

Technical Note

Using Linear Average Logging with a Level TROLL® 700 or Aqua TROLL® 200 Data Logger

Introduction

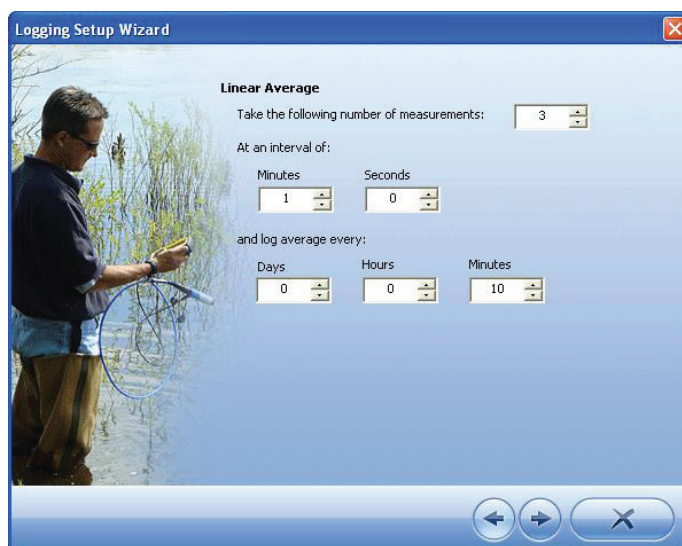
Both the Level TROLL 700 and the Aqua TROLL 200 provide a logging method known as “Linear Averaging.” This method is useful to capture data trends in long-term studies by smoothing out high and low anomalies. Such applications include wave monitoring, tidal monitoring, reservoir elevation monitoring, and turbulent stream flow elevation monitoring. This technical note will discuss:

- How Linear Averaging works
- Possible rounding effects to the time stamps
- Advantages of a Level TROLL 700 and an Aqua TROLL 200 in different applications
- Battery life implications of Linear Averaging
- An example: How the U.S. Naval Oceanographic Office uses Level TROLL 700s to characterize tides

Note: This technical note pertains to Level TROLL 700 firmware 2.07 or higher and Aqua TROLL 200 firmware 1.13 or higher.

Linear Averaging

Linear Averaging works by taking a user-requested number of measurements at a user-specified interval, averaging the measurements, and logging the average to the data logger at a user-specified frequency. The software screen for user input is shown below, followed by a discussion of the individual inputs.

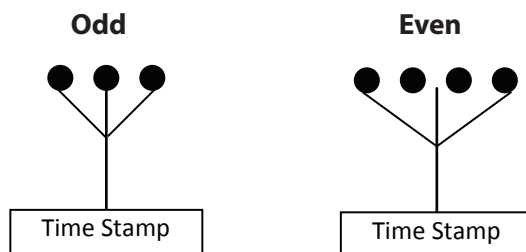


Number of Measurements

The number of measurements that will be averaged:

- Minimum: 2
- Maximum: 600

For an **odd** number of measurements, the time stamp will coincide with the middle measurement within the number of samples. For an **even** number of measurements, the measurement intervals will be evenly spaced on either side of the time stamp. This is visually shown below.



Measurement Interval

How far apart the measurements are:

- Minimum: 1 second
- Maximum: 6 minutes

Logging Interval

How often the average of the measurements is recorded (logged) to the logger's memory:

- Minimum: 1 minute
- Maximum: 40 days

Valid Input Values

When setting up a Linear Average Log, these conditions must be met:

- The input values must be within the maximum and minimum constraints listed above
- The logging interval must be equal to or greater than the measurement interval times the number of measurements. In the example shown on page 1, 3 measurements x 1 minute = 3 minutes. The software will issue an error message if the user attempts to set a logging interval of less than 3 minutes.

Start Time and Time Stamp

When programming a Linear Average Log, a manual or scheduled start can be selected. A **manual start** will initiate the sample measurement immediately and store the first averaged data point based on the input values.

