

MODEL IFW

INTELLIGENT FILTER WHEEL

TECHNICAL MANUAL FOR
THEORY OF OPERATION AND OPERATING PROCEDURES

Revision 4, August 2007



OPTICAL AND ELECTRONIC PRODUCTS

sales@optecinc.com
www.optecinc.com

199 Smith St.
Lowell, MI 49331
U.S.A.
(888) 488-0381
(616) 897-9351
(616) 897-8229 FAX

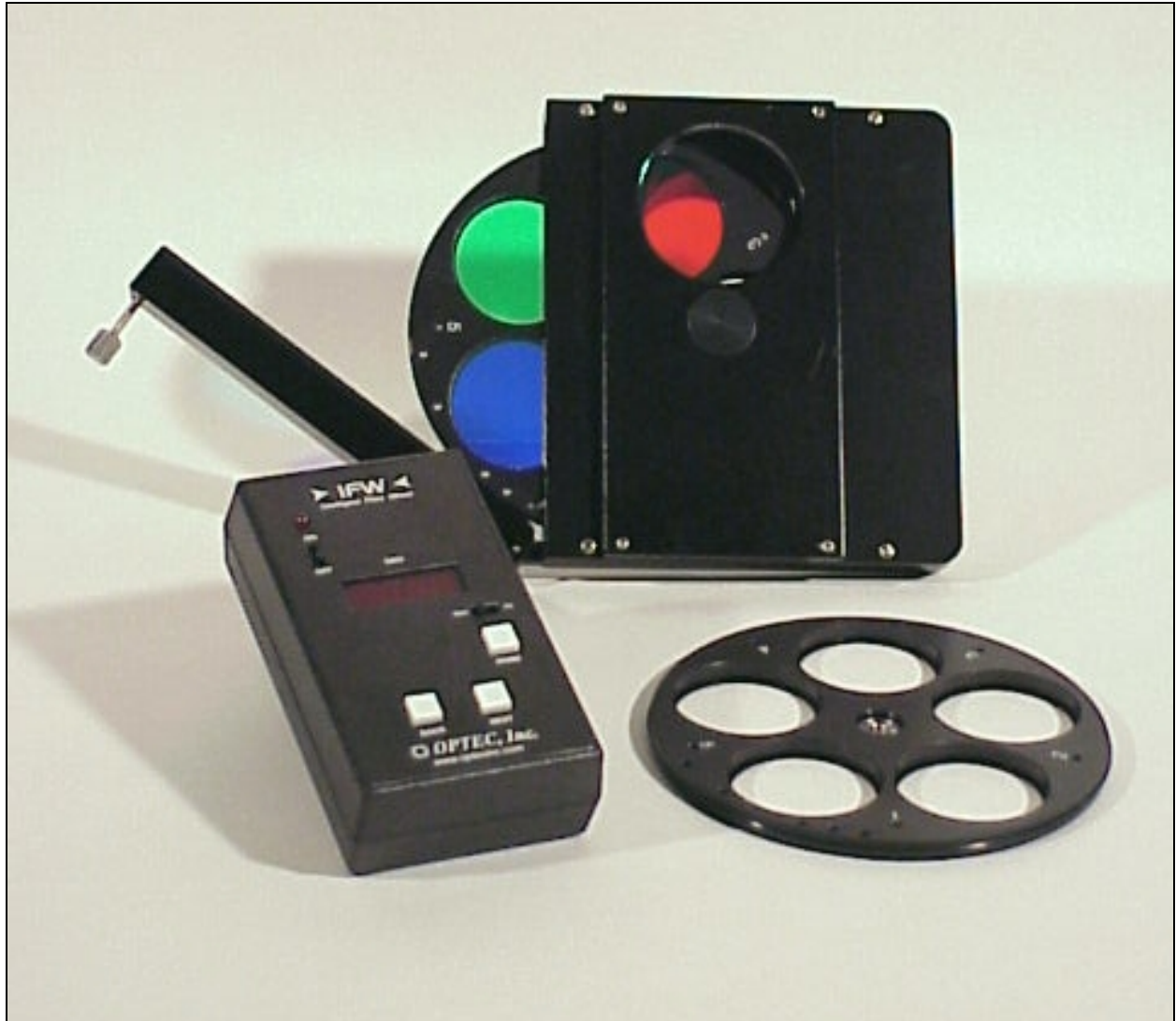


Figure 1-1. Model IFW Intelligent Filter Wheel with 5-position filter wheels

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SECTION 1.0

INTRODUCTION

The Optec Intelligent Filter Wheel brings to astronomy a new level of sophisticated equipment for the benefit of the astro-imager. Astro-imaging in this age of astronomy requires the use of many color filters and the management of these filters during an observational session can sometimes be confusing. The use of the wrong filter could easily spoil an otherwise successful imaging run.

The Optec IFW has the ability to determine the identification (ID) of a particular wheel and apply that wheel ID to a stored set of filter names. The names, not just position numbers of these filters, are displayed on the eight character display and are also available to the camera operating software via a RS-232 interface using a simple command structure. Up to 5 different filter wheels can have separate IDs and each wheel can have up to five 50mm or 2-inch filters for a total of 25 identifiable filters. For non-astronomical applications, an 8-position filter wheel is available that holds 1-inch diameter filters. In this configuration, up to three unique filter wheels with a total of 24 are possible.

The IFW filter wheel can easily be removed from the IFW system without tools or removal from the telescope. A hinged door is secured by a single captive thumbscrew. Once opened, the wheel can be extracted and another inserted in its place. The entire process takes only a few seconds. Hitting the HOME switch on the hand control or invoking the HOME function in the operating program will set the wheel to position one and bring up the available filter names for that wheel.

The IFW can be controlled by either the switches on the hand control, an SBIG camera controller (TTL level pulses), or by an external computer via a RS-232 interface. The RS-232 operating protocol is a set of simple ASCII commands that any programmer can easily implement. Optec's IFW control software can be used for the filter description programming and also for filter selection and control. Many of the available CCD camera control software have IFW filter wheel control.

SECTION 2.0

INSTALLATION

Attach a telescope adapter to the telescope securely without the IFW connected. Using the included hex ball-driver, loosen the three #8 setscrews around the 2.4" diameter hole on the front side of the IFW so that it can slip easily onto the telescope adapter. After rotating the IFW to the desired orientation, tighten the three setscrews evenly making sure no gap is visible between the IFW and the telescope adapter.



Figure 2-1. IFW Intelligent Filter Wheel System Components.

A control cable with 8-pin modular connector on one end and a 9-pin sub-D connector on the other is used to connect the IFW to the hand control box. Lengths of cable 6, 12, 25 and 50 feet as well as custom lengths are available from Optec. This is the same cable used with the TCF focuser and can be interchanged. **IMPORTANT NOTE:** Accidentally switching controllers from the TCF and the IFW will NOT cause damage to either unit.

The power supply for the IFW is regulated at 12 VDC and 1.25 amp. Use only this type to power the IFW controller.

