Lowell Instruments

Application Note #TCMA

Deploying the TCM-1 Tilt Current Meter in an Inverted (Hanging) Orientation

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1 Introduction

The TCM-1 Tilt Current Meter (TCM) is typically mounted in a vertical orientation where the meter is anchored on (or near) the sea bed and the meter floats above the anchor. But for some deployments, it is advantageous to measure water velocity near the top of the water column in an inverted orientation with the meter hanging below the attachment point. This application note describes how to use the TCM in an inverted orientation and includes recommendations on site selection, data logger configuration, anchoring techniques and data post-processing.

2 Requirements

The following items are required to use the TCM-1 in an inverted orientation:

- TCM-1 Current Meter consisting of:
  - MAT-1 Data Logger
  - 46 cm (18”) float
  - Nose cone with lanyard
  - 1 x Ballast Washer
- TCM-1 Inversion Kit consisting of:
  - 2 x Silicon Bronze TCM Ballast Washer Range Weights
  - 1 x 5/16-18 by 1-1/4 inch long silicon bronze hex head cap screw
- Windows PC with MAT Logger Commander Software
- USB A to micro-B cable (not shown)

3 TCM Theory

Tilt Current Meters operate based on the drag-tilt principle. The meter is tethered to a fixed point and the instrument floats (or sinks) vertically when there is no flow and tilts as water velocity increases. The direction of flow is determined by the direction of tilt.

Modern TCMs use three-axis accelerometers to determine the angle of tilt and 3-axis magnetometers to determine the direction of tilt. An important assumption is that the tilt measurement is determined in quasi-static conditions (i.e. the meter is not accelerating). TCMs typically oscillate between 0.25 and 0.5 Hz due to vortex shedding. This relatively low-frequency oscillation is averaged out of the raw data by sampling above the Nyquist frequency (twice the oscillation frequency). Likewise, the effect of swells can be filtered by increasing the averaging period to at least double the swell period. But movement and vibration of the anchor point, especially above the sampling frequency, adds error that is difficult to eliminate. Therefore, care must be taken when selecting a site for a top-mounted TCM to reduce or eliminate motion/oscillations/vibrations at the anchor point.

4 Site Selection

There are several factors that should be considered when selecting a site for a TCM.

Water Velocity: The TCM-1 is recommended for sites with water speeds of 0-80 cm/s. The meter saturates at 120 cm/s. Accuracy between 80 and 120 cm/s is not specified.

Waves: The TCM is designed for sites with low wave energy. Avoid sites with breaking waves as the rapid acceleration of the TCM will break the quasi-static assumption and will add error to the measurements. Waves are even more of a concern for meters deployed near the surface. Even when oversampling and filtering are used, the meter will be more accurate in relatively protected

environments, such as protected harbors and coves, or deployed at least twice the wave height below the surface.

Anchor Point: The ideal anchor point is a fixed structure because it will eliminate the possibility of movement of the anchor point. But fixed structures are often not available, so the next best attachment point is a large floating dock, fish pen or other anchored floating structure. Small floats and buoys should be avoided because they are much more likely to move/oscillate/sway due to wind, waves and currents.

5 Meter Assembly

To assemble the TCM-1, screw the MAT-1 Data Logger into the threaded end of the float until tight. A firm grip is sufficient. Attach the three ballast washers to the end of the float using the bronze cap screw. Do not overtighten.

Use a firm grip and screw the logger all the way onto the threaded bronze stud until tight.

Use 1/2 inch wrench. Do not overtighten.

6 Meter Configuration

The “brains” of the TCM-1 is the MAT-1 data logger. The MAT-1 has the ability to use a “burst mode” recording interval (see Figure 1). This note highlights the three “burst mode” parameters that are stored in the MAT.cfg file and are used to configure the TCM for a range of environments. (For complete operating instructions see the MAT-1 & TCM-x Universal User Guide.)

Burst Logging allows the logger to alternate between rapid sampling and sleep mode. Burst Logging allows for accurate measurements while conserving battery life. For example, a typical configuration would have the meter wake up every minute, record at 8 Hz for 15 seconds and then sleep for 45 seconds. The result of this setup would be 120 samples recorded every minute. After the deployment is complete, the 120 samples will be post processed into 1 minute velocity records. Thus, in this example, each velocity measurement is an average of 120 samples taken over a 15 second period.

