HydroRad
Multi-Channel
HyperSpectral Radiometer

User's Manual

Revision date: October 10, 2001

HydroRad Series: 200

Current Firmware Version: 1.232

Other firmware versions may differ in some respects. Contact HOBI Labs for information about firmware upgrades.

Hydro-Optics, Biology, and Instrumentation Laboratories, Inc.
P.O. Box 859, Moss Landing, CA 95039
1-888-414-HOBI
1-888-414-4624

Revisions

Version 1.232, October 10, 2001:

1. Start of revision tracking.
2. Update HOBI Address
3. Inserted section 1.2, Quick Start Troubleshooting
4. Revised sections 4, Power and Data Connections, and 4.1, Internal Battery
5. Revised sections 5.1.1 and 5.1.2, Instructions for Detaching & Reattaching HydroRad fiber optic cables.
6. Updated wording in section 7.1 that specified how spaces and comma form delimiters between arguments.
7. Added section 7.1.1 that explains HydroRad Reserved Words
8. Added section 7.1.2 that explains HydroRad Channel Numbering
9. In section 7.2.2, clarified the syntax for using the /Q option in the BAUD command
10. Revised section 7.2.5 for the ECHO command
11. Inserted section 7.2.17 for the new SET command
12. Updated section 7.4.5 for the new *Time, /Time, +Time, and –Time arguments to the INT command.
13. Updated section 7.4.7 for the new *Time, /Time, +Time, and –Time arguments to the LOGFIXED command.
14. Inserted section 7.4.10 for the new SHUTTER command
15. Updated section 7.5.8 with the new Textmode, ShowNames, and Delay arguments to the TYPE command.
16. Clarified syntax in section 11, HRCAL Calibration Utility, and inserted section 11.3, that explains the Windows drag/drop modes for the DOS program.

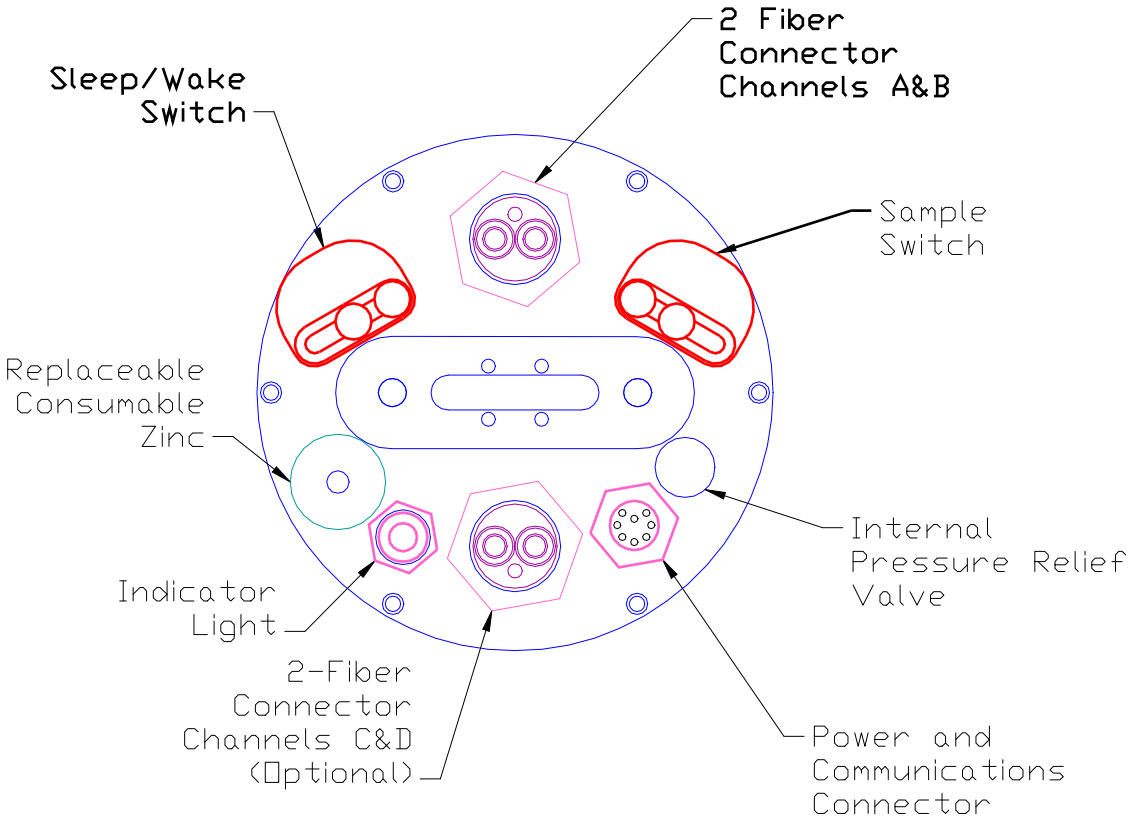
1. QUICK START

1.1. Basic Hookup

1) Communication with HydroRad can be conducted through an RS232 serial port using almost any terminal emulator software on the PC. HyperTerminal is the general-purpose communication program supplied with Microsoft Windows, and is a good way to communicate with HydroRad. Whenever it is necessary to refer to a specific communication program in this manual, we will refer to HyperTerminal. However the user may use another program if it supports the same features.

2) Start the communication software and configure it for 9600 baud (bits per second), 8 data bits, no parity, 1 stop bit, no flow control (no handshaking). If the HydroRad was previously set to a higher baud rate (such as 57600), the communication software should be set to that rate also.

HydroRad Layout



3) Connect the supplied data download/charging (DD) cable to the appropriate serial port on your computer.

4) Connect the cable to the power and communications connector on the HydroRad.

5) Plug the cord from the 18-volt battery charger transformer into the barrel connector on the data cable.

6) Plug the battery charger transformer into a 120 VAC jack.

7) From HyperTerminal, press the space bar several times to wake the sensor if it is asleep.

8) If you receive no response, slide the sleep/wake switch towards wake (towards the center of the instrument.) A response now (green light on HydroRad or serial port data) indicates a communication problem (i.e., wrong communication settings, cord not plugged in correctly, communication software needs to be reset).

9) If there is still no response, reset the instrument by disconnecting the DD cable from the HydroRad and inserting the shorting plug into the instrument bulkhead connector. The shorting plug looks identical to the dummy plug except the shorting plug has a colored marker band. Then remove the shorting plug and reconnect the instrument to your computer with the DD cable.

10) If the shorting plug was used, you may need to reset your communication software to the baud rate stored in the HydroRad's `AUTOEXEC.BAT` file. You should also type `DATE` followed by the date and/or time in the format `MM/DD/YY HH:MM:SS`, to set the sensor's real-time clock.

11) Once the instrument is awake and initialized, entering the "LOGAUTO" command or momentarily sliding the trigger switch in and out will result in an integration of all enabled channels, which will be saved to the flash disk.

12) If the shorting plug was used, type `DATE` followed by the date and/or time in the format `MM/DD/YY HH:MM:SS`, to set the sensor's real-time clock.

1.2. Quick Start Troubleshooting

1) If there is no response from the instrument, try toggling the sleep/wake switch a few times. This should cause the indicator light to alternate between green to off.

2) If the indicator light turns red, the sample switch likely needs to be pushed out. After doing so, send a few Control-C's to break out of sampling mode

3) If garbage characters are received during either of these operations, the baud rate likely needs to be adjusted on the PC.

4) If the indicator light is still off, the batteries may be either dead or at too low a level to operate the HydroRad's microcontroller properly. In this case, try charging the HydroRad for a while. In some cases, it may be necessary to use the shorting plug momentarily after charging to revive the microcontroller.

5) If the HydroRad will not take a charge, be sure to check that the sample switch is pushed out. The battery charger cannot simultaneously charge the instrument and provide enough current for sampling.

1.3. Basic Logging

1) Type `LOGAUTO<enter>` or momentarily slide the trigger switch in and out to integrate all enabled channels and save the data to the flash disk.

2) Type `DIR<enter>` to see a directory of the flash disk. The data you just recorded will be distributed in up to four files, depending on the number of enabled spectrometer channels. The default file names are the date followed by a letter, "a" through "d" designating the channel contained in that file.

3) To see the data in a file, type `TYPE filename <enter>`.

4) When finished with the instrument, type `SLEEP<enter>`. Unplug the battery charger, then unplug the cable from the sensor and plug in the standard black dummy plug. The standard dummy leaves it powered in its sleep state and allows it to be woken up via the wake switch.

2. PRECAUTIONS AND MAINTENANCE

2.1. Precautions

- Protect the fiber optic connectors. Cover them with vinyl caps or leave fiber optic cables connected whenever possible. Do not immerse or spray the instrument without fiber optic cables installed.
- Do not use acetone to clean any part of the instrument.
- Never lift the HydroRad by the fiber optic cables, even if they appear to be very heavy duty.
- Thoroughly clean the pressure port (under the lifting eye) with fresh water before storing the HydroRad.
- Avoid letting the instrument sit in direct sun for prolonged periods. If the water temperature is very different from the temperature on deck, let the instrument stabilize in the water for 10 minutes before collecting data.

2.2. General Cleaning

Upon removing the instrument from salt water, before removing fiber-optic cables, rinse it thoroughly with fresh water.

2.3. Pressure Transducer

The pressure transducer is underneath an array of four small holes in the lifting ring. Before storing the instrument, flush the transducer with a gentle stream of fresh water into the holes. A squeeze-bottle is ideal for the purpose. A low-velocity stream from a hose is also acceptable.

2.4. Electrical Connectors

Occasionally spray the connector pins with silicone lubricant. The connectors should mate smoothly without great force. Well-lubricated connectors also separate fairly easily; so always use the locking sleeves. NOTE: use care to avoid contaminating the optical connectors with lubricant.

2.5. Fiber Optic Connectors

When detaching and re-attaching a fiber optic connector, there is always the possibility that contamination could enter the connection will change. Therefore, the fibers should be left attached at most times. It is recommended that a recalibration be performed if the fiber ends are scratched or contaminated with lubricants.

2.6. Mounting and Deployment

The metal pad-eye on the HydroRad is designed for convenience lifting and back-up tie-down only. It is not designed for profiling with the instrument. For profiling, the HydroRad should be secured in a HOBI-supplied cage, or strapped to another support. A tag line should be connected from the HydroRad's metal pad-eye to the support cage.

3. INTRODUCTION TO HYDRORAD

HydroRad is a hyperspectral radiometer that can be configured with up to four channels (spectrometers). It includes a powerful programmable controller with extensive flash memory and the ability to collect and store data on an arbitrary schedule. When powered by its internal rechargeable batteries, HydroRad can operate autonomously for days or weeks. Logged data can be downloaded from HydroRad into any laptop or desktop computer with a standard serial communications port.

