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So You Want Small PTTs

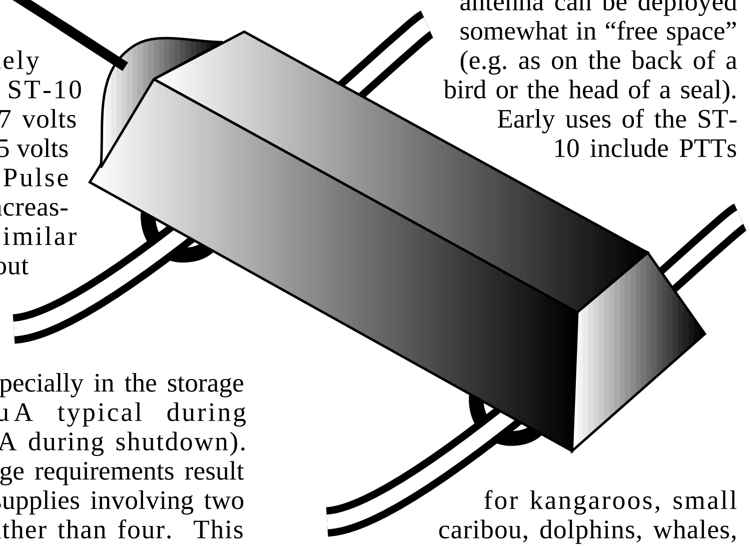
Wildlife researchers have consistently wanted smaller PTTs to use on smaller species and/or species where aerodynamic or hydrodynamic drag are important considerations. We have continued to design smaller and more advanced PTTs as component technology has allowed.

In 1984, our ST-2 began to be used on several large mammal species and in oceanographic applications. The ST-3 followed in 1986 and was a step down in size and up in performance. It has been deployed on numerous large wildlife species with the smallest configurations being designed for wolves, sea turtles and seals. The smallest ST-3 packages weigh about 750 grams and measure 16.5 x 10 x 3 cm. The ST-3 continues to be used for many applications, primarily involving larger species of wildlife.

Introduction of our ST-6 in 1988 allowed production of even smaller packages for wildlife applications. The ST-6 has been used on large birds and marine animals. Deployments include use on whales because larger PTTs create too much hydrodynamic drag and are difficult to attach.

The ST-6 PTT electronics are 35% smaller than the ST-3 electronics. Additional size reductions in the overall configuration were achieved by decreasing power output from the 1 watt ARGOS standard to about 0.25-0.4 watt. This resulted in lower pulse current requirements from the batteries and allowed use of smaller cells to power PTTs. These modifications produced configurations weighing as little as 145 grams and measuring 12 x 5 x 4 cm. Other than reduced output power, ST-6 capabilities remain nearly identical to many of our other PTTs. Activity, temperature, salt-water-switch, pressure, or other sensors allow collection of various data to supplement location information provided by ARGOS.

The ST-10, introduced in 1993, provided another substantial reduction in PTT size. The electronics were reduced in volume by about 62% relative to the ST-6, and their weight has been decreased to about 10 grams. Voltage requirements were reduced by approximately half, so the ST-10 operates using 4-7 volts rather than the 7-15 volts of the ST-6. Pulse current slightly increased to provide similar output power (about 0.2-0.4 watts) but quiescent current has been considerably reduced, especially in the storage mode (39-42 µA typical during operation, 3-4 µA during shutdown). The reduced voltage requirements result in typical power supplies involving two cells in series, rather than four. This reduces battery volume by 50%. The result is packages weighing as little as 48 grams and measuring 8 x 3.3 x 1.8 cm (see drawing).



In the ST-10, size reductions were considered more important than sensor data. Information available with the ST-6 (e.g. number of dives, length of dives, temperature and activity) is not currently available with the ST-10. The ST-10 can be equipped with a salt-water-switch (SWS) which synchronizes transmissions with surfacing on marine animals, a critical factor in obtaining locations of diving animals at sea. The SWS also suppresses transmissions when the animals are under water, thereby conserving battery life.

