



Hopper Dredge Instrumentation

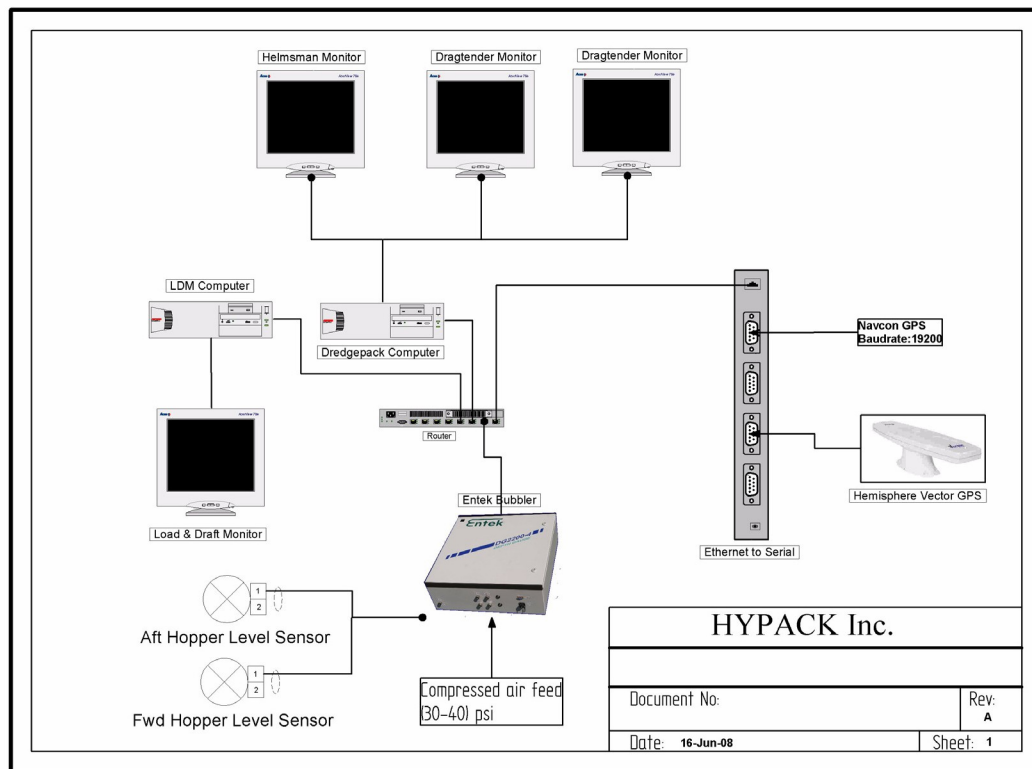
by Christian Shaw

We have installed DREDGEPACK® on a number of dredges and, working together with our suppliers, I think we now have a fairly “standard” configuration that we can use. The advantage of a standard configuration is that it eliminates much of the “guess work” for the installation technician and assures consistent good results in a short period of time.

HARDWARE COMPONENTS

First, we’ll concentrate on the hardware elements that make up the system.

FIGURE 1. Hopper Instrumentation Diagram



COMPUTERS AND MONITORS

We use 2 computers with identical hardware. One of them is dedicated to DREDGEPACK® application while the second is used for the Load and Draft Monitor (LDM) program that is part of the standard DREDGEPACK® suite. There are 3 monitors connected to the

DREDGEPACK® computer: one for the captain/helmsman and two for dredge arm operators. On a dredge with only one arm we would use only two monitors. The LDM monitor shows only the load graph and produces the load reports.

Having two identical computers allows for a backup of the main DREDGEPACK® computer. If the main computer goes down it can easily be replaced with the LDM computer until it can be repaired.