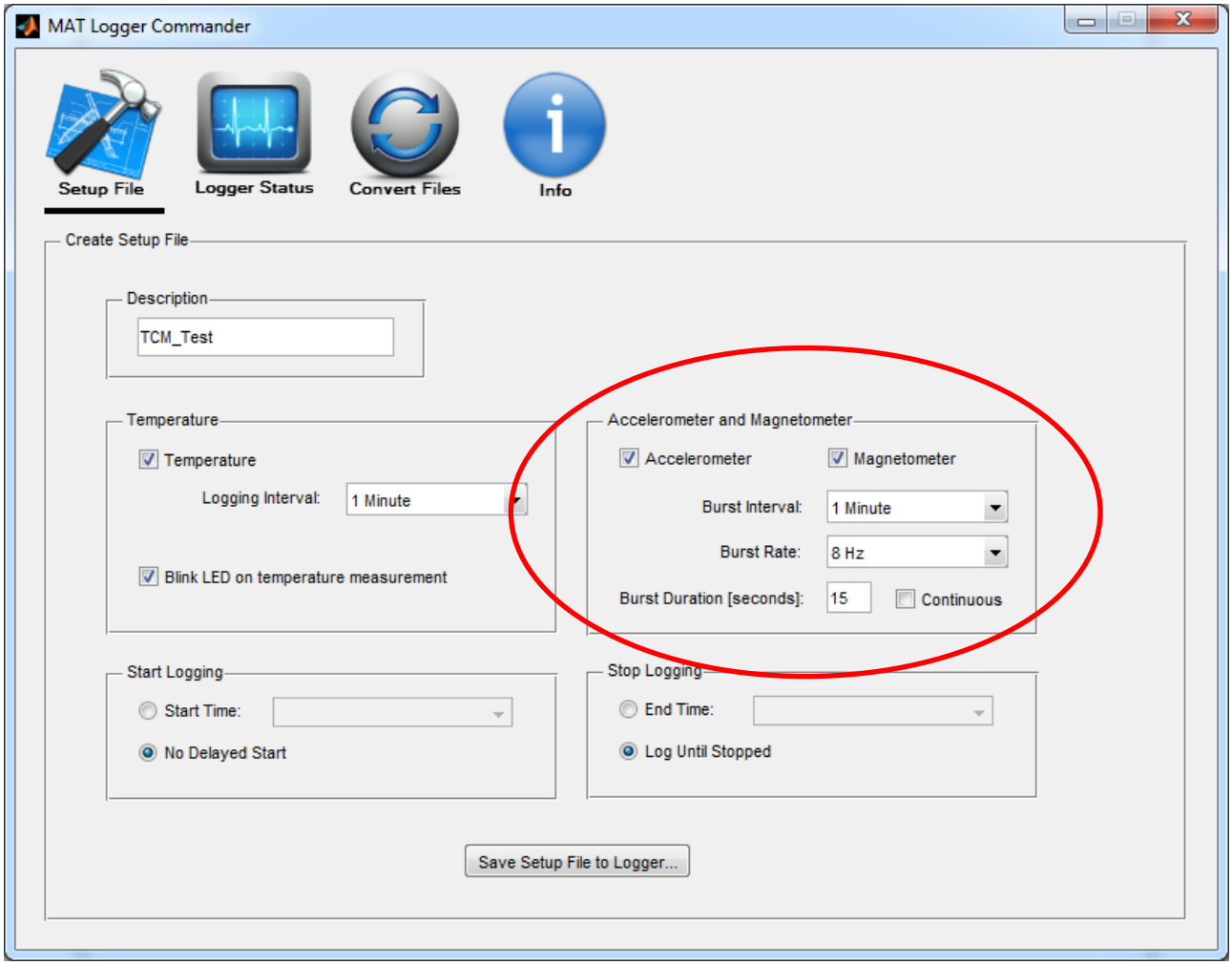

Figure 1: Typical settings for a TCM deployment. The burst mode parameters are circled.

Burst Interval: This parameter sets the measurement interval. Each current measurement is comprised of a series (or a “burst”) of measurements. The Burst Interval is the length of time between the start of

any two intervals. Typically, the Burst Interval is set between 1 and 5 minutes, providing high temporal resolution data that can be post-processed into longer intervals if desired.

Burst Rate: This parameter sets the rate at which samples are recorded during the "burst". Even in ideal conditions, the meter oscillates with a period of 2-4 seconds. Thus to record the average tilt and bearing more than one measurement is required. The minimum recommended burst rate is 4 Hz, with 8 Hz typical. 16 Hz is recommended for more energetic environments with waves.