3.1. Spectrometers

Each HydroRad channel consists of its own miniature spectrometer. The spectrometer disperses incoming light onto a 2048-pixel Charge-Coupled Device (CCD) such that each pixel on the CCD corresponds to a specific optical wavelength. When exposed to light, the pixels accumulate charge that is proportional to the total energy at their respective wavelengths. Under the control of a microprocessor, the pixels accumulate charge for a certain integration time. At the end of the integration time, the charge from each pixel is read out and digitized, resulting in an array of numbers that represents the spectrum of the incoming light.

By varying the integration time of each spectrometer over a range of 20 ms to many seconds, HydroRad accommodates a very wide range of light levels. The user can set specific integration times for each channel, or allow HydroRad to automatically adjust the integration time according to the light levels it detects.

3.2. Optical Inputs and Collector Heads

HydroRad's optical inputs are fiber optic connectors, to which various light collectors can be connected through fiber cables. HOBI Labs supplies irradiance and radiance heads for measurement of the most common radiometric quantities, but users may also connect inputs from other sources.

3.3. Control Electronics

A miniature computer controls all aspects of HydroRad's operation. Its primary functions are to:

- control power to the spectrometers and other subsystems,
- generate timing signals for the spectrometers,
- digitize the spectrometer outputs,
- calibrate and filter data,
- store data in flash memory,

- accept configuration instructions and commands from the user,
- execute commands stored in files,
- sleep and wake according to programmed schedules,
- download data from flash memory.

The user interacts with the controller by sending commands and receiving replies over an RS-232 serial link. A large variety of commands let the user configure and control HydroRad for many different situations. HydroRad can also run sequences of commands stored as files in the flash memory, in the manner of MS-DOS batch files. HydroRad command files can include assigned times at which specific commands are to be executed, allowing users to set up arbitrary data logging schedules.

When not actively collecting data, the controller can be instructed to go into a low-power sleep mode to preserve power in the batteries. This, combined with scheduled command files, allows HydroRad to operate autonomously for extended periods while powered by its internal batteries.

3.4. Data Logging and Processing

The flash memory in HydroRad is configured as a virtual hard disk, with a standard capacity of 15 Megabytes and optional capacities up to 48 Megabytes. The flash disk supports a file system like that found on desktop computers, which allows the user to manage files using familiar commands like “erase”, “copy”, “dir” (for directory) and “ren” (for rename).

HydroRad offers various options for processing spectra before storing them. It can store data in raw, partially calibrated, or fully calibrated form, average multiple spectra, and apply spectral filtering.

4. POWER AND DATA CONNECTIONS

HydroRad can be powered from three sources:

1) External 9V to 15V supply,

2) Internal battery,

3) External 18V to 24V battery charger.

Any combination of these sources may be safely connected simultaneously. Power will be drawn from the source with the highest voltage. Nominal power draw is 120 mA plus 40 mA per channel during sampling, and 1 mA during low-power sleep. Note that if the battery charger is connected as the only power source, operating HydroRad will reduce the charging current to the battery and increase the needed charging time.

The HydroRad communicates via RS-232 through a standard computer serial port.

Power and data lines are brought out on a SubConn MCBH8M connector (mate: MCIL8F), with pins assigned as shown below.

PIN	FUNCTION
1	Supply voltage (9 to 15 VDC)
2	Common
3	RS232 Instrument Receive
4	RS232 Instrument Transmit
5	Battery charging input (18 to 24 VDC)
6	Output to Shutter -/+
7	Output to Shutter +/-
8	Short to Common to Disable Battery

The supplied cable splits into a DB9 for communication, a “barrel” connector for the battery charger, and a pigtail for an external DC supply.

4.1. Internal Battery

4.1.1. Battery Capacity

The capacity of the battery depends on the temperature at which it is charged, stored, and discharged. Charging and storage at temperatures of 20 C or

less improve capacity. On the other hand, low temperatures during discharge lower the realized capacity. Peak capacity for a battery charged and discharged at room temperature is 15 hours of continuous operation with an HR-2, and 11 hours with a HR-4.

In response to the sleep / wake switch being turned to “sleep”, or the SLEEP software command, the HydroRad will enter a low-power sleep state during which its current drain is reduced to about 1 mA. In this state fully charged batteries will last about 2 months. Hourly sampling schemes can typically last about 1 month.

Capacity decreases slowly as the battery ages. The capacity loss depends greatly on charging conditions, but is typically less than 10% after 200 charge / discharge cycles, and 20% after 500 cycles.

4.1.2. Battery Voltage and State of Charge

To read current value of the battery voltage whenever communication is established with the sensor, enter the BATT command. This will display the current voltage and the battery charging current. The battery voltage gives a rough indication of how much charge remains. When the battery voltage falls below 11 V, indicating it is virtually completely discharged, the HydroRad should not be used in battery-mode operation. HydroRad will go into its low-power sleep mode whenever the voltage falls below this threshold.

4.1.3. Charging

HydroRads with batteries installed include constant-current chargers that recharge the battery in a maximum of 15 hours. Any replacement charger used for a HydroRad should put out between 18 and 27 volts DC; chargers that puts out less than 18 volts will not be able to fully charge the HydroRad. The actual charging time required after a partial discharge is about 40% longer than the full power operating time for a HR-4, and about equal to the full power operating time for a HR-2. Charging continues at the same rate as long as the charger is plugged in.

If the HydroRad is operating with the battery charger plugged in, note that the current going to the batteries will be reduced and the charging time will increase. For a HR-3 or HR-4 continuously sampling, the batteries can drain, even with the charger plugged in. For fastest charging, either put HydroRad to sleep, or provide an external power supply whose voltage is higher than the battery voltage. A 13.8V power supply is recommended for this situation.

NOTE: to protect against disruptive transients, connect the output of the charger to the instrument before plugging the charger into an AC outlet.

While the battery tolerates indefinite periods of charging, repeated, prolonged charges can eventually degrade battery capacity. For best battery life we recommend that you charge, on average, not more than 3 times the time that the sensor is operated from the battery (not including “sleep” time).

4.1.4. Battery Disable

The battery can be electronically disconnected from the HydroRad circuitry by shorting pins 2 and 8 of the bulkhead connector together. A special dummy plug, distinguished from the normal dummy by a colored band, is provided for momentarily disconnecting the battery to reset the instrument in case of a software fault. The special dummy plug can also be used to save battery charge during extended storage.

In some cases, it may be desirable to permanently disable the battery if HydroRad is to be externally powered for several months on a mooring. This will require a communication cable that shorts pins 2 and 8. This will protect the instrument firmware from hanging if the batteries drain to a very low voltage level due to current leakage, and the external voltage is accidentally cycled. However, the mooring controller will then have to reset the HydroRad's clock. In most cases, it is preferable to leave the batteries connected so that the HydroRad's clock is maintained during mooring power outages.

Note that like the hard disk in a computer, HydroRad's flash "disk" can be corrupted if power is removed while it is updating its directory. Therefore, do not disable the battery while HydroRad is storing data or performing file operations. If you remove power when the indicator light is green or off, there is no risk of losing data.

Disabling the battery will cause HydroRad's real-time clock to reset, and will also reset any parameters that were changed without being saved to flash by the SAVEPARAMS command.

5. FIBER OPTIC CONNECTIONS

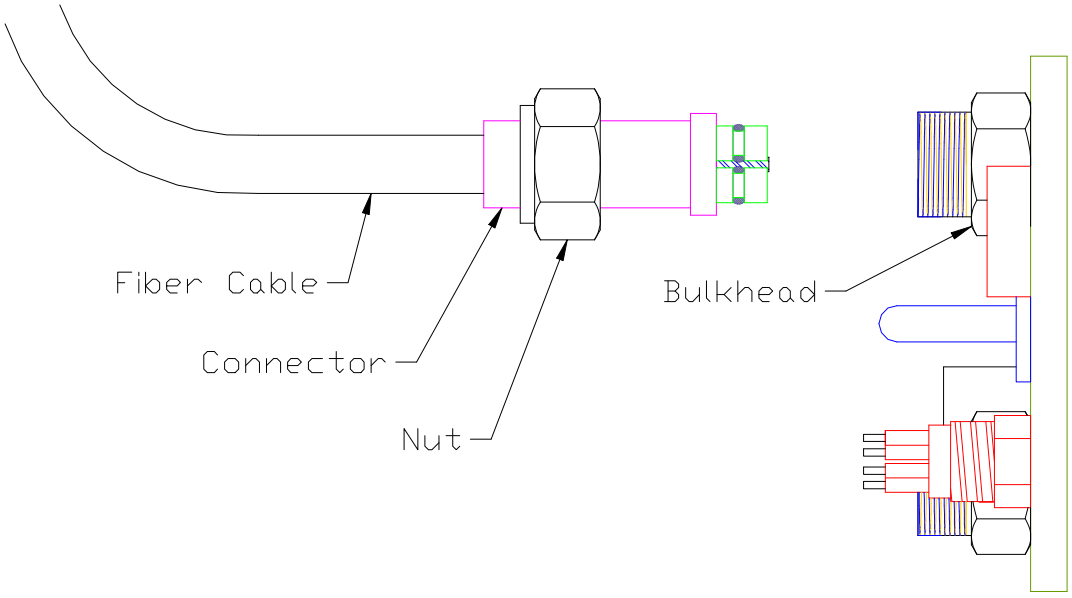
The HydroRad fiber optic bulkheads are designed for use only with HOBI Labs HydroRad fiber optic cables.

The fiber optic cables should be detached and re-attached one at a time, to reduce confusion about which fiber goes to which connector, and to reduce the possibility of contamination entering the HydroRad's connectors. The cables cannot be attached or detached while the instrument is submerged.

When detaching and re-attaching a fiber optic connector, there is always the possibility that contamination could enter the connection. Therefore, the fibers should be left attached at all times, if possible.

5.1. HOBI Labs HydroRad Fiber Optic Cables

The HOBI Labs HydroRad fiber optic cable is designed with a stainless steel jacket and o-ring seals to protect and keep water away from the fiber optic connector. Detaching and reattaching a HydroRad fiber optic cable is a delicate operation, and should not be done in the field.



5.1.1. Detaching a HydroRad fiber optic cable from a HydroRad

1) On three and four channel HydroRads, note the cable number being removed to ensure that the same cable is replaced onto the same connector on the HydroRad (see the diagrams in Section 1 for connector numbering).
2) Unscrew the connector nut from the HydroRad. <NEW> Instruments with recent calibrations will require a wrench to loosen the connector nut.
3) Pull the connector straight out of the HydroRad. Also remove the ¾" (size 2-018) o-ring from the face of the HydroRad bulkhead.
4) Cover the exposed HydroRad bulkhead and connector to prevent the fiber mating faces from becoming contaminated.