FIGURE 2. Comark Duramobile PC

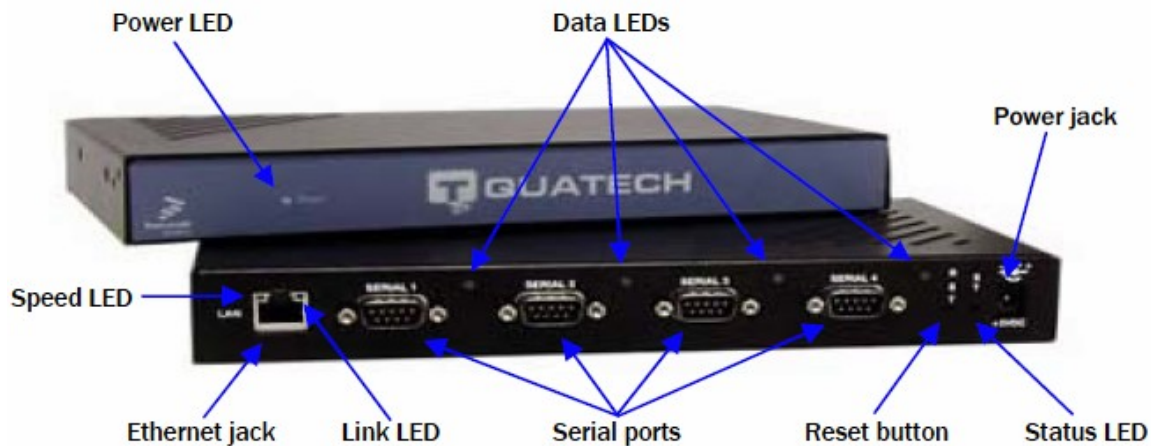
For the computers, we are currently using the Comark Duramobile PC. It is a nice, ruggedized computer that can withstand the harsh marine environment.



SERIAL TO ETHERNET CONVERTER

All serial devices are connected through the serial-to-ethernet converter. Although the computers we are using have 4 serial ports, passing all the data through the network interface makes it easier to replace the computer without worrying about multiple serial port cards and drivers for those. We have successfully used either Qatech units or the Moxxa (more popular in Europe). They are fairly simple to configure through a Web page.

FIGURE 3. Qatech 4-port Serial to Ethernet Converter



The GPS, gyro compass, echosounder and tide receiver can all be connected to a 4-port converter.

BUBBLER SYSTEM

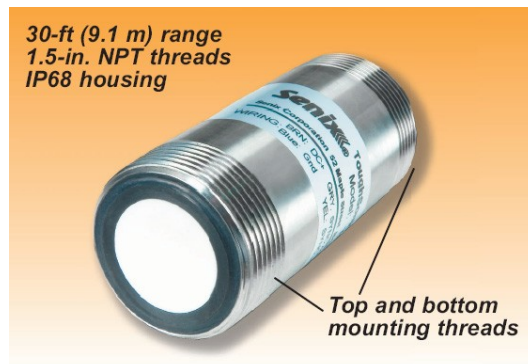
We have worked with Entek, the manufacturer of the bubbler system, to bring in some important changes. The latest bubbler units have a network interface so they plug-in directly into the network hub. Also we have added the ability to integrate other ancillary sensors like the

hopper level sensors. All of this simplifies the general structure of the system because it doesn't require any additional A/D converter boxes.



HOPPER LEVEL SENSORS

We have had good results using ultrasonic sensors from Senix. These are water-proof units that can be easily programmed and calibrated through a single push-button located on the back of the unit. Normally we recommend installing two sensors, one in the front of the hopper and the other aft. This allows the LDM program to calculate an average volume of material in the hopper, but the system can be configured to work with only one sensor if the other breaks down.



OTHER HARDWARE

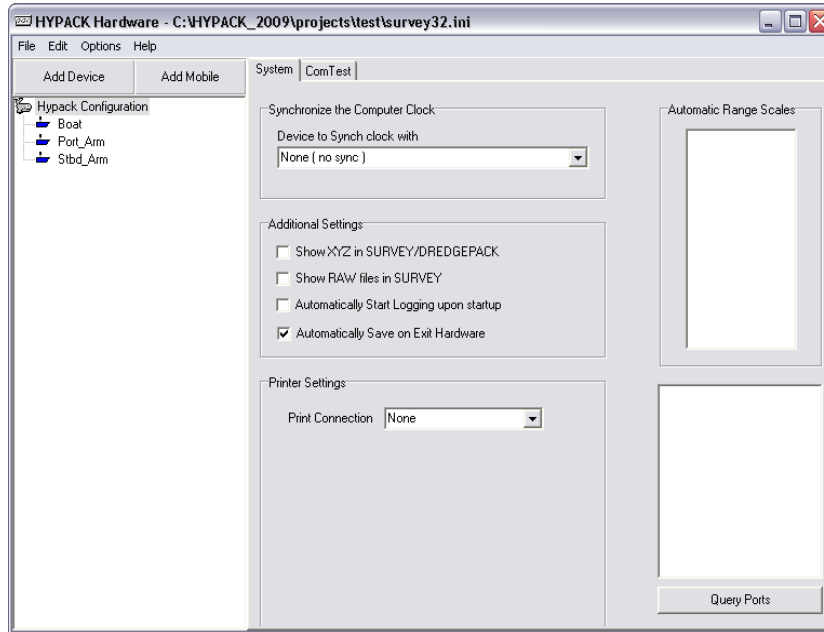
- **A good UPS** is essential for the reliable operation of the system. We recommend a UPS of 1000 VA with enough battery power to run the system for 20-30 minutes.
- **A service arm or a retractable hose reel (dual)** is recommended for passing the bubbler hoses from deck to the drag arms .
- **The pneumatic circuit needs a clean dry air supply of at least 30 psi.** Dry air is important to prevent corrosion of the bubbler sensors and flow regulators.

