TELONICS QUARTERLY™

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View From The Basement

Developing New Products Is A Joint Effort

In the 1960's, I began traveling to the field and speaking with many of you "oldtimers" regarding what form "ideal" telemetry tools ought to take. The input resulted in many of our early products, including the workhorse Telonics TR-2 Receiver and MK-V Transmitter. Both have served the research community well, and have resulted in many related configurations. Over the last 20 years our staff has solicited similar input from around the world, and your study objectives and species-specific constraints have consistently influenced our hardware designs. For example, you have helped satellite transmitters shrink from large, ungainly packages to the new ST-6, which requires only 15 grams of circuitry and weighs less than 150 grams fully packaged with batteries and housing. We are on the brink of similar breakthroughs with our new implantable heart rate transmitters. The near future will bring a family of intelligent IDentitycoded VHF transmitters, the TR-5 Automatic Data Acquisition Receiver/ Logger, and a full complement of hardware/software supporting the capabilities of the GOES geostationary satellite system — including pocket receivers, DCP transmitters, uplink receivers, and a low-cost downlink DOMSAT earth station to receive GOES data directly at field research centers and/or universities and base sites.

What the world needs most! Lest anyone think we have forsaken our roots, we are also continually scrutinizing the needs of the VHF tracking field. When you summarize all the input, what the world needs most is a good, small, cheap, smart, VHF tracking receiver. In fact, the needs you have expressed over the years form a comprehensive matrix describing a whole new generation of receivers. The criteria includes the following:

• low cost (a 50% reduction in price);
• simple to use (no new system to learn and not so many numbers to remember)
• small and significantly lighter than existing high performance receivers;
• very sensitive, with no sacrifice in operating range, and able to accommodate "lots of transmitters";
• incorporating a small and simple battery pack, with replacement batteries available from your corner store;
• capable of warning users before batteries get low and housing a backup battery;
• complete with inexpensive, lightweight earphones which are easily replaced;
• and with an inexpensive, but "serious" protective case which houses earphones and spare batteries.

The list goes on. Since joint projects and an increasing amount of field work between cooperating agencies are becoming commonplace, the new generation of receivers should incorporate full frequency synthesis technology. This would allow frequencies to be changed easily and inexpensively, so receivers can be loaned back and forth as need arises. It would also allow frequency changes within a given band to be accomplished without purchasing, installing, and testing crystals.

Frequency programmability is another criteria. With the use of a suitable interface device, users should be able to produce a hard copy and a personal computer disk file of the frequencies programmed into each specific receiver in the inventory.

Conventional keyboard entry is laborious with a high error risk. Users should be able to "clone" multiple receivers with regard to specific frequency lists or tables — quickly, easily and without error.

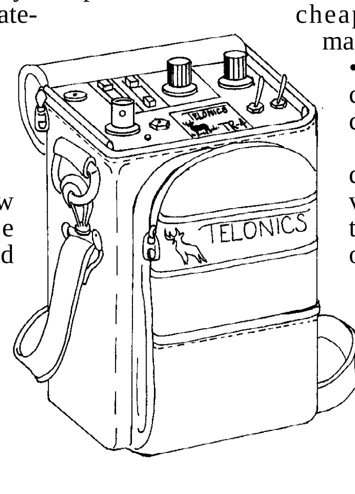
Off-road vehicles and motors emit substantial amounts of impulse-type electrical interference. A truly effective noise blanking capability should be incorporated which, when activated, does not in any way degrade the sensitivity of the receiver. However, since the circuitry necessarily increases costs, and since not everyone requires a noise blanking capability, it should be available as an option at the time of purchase.

The frequency selection process should also be simplified. Direct readout frequency synthesis and selection (incorporated in our TR-2) clearly has its place. However, we see a clear additional need to provide a greatly simplified receiver which employs state-of-the-art technologies to effec-tively bring back the simple "channelized" man-machine interface needed for smaller studies. By so doing, the best of both old and new technologies may be effectively mar-ried and utilized.

Now, these are not new requirements; many of them existed in the 1960's. However, improving on our TR-2 Receiver required some new developments in technology. Fact is, we have been working on some pretty hot receiver technologies for more years than we care to admit, waiting for things to advance to the point where our approaches became practical and producible at a reasonable cost.

Well, here it is. The first of a new generation, the Model TR-4 miniaturized telemetry receiver directly addresses these requirements.