Both the ST-6 and ST-10 can be configured with various power supplies, packaging options, and attachment mechanisms depending on requirements. Each has been designed to allow the circuit board to be split and stacked, thereby expanding packaging options and making more aerodynamic and hydrodynamic packages possible. Full internal casting is also an option with both units, allowing greater pressures to be withstood when required for deep diving animals. Both PTTs can be programmed with on-off duty cycles to provide the optimal combination of battery life and transmission frequency. While reduced power output may not always be suitable, it does allow use on smaller species and in some additional applications.

The ST-6 has been used quite successfully in applications where the antenna can be deployed somewhat in "free space" (e.g. as on the back of a bird or the head of a seal). Early uses of the ST-10 include PTTs for kangaroos, small caribou, dolphins, whales, eagle and goose size birds, arctic foxes, and a head mount for male polar bears. Deployments on terrestrial mammals often involve the antenna being at least partially enclosed in the collar for physical protection. The close proximity of the antenna to the animal's body typically reduces signal radiation, but initial results with the ST-10 are encouraging.

Most early users of the ST-10 are researchers who have been interested for years in "small" or "smaller" PTTs. As results become available from these early studies, the extent of practical applications will become clearer. In the interim, the ST-6 continues to offer a reduced power PTT with expanded data capabilities. The ST-3 and some of our other PTTs offer extensive data capabilities, higher power and additional flexibility for applications where size is not a primary requirement.

By the way, biologists still want smaller PTTs. In the last six months, I've spoken with researchers wanting satellite transmitters for birds with body weights of 50 and 150 grams. We'll keep working. *Bill Burger*

GPS Update

On 26 June, 1993, the twenty-fourth satellite of the GPS Constellation was launched achieving System IOC (Initial Operational Capability). The system is now "fully operational" although military users still wish to replace some Block One satellites with Block Two to achieve Full Operational Capability for military use.

The GPS constellation of 24 satellites orbits the earth approximately every 12 hours at an altitude of approximately 20,200 km. Developed at a cost of $10 billion (or more), the satellite based positioning system began in 1973 with a directive from the Deputy Secretary of Defense. It created a Joint Program Office to develop, test and acquire a space borne positioning system to be known as GPS or NAVSTAR (Navigation System using Time and Ranging). The system's concept is based upon the idea that a receiver's distance from a satellite is determined by measuring the time it takes for the signals to reach the receiver from the satellite. Measuring the time delay from four satellites allows 3-D position fixing (latitude, longitude and altitude). The existing system has an accuracy of 20-30 meters, which exceeds the design accuracy of 100 meters.

The initial design for the space segment of the system was predicated on using two downlink frequencies (L1 at 1575.42 MHz and L2 at 1227.60 MHz). L1 frequency was designed for non-military users and carries both the CA (Course) and P (Precise) codes. The L2 frequency carries only the P code.

The second segment is the operational ground control. This includes five tracking stations distributed throughout the world. The master control station is at the Consolidated Space Operations Center in Colorado Springs, Colorado.

The third segment is the GPS receiver. It is designed to track, measure time of signal arrival, demodulate, and utilize navigation messages. There are three types. Multi-channel receivers utilize parallel, identical channels which receive signals from several satellites simultaneously. Sequential receivers track each satellite for about one second. Multiplex receivers sample four to five satellites in short sequences (i.e. one bit length).

The military maintains the most precise system operation exclusively for military operations, and degrades performance accuracy for commercial or non-military applications by an approach called Selective Availability (SA) which was initiated on 27 March, 1990. Selective availability essentially involves jittering the clock frequency to degrade the accuracy of commercial performance to approximately 100-200 meters. The P-code contains encrypted information to remove the clock frequency jitter from the military GPS receiver calculations, recovering the system's accuracy.

Interestingly, commercial users have developed an independent alternative to this induced SA error, called DGPS ("differential" GPS). In this mode, the error introduced by jittering the clock frequency is minimized by establishing an observed error of a receiver at a known location, and applying that observed error as a correction factor to a receiver at an unknown location. By using differential GPS, most of the induced SA error can be removed.