CONFIGURING THE SYSTEM IN HYPACK HARDWARE

ONE DREDGE, MULTIPLE MOBILES

In the HARDWARE program, we first need to add the different mobiles that will be used. For a dredge with one arm, we need two mobiles: the dredge itself (the default mobile) and the arm. For a dredge with two arms, we would need three mobiles: the dredge and two additional mobiles--one for each arm.

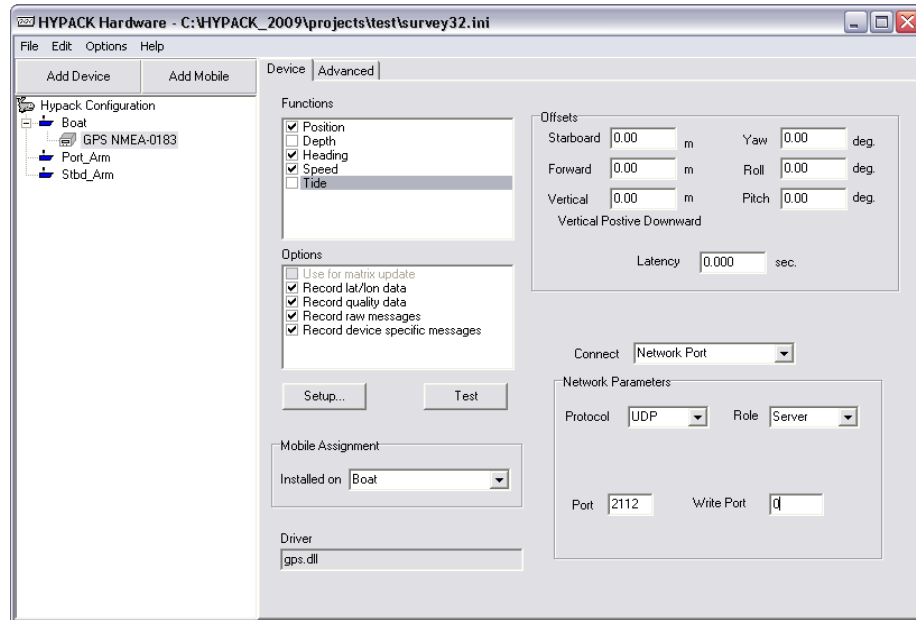
FIGURE 4. Adding Mobiles for a Hopper Dredge with Two Arms



CONFIGURING THE GPS RECEIVER

Starting with the simplest things, let us add the GPS driver and configure it to receive data over the network. (The GPS is connected through an Ethernet to serial converter.):

FIGURE 5. GPS Setup



The important parameters are as follows:

- **Communication Protocol:** UDP
- **Function:** Server - that means the driver will receive data from any device that sends it on this port.
- **Read Port Number:** this is an arbitrary number but we have to remember to configure the same value in the serial to Ethernet converter.

We don't care about the Write Port because DREDGEPACK® is never going to send data to the GPS unit.

THE INTEGRATED HOPPER SYSTEM DRIVER (CATLEYA.DLL)

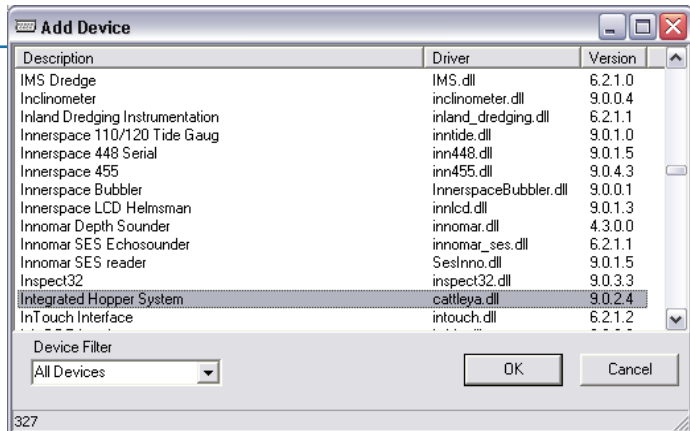
The driver we use is listed as the “Integrated Hopper System” and the library name is cattleya.dll (in reference to dredge were it was first developed).

