QSP-2300
Log Quantum Scalar Irradiance Sensor

and the

QCP-2300
Log Quantum Cosine Irradiance Sensor

User's Manual

Biospherical Instruments Inc.
5340 Riley Street
San Diego, CA 92110 USA

VOX: (619) 686-1888
FAX: (619) 686-1887
E-mail: support@biospherical.com

Version 005626UC

Date Printed: 10/3/2006

NOTICE

The information contained in this document is subject to change without notice. BIOSPHERICAL INSTRUMENTS MAKES NO WARRANTY OF ANY KIND WITH REGARD TO THIS MATERIAL, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Biospherical Instruments shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

Document 005626UC

LIMITED WARRANTY

BIOSPHERICAL INSTRUMENTS INC. (Company) warranties this instrument, system or software (Product) to function properly and be free of defects in materials for a period of one (1) year and in workmanship for a period of ninety (90) days from the date of original shipment from our factory. Should Product fail to be in good working order at any time during the above stated warranty period, Biospherical Instruments Inc. will, at its option, repair or replace Product at no additional charge except as set forth below.

Repair parts and replacement Products will be furnished on an exchange basis. All replacement parts and products become the property of Company. This limited warranty does not include service to repair damage to Product resulting from accident, disaster, misuse, abuse, or revisions made to the product by parties other than Company. Devices manufactured by other parties and delivered as part of the Product are warranted to the extent and manner provided by the original equipment manufacturer. Repairs made by Company to its products carry the same warranty as new products manufactured by Company.

Warranty service may be obtained by delivering Product during the warranty period to Biospherical Instruments Inc. at its San Diego, California location. If the problem is not within the scope of this warranty, Company reserves the right to charge a reasonable fee for services provided in determining the nature of a malfunction and the preparation of a written repair estimate. Company is not responsible for any costs for shipping or insurance, customs, duties, etc. If Product is delivered by mail, courier, or other public carrier, you agree to prepay shipping charges to the San Diego, California location, to insure the product or assume risk of loss or damage in transit; to use the original shipping container or equivalent; and to pay for return shipping charges.

ALL EXPRESS AND IMPLIED WARRANTIES FOR THIS PRODUCT INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO THE ABOVE WARRANTY PERIOD, AND NO WARRANTIES, WHETHER EXPRESSED OR IMPLIED, WILL APPLY AFTER THIS PERIOD.

IF THIS PRODUCT IS NOT IN GOOD WORKING ORDER AS WARRANTIED ABOVE, YOUR SOLE REMEDY SHALL BE REPAIR OR REPLACEMENT AS PROVIDED ABOVE. IN NO EVENT WILL BIOSPHERICAL INSTRUMENTS INC. BE LIABLE TO YOU FOR ANY DAMAGES, INCLUDING ANY LOST PROFITS, LOST SAVINGS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE SUCH PRODUCT, EVEN IF BIOSPHERICAL INSTRUMENTS INC. HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. NOR WILL BIOSPHERICAL INSTRUMENTS INC. BE LIABLE FOR ANY CLAIM BY ANY OTHER PARTY.

SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO YOU.

THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS THAT MAY VARY FROM STATE TO STATE.

INITIAL INSPECTION AND SHIPPING PROCEDURES

This instrument was carefully inspected mechanically and electrically, and was calibrated before shipment. It should be free of mars or scratches and in perfect operating condition upon receipt. To confirm this, the instrument should be inspected for physical damage incurred in transit. If the instrument was damaged in transit, file a claim with the carrier. Check the instrument for proper operation as outlined in this manual. If there is damage or deficiency, see the Warranty in the preface of this manual.

WARNING: Read the sections on installation, operation and maintenance before attempting to operate or disassemble the instrument.

Retain original packing material for shipment to the factory. The instrument must be carefully wrapped and cushioned with appropriate packing material before it is shipped.

PRECAUTIONS

PROTECT THE UNDERWATER CABLE AND CONNECTOR. Properly clamp the cable onto the lowering frame. Avoid any sharp bend in the cable. Make sure the cable is tightly clamped. A loose clamp will result in the cable slipping and possibly kinking under the small radius bend. On more than one occasion, cables have been damaged by failure to secure the cable. The underwater connector is the most vulnerable part of the system. Protect the connector contacts from moisture, both during use and while in storage. Do not step on it, or strike it while it is plugged into the instrument.

PROTECT THE INTEGRATED CIRCUITS. A person walking across a carpet on a dry day can generate a static charge of over 10,000 Volts. The resulting discharge can destroy an integrated circuit. Use standard anti-static equipment any time the instrument is opened up and the components are removed.