• It is truly a no-compromise receiver, with sensitivity equal to our TR-2 Receiver.
• It is amazingly small and lightweight (only 425 grams with batteries included) and measures only 4 x 8 x 18 cm. Even with two spare batteries and the headphones in the case, the whole kit n'caboodle weighs in at 0.85 Kg (I guess that's about 0.15 stone for Gordon, Sam and our good friends down under).
• It operates from the simplest battery pack we have seen utilized in high sensitivity receivers, and incorporates a spare back-up battery in its powerpack compartment (you shouldn't run out of battery power in the field again with this receiver).
• It uses the cheapest battery you can buy for transistor radios and offers a wonderful background noise reduction filter to ease operator hearing fatigue and further increase sensitivity.
• It can be programmed for up to 100 frequency "channels" with our standard TIPS Personal Computer Interface Unit, which provides both a disk file and hard copy record of frequency programming tables, and a fool-proof method of "cloning" receivers for common projects. There are no crystals to buy, and reprogramming within a given frequency band is simple — do it as often as you like.
• It maintains the "feel" of our TR-2, so there is no new-fangled system to master the same work you did before.
• It's cheap. Not quality cheap, hard dollars and sense cheap. Cheap to buy, cheap to use and cheap to maintain.
• It comes in the best little custom padded carrying case I've ever seen.



Although the new TR-4 doesn't slice, dice or chop veggies, I suppose you can tell I'm excited about this one. After all, I have a perfect right — I've waited 30 years for it!

Dave Beaty

The Phenomena of Signal Bounce and Phase Cancellation

Two Complicating Factors

As a practitioner in radio telemetry, you have no doubt experienced signal bounce and may, to some extent, have also experienced phase cancellation.

There are usually some interesting "first time" stories associated with following a bounced signal. For example, you may have been studying ducks (in eclipse plumage) on a lake. All of a sudden you heard a strong signal emanating from an entirely different direction. As you hiked up a narrow valley, you continued to work your way along until you reached the 10,000 foot level. If you had found that duck, you would have made the cover of "Science"! More than likely, however, when you reached the pinnacle either the signal became dramatically weaker or it was now emanating from an entirely different direction. The distance you walked before rechecking your bearings is a telling indication of how reliant you are upon technology. If you only moved a few hundred yards, you showed a healthy suspicion of strange gadgets.

Signal bounce and the entire propagation phenomenon surrounding this aspect of radio telemetry were probably never divulged during your classroom days. It is one of those events that comes from the real world to strike unexpectedly and, essentially, it works as follows.

Radio waves propagate as changing electro-magnetic fields through the air path. As they encounter objects in the environment (e.g. hillsides, wet rocky outcroppings, electrical lines, or any manner of physical feature), some amount of the signal is absorbed and some is reflected or "bounced", thus causing the wave to travel in a different direction. The signal bounce phenomenon occurs throughout the VHF spectrum, increasing at the higher frequencies. Therefore, when receiving radio waves, we can never be quite certain whether we are in direct "line-of-sight"or receiving a reflected signal. Practitioners have been "myth-lead" if they feel there is an easy way to determine the difference. While we may be able to intellectually determine the occurrence of a bounced signal — we simply know the animal cannot be in the direction indicated — there is no reliable factor that changes after the signal is reflected to indicate that it is not direct.

Another complicating factor is that you will almost certainly receive more than one bounced signal, each emanating from different reflective surfaces and at varying intensity levels. In radio telemetry, we simply "throw our bearing" in the direction of the strongest combination of signals impinging upon the antenna. If the animal is not line-of-sight, then the signals we hear must be reflected. When we take a bearing under these conditions, it is highly unlikely that we are actually obtaining the bearing to the animal.

Much of radio location work involves precision direction finding which is complicated by signal bounce. Initially, you must determine that you have line-of-sight. Sometimes it can only be established by throwing bearings from a number of different positions and comparing the readings. You must then select the intersection which is most consistent. From a study design perspective, precision direction finding using only two antenna sites is doomed to failure. Unless the bearings taken from two different sites are parallel, they will always intersect indicating the animal is at the point of intersection. In fact, either or both could be bounced signals. Bearings taken from three antenna sites may all agree but, because of signal bounce, the possibility exists for two different intersection points. Therefore, the typical approach is to use additional antennas. When such systems are analyzed, it is apparent that it takes five antenna sites to obtain a consensus. If there is no common intersection with five antennas, then the animal is probably out of line-of-sight and we are working strictly with bounced signals.