FIGURE 6. Adding the Catleya Driver

It is a complex driver that serves a multitude of purposes:

- Position and depth calculation for drag arms
- Draft and ullage calculation for hopper
- Communication with the Load and Draft Monitor (LDM) system.

We use the same driver in our hardware configuration twice—once for position and depth of the arm, and once for draft and ullage measurements.

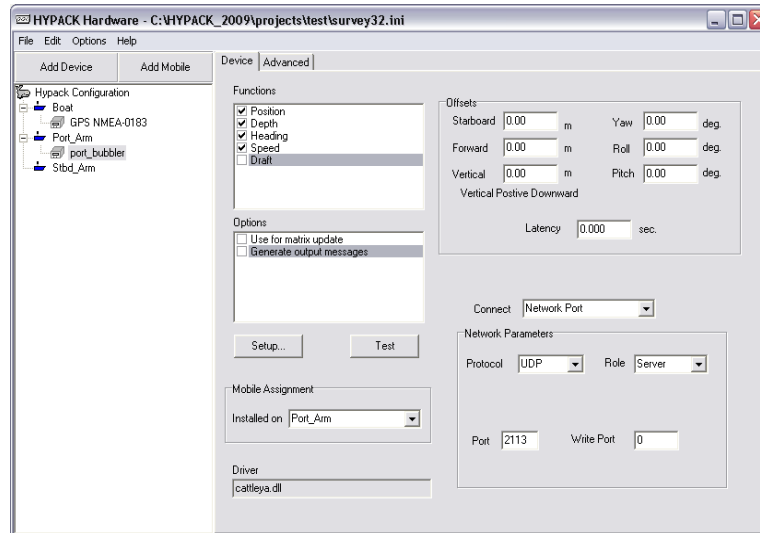


CONFIGURING THE ARM POSITION AND DEPTH

When used for position and depth, we don't need the draft information or the output function (used to communicate with the LDM system), so we have to uncheck these functions.

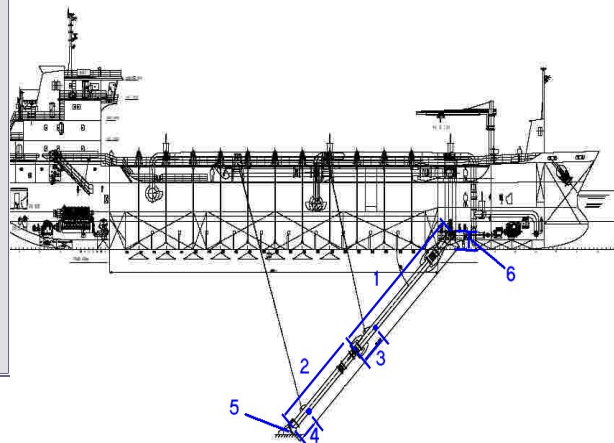
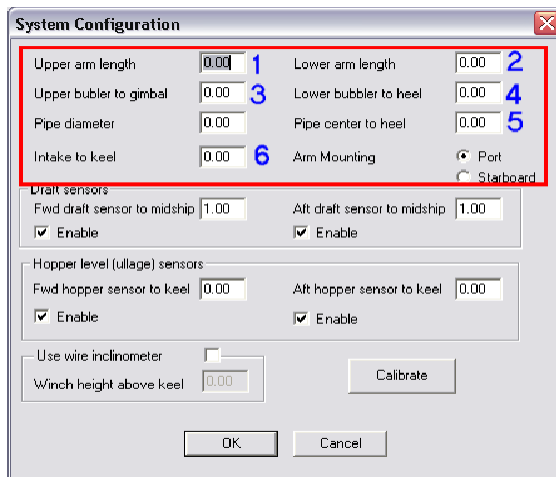
In the network configuration, the read port number must match the one configured in the bubbler system.

