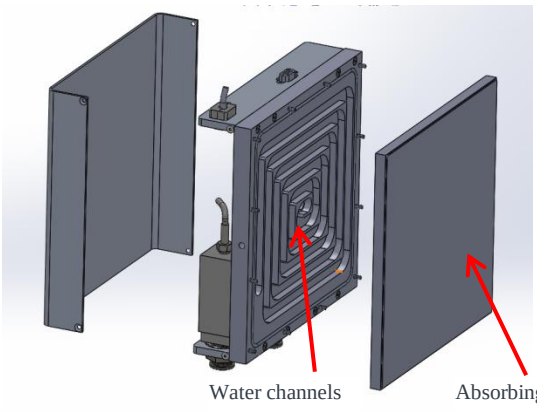
User Notes for
Ophir 6K-W-BB-200x200 Power Meter (P/N 7Z02764)

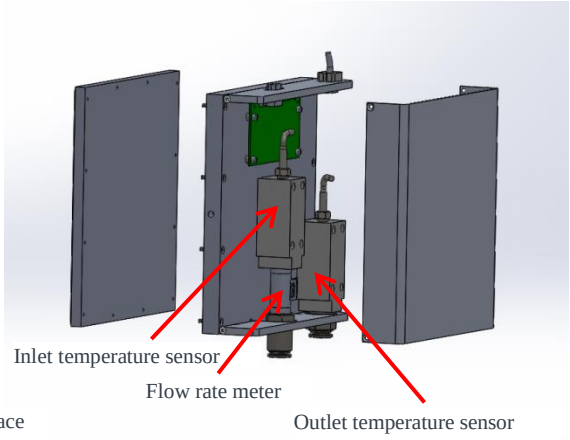
The 6K-W is designed to measure a large laser beams and other light sources of up to 200x200m in size at powers up to 6000W. The broadband absorber surface is flat spectrally so can measure either single wavelength or broadband light sources.

Section 1: Principle of Operation

The 6K-W measures laser power by measuring the difference in temperature between water at the inlet and water at the outlet = ΔT. At the same time, the water flow rate V is measured. The power absorbed is proportional to the ratio $\Delta T/V$ so if we measure these factors, we can determine the power absorbed.



Top view

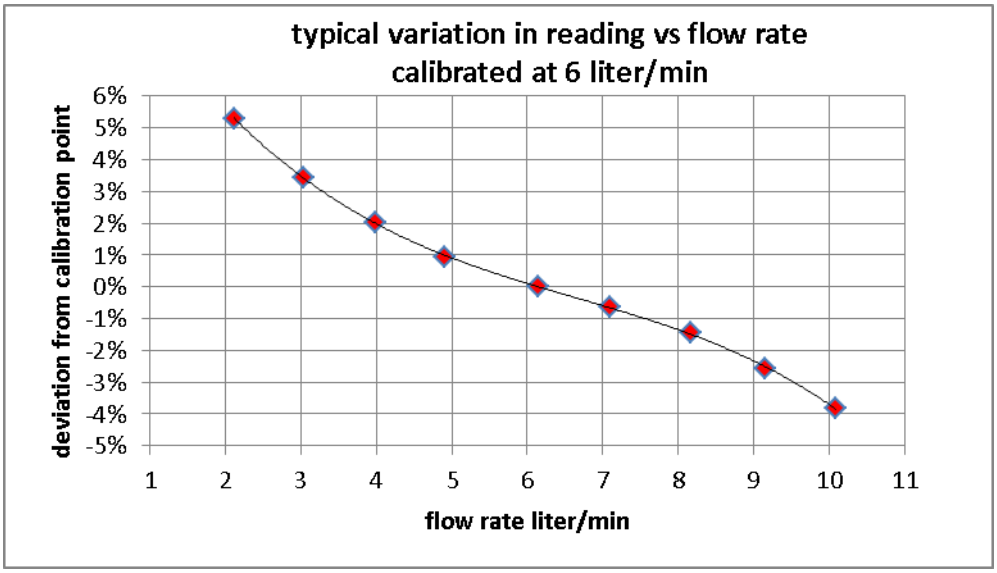


Bottom view

Looking at the top view, the power is absorbed on the absorbing surface and is conducted to the water flowing in the water channels. Looking at the bottom view, the inlet temperature, outlet temperature and water flow rate are measured by the respective sensors and the electronic module uses this information to calculate the power.

Section 2. Water flow conditions

The water flow rate meter has a particular range of flow rates over which it is accurate so the user should stay within these recommended rates in order for the measurement to stay within specification. In particular, the maximum rate should not be exceeded or **damage can occur to the flow meter**. Below we see a typical variation in reading with flow rate. Furthermore, the difference in temperature can only be accurately measured if the water inlet temperature is constant. This means that the best way to measure the power is to flow the water one way from a constant temperature water source and dispose of the exit water. Alternatively, the flow can be in a closed circuit with a chiller as long as the chiller has a carefully regulated water temperature and does not loosely control the temperature by turning on and off. In the latter case the measurement will be jumpy and highly inaccurate. **The water should be filtered using a <50µm filter.**



The sensor has a flow meter located near the input to the water channel.