SECTION 3.0

THEORY OF OPERATION

3.1 WHEEL & HOUSING

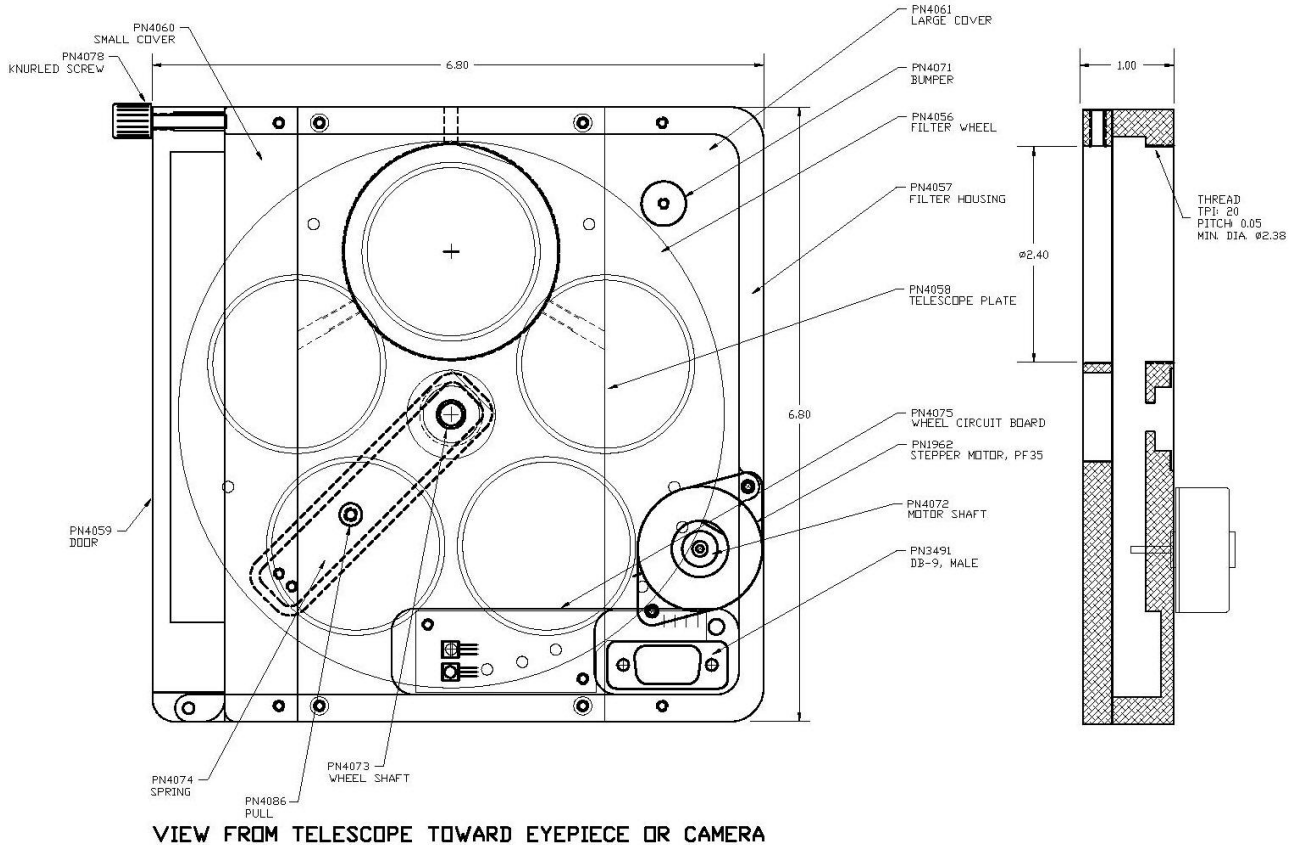


Figure 3-1. IFW Cross-Section View with Part Descriptions (view from back/camera side).

The IFW wheel is 6 inches in diameter and is rotated on the center axis by a small stepper motor. Filter wheels are available to hold five 50mm or 2-inch filters, which are mounted in place using an RTV silicone sealant or plastic holding tabs. For industrial and non-astronomical applications, an 8-position wheel is available. This option requires a different firmware to be installed in the controller. Firmware versions for the 5-position only wheels are in the range of 1.00 to 1.99. Firmware versions for the 8-position wheels are the range of 2.00 to 2.99. The 8-position firmware can accommodate both 5 and 8 position wheels and have the means to detect which wheel has been installed. Beginning in 2007 a new tab mounting filter wheel is available that avoids the need for mounting the filters with RTV. See Appendix E for more information.

The shaft of the stepper motor makes friction contact with a Neoprene O-ring that is secured to the circumference of the wheel. It takes approximately 2000 steps of the stepper motor to complete one rotation of the wheel. At 125 steps per second, it takes approximately 16 seconds for one complete wheel rotation. One filter position change takes approximately 3.2 seconds.

Small magnets are inserted into each wheel opposite the filters, which indicate to the electronics the current wheel ID and filter position. Hall effect sensors detect the magnets and send a logic control signal to the hand control micro controller. The numbers 1, 2, 3, 4, and 5 (6, 7 and 8 for 8-position wheels) mark the filter position magnets on the wheel and correspond to the filter on the opposite side. (See *Figure 3-2.*) The tab mounted filter wheel is marked differently with the filter numbers near the filter and not the associated magnet.

Another set of holes, only one of which contains a magnet, are used to identify the wheel and are referred to as the filter ID. These holes are marked with the letters A, B, C, D, and E for the 5-position wheels and the addition of F, G and H for the 8-position wheels. As the wheel rotates during the HOME procedure, the lettered ID hole with the magnet will pass over a second Hall effect sensor initiating a control pulse. The number of steps from this control pulse to the next signal pulse by the position magnet (filter position number 1) determines the wheel ID and position number 1. The wheel will stop at filter 1 and wait for further commands.



Figure 3-2. 5-Position Filter Wheel with RGB-IR and Luminance filters.

The wheel is held in place by a center shaft which is spring loaded and can be pulled from the wheel by use of a small pull knob on the back of the wheel housing. Rotating the pull knob counter clockwise will allow the spring shaft to retract from the wheel. At that point, the door can be opened and the wheel removed by hand. (See *Figure 3-4.*) A different wheel is inserted and the pull knob turned clockwise until the shaft falls into the wheel center bearing. Proper operation of the wheel is dependent on the friction for the O-ring and motor shaft. If the pressure is too light

or too heavy, or if there is oil or grease on the O-ring, the wheel will not rotate properly and an error condition will occur. Usually, cleaning the O-ring will solve this problem. See Section 6.0 for troubleshooting information. It is a common mistake to put the filter wheel in backwards. If this is done the filter wheel will not rotate. Make sure the numbers and markings on the filter wheel face the telescope when inserting the wheel.

A lightweight, 6061 aluminum alloy is used for all machined parts. All parts are machined from solid aluminum blocks for optimum strength. In addition, all aluminum parts are bright dip and black anodized for maximum corrosion protection. See *Figure 3-1* for views and part descriptions of the IFW assembly.

3.2 IFW CONTROLLER

Note: The circuit board used in the controller was revised in July 2007. This new design is referred to as Revision 1 circuit board. To determine which revision is in the controller, note that the original version has a switch labeled “SBIG - PC” and is located above the “HOME” pushbutton. Revision 1 controllers do not have this switch.

The heart of the controller is the PIC programmable CMOS micro controller made by Microchip. This device has 22 I/O pins, 4K of program memory, 192 bytes of RAM and operates at 8 MHz. Using CMOS technology, this device uses very little power and can operate within the industrial temperature range specification of -25°C to +80°C. All programming was done in basic and compiled using PIC Basic Pro by *microEngineering Labs* of Colorado Springs. See *Figure 3-3* for a function diagram view of the IFW controller.

The input power source is from a switching DC power unit rated at 12 VDC regulated and 1 amp maximum output current. Normally, the IFW uses only 200 ma when operating. A three terminal regulator produces +5 VDC for use by the PIC micro controller, EEPROM, DRO display and stepper motor controller chips. Using a variety of protection devices, the input power port is well protected from voltage surges, reverse voltage, low voltage (brownout) and other circuit busting conditions. A replaceable 5x20 mm fuse rated at 0.5 amps is used for final input protection. This fuse will blow if the input voltage is reversed which could only happen if the user incorporates a custom power source such as an automotive battery. In revision 1 circuit boards sold after July 2007, the 0.5 amp fuse has been replaced with a resettable fuse. This protection device will operate like a fuse but will not need to be replaced if an over-current condition is encountered. After the over-current condition is corrected, the fuse will automatically reset for normal operation.