FIGURE 7. *Catleya Driver Device Configuration*



The next step is to press [Setup] and enter all the parameters related to arm geometry in the driver configuration dialog box:

FIGURE 8. *Catleya Driver Setup*



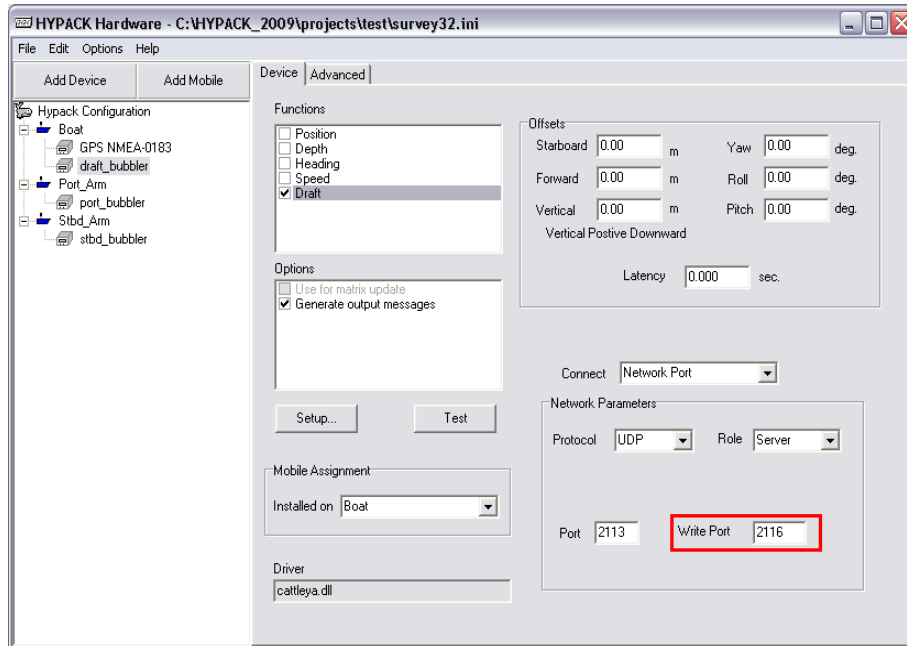
The exact same setup must be repeated for the starboard arm.

HOPPER DRAFT AND ULLAGE

As we said, we use the same driver for the draft and ullage. As the hopper fills, the driver increases the draft and sends the ullage data to the LDM computer.

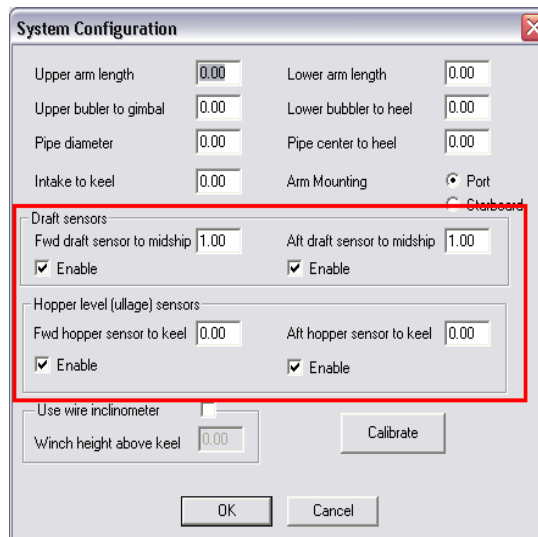
This time we select the Draft and Generate Output Message functions omitted before. We must also configure the write port number because this instance of the driver will send the draft and hopper level values to the LDM program. The default port number for LDM is 2116.

FIGURE 9. *Configuring the Catleya Driver for Draft and Ullage*



In the driver setup dialog box, this time we have far fewer parameters to enter:

FIGURE 10. *Driver Setup for the Catleya.dll Recording Draft and Ullage*



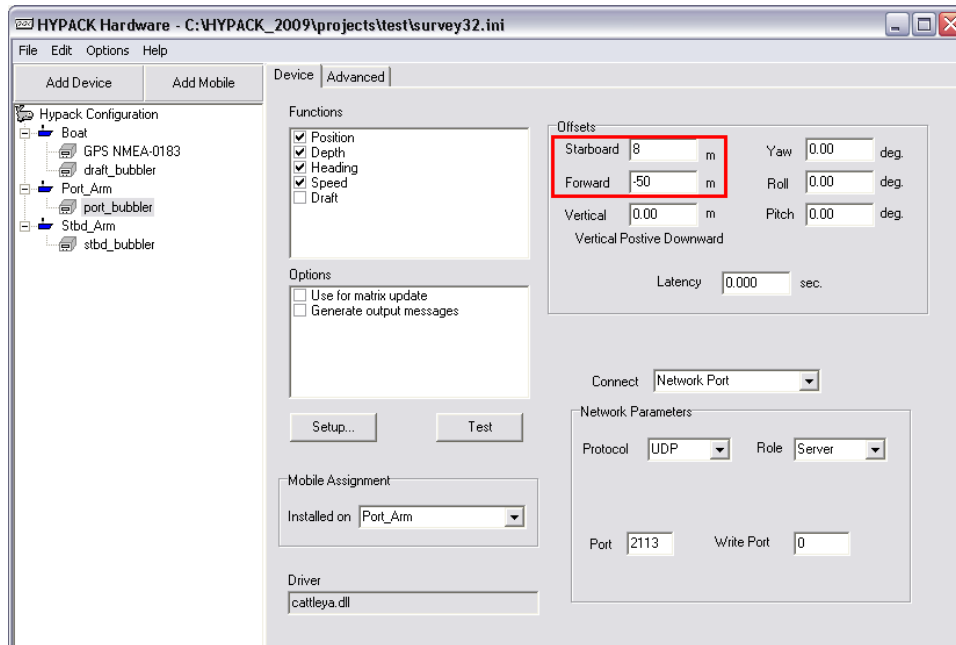
For draft sensors we need their location relative to midship draft scale and for hopper level sensors we need their height above the keel.