Burst Duration: This parameter sets the length of time that the accelerometer and magnetometer sample at the burst rate. To obtain an accurate average, the burst duration should be at least twice the period of any oscillation in the system. As previously mentioned, the TCM oscillates with a period of 2-4 seconds. The recommended minimum burst duration is 10 seconds, with 15 seconds more typical. If there is a dominant swell, the burst duration should be increased to 30-60 seconds depending on the swell period.

Note that all three of these settings impact battery life. The MAT-1 will run for many months with typical settings before battery failure (memory is never the limiting factor). However, running continuously at the maximum rate will reduce the battery life to as little as 6 weeks. See the Universal User Guide for more information on battery life. Three sets of recommended settings are shown in the table 1 below.

Table 1: Recommended settings for TCM-1 deployments in three typical environments.

Configuration	Burst Interval (s)	Burst Rate (Hz)	Burst Duration (s)	Notes
Typical	60	8	15	Suitable for most environments with limited swells. Battery life: 12-14 months
Swells	120	8	45	Increased burst duration for filtering long-period swells. Battery life 10-12 months.
Waves & Turbulence	60	16	30	Increased burst rate and duration for filtering moderate swells and wave induced turbulence. Battery life 5-6 months.

7 Mounting the Meter

The TCM is supplied with a flexible lanyard for mounting to an anchor or other hard point. There are many ways to mount the meter but there are several factors that will improve the quality and accuracy of the data.

- Mount the lanyard in such a way that the lanyard length does not change based on the direction of pull. This is typically done by drilling a hole through the anchor and knotting the lanyard on the back side (see Figures 2A, 2B and 3A, 3B, 3C).
- Limit the lanyard to 2 cm (3/4 inch) or less (see Figure 2B). The lanyard should only be long enough to allow for full range of motion. Long lanyards may result in the meter oscillating, bumping into the anchor or even moving into the "wake shadow" of the attachment point.
- If the TCM will be mounted on a floating dock, mount the meter towards the middle of dock to minimize motion from waves and dock loading (Figure 4).

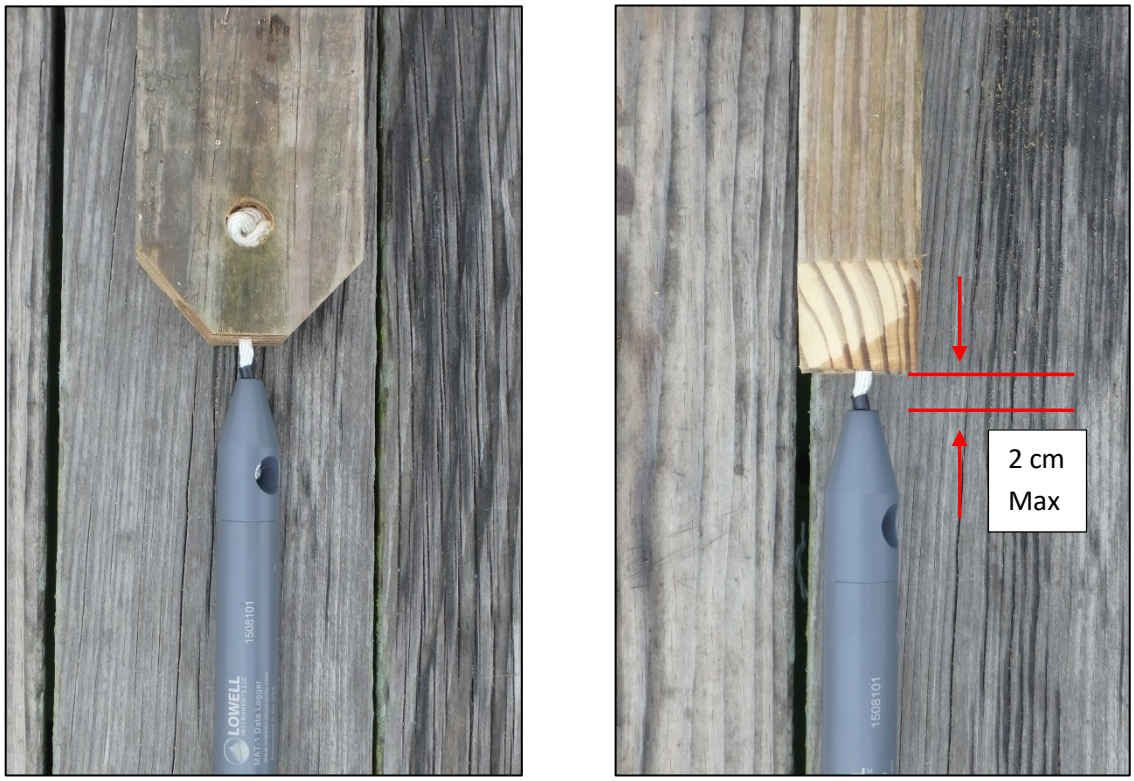

Figure 2A & 2B: Recommended mounting method using dimensional lumber. A hole is drilled through the end of the board with a second hole for the knot (left). The lanyard length is limited to less than 2 cm (right).