GPS allows you to determine position on the surface of the earth, in an aircraft, or in a space vehicle. It has been clear for some years that if this position could be relayed to a receiving site, then GPS could be used to locate the position of objects to be tracked such as ocean buoys, meteorological balloons, and animals. If combined with a telemetry system, the information could be relayed to another site and recovered.

Telonics has been looking at relaying GPS information via telemetry systems for several years. (See *Telonics Quarterly*, Vol. 4, No. 3, Fall 1991.) Although there are various telemetry systems which could relay GPS, our first step into this area will utilize the ARGOS system. Initially, we plan to relay position information from drifting buoys and balloons. Over the next 12-18 months, we plan to apply these approaches to free ranging wildlife.

As most researchers know, ARGOS itself is a positioning system; however, there are several reasons why adding a GPS receiver to an ARGOS based project can be advantageous.

1) The GPS system allows for more consistently accurate position fixes than ARGOS. Even with Selective Availability turned on, GPS is typically accurate to about 100 meters or better.

The ARGOS system provides different levels of accuracy depending upon numerous factors such as overpass elevation, number of uplink messages received, distribution of messages received over the course of the overpass, and PTT oscillator stability. Typically, with four good transmissions getting through to the satellite, most ARGOS position fixes will be within one kilometer. With five or more transmissions getting through, many of the position fixes will be within 150 meters. ARGOS calculates position using the doppler shift of the carrier (calculated from the measured carrier frequency) of multiple uplink transmissions received throughout the entire overpass. The ARGOS system generally assumes the PTT to be stationary and at sea level. Therefore, altitude errors of as little as 100 meters and/or velocity errors of as little as 1 meter/second can directly translate into position errors.

2) The GPS system allows for 24 hour coverage, with position updates occurring in rapid succession (i.e. one location update per second). This means that a position fix can be made at any time and several positions taken in rapid succession can be analyzed, selected, or averaged to help assure accuracy.

With ARGOS, position fixes can only be made when a satellite is in view, and only when the PTT transmits.

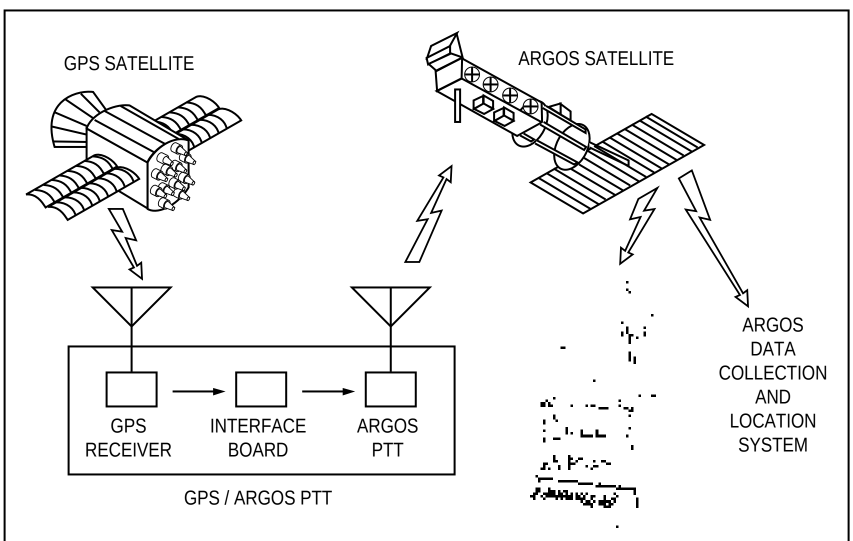


Figure 1

Depending on your location, periods of up to four hours may go by with no ARGOS satellite in view.

3) The GPS system allows for extremely accurate time stamping of position fixes. GPS receivers obtain a time signal from the GPS satellites. Therefore, you can know very accurately WHEN a position fix was obtained even if no ARGOS satellite was in view at the time to relay the GPS position back to the user. The position fixes obtained, including their time stamps, are simply remembered until an ARGOS satellite is available for relaying the data.