OFFSETS

The recommended location for the boat reference point in hopper installations is the stern of the ship on the centerline. More precisely, we like to pick the 0 frame as a reference because

it is easier to figure out the offsets from the boat drawings¹. For drag arms the offsets are the location of the hopper reference point as seen from the arm inlet. Typical settings would be similar to these:

FIGURE 11. Sample Offsets



NOTE: For both arms, the forward offset is negative and the starboard offset is positive for the left (port) arm. The GPS forward offset will probably be a positive number and the starboard offset depends on the antenna location.

This concludes the configuration that has to be done in the HARDWARE program. It is a good idea to summarize the different network parameters we have entered in a table like this:

Unit	IP Address	Port Number
DREDGEPACK® Computer	192.168.1.1	-
LDM computer	192.168.1.2	2116
Serial to Ethernet converter	192.168.1.3	2112 GPS (port 1) 2118 echosounder (port 2) 2119 spare (port 3) 2120 spare (port 4)
Bubbler	192.168.1.4	211

We still have to configure the bubbler unit itself, the Serial-to-Ethernet converter and calibrate the whole system.

1. Ship builders operate with “frames” that are equally spaced. On most drawings you will find the frame scale somewhere under the boat keel and a note defining the frame spacing. Figuring out a longitudinal offset becomes just a question of finding the frame number and multiplying it by the frame spacing.

CONFIGURING THE ENTEK DG2200 DEVICE IN THE ENTEK INTERFACE

After many trials with different bubblers, we have settled for the Entek DG2200 units. These are small, compact units that easily fit on any hopper dredge.

FIGURE 12. Entek DG2200

We've worked together with Entek to replace the serial output with an Ethernet connection and all of the configuration and calibration can be done using your favorite browser (Internet Explorer, Firefox, Chrome, etc.). The electronics board of the bubbler is also used to bring in the signal from hopper level sensors.



One important parameter you need to know is the IP address of the bubbler. The default address is 192.168.1.100, but it can be changed.

1. **Start Internet Explorer and navigate to that IP address** to show a window like [Figure 13](#).

FIGURE 13. Initial Status Page

DG2200

Status
Config
System

STATUS

This screen allows you to monitor all channels of the DG2200 depth gauge. It shows the raw voltage measurements as well as the "scaled" engineering units.

Value is calculated with the following formula:

$$\text{VALUE} = (\text{VOLTAGE} + \text{OFFSET}) * \text{SCALE}$$

Channel	Raw (V)	Value (EU)	Scale Factor	Offset	Filter (K)
1 - Channel	1.71	1.71	1.000	0.000	0.0
2 - Channel	1.71	1.71	1.000	0.000	0.0
3 - Channel	1.71	1.71	1.000	0.000	0.0
4 - Channel	1.71	1.71	1.000	0.000	0.0
5 - Channel	1.71	1.71	1.000	0.000	0.0
6 - Channel	1.71	1.71	1.000	0.000	0.0
7 - Channel	1.71	1.71	1.000	0.000	0.0

This is the status page of the bubbler where one can see the voltage values for each channel.

2. **Set global bubbler parameters** in the System page.

FIGURE 14. Setting Global Parameters in the Entek Bubbler

The screenshot shows a web browser window titled "Change parameters" for an Entek DG2200. The page has a green header with the Entek logo and "DG2200" in the top right. Below the header are tabs for "Status", "Config", and "System" (which is highlighted). A message states: "This screen allows you to change the system settings for the DG2200 gauge. If you change the IP address, you will need to redirect your browser to the new IP address." The main content area is divided into a green sidebar labeled "SYSTEM" and a white configuration area. The configuration area contains four input fields: "IP Address" with the value "192.168.3.101", "Port Number" with "1238", "Number of Channels" with "9", and "Remote IP Address" with "255.255.255.255". A "Change" button is located at the bottom of the configuration area.

