Submersible Load Cell Data Logger Manual

Bill DeVoe 11/20/2020
Updates by Marinna Martini April, 2023

Introduction

This instrument takes the output from a four-wire load cell and both logs it to a microSD card and if requested, displays the data to a serial port (USB). It must be calibrated before use.

The electronics are off the shelf: a Sparkfun scale interface and an Adafruit Feather system with an oversized Lithium-ion battery in a Blue Robotics acrylic housing.

The system was first conceived by William DeVoe of the Maine Department of Marine Resources and has been upgraded and repackaged for longer deployment duration by Marinna Martini of the NOAA Northeast Fisheries Science Center.

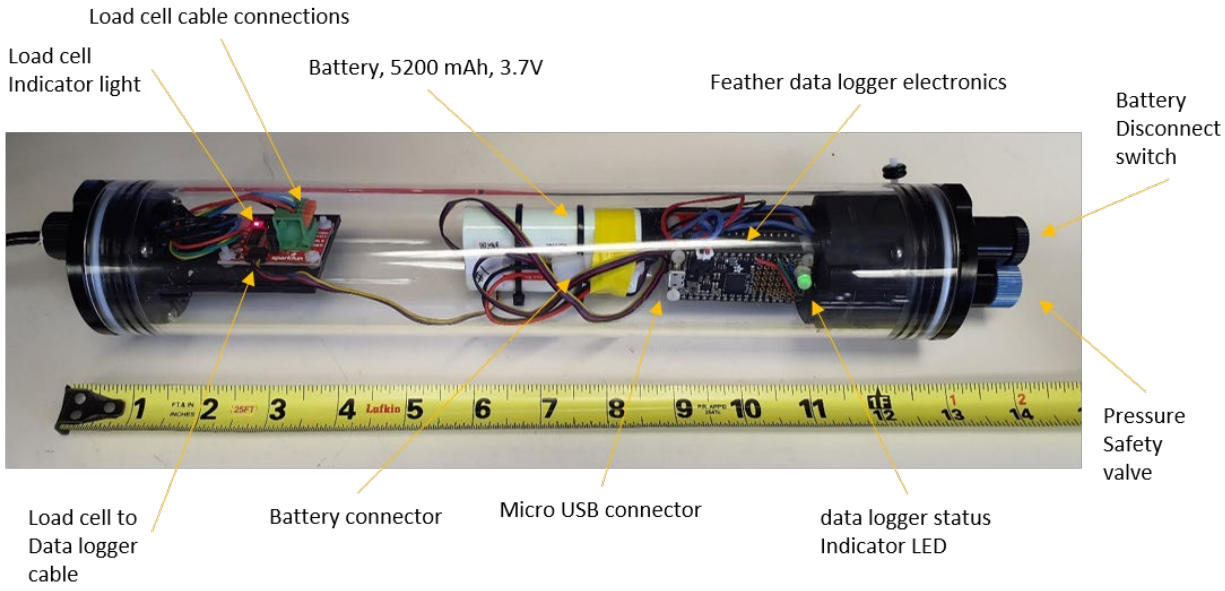

Figure 1: Parts of the load cell logger.

Setup

Load Cell Connection

The load cell should be connected to the green jumper block on the SparkFun Load Cell Amplifier. The jumper block is labeled with standard load cell wire colors; however, the NEFSC submersible load cell uses non-standard colors. The appropriate connections for the NEFSC submersible load cell cable are as follows:

Load Cell Cable	Logger Terminal	Spring Connector Pin	Function
Red	Red	1	Voltage +
Blue	Black	2	Voltage -
Yellow	White	3	Signal +
Green	Green	4	Signal -

There is an additional black wire on the NEFSC load cell that is to the shield of the cable and it goes to YLW/SD, the label for which is inconveniently hidden on the bottom of the board. A black header has been added next to the spring connector. The black “shield” wire gets inserted into the 3rd hole on the header. The third hole should be marked, if not, it is the third hole from the end of the connector closest to the label “Qwiic Scale” on the board. See Figure 2.