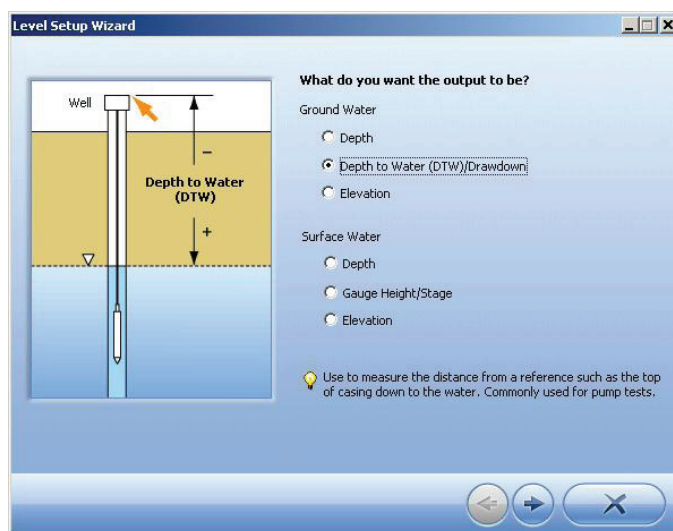
A **scheduled start** works differently. The scheduled start time is the time stamp value that will initiate the recording interval, and it will be the first time stamp value in the report. Therefore, the actual start time, calculated by the software, will be at an earlier time than the time the user entered for the "scheduled start." For example, a Linear Average Log is programmed to take 3 measurements at 1 minute intervals with a scheduled start of 12:00:00 PM. The Log would actually start at 11:59:00 AM taking the first measured value, and Win-Situ® 5 Software would display this scheduled start time in the software before the Log starts. Then the next two readings would be taken at 12:00:00 PM and 12:01:00 PM. These three measured values would be averaged and logged with a time stamp of 12:00:00 PM.

When the Logging Interval is in **minutes** and a scheduled start is selected, the time stamps will be based on the entered "scheduled start" time with no rounding effects.

When the Logging Interval is in **seconds** and a scheduled start is selected, there may be some rounding effects to the time stamp depending on the number of measurements and sample interval. For example, a Linear Average Log is programmed to take 4 measurements at 1 second intervals with a scheduled start of 12:00:00 PM. In theory, the sample interval would start in the milliseconds at 11:59:58:500, but this is beyond the capability of the data logger. Additionally, Win-Situ 5 would display a scheduled start time of 11:59:59 AM. Therefore, the first logged reading after averaging the 4 measured readings would be 12:00:01 PM instead of 12:00:00 PM, and the rest of the time stamps will have hh:mm:01 time stamps.

Level TROLL 700 versus Aqua TROLL 200

The **Level TROLL 700** is a smart sensor that logs Pressure and Temperature, and it can log one of three derived Level parameters based on Pressure and Specific Gravity. The three derived Level parameters are Depth, Surface Elevation, and Depth to Water (see below). The Win-Situ 5 Software Help section "About Logging Level" goes into more detail on the differences between these three parameters.



The **Aqua TROLL 200** is a smart sensor that logs Pressure, Temperature, and Actual Conductivity. Like the Level TROLL 700, it can calculate Depth, Surface Elevation, or Depth to Water from Pressure and a fixed Specific Gravity value. In addition, since the Aqua TROLL 200 can measure conductivity, Specific Gravity

can be calculated by means of a “dynamic density” function that uses conductivity readings to determine water density. This can improve the accuracy of Level when the Specific Gravity (density) of water fluctuates over time. Moreover, additional parameters can be derived from Actual Conductivity: specific conductivity, salinity, total dissolved solids, resistivity, and water density. More information on these functions can be found in these In-Situ technical notes: *Aqua TROLL 200 Measurement Methodology and Dynamic Density Correction with the Aqua TROLL 200*.

Level monitoring with the **Level TROLL 700** using Linear Average logging is best used in applications where Specific Gravity is not likely to change. These applications include wave monitoring in oceans or large lakes, reservoir level monitoring, and turbulent stream level monitoring where the Specific Gravity is constant.

The **Aqua TROLL 200** is best used for Level monitoring where the Specific Gravity of the water may change (for example, due to tides or the fresh water-brackish water interface in estuaries) or when conductivity is also a desired parameter. The Aqua TROLL 200 is best used in Linear Average mode when monitoring Level in a tidal estuary.