The parameters you set here are as follows:

- **IP address** matches the rest of your addresses
- **Port Number** (matches the value configured in the HYPACK® HARDWARE program),
- **Address of the DREDGEPACK® computer:** The remote IP address can be set to 255.255.255.255 and the number of channels used.

Tip: The address of the DREDGEPACK® computer can be left as 255.255.255.255 because this is the broadcast address, meaning that data from the bubbler goes to all computers on the network. You could send it to only one computer by entering its IP address, but there is no benefit to this and you will just have to remember to change it here if you change the IP address of the DREDGEPACK® computer.

- The **Number of Channels** depends on the number of drag arms and whether you have hopper level sensors installed. In the most general case you need:
 - 2 channels for forward and aft draft
 - 2 channels for port arm
 - 2 channels for starboard arm
 - 2 channels for hopper forward and aft hopper level sensors.

3. **Configure each individual channel** in the “Config” page.

FIGURE 15. Sample Config Page

Change parameters

Entek DG2200

Status Config System

This screen allows you to configure the calibration of the channel data. Use the "system" tab to specify the number of channels required.

Value is calculated with the following formula:

$$\text{VALUE} = (\text{VOLTAGE} + \text{OFFSET}) * \text{SCALE}$$

Set the low pass filter time constant (k) as follows:

0 -> No Filter 1 to 1000 -> samples @ 100ms per sample

Channel	Name	Scale	Offset	Filter (k)
- Select -	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Save Changes

The purpose of the scaling factor and offset is to convert from a voltage reading to a real world value.

The pressure transducers convert the pressure of the water column to an electrical signal in the range 4 to 20 mA where the 4 mA value corresponds to atmospheric pressure (0 depth) while 20 mA corresponds to the maximum pressure (30 psi if the transducer is rated for that pressure). This electrical current passes through a 250 ohms resistor. According to Ohm's law, the voltage across the resistor will be between 1V and 5V ($4 \times 0.25 = 1\text{V}$ and $20 \times 0.25 = 5\text{V}$). This is the voltage that is presented on the Status page. If we want to go from this voltage to a depth value, first we calculate that 30 psi corresponds to 21 m of fresh water (or 20.5 m of seawater).

The scale factor:

$$(EU_{\text{max}} - EU_{\text{min}}) / (V_{\text{max}} - V_{\text{min}}) = 21/4 = 5.25$$

The offset:

$$(EU_{\text{min}}/\text{scale}) - V_{\text{min}} = -1$$

The scaling for all channels connected to pressure transducers will be the same. The only exceptions are the channels connected to hopper level sensors.

When all is said and done, the status page should look similar to [Figure 16](#). My electronic board was not connected to pressure transducer; hence, the meaningless readings:

FIGURE 16. Status Page After Configuration

The screenshot shows a web browser window with the URL `http://192.168.3.101/status.shtml`. The page header includes the Entek logo and the model name **DG2200**. There are three tabs: **Status** (selected), **Config**, and **System**. The main content area is titled **STATUS** and contains the following text:

This screen allows you to monitor all channels of the DG2200 depth gauge. It shows the raw voltage measurements as well as the "scaled" engineering units.

Value is calculated with the following formula:

$$\text{VALUE} = (\text{VOLTAGE} + \text{OFFSET}) * \text{SCALE}$$

Channel	Raw (V)	Value (EU)	Scale Factor	Offset	Filter (K)
1 - Aft Draft	1.71	3.73	5.250	-1.000	0.0
2 - Fwd draft	1.71	3.72	5.250	-1.000	0.0
3 - Port trunn.	1.71	3.72	5.250	-1.000	0.0
4 - Port heel	1.71	3.72	5.250	-1.000	0.0
5 - Stbd trunn.	1.71	3.72	5.250	-1.000	0.0
6 - Stbd heel	1.71	3.75	5.250	-1.000	0.0
7 - Hopp fwd	1.71	1.72	1.000	0.000	0.0
8 - Hopp aft	1.71	1.71	1.000	0.000	0.0

