Stomach Temperature Pill 2 (STP2)
User Guide

Wildlife Computers

Innovative Tags for Innovative Research

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General Information and New STP2 Features

The Stomach Temperature Pill 2 (STP2) is a replacement for the first generation STP. New features include:

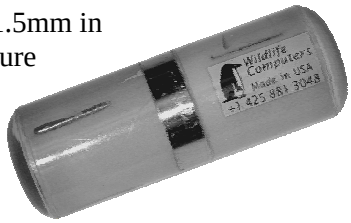
- 4 thermistors instead of one, to better differentiate internal temperature
- Reports absolute temperature ±1.0°C
- Incorporates the Wildlife Computers smart on/off magneting protocol, which is standard to all newer Wildlife Computers tags. There is now no need to ship or store pills with magnets taped to them.

Overview of Functionality

The STP2 is designed for use with the Wildlife Computers Heart Rate/Stomach Temperature Recorder (HTR). As with the STP, this second generation Stomach Temperature Pill is primarily designed to give insight as to when an animal feeds. The STP2 must be swallowed and then resides in the stomach of a warm-blooded study animal. Four thermistors monitor temperature, and the coldest measured temperature is relayed to a HTR. A sudden drop in the measured temperature may be an indication that the study animal ingested cold prey. The STP2 must be within approximately 1.5m of the Heart Rate/Stomach Temperature Recorder for the temperature to be received by the recorder.

The STP2 "pings" a radio-pulse of 5kHz. The ping-rate is temperature-dependent; the warmer the temperature, the faster the ping-rate. The STP2 is calibrated to measure 0 to 50C, with a resolution of 0.1C, and accuracy of approximately ± 1C. Battery life is expected to be approximately 20 days using the default setting of a 5ms ping width.

The components are cast in an epoxy tube which measures 63mm in length and 21.5mm in diameter. The thermistors are attached to a titanium ring to minimize the temperature response time. The STP2 is turned on (Deployed) and off (Shutdown) with a magnet. An LED flashes in response to confirm whether the STP2 is "on" or "off."



How It Works

The stomach temperature is measured by the "pill" (cylinder). This pill consists of 4 thermistors, a transmitter which sends a "ping" (radio pulse with a frequency = 5kHz), and a controller-board. The titanium ring conducts temperature changes to the thermistors. The pill's controller-board causes the transmitter to ping at different temperature-dependent rates. The ping is directional.

The HTR processes the pings. It has two receivers that compensate for the directionality of the transmitter. The warmer the stomach temperature, the faster the pill pings. The HTR scales the received "pings" to temperature.

Temperatures 0°C and below will be reported as 0°C and temperatures 50°C and above will be reported as 50°C.

Operational Mode(s)

The STP2 was developed to have 3 different transmission modes. While all three are described here, at the present time ONLY the first mode, Coldest Temperature, is currently available. Once the additional modes are available, the user will need to specify which mode is desired for the current research project at the time the order is placed.

There are three variables in the production and/or set-up of the STP2. They are transmission mode, ping width and, depending on transmission mode, ping-rate.

Transmission modes:

1. Coldest Temperature. In this mode, the coldest of the four thermistors will be used to determine the temperature. This is the default mode, and the only mode currently available for purchase.
2. Sequence. All four thermistors will be sampled, and the results transmitted in sequence.
3. Fixed Ping-Rate. In this mode, the user will be able to define the time period between pings. The range is 1 – 4 seconds. This mode is not used to determine stomach temperature, as in the first two modes listed. Rather it is used to determine the proximity of several animals to a fixed site. An STP2 is given to each study animal, with a different fixed ping-rate to distinguish among them. This will allow the researcher to identify when an individual animal is near the stationary receiver.

Ping width is a user-defined parameter which affects the lifespan of the pill. The range of the ping width is from 1 – 100ms. The default of 5ms provides a lifespan of about 20 days. The user may define the ping width for the Coldest Temperature mode, but not for the Fixed Ping-Rate mode.

Interpreting Temperature Readings

1. While the STP2 is able to report temperatures from 0° - 50°C, the HTR has been calibrated to measure temperatures from 8 - 44°C. It will record apparent temperatures up to 56°C.