AVOID SHADOWS AND REFLECTIONS. During deployments or installations, be careful to keep the instrument away from reflections and shadows caused by surrounding structures. An underwater instrument package should be positioned for lowering on the side of the ship toward the sun. If the instrument is lowered into the shadow created by the ship, this shadow will contaminate measurements for depths up to 100 meters. When positioning a ship and deploying an underwater sensor, the wind direction is also a factor since the wind or wind-driven currents can push the ship over the sensor when it is being lowered, thereby causing shadowing. A surface sensor should be mounted so that it will not be shaded by or experience reflections from surrounding structures.

MAINTAIN PROPER CALIBRATION. The proper conversion factors for the sensor voltages to engineering units are contained on the calibration certificate issued with the instrument, and are updated on subsequent recalibrations. It is ultimately the user's responsibility to ensure that the proper calibration factors are used during data analyses. Any calibration factors published in this manual are for example only; valid entries may be found on the calibration certificate issued with each BSI instrument.

CARRY SPARE CABLE AND POWER SUPPLIES. For extended operations, it is strongly recommended that the user maintain spare cables and power supplies for the entire instrument system.

HANDLING. It should not be necessary to disassemble the underwater housing. However, if this does become necessary, follow the disassembly procedure in Section 4.2.2.

CAUTION: *The Teflon ball and mount are critical optical components. They have been aligned at the factory before calibration. It is possible to remove the ball, but this voids the calibration. The stainless steel mount contains a quartz light pipe and is FRAGILE. If you suspect damage or if the ball has been removed, consult the factory.*

INTRODUCTION

The QSP/QCP-2300 Logarithmic Output Light Sensors are designed to allow researchers to measure widely variant light fields found in aquatic environmentswhile taking measurements with an STD (salinity-temperature-depth), CTD (conductivity-temperature-depth), current meter, or other fixed range data acquisition system.

The exponential decay of light in aquatic systems places special demands on the design of light sensing instruments, especially where accurate measurements are required at light levels ranging over decades. To meet these demands, the QSP-2300's logarithmic output allows up to four decades of accurate measurement of light intensity using a 12 bit, fixed range data acquisition system, which is normally limited to two decades.

NOTE: The only difference between the QSP-2300 and QCP-2300 is the collector geometry.

The QSP-2300 (Figure 1) uses the patented (US Patent 4,178,101) Biospherical Instruments scalar optical collector to measure light from all directions, an important consideration in optical and oceanographic research. Note that the QSP-2300 has a sister instrument, the QCP-2300, which uses a cosine collector rather than a scalar one. Both instrument's spectral response is designed to measure PAR (Photosynthetically Available Radiation) between 400 nm and 700 nm with a constant quanta response. The 2300 is calibrated with constants for microEinsteins/cm^2 or quanta/second/cm^2. Its power requirements are very low and are compatible with most CTDs and data acquisition systems. The standard pressure housing is tested to 1000 meters.

It is important that this operating manual be read carefully since there are several precautions that should be taken to extend the inherent accuracy of the instrument itself to the desired measurement. These precautions include avoiding shadows during the deployment of the instrument and avoiding temperature extremes.

Figure 1. QSP-2300 Quantum Scalar irradiance sensor. The output of this device is a voltage that is proportional to the log of the scalar irradiance.

SPECIFICATIONS

QSP-2300 SCALAR IRRADIANCE COLLECTOR: 1.9 cm (3/4") diameter solid Teflon (Teflon is a registered trademark of the Dupont Corp.) sphere optically connected to the main housing by a 2.5 cm (1") stainless steel encased quartz light pipe. O-ring seal to main housing.

QSP-2300 SCALAR DIRECTIONAL RESPONSE: Each instrument's directional response is optimized before final calibration and is constant within ±6% over a range of ±110° zenith angle. Individual detector response plots are optionally available.

QCP-2300 COSINE COLLECTOR: 1.15 cm (.45") diameter x 0.5 cm (.2") high cylindrical solid translucent acrylic collector fused to transparent Plexiglas support. O-ring seal to main housing.

QCP-2300 COSINE DIRECTIONAL RESPONSE: cosine response when fully immersed in water. Typical agreement is +/-5% 0 to 65^{o}; +/- 10% 0 to 85^{o}

PHOTODETECTOR: Blue-enhanced high stability silicon photovoltaic detector with dielectric and absorbing glass filter assembly.