This flow meter is designed to measure water flow rates of 1 to 10 liters per minute.

Bursts of high velocity or high pressure water or air can damage the flow meter.

The following cautions should always be observed:

1. When starting water flow through the sensor, the flow should be started at a low rate and gradually increased.
   Starting the flow at a high rate and then decreasing it may damage the flow meter.
2. **Pressurized air should not be used to remove water from inside the sensor**. It may damage the flow meter. Water in the sensor should only be removed by tilting and turning the sensor. The sensor is supplied with plastic plugs that close the water inlet and outlet. These plugs should be used when the sensor is being stored or shipped.

Section 3. Operation

The 6K-W-BB-200x200 can operate as a standard Ophir smart sensor with Ophir smart meters or PC interfaces using the DB15 plug. In that case, the sensor gets its power from the interface and nothing further is required. However, in this case, you will not know what the water flow rate is. Therefore, it is recommended, at least for initial setup and operation, to use the RS232 connection and the PC program provided to measure with. This method provides more details including the water flow rate, water temperatures and other information. See below for details on how to operate with the RS232 and PC program.

Operation with the PC program and RS232

1. MAIN WINDOW: After opening the PC program it will identify the attached sensor in the upper left hand side of the window: The screen displays the measured power and standard deviation at the top center. In addition the flow rate and temperatures used to calculate the power are displayed.

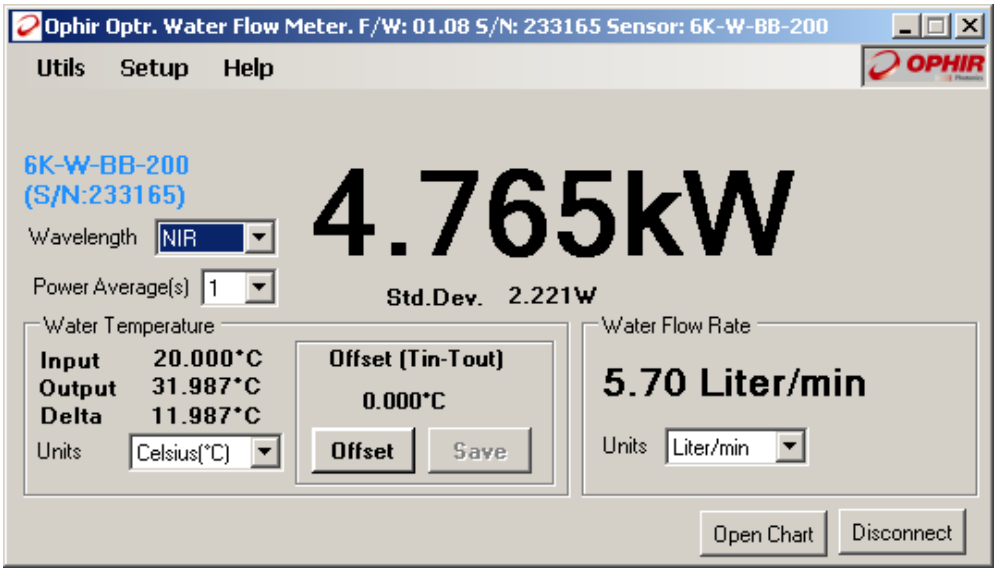


Figure 1 Main Window

Before beginning, the offset should be set to remove any constant temperature difference between the water at the input and output.

2. SETUP WINDOW: Before beginning operation the water flow limits should be specified in the setup window. If the water flow deviates from these critical flow limits an alarm will be shown in the main window, as can be seen in figure 3.

   If a calibration factor needs to be added there is an option of either a Global factor that will affect all wavelength ranges on the sensor or a wavelength range dependent factor.

   In software versions from 1.12 and above there is an additional field for User Tubing parameters – these fields should be zeroed.