5.1.2. Reattaching a HydroRad fiber optic cable onto a HydroRad

1) On three and four channel HydroRads, note the cable number being reattached to ensure that the same cable is replaced onto the same connector on the HydroRad (see the diagrams in Section 1 for connector numbering).
2) Visually inspect the fiber terminations sticking out of the bulkhead and inside the connector. The stainless fiber mating faces should have a mirror finish free of blemishes. If the fiber mating faces are smudged or otherwise contaminated they can be cleaned and dried with q-tips soaked in 99% alcohol or Tech Spec lens cleaner (91% alcohol tends to leave smudges). All traces of alcohol or lens cleaner must be quickly removed with dry q-tips to reduce the chance of new smudges and ensure calibrated throughput.
3) Carefully inspect the two size 2-009 o-rings on the connector. Replace them with new lubricated o-rings if there is any sign of nicks or scratches on the o-rings.
4) Clean the two faces of the connector so they will not contaminate the bulkhead fibers during connection.
5) Lay the size 2-018 o-ring on the face of the HydroRad bulkhead.
6) Plug in the connector, by first aligning the alignment pin into its hole, then pushing the connector very slowly in, being careful not to pinch the connector o-rings. A gentle rocking motion may be required to prevent the connector o-rings from being pinched.
7) <NEW> Tighten the connector nut firmly, but no tighter than hand-tight.
8) <NEW> With a wrench, tighten the connector 1/12 turn (15 degrees).
9) <NEW> After 30 seconds or so, loosen the connector, hand tighten, and wrench tight 1/12 turn again.

6. COMMUNICATIONS

HydroRad communicates through a standard RS-232 serial connection to virtually any computer serial port. Any common terminal emulator program can be used, but for purposes of instruction we refer to HyperTerminal, which is included with Windows operating systems, throughout this manual.

6.1. COMMUNICATION PARAMETERS

HydroRad's serial protocol is 8 bits, no parity, 1 stop bit, and no flow control. Only the transmit, receive and ground lines are connected between HydroRad and the computer.

6.2. BAUD RATES

The default communication rate is 9600 baud. This rate is robust and adequate for routine communication with the instrument, but when downloading large amounts of data it is desirable to increase the rate by using the BAUD command (see 7.2.2). Standard baud rates from 300 to 230,400 baud are supported. Note that most PC serial ports do not support 230,400 baud, and some may have trouble with even lower rates. Also note that high baud rates may not work over long cables. If you plan to use high baud rates and long cables in the field, test your system first in the lab!

Changes made with BAUD remain in effect until one of the following events causes HydroRad to return to its default baud rate:

- execution of the RESET command,
- exiting the HydroRad operating program via the QUIT, PicoDOS or TOM8 command,
- interruption of power by disabling the battery (see section 4.1.4)

6.3. CHANGING DEFAULT BAUD RATE

You can change the default baud rate by creating an `AUTOEXEC.BAT` file containing a BAUD command on the flash disk. This file will be executed each time the HydroRad operating program starts, resets or quits to PicoDOS (quitting to TOM8 always returns the baud rate to 9600). NOTE: before setting a high baud rate as the default, test it with the BAUD command. If you set the default to a rate that isn't supported well by your computer or cabling, it may be very difficult return to a usable rate!

To create a file setting the baud rate to 57600 (note that this process will erase any existing `AUTOEXEC.BAT` file):

1) At the HydroRad prompt, type `CAPTURE AUTOEXEC.BAT<enter>`.

2) At the `Capture>` prompt, type `BAUD 57600 /Q <enter> <control-z>`.

You can delete `AUTOEXEC.BAT` or capture a new one at any time to change the default rate. If you want the new `AUTOEXEC.BAT` (or lack of one) to take effect immediately, type `RESET<enter>` at the HydroRad prompt.

6.4. HYPERTERMINAL

HyperTerminal is included as an accessory application with Microsoft Windows versions starting with Windows95. In order to use it you may need to install it by double clicking on Add/Remove Programs in the Windows Control Panel. Select the Windows Setup tab, and double-click on Communications. Then find HyperTerminal and activate the appropriate check box. Click OK and follow Windows' instructions to complete the installation.

To set up HyperTerminal once it is installed, start the application (probably listed under programs|accessories on the start menu) and select File|New Connection. Enter a name for the setup (include the baud rate you plan to use in the name for future reference). In the Phone Number dialog, select Direct to Com 1 (or whatever com port is appropriate to your computer) in the Connect Using field. Select the current baud rate, 8 bits, no parity, 1 stop bit, no flow control. Then select Connect from the Call menu.

6.5. FILE TRANSFERS

Most users need to at least occasionally transfer large amounts of data from HydroRad's flash memory to a PC, and load command files and calibration files from the PC to HydroRad. HydroRad provides the following methods for transferring files.

6.5.1. TYPE

The TYPE command (see 7.5.8) is the most direct, but most limited, way of transferring a file from HydroRad to a PC. It simply sends the contents of a file across the serial link without any modification or addition. To save the file on a PC, you would first instruct your terminal program to "capture" incoming data, and then send the TYPE command (with the name of the file you wish to transfer) to HydroRad.

In HyperTerminal, select "Capture Text…" from the "Transfer" menu. Enter the name and location of the file that will be created on the PC to contain the typed file, and click the "Start" button. Type `TYPE filename`, where filename is the name of the file on HydroRad you wish to transfer. When the file has been completely sent, again selected "Capture Text…" from HyperTerminal's "Transfer" menu, then select "Stop". If the file is binary, use the syntax `TYPE filename OFF`, to turn off textmode, which converts single ASCII carriage returns and line feeds to carriage return/line feed combinations.

6.5.2. CAPTURE

HydroRad's CAPTURE command (see 7.5.1 and 7.5.3) is the converse of TYPE. However it is primarily designed for manual entry of text and not well suited to transferring files automatically.

6.5.3. XMODEM

Xmodem is simple error-detecting and correcting protocol for transferring single binary or ASCII files either from HydroRad (using the XS—for Xmodem Send—command), or to HydroRad (using XR— Xmodem Receive).

HydroRad to PC Transfer Procedure

To send a file from HydroRad to the PC using Xmodem, type `XS filename`, where filename is the name of the file as it is stored on HydroRad. Then ready your terminal program to receive the transfer, and designate the name and location where the file will be saved. In HyperTerminal, select "Receive File…" from the "Transfer" menu. In the dialog box, select "Xmodem" from the list of protocols, click the "Browse" button to select a location for the file on the PC, and enter a name for the file (the name under which the file is stored on the PC is independent of its name on HydroRad). A dialog box will appear in HyperTerminal to show the transfer's progress, and then disappear when the transfer is complete. To cancel a pending transfer, press `<control-X>` several times.

PC to HydroRad Transfer Procedure

To send a file from the PC to HydroRad using Xmodem, type `XR filename`, where filename is the name by which the file will be known on HydroRad (this need not be the same as its name on the PC). Then initiate the transfer from your terminal program. In HyperTerminal, select "Send File…" from the "Transfer" menu. In the dialog box, select "Xmodem" from the list of protocols, click the "Browse" button to select the file to send, the click the "Send" button. A dialog box will appear in HyperTerminal to show the transfer's progress, and then disappear when the transfer is complete. To cancel a pending transfer, press `<control-X>` several times.

6.5.4. YMODEM

Ymodem is an extension of Xmodem that automatically maintains file names through the transfer, and allows batch transfers of multiple files. For these reasons it is much more convenient for downloading large amounts of data from HydroRad than Xmodem. HydroRad's YS command (see 7.5.11) allows you to specify a group of files to send by using wildcards in the file name. YR (see 7.5.12) prepares HydroRad to receive a file or group of files from the PC.

HydroRad to PC Ymodem Procedure

Prepare HydroRad for the transfer by typing `YS filespec`, where filespec may be the name of a file, or may include ? and * wildcards to specify a group of related

files. Assuming you have specified files that exist on HydroRad's flash card, you will see a message that starts with "Sending..." followed by the list of files. From HyperTerminal's "Transfer" menu, select "Receive File." Select Ymodem from the list of protocols. In the resulting dialog box, select a destination directory for the files, the press the receive button. A dialog box will appear to show the transfer's progress, and disappear when it is finished. After the transfer, the files should appear in the PC directory you specified, with the same names they had on HydroRad. To cancel a pending transfer, press <control-X> several times.

If the group of files you specified is large, HydroRad may have to send them in several batches. If so, it will display the message "MORE FILES REMAIN TO SEND. Continue?" after sending the first batch. Press Y to continue, and then select "Receive File" again from HyperTerminal's "Transfer" menu as above, or press any other key to halt the transfer.

Some computers (especially laptops) are more sensitive to the Ymodem protocol. If YS appears not to work well on your computer, it may work better if you run YS from the PicoDOS operating system. To enter PicoDOS, type PICODOS<enter> at the HydroRad> prompt. The PicoDOS version of YS operates differently than the normal HydroRad version; instead of wildcard file specifiers it can only accept a list of individual files. At the PicoDOS> prompt, type YS followed by one or more file names. Proceed with the transfer as above. When all transfers are complete, quit PicoDOS by typing RESET<enter>.

PC to HydroRad Ymodem Procedure

At the HydroRad> prompt, type YR<enter>. HydroRad will respond, "Receiving..." From HyperTerminal's "Transfer" menu, choose "Send File." In the resulting dialog box, click the Browse button to select a file to send (HyperTerminal cannot send multiple files), select the "Ymodem" protocol, and then click the Send button. A dialog box will appear to show the transfer's progress. The file will be stored on HydroRad's flash card with the same name it had on the PC (though it is limited to 8 characters plus a three-character extension). To send several files at once, select one file, and edit its name to include wildcards. All files matching the wildcard will then be sent. To cancel a pending transfer, press <control-X> several times.

Some computers (especially laptops) are more sensitive to the Ymodem protocol, and work better if the HydroRad is running the PicoDOS operating system. To enter PicoDOS, type PICODOS<enter> at the HydroRad> prompt. At the PicoDOS> prompt, type YR. Then select a file to send, as above. When finished, type RESET <enter> to return to the HydroRad firmware.

7. COMMANDS

HydroRad is controlled and configured with text commands received via its serial port. Its commands are designed to be human-readable and reply with informative messages, although they could also be generated from a user-programmed computer or logger. All commands can also be executed from files stored in HydroRad's flash memory (see section 8).

7.1. COMMAND CONVENTIONS

For clarity in this document commands are shown in upper case, but they are not case-sensitive.

Some commands accept arguments, which are separated from the base command, and from each other, by commas or spaces. Arguments may be individually omitted, in which case they will have no effect. For example, if a command accepts three arguments, in the form `COMMAND,arg1,arg2,arg3` (or `COMMAND arg1 arg2 arg3`), you may adjust only arg3 by entering `COMMAND,,,arg3`.

In firmware versions 1.17 and above, combinations of spaces and/or a single comma are treated as a single delimiter. In previous firmware versions, every space or comma was treated as a separate delimiter.

Most commands reply with the settings of relevant parameters, or other status information.

7.1.1. HydroRad Reserved Words

The words "on", "open", or "yes" are all defined as equal to 1 in command arguments that expect logical values, and may be used in place of the value 1. In place of the value zero in command arguments, the words "off", "close", or "no" may be used. These words are not case sensitive.