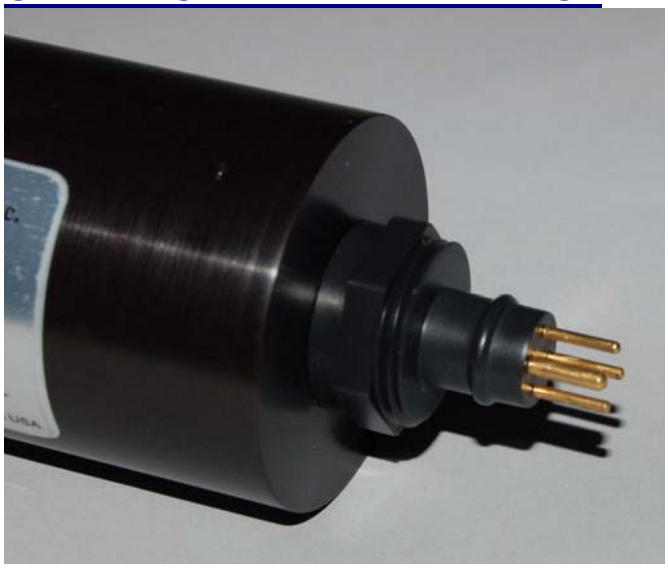
SPECTRAL RESPONSE: Constant (better than ±10%) quantum response from 400 to 700 nm with response sharply attenuated above 700 nm and below 400 nm. Spectral response induced errors will cause less than ±5% errors in naturally occurring light fields.

OUTPUT: Output is a DC voltage typically between 0 and 5 VDC that is proportional to the log of the incident irradiance.

OUTPUT IMPEDANCE: 30 ohms.

CALIBRATION: Calibrated using a National Institute of Standards and Technology traceable 1000 watt type FEL Standard of Spectral Irradiance. Annual recalibration is recommended.
DEPTH: Not to exceed 1000 meters
TEMPERATURE: -2 to 35°C. The 2300 has a small temperature coefficient of sensitivity (typically less than 0.15%/°C) and a small zero or dark signal temperature coefficient. For this reason, the instrument should not be left out in the hot sun because the black housing will become warm and experience a sharp temperature gradient when lowered from the ship. If the instrument does become overheated, allow it to sit in the surface water for a few minutes to come into temperature equilibrium before you begin your profile.
ENVIRONMENTAL: O-ring sealed using high quality oceanographic type connector. It is recommended that the 2300 housing be rinsed in fresh water after using. The operating temperature range is -2 to 35°C.
POWER REQUIREMENTS: +6 to +15 volts DC at typically less than 5mA
TRANSFER FUNCTION: Irradiance = CALFACTOR * $10^{(measurement)}$

OPERATION AND MAINTENANCE



The thicker pin is Pin 1, power ground
Pin 2 is signal out
Pin 3 is signal ground
Pin 4 is power +

OPERATION

When you initially receive your QSP-2300 and before leaving for the field, you should fully connect the instrument and data acquisition system you intend to use. Make certain that the system runs properly. If it does not, consult the factory for assistance.

Before deploying the 2300, you should cover it completely (aluminum foil works well) and take a "dark" reading. With this information, you can correct your data for any dark offsets.

The normal output of the QSP-2300 is a positive voltage ranging between +5 volts at the maximum irradiance level and a minimum voltage near zero irradiance, where the sensor drops into the noise. This output is proportional to the log of the incident irradiance. The relationship is:

$$\text{incident irradiance} = CF * 10^{(measurement)}$$

CF is the calibration factor obtained from the calibration certificate and "measurement" is the voltage output by the sensor when exposed to the incident irradiance.

Note: the 2300 reports 0 volts if the light levels saturate the response of the instrument.

The QSP-2300 should be connected to a data acquisition system that will correctly digitize the voltage output. The voltage may be converted into the measurement of quanta/(sec*cm^2) incident on the collector by using the information on your calibration certificate. The calibration factors for the instrument include an immersion correction that will compensate for the "immersion effect" (which causes different collection efficiencies for wet and dry optical diffusers due to a combination of refractive indicies and scattering coefficients) and provide correct readings in water. It is important to note that this correction will cause a 2300 sensor to give a higher (and incorrect) reading when placed in air alongside a surface reference sensor. This discrepancy is normal, and the ratio between the measurements should be fixed provided the sensors' fields of view are the same.

If the instrument has been sitting in the sun for a long period of time, remember to allow it to sit in the surface water for a few minutes so that its temperature can come into equilibrium before you start your profile.

When you deploy the instrument, make certain that it is lowered so that the sensor does not pass through the ship's shadow. Deployment from the bow with the ship backing very slowly in a direction that points the bow to the sun is the best option for avoiding shadow. This will trail the meter away from the ship and its shadow. Pointing the bow away from the sun and lowering the instrument from the stern is the next best option. Some investigators have even devised small floats from which to lower the instrument to avoid shadow effects.