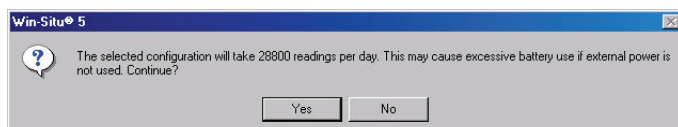
Power Implications

Typical battery life for both the Level TROLL 700 and the Aqua TROLL 200 is shown in the following table:

Data Logger	Battery lifetime, typical	Data records*	Deployment temperature
Level TROLL 700	10 years	260,000	-20 to 80° C
Aqua TROLL 200	5 years	190,000	-20 to 80° C

* Data records include the measured values that are averaged but not shown in the data log.

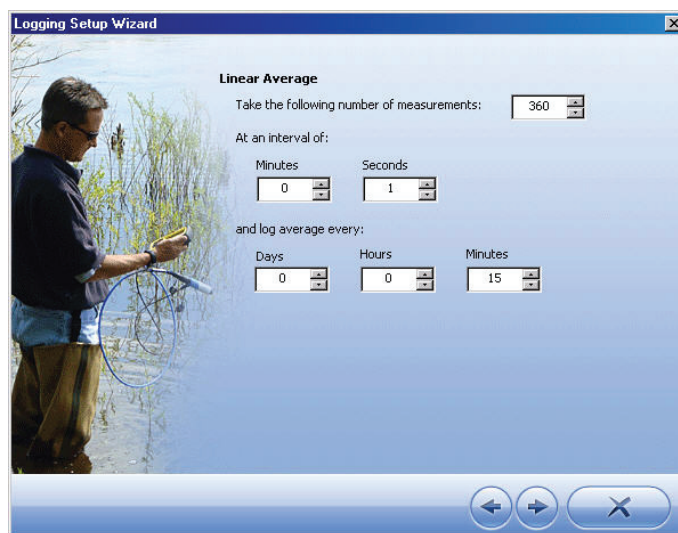
Both devices can collect data using the Linear Averaging logging method without the need for external power. However, the software may issue a warning during programming that battery power will be consumed quickly if the user-specified sampling rate is very high. An example of the warning is shown below:



If such a warning appears, In-Situ Inc. strongly recommends that the sampling rate be adjusted or that external power be supplied to the data logger. In locations where external power is not available, external power options are available from In-Situ Inc.

Naval Oceanographic Office Usage

The U.S. Naval Oceanographic Office uses Level TROLL 700 absolute/non-vented and gauged/vented sensors to characterize tides around the world using the Linear Average logging method. The Naval Oceanographic Office protocol requires the devices to take measurements at 1-second intervals for 6 minutes, average the measurements and log the average every 15 minutes. The screen below shows how the inputs would be entered into the software to achieve this result (6 minutes x 60 measurements per minute = 360 measurements):



The logs use a scheduled start. Since the desired logging interval is in seconds, the data will experience the rounding effects to the time stamp: For example, if the user-entered scheduled start time is 12:00:00 PM., the start time calculated by the software would be 11:57:01 AM, and the time stamp in the first reading in the report will be 12:00:01 PM.

The Naval Oceanographic Office has been using the Level TROLL 700 in characterizing tides since 2006. They deploy the devices for 45-60 days at a time in order to capture a full lunar cycle of tidal effects.

Conclusion

The Linear Average logging method, available in the Level TROLL 700 and Aqua TROLL 200, is valuable in applications where detection of trends is more important than instantaneous individual readings. The best example of the need for Linear Average mode is to capture Level data in tidal monitoring projects.

However, Linear Averaging typically requires quick sample measurements over a long period of time to average the data set to one value. Each measurement consumes battery power even though these readings are not shown in the data report. As a result, Linear Average has the possibility of depleting the internal battery, quickly reaching the typical data records of the data logger if external power is not used. The addition of external power is strongly recommended if a Linear Average log has been set to measure values at a rapid rate.

When Linear Average mode is needed, always consider the location where the data logger will be deployed. Consider if the Specific Gravity will be constant or if there is a possibility it will change given your project conditions. This will help determine which data logger should be used, Level TROLL 700 or Aqua TROLL 200.

Finally, check the firmware on older data loggers to be sure the firmware is up to date in order for Linear Average to work as described in this technical note.



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