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Microprocessors, Microcontrollers, Microcomputers

The computer revolution has generated its share of jargon, and is responsible for unprecedented confusion for anyone attempting to grasp the real meaning behind terms like PC's, AT's, RAM's, SRAM's, ROM's, E2 PROM's, I-O lines, serial communications, RS232C, and "friendly software." Many of us who have been involved in the development of radio telemetry have been spared this barrage of terms simply because the advances were made in big computers that required high current consumption and operated on line voltages. Until recently, they did not lend themselves to supporting small, portable telemetry systems.

The first "computing" devices to arrive on the scene were microprocessors which could be programmed to execute instruction sets in an orderly fashion. Generally, the term "microprocessor" referred to a device without input/output lines (I-O lines) and without on-board memory. Before long, however, it became clear that portable lap-top computers could be useful and the industry began to address the problem of reducing current consumption and voltage requirements to enable operation of computers from portable battery systems. Moreover, an entire new class of microprocessors was developing with on-board "Read Only Memory" (ROM), "Random Access Memory" (RAM) and I-O lines, termed "microcontrollers" or "microcomputers". For the past decade, these highly integrated devices have been stuffed into a whole range of products in place of discrete logic components.

As microcontrollers developed, it became apparent that they could replace the discrete logic components required to operate a transmitter, especially a sophisticated transmitter like the ARGOS PTT. With the programming of a single chip, it was now possible to alter the role of the PTT, change the data rate, send data to the transmitter from data collection systems via a serial communications port, collect data in a sophisticated scenario, process and uplink the data. The individuals working with our satellite telemetry have grown up with microcontroller systems, and have helped them develop far beyond the simple ability to switch the transmitter "on" at a certain repetition rate. It quickly became possible in more sophisticated programs to duty cycle the transmitter for certain periods of the day, skip several days and then return to a more or less intense duty cycle (see "Duty Cycling of Satellite Transmitters" in this issue). The more choices available and the more powerful the programs, the more user-selectable parameters were designed into the protocol.

During the 1980's, microcontrollers did not operate at power consumption or voltage levels suitable for VHF telemetry. Discrete logic controlled the duty cycle (pulse rate and pulse width) and data collection. However, it has always been restrictive in conventional VHF units because only a few discrete logic components could be incorporated and still keep the size suitable for deployment on smaller animals.

The newest microcontrollers operate at sufficiently low current and voltage, and are sufficiently small in size, to replace the discrete logic controlling the VHF telemetry used to track wildlife. For individuals who wish to be on the cutting (or bleeding) edge of technology, a new generation is opening the door to more powerful control of the data collection and transmission scheme and, quite frankly, closing the door to simplicity.

The newest microcomputer chips are often physically smaller than the integrated circuits currently used in VHF telemetry. In addition to directly controlling duty cycling of the transmission, the program can establish time periods where the transmission can be turned off entirely to provide a "sleep mode." For example, if tracking is done only one day per week, it is possible to put the transmitter into "tracking mode" during that time period and into "sleep mode" (a very slow clocking rate) during the rest of the week. Most of the time, the transmitter consumes only minimum current, but for that one day the pulse rate could be rapid enough to accommodate preplanned aircraft tracking in the area.

Another request that people have made of us is the ability to put several hundred transmitters on a single frequency. The units only transmit in the event of a mortality. When an animal dies, the unit transmits an ID code, plus a tracking pulse train for use in location finding. Since the transmitter only activates with a mortality, a minimum number of transmitters are on the air at any given time. Battery power is conserved, resulting in a smaller, or longer-lived transmitting subsystem. The system utilizes a single or small number of channels (frequencies), thus scanning times are also reduced.

Mortality and tip switch activity sensors have been around for many years. However, the development of microcontrollers allows the monitoring of activity to be conducted in new and different ways. Many individuals who have done mortality studies have been frustrated by the fact that a dead animal in the mortality mode might be "shaken out" of that mode if a predator moves the animal's body. Even a slight movement might be enough to reset the transmitter to active mode. Thus, the transmitter must "time out" again before transmitting in the mortality mode. If predators were feeding on the animal, it might appear as if the animal is alive due to the continued low level disturbance. Microprocessors can establish preset levels of activity which give us the ability to distinguish between mortality and simple, low-level activity. Information can also be processed and retained in memory for a longer period, so more extensive data and a history of what has happened can be transmitted.