4) With GPS, YOU can establish the interval at which position fixes are acquired. For example, it can be every 15 minutes, every hour, every four hours, or every day. The sample interval you choose has everything to do with the needs of your experiment, and nothing to do with the availability of ARGOS satellites.

After much research, and waiting for technology to advance to the point that a suitably small and low power GPS receiver could be built, we now have a working prototype. It consists of a GPS receiver, ARGOS PTT (our ST-5), and interface electronics which “go between” the receiver and the PTT. Figure 1 shows the configuration of this system.

Now that we have a system up and running, we have begun on-the-air tests. They include the amount of time required to acquire a fix, and power supply tests and performance evaluations to determine antenna requirements. Typically, a worst case acquisition time of 15 minutes can be assumed for systems starting cold. A cold start implies that the receiver does not have a current copy of the GPS almanac, which is updated and periodically downlinked. In other words, it has no idea what time it is or which GPS satellites are within view. The almanac identifies which satellites are operational and gives a rough idea as to where they are in their orbits. What we have observed is that if the battery-backed-up memory of the receiver is maintained and the almanac is not too old, fixes are available from within a few seconds after applying power to just a couple of minutes.

The GPS receiver draws about 250 milliamps when in operation and uses a 5 Vdc supply. Therefore, add the 250 milliamps for the receiver to the peak current consumed by the PTT of your choice when selecting your battery pack. Note that l-watt PTTs (e.g. ST-5, ST-13, or ST-9) require approximately 700 milliamps when transmitting. However, you need not worry about generating the proper regulated voltages as we have already done this for you.

To minimize battery drain, the receiver is turned off as soon as a fix is obtained. Even when powered off, the receiver has battery backed-up RAM which is used to store the GPS almanac. This minimizes the time required to acquire a position fix after the receiver is powered up.

The amount of extra power required to obtain a position fix is a function of how often you wish to obtain one, and how long it takes the receiver to acquire it after being powered up. It should be remembered that the time to acquire is partly dependent upon how long the receiver has been off, and how far it has moved since the last fix was obtained.

Figure 2 gives you an idea as to how much extra average current is required for various position sampling regimes. Note that these figures do not include any power for ARGOS transmissions because of the great differences in transmission duty cycles requested by our customers.

The GPS receiver makes a variety of data available including position data, quality indices, and health status of the receiver. Figure 3 shows the data that our prototype unit is transmitting via the ARGOS system. Those of you already familiar with PTTs in buoy applications will recognize that the Amount of Time Underwater comes from our Salt-Water-Switch and the Temperature data comes from a thermistor, which could represent air or water temperature.

Elevation, velocity, bearing and various information about the GPS satellites are also available from the receiver. For our initial testing (aimed at buoy applications), we have chosen to simply ignore these additional data. They may be of value to your application, however, and an alternative data format could be established.

At present we are in the process of redesigning the interface electronics and intensively studying antenna requirements. The new interface printed wiring board will be smaller than our prototype and compatible with other Telonics PTTs. We are also developing a compact and robust packaging so that the system may easily fit into most applications.

We will soon begin the next step of the development, which is to eliminate the special interface and connect the GPS receiver directly to the PTT digital electronics. This will make the system even smaller. When used with an ST-6 or ST-9, GPS receivers will then be suitable for use on larger wildlife species. However, much remains to be learned before we will actually be able to produce such units. What effect does the position of the GPS antenna on the animal have upon the time required to obtain a fix? Since wildlife applications require small battery packs, how does the GPS receiver affect the life expectancy of the system, and what will be the most effective duty cycling regime? Since the system should influence the animal as little as possible, what kind of packaging and attachment will be required?

We plan to ship our first systems suitable for oceanographic applications in the Fall and, of course, we will be using the knowledge acquired to create systems suitable for wildlife applications. Stay tuned as this exciting adventure unfolds.