7.1.2. HydroRad Channel Numbering

Commands that refer to channels will accept either a channel number or letter as an argument. Thus, the first channel can be referred to as either "1", "a", or "A".

7.2. CONFIGURATION COMMANDS

7.2.1. AUTOPARAMS SatValue MinPeak MaxSatPixels MinPeakPixels MaxAttempts PreFilter

Shows and sets parameters governing the automatic setting of integration time (used by AUTO and LOGAUTO).

The first four parameters define what is considered an acceptable dynamic range for the pixel values in a spectrum. SatValue defines the value at which a pixel is considered saturated. MinPeak is the minimum value at which a pixel is considered fully exposed. The algorithm will attempt to find an integration time that results in a spectrum that has at least MinPeakPixels whose values are between SatValue and MinPeak. It will allow up to MaxSatPixels that exceed SatValue. MinPeakPixels has the lowest priority of the criteria. A spectrum may be considered well exposed even if it does not meet MinPeakPixels.

MaxAttempts is the maximum number of trial integrations allowed. The algorithm will terminate after this many integrations if it does not achieve a spectrum that meets the dynamic range criteria. Within LOGAUTO, the last integration will be logged whether or not it terminated normally.

PreFilter sets the width of a filter that excludes occasional "hot" pixels from consideration. Under most circumstances this should be set to 3.

7.2.2. BAUD newrate [/Q]

Change to a new baud rate. Without the /Q flag, BAUD replies:

```
Changing to XXXX BAUD.
Hit <return> when ready…
```

and waits until it receives another character (not necessarily <return>). With the /Q flag (which stands for “quiet”), the baud rate will immediately change without any further input. There must be a space between the newrate parameter and the /Q flag, or the /Q will be ignored.

Standard baud rates from 300 to 230,400 baud are supported. Note that most PC serial ports do not support 230,400 baud, and some may have trouble with even lower rates. Also note that high baud rates may not work over long cables. If you plan to use high baud rates and long cables in the field, test your system first in the lab!

The baud rate you set remains in effect until changed by another BAUD command, you exit the HydroRad operating software, or the HydroRad is reset by removal of power or the RESET command. See also sections 6.2 and 6.3.

7.2.3. DEPTHCAL Offset ScaleFactor

DEPTHCAL sets the coefficients used to calculate calibrated depth readings from the HydroRad pressure sensor. Offset is the raw reading at atmospheric pressure. ScaleFactor is the coefficient to convert digital counts to equivalent meters of depth in water. Values entered with DEPTHCAL take effect immediately, and are saved in the file `DEPTH.CAL` so they will remain in effect until changed with another DEPTHCAL command.

7.2.4. DATE mm/dd/yy hh:mm:ss

Identical to the TIME command. Sets the date and/or time of the real-time clock. The command will accept partial dates (for example 3/1 sets the month to 3 and the day to 1 without affecting the year) and times (for example 13:24 sets the hour and minute without affecting the seconds). Years may be entered with 2 or 4 digits.

7.2.5. ECHO state or ECHO string

State specifies whether characters sent to HydroRad's serial port are automatically echoed. If state is "on" (1) then echo is turned on, if state is "off" (zero) then echo is turned off. The default is on. With echo off, characters you type will not appear in your terminal software.

If a string follows the echo command, the string will be echoed to the command line. Be careful, because if the first word of the string is one of the HydroRad reserved words: "on", "open", "yes", "off", "close", "no", the value of the reserved word will be used as if you were specifying a State, and the rest of the string will be ignored.

7.2.6. FILTPARAMS FirstPixel LastPixel PixelIncrement FilterSpec FilterSize

Before a spectrum is saved by one of the logging commands (LOGFIXED, LOGRANGE, LOGAUTO), or displayed by the FILT command, it is filtered by convolution with a filter specified by the parameter FilterSpec. Then a subset of pixels, defined by the FirstPixel, LastPixel and PixelIncrement parameters is selected from the filtered spectrum. IMPORTANT: If you set PixelIncrement to a value other than 1, you should set the processing parameter of LOGPARAMS to a value of 1 or higher. See section 9 for information about how filtering and selecting pixels can affect the quality of your data.

The filter may be specified in several ways: as a single integer, a series of coefficients, or a file name. FilterSpec can either be a number or a file name. If it is a number, it specifies what type of filtering operation to perform. Presently the only defined filter type is 1, which indicates a boxcar average (zero indicates no filtering). That is, each pixel in the output spectrum will be the result of an equally weighted average of the number of pixels specified by FilterSize.

If FilterSpec is a file name, HydroRad will read a set of coefficients from the specified file and convolve those coefficients with the output spectrum. FilterSize will be determined by the number of coefficients in the file (up to 33). If you specify a valid file for FilterSpec, any value you supply for FilterSize will be ignored.

Regardless of how the filter is specified, its coefficients will be normalized so that their sum is 1.0, to avoid changing the overall amplitude of the filtered spectra.

Whether or not arguments are specified, FILTPARAMS displays the parameters and the currently loaded filter coefficients, if any.

7.2.7. ID

Displays the factory-set model, serial number, and configuration information about the HydroRad.

7.2.8. IMPORTCAL Filename

Given a file containing properly formatted calibration data for one or more channels, translates the file into a binary format for future rapid loading. The resulting binary files are named `A.CAL` for channel 1, `B.CAL`, etc.

7.2.9. INTPARAMS MinTime MaxTime WarmupTime AutoPowerDown Channels

Shows and sets parameters governing integration. MinTime is the minimum integration time, in milliseconds, used in auto-integration commands such as AUTO, LOGAUTO, and START. This is typically set to the electronic limit of 20 ms. MaxTime is the maximum integration time, in milliseconds, used in auto-integration commands such as AUTO, LOGAUTO, and START. Practical values of MaxTime range from 2000 to 30000 milliseconds, although it can be set higher.

WarmupTime is the number of seconds HydroRad will wait before collecting spectra after power is first applied to the spectrometers.

AutoPowerDown can be either zero, or a number greater than zero. If it is nonzero, then power to the spectrometers will be turned off if they are idle for more than 2 seconds plus WarmupTime.

Channels is a string of digits or letters specifying from which channels data will be collected. For example, 13 or AC indicates that channels 1 and 3 are enabled. Note that HydroRads may be equipped with different numbers of channels. Normally all installed channels should be enabled.

7.2.10. LAMBDA Channel Pixel

Given a channel and pixel (ranging from 0 to 2047), displays the wavelength (in nm) corresponding to the pixel. Channel may be specified with a letter or number. If no channel is specified, the current CHAN setting is used.

7.2.11. LOADFILT FileName

LOADFILT attempts to load a set of up to 33 filter coefficients from the specified file. The coefficients can be integers or floating point, and may be separated in the file with spaces, tabs or carriage returns. HydroRad will automatically normalize the coefficients so that the filter will not change the overall amplitude of spectra to which it is applied. Normally this is performed automatically when a file name is specified with FILTPARAMS.

7.2.12. LOADPARAMS FileName

LOADPARAMS restores parameters saved in a file by SAVEPARAMS. If no FileName is specified, it loads `HYDRORAD.INI`.

7.2.13. LOGPARAMS SampleInterval SampleDuration Processing OutputFormat

SampleInterval and SampleDuration, both in seconds, are used for continuous periodic collection as initiated by the START command. They are not relevant to collection scheduled by a command file.

IMPORTANT: See section 9 for information about how the Processing parameter can interact with other parameters to affect the quality of your data.

The Processing parameter controls which calibration steps are applied to data before they are filtered and saved:

0 - raw, unprocessed “counts” are returned
1 - "weak pixel" adjustments are performed
2 - dark-current is calculated and subtracted from the counts
3 – counts are divided by the integration time
4 - engineering units are returned (full calibration)

OutputFormat controls whether spectra generated by the logging commands (LOGFIXED, LOGRANGE and LOGAUTO) are in ASCII or binary format, and whether they are saved in files or transmitted immediately via the serial output:

0 Indicates spectra will be saved in binary files (with `.BIN` extension)

1 Indicates spectra will be saved in text files (with `.ASC` extension)

2 Indicates spectra will be transmitted in binary form

3 Indicates spectra will be transmitted in text form

7.2.14. PARAMS

PARAMS takes no arguments and simply displays all the settings that are entered by the other “PARAMS” commands. This is handy if you forget which parameters are available, or which command to use for a particular setting.

7.2.15. PIXEL Channel Wavelength

Given a channel and wavelength, displays the pixel most closely corresponding to the wavelength. Channel may be specified with a letter or number. If no channel is specified, the current CHAN setting is used.

7.2.16. SAVEPARAMS Filename

SAVEPARAMS stores all the parameters set with LOGPARMS, INTPARAMS, AUTOPARAMS and FILTPARAMS in a file with the given Filename.

If no Filename is specified, they will be stored in `HYDRORAD.INI`, which is automatically loaded whenever HydroRad starts up.

7.2.17. SET VariableName Value

Sets the value of environment variable VariableName to Value, which can be a string or numeric expression. Use %VariableName% to insert the value into other expressions.

7.2.18. SHOWCAL Channel FirstPixel LastPixel

Displays, in ASCII, the currently loaded calibration data for a given channel, from the FirstPixel to the LastPixel. Header information displayed includes HydroRad Serial Number, Channel name, Units, and Scale. For each pixel between FirstPixel and LastPixel, the constants displayed include "F," which determines the dark current calibration function to use, "C," which is the floating point constant used in the dark current calibration, and "Epsilon," which the count rate is divided by to obtain engineering units. Channel may be entered as a letter or number.

7.2.19. TIME mm/dd/yy hh:mm:ss

Identical to the DATE command. Sets the date and/or time of the real-time clock. The command will accept partial dates (for example 3/1 sets the month to 3 and the day to 1 without affecting the year) and times (for example 13:24 sets the hour and minute without affecting the seconds). Years may be entered with 2 or 4 digits.

7.2.20. TXDELAY Delay

Sets the minimum time (in milliseconds) by which HydroRad delays its responses to commands, in case the system with which it is communicating requires such a delay.

7.2.21. VER

Displays the version number and date of the HydroRad firmware.

7.2.22. ZERODEPTH

ZERODEPTH measures the current raw reading of the pressure transducer, then records this as the Offset used for calculations of calibrated depth (which may also be set with DEPTHCAL). If executed while the HydroRad is at atmospheric pressure, ZERODEPTH compensates for offset errors due to the effects on the transducer of temperature and barometric pressure.

7.3. GENERAL OPERATIONS

7.3.1. <enter>

Pressing the enter key on a blank line will repeat the last command.

7.3.2. \command

Any command preceded by a backslash will be passed to PicoDOS for execution. In this manner you can execute any PicoDOS command from within HydroRad. This is not needed under normal circumstances.