Additionally, it could be possible to instrument animals (e.g. waterfowl) at a time of year when they can be captured inexpensively and delay data recovery until migration. Presently, this requires a larger battery to keep the transmitter and data collection system operating continuously until the pertinent time period arrives. However, a microcomputer can simply time its way along, not turning on either the transmitter or data collection system until the appropriate time.

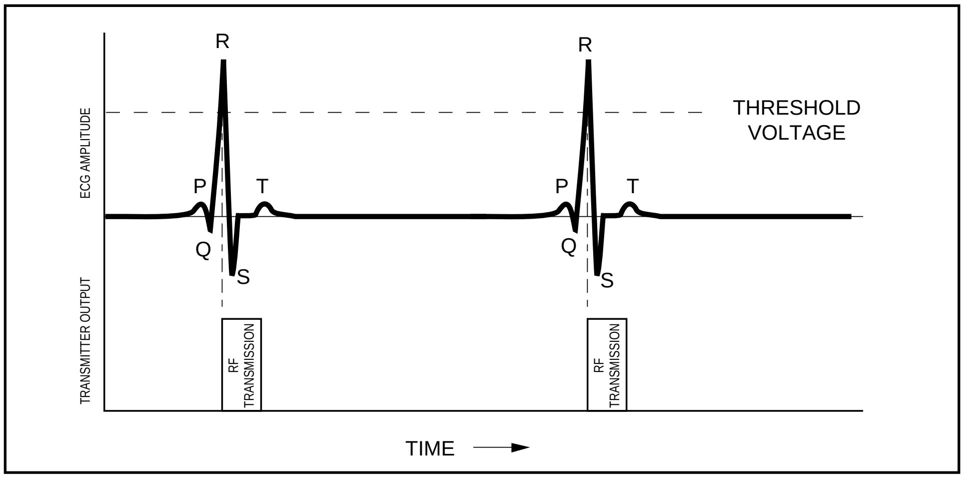
At first, the new microcontroller subsystems will be more suited to deployment on medium sized animals. As time goes on, they will continue to get smaller and more suitable for a wider variety of wildlife. The freedom of the programming duty cycles and data collection systems will open the door to a wide range of imaginative research programs utilizing the new capabilities.

Yes, it will also drag users of VHF radio telemetry kicking and screaming into the new decade—a place of microprocessors, microcomputers, and microcontrollers.

Stan Tomkiewicz

New Implantable Heart Rate Transmitter

We've been working on it for years!



The idea of monitoring the heart rate of an unrestrained animal under field conditions via an implantable "heart rate" transmitter is certainly not new. In fact, almost all telemetry manufacturers have tried their hand at producing units with various levels of success, ranging from complete and total failure to moderate performance. As long as 15 years ago, Telonics also experimented with such a unit. At the time there were many problems associated with implantable biotelemetry in general, and with heart rate units in particular, and these first projects often proved impractical.

As the technology developed, the packaging problems associated with self-contained implants (units which did not require external leads and had internal antennas) were solved. However, many manufacturers were not able to handle the internal antenna efficiently and the range performance of their units was moderate to poor. By the late 70's, we had developed an internal antenna which dramatically increased the range performance of implantable units. However, the problem of packaging units with external leads still remained significant. Now, with several years of experience in implantable transmitters, some new technology, and some innovative approaches to the packaging problem, we are working on a new generation heart rate transmitter.

The heart rate transmitter has not changed in basic function over the years. Here's a quick refresher from an electrical engineer's viewpoint (so please forgive my "un-medical" terminology). As the heart beats, a series of very weak electrical impulses or waves travel through the body. If we measure the voltage created by these electrical impulses with two well-placed electrodes, we observe the familiar electrocardiogram (ECG). Contained in the ECG is the QRS complex, which occurs each time the ventricles depolarize prior to contraction. Also associated with the ECG are the P and T waves (see graph). The heart rate transmitter outputs a short transmission (pulse) every time the waveform exceeds a certain "threshold" voltage. Ideally, this threshold is set low enough that the R wave will trigger the transmitter, but high enough that the P or T waves will not cause multiple transmissions on each heartbeat. So far, it seems pretty easy! However, once this simple concept hits "real world" constraints, several challenges present themselves. Here are a few of the ones that must be overcome.

First, since body fluids are conductive and corrosive, the transmitter must be adequately sealed. Electrode leads must exit the package and, at this exit point, there is a potential path for moisture to creep in. Body fluids are very conductive and even the slightest amount of leakage can effectively "short out" the input terminals, eliminating the tiny EEG waveform. Historically, leakage has been the most pervasive problem associated with heart rate transmitters. Over the past decade, however, we have successfully used various polymers in sealing self-contained implantable transmitters. Using this technology, coupled with some other new ideas in electrode isolation, we feel that we have made significant progress in solving the leakage problem.

Second, as the animal moves, gets excited, relaxes (or even dies), the QRS waveform can vary in amplitude (in the latter case, amplitude goes to zero). If the amplitude decreases, a transmitter with a fixed threshold voltage can miss beats. On the other hand, if the amplitude increases, the transmitter can trigger on the P and/or T waves, causing multiple pulses on each beat of the heart. The new Telonics heart rate transmitter incorporates an automatic gain control (AGC) circuit which adjusts its threshold up or down depending on the average amplitude of the incoming QRS wave. If the animal dies, the transmitter reverts to a very slow and unique default pulse rate. This allows the researcher to locate a dead animal and retrieve the transmitter. As far as we know, the AGC and default pulse rate are unique among currently available heart rate transmitters.

Third, the electrodes and connecting wire, which maintain electrical contact with body tissues, must be strong, electrically conductive, biologically inert, and flexible enough to withstand the rigors of subcutaneous implantation. Many failures of heart rate transmitters can be attributed to failure of electrodes and associated wires. To further reduce the chances of electrode or wire failure, the transmitter, electrodes, and leads must be located in the body so as to minimize movement or physical abuse. Two options present themselves. The conventional solution (the one used in our prototypes) consists of a transmitter unit with two flexible, coated leads going to the remote electrodes. The transmitter unit may be best protected if sutured inside the body cavity, while the electrodes function best when adequate separation is available. This separation is often accomplished by suturing the electrode just under the skin. Another concept places the electrodes in opposite ends of the transmitter unit itself, thus eliminating the need for external wires. This approach was successfully used in grizzly bears some years ago. It is somewhat limiting, however, in that the package must be fairly long to provide proper separation between electrodes (separation will vary with the species).

Fourth, implantable transmitters have always suffered from the range vs size vs operational life quandary. It seems that the ideal setup is infinite range, infinite life, and infinitesimal size! Since this setup is not possible, compromises are always in order and can be developed on an individual basis. For example, in past months we have been working with a research team from the University of Arizona to develop a prototype heart rate unit for Big Horn Sheep. In this study, lifetime and range are important design parameters, but transmitter size is less critical. Since a large battery (C-cell sized) is required to achieve an expected 16-month life with a 1 to 2 mile range, the total package turns out to be 1.4" dia. x 4.2" long, weighing approximately 100g. However, the electronics are actually quite small (1.0" x 0.65" x 0.25") and we are able to custom design smaller configurations by modifying either range or expected lifetime.

It is ironic that while almost every other telemetry designer is getting out of the "heart rate" transmitter business, Telonics is ready to get back in! As design and prototype testing continues in the field, we will try to keep you informed of future developments and, hopefully, successes!

Timo Hansen and Phil Cox

Duty Cycling of Satellite Transmitters

Some practical considerations.

Satellite linked transmitters which operate through the ARGOS system are termed Platform Transmitter Terminals, or PTT's. Previous articles have reviewed various pieces of satellite linked hardware and some of the software options available with PTT's. This article reviews the concept of "duty cycling" PTT's.

Duty cycling can be defined as turning a PTT on and off at programmed intervals during the operational life of the PTT. There can be various reasons for imposing a duty cycle on a PTT, but primary reasons often include a desire by researchers to extend operational life as compared to that possible with continuous operation, or to reduce costs for data processing by reducing the number of days on which a PTT operates.

It is important to distinguish a PTT's duty cycle from its repetition period. The repetition period defines the time between transmissions from a PTT, and is assigned by ARGOS along with an ID number for the PTT. Repetition periods typically range from 50 - 90 seconds for PTT's which are being used to provide location, to over 200 seconds for PTT's which are used only for data transmission. The duty cycle defines periods of time when a PTT is on (with transmissions controlled in accordance with the repetition period), and off (no transmissions). For example, a PTT might be on for 8 hours and off for 16 hours (the duty cycle), and during on times it might transmit every 70 seconds (the repetition period).

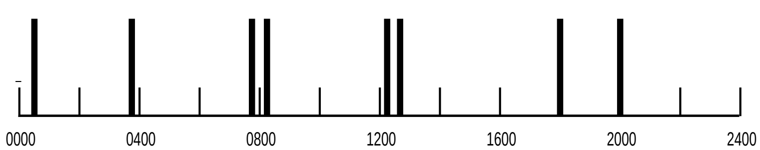
PTT's which collect data (e.g. temperature, activity, submergence in salt water) continue to do so during off portions of a duty cycle. If data is programmed to be transmitted immediately and then updated, it will not be recovered during off portions of the duty cycle. If, however, the data is compiled over a period of time and then transmitted, it is certainly possible to recover data corresponding to off portions of the duty cycle. For example, activity data could be compiled in 24 hour buffers and recovered during a PTT's 8 hour on cycle.

Duty cycling capabilities of a particular PTT depend on the applications software installed. Many PTT's are able to be programmed with one or more distinct seasonal cycles. Within each season, several on/off cycles may also be defined. All duty cycle timing is referenced to the start of the PTT, rather than to a real-time clock. Thus, the duty cycle can be restarted by shutting the PTT off, either by use of the magnetic switch or by disconnecting the power supply. Rather complex duty cycles are possible, and sometimes useful; however, much simpler cycles are frequently utilized. Possible advantages of a simple cycle include a reduction in the effect caused by changes in satellite orbitography over the period of time in which a PTT is deployed, or by an inadvertent reset of the microprocessor controlling a PTT, which would re-start the duty cycle. Such resets do rarely occur, usually caused by an abnormally large drop in battery voltage as a PTT transmits under very cold conditions when the pulse current capability of the power supply is most limited.

On/off cycles of a PTT should be carefully considered to optimize the chances for successful transmissions to the satellite, and to achieve the optimal combination of data collection intensity and PTT longevity for a specific application. In optimizing the probability of successful data transmission and/or location determination, it is critical to realize that the satellites used in collecting ARGOS data are in sun-synchronous, near polar orbits. At any given location on earth, the satellites are within "view" (i.e. above the radio horizon and therefore able to receive PTT transmissions) for only a portion of each day. The total number of satellite overpasses, and the cumulative amount of time a satellite is within "view", is greatest at high latitudes and least at the equator. Duty cycles should thus be established such that on periods are of sufficient duration to encompass several satellite overpasses in the area in which the PTT is deployed. Further, because the distribution of overpasses is not evenly distributed throughout a day, the user should start each PTT at the appropriate time to synchronize on portions of the duty cycle with the maximum number of satellite overpasses. A 24 hour distribution of satellite passes over Mesa, Arizona is shown in the accompanying drawing. Other locations will have different pass distributions. If seasonal cycles are utilized, the PTT must be started on the appropriate day to synchronize the programmed duty cycle with real-time events.

A PTT's duty cycle affects operational life, data collection costs, data collection intensity, and the probability of location determination and successful data transmission to the satellite. Thus an understanding of this concept is important for those working with PTT's. If you have questions or need help in determining the most efficient duty cycles for your particular purposes, please don't hesitate to call. We are here to help.

Bill Burger



SATELLITE PASSES - OVER 24 HOUR DAY

You Want It When?

No problem (most of the time).

Over the years Telonics has developed a pretty good reputation for on-time delivery. We work hard at every aspect of our service, and will continue improving in every way we can. However, the occasional glitch still occurs!

Magnets are a good example. We use high quality alnico alloy magnets in many of our transmitters to shut them down for storage or for transporting. It sounds simple enough, but the cobalt used in the magnets comes primarily from Zaire and Zimbabwe. Since much of Africa has chronic political and military problems, the price and availability of cobalt is erratic. We're forced to pay the going rate (often exorbitant) and live with the occasional delays.

As a consultant/supplier to the VHF and UHF tracking communities, Telonics makes a wide variety of customized products and we make them in very small numbers. If we manufactured every component, our products would be priced far beyond the financial capabilities of most field researchers. Thus, we have to take into consideration the commercial availability of some components when we first decide to develop a product. That availability affects everything from pricing and delivery to basic design.

For example, some of our VHF transmitter packages were designed to be housed in specialized canisters. We were notified recently that the product was no longer available due to lack of volume. After researching the market we redesigned the product, negotiated with a new vendor for a custom housing, and elected not to pass on the costs to users.

Certainly mergers, buyouts, bankruptcies and every other kind of economic disruption can affect production, but so can natural disasters. Last summer a Texas Instruments factory in the Philippines was severely damaged in an earthquake. One of the products produced in that facility was an integrated circuit that we use in our satellite transmitters (specifically, the ST-5). In fact, that particular plant was the only source for the component and, until TI was able to initiate production in another facility, supply was delayed.

Telonics produces many highly specialized products using thousands of components. While our dependence on some commercial markets can leave us at the mercy of both local and international events, the advantages in both cost and design flexibility far outweigh the rare delays we may experience from time to time. In our effort to bring you the highest quality, lowest cost products available, we hope you are never inconvenienced. But if you are, we can probably just about guarantee a really interesting excuse!

David Lee Beaty

Antennas Can Double As Lightning Rods

The Telonics Quarterly is published as a customer service and we use it to keep readers abreast of new developments in technology. One revolutionary change in antenna use has resulted in a novel application of readily available hardware.

Research scientists at Telonics report that many of today's antennas are fully capable of doubling as lightning rods. In fact, all it takes is a long, metal support pole buried firmly in the earth.

How To Do It...

The antennas should be installed in the manner of vertical polarization. For maximum effectiveness, the base of the support pole may be saturated with salt water to enhance conductivity. The scientist may stay in the area of the antenna until such time as the fine hair on the posterior of the observer's neck is felt to rise. It is then strongly recommended that the field biologist assume a prone position on the ground as rapidly as possible, with both toes and fingers placed within a three-inch diameter circle on the earth. Note: This will help reduce the available shunt voltage gradient.

Actual field reports suggest that these new techniques have dramatically reduced loss of life due to radical celestial discharge. The reporting technique is assumed to be infallible, as personnel who have not survived the tests could not he reached for comment. It should be noted, however, that the "channeling" technique pioneered by S. MacLaine et. al. of California is currently under consideration as a possible method of broadening the data base.

Field scientists who have documented experience with antennas in this application are encouraged to communicate with Telonics. Data collection activities for the current study will remain open until April 1, 1992, for your convenience.

No Joke, etc.

Fact is, antennas which employ capacitive matching networks are the most dangerous "lightning attractors." The capacitance utilized to adjust the impedance match where the coaxial cable is attached acts as a "spark gap." Instead of bleeding off high voltage static charge, such designs serve to block the accumulating charge until it reaches a critical arc-over point as determined by the physical spacing of the gap, the material around the gap, and the conductivity of the air due to current conditions of humidity.

What to look for...

Antennas with a short rod extending out parallel to the large driven element from the point where the cable attaches, and held to the large element by an adjustable metal clip, are typical of the designs which are prone to the arc-over phenomenon. Although several suppliers utilize this technique, the largest is Cushcraft, whose antennas are relabeled and sold by many telemetry suppliers. If you connect a light or ohmmeter between the center pin and the shield of the coaxial connector on your antenna, and a "short" or continuity is not indicated, you may be asking for trouble.

What to get...

The problem is greatly ameliorated by matching designs which directly connect every section of the antenna together. In short, everything should be grounded out from a direct current standpoint, including the mounting mast or pole. (For this reason, your pole should be metal, and it should be well grounded to the earth if you are operating in an area which may experience lightning storms.) All our fixed site antennas utilize DC grounded designs. Take a moment and check your antennas to see what type you are using. It just makes good sense...no joke! *Dave Beaty*