Roger Degler and Stan Tomkiewicz

Figure 2

Average current (not including ARGOS uplink transmissions) for an ST-5 PTT, interface electronics, and GPS Receiver:

GPS Receiver Sample Rate	Best Case*	Worst Case*
None	100 µA	100 µA
1 fix/1 hour	794 µA	62.6 mA
1 fix/4 hour	274 µA	15.7 mA
1 fix/day	129 µA	2.7 mA

*Best case based upon 10 seconds required to acquire fix.

*Worst case based upon 15 minutes required to acquire fix.

Figure 3

Each GPS transmission consists of

- 2-bits Low Battery Voltage Indicator
- 1-bit GPS Interface Error Indicator
- 82-bits Fix Data Packet (1-3 packets allowed)

Each Fix Data Packet consists of

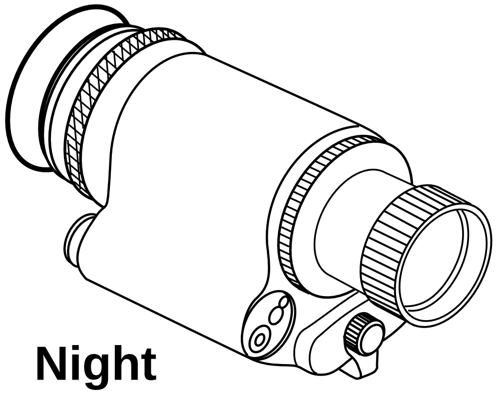
- 1-bit Latitude Direction (N=0, S=1)
- 8-bits Latitude Degrees (0 - 90)
- 6-bits Latitude Minutes (0 - 59)
- 6-bits Latitude Seconds (0 - 59)
- 1-bit Longitude Direction (E=0, W=1)
- 8-bits Longitude Degrees (0 - 180)
- 6-bits Longitude Minutes (0 - 59)
- 6-bits Longitude Seconds (0 - 59)
- 9-bits Time of Fix, Day of Year (0 - 365)
- 5-bits Time of Fix, Hour (0 - 23)
- 6-bits Time of Fix, Minute (0 - 59)
- 8-bits Time Under Water (0 - 255)
- 10-bits Temp. at Time of Fix (0 - 1023)
- 2-bits Parit

Paxarms

Telonics first became involved with Paxarms several years ago. Our transmitter darts were being successfully used for the capture of red deer in New Zealand and we began distributing the Paxarms technology to the wildlife community in the United States.

Over the past few years, there have been an increasing number of regulations placed on the importation of firearms (even dart guns) and cartridges. The number of rules set forth by ATF with regard to taxation have increased and the paperwork has become very time consuming. This, in addition to the required firearm import and federal firearms licenses to supply this equipment to our customers, has caused us to regretfully relinquish distribution of Paxarms equipment in the United States.

We continue to recommend Paxarms as a technology suitable for use in the remote capture of free ranging animals and suggest you contact them directly for information. Their current address is: Paxarms Ltd., 37 Kowhai Street, PO Box 317, Timaru, New Zealand. *Susie Crow*



Night Vision Scope

Telonics periodically provides researchers with night vision equipment. We currently have a night vision scope which we are making available at a special reduced price. The equipment available is as follows:

- Litton M911A Night Vision Scope
- 10X Eyepiece
- C-mount Collar
- Litton 75mm Low Light Lens
- Case, batteries, instructions, & lens tissue

This equipment is very high quality and state-of-the-art. It has never been used. Retail price is over $5000.00 if purchased individually. Package price is $4745.00. As a one-time offer we will sell the package for $3500.00, or consider other offers. This offer is only available to researchers in the United States. The warranty is now expired but it’s still a good deal if you want to see in the dark. Contact Bill Burger.

Correction

In our spring 1993 issue (Telonics Quarterly, Vol. 6 No. 1, “Software Updates”), we incorrectly noted that ARGOS “ID numbers under 16,383 have 16 bits reserved for the actual ID and 6 error detection bits, while numbers over 16,383 have 15 bits reserved for the actual ID and 5 error detection bits.” The statement should have read, “...ID numbers under 16,383 have 14 bits reserved for the actual ID.” We apologize for any confusion.

Brenda Milam

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