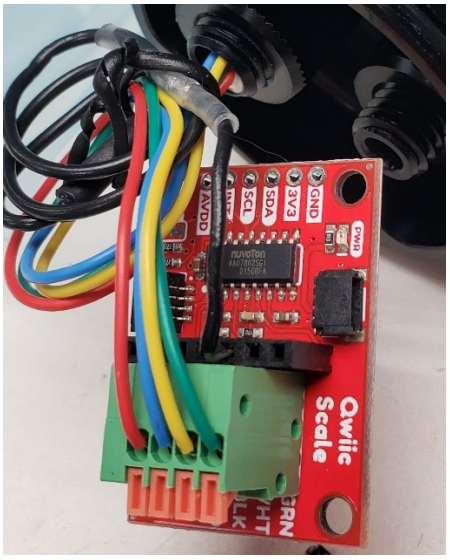

Figure 2: Hook up for the NEFSC load cell.

Power

The logger can be powered by a lithium-ion battery plugged into the battery connection on the top circuit board of the logger (the Feather M0 board). The lower capacity battery can be recharged by connecting a mini-USB cable to the USB connector on the end of the board. Additionally, the logger can be powered by any USB power source connected to this jack, such as a USB power bank. If being charged by the Feather, a red LED on the Feather next to the USB jack will light. It will turn off when the battery is fully charged.

Users have a choice of two batteries to operate the logger. Batteries must be 3.7V:

- Lithium ion rechargeable 2500 mAh, Adafruit part #328, is a small, flat cell that will fit in a smaller housing under the and will last about 2 days. It can be recharged by the Feather, while connected to the Feather and the enclosure end cap switch is turned on.
- Lithium ion rechargeable 5200 mAh, Tenergy part #31001, is an oblong battery pack that requires the larger housing (Figure 1) to accommodate, and will last about 6 days. It is best to use the Tenergy smart charger to recharge these batteries while disconnected from the data logger. The charger is Tenergy model TLP-4000; part #01281.

Memory card

A microSD card formatted to FAT32 should be inserted into the memory card slot on the middle circuit board of the logger. Formatting the card with the official SD association formatter before use (https://www.sdcard.org/downloads/formatter/) is recommended.

The logger is mounted with the memory card abutting the end cap. This is intentional, so that the microSD card is less likely to become unseated. To download files from the card, it is best to use the serial terminal and the file menu. To remove the microSD card, one will need to remove the logger from its mount.

Stored Settings

Logger settings, including load cell calibration, are stored in a text file `config.txt` on the root level of the SD card. This allows settings to be easily transferred between loggers. If this file is absent, the logger will write this file with the default settings, as specified in the header of the logger source code. The `config.txt` file contains the following settings, one per line:

- `echo = 1` - 1 or 0, whether load cell readings should be echoed over the data logger serial ort.
- `log_interval = 250` - The interval in milliseconds between each load cell reading saved to
- the SD card. `sync_interval = 10000` - The interval in milliseconds between data writes to the SD card. Longer intervals
  save on power consumption, but if power is cut to the logger all data since the last write will be lost. This value must be larger than the `log_interval` .
- `cal_factor = 1` - The calibration factor for the load cell. This can be set using a known weight using the
- built-in calibration procedure.
  `zero_factor = 0` - The zero factor for the load cell. This can also be set using the built-in calibration
- procedure.
  `trip_value = 1700` - This value, in calibrated load units, controls the behavior of the RGB LED on the logger board. The RGB LED will indicate when the load cell has reached 50%, 75% and 100% of this value since power up.

Logger Enclosure

The electronics for the enclosure are enclosed in a Blue Robotics Water Tight Enclosure. This enclosure is submersible up to 100m depth. Blue Robotics housing information can be found here: https://bluerobotics.com/store/watertight-enclosures/locking-series/wte-locking-tube-r1-vp/, including assembling and opening these enclosures.