Figure 3A (top left): The recommended mounting method for an aluminum bracket is to drill through the bracket, deburr the hole and knot on the back side.

Figure 3 B (top right): If drilling through is not an option, tie the lanyard short and tight against the mounting point.

Figure 3 C (bottom left): Avoid loose knots that can get fouled and may pull asymmetrically when the current changes direction.

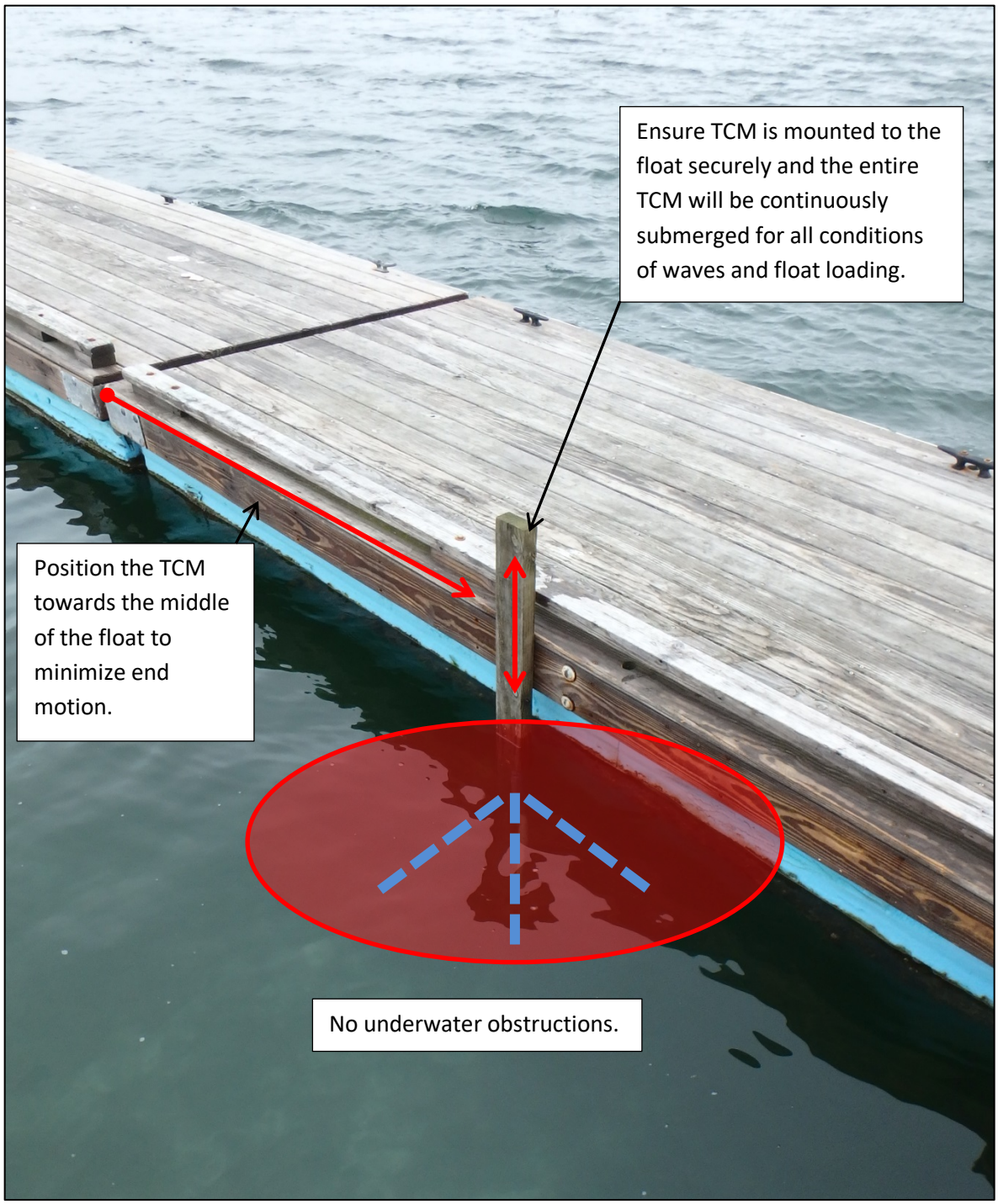

Figure 4: Suggested mounting on a floating dock. Meter is free from obstructions, fully submerged and away from the more lively ends of the dock.