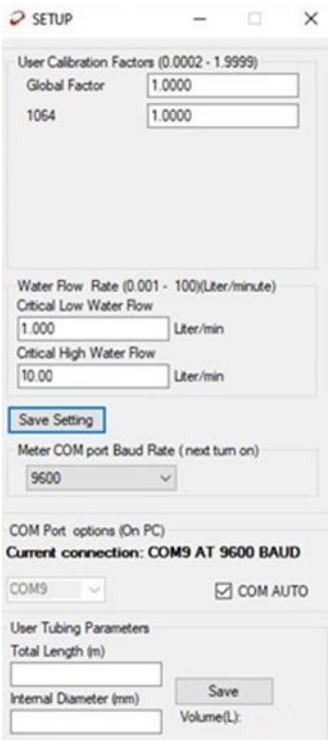


Figure 2 Setup Window

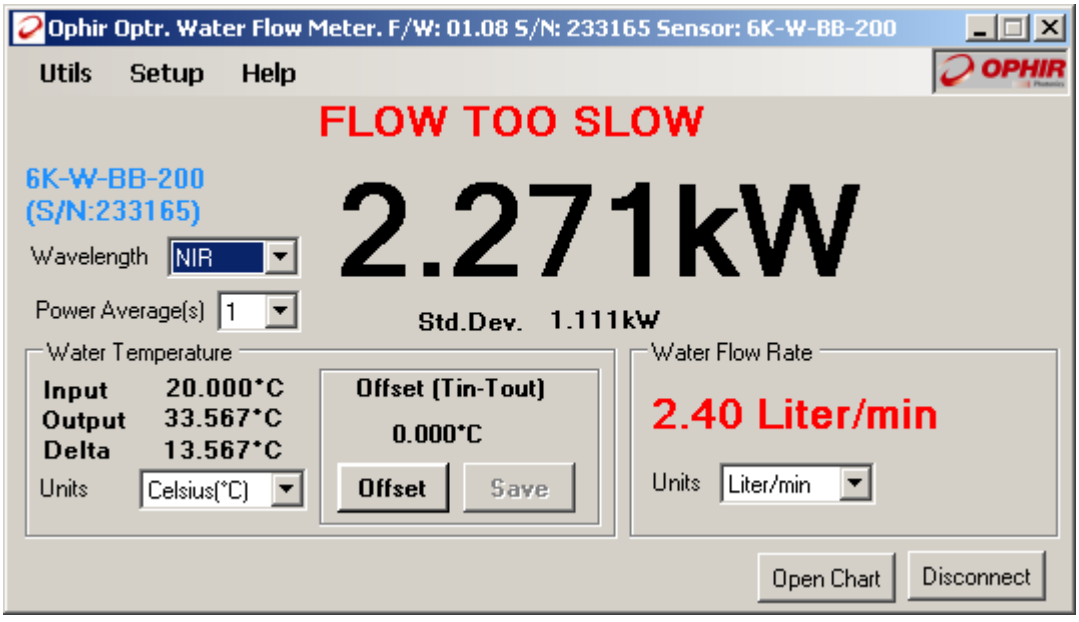


Figure 3 water flow deviation alarm

3. GRAPH WINDOW: It is possible to log and chart the data from all of the input streams over a given time period. By pressing the 'Open Chart' button in the main window will appear which gives a visual view of the power, flow rate and temperature over time. Data is logged to 'WaterFlowMeterApp' f in the 'My documents' folder.

4. Calculator Window: The calculator allows you to test various flow parameters and temperatures in order to determine the expected outcome and set correct water flow rate.