- O-rings on the end caps should be cleaned and inspected, each time the end cap is opened and preferably replaced, for each deployment. These are Dash #030, McMaster part # 9452K117, or Blue Robotics kit https://bluerobotics.com/store/retired/wte2-o-ring-set-r1/. Note this housing does not have a face seal.
- O-rings on the penetrators for the load cell cable, the pressure relief valve and the switch are Dash #013, McMaster part # 9452K57. Blue Robotics also sells packs of these that are blue colored, which is better as it makes it easier to confirm the o-ring is seated properly. https://bluerobotics.com/store/cables-connectors/penetrators/penetrator-o-ring-set-r1/
- The NEFSC version has added the pressure relief valve for safety. Learn about the valve here: https://bluerobotics.com/learn/pressure-relief-valve-installation-and-usage/.
  - On recovery, the safest way to access the housing is to unscrew the relief valve first, and allow pressure to equilibrate. Be sure to check the O-rings and screw it back on before deployment!
  - If there is a vacuum in the housing, or less pressure than outside, the end cap will be very hard to remove. This might happen if the housing was sealed on a warm day and recovered on a cooler day, or never warms up for water temperature.
  - If there is more pressure in the housing than outside, then when the locking thread is removed, the end cap might come flying off, neither good for the person servicing the housing or the electronics. This might happen if the housing is sealed on a cold day and then warmed up.
- All O-rings should be kept greased with a light coating of silicone grease, Molykote 111 compound. Blue Robotics sells packets of this, and it is McMaster #1204K32.

- It is recommended to remove only the endcap with the switch and cable penetrators, and leave the load cell endcap in place.
- Be mindful off the potted connector to the load cell cable, repotting will be necessary if this is damaged.
- Use of desiccant packs as a fail-safe is helpful.
- The enclosure can be pressure-tested by connecting the included vacuum pump to the switch penetrator (remove the knob), negatively pressuring the enclosure, and monitoring the pressure. Blue Robotics has a guide on this here (https://bluerobotics.com/learn/using-the-vacuum-test-plug/). While the pump will not apply enough negative pressure to simulate the maximum depth of 100m, it is helpful for checking for leaks.
- A hand vacuum pump sold by Blue Robotics is here: https://bluerobotics.com/store/watertight-enclosures/enclosure-tools-supplies/vacuum-pump-kit-r2-rp/

RGB LED

A single RGB LED is mounted on the logger base circuit board and is used to convey logger status when the logger is not connected via USB. The RGB LED uses the following color codes:

- `Green` - The logger has successfully powered up, communicated with the load cell, and is writing to the CSV log file.
- `Blue` – The logger battery voltage is less than 3.5 volts:
  - For the small, flat, 2500 mAh battery, this indicates that ~20% of the battery life remains.
  - For the large, 5200 mAh battery, this indicates that ~60% of the battery life remains.
  - Battery voltage is checked each time the SD card is synced (the `sync_interval` setting.).
- `Magenta` - A critical error has occurred and the logger is unable to record data. For more details, connect to the logger over USB to see debugging output.
- `Pale Yellow` - The maximum load on the load cell since power up has been between 50% and 75% of the `trip_value` .
- `Orange` - The maximum load on the load cell since power up has been between 75% and 100% of the `trip_value` .
- `Red` - The maximum load on the load cell since power up has exceeded the `trip_value` .

The LED might turn red if the load cell shackle is dropped or handled. If the RGB turns red while one is preparing for deployment, this can be cleared by turning the power on and off to the logger by using the switch on the end cap. Make sure the LED is green on deployment.

CSV Format

A new CSV file is created each time the logger powers on. CSV filenames are eight characters in length and contain the date followed by a sequential identifier 01-99. The format is therefore `{two-digit year}{zero-padded month}{zero-padded day}{01-99}.csv` . If the logger is powered on more than 99 times in a day, this will likely produce an error. This is a result of SD library used in the logger firmware, which uses DOS 8.3 filenames (eight characters in length maximum).
The produced CSVs contain the following fields:

- `millis` - The number of milliseconds since the logger powered on.
- `time` - The load cell reading timestamp in ISO format, yyyy-MM-ddThh:mm:ss.sZ, where the Z indicates the
- timezone as UTC.
- `raw_load` - The raw load output by the SparkFun Load Cell Amplifier. This is NOT the load cell output in
- mV/V, but rather a unitless value specific to the chipset used. `load` - The calibrated load value - this is a result of solving the line equation using raw load and stored settings, `load = cal_factor * raw_load + zero_offset .`

The Serial Interface

One connects to the Feather logger via the USB connector on the Feather card, see Figure 1.