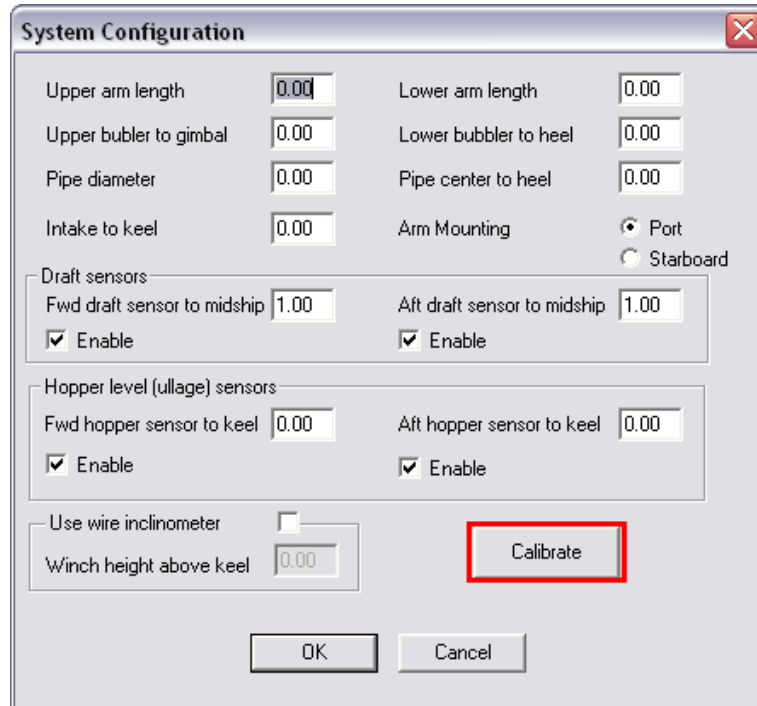
In your case, if all the computations are correct, the EU values should be very close to the actual depth values.

BUBBLER CALIBRATION

It happens that different pressure transducers can give slightly different readings and they can also age over time. We need a method to calibrate transducers and that is the purpose of Calibrate function in the HYPACK® Cattleya driver.

1. In the **HARDWARE** program, configure your Cattleya device driver.
2. Select the Integrated Hopper System and click [Setup].

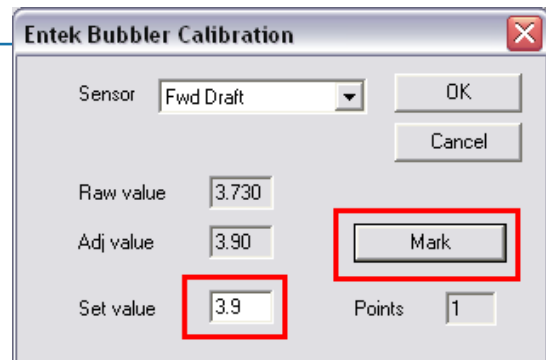
FIGURE 17. Driver Setup Dialog



3. Access the Calibration dialog by clicking [Calibrate]. The dialog shown in [Figure 18](#) shows up:
4. For each individual transducer you want to calibrate do the following:
 - a. Measure the value that you want to calibrate. (In this example, it is the forward draft.)
 - b. Select that value under Sensor.
 - c. Enter the measured value in the Set Value box and click [Mark].

FIGURE 18. Calibrating the Forward Draft

Tip: We recommend at least two calibration points and, if possible the points should span the entire measurement range. For instance, when you calibrate the drag arm sensors you should use a point at the water surface and a second one as deep as possible.



VERIFYING CORRECT VALUES IN DREDGEPACK

After finishing the calibration process, you can verify that DREDGEPACK® shows correct values for draft and drag arm depth.

Some notes about this process:

- The values indicated in DREDGEPACK® for gimbal depth and head depth are corrected for the arm geometry. Meanwhile the value you enter in the calibration dialog is not corrected. So you have to tie your measurement line close to the end of the bubbler hose.
- The calibration in DREDGEPACK® calculates another set of constants like the scale and offset values previously discussed. This correction is applied after the scaling in the bubbler unit (i.e. the “Raw value” in DREDGEPACK® is actually the calculated value coming from bubbler).
- If you use more than 2 calibration points, the program interpolates the best fitting scaling and offset parameters.
- At the end of the calibration, the program generates a calibration report similar to this:

FIGURE 19. *Bubbler Calibration Report 25-Sep-2009*

```
Time: 20:34:49
Fwd Draft Initial values: A= 1 B= 0
No. of calibration points: 1 Final values:
A= 1.00 B= 0.17
Aft Draft Initial values: A= 1.00 B= 0.00
No. of calibration points: 0 Final values:
A= 1.00 B= 0.00
```