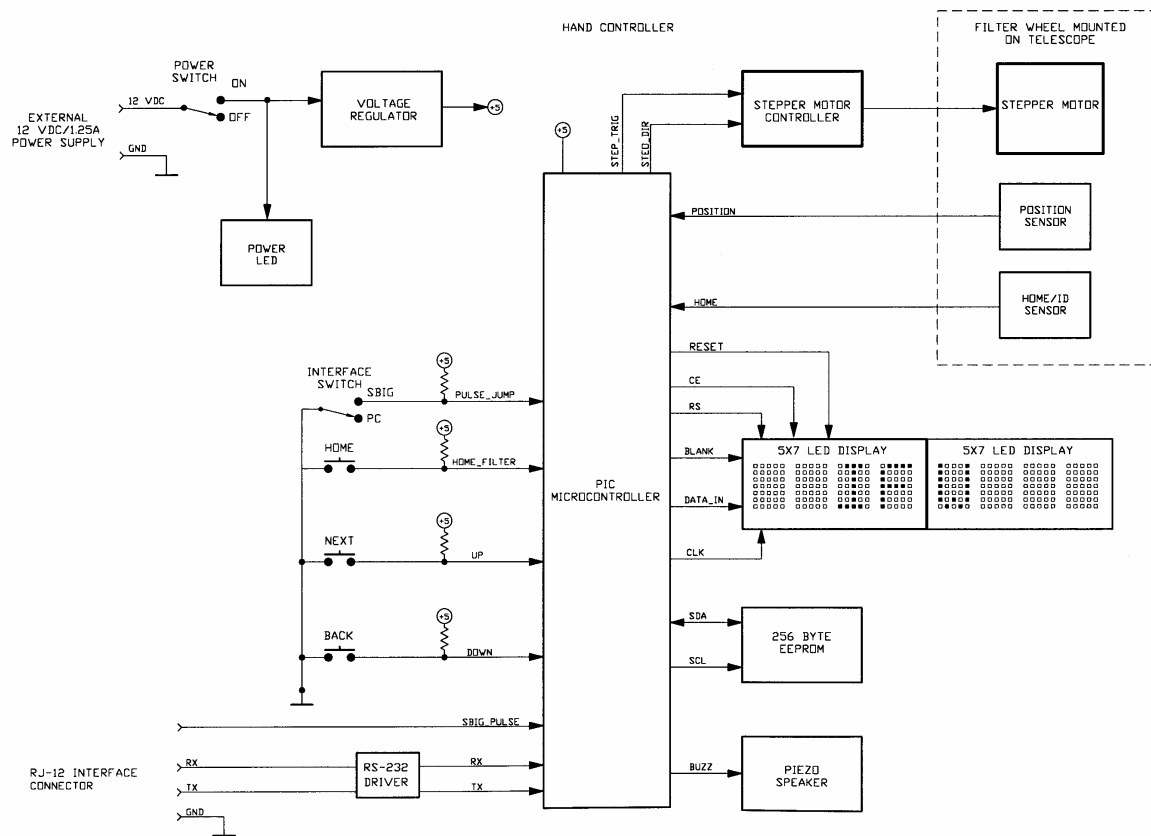


Figure 3-3. IFW Function Diagram.

The DRO uses a premium Hewlett Packard CMOS 5x7 matrix LED display showing four characters with a height of 0.15 inch. Two of these are used in series to give an eight-character display. The selection of this device over a lower cost LCD unit is primarily based on performance. This unit can operate down to -40°C and the LED dot matrix display is far more visible in low light conditions compared to an LCD device. In addition, the face of the display is protected by a piece of 1/16 inch thick red acrylic lens which also enhances contrast.

For original version circuit boards manufactured before July 2007, an integrated BiMOS unipolar driver chip UCN5804B is used to operate the stepper motor. This device is rated to operate within the industrial temperature range of -25°C to +85°C and can output a maximum current of 1.5 amps far exceeding the needs of the motor. This integrated circuit is fully protected against inductive transients. In addition, thermal protection circuitry will disable the outputs when the chip temperature is excessive. This could happen if the output cable is shorted because of damage or wear.

For revision 1 circuit boards, the UCN5804B was replaced by discrete components controlled by a separate PIC microcontroller. The UCN5804B was discontinued by the manufacturer requiring this change. Operation is the same.



*Figure 3-4. IFW with Door Open for Wheel Change
(shown with TCF focuser)*

SECTION 4.0

OPERATING PROCEDURES

Refer to *Figure 4-1* for a view of the hand controller front panel. Tables 4-1 through 4-3 below explain the three most typical procedures of the IFW. Switch settings, functions, and errors are described.

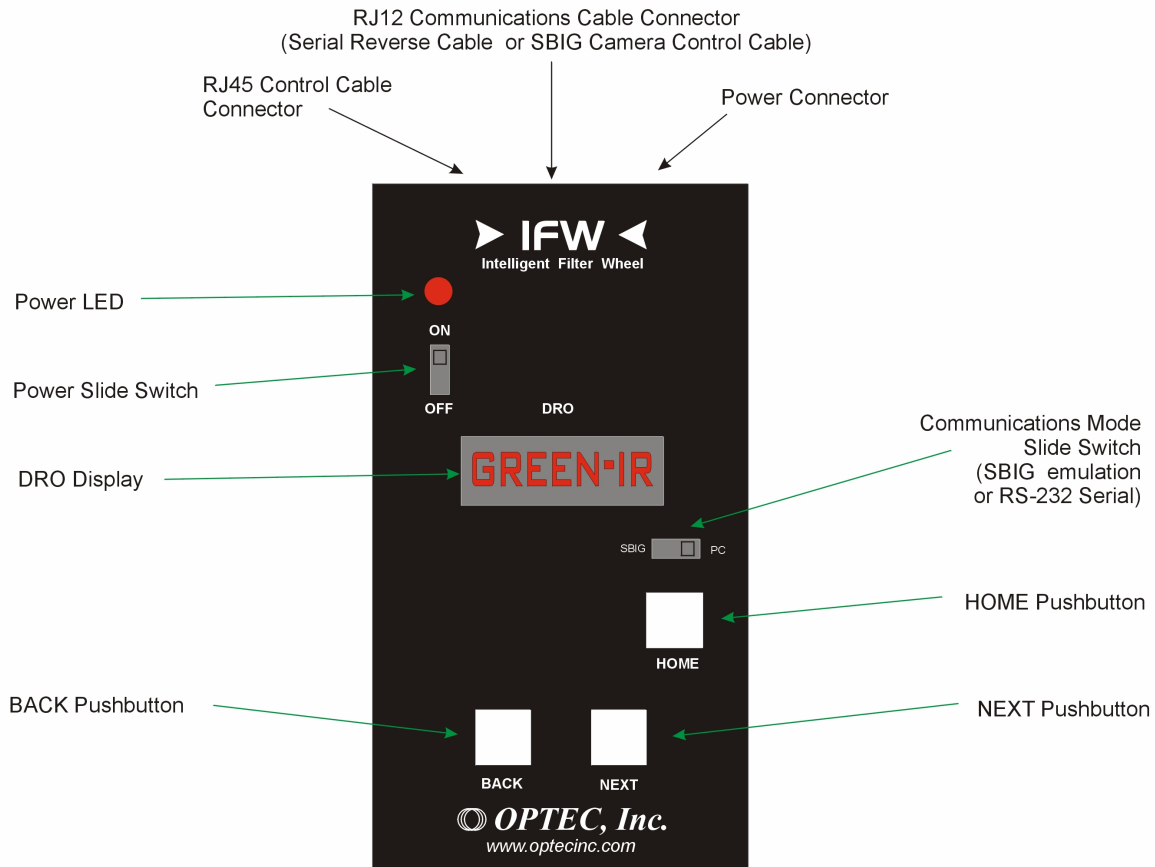


Figure 4-1. IFW Hand Control Layout for units sold before July 2007. Revision 1 units do not have the Communication Mode switch on the front panel. Since the use of SBIG emulation is losing popularity, the switch was replaced by jumpers on the main board. The box comes apart easily by first removing the four rubber feet and then using a Phillips screwdriver to remove the four screws. The jumper is well marked on the circuit board for selecting SBIG or PC mode.

MANUAL MODE

SWITCH SETTINGS:

Power switch is put in the ON position.
Mode switch is in either position, SBIG or PC.