8 Data Post Processing

Data conversion for the inverted logger is very similar to conversion of binary data from a bottom mounted TCM. The only difference is that a different calibration curve will be selected for the inverted configuration.

Begin by stopping the meter and copying the .lid file to your local drive. Then switch to the "Convert Files" screen in MAT Logger Commander and use the settings as shown in Figure 5 (below).

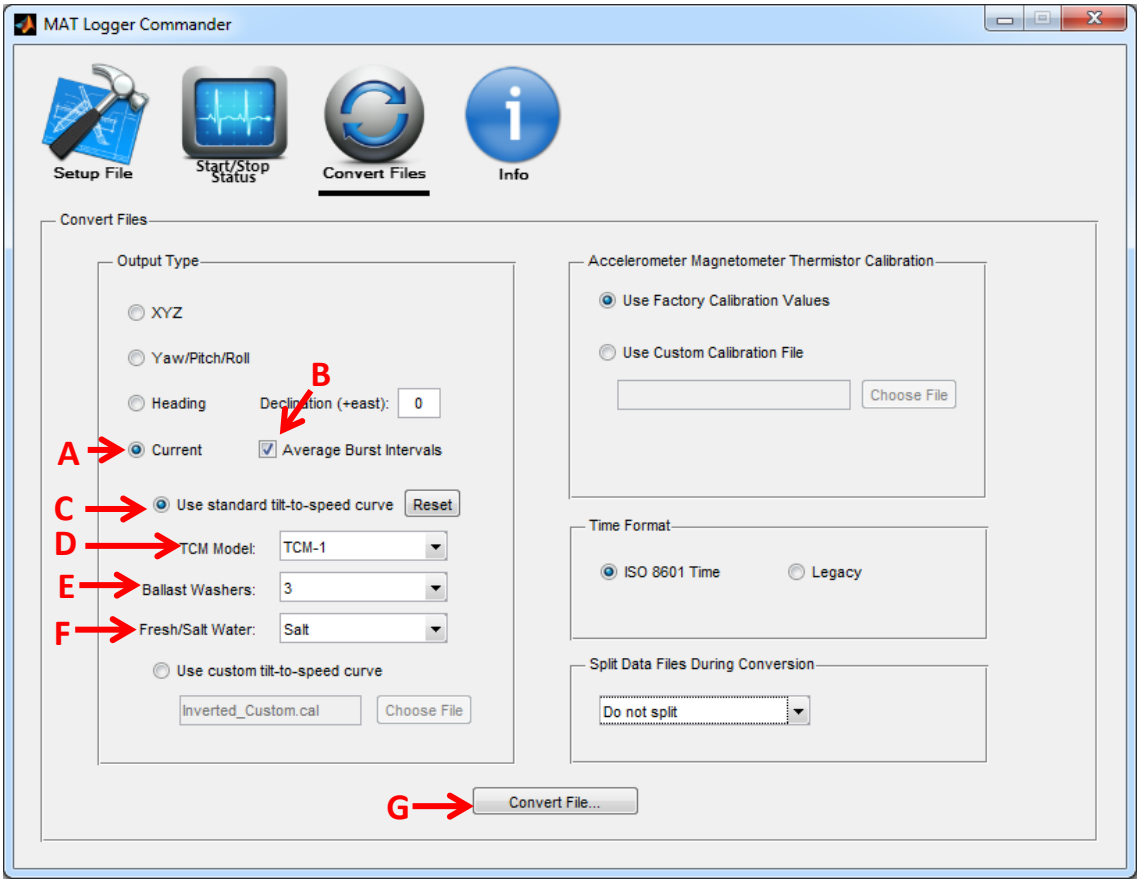

Figure 5: The recommended settings for post-processing a TCM .lid data file are shown. Select an output type of "Current" (A), with averaging enabled (B). Use a standard tilt-to-speed curve (C) with model of "TCM-1" (D) and three ballast washers (E) then select "Salt" or "Fresh" depending on the water type at the deployment site (F). Finally select Convert File (G) and navigate to the location on your local drive where the .lid file was saved.

9 Additional Information

Lowell Instruments has made a good faith effort to make sure that the information in this application note is accurate and complete. However we are not perfect and this document may contain errors. We also reserve the right to change the software, hardware and instructions at any time and without notice.

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