WARNING: Although you can use this mechanism to launch another program, or run a PicoDOS batch file, from within HydroRad, this is not advisable. It leads to a disorderly exit from HydroRad, and the computer may not return to HydroRad upon completion of the other program.

7.3.3. BATT

Displays the current supply voltage and charge current (if battery is being charged). This is typically the voltage of the internal battery, but may also be supplied by an external source. If the external source's voltage is higher than the battery voltage, its voltage will be reported. The voltage reported will be somewhat lower than actual voltage of the source, since it is measured after passing through a protective diode.

7.3.4. DEPTH

Displays the current calibrated depth reading in meters.

7.3.5. Filename

Executes the command file `FILENAME.CMD`, if it exists. See section 8 for a discussion of command files. Synonymous with typing RUNFILE Filename.

7.3.6. PAUSE Seconds

Used primarily in command files, PAUSE illuminates the red indicator, waits for the given number of seconds (5 if Seconds is not specified), then switches the indicator to green.

7.3.7. PICODOS

Exits the HydroRad program and sends control to the PicoDOS (operating system) prompt. Note that if an `AUTOEXEC.BAT` file is present on the flash disk, it will be executed. If the current baud rate is other than 9600, PicoDOS will set it to 9600, unless otherwise instructed in an `AUTOEXEC.BAT` file (see also 6.2 and 6.3).

7.3.8. POWER State

Turns on (state = 1) or off (state = 0) power to the spectrometers. POWER may also be used without an argument to display the current status. Any command that initiates an integration will automatically turn on the power first if necessary, and executing SLEEP will turn it off, so this is rarely needed in normal use.

7.3.9. PRESSURE

Displays the current raw reading of the pressure transducer. See also DEPTH.

7.3.10. RESET

Reinitializes the HydroRad program, which executes any BAUD command in `AUTOEXEC.BAT` if it exists, loads the parameters in `HYDRORAD.INI` if it exists, executes the commands in `HYDRORAD.CMD` if it exists, and loads any calibration files that exist.

7.3.11. RUNFILE FileName

Executes a command file named `FILENAME.CMD`. See section 8 for a discussion of command files.

7.3.12. SETDCHAN Channel State

Sets the state of an external I/O channel to State. Channel 1 = underwater connector pin #6, and channel 2 = underwater connector pin #7. State can be either 0 or 1.

7.3.13. SLEEP Seconds

Turns off the spectrometers and puts the system in low-power sleep for the given number of seconds. If Seconds is not specified, sleeps indefinitely. Sleep can always be interrupted by receipt of characters on the serial port, or by the sleep/wake switch.

7.3.14. TEMP

Displays the internal temperature of the spectrometers in degrees C.

7.3.15. TIMES

Lists the most recent integration time used for each spectrometer channel. These are the values that will be used as defaults if you do not specify a time to AUTO or INT.

7.3.16. TOM8

Exits the HydroRad program, sets the baud rate to 9600, and enters the TOM8 monitor program. Unlike exiting to PicoDOS with the PicoDOS or QUIT command, this allows exiting the HydroRad program without executing an `AUTOEXEC.BAT` file, if one is on the flash disk. Therefore TOM8 is not affected by any BAUD instructions.

7.4. DATA COLLECTION

7.4.1. AUTO Channel IntTime

Collects a spectrum to memory from the given channel, automatically seeking the optimum integration time. If IntTime is specified, it will try that time first. If not, it will start with the integration time that was last used for that channel (regardless of which command triggered the previous integration). If no Channel is specified, it will collect from the last used channel. Channel may be entered as a letter or number.

7.4.2. CHAN Channel

If no Channel is specified, displays the most recently used spectrometer channel. If a Channel is specified, sets the current channel to that value. Channel may be entered as a letter or number. This channel setting will be used as the default channel for subsequent AUTO or INT commands.

7.4.3. FILT FirstPixel LastPixel PixelIncrement

Displays the most recent spectrum collected with INT or AUTO, after applying the current filter (see FILTPARAMS). Press Control-C, or send an ASCII code 03 to break out of the listing.

7.4.4. GRAPH FirstPixel LastPixel VerticalScale

Displays a crude graph of the most recent raw spectrum (whose numerical values can be viewed with RAW). The X-axis represents pixels numbers over the range specified by FirstPixel and LastPixel. The width of the graph is fixed at 80 characters. If no FirstPixel and/or LastPixel are specified, the corresponding values set by the FILTPARAMS command will be used.

The Y-axis represents pixel amplitudes in digital counts. VerticalScale specifies the graph's height in lines. The Y-axis always covers the full range of pixel values from 0 to 32767. Therefore the default VerticalScale value of 32 is equivalent to 1000 counts per line.

Note that because of the low resolution of the display, many details of the spectrum may not be apparent.

7.4.5. INT Channel Time

Collects a spectrum from the specified Channel, with the specified integration Time (in ms). Channel may be entered as a letter or number. If no Channel is specified, uses the most recently specified channel (that displayed by CHAN). If no Time is specified, uses the time most recently used by the current or specified channel.

The Time parameter may also take the form of *Time, /Time, +Time, or –Time. In this case, the operator specified and the new Time argument will be applied to the previous integration time for the channel. So if the previous integration time for

channel A was 35 ms, and the command INT, A , *2 was used, channel A would be integrated for 70 milliseconds. This may be useful for intentionally overexposing the spectrometer after a AUTO command, to get better resolution in the UV in UR ranges.

7.4.6. LOGAUTO Duration [SAMPLES] Average BaseName

LOGAUTO repeatedly integrates all the channels, adjusting their integration times to achieve the highest possible dynamic range for the specified Duration (in seconds). Alternatively, the word "samples" (or an abbreviation as short as “sam”) may appear as the second argument, indicating that the first is to be interpreted as an exact number of samples rather than a duration in seconds.

Example:

```
LOGAUTO,3 samples,1,hydro
```

For each channel, 3 spectra will be collected and averaged, and the average from each saved in a file with the base name "hydro". If the word "samples" were omitted, this would specify a total time of 3 seconds.

The duration of each integration is set automatically to maximize the dynamic range, within the limits set with INTPARAMS. After the optimum integration time is determined, each spectrum is filtered according to the current FILTPARAMS, then saved in a file or transmitted to the serial port, depending on the OutputFormat set in LOGPARAMS.

If Average is nonzero, only one averaged spectrum will be saved for each active channel. Otherwise each spectrum measured will be saved. IMPORTANT: See section 9 for information about how averaging can affect the quality of your data.

If BaseName is specified, and the OutputFormat setting in LOGPARAMS indicates data are to be saved in a file, the file name for each channel will be formed from the BaseName, followed by a letter indicating the channel (A = 1, B = 2, etc.), followed by an extension indicating the data format (see LOGPARAMS). If BaseName is not specified, the base name will be the date, in the form MMDDYY.

Note that when Samples is omitted, Duration is actually a minimum. LOGAUTO only checks each time it finishes the last channel to see whether it has exceeded the specified time. In the worst case it could finish one cycle shortly before the time limit, then do another measurement on all channels before stopping. So the actual time could be as much as the maximum integration time, multiplied by the number of channels, greater than Duration. To force LOGAUTO to cycle through the channels only once, set Duration to 1 (with or without the samples option).

A pair of control-c characters received through the serial port during execution of LOGAUTO will abort the process.

7.4.7. LOGFIXED IntTime Averages BaseName

LOGFIXED integrates each channel for the same fixed integration time, given in milliseconds by IntTime. However if IntTime is not specified, each channel will integrate for the time of its last integration. In this case the integration times may be different from channel to channel.

The IntTime parameter may also take the form of *IntTime, /IntTime, +IntTime, or –IntTime. In this case, the operator specified and the new IntTime argument will be applied to the previous integration time for the channel. So if the previous integration time for channels A and B were 135 and 178 ms respectively, and the command LOGFIXED *3 was used, channels A and B would be integrated for 405 and 534 milliseconds, respectively. This may be useful for intentionally overexposing the spectrometer after a LOGAUTO command, to get better resolution in the UV in UR ranges, at the expense of over-saturation in the midrange.

If Averages is specified and greater than 1, that number of integrations will be performed and each channel's average spectrum saved. IMPORTANT: See section 9 for information about how averaging can affect the quality of your data.

If the OutputFormat parameter of LOGPARAMS specifies data are to be saved in files, the files (one for each channel) will be named with BaseName, followed by a letter A through D designating channel 1 through 4, followed by the extension `.DAT`. If BaseName is not specified, the base name will be formed from the current date, in the form YYMMDD.

A pair of control-c characters received via the serial port during execution of LOGFIXED will abort the process.

7.4.8. LOGRANGE MinTime MaxTime TimeStep Mode Averages BaseName

LOGRANGE repeatedly executes LOGFIXED, over a range of integration times. The first integration on each channel will be for MinTime milliseconds. If Mode is 1, the second integration will be at MinTime * TimeStep. If Mode is 0 (zero), the second will be at MinTime + TimeStep. Integrations continue with increasing length until the integration time is equal to MaxTime. If the last calculated time is greater than MaxTime, a final integration will be performed for MaxTime. For example, `LOGRANGE,20,1000,3,1` will integrate each channel at 20, 60, 180, 540 and 1000 milliseconds.

If MinTime, MaxTime, or TimeStep is omitted, the corresponding value set by INTPARAMS will be used. Averages and BaseName have the same meaning as with LOGFIXED. IMPORTANT: See section 9 for information about how averaging can affect the quality of your data.

A pair of control-c characters received through the serial port during execution of LOGRANGE will abort the process.

7.4.9. RAW FirstPixel LastPixel PixelIncrement

Displays the most recent spectrum collected with INT or AUTO. Does not apply the filter, but does apply the pixel limits set with FILTPARAMS. If FirstPixel, LastPixel, or PixelIncrement are specified, then these values are used in place of the FILTPARAMS limits. Press Control-C, or send an ASCII code 03 to break out of the listing.

7.4.10. SHUTTER State Delay

Opens (Shutter open) or closes (shutter close) the detector shutters, if attached. State can be either "open" (1) or "close" (0). Delay determines how long, in milliseconds the HydroRad will give the shutters to open or close.

7.4.11. START

START initiates a continuous cycle of periodic data collections. The schedule is determined by the SampleInterval and SampleDuration parameters set with LOGPARAMS. Upon receipt of the START command, HydroRad will execute a LOGAUTO command with SampleTime as its TotalTime. When sampleTime has expired, HydroRad will go into low-power sleep mode until SampleInterval seconds have passed since the beginning of the previous collection. It will continue this cycle until halted by the STOP command. During collection, LOGAUTO may be aborted by <control-C> characters received via the serial port, but the cycle will resume at the beginning of the next SampleInterval.

7.4.12. STOP

Halts data collection initiated by START.