In situations of greater signal bounce, it is also important to use an antenna of lower gain. This can mean using a loop antenna (e.g. the RA-l paddle antenna) to reduce the number of bounced signals received. This is especially true in rocky canyons or in bird studies when the birds are in flight and the signals seem to be coming from all directions. Signal bounce can also be minimized by tracking from aircraft because the animal can often be positioned within a line-of-sight vantage point (not that signal bounce can't occur when tracking from aircraft — there certainly can be reflections, especially in mountainous regions).

The entire phenomenon of signal bounce leads us to another phenomenon known as "phase cancellation." An extreme example was encountered some years ago by a researcher monitoring an animal in Death Valley. The researcher complained that the transmitter was "double pulsing." This was highly unlikely and, after listening, we determined that one pulse was coming directly from the animal and the other was a reflected pulse coming from the Panamint Mountains. This is an extremely unusual situation because the distance traveled was so great it delayed the pulses sufficiently to be separate in their occurrence. In most conditions the distance traveled is not as far *and the delay* is not as great. Thus the signals arrive "simultaneously."

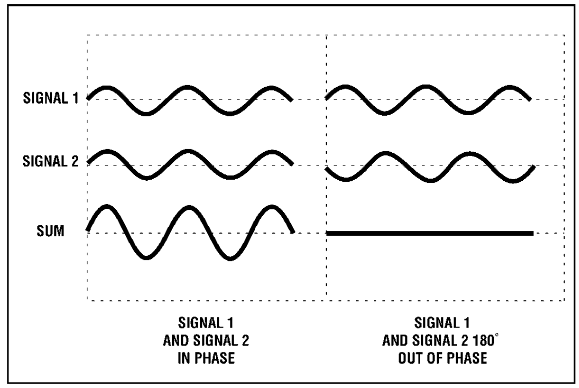


Figure 1 illustrates two waves arriving in phase and increasing the intensity of the received signal by 3 dB. Conversely, when the received signals are 180° out of phase, they cancel one another and no signal is heard.

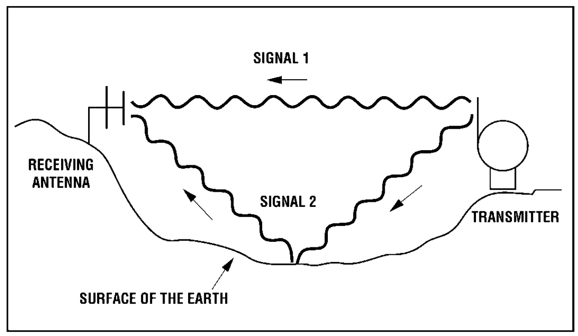


Figure 2 illustrates that phase cancellation can occur in relatively flat terrain. The phenomenon has been observed when monitoring from a line-of-sight vantage, as in the following scenario.

All conditions are seemingly optimum (e.g. the collar is in plain sight, the observation point is from a hillside, etc.). Still, a signal cannot be heard. The situation is particularly perplexing since you have successfully monitored other animals all day. So you recheck frequencies and the antenna connection, assuring yourself that everything is correct. Finally, you become convinced that the difficulty is collar failure. As you drop your antenna and walk away in disgust, you suddenly hear a loud signal. Aside from black magic, you are at a loss to explain what happened.

This is what may have happened. For a period of time, you were in a situation where phase cancellation was virtually complete, totally obscuring the signal. As you moved some function of a wave length away from the animal, the phase relationship of the received signal changed and the signal appeared to become stronger. What complicates these situations is that bounced signals can arrive simultaneously from a multitude of different directions. Each signal can arrive at the antenna at a given phase angle, and the antenna then sums all the imposed signals as its output to the receiver.

The effects of signal bounce and phase cancellation, in conjunction with the polarization discussed in the last issue of the Telonics Quarterly, produce the significant propagational effects experienced by individuals in field situations. Hopefully, these articles help to explain these effects, making the art a little less "artsy" and the black magic a little less black. *Stan Tomkiewicz*

The "F" Word

What lf It Fails?