FUNCTION:

At power on, the IFW will rotate to the HOME position, which is position 1, and stop. The DRO will display the letters IFW during the time it is finding position one and the wheel ID. When position 1 is found the filter name will be displayed. Filters can be selected by using the NEXT or BACK pushbuttons. Press one of these buttons repeatedly to find the desired filter and then stop. After one second of no input, the wheel will begin to move to the selected filter. At the start and end of the movement an audible beep will occur and the display will flash. No further input will be accepted until the wheel is in the selected position.

ERRORS:

If the wheel takes too many steps to find the HOME position or the filter ID is not read correctly an error message will be displayed for a short time.
An ERROR= 1 would display if the wheel rotation to find the HOME position takes an excessive number of steps
An ERROR= 4 would display if the wheel is stuck in a position
An ERROR= 6 would display if moving to another position uses an excessive number of steps.
See the trouble shooting section for guidance.

Table 4-1. Start-Up (Manual Mode).

SBIG (SANTA BARBARA INSTRUMENT GROUP) MODE
<p>SWITCH-SETTINGS: Mode switch is in the SBIG position Power switch is in the ON position</p>
<p>FUNCTION: In this mode, the unit can be operated by the SBIG controller that uses pulse width as a filter indicator. Use the pull down menu in CCDOPS or other software that is compatible with the SBIG camera controller and select the filter.</p>
<p>ERRORS: An ERROR= 5 message would appear if the pulse width from the SBIG controller is not within specifications.</p>

Table 4-2. SBIG Operating Mode.

PC (RS-232) MODE
<p>SWITCH SETTINGS: Mode switch is in PC position Power switch is in the ON position</p>
<p>FUNCTION: In this mode, the IFW can be operated manually until a WSMODE command is received. At that point, no hand controller input will be accepted until a WEXITS command is received from the PC to relinquish control or the unit is switched off. The PC has complete control of the IFW for selecting filters. When a filter is selected the new filter is displayed on the 8 character DRO and the audible beep is also heard at the start and stop. When a new wheel is inserted, the HOME function must be invoked by the PC to identify the wheel and load the filter names. See Section 5 for details of PC control.</p>
<p>ERRORS: All error codes are transmitted on the RS-232 interface and displayed on the 8 character DRO.</p>

Table 4-3. PC Operating Mode.

SECTION 5.0

REMOTE CONTROL

The IFW uses a communication protocol that is very similar to our TCF focuser.

5.1 SBIG CONTROL

The SBIG control for the filter wheels has been around for some time. The Optec IFW uses this protocol for selecting one of 5 filters. The selection of the filter is dependent on the width of a TTL level pulse that comes from the SBIG camera controller. The following range of pulse widths are used in the Optec IFW program to select position:

Position	Pulse Width μ s
1	369-659
2	666-950
3	957-1248
4	1255-1546
5	1553-1850
6	1858-2148
7	2155-2453
8	2460-2765

Table 5-1. SBIG Position Pulse Width. Positions 1 to 5 are for the 5-position wheels only.

The pulse resolution of the PIC micro controller is 5 microseconds.

The incoming signal uses pins 3 (signal) and 4 (common) of the 6-pin RJ-12 jack on the hand control. These cables are listed on the Optec price sheet as SBIG Camera Control Cables and replace the SBIG Tracking Interface Cable. Optec can supply cables of almost any length to accommodate this interface protocol.

5.2 PC (RS-232) SERIAL COMMUNICATIONS

The IFW provides a serial communications feature as standard for this model. The hand controller of the IFW includes built-in circuitry with a limited RS-232 interface allowing the user

to communicate with the wheel from any external PC. Using simple ASCII commands, the IFW can be commanded to select any filter, identify the wheel ID, read the filter name array or upload a new set of filter names to be stored into the onboard EEPROM. The RS-232 interface operates at 19.2 K baud with 8 data bits, one stop bit and no parity.

5.2.1 CONNECTING THE IFW TO THE PC

For the physical wiring connection between the PC and the IFW, Optec recommends our PC serial port converter (stk. #17695) and an RJ-12 reverse cable. Optec offers a number of these cables in lengths from 6-ft to 50-ft. Custom cables can also be ordered. The reverse cable is wired pin 1 to pin 1, pin 2 to pin 2, etc. A six-wire flat cable with RJ-12 connectors on each end works well up to at least 120 ft. (Refer to Appendix A for wiring details.)

The RS-232 implementation used with the IFW is a simple 3-line interface using RX, TX, and GND. (Refer to Appendix A for wiring details.) A terminal emulation program such as Hyper Terminal is needed to directly interface to the controller for sending the ASCII character commands.

If you are not interested in doing your own program interface, you can use the Optec control program described in appendix D. The setup program is shipped on a CD with every new IFW and is available for free download from the Optec web site at www.optecinc.com.

5.2.2 COMMUNICATIONS PROTOCOL

The remote PC communication program should be set for 19.2 K baud rate with 8 data bits, 1 stop bit, and no parity (8N1). The IFW controller is preset for these values and will not respond to other settings and cannot be changed. Tables 5-1 through 5-11 below describe in detail the commands used to control and communicate with the IFW. To establish communications a WSMODE command must be sent along the serial line to the IFW. This command should consist of the ASCII serial string "WSMODE" (without the quotes). If a partial command string is received, the IFW micro controller will timeout after only a few milliseconds and may not parse the entire command string properly. The controller program may timeout between characters when sent one at a time. PROCOMM 4.8 can be used successfully in the chat or host mode where the string command is not sent until a CR/LF is typed. Once the WSMODE command has been received and accepted by the IFW, a return character of "!" (followed by a CR/LF) will be sent back to the PC communications program. None of the other commands will work before the WSMODE command has properly initialized the serial connection.

5.2.3 IFW SERIAL COMMANDS

Command	Return
WSMODE	“!”
<p><i>Function:</i></p> <p>This command initializes the serial connection between the PC and the IFW. WSMODE causes the IFW program to enter into the main serial loop which checks for additional inputs along the RJ-12 connector. A successful return from this command (!) is required before the IFW will accept any other user commands.</p>	
<p><i>Warning:</i></p> <p>If “!” not returned repeat WSMODE. There is a possibility that the command will timeout. This is also true if the wheel is being operated manually when the WSMODE is sent.</p>	

Table 5-2. Enter IFW serial control.

Command	Return
WHOME	“y” y = A, B, C, D or E y = A,B,C,D,E,F,G, or H for 8-position wheels
<p><i>Function:</i></p> <p>Make wheel find position 1 and identify filter wheel . Load from EEPROM set of filter names that relate to filter wheel.</p>	
<p><i>Warning:</i></p> <p>It may take up to 20 seconds for HOME function to complete. ER= 1 is returned if number of steps to find position 1 is excessive. ER= 3 is returned if filter ID is not found successfully.</p>	

Table 5-3. Home Wheel Command.

Command	Return
WIDENT	"y" y = A, B, C, D or E y = A,B,C,D,E,F,G or H for 8-position wheels
<i>Function:</i> This returns the identity of the filter wheel to the PC.	

Table 5-4. Identify Wheel Command.

Command	Return
WFILTR	"x" X x = 1, 2, 3, 4 or 5 x = 1,2,3,4,5,6,7 or 8 for 8- position wheels
<i>Function:</i> This returns the current filter position.	

Table 5-5. Identify Current Filter Command.

Command	Return
WGOTOx x = 1, 2, 3, 4 or 5 (6, 7 or 8 for 8-position wheel)	"*"
<p><i>Function:</i></p> <p>Wheel will go to selected filter position "x". No further command should be sent until the "*" character is returned.</p>	
<p><i>Warning:</i></p> <p>ER=4 is returned if the wheel is stuck in a position ER=5 is returned if a number not in the set (1, 2, 3, 4, 5) is sent or (1,2,3,4,5,6,7,8) for 8-position wheels ER=6 if the wheel is slipping and takes too many steps to the next position</p>	

Figure 5-6. Goto a Selected Filter Command.