7.5. FILE OPERATIONS

7.5.1. CAPTURE Filename

Opens the file named Filename, and copies lines of text to the file as they are typed. Editing keys may be used to edit each line as it is typed. During editing, the prompt changes to Capture>. The file is closed when a <control-z> character is received. CAPTURE automatically overwrites any previously existing file called Filename. The HyperTerminal cut and paste functions, on the Edit menu, may be used to give this command considerable power.

7.5.2. COPY File1 File2

Copies the contents of File1 to File2.

7.5.3. COPY CON FileName or COPY CON: FileName

Synonymous with CAPTURE FileName.

7.5.4. DEL Filespec

Deletes the indicated file or files from the flash disk. Any combination of * and ? wild cards that can be used with MS-DOS can be used with this command. The ? wildcard matches any single character, and * matches any group of characters. For example, `DEL,TEST?.*` deletes any file whose name starts with "TEST", followed by any single character, and with any extension. `TESTA.DAT, TEST2.BIN, TESTA` and `TESTT.X` all match; `TEST12.DAT` does not. DEL presents a list of files meeting that file specification, and their sizes, then asks "Delete all the above files?". If you press Y it will immediately delete them. Pressing any other key will abort the command.

7.5.5. DIR Filespec

Lists all the files on the flash disk whose filenames are described by Filespec. Filespec can contain MS-DOS wild cards such as "*" and "?."

7.5.6. ERASE Filename

Synonymous with DEL Filename.

7.5.7. REN OldName NewName

Renames the file called OldName to NewName

7.5.8. TYPE Filename Textmode ShowNames Delay

Transmits the contents of the file named Filename via the serial port. Filename can contain wildcards. If Textmode is specified as 1 or "on" (default), then Carriage Returns and Line Feeds will be expanded to Carriage Return/Line Feed combinations. If Textmode is specified as 0 or "off", then the output will be pure binary. If ShowNames is specified as 1 or "on" (default="off"), then filename(s) precede the output from each file. If Delay is specified, then the HydroRad waits Delay milliseconds before displaying the output.

7.5.9. XS [/Q] [/X] [/C] Filename

Initiates an XMODEM send from the HydroRad. It is expected that the user will instruct the host computer to receive. It should synchronize with hosts that support original 128-byte block XMODEM, CRC, and 1k XMODEM. Original XMODEM can be forced with the /X option, or XMODEM 128CRC with the /C option. The /Q option inhibits messages. To cancel a pending transfer, press `<control-X>` several times. See also 6.5.3.

7.5.10. XR [/Q] [/X] [/C] [FileName]

Prepares HydroRad to receive an XMODEM transfer. It is expected that the user will instruct the host computer to send. It should synchronize with hosts that support original 128-byte block XMODEM, CRC, and 1k XMODEM. Original XMODEM ca be forced with the /X option, or XMODEM 128CRC with the /C

option. The /Q option inhibits messages. To cancel a pending transfer, press <control-X> several times. See also 6.5.3.

7.5.11. YS [/Q] [/G] FileSpec

Initiates a batch file send using the YMODEM protocol. Sends all files whose filenames match FileSpec, which can contain DOS wildcards such as "*" or "?". YS can be forced to YMODEM-G (no error checking/recovery) with the /G option. The /Q option inhibits messages. To cancel a pending transfer, press <control-X> several times. See also 6.5.4.

7.5.12. YR [/Q] [/G]

Initiates a batch file receive with automatic file naming using the YMODEM protocol. YR can be forced to YMODEMG (no error checking/recovery) with the /G option. The /Q option inhibits messages. To cancel a pending transfer, press <control-X> several times. See also 6.5.4.

7.6. TESTING AND TROUBLE-SHOOTING

7.6.1. FREEMEM

Displays the amount of RAM available (for debugging).

7.6.2. PIXDELAY

Used only for testing.

7.6.3. SIM State

Turns on or off simulation mode. In simulation mode the actual spectrometer data are ignored, and each integration results in a triangular spectrum whose overall amplitude is proportional to the value of State. If State is 1, the amplitude will be based on a random value.

7.6.4. TEST

Used for debugging.

7.7. HELP

7.7.1. ? Command or HELP Command

Displays information related to specified command. If no command is specified, lists available commands.

8. COMMAND FILES

HydroRad commands can be loaded and executed from files stored on its flash card, exactly as if they had been received on the serial port from a user. By convention, these files have the extension `.cmd` and are referred to as command files. They are similar to MS-DOS batch files, with the addition that they may specify a real-time schedule for executing commands.

Most command files are executed by typing the file name of the command file, minus the `.CMD` extension. Command files can also be executed with the RUNFILE command. Upon startup, HydroRad will automatically execute the file `HYDRORAD.CMD`, if it exists. Also, the file `TRIGGER.CMD`, if it exists, will be executed whenever the trigger switch is engaged.

Command files can be created and edited using a Windows text editor, then download the finished file onto the flash card using one of the file transfer procedures described in section 6.5, or they can be typed or pasted to the HydroRad by using the CAPTURE command.

8.1. GENERAL FORMAT

Each line has one command followed by a carriage return and optional linefeed. Commands have the same format they would have if entered in real time.

8.2. SIMPLE EXAMPLE

```
auto 1 20
auto 2 20
auto 3 20
```

The above example simply determines the optimal integration time for channels 1, 2, and 3. Nothing is saved to the flash disk.

8.3. TRIGGER.CMD EXAMPLE

```
pause 10
logauto 5 samples 1 dive1
```

The above example was used for a diver-operated HydroRad. Whenever the trigger switch is toggled, the HydroRad will wait for ten seconds while the diver gets out of the way. For each channel, 5 spectra will be collected and averaged, and the average from each saved in a file with the base name "dive1". If the word "samples" were omitted, this would specify a total time of 5 seconds.

If the trigger switch is left on, this sequence will continuously repeat.

8.4. TIMED COMMAND FILE FORMAT

Timed commands are preceded by a time in the form HH:MM (hours and minutes), with a comma separating the time from the command. Note that whereas command arguments may be separated with a space or comma, scheduled commands MUST be separated from their times by a comma only.

Lines that contain a time, but no command, instruct HydroRad to repeat the last executed command at the designated time.

8.5. EXECUTION

When a file is run, HydroRad begins by executing commands in the sequence they are found in the file. If the file contains no timed commands, HydroRad simply executes them once in order, then closes the file and returns to interactive mode.

When HydroRad encounters a scheduled command, it goes into low-power sleep mode until the scheduled time, then wakes and executes the command. On its first pass through the file, HydroRad will skip any commands whose times have passed.

HydroRad continues executing commands in sequence; unscheduled commands as soon as they are read, and scheduled commands according to their designated times.

When it reaches the end of the file, or if all the schedule times have already passed, HydroRad will return to the first scheduled command in the file, and wait for that time to arrive on the following day.

If a file contains no timed commands, HydroRad will execute all the untimed commands once, then return to the HydroRad> prompt. If the file contains one or more timed commands it will repeat the schedule every day until halted by the user.

8.6. HALTING EXECUTION

To halt execution of a command file, press `<control-C>`. You may need to repeat this several times, depending on the command being executed. After one or more control-C's HydroRad will reply

```
Really abort command.cmd ? Press Control-C to confirm.
```

If you press `<control-C>` again within 4 seconds, execution of the command file will end. If you press a different key, or do not respond with 4 seconds, execution will resume.

8.7. TESTING

HydroRad command files are essentially computer programs, and it can be surprisingly easy to create "bugs" in them. Before deploying a command file of any complexity you should test it to verify it that it behaves as you intend. If your file includes long periods of sleep, you can accelerate its execution by pressing a key (not

control-C, unless you want to halt execution) once or twice to wake it from each sleep. It will detect that it woke early, and display the message "sleep interrupted", but will nevertheless continue with the next command, then sleep until the next scheduled time. You can also interrupt time-consuming LOGAUTO, LOGFIXED and LOGRANGE commands, without halting file execution, by pressing <control-C> once during the command.

8.8. TIMED EXAMPLE 1

```
20:00,logauto 600
21:00,logauto 600
22:00,logauto 300
logfixed 10000
23:30,logfixed 100
```

This file will do LOGAUTO,600 at 8PM and 9PM, Sleeping after it's done each one. At 10PM it will do LOGAUTO,300 immediately followed by LOGFIXED,10000, then sleep until 11:30PM and do LOGFIXED,100. Then it will sleep until 8:00 the following day. It will repeat this cycle daily until instructed to do otherwise.

8.9. TIMED EXAMPLE 2

```
intparams,20,1000
0:00,logrange,20,1000,2
6:00,logauto,300
7:00
8:00
9:00
10:00
11:00
12:00
logfixed,10000
```

Note that example 2 starts with an untimed line. Untimed lines that appear before the first timed line are executed only once each time the file is opened, whereas timed commands are repeated each day. Once all the untimed lines are done, the program waits for the first timed line whose time has not yet past. So if you were to start this file at 5:00, it would execute intparams,20,1000, then wait until 6:00 and do that line.

Lines that have a time but no command will repeat the last command that appears before it in the file. If you started example 2 at 8:30, it would do the untimed line, then at 9:00 it would do LOGAUTO,300.

After doing LOGAUTO,300 at 12:00 in this file, then LOGFIXED,10000, HydroRad will sleep until 0:00 the next day, then do LOGRANGE,20,1000,2.

8.10. REALISTIC TIMED EXAMPLE

```
intparams,20,10000
filtparams,100,1000,10
00:00,logrange,20,13000,5
6:00,logauto,600
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
```

When it is first started this file will do the INTPARAMS and FILTPARAMS commands, then wait for the next listed hour to start. It will collect 10 minutes (600 seconds) of data every hour during daylight hours, and a range of dark integrations every midnight.

9. DATA PROCESSING AND STORAGE

9.1. CALIBRATION PROCESSING STEPS

HydroRad's operating software can save data in raw form, as fully calibrated engineering data, or in any of several intermediate stages of processing. Data saved in various stages of processing can be further processed after offloading by the PC-based HRCAL utility (see section 11). The stages in processing are described below. These steps are always performed in sequence; all the steps up to and including that specified by the LOGPARAMS command are performed before data are saved in files. In addition, multiple spectra may be averaged (see 7.4.6, 7.4.7, 7.4.8), and spectral filtering applied (see 7.2.5) after the specified processing.

9.1.1. Process 1: Pixel Compensation

Step 1 uses information from adjacent pixels to compensate for pixels that are identified during calibration as more unpredictable than others. A small but significant percentage of such pixels are found in most CCD chips. This process may result in a small shift in effective wavelength for these pixels. The worst-case shift is equivalent to 2 pixels, or about 0.6nm. IMPORTANT: This process can only work when every pixel within the desired spectral range is available. Therefore if you plan to select a subset of pixels (using the PixelIncrement parameter of INTPARAMS) you should select a processing level of 1 or higher so that step 1 will be performed in situ, before the pixels are selected.