Selecting a serial interface program

There are two specific operations in using the logger which require certain capabilities in a serial interface. These are the entry of the load when calibrating the load cell and downloading data files over serial. Calibration requires entry of multiple characters on a single line to enter the load on the cell. If you need to download data from the uSD card without removing it, you will need a serial terminal emulation program that will allow logging. For this, the program RealTerm is recommended (https://realterm.sourceforge.io/).

For simple monitoring and one character command operation, PuTTY and Hyperterminal will work. PuTTY is easy to find and download, the old windows hyperterm is no longer supported by windows and download sites might be unreliable. Hilgraeve makes a paid modern version that has not been tested for this use.

Commands can be sent to the logger over the USB interface, using a serial terminal program like PuTTY or the Arduino Serial Monitor. This can be used to debug the logger and change settings (which can also be changed by editing the CONFIG.TXT file.)

Using a serial interface program

Realterm is used here to show how to communicate with the logger via a serial terminal, enter multiple characters (such as when entering the load during calibration) and download data. To connect to the logger, use a serial baud rate of 9600, No parity, 8 data bits, 1 stop bit and No flow control.

The following serial output indicates successful load cell power up:

```
----------------------------------------
     Lobster Endline Tension Meter

Created by Bill DeVoe, MaineDMR
For questions, email william.devoe@maine.gov
----------------------------------------
Init SD card
SD card OK

RTC OK

LC OK

LC 0 offset: 1000
LC cali factor: 0.00

Logging to: 20102202.CSV at 1000ms interval.

Type the following menu commands at any time:
 l - Change logging interval
 s - Change card sync interval
 e - Toggle echo to serial
 z - Get current real-time clock time
 d - Set real-time clock time
 c - Calibrate load cell with known weight
 m - Manually calibrate load cell with known values
 v - Retrieve load cell calibration values
 t - Tare the load cell
 f - Enter the file manager.
Type menu CMD any time.

RGB set to:
0
255
0
```

Once the logger is recording, if `echo to serial` is enabled, each load cell reading will be output to the terminal.

This output is identical to the data written to the CSV file:

```
46292,2020-10-22T12:42:22Z,2101,0.01
47292,2020-10-22T12:42:23Z,2194,0.1
48292,2020-10-22T12:42:24Z,2565,0.5
```

If the last value (the calibrated load) is `inf` or `NaN`, this indicates the cell has not been calibrated.

Menu options are available for multiple functions. In general, guidance on how to use these functions will be printed to the console as they are accessed.

Setting the clock looks like:

```
--- Set RTC ---

Provide a UTC datetime.
Enter year:
Enter month:
Enter day:
Enter hour (24 format):
Enter minute:
Enter second:
Press any key when ready to set time...
283022,2023-05-11T12:16:30Z,-2107,0.00
```

Retrieving load cell calibration values looks like:

```
LC 0 offset: -1047
LC cali factor: 44.00
LC gain: 16
LC trip value: 1700
```

Calibrating, or manually entering the calibration factors looks like:

```
484384,2023-05-11T12:19:51Z,-1831,nan

Are you sure you want to change the calibration? Enter y to continue, any other key to
abort:

Enter the 0 offset:  -1047
Enter the cali factor:  44.50
LC calibrated

LC 0 offset: -1047
LC cali factor: 44.50
LC gain: 16
LC trip value: 1700

507989,2023-05-11T12:20:15Z,-2164,0.00
```

Appendices

Troubleshooting

- Values of 99999 are reported for computed weight: No readings are being obtained from the load cell. Power cycle logger.
- Values of 0 are reported for raw weight: No readings are being obtained from the load cell. Power cycle logger.
- The battery level sense will trigger at 3.5V, turning the LED blue. If the Tenergy high capacity battery is in use, this is at about 60% of capacity.