Command	Return
WREAD	"n _{1...40} " "n _{1...64} " for 8-position wheel
<p><i>Function:</i></p> <p>This command returns a string of 40 characters (64 characters for 8-position wheels) that are the stored names for the filters in the current wheel. Each filter name consists of 8 characters</p>	

Figure 5-7. Read Current Wheel Filter Names Command.

Command	Return
<p>WLOADy*n_{1..40} y = wheel ID (A, B, C, D or E) n_{1..n₄₀} = filter names from position 1 to position 5</p> <p>For 8-position wheels WLOADy*n_{1..64} y = wheel ID (A, B, C, D, E, F, G or H) n_{1.. n₆₄} = filter names from position 1 to position 8</p>	<p>“!”</p>
<p><i>Function:</i></p> <p>This command allows the user to program the on board EEPROM with the filter names for a selected filter wheel. After sending the string, you must wait a minimum of 10 ms before entering another command to allow time for the micro controller to program the on board EEPROM. If data is received and stored successfully, a “ DATA OK “ will be displayed on the DRO and a “!” character will be returned on the serial interface. Only a limited number of characters are allowed and these are: 0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ=.#/-% A space is also allowed.</p>	
<p><i>Warning:</i></p> <p>The EEPROM will store any ASCII character but only a limited number of characters can be displayed. An ER=3 is returned if an improper value for the wheel ID is received. Character pacing of 25 ms minimum is also required for sending the data string.</p>	

Figure 5-8. Load Filter Names Command.

Command	Return
<p>WEXITS</p>	<p>“END”</p>
<p><i>Function:</i></p> <p>This command causes the program to exit the serial loop and return to normal manual operation.</p>	

Figure 5-9. Exit Serial Mode Command.

SECTION 6.0

TROUBLE SHOOTING

1. The number one problem that could occur with the IFW is a slipping or stalled wheel. Keeping the wheel O-ring clean will probably solve most problems of this nature. Use rubbing alcohol and a Q-tip or clean cloth to wipe the O-ring clean. The right cover could also be removed to expose the motor drive shaft. Use the same alcohol and Q-tip method to clean the friction area of the drive shaft.
2. ERROR = 1 indicates that the total number of steps to find the HOME filter position has exceeded 2600. The total number of steps should be less than 2000 unless the wheel is slipping. Clean the O-ring and drive shaft as described in paragraph 1. If this does not solve the problem, loosen the screws holding the motor and, while holding the motor against the filter wheel O-ring a little harder, retighten the screws.

This error could also occur if the filter wheel is put in backwards. If this is done the filter wheel will not move. Make sure that the numbers and markings on the top face of the filter wheel are facing the telescope when it is inserted.

If this error condition is not corrected with the remedies described above, it may be due to the user inadvertently plugging the PC serial control cable into the RG-45 connector for the control cable going to the IFW. This sometimes bends back pins 1 and 8 of the RJ-45 connector. If pin 1 is bent back, then the ground conductor going to the Hall effect sensors will be disconnected. With a magnifier and a strong light, make sure all 8 pins are at the same level. If pins 1 and 8 are bent back slightly, use a knitting needle or small wire with a hook on the end to bend these pins back.

3. ERROR = 2 indicates that the SBIG pulse does not have the proper width for the IFW. This error condition will occur if filter positions 6, 7 or 8 are selected from the camera control software. Only positions 1 through 5 are acceptable for firmware supplied with 5-position wheels. There is an 8-position filter wheel available for industrial and other non-astronomical applications. When ordered with this filter wheel a different firmware is supplied which does allow for position 6, 7 and 8 to be selected.
4. ERROR = 3 indicates that a non-valid ID was obtained. Since the ID is first found during the HOME function by counting the number of steps from the home/ID magnet to the position magnet, a slipping or stuck wheel would give an erroneous step count. Clean the O-ring as described in paragraph 1. Less likely to occur, if the controlling software sends a non-valid wheel ID in the WLOADy command, this error condition will occur. A, B, C, D and E are valid wheel IDs for 5-position wheels. F, G and H are valid IDs for 8-position wheels.

5. ERROR = 4 indicates that the wheel is stuck in a position or moving much too slowly to move out from under a magnet during a position change. Clean the O-ring as described in paragraph 1. Leaving a wheel in the housing unused for a long time could create a flat spot on the O-ring which may cause this error condition. Remove the wheel and work the flat spot with your fingers until it has come out. Clean the O-ring before replacing the wheel.
6. ERROR = 5 is a rare condition since it means that the controlling camera software has sent a non-valid position to the IFW. Only whole integer numbers 1, 2, 3, 4 and 5 are acceptable for firmware supplied with 5-position wheels. For 8-position wheels, any number over 8 will result in this error code.
7. ERROR = 6 indicates that a position change has taken over 800 steps which is far too many. Clean the O-ring as described in paragraph 1.
8. Clean filters with rubbing alcohol or lens cleaning tissue. Avoid using xylene or acetone unless you are confident in your methods. These solvents will soften the silicone sealant used to hold the filters in and may also attack the adhesive compounds used to hold multiple glass filters together. Another good idea is to blow off the filters with a compressed gas such as “Dust-Off” before proceeding with any cleaning operation that requires rubbing. At Optec, we prefer to use 70% Ethanol rubbing alcohol and Q-tips for cleaning optics.
9. Computer interface problems are too numerous to mention here. Call Optec or the camera control software company for advice. However, connector or cable problems usually are the number one reason for a failed interface. Double check all pins and connections for continuity and make sure the cables are all the way into the mating connector.
10. If a serial-to-USB converter is used with the Optec control software, it is necessary that the converter have a compatible chip set. If an incompatible converter is used, an error message is displayed when trying to connect indicating that it “cannot connect”. Even with all the settings and COM port number correct this error message will still be displayed. This is a shortcoming of the compiler (Liberty Basic) used for the Optec control software. The converters sold by Optec use the FTDI chips set and are compatible with the Optec control software. There are many different serial-to-USB chips sets available and it is not possible for Optec to evaluate them for compatibility. You can find the driver name in the Device Manager – Ports – Driver tab of your computer.

SECTION 7.0

SPECIFICATIONS

FILTER WHEEL

Maximum number of positions	5 (8 for 8-position wheels)
Filter Diameter	50mm, 2.00 inch or 1-inch
Maximum Filter Thickness	5.5mm
Wheel Diameter	6.00 inches
Wheel Thickness	0.30 inches
Position/ID magnets	Neodymium, 0.125D x 0.125L
Weight (without filters)	6 oz.
Material	6061 T6 aluminum alloy

HOUSING & WHEEL

Size	6.65 x 6.80 x 1.00
Weight	35 oz.
Stepper Motor	PF-35 Nippon, 48 steps/rev
Position/ID sensors	Hall effect
Steps for wheel rotation	2000 approx.
Steps for each position change	400 approx. (250 for 8-position)
Time for each position change	3.2 sec. approx. (2.0 sec. for 8-position)

CONTROLLER

Type	PIC micro controller, 16F76 series
I/O ports	22
Clock frequency	8 MHz
CPU Memory	4K EPROM
	192 bytes RAM
EEPROM	256 bytes
IFW connector	8-pin modular jack, RJ45 type
PC connector	6-pin modular jack, RJ12 type
Power connector	2.5 mm power jack
Power	12 VDC and 200ma
Size	5.6 x 3.2 x 1.5 inches (L x W x H)
Weight	6 oz.