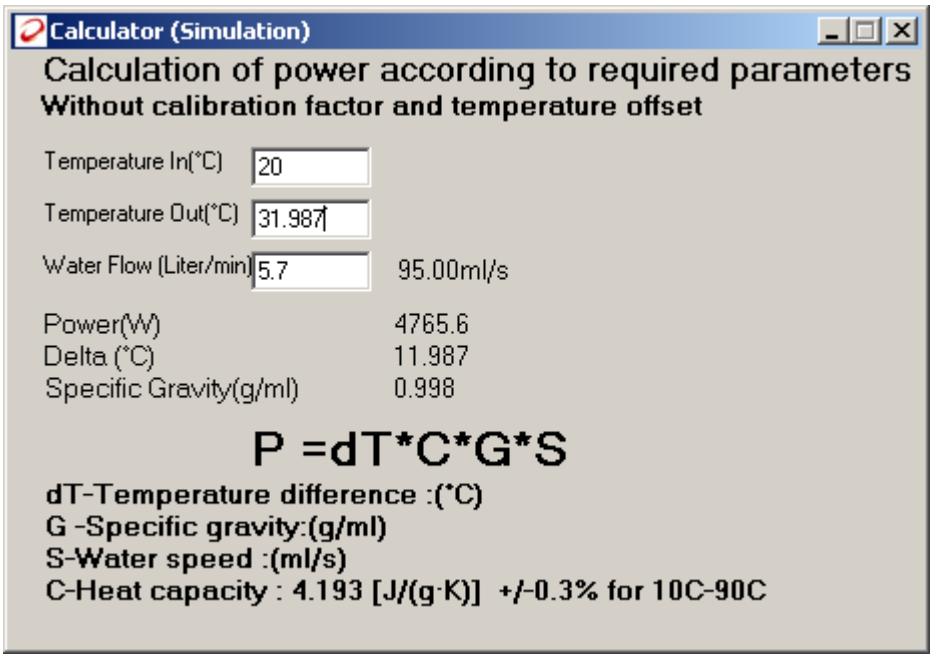


Figure 4 Calculator Window

Section 4: RS232 Commands

4.1 General Information:

All commands are initiated by PC; sensor responds to them ONLY AFTER RECEIVING THE FINAL [CR] symbol
All communications with PC are in ASCII symbols – not binary values
All commands from PC begin with '$' symbol
All commands should end with Carriage Return symbol (#13, 0xD, '[CR]','\r' in "C" language). Adding Line Feed (#10, 0xA, [LF], \n) is optional.
All commands are defined by two ASCII characters that can be lower or upper case
All REPLIES begin with a '*' symbol (for 'OK') or a '?' (for an error) and end with [CR][LF]

4.2 Commands:

Test communications ("Ping"): $HP[CR][LF] -> *[CR][LF] {Checks communications in Winpack}
Send Version: $VE[CR][LF] -> *WM1.23[CR][LF] {Returns software version}
Send Power: $SP[CR][LF] -> *1.23456E5[CR][LF] {Returns power in Watts in E format, up to once a second}
Send Temperature: $ST[CR][LF] -> *24.567 36.789[CR][LF] {Returns temperature of water entering and leaving sensor in Degrees Celsius, once per second}
Send Water Flow: $FV[CR][LF] -> *10.657[CR][LF] {Returns water flow rate in liters/minute, once per second}
Continuous Send: $CS 0[CR][LF] -> 0 | 1 | 2[CR][LF] {Queries present continuous send mode, 0, 1, 2, 3, default at power up is 1}
$CS 1[CR][LF] -> *[CR][LF] {Switches OFF continuous send mode}

$CS 2[CR][LF] -> *[CR][LF] {Switches ON continuous send mode, Power Only Mode. Sensor then begins sending power data once a second for example:

*1.23456E5[CR][LF]

*1.24456E5[CR][LF]

*1.25456E5[CR][LF]

*1.24456E5[CR][LF] }

$CS 3[CR][LF] -> *[CR][LF] {Switches ON continuous send mode, FULL Mode. Sensor then begins sending temperature, water flow and power data (in that order) once a second, for example:

*24.567 36.789 10.657 1.23456E5[CR][LF]

*24.567 36.879 10.657 1.27456E5[CR][LF]

*24.567 36.789 10.657 1.23456E5[CR][LF]

Note: when in continuous send mode, only the $CS 1 command will switch OFF continuous send mode. In this mode, the PC s/w should poll receives continuously after sending the $CS 1 command, to make sure no more data has been sent by the sensor, before sending another command. Otherwise the response to the new command will be confused with the data being continuously sent by the sensor.

Global Calibration factor: $CQ

Queries/Sets Global Calibration Factor.
Query: returns a float number
Set: Uses an integer value (10000 x calibration factor)
$CQ or $CQ 0 – queries present calibration factor
$CQ 0[CR][LF] -> ***1.1121** 1.0000 1.0000 2.3321E-09[CR][LF] (present Calibration Factor is 1.1121, *the other parameters are not relevant*)
$CQ 1 **12345**[CR][LF] -> ***1.2345** 1.0000 1.0000 2.1009E-09[CR][LF] *(sets new Calibration Factor to 1.2345)*
Send $HC to save new parameters into EEROM

Set Tubing Parameters: $PM:

$PM has 2 arguments: Length of Tubing (in mm) and inner diameter of Tubing (in um).
Set the parameters using integers:
$PM 2345 2111[CR][LF] -> * 2345 2111[CR][LF] (sets Length to 2.345m, Diameter to 2.111mm)
Query:
$PM[CR][LF] -> * 2345 2111[CR][LF]

Set/Get Temperature offset $OT:

Sets Temperature Offset (Tout-Tin) in "milli °C" (°C x 1000). This is the difference in temperature reading between the input and output without a laser, with only water flowing. Saved in EEROM using $HC command.
Parameters:
No parameter or 0: Get present temperature offset
2: Set current delta temperature as new offset (automatically measured by sensor)
Query:
$OT[CR][LF] -> *1234 [CR][LF] (meaning 1.234°C)
$OT[CR][LP] *-432[CR][LF] *-432 (meaning -0.432°C)
$OT 2[CR][LF] -> *1234[CR][LF] (measures new value and returns the measured value)

Flow Limits $FL:
Queries or sets lower and upper flow rate limits in Liters per minute for warning levels in GUI. Use $HC command to save.
Set:
$FL 1 10.000 : sets MIN value to 10.000
$FL 2 30.000 : sets MAX value to 30.000
Query:
No parameter: returns values Min, Max in Liter/min with resolution of 1ml/min
$FL[CR][LF] -> 10.000 30.000 [CR][LF]