CAUTION: Exercise caution when deploying in very strong currents. Also, the boat operator or Captain must be notified when lowering any instrument where it may become caught in the ship's propeller.

Keeping the instrument out of shadows helps to maintain the integrity of data. However, to achieve a truly accurate computation of the diffuse attenuation coefficient "K", you must monitor the surface irradiance and depth of the instrument during each profile. Correct depth readings can easily be obtained by deploying a depth-measuring instrument simultaneously with the 2300. Changes in surface irradiance are most easily obtained by using a surface reference sensor, such as the QSR-2200, during each vertical profile. These data can then be used to provide an approximate correction to the underwater irradiance field. Consult Biospherical Instruments Inc. for further information on available surface references.

When you are finished with your deployment, rinse the sensor with fresh water. **Storing the instrument with residual salt drops will ruin the connectors and corrode and pit the metal surfaces.**

MAINTENANCE

The irradiance collector may become dirty during normal use. It may be cleaned with warm water, or a gentle soap using a soft tissue or towel. Do not use acids or abrasive cleaners or brushes as this will damage the surface and alter the instrument's calibration. Should the

collector become damaged or heavily soiled, return the instrument for service and recalibration. ALWAYS rinse cable and underwater sensors with fresh water after using. If installed in a lowering frame, check fasteners for tightness.

The 2300 requires no other maintenance except that O-rings should be replaced occasionally, usually when the instrument is calibrated (consult factory for details). The optical section of the instrument should not be disassembled as this will void the calibration of the instrument.

NOTE: IF THE UNDERWATER BULKHEAD CONNECTOR MUST BE REMOVED FROM THE HOUSING FOR ANY REASON, DO NOT RE-TIGHTEN TO OVER 15 INCH- POUNDS OF TORQUE OR BREAKAGE MAY OCCUR.

TROUBLESHOOTING AND INSTRUMENT REPAIR

WARNING: TO PREVENT DAMAGE TO THE SENSITIVE ELECTRONIC CIRCUITRY, DISCONNECT POWER BEFORE OPENING THE SENSOR. THIS INSTRUMENT CONTAINS CMOS INTEGRATED CIRCUITS AND IS HIGHLY SUSCEPTIBLE TO FAILURE DUE TO ELECTROSTATIC DISCHARGE. EXTRA HANDLING PRECAUTIONS SHOULD BE USED WHEN SERVICING.

Most problems in aquatic instruments can be traced to failures in underwater connectors and cables. Carefully inspect the underwater cable and connector before use and anytime problems occur during use. The best method of inspection is to remove the sensor from the profiling system and test it on a bench.

BENCH TESTING

Set the 2300 sensor on the bench and carefully connect it to a battery or laboratory power supply set for between 5 and 15 VDC (see pin assignments to the right). Check to see if it responds to light using a voltmeter. Next, measure the current drain through the power pinout. Current drain should be measured with the sensor dark (completely covered). Compare this value to the value on your calibration certificate.

Pin 1 is power ground
Pin 2 is signal out
Pin 3 is signal ground
Pin 4 is power +

INSTRUMENT REPAIR

No parts inside the 2300 are actually intended to be user serviceable, as any disturbance or movement of the optical components (held in place by the PC board mounting screws) will almost certainly alter the system calibration. If it becomes necessary to service the instrument in the field, contact the factory for more detailed instructions.

LEAKAGE OR FLOODING: WHAT TO DO

The instrument has been engineered and individually tested to be water-proof to a depth of 1000 meters. Nevertheless, in the event that the instrument leaks, do not panic, the instrument can usually be saved if the proper procedures are followed:

1. Remove the 6 nylon screws and open housing. Save these screws. They are glass-reinforced nylon and ordinary nylon screws are not satisfactory.
2. Remove the two screws retaining the circuit board, and remove the optical components.
3. BRIEFLY rinse with distilled water or equivalent.

4. Rinse briefly with 70-90% ethyl or isopropyl alcohol. Do not use methanol, as it may damage the electronics.
5. Dry, preferably vacuum desiccate (40-50°C for 24 hours is recommended).
6. Carefully package all components and return to manufacturer for inspection and recalibration.

NOTE: Any disassembly of the optical components will change the calibration of the instrument. THE INSTRUMENT SHOULD BE RETURNED TO THE FACTORY FOR RECALIBRATION. For details, see http://www.biospherical.com/BSI%20WWW/Support/Returns.htm.

Biospherical Instruments Inc.
5340 Riley Street
San Diego, CA 92110 USA
VOX: (619) 686-1888
FAX: (619) 686-1887
E-mail: support@biospherical.com