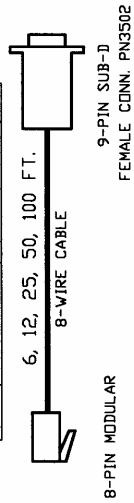
POWER SUPPLY

Input	100 - 240 VAC, 50/60 Hz, 0.4 A
Output	12 VDC, 1A regulated
Input connector	IEC 320/7
Listed by	UL, CSA, CE
Output Connector	2.5 mm power plug
Center Pin	positive

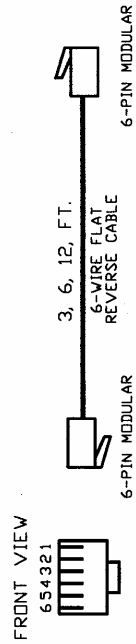
Appendix A

WIRING DIAGRAM

CONTROL CABLE 8 WIRE, 24 AWG		
PIN	COLOR	FUNCTION
1	ORG-WHI	GND
2	ORG	+12 VDC
3	GREEN-WHI	POSITION
4	BLUE	HOME
5	BLUE-WHI	STEP/T1, BLK
6	BROWN	STEP/T3, BROWN
7	BROWN-WHI	STEP/T2, ORG
8	BROWN	STEP/T4, YEL
9		NC

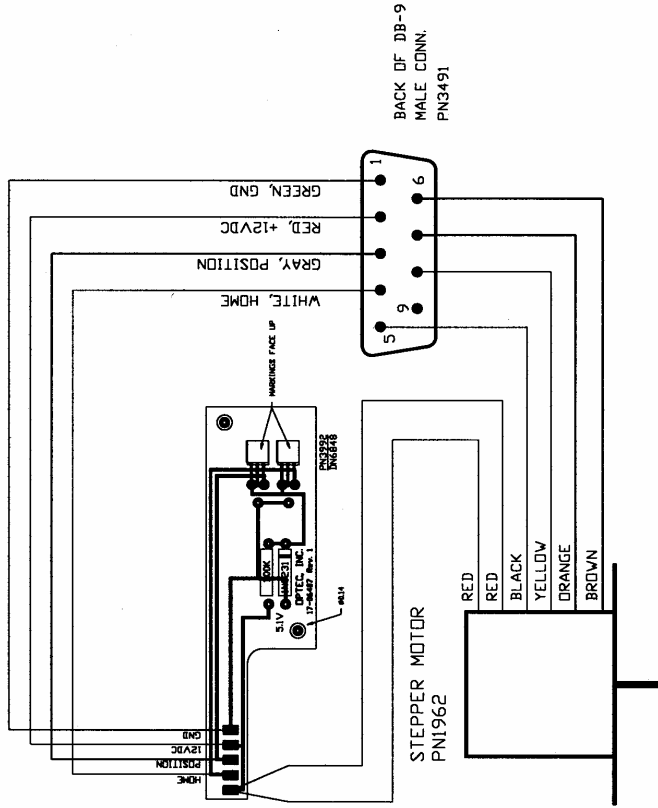


PC/SBIG CONTROL CABLE				
MOD. PIN	COLOR	FUNCTION	PC PAR. PORT DB-25	PC SERIAL DB-9
1	WHITE	RS-232, RX		3 (TX)
2	BLACK	NC		
3	RED	PULSE	USER DEFINED	5 (GND)
4	GREEN	GND		
5	YELLOW	NC		
6	BLUE	RS-232, TX		2 (RX)



NOTES:

1. USE 26AWG STRANDED WIRE
USE HEAT SHRINK ON ALL SOLDER CONNECTIONS



CONTRACT
IFW

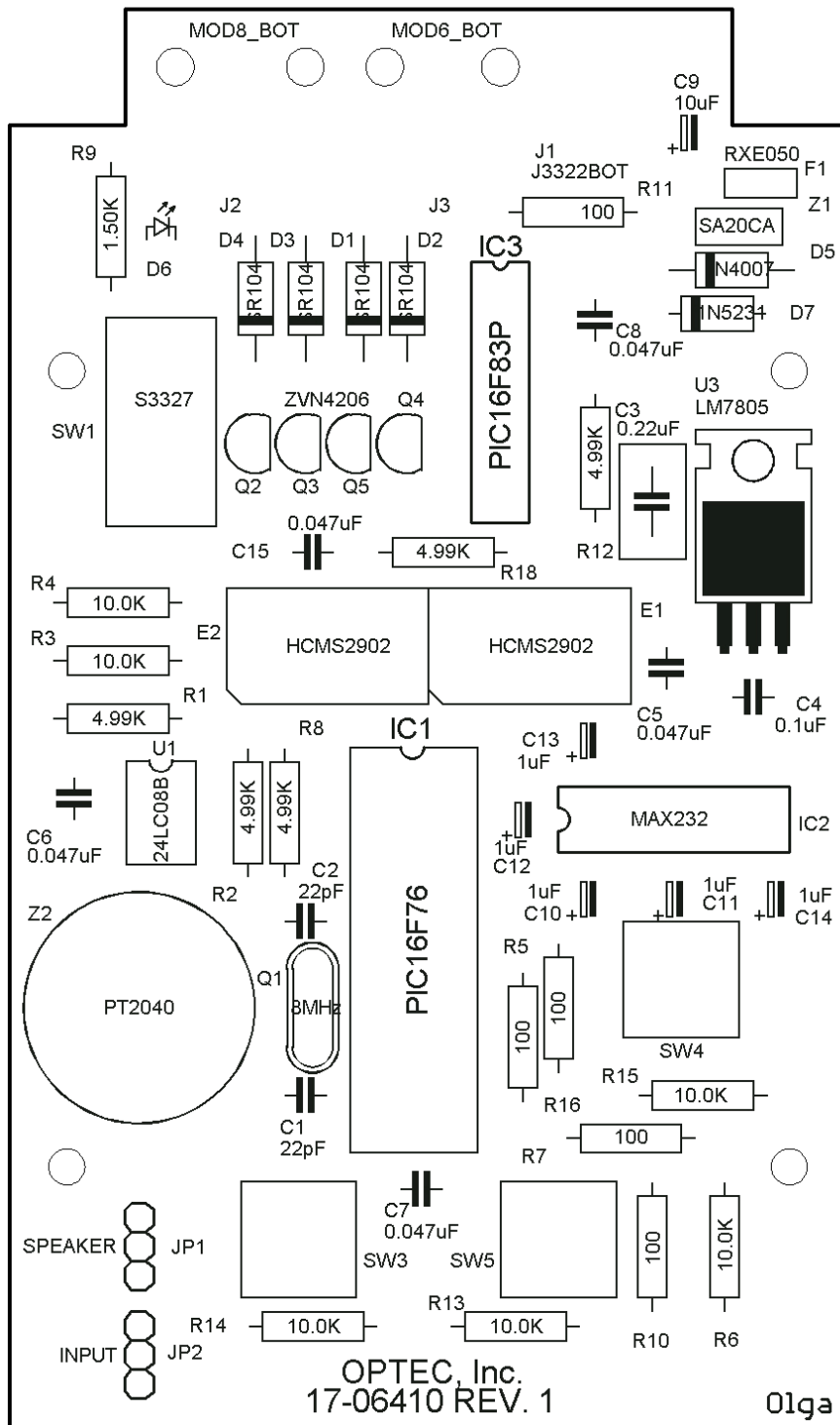
OPTEC, Inc.

REVISION
7/25/2001
9/10/2001
4/14/2002

IFW WIRING DIAGRAM

SCALE:

NO: 17-06411



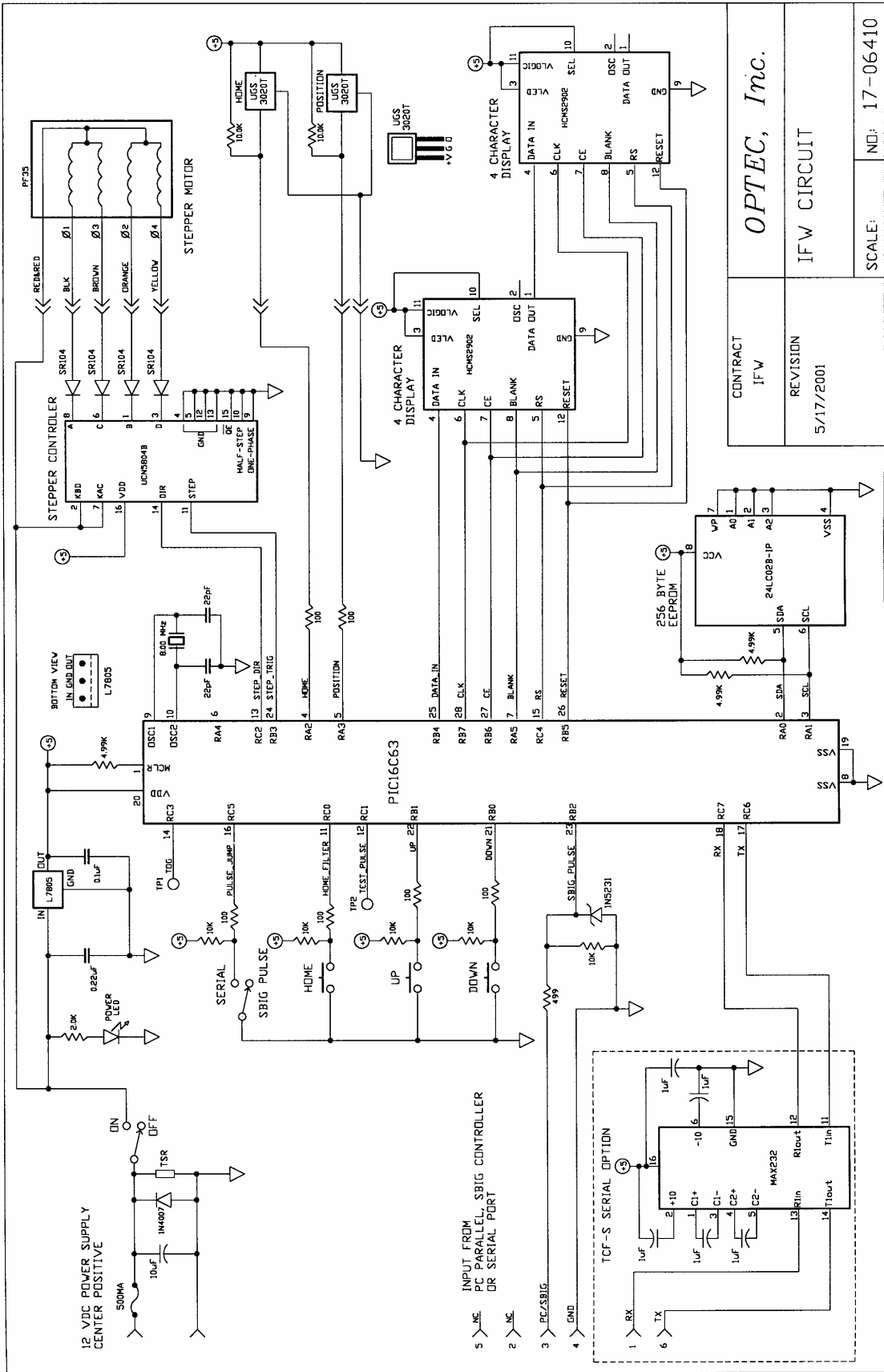
Revision 1 board produced after July 2007

Appendix C

CONTROLLER BOARD CIRCUIT

C-2: Original circuit board produced until July 2007

C-3: Revision 1 circuit board produced after July 2007. Obsolete UCN5804B stepper driver replaced with PIC and discrete components, SBIG-PC switch removed from front panel and placed on circuit board and replaced the flat-pack RS-232 driver with one packaged in a DIP-16 for socket mounting. 0.5 amp fast acting fuse replace with 0.5 amp resettable fuse.



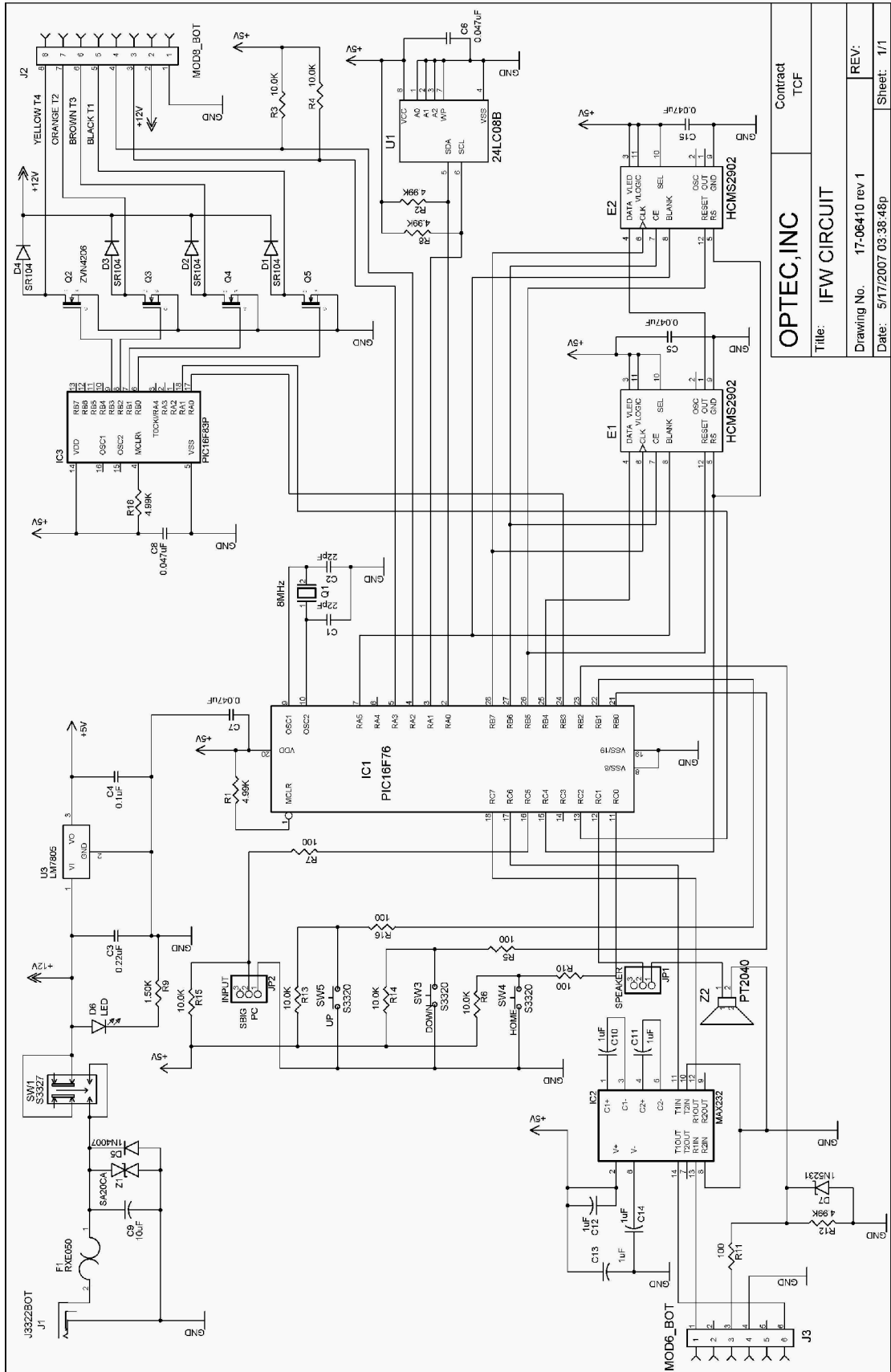
CONTRACT
IFW

REVISION
5/17/2001

SCALE: NDI: 17-06410

OPTEC, Inc.

IFW CIRCUIT



Contract
TCF

Title: **IFW CIRCUIT**

Drawing No. 17-06410 rev 1

Date: 5/17/2007 03:38:48p

REV:
1/1

Sheet: 1/1

Appendix D

IFW CONTROLLER SOFTWARE

The IFW Controller software program offers the user easy filter selection from the computer using the IFW in the PC or RS-232 serial mode. Additionally, the user can also rename any or all of the filters for a 5-position or 8-position filter wheels and set the filter names into the IFW's built-in EEPROM memory. After renaming, the IFW will recall the new filter names whenever the IFW is turned on or whenever the filter wheel is reinserted into the IFW.

To install the IFW Controller program on your WIN95/98/2000, WIN NT, Windows ME, Windows XP or Vista operating system run the setup program. The latest version of the IFW Controller software package is available for free download from:

www.optecinc.com

Look for the Software Download link in the IFW section.