9.1.2. Process 2: Dark Offset Subtraction

Each pixel in a CCD produces a characteristic offset, which is a function of temperature and integration time, in the absence of light. HOBI Labs measures the offsets over a wide range of conditions, then distills this information into a set of parameters for each pixel. Processing step 2 is to calculate and subtract this offset from the measured signals.

9.1.3. Process 3: Time Normalization

CCDs are inherently integrating, and their output is proportional to the energy accumulated during their integration time. However most applications call for a measure of power, such as irradiance or radiance. Step 3 is to divide the measured signal by the integration time to convert from energy to average power.

9.1.4. Process 4: Spectral Normalization and Units Conversion

Based on measurements with a well-calibrated standard light source, step 4 compensates for the non-uniform spectral response of the CCD and other optical components, and converts the measured spectra to engineering units.

9.2. CHOOSING THE PROCESSING LEVEL

The level of processing applied is set by the processing parameter of the LOGPARAMS command (see 7.2.13). The HRCAL utility program can perform any processing steps not performed in situ after data are offloaded to a PC, with a few exceptions. If your files do not contain every pixel within a range, that is if you have set FILTPARAMS's PixelIncrement parameter to a value other than 1, it will be impossible to perform the pixel compensation process. Spectrally filtering data whose dark offsets have not been subtracted can seriously degrade their signal-to-noise ratio. Also, averaging spectra processed to a level less than 3 can degrade their accuracy, although the effect may not be severe if the range of integration times included in the average is modest.

For most purposes, especially if you wish to use averaging and/or spectral filtering, you should select level 4 (fully calibrated) data. The exceptions are if you wish to

- save the most compact binary data files,
- collect spectra as rapidly as possible,
- apply the results of later calibrations.

In these cases you should usually select level 0, use no averaging or filtering, and set the PixelIncrement parameter of FILTPARAMS to 1. Saving complete raw spectra is in fact the "safest" practice, since you can easily apply adjusted calibrations, should this become necessary. Raw binary files produce the most compact possible data files, pixel for pixel. However if you process and filter the spectra in situ you may be able to save a smaller set of pixels and reduce the overall file size (see 9.8).

The computation time required for processing varies widely depending on the settings of various parameters, from a small fraction of a second to several seconds per spectrum. If your application requires collecting spectra in rapid succession, you may wish to store raw data for later processing.

9.3. CALIBRATION FILES

To apply any of the calibration processing steps, a calibration file for each active channel of the HydroRad must be stored on the flash disk. Calibration data for each instrument and channel are generated during HOBI Labs' calibration, then transferred to HydroRad in the form of an ASCII comma-separated values file. This file must be converted by the HydroRad operating software into binary files of the proper format for each channel. This conversion is performed by the IMPORTCAL command (see 7.2.8). The conversion is only needed once, then the `.CSV` file can be deleted. The working calibration files are named `A.CAL`. `B.CAL`, etc. HOBI Labs normally loads these files at the time of calibration. Note that these files are not the same as the `.CAL` files that are generated similarly by HRCAL.

9.4. ASCII CALIBRATION FILE FORMAT

The file is split up into sections, which can be in any particular order. Sections are identified by strings in square brackets, e.g. [ID]. The firmware ignores extra lines outside the defined sections, and ignores extra information at the end of lines, as long as it is separated by a comma. There is one section that identifies the HydroRad, and four sections associated with the calibration of each HydroRad channel.

The equations to which this calibration data applies are:

Do, time invariant Dark Offset = Average Signal from Pixels Do_{low} to Do_{High}

Dt, time variant Dark Offset = Average Signal from Pixels Dt_{low} to Dt_{High}

DarkCorrection[Pixel]= Do + C[pixel] * (Dt - Do)

FixedSignal[Pixel] = FixFunction(Signal[Pixel], F[Pixel])

Corrected[Pixel] = FixedSignal[Pixel] - Dark Correction[Pixel]

LinearityAdjusted[Pixel] = Corrected[Pixel] + Adjustment(Corrected[Pixel])

Rate[Pixel] = Linearity Adjusted[Pixel] / (Integration Time + Offset)

EngineerngUnits[Pixel] = ϵ[pixel] * Immersion [Pixel] * Rate[Pixel] * Scale

Wavelength = W_0+Pixel*W_1+Pixel^2* W_2

9.4.1. Identification

This section identifies the instrument to which the calibration belongs. The first line after the label is taken as the serial number of the instrument. The firmware compares this to the serial number of the HydroRad and warns the user if it's different. The next line is the configuration string.

Example:

```
[ID]
HR990501
CD4S50L2
```

9.4.2. Channel Information, Dark Correction, Epsilon, and Immersion Correction

This section begins with the channel letter in brackets, such as [A] for the first channel. The firmware only looks for letters A through D.

Line 1 after the marker contains a string of up to 31 characters that gives the real name of the channel. For example, "Irradiance_down" or "Radiance_up". At this time, these strings cannot contain spaces.

Line 2 contains the units of the calibrated data, e.g. "W/m^2/nm" or "W/m^2/nm/sr".

Line 3 gives an overall scale factor which is applied to all the data in the channel. This could be used, for example to boost the output of a detector that is put behind a neutral density filter.

Line 4 gives the inclusive range of pixels to be averaged to produce the Time Invariant Dark Factor "Do".

Line 5 gives the inclusive range of pixels to be averaged to produce the Time Variant Dark Factor "Dt".

Line 6 gives the number of the first pixel for which calibration data is supplied.

Lines 7 and up contain, for each pixel: the factor F used in FixFunction, the constant C used to calculate the DarkCorrection, and the values of ϵ (epsilon) and Immersion used in calculating Engineering Units. The firmware will keep reading pixel values from successive lines until it hits a line that doesn't begin with a digit, or until the pixel number reaches 2047.

Example channel information, dark correction, epsilon, and immersion correction:

```
[A]
Ed1, name of the channel, 31 chars max
W/m^2/nm, physical units, 31 characters max
1, overall scale factor
3,18, Do_Low and Do_High
20,35, Dt_Low and Dt_High
1, number of first pixel for which calibration data is provided
3,-0.01319,0.2019938,1.3991, F[1], C[1], epsilon[1], Immersion[1]
1,-0.01351,0.2019345,1.3991, F[2], C[2], epsilon[1], Immersion[2]
1,-0.00243,0.2018741,1.3992, etc...
4,-0.00862,0.2018413,1.3992
...
```

9.4.3. Non-Linearity

The values in this table are used in the linearity correction function Adjustment(Corrected[Pixel]). To speed up calculation time and reduce required memory, values are interpolated from a lookup table. The first two entries, “63” and “128” in the example below, define the X-axis of the lookup table. The rest of the data define the Y-axis of the lookup table. The first Adjustment (1) is at counts=63, the second (4) is at Counts=191 (63+128). The third (6) will be at Counts = 319 (63+256), and so on.

Example non-linearity calibration for channel A:

```
[A NLTABLE]
63,128, 1st lookup value, increment
1, Adjustment factor at Counts = 63
```

```
4, Adjustment factor at Counts = 191
6, Etc…
7,
...
```

9.4.4. Time Offset

This single value in this section is the amount of time, in milliseconds, added to the integration time requested by the HydroRad firmware, to account for signal processing delays in the HydroRad hardware.

Example time offset for channel A:

```
[A TIME]
9, Time Offset
```

9.4.5. Wavelength Calibration

This section contains the three constants W_0, W_1, and W_2 that are used in the second order equation relating pixel numbers to wavelength in nanometers. In the example below, [A WAVE] indicates channel A. [B WAVE] would have indicated channel B, and so on. The text "W0," "W1," and "W2" is optional, and could have been omitted.

Example wavelength calibration for channel A:

```
[A WAVE]
327.835,    W0
0.38022,    W1
-2.192E-05, W2
```

9.5. DATA FILES

HydroRad saves spectra collected with the LOGAUTO, LOGFIXED, and LOGRANGE commands in files on the flash disk, which can be downloaded via the serial connection to a PC (see 6.5). Files are assigned a base name of up to 7 characters, to which HydroRad appends a letter indicating to which channel it corresponds (A for channel 1, B for channel 2, etc.), and an extension indicating whether the file contains binary or ASCII data (`.BIN` and `.ASC`, respectively). For example a base name of "hydro" on a HydroRad-3 will result in files named `hydroA.ASC`, `hydroB.ASC`, and `hydroC.ASC` containing data from the three channels.

The base name may be entered as part of the command (see the descriptions of LOGAUTO, LOGFIXED and LOGRANGE for details). If no base name is specified, a name will be formed from the current date, in the form YYMMDD. All the spectra saved at any time on a given date are stored in the files named for that date. In the unlikely event the integration time actually starts in one day and ends in the next, the spectrum will be saved under the later date.

Data assigned to files that already exist are always appended to the existing file.

Files may be stored in binary or ASCII format. The format is set with the LOGPARAMS command, and defaults to ASCII.

9.6. ASCII FILE FORMAT

The first line of each data file indicates the model and serial number of the instrument that generated it.

The second line indicates the channel, the name of the channel, and the units of calibrated data produced by the channel. The name and units may not be included if raw data are recorded.

In ASCII files, each spectrum is saved as a line of comma-separated decimal values, as follows:

```
RawTime, Temp, Voltage, Depth, Process, N, Scale, Do, Dt, IntTime,
FirstPix, PixInc, PixCount, Pixel[FirstPix], Pixel[FirstPix+PixInc],
...Pixel[FirstPix+(PixCount-1)*PixInc] <return> <linefeed>
```

RawTime is the time of the sample in seconds since 00:00 on Jan 1, 1970. If using Excel to display data, you can use the following formula to convert the time to a conventional date/time format:

```
=rawTime/86400 + DATEVALUE("1/1/70")
```

Temp, Voltage, and Depth are real numbers representing the internal temperature in C, the supply voltage in volts, and the depth in meters.

Process indicates what steps in the calibration process have been applied to the data. A value of zero indicates the data are raw; 4 indicates they are fully calibrated and in engineering units. Intermediate values indicate intermediate steps in the process.

Scale is a number by which all the pixel values must be multiplied to restore them to their correct values. As of firmware version 1.00, this number is always set to 1.0.

Do, and Dt are used in the dark current calculation portion of the calibration procedure. They are needed to calibrate raw data, or to convert calibrated data back to raw.

N indicates the number of samples in an averaged sample and has the value 1 if no averaging was done.

IntTime is the integration time in milliseconds.

FirstPix, PixInc, and PixCount indicate the range of pixels included in the saved spectrum.

9.7. BINARY FILE FORMAT

Binary files can be converted to ASCII files, with the HRCAL utility after being transferred to a PC.

Binary files begin with two lines of text in the same format as ASCII files. The first line indicates the model and serial number of the instrument that generated it.

The second line indicates the channel, the name of the channel, and the units of calibrated data produced by the channel. The name and units may not be included if raw data are recorded.