Realterm

Installing

1. Download Realterm from SourceForge https://sourceforge.net/projects/realterm/
2. Run the installer, admin rights will be needed.
3. Do leave register automation server checked.
4. Realterm will not automatically be added to the start menu. It is installed to the directory C:\Program Files (x86)\BEL\Realterm, so go there and right click on realterm.exe and select “pin to start”. One can always find realterm by typing realterm in the windows search bar.
5. To make start up easier, create a shortcut with the following in the Target box: "C:\Program Files (x86)\BEL\Realterm\realterm.exe" display=1 scrollback=50 baud=9600 flow=0 capdirect capfile=.\capture.txt
6. Put your shortcut in a convenient place where you will also download your data files.
7. Realterm’s documentation can be found here: https://realterm.sourceforge.io/

Running & connecting

1. Plug in the load cell logger with the USB cable (USB A to USB Micro B).
2. Determine which COM port has been assigned by windows to the logger.
    a. Bring up the device manager:
        i. Type devmgmt in the search bar or in a cmd window or
        ii. In windows settings search for device manager
    b. When it warns you you are a standard user, say OK
    c. In the device manager, find “Ports (COM & LPT)
    d. The logger will appear as “USB Serial Device (COMXX). Note the COM number.
    e. If you are not sure – unplug and replug the logger, observing which port disappears and reappears in the device manager
3. Run realterm.
4. In the Display tab, it is important that these things are set (should be automatic if your shortcut is set up):
    a. Display as: Ansi
    b. Rows:10
    c. Scroll Back: ticked
5. In the Port tab, it is important that these things are set (should be automatic if your shortcut is set up):
    a. Baud: 9600
    b. Port to the port you determined earlier (may look like “15 = \USBSER000”)
    c. Click on change to apply the new settings

Interacting with the logger

- You can enter single character commands by clicking in the terminal window and typing the character. A good test is the “e” command, which will turn the data echo on or off. Sometimes it will take a few tries to slip a character into the busy logger between readings.

Downloading files with realterm

1. It is helpful to have the file folder to which you will capture data files open.
2. In the terminal window, enter f and get to the file menu
3. In the terminal window, enter l to list files, note the name of the file you want to download
4. In the file window, enter t to transfer, you should see “Enter FN:”
5. Go to the Capture tab
    a. File: Enter the path and file name, or “…” browse to a directory
    b. Click “start overwrite” or “start append”
    c. Do not untick direct capture to make sure all data is transmitted
6. Go to the send tab
    a. Type in the file name, which is typically YYMMDDXX.CSV
    b. Click “send ASCII”
    c. Watch the animation in the upper left corner of reaterm’s window, a red square orbiting the terminal icon. This means data is transmitting even if it doesn’t appear on the screen.
7. Wait for the animation or data scrolling to stop.
8. Back at the capture tab, stop capture

9. Check the file folder, did the data arrive intact? Inspect the file, does it start with

```
FILE: 23041201.CSV

File dump from 23041201.CSV

---------------------------

millis,time,raw_load,load
```

```
---------------------------

Done!
```

10. Does it end with:
11. Does the file name in the header match the file name of your captured file?
12. Are there gaps (empty lines) in the data or truncated lines?
13. There might be some extra text from your session. This can be deleted.
14. For more files, repeat steps 3-10
15. When done, select the file option x to exit the file manager

Jupyter

Install Anaconda's miniconda. Either Anaconda or miniconda will install Jupyter.
Jupyter is run by starting an anaconda prompt window and typing "jupyter lab".
There is a trick to starting Jupyter Lab where you want. If Jupyter Lab is started from a directory on drive C, you can't get to drive D, where our ITD likes to put all our project files.

- Open cmd (or Anaconda Prompt) and run jupyter notebook --generate-config. This writes a file to C:\Users\username\.jupyter\jupyter_lab_config.py.
- Browse to the file location and open it in an Editor
- Search for the following line in the file:
  # c.ServerApp.notebook_dir = ''
- Replace with:
  c.ServerApp.notebook_dir = 'D:/MyDirectory/Ropeless/LoadCellLogger/Code/'
- Make sure you use forward slashes in your path and use /home/user/ instead of ~/ for your home directory, backslashes could be used if placed in double quotes even if folder name contains spaces as such : "D:\yourUserName\Any Folder\More Folders\"
- Remove the # at the beginning of the line to allow the line to execute