2. Temperature readings between 44.2 and 56°C are not real, but an encoding of an ambiguous temperature.

   - If you had the HTR recording on every pulse, you will use HyperTerminal to download the data, and Wildlife Computers HexDecode to analyze your data.
   - If you sampled at timed intervals, you will download collected data as a HEX file, and use the Wildlife Computers 3M analysis program to look at the data.
   - All will be fine as long as the reported temperatures are less than 44°C.
   - If the reported temperature is greater than 44°C, it means the interval between pings was too long to be unambiguously converted to a temperature. One or two pings must have been missed. You can translate these reported temperatures as follows.

One pings missed	actual temp = reported temp - 12 (actual=between 32.2 and 44)
Two pings missed	actual temp = (reported temp x 1.5) - 58 (actual=between 8.3 and 26°C)

The first option is more likely, as the stomach temperature will mostly be above 32°C, however, you should infer whether one or two pings were missed based upon the stomach temperature reported before and after the ambiguous reading.

3. If the interval is too short, a temperature of 56.4°C will be reported as the reading. If the interval is too long, a temperature of 56.2°C will be reported.
4. The HTR uses the "A" command to display stomach temperature conversions. If any of the temperatures are ambiguous (see 2 above), the HTR will still adjust the reading to the 32.2 - 44°C range, and a question mark appears after the reading. Note that the HTR always assumes one ping was missed on ambiguous readings.
5. When you download data using the L0 and L1 listings, temperatures are scaled to the 8-44°C range. If the data are ambiguous, they are scaled in the 32.2 to 44°C range (one beat missed), with a question mark suffix on the reading.
    - If the interval is too long, the temperature is perceived as too hot, and E241 is reported. This is likely to occur at the first reading each time data are downloaded.
    - If the interval is too short, the temperature is perceived as too cold, and is reported as E242.

Understanding STP2 LED Flashes

The STP2 incorporates Wildlife Computers Smart On/Off Protocol. The LED flash sequence indicates the different modes.

- Shutdown: Two rapid blinks (75ms on, 75ms off), then off for 2 seconds. Two more rapid blinks (75ms on, 75ms off), then off for 2 more seconds, for a total time of 6.5 seconds.

- Deploy: Ten rapid blinks (200ms on, 50ms off) for a total of 2.5 seconds. Once in Deploy mode the unit will start transmitting immediately according to the stored parameters, and will transmit for approximately 20 days.

To toggle the tag from Deploy (on) to Shutdown (off), and vice versa, requires 2 properly timed magnet swipes. After the first swipe from the bottom of the serial number label to the bottom of the penguin label, the LED will flash indicating the current state of the pill (Shutdown or Deploy).

After current state flash sequence, the LED will be on solid for 2 seconds. During this period a second magnet swipe from the bottom of the serial number label to the bottom of the penguin label will toggle the state of the STP2. If you keep the magnet away from the STP2 during this long LED flash, the STP2 will stay in its current mode. If the state has been toggled during the long LED flash, the blinking sequence will start over.

Ping LED Flash Sequence – Once the pill is Deployed, the LED will flash for the first 50 pings. A single short LED flash indicates that all is operating as it should. Any other flash sequence, e.g., a double short flash or no flash at all, indicates there is a problem with the pill and it should not be deployed in an animal. If the LED has ceased flashing after the 50 pings, has been shutdown and redeployed, the LED will again flash for 50 pings.

Set-up Tips and Other Advice

- Do not set the fundamental sampling interval any faster than every 10 seconds, preferably no faster than every 30 seconds. The HTR needs 3 good "pings" between sampling wake-ups in order to figure temperature. It needs between 6 seconds (if the stomach is warm) to about 12

seconds (if the stomach is cold) to correctly detect temperature. The HTR must not wake up for a reading during this time or the temperature detection process will start over. Since the HTR wakes up at every fundamental sampling interval, setting a 3 x 5 second sampling protocol will not work.

- In the A command, the stomach temperature channel may pick up "extra" pings due to interference. You may improve upon this by moving things around on the work surface.
- Battery voltage is monitored while the ping is active. If the batteries are passivized or are running low, the pulse width will automatically be shortened to prevent the batteries from falling below 2.6V. The STP2 makes this change to extend the life of the pill.
- In Shutdown mode, the STP2 can be stored for years. For long storage, the STP2 should be kept in a cool environment, preferably at +5C in a refrigerator or in a non-commercial freezer, to help prevent the battery passivation.
- You can verify the STP2 is transmitting using a Polar-brand receiver watch.
- Other researchers have found that the animal may regurgitate objects if too large or pass them if too small. We were unable to make these “pills” any smaller. If, however, you feel the pill is too small and want to add more epoxy or other inert material, ensure that the metal ring is still exposed.