Spectra in binary files contain the same data in the same order as ASCII files, with the addition of a pair of "tag" bytes. The data sequence is as follows:

```
0FF0 <RawTime> <Temp> <Voltage> <Depth> <Process> <N> <Scale> <Do>
<Dt> <IntTime> <FirstPix> <PixInc> <PixCount> <Pixel[FirstPix]>
<Pixel[First+PixInc]> ... <Pixel[FirstPix+(PixCount-1)*PixInc]>
```

The first two bytes have the arbitrary value 0FF0 hex to mark the start of the record. RawTime and IntTime are 4-byte integers. Temp, Voltage, Depth, Scale, Do, and Dt are 4-byte IEEE floating-point values. FirstPix, PixInc, PixCount, Process, and N are 2-byte integers. If the value of process is zero, then the pixel values are 2-byte integers. If process is greater than zero, the pixel values are 4-byte IEEE floating-point values. The most significant byte of each value is stored first (opposite to the native byte order on DOS and Windows PCs).

9.8. DATA FILE SIZES

File sizes vary widely according to their format, and the number of pixels included. They can be reduced drastically (to as little as a hundred bytes) by setting the FILTPARAMS to select a small subset of pixels, although subsampling requires careful attention to the appropriate processing level (see 9.2).

A good compromise between file size and data security is to save all the raw pixel data in binary form. Saving all 2048 pixels results in spectra of about 4200 bytes. In most cases the number of spectrally useful pixels is closer to 1500, reducing the spectra to about 3200 bytes. With the minimum 4 Mbyte flash card, this gives a practical capacity of over 1000 spectra.

Whereas raw binary files save pixels as 2-byte integers, processed pixels are stored as floating-point numbers requiring twice the space.

ASCII files are the easiest to read, but can be as much as five times larger than raw binary files and two to three times larger than processed binary files (up to 20,000 bytes per spectrum). For many applications even this size is not prohibitive, but clearly the user must consider data capacity for long-term or high duty cycle logging. Also, ASCII files take longer to write to the flash disk, possibly slowing the data collection rate.

9.9. LOG FILE

HydroRad keeps a text file called `HYDRORAD.LOG` on the flash disk that records the dates and times (in a human-readable form) at which it stores data and performs various other actions. This can be useful for post-analysis of data, and

troubleshooting. The operating software continuously adds to this file, so you may wish to delete it occasionally. If no HYDRORAD.LOG exists, the operating software will generate a new one.

10. EXTERNAL SWITCHES

HydroRads include magnetically coupled switches that can be used to control the sensor without connecting to a computer. See Section 1 for the location of these switches.

10.1. SLEEP/WAKE SWITCH

One switch acts as an on/off power switch, although it cannot actually turn off power to the sensor. When switched from wake to sleep, it signals HydroRad to go into an indefinite sleep (as if it had received the SLEEP command). When switched from sleep to wake it wakes the sensor from sleep. Because the switch only signals the sensor to sleep or wake, it is possible to wake HydroRad with serial communication from a computer, even if the power switch is in the off position. It is likewise possible to command the sensor to sleep even if the switch is on. Switching the power switch to off while the sensor is asleep will have no effect. Note that the sleep and wake functions only work while the HydroRad operating program is running, and will not work when running PicoDOS.

10.2. TRIGGER SWITCH

The second switch triggers data collection. If the sensor is awake, the trigger switch signals the HydroRad firmware to execute a command file `TRIGGER.CMD`. This allows the user to specify an arbitrary response to the trigger switch. If no `TRIGGER.CMD` file is present on the flash card, LOGPARAMS will be executed, with its default parameters. If the trigger switch is operated momentarily, LOGPARAMS or `TRIGGER.CMD` will be executed once. Switching off the switch while a command is in progress will not interrupt the command. If the trigger switch is on when the command completes, it will repeat. The trigger switch has no effect if the sensor is asleep.

11. HRCAL CALIBRATION UTILITY

HRCAL operates on ASCII or binary files produced by the HydroRad. Depending on the input file format and the optional switches specified, it can perform the following functions:

1) Convert ASCII calibration files into binary calibration files for the PC.
2) Convert HydroRad output files from binary to ASCII
3) Apply calibration formulae to produce output data in engineering units (controlled with the -c or -r switch).
4) Transposes rows and columns in the file so that spectra appear in columns (controlled with the -x switch).

HRCAL is usually run from the MS-DOS command line within Windows. If you simply double-click on the HRCAL icon in Window Explorer, Windows will launch the program without giving you the opportunity to enter command-line arguments. Instead, open a command-line window by selecting "Command Line" or "MS-DOS Prompt" (the exact name depends on your system configuration) from the Start menu. This will put you in a DOS environment for typing commands.

HRCAL can also be run in Windows Drag/Drop mode. To use this mode, the HRCAL.exe file and the calibration file(s) must be in the same directory as the files to be processed. Data files can then be dropped onto the HRCAL.exe program for automated processing.

11.1. ASCII CALIBRATION FILE CONVERSION

Before HRCAL will work on HydroRad data, the ASCII calibration file associated with that HydroRad must be converted into binary files. The following syntax is used:

```
HRCAL –convert FILENAME.csv
```

This will create one binary file for each channel described in FILENAME.csv. they will be called FILENAMEA.cal, FILENAMEB.cal, etc. These files will only work on the PC. The equivalent files, A.CAL, B.CAL, etc. must be made on the HydroRad with the syntax `IMPORTCAL FILENAME.csv`.

Alternately, using MicroSoft Windows, the `FILENAME.csv` file can be dropped onto the HRCAL.EXE file, and the conversion will be automatic.

11.2. HRCAL USAGE

Once binary calibration files are made, HRCAL is invoked with the following syntax:

```
HRCAL datafile [calfile] [-c] [-r] [-x] [-t] [-s]
```

where parameters in brackets are optional. Do not include channel letters or file extensions. "A", "B", "C", "D", and ".BIN" or ".ASC" will be added to data files (If channel letters and file extensions are included, HRCAL uses the Windows Drag/Drop Mode conventions -- see section 11.3). Filenames may include full DOS paths. If no path is specified, HRCAL will seek the file in the current working directory. Optional arguments may be in any order, except that the calfile, if specified, must be after the data file.

If no calfile is specified, HRCAL will look in the current working directory for a cal file matching the instrument serial number recorded in the input file. Even if raw output is specified, it will look for a cal file to determine the pixel-to-wavelength conversion for the file header. But lack of a cal file will not prevent production of a raw output file.

The -r switch disables the calibration function, producing a raw ASCII file with the extension `.RAW`.

The -c switch controls calibration. Calibration is turned on by default, but -c can be also be followed by a single digit to indicate which of 4 calibration steps to perform. The steps are (1) weak pixel adjustment, (2) dark current subtraction, (3) normalization by integration time, and (4) final scaling to engineering units. -c4 is the default; -c0 specifies raw data and is identical to -r. Output files with any calibration option other than raw data are assigned the extension `.DAT`.

Files produced by the HydroRad may already be partly or fully calibrated. HRCAL reads the processing status of each spectrum and skips any cal steps that were performed in situ.

HRCAL output is comma-delimited by default. The -t and -s switches specify tab- or space-delimited output, respectively.

Multiple option switches may be grouped together on the command line. For example, `HRCAL datfile -rxt` is equivalent to `HRCAL datfile -r -x -t`.

11.3. WINDOWS DRAG/DROP MODE

If HRCAL is in the same directory as the cal files and the data files, then HRCAL can be used in Windows Drag/Drop mode. In this case,

- Dropping channel A onto HRCAL = full cal.
- Dropping channel B onto HRCAL = full cal, transpose rows and columns
- Dropping channel C onto HRCAL = full cal, transpose with space-delimited output
- Dropping channel D onto HRCAL = full cal, transpose with tab-delimited output
- Dropping files like *.c* onto HRCAL will force -convert mode (see section 11.1)

11.4. INPUT DATA FILES

Files produced by the HydroRad may also be partly or fully calibrated. HRCAL skips any cal steps that have been performed in-situ.

The first argument is the base name of the data file series you wish to convert. Data files are assumed to be in the form `baseA.ASC`, `baseB.ASC`, etc., or `baseA.BIN`, `baseB.BIN`, etc., where the letters A through D correspond to HydroRad channels 1 through 4. HRCAL assumes you will only supply the base portion of the name. It appends `A.ASC`, `B.ASC`, etc. to the name you supply. For each of up to 4 channels it searches first for a binary `.BIN` file. If it finds no binary file, it then searches for an ASCII file.

11.5. OUTPUT FILES

Calibrated data files are given the same base name as the input file, with the extension `.DAT`. Raw output files (indicated with the -c0 or -r switch) take the extension `.RAW`. NOTE: If a file exists with the same name as a file being created, the existing file will be overwritten.

The file begins with an informational header. The first line states that this is a HydroRad calibrated data file. The second line names the source file from which data were extracted. The third line names the file containing the calibration data used in processing the data. The fourth line identifies the channel by its number, name and the units in which calibrated data are produced. Future versions of HRCAL may include more header lines.

The format after the initial header lines depends on whether the -x command line switch is used to indicate transposition of the rows and columns.

11.5.1. Untransposed Output

The final header line lists the names of the parameters that will be displayed for each subsequent spectrum. These are:

```
  Time, temp, volts, depth, process, N, scale, Do, Dt, IntTime,
firstPix, pixInc, numPix
```

These parameters are the same as described in section 9.6. After `numPix`, the fourth line continues with a list of the wavelengths corresponding to each pixel in the following spectra. These numbers will not appear if no calibration files are available.

After the header, each spectrum is stored as one line of data in the output file. Each spectrum starts with the housekeeping parameters listed above, then lists the pixel values of the spectrum.

11.5.2. Transposed Output

Transposed files contain the same data as untransposed files, but their spectra are presented in columns instead of rows. This makes them easier to load into some

analysis software. Each column contains the same housekeeping parameters as the untransposed rows, followed by the spectrum's pixel values. The left-most column contains the parameter labels and wavelengths.

12. CUSTOMER SERVICE

12.1. Administrative Support

If your HydroRad needs to be returned to HOBI Labs for repair, maintenance or calibration, please contact HOBI Labs Customer Service Department with the following information at hand:

- Instrument Serial Number
- Reason for return
- Method of return (Federal Express, United Parcel Service, etc.)
- Point of contact
- Date needed (allow minimum three week turnaround)
- Delivery address

HOBI Labs Customer Service Department

Telephone: 1-888-414-HOBI (1-888-414-4624)

Fax: 1-831-884-9411

E-mail: service@hobilabs.com

Normal business hours are Monday through Friday, 8 a.m. to 5 p.m., PST

The Customer Service Representative will start the process by collecting all necessary information. HOBI Labs will notify the customer of estimated cost and turnaround time as soon as possible after receiving the instrument. Repairs will not be started until customer approves cost estimate and length of turnaround time.

12.2. Software/Hardware Support

For technical support or questions about your instrument, contact our technical support department at support@hobilabs.com or call the HOBI Labs Customer Service Department.