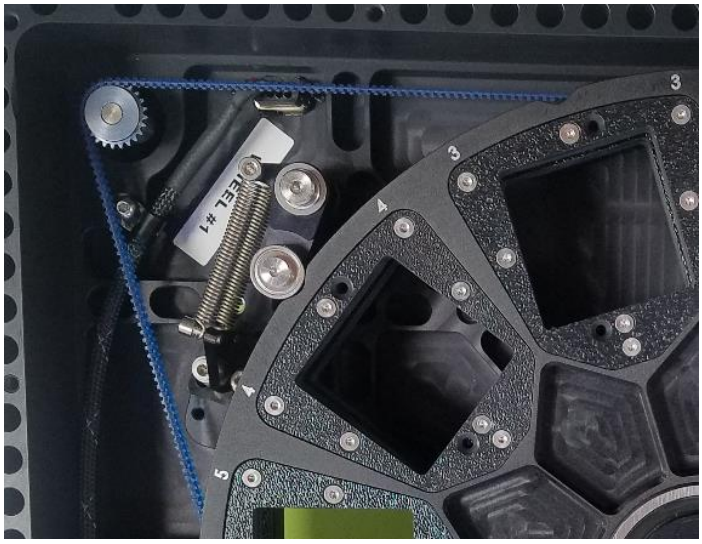


FIGURE 1-2 DETENT BEARING AND SPRING

A fourth roller switch rides in and out of a detent slot, which is also used by a roller bearing to lock the wheel in position using a precision spring.

2.0 CONTROLLING THE FILTER WHEEL

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`.

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-18 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 only 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 (MOVE) 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 (HOME) 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 RS (RESET) COMMAND

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

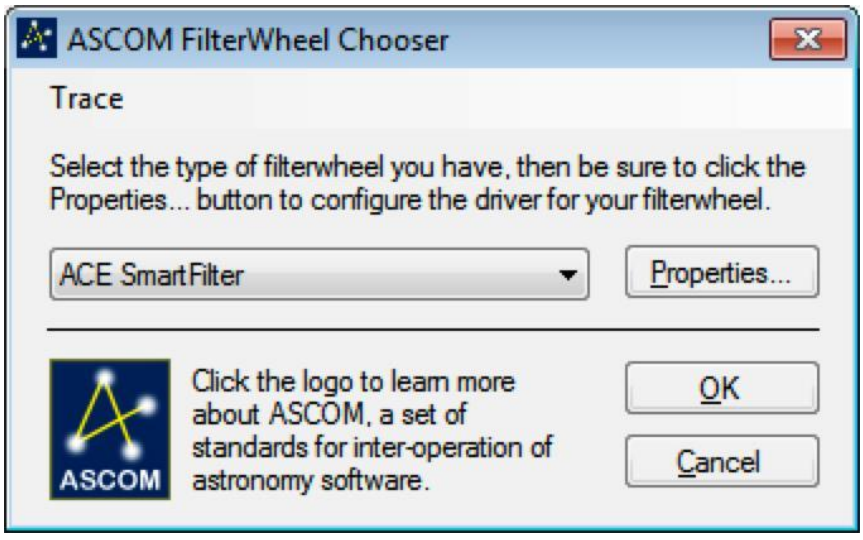
```
>RS
A.C.E Smart Filter Wheel (TM)
www.astronomical.com
28-Sep-18 Copyright(c)
System INIT
>
```

3.0 ASCOM SOFTWARE

The filter wheel is controlled by a USB-serial connection to a circuit board that controls the two filter wheel motors and the sensor switches that are used to read the position of the filter wheel. In Windows, install the included software for the filter wheel onto the computer before using the filter wheel. When you plug the USB connection into a computer, the filter wheel will be recognized and will appear in the Windows Device Manager under the "Ports" section, with the name "ACE Smart Filter Wheel". In Device Manager, note the name of the COM port that Windows has assigned to your filter wheel. Usually the assignment will have the form "COMn," where "n" is a number; for example, "COM5." This is the port you will need to use to access your Smart Filter.

The included software provides an ASCOM driver for the Filter Wheel and a demonstration program that can be used to operate the wheel. The demonstration program loads with two buttons shown: "Choose" and "Connect."

Start by pressing the "Choose" button. This causes the ASCOM Chooser Dialog to appear. The Chooser Dialog shows the ASCOM filter wheel drivers that are available. Select "ACE SmartFilter" from the dropdown list, and then click the "Properties…" button to configure the ACE SmartFilter driver to view the ACE SmartFilter Setup dialog.



In the ACE SmartFilter Setup, you can configure the following items:

- The COM port used to communicate with ACE SmartFilter. This is the COM port identified by Windows Device Manager.

- The empty positions for each wheel. These wheel positions should not be loaded with a filter. When a filter in wheel 1 is selected, wheel 2 will be moved to its empty position, and when a filter in wheel 2 is selected, wheel 1 will be moved to its empty position.

- The filter names for all the filters. In the box on the left, type the names to be assigned to the filters in wheel 1, with one name per line. In the box on the right, type the names to be assigned to wheel 2. This information is used by ASCOM client programs.

- Focus offsets for each filter. You may provide an integer focus offset to be applied when that filter is selected. This is used by ASCOM client programs to keep the image in focus as you change filters.

- Use the "Trace on" checkbox to write debug information to the ASCOM logs. This can be used for troubleshooting the software.

When you have finished setting up the filter wheel, click the OK button to dismiss the ACE SmartFilter Setup dialog, and click the OK button in the ASCOM Chooser Dialog to dismiss that dialog.

After you have finished the ASCOM setup steps, you can click the "Connect" button to connect to the filter wheel. This will cause rows of buttons to appear in the window. Each button corresponds to a filter wheel position. To move the filter wheel, select one of the buttons. An arrow will indicate the current position of the wheel.