Uninstall any previous version of the program before installing a new one. Make sure that any anti-virus programs are turned off. Download the file to your desktop and then run it. The program files are copied to a folder under OPTEC in the Program Files directory. You can delete or save the setup program at your option after installation.

To start the program, double-click the IFW Controller icon in the Optec program group under the start menu. The default serial port for the IFW Controller is COM 0 which means that the program will not connect until you set a valid COM port. If you are using a serial-to-USB converter, go to the Device Manager and find the COM port number that is associated with your device. See important note below. Be sure the jumper is set to PC on the circuit board (default setting from factory) or, for units sold before July 2007, that the SBIG/PC slide switch on the IFW control box is set to PC mode.

The HELP file available from the start menu or from within the IFW control program has more information concerning startup and operation.

NOTE: If using a serial-to-USB converter, make sure that the converter is using the FTDI chipset. Other versions may not work with the Optec control program. This is not the case for other software operating the IFW such as CCDSoft or Maxim DL which should work fine with most serial-to-USB converters. Optec sells compatible serial-to-USB converters. Check web site for available models and prices.

Appendix E

FILTER WHEELS

There are three different wheels that can be ordered with the IFW. The one most commonly used is #17355 for 50 mm diameter filters. Sometimes, commercial filters from other sources come with a diameter of 2.00 inches (50.8 mm). These filters need to be mounted in #17352 designed for 2 inch diameter filters. Primarily encountered in industrial and medical applications, 1.00 inch filters may be used with the IFW. Optec offers an eight position wheel for mounting filters of this size. A firmware change to 2.00 and above is required for the eight position wheel. This firmware supports both 5 and 8 position wheels. For applications that require only 5 position wheels, firmware 1.00 and above is supplied with the IFW control box. In all cases, the filters can not exceed 5 mm in thickness. In July 2007, Optec introduced a new tab mounting version of these filter wheel which avoids the use of a sealant to secure the filters in place. See page E-3 for more information.

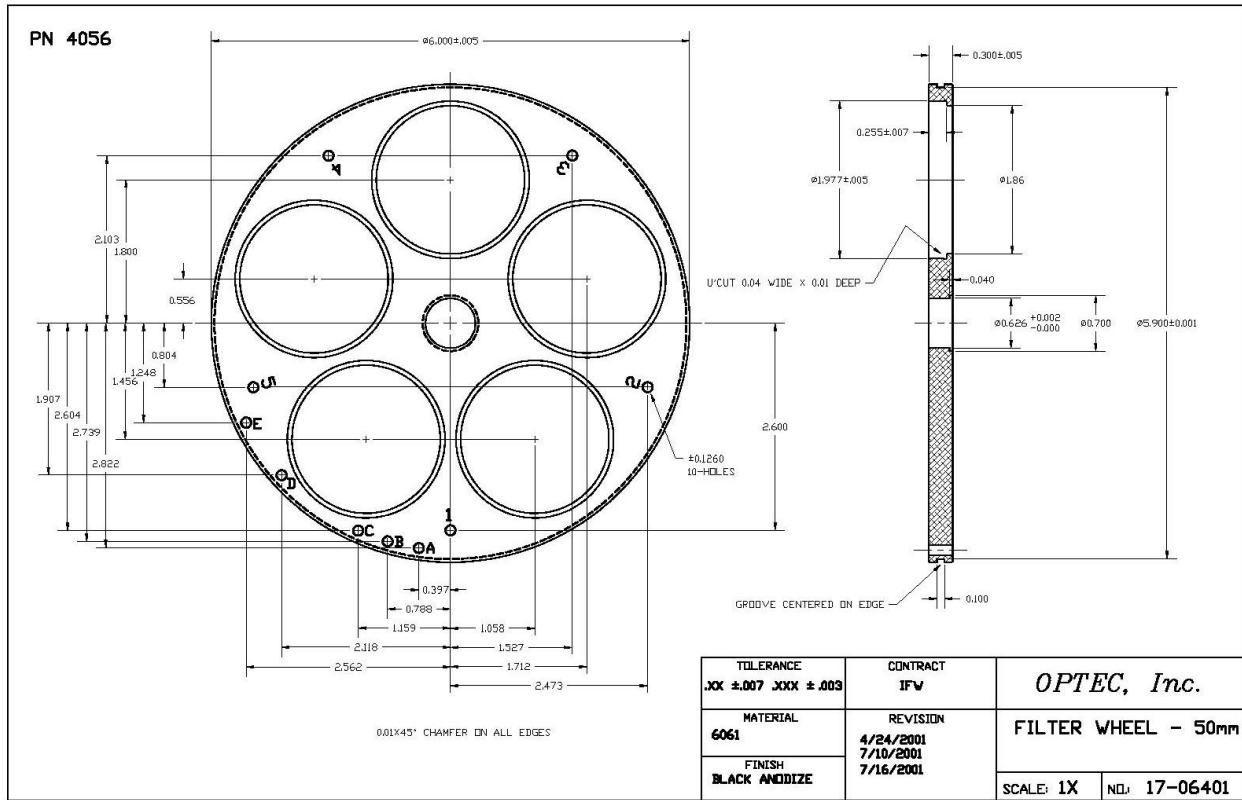
Filters for wheels not using tabs are secured in place by use of a RTV silicon sealant type 157 from GE. A small and thin bead of silicon is placed around the interior shoulder of the filter opening and then the filter is pressed in. This has advantages and disadvantages. Have an impervious silicon seal around the edge of the filter prevents solvents used in cleaning from dissolving the cement that holds some filters together. In addition, this resilient gap prevents thermal and physical shock from breaking the filter. Since these wheels can be removed from the IFW housing easily, there is a small chance that the user could drop the wheel in the dark observatory. Filters mounted with the customary metal retainer may break from the shock of falling. Retainers can sometimes cause excessive pressure at the edge of filters that may break a chip out of the glass if excessive torque is applied in mounting the filter. The disadvantage of this method is self evident. It is more difficult to remove the filter from the wheel. Optec has equipment to do this and will remove filters when requested.

Optec will mount any suitable filter into the wheel. Optec offers a complete line of Wratten, LRGB and Bessell filters for mounting at no charge. User supplied filters can be mounted if sent to Optec. Mounting of these filter at the time of a new purchase of a wheel is at no charge. Changing and mounting filters later may incur a small cost.

The wheel is rotated by means brass capstan that make contact with a Neoprene O-ring mounted on the outside of the filter wheel. This methods provides and quite and secure method of rotating the wheel. Once the edge of a position magnet is passed over a Hall effect sensor, a predetermined number of steps is counted before the wheel is stopped in order to get to the center of the filter position. The number of steps for CW and CCW rotation can be programmed into the control box by means of the Optec IFW control program described in Appendix D. The nominal number of steps for both CW and CWW rotation is 13. Values from 8 to 16 are acceptable.

Over time, the O-ring will degrade and slipping will become a problem. These O-rings are easy to replace and a 3-pack replacement (#17575) can be purchased from Optec. To install the O-ring,

wet with a small amount of mineral spirits to provide some lubrication and mount over the wheel. It sometimes helps to have an extra pair of hands. Use your finger to even out any high spots and make sure the O-ring is completely in the groove. Wipe the O-ring with a clean paper towel and allow the mineral spirits to dry before using.





Introduced in July 2007, the tab mounting filter wheels allow easier insertion of filters. The black delrin tabs and spacers will hold filters from 1 to 5 mm in thickness.

Spacer rings with thickness of 0.75 and 1.50 mm are stacked first in the filter wheel so that the filter's top surface is just above the level of the tab. The tab is then inserted and held in place with the supplied Phillips pan head screws (4-40 x 3/16 long) so that there is a small amount of pressure on the filter and the delrin tab is slightly bent. Delrin is very resilient and it will not be deformed easily even if the bend is steep. Don't tighten the three pan head screws until all the tabs are mounted and in contact with the filter. Then tighten each one slightly until the pan head screw is fully seated and the head is not above the surface of the filter wheel.