Equipment failure is a subject that most of us would prefer was unnecessary to discuss in the wildlife telemetry field. It is a part of our everyday world, however, and the effects can range from mild annoyance to something so devastating as to render an entire research project worthless after many dollars and hours of effort have been spent. The degree the researcher, as well as the manufacturer, considers and plans for such an eventuality can go a long way in preventing or at least minimizing the effects of equipment failure.

Wildlife research has placed a unique set of reliability requirements on the radio telemetry field. Those familiar with equipment designed and fabricated for the military will readily admit that a transmitter with the desired characteristics for wildlife research, built to army requirements, could easily cost ten times that of a wildlife unit and then not be practical because of size and weight.

Transmitters placed on any species must be as lightweight as possible, yet built to withstand severe levels of physical abuse. Long transmitting life is usually essential, but package volume must be kept to an absolute minimum. The units must be highly reliable and still the cost must be low enough that graduate students operating on a minimal budget can still afford equipment for their research. These requirements force trade offs in design that almost always strain most of the desired characteristics to the limit.

Failures can be broadly classified in two categories, infant mortalities and latent failures. While the division between the two is rather arbitrary, it's still useful. As the name implies, infant mortality failures occur early in the expected life of a piece of equipment, often before it leaves the factory or before deployment. They are often one-of-a-kind and usually the result of a gross defect or an assembly error. An example might be an unsoldered electrical connection which, after a few temperature cycles, opens and remains open or makes intermittent contact.

Latent failures are more subtle, occurring well into the expected operational life of the equipment. This type of failure frequently appears in a particular production lot that was produced with a slight process change that "couldn't have any effect on the performance of the equipment." It is usually very difficult to determine the exact cause of the failure, and may require the examination of several additional units before a cause can be determined and corrective action taken.

What this means is that field failures with wildlife telemetry equipment can and do happen. While Telonics enjoys the highest reliability in the industry, typically in the high 90 percent range, the one or two percent that fail are a deep concern to us. Active measures are constantly pursued to identify and correct any known or suspected failure modes. To this end, you play an important part in identifying problems so that corrective measures can be taken. Accurate written records kept by researchers are essential in identifying, and often eliminating, a particular element as a source of the problem.

Sometimes failed equipment is received with a very good description of the suspected failure. More often, there is a simple note with a tag attached to the transmitter saying something like "failed." Such a note obviously leaves a myriad of questions unanswered and necessitates a phone call to the researcher. By this time, he is usually relying strictly on his memory as to the precise history of the unit in question. Many times no written records have been kept other than the times and dates the animal was located.

It is recommended that a log be kept for each piece of gear so that the following items can be addressed should it become necessary to return the equipment for failure analysis. While the list is oriented to the transmitting subsystem, similar considerations should be given to any piece of equipment.

- Provide a pre-deployment history of the unit including receipt date, storage times and conditions, and any testing that was performed to verify operation during the period of storage.
- Include a brief history of the unit after it has been put into service. Dates are important so that total operating life can be considered. If a transmitter is capable of transmitting two or more periods, any information about the percentage of time observed in each mode can be helpful.
- If there is anything unusual about the area of deployment or behavioral characteristics of the animal, be sure and mention it in the log.
- Be specific as to the failure that has occurred. A statement such as "unit operated normally until 6 June 1990, at which time transmitter was observed transmitting at the mortality rate (450 msec period) even though the animal was moving...collar was rotated about 90 degrees from normal position..." is considerably more informative than "transmitter failed June 1990."

To be effective, failure analysis is a cooperative effort between user and manufacturer. The cause of a failure is usually difficult to determine, and sometimes misdiagnosed. Often a small, seemingly insignificant tidbit of information thrown in by an alert researcher has made the difference between a timely solution and one that recurs and evades identification for months.

At Telonics, equipment reliability is a primary concern and your help in that effort is sincerely appreciated.

Boyd Hansen

Peace and Happiness To You and Yours...

A Holiday Greeting

Although there is no snow on the cactus, the roses are in bloom, and it is easier for many of us to imagine Santa arriving in a convertible than riding a sleigh — there is still a special excitement in the air here in Mesa, Arizona.

The busy holiday season is just around the corner and once again we look forward to happy times with families and friends. Because it is important that we share the holidays with those who are most special to us, Telonics will be closed from December 22 through January 1. We will reopen on January 2, at which time we will resume our normal business hours of 7 AM to 4 PM, Mountain Standard Time.

We would like to take this opportunity to thank each of you for your support throughout this past year. We sincerely appreciate your business and it has been our pleasure to work with you. We look forward to working with you in the future and are committed to meeting your individual needs and providing you with the excellent service you deserve.

If you are in our area or have the opportunity to visit, we invite you to stop by Telonics at any time. It is always a treat to have our customers visit us here in the laboratory. It gives us the chance to meet, in person, many of you with whom we have worked and feel we know.

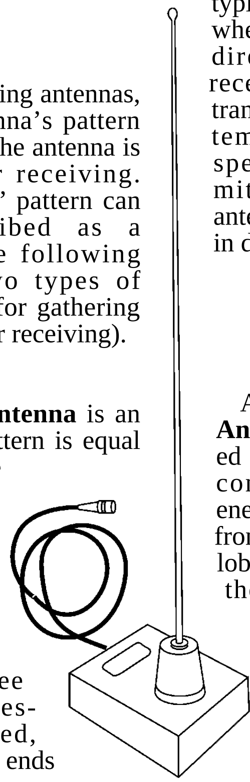
May the magic of the holiday season be with you and yours. Peace, happiness and prosperity is our wish for you in 1991.

Susie Crow

Directional and Omni-Directional Antennas

It is helpful, when discussing antennas, to understand that an antenna's pattern and gain are equal whether the antenna is used for transmitting or receiving. Consequently, a "radiation" pattern can be alternatively described as a "receiving" pattern. The following definitions focus on two types of antennas used in the field for gathering data (whether transmitting or receiving).

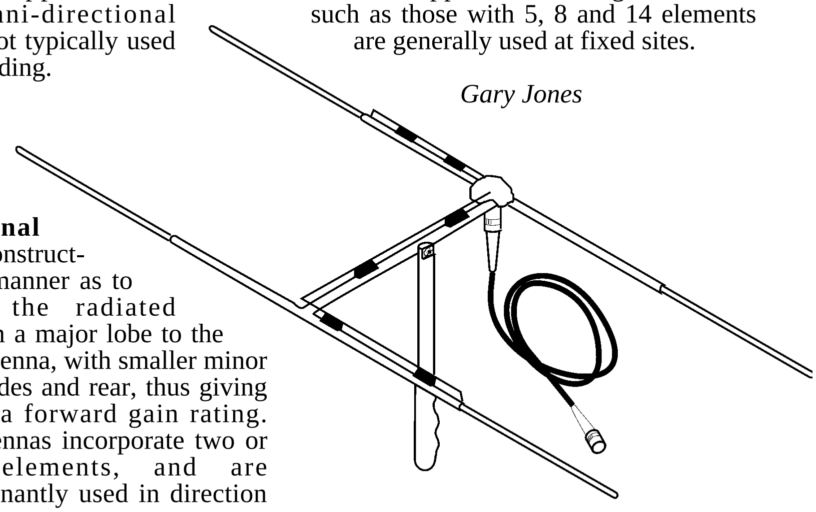
An **Omni-Directional Antenna** is an antenna whose radiation pattern is equal in all directions in one plane. Commonly used omni-directional antennas in-clude whips of various fractions of a wavelength. The actual pattern of the whip antenna is nearly uniform in the horizontal plane. The antenna's three dimensional pattern is es-sentially doughnut-shaped, with holes or "nulls" off the ends of the whip.



Omni-directional antennas are typically used for transmitting antennas where it is desirable to transmit in all directions. They are also used as receiving antennas to determine if a transmitter is in the area, or to collect temperature or activity data from specially equipped trans-mitters. Omni-directional antennas are not typically used in direction finding.

A **Directional Antenna** is construct-ed in such a manner as to concentrate the radiated energy to form a major lobe to the front of the antenna, with smaller minor lobes to the sides and rear, thus giving the antenna a forward gain rating. These antennas incorporate two or more elements, and are predominantly used in direction finding.

In general, the greater the number of elements, the greater the gain or sensitivity.



The physical size of the antenna increases as the number of elements increases. Two element "H" antennas or 3-element Yagis are frequently used in hand-held applications, but this does not preclude them from also being used in fixed site applications. Larger antennas such as those with 5, 8 and 14 elements are generally used at fixed